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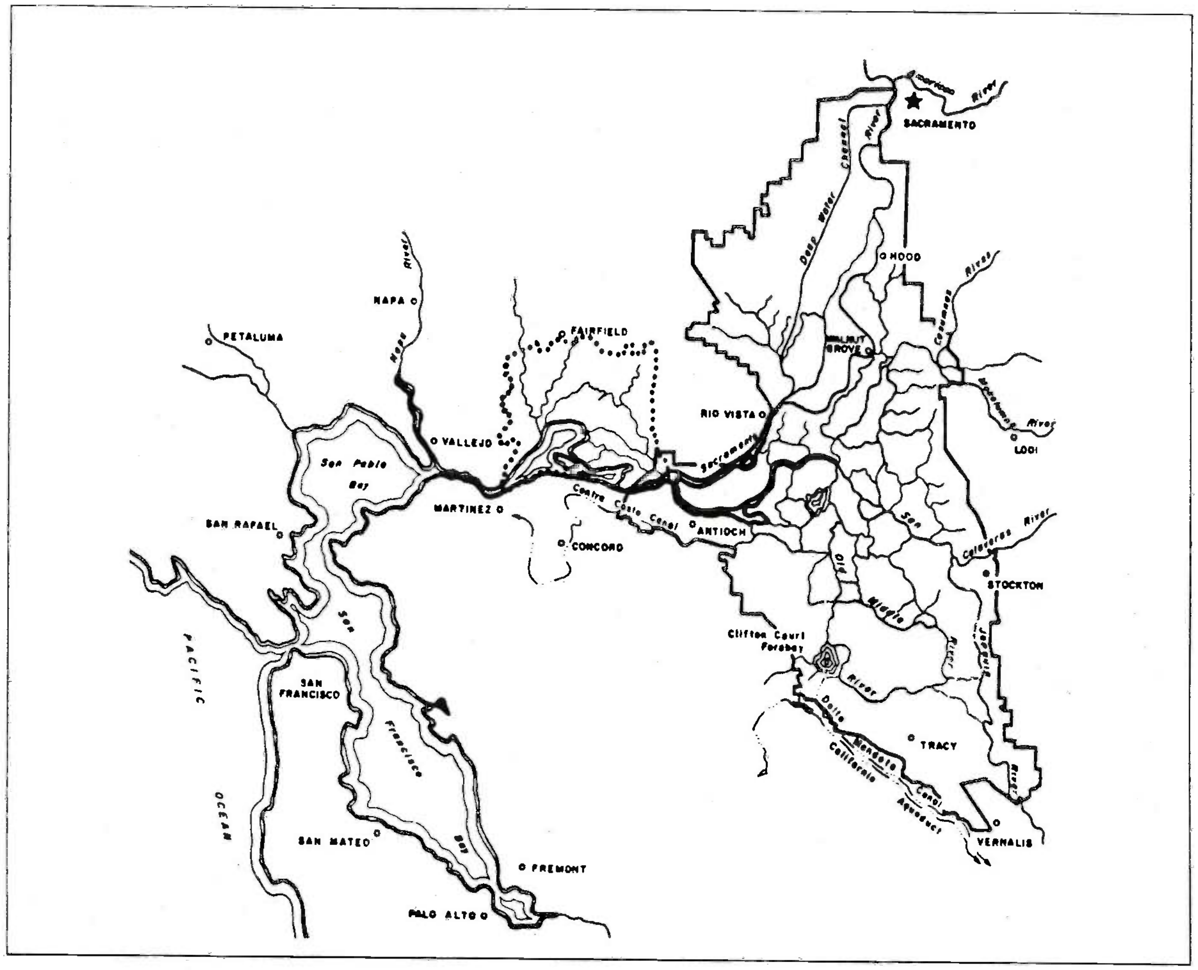

Pollutant Policy Document

San Francisco Bay / Sacramento - San Joaquin Delta Estuary

June 21, 1990

STATE WATER RESOURCES CONTROL BOARD

COV0023

STATE WATER RESOURCES CONTROL BOARD
RESOLUTION NO. 90-67

ADOPTION OF POLLUTANT POLICY DOCUMENT
FOR THE
SAN FRANCISCO BAY/SACRAMENTO-SAN JOAQUIN DELTA ESTUARY

WHEREAS:

1. California Water Code Section 13140 provides that the State Board shall formulate and adopt state policy for water quality control; and

2. California Water Code Section 13240 provides that water quality control plans shall conform to any state policy for water quality control; and

3. The Pollutant Policy Document for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Pollutant Policy Document) contains policies directed to the Regional Boards for the San Francisco Bay Region and the Central Valley Region; and

4. The Regional Boards for the San Francisco Bay Region and for the Central Valley Region can conform their water quality control plans to the policies in the Pollutant Policy Document by amending the plans to implement the policy; and

5. The State Board must approve any conforming amendments pursuant to Water Code Section 13245; and

6. The policies contained in the Pollutant Policy Document are designed to provide solutions to specific pollutant problems, ensure consistency in the regulatory approach used by the San Francisco Bay Regional Board and the Central Valley Regional Board, and provide a basis for future regulatory efforts; and

7. All documents listed in the REFERENCES at the end of each chapter of the Pollutant Policy Document that have not already been received in evidence, have been offered in evidence; and

8. The Pollutant Policy Document is part of the State Board's Water Quality Control (Basin)/208 Planning Program which has been certified by the Secretary for Resources under Public Resources Code Section 21080.5 as being exempt from the requirements for preparing Environmental Impact Reports, negative declarations and initial studies; and

9. The Pollutant Policy Document is a substitute for an environmental document under Public Resources Code Section 21080.5, and all notice requirements have been met.

THEREFORE BE IT RESOLVED THAT:

1. The Pollutant Policy Document is adopted as state policy for water quality control under Water Code Section 13140.

2. All documents listed in the REFERENCES that have not already been received in evidence are hereby received in evidence.

3. The Chief of the Division of Water Rights is directed to file a Notice of Decision with the Secretary for Resources.

CERTIFICATION

The undersigned, Administrative Assistant to the Board, does hereby certify that the foregoing is a full, true, and correct copy of a resolution duly and regularly adopted at a meeting of the State Water Resources Control Board held on June 21, 1990.

Maureen Marché

Maureen Marché
Administrative Assistant to the Board

PREFACE

On July 7, 1987 the State Water Resources Control Board (State Board), pursuant to commitments in its 1978 Water Right Decision 1485 (D-1485) and Water Quality Control Plan (Delta Plan) for the Sacramento-San Joaquin Delta and Suisun Marsh, opened a public proceeding to receive evidence on beneficial uses and water quality issues for the San Francisco Bay and Sacramento-San Joaquin Delta Estuary (Estuary). Differing procedurally from that held for D-1485, the current proceedings will be conducted in four separate phases: Phase I (Draft Document Development), the Water Quality Phase, the Scoping Phase and the Water Right Phase. Completing the Phase I, a Draft Pollutant Policy Document (PPD) and a separate Draft Water Quality Control Plan (Plan) were distributed for review in November, 1988.

As a result of comments received on the PPD and efforts to coordinate it with other water quality documents being developed by the State Board, the PPD has been revised and given a separate hearing which was noticed in October 1989. After informational hearings in Sacramento and the Bay area in December 1989, the State Board directed staff on PPD revisions. After receiving further comments, the State Board revised and adopted the PPD on June 21, 1990. (Minor typographical errors and oversights have also been corrected after its adoption. (Water Code Section 1359; Resolution 90-16))

Regional Boards 2 and 5 will use the PPD as a guide in updating portions of their Basin Plans. Each Regional Board will then send its amended Basin Plan to the State Board for approval. The PPD will establish state policy for water quality control under Water Code Sections 13140-13147 to be used by the San Francisco Bay and the Central Valley Regional Boards.

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LIST OF FIGURES AND TABLES

CITING INFORMATION

When citing evidence in the hearing record, the following conventions have been adopted:

Information derived from the <u>transcript</u>:

(a) for a single excerpt from a single transcript:

I,T,XIX,123:09-125:20

- ending page and line number (can be same as the starting page) - may be omitted if a single line reference is used
- beginning page and line number
- volume number
- identifying abbreviation of the information source (T = Hearing Transcript)
- identifing abbreviation for hearing phase (I = Phase I, 6/87-12/87 (optional)
  II = Phase II, 1/88-6/89
  PPD = Pollutant Policy Document, 12/89
  WQCP = Water Quality Control Plan, 2/90-Present)

(b) for multiple excerpts from a single transcript:

I,T,XIX,123:09-125:20,139:3-8,...,146:22-147:10

- Nth excerpt location
- 2nd excerpt location
- 1st excerpt location
- transcript volume identification

(c) for multiple references to the same information:

I,T,XIX,123:09-125:20;II,T,I,12:02-13:10

- 2nd reference identification
- 1st reference identification

Information derived from an exhibit:

I,SWRCB,25,45

- 45 — page number, table number, graph number
- 25 — exhibit number
- SWRCB — identifying abbreviation of the information source (see Appendix C, Abbreviations)
- I — identifing abbreviation for hearing phase

When citing references outside of the hearing record, the following conventions have been adopted:

Information derived from published documents,
(a) in the text of the Document or Plan:

Denton, R.A.,1985

- 1985 — year of publication
- Denton, R.A. — author's name or agency abbreviation

CITING INFORMATION (Continued)

(b) at the end of the appropriate Chapter of the Document or Plan:

Denton, R.A., Currents in Suisun Bay, January 1985, pg. 4.

- pg. 4 — page no.
- January 1985 — publication date
- Currents in Suisun Bay — title of document cited
- Denton, R.A. — author's name or agency abbreviation

Information derived from Phase I closing briefs,
(a) in the text of the Document or Plan:

I,RIC,Brief,8

- 8 — page number
- Brief — "Brief"
- RIC — identifying abbreviation of the information source
- I — identifing abbreviation for hearing phase

(b) at the end of the appropriate Chapter of the Document or Plan:

Phase I hearing Brief of the Rice Industry Committee, pg. 8.

Appendix B is a Glossary of Terms.

Appendix C is a complete list of the abbreviations for information sources, citations and symbols used in this document.

1.0 EXECUTIVE SUMMARY

1.1 Introduction

The PPD establishes state policy for water quality control under Water Code Sections 13140-13147 to be used by the San Francisco Bay Regional Water Quality Control Board (Region 2) and the Central Valley Regional Water Quality Control Board (Region 5) in updating portions of their regional water quality control plans (Basin Plans). The PPD also identifies and characterizes pollutants with the greatest potential biological significance in the Bay-Delta Estuary. Pollutants addressed in this work were selected because of their widespread or repeated occurrence and their potential to cause adverse effects on beneficial uses in the Estuary. The pollutants of concern are: arsenic, cadmium, chromium, copper, chlorinated dibenzodioxins and dibenzofurans, hydrocarbons, lead, mercury, nickel, organochlorines, selenium, silver, tributyltin and zinc[1/]. Information on point, nonpoint and riverine sources of pollutants presented during the hearing is discussed as well as the effects of these pollutants on public health and biological resources. Other related issues that the Regional Boards requested the State Board to resolve, such as the impacts of dredging spoils, trihalomethanes, cumulative pesticide loads and database evaluation, are also addressed.

Widespread public concern over the vitality of the Bay-Delta Estuary calls for definitive action to protect this important resource. In addition to the direct effects of single-occurrence events of pollutants being discharged or spilled into the Bay-Delta waters, an important potential cause of impairments to the aquatic resources of the Estuary is the cumulative effects of toxic pollutants discharged to the system. The PPD is intended to provide solutions to specific pollutant problems, ensure consistency in the regulatory approach used by the San Francisco Bay Regional Board and the Central Valley Regional Board, and provide a basis for future regulatory efforts.

Chapter 2 begins with an overview of the physical characteristics of the Estuary and provides information on sources and loading for the various constituents. Chapter 3 reviews the toxicological effects, regulatory standards and reported concentrations available for each constituent. Chapter 4 presents specific policy guidance for Regional Boards 2 and 5 to use in amending their Basin Plans. This guidance includes policies to establish a mass emissions strategy and to implement site-specific as well as general control measures for pollutants. Chapter 5 establishes a program to direct monitoring, to track the progress of implementing these policies, and improve the quality and quantity of information needed for future policy decisions and basin planning.

1/ This policy is not intended to address all pollutants for which objectives are required under Section 303(c)(2)(B) of the federal Clean Water Act. The State Board intends to establish objectives for all of the other required pollutants in the forthcoming Statewide Water Quality Control Plans for Inland Surface Waters and for Enclosed Bays and Estuaries of California.

The PPD is part of the State and Regional Boards' Water Quality Control and 208 Planning Program, which has been certified by the Secretary for Resources as an exempt regulatory program under Public Resources Code Section 21080.5. Consequently, the PPD is a substitute for an environmental document under the State Board's regulations at 23 CCR Section 3775 et seq.

The State Board has reviewed the PPD for significant or potentially significant effects on the environment and its review of the PPD shows that the policies established by the PPD will not have any significant or potentially significant adverse effects on the environment. Therefore, no alternatives or mitigation measures are proposed in the PPD to avoid or reduce any significant effects on the environment (14 CCR Section 15252, 23 CCR Section 3720).

1.2 Concerns

During Phase I and the Water Quality Phase of the hearings on the PPD, evidence was offered about the sources and amounts of pollutants in the Estuary. The evidence was reviewed and the following conclusions were reached:

- Several pollutants were identified at concentrations which may cause direct toxic effects to aquatic life and may pose a threat to human health through consumption of contaminated biota. Water quality objectives for these pollutants appear to be inadequate or lacking. For freshwater, these are tributyltin, zinc, nickel, cadmium, hexavalent chromium, selenium, copper and dioxin. For saltwater portions of San Francisco Bay, these are tributyltin, zinc, cadmium, hexavalent chromium, selenium, copper, silver and dioxin.

- Existing data indicate that the pollutants of concern in the Bay-Delta Estuary are, for the most part, persistent pollutants which accumulate over time in sediment and biota.

- Enforcement of water column objectives alone is inadequate for controlling many pollutants which bioconcentrate. Tissue level objectives are also needed, specifically, for polynuclear aromatic hydrocarbons, mercury, arsenic, cadmium, copper, selenium and silver.

- Little information is available on the potential detrimental effects to human health and biological communities as a consequence of elevated pollutant concentrations in sediment and biota. This lack of information about these pollutants -- arsenic, cadmium, hexavalent and trivalent chromium, lead, mercury, nickel, polychlorinated biphenyls and DDT -- hampers regulatory decisions.

- Tributyltin concentrations measured in poorly circulated harbors and marinas have exceeded levels known to cause adverse effects on aquatic organisms.

- The public perception is that pesticides pose a significant and growing threat to the vitality of the Bay and Delta. Current understanding of pesticide dynamics in the Bay and Delta is limited.

- o The concentrations of dioxins and related compounds in the Sacramento River and the Delta have exceeded levels known to cause adverse effects. Health advisories have been issued warning against consumption of fish in some areas of the Sacramento River.

- o Inadequate monitoring data hamper both problem identification and the ability to respond to specific circumstances. The quality and quantity of existing data need to be improved. Lack of coordination of existing monitoring efforts has led to inefficient programs and under-utilization of the data collected.

1.3 Pollutant Policies and Actions

In order to address these problems, the State Board has concluded that the following principles and actions, pages 1-3 through 1-6, are necessary to control pollutant sources and loadings to the Estuary.

1.3.1 Pollutant Policies

1. Programs which reduce and eliminate pollutants in the San Francisco Bay-Delta Estuary must be supported to the extent they are reasonable and feasible.

2. Beneficial uses in the Bay-Delta Estuary shall be protected against all pollutants known to be harmful, as well as those which are potentially harmful to humans and aquatic species.

3. At this time, the use of Delta outflow solely to flush pollutants, other than ocean derived salts, out of the Estuary does not appear necessary. The need for such flows may be considered in the future after all reasonable source control methods have been implemented and only if it is found to be in the public interest.

4. The in-Bay dumping of dredge sediments that have the potential to cause significant adverse impacts on the Bay's resources should be eliminated.

5. Expansion and ongoing assessment of the effectiveness of existing monitoring programs are needed.

6. Due to the extreme toxicity and persistence of dioxin and related compounds (Section 3.15), it is the goal of the State Board to eliminate the discharge of these compounds to waters of the Bay-Delta by the year 2000. This date, the State Board believes, will provide dischargers with a reasonable amount of time to find suitable substitutes for the processes that create these compounds.

1.3.2 Actions

1. Department of Health Service Guidance

   Pursuant to its authority under Sections 13146, 13163 and 13165 of the California Water Code, the State Board requests the Department of Health Services (DHS) to report to the State Board on the human health impacts of arsenic, cadmium, hexavalent and trivalent chromium, dioxins and related compounds, lead, mercury, nickel, selenium, polychlorinated biphenyls and DDT, as single constituents and in combination with each other. Based on this information, DHS is requested to provide guidance to the State Board in directing regulatory efforts to prevent any impairment of human health from the consumption of aquatic life.

2. Mass Emissions Strategy

   The San Francisco Bay and Central Valley Water Quality Control Boards shall implement the mass emissions strategy described in this document as a program to regulate mass emissions of the following substances: arsenic, cadmium, copper, mercury, selenium, silver, and polynuclear aromatic hydrocarbons. The purpose of this mass emissions strategy is to control the accumulation in sediments and the bioaccumulation of these substances in the tissues of aquatic organisms in accordance with the statutory requirements of the Porter Cologne Act, and the Clean Water Act. The program shall accomplish the following:

   - Identify locations, based on available data, where pollutant concentrations in tissue and sediment are elevated and are of concern due to potential impairment of beneficial uses;
   - Identify the sources of pollutants for these locations;
   - Develop and implement a program to regulate mass emissions based upon an assessment of alternative control actions for principal sources;
   - Monitor and report progress; and
   - Develop tissue and sediment objectives.

   The Regional Boards are to develop a workplan for implementation of the MES no later than December 1, 1990. The workplan shall include a schedule for adopting MES implementation measures into their respective Basin Plans no later than June 1, 1992.

3. For chlorinated dibenzodioxins and dibenzofurans, the Regional Boards shall develop plans of implementation which will achieve the goal of elimination. The Regional Boards shall also establish monitoring programs to track the decreased concentration of these compounds in fish tissues that result from implementation of this program.

4. Tributyltin

   Unless appropriate state objectives exist, the San Francisco Bay and Central Valley Regional Water Quality Control Boards shall adopt a water quality objective for tributyltin. The direct discharge of tributyltin resulting from in-water paint stripping operations shall be prohibited. National Pollutant Discharge Elimination System (NPDES) permits shall be required for boat and shipyards.

5. Dredge Sediments

In order to limit any adverse impacts caused by disposal of dredge sediments in the San Francisco Bay, including remobilization of pollutants, the U.S. Environmental Protection Agency is requested to designate an ocean disposal site by January 1994. In the interim, the U.S. Army Corps of Engineers, working with EPA as part of the long term management strategy (LTMS), is requested to submit a proposal listing potential interim sites and the feasibility of use of those sites for new work in San Francisco Bay. The proposal is to be submitted to the State Board and San Francisco Regional Board within six months of the date of adoption of this document. As part of the LTMS, the U.S. Army Corps of Engineers and the San Francisco Bay Regional Board will make available to the State Board an assessment of the impacts of in-Bay disposal of dredge sediments on the beneficial uses of the waters of San Francisco Bay. This assessment shall include at least:

- o Identification of toxic constituents in dredge sediments from San Francisco Bay;
- o Assessment of the potential bioavailability, bioaccumulation and toxicity of toxic constituents in such dredge spoils;
- o Development of regional regulatory compliance monitoring program as described in the LTMS workplans; and
- o Development of sediment quality objectives for San Francisco Bay.

As part of the LTMS, general guidance for the disposal of dredged material to land will be developed with the assistance of the San Francisco Bay and Central Valley Regional Boards. The suitability of dredge sediment for levee rehabilitation in the San Francisco Bay and the Delta will be considered. No dredged material shall be deposited on land surrounding the Bay and in the Delta until the Regional Board determines that pollution will not be increased in the waters of the Bay-Delta Estuary.

6. Pesticides

During Phase I of the proceedings and during the Water Quality Phase hearings on the PPD, the discharge of pesticides from agriculture was a major topic. The discussion focused primarily on the pesticides discharged to the Sacramento River. Extensive requirements for the Regional Boards were set forth in the two drafts of the PPD prior to the Water Quality Phase hearing on the PPD.

In replacing the previous cumulative pesticide objective, the Central Valley Regional Water Quality Control Board has acted expeditiously to develop and adopt a program aimed at reducing and eliminating the discharge of pesticides to the waters of the Bay-Delta Estuary. On January 26, 1990, the Central Valley Regional Water Quality Control Board amended its Water Quality

Control Plan for Basins 5A, 5B, and 5C to include the new program (Resolution NO. 90-028). The State Board, having reviewed the basin plan amendment, approved it on February 15, 1990. The State Board's approval put the basin plan amendment into effect. Therefore, a discussion in this document of changes in the 0.6 ppb cumulative pesticide objective in Basin Plan 5B is no longer needed, and has been deleted from the PPD.

7. Water Quality Monitoring and Assessment Program

A Bay-Delta Quality Assessment Program shall be established which will include monitoring efforts to track progress of the programs instituted by this Policy and to recommend changes for improvement of the quality and quantity of information available (see Chapter 5 for details). The responsibilities of the Program shall include:

- o Coordinating water quality monitoring activities related to the Bay-Delta Estuary;
- o Preparing a Bay-Delta Water Quality Assessment report to the State Board and to the public recommending a coordinated monitoring strategy which will include goals and objectives, station locations, frequency of monitoring, constituents to be monitored and associated costs;
- o Recommending changes to State and Regional Board Basin Plans, policies and programs needed to protect the beneficial uses of the Bay-Delta Estuary.

In order to have all users share in the cost, the State Board intends to establish, perhaps by recommending legislation, a procedure whereby users of Bay-Delta waters will contribute equitably towards the total cost of development and maintenance of a monitoring program.

2.0 POLLUTANT SOURCES AND LOADINGS IDENTIFIED IN THE SAN FRANCISCO BAY-DELTA

2.1 Physical Boundaries

The following defines the physical boundaries of the area within which objectives have been set in the PPD. A map has been provided for reference (See Figure 1).

2.1.1 Sacramento-San Joaquin Delta

The Delta, as defined in Water Code Section 12220, is a roughly triangular area extending from Chipps Island near Pittsburg on the west to Sacramento on the north and to the Vernalis gaging station on the San Joaquin River in the south. Also included within the Delta boundary are the Harvey O. Banks Pumping Plant and the Tracy Pumping Plant, SWP and CVP facilities, respectively. Water quality objectives are set at the pumping plants in the Delta for water exported for use in central and southern California.

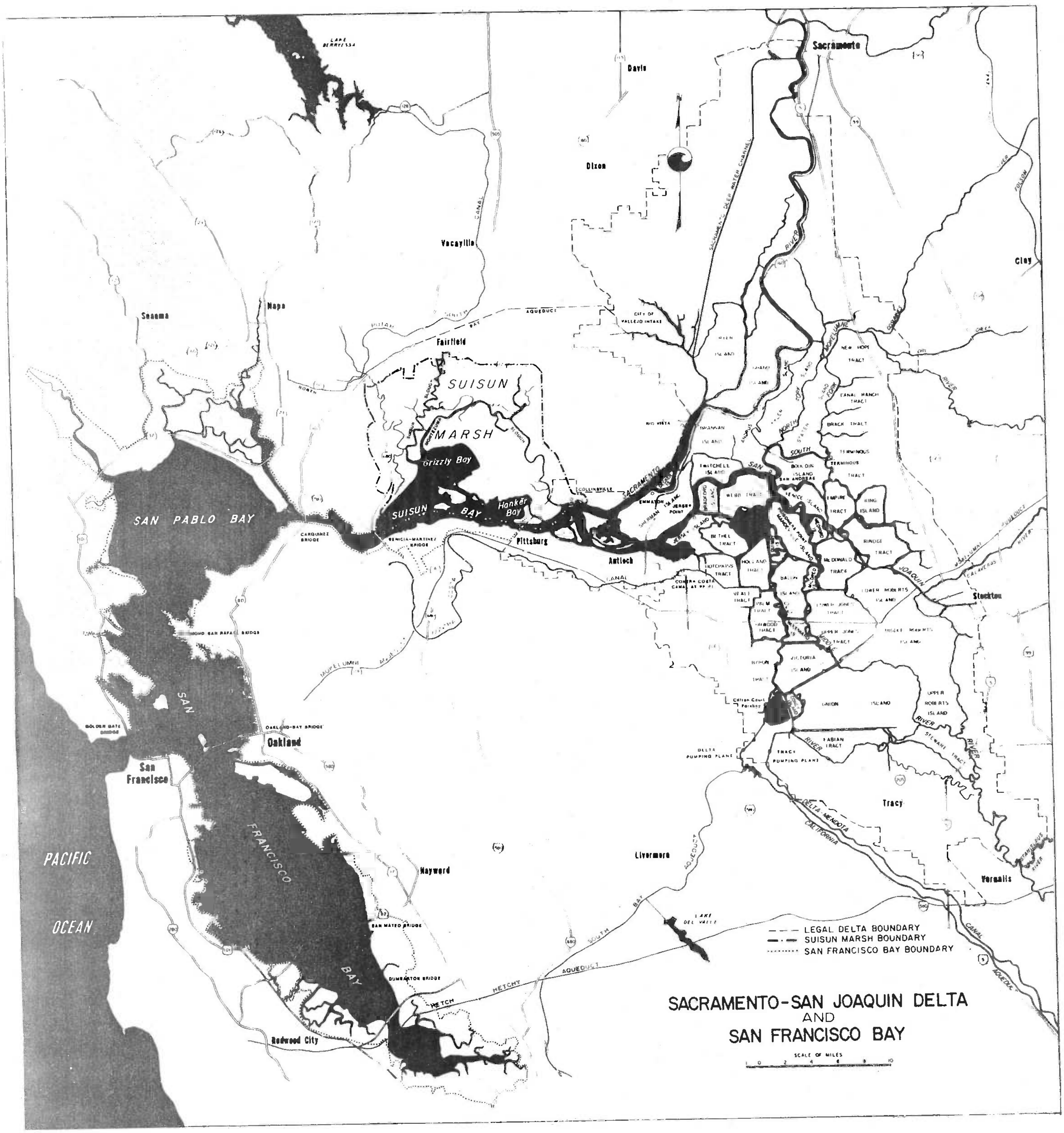
2.1.2 San Francisco Bay

San Francisco Bay (Bay) is located at the mouth of the Sacramento-San Joaquin Delta, at the outlet for the Sacramento and San Joaquin rivers. These rivers drain about forty percent of the state. The Bay is composed of four primary embayments which are: (1) The South Bay, stretching from the Oakland Bay Bridge on the north to Mountain View on the southern edge; (2) the Central Bay, the area between the Richmond-San Rafael Bay Bridge and the Oakland Bay Bridge; (3) the San Pablo Bay to the north, encompassing the area from the Richmond-San Rafael Bay Bridge on the south side to the Petaluma River on the north and the Carquinez Strait on the east; and (4) the area between the entrance to the Carquinez Strait and Chipps Island, encompassing the Carquinez Strait, Suisun Bay, Grizzly Bay and Honker Bay. The definitions of the four primary embayments comprising the Bay, as used in this document, are the definitions commonly used in hydrodynamic literature (Denton and Hunt, 1986). The definitions of the five embayments used in the San Francisco Bay Water Quality Control Plan are not based on hydrodynamic considerations but rather in a manner suited to group clusters of waste discharge locations.

2.1.3 Suisun Marsh

While the Suisun Marsh is part of San Francisco Bay, its boundaries are legally defined (Public Resources Code Section 29101 and 29101.5). The Suisun Marsh is generally located in southern Solano County, south of the cities of Fairfield and Suisun City. It is bordered on the south by Suisun Bay, Honker Bay, and the confluence of the Sacramento and San Joaquin rivers; on the east from Denverton along Shiloh Road to Collinsville.

FIGURE 1


SACRAMENTO-SAN JOAQUIN DELTA
AND
SAN FRANCISCO BAY
LEGAL DELTA BOUNDARY
SUISUN MARSH BOUNDARY
SAN FRANCISCO BAY BOUNDARY
SAN PABLO BAY
SUISUN MARSH
Grizzly Bay
SUISUN BAY
Honker Bay
SAN FRANCISCO BAY
PACIFIC OCEAN
Sacramento
Davis
Dixon
Vacaville
Fairfield
Napa
Sonoma
Pittsburg
Antioch
Oakland
San Francisco
Hayward
Livermore
Redwood City
Tracy
Stockton
Vernalis
Clay

2.2 Identification of Pollutant Sources and Loadings

The San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta Estuary) is affected by streamflow and effluent discharge carrying pollutants from a watershed which provides about 40 percent of California's surface water runoff (DWR,14,9). The watershed includes some of the most intensively cultivated land on earth, as well as substantial urban development, major industrial and chemical complexes, a variety of military facilities, and both active and abandoned mining areas.

Past attempts to deal with pollution have focused on the most obvious and treatable problems. The major effort in recent years has been to control point source discharges of all wastewater; less effort has gone into control of nonpoint sources of pollution. Basin Plans have been established that contain objectives for dissolved oxygen, suspended solids, trace metals and trace organics among others. These Basin Plans, the enforcement efforts of the Regional Boards, and compliance by the dischargers have resulted in a significant improvement in the chemical and physical condition of San Francisco Bay (BADA,3,III-2).

Although overall chemical and physical conditions such as turbidity, nutrients, coliform organisms and chemical oxygen demand in the Bay -Delta have been improved, some pollutants still exist in the water column, sediments and tissue in concentrations which are cause for concern (CBE,1,2). To address these and other concerns, the State Water Resources Control Board (State Board) contracted the Aquatic Habitat Institute (AHI) to prepare comprehensive reports on the sources and loadings, i.e., the total mass from all sources of various pollutants, in the Bay-Delta basin (AHI,302), and their possible biological effects (AHI,304).

Pollutants may enter the Estuary through flows and discharges from a number of sources. Once in the Bay-Delta, a wide variety of processes may occur which redistribute, concentrate or dilute the pollutants.

This pollutant policy document not only identifies the quantities and sources of the significant pollutant loads, but also the most effective course of action to protect the state's water quality. The PPD suggests the use of available regulations and takes into account the particular measures which may lead to the control of each element of the pollution problem.

Five sources of pollutants and their loadings will be discussed:

- o 2.2.1 -- Point sources
- o 2.2.2 -- Urban runoff
- o 2.2.3 -- Nonurban runoff
- o 2.2.4 -- Riverine sources; and
- o 2.2.5 -- Other sources.

The pollutants of concern are: arsenic, cadmium, chromium, copper, hydrocarbons, lead, mercury, nickel, organochlorines, selenium, silver, tributyltin, and zinc. For convenience, the "total hydrocarbons" is used to refer to an extensive and artificial group of compounds which includes oil and grease, mononuclear hydrocarbons (MAHs), polynuclear aromatic hydrocarbons (PAHs), and other hydrocarbon or organic compounds such as trihalomethane formation precursors (THMFPs).

Likewise, "organochlorines" refers to chlorinated hydrocarbon pesticides and polychlorinated biphenyls (PCBs). (EPA has requested monitoring information concerning dioxins in the effluent of several refineries in the Richmond-Pittsburg area. There is also concern about dioxins from pulp mills near Antioch.)

The sources and loadings of these pollutants are summarized in Table 1. A bar graph depicting summations of annual loadings of pollutants from the various sources is shown in Figure 2. The years of record used as a basis for the PPD are January 1984 through December 1986.

Annual pollutant loadings do not provide a total indication of pollutant impact. Some pollutant sources, such as urban runoff, are highly variable with time. Other sources, though relatively constant, may have different impacts based on the season of the year, i.e., they may have greater impacts when receiving water flows or flushing flows are low. Variability in loadings and receiving water conditions should be kept in mind when reviewing the time-averaged estimates provided in this text.

Information presented in this chapter on sources and loadings were derived from exhibit numbers 301 and 302 presented by the Aquatic Habitat Institute.

2.2.1 Point Sources

Point sources refer to publicly owned treatment works (POTW's) and industrial dischargers. Estimates of pollutant loadings from point sources are more accurate than other sources because they are recorded in self-monitoring reports and are derived from loading data averaged over three years. These reports are required by permits issued under the National Pollutant Discharge Elimination System (NPDES) program. Three year average loadings were also used to characterize the other sources of pollutants.

POTWs and industries have significantly reduced the discharge of toxic metals to the Bay-Delta over the past several decades. Point sources contribute far less total loads (ranging from about 1 to 6 percent) to the Bay-Delta Estuary than non-point sources (Figure 2, urban runoff, nonurban runoff and riverine sources). However, care should be taken when comparing AHI's calculated total loads between point and non-point sources. For example, in Table 1 it is estimated that about 95 percent of the total pollutant load in urban runoff is comprised mainly of oil and grease, while about 5 percent is comprised of trace metals, PAHs, and organochlorines. In comparison, Table 1 shows that trace metals comprise nearly 100 percent of point source loads.

TABLE 1
SOURCE AND POLLUTANT LOADINGS IN THE SAN FRANCISCO BAY-DELTA
(FROM AHI, 1987)

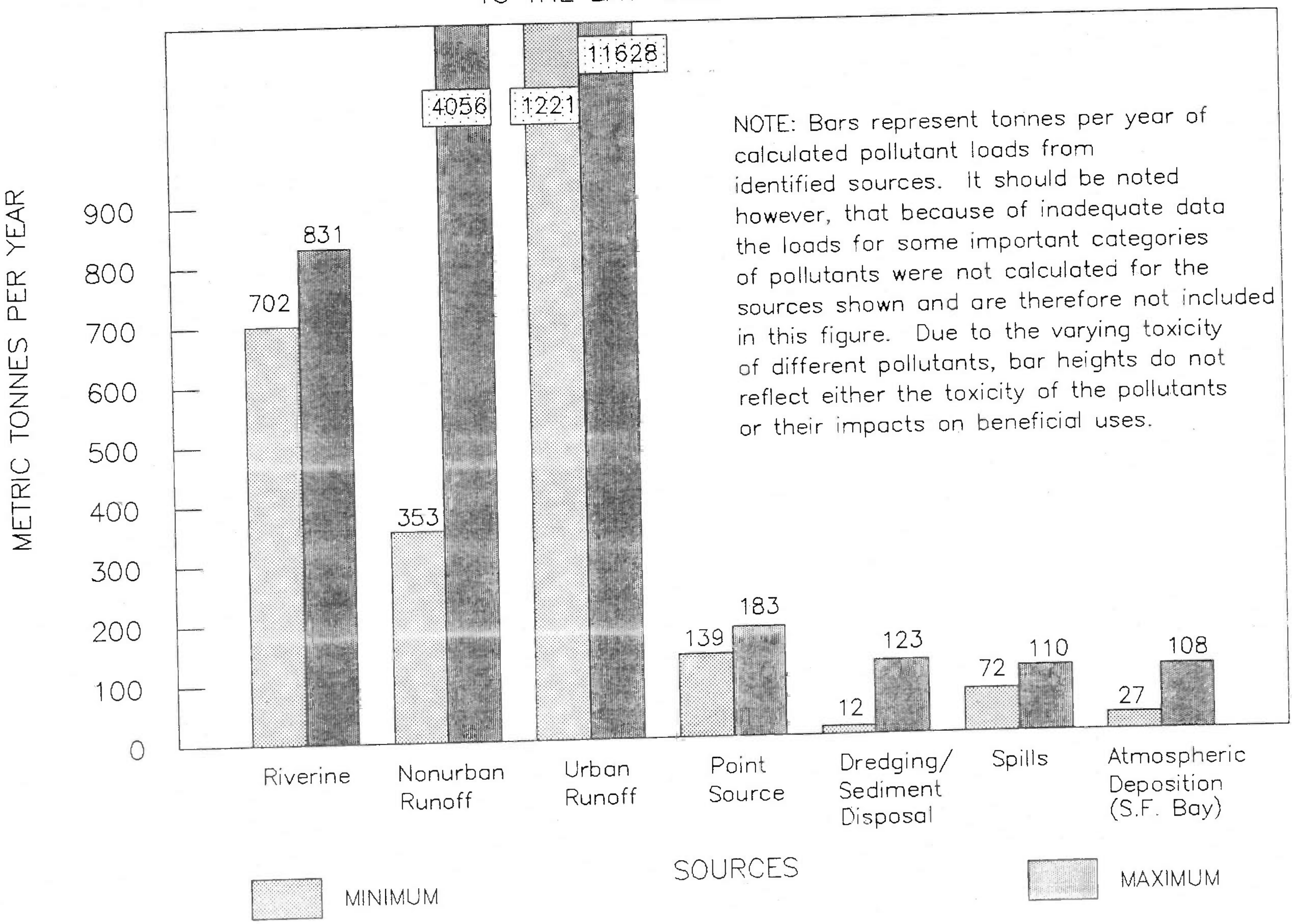
Pollutant Type	Major Sources					Other Sources	
	Riverine	Non-Urban Runoff	Urban Runoff	Point Source	Dredging and Sediment Disposal	Spills	Atmospheric Deposition
Arsenic (As)	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max
%	71.6 21.4	22.4 68.9	2.2 5.2	3.4 3.3	0.4 1.2	0.0 0.0	0.0 0.0
(tonnes)	32-37	10-119	1.0-9.0	1.5-5.7	0.2-2.0	NA	NA
Cadmium (Cd)	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max
	65.8 66.6	6.0 14.8	3.6 7.4	22.7 9.9	0.2 0.5	0.0 0.0	1.7 0.9
	5.2-27.0	0.5-6.0	0.3-3.0	1.9-4.0	0.02-0.2	NA	0.14-0.35
Chromium (Cr)	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max
	33.3 5.4	58.0 90.0	1.3 0.9	5.2 0.8	2.2 2.9	0.0 0.0	0.0 0.0
	77-92	134-1,537	3.0-15	12-14	5.0-50	NA	NA
Copper (Cu)	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max
	72.0 22.9	18.1 65.5	2.5 6.7	6.4 3.5	0.4 1.1	0.0 0.0	0.7 0.3
	202-203	51-581	7.0-59	18-31	1.0-10	NA	1.9-3.1
Hydrocarbons (PAHs)	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max
	0.0 0.0	0.0 0.0	37.0 48.7	0.0 0.0	3.7 4.6	0.0 0.0	59.3 46.7
	NA	NA	0.5-5.0	NA	0.05-0.47	NA	0.8-4.8
Total Hydrocarbons (oil & grease)	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max
	0.0 0.0	0.0 0.0	93.9 98.6	0.0 0.0	0.0 0.0	5.9 1.0	0.2 0.4
	NA	NA	1,143-11,016	NA	NA	72-110	2.1-45
Lead (Pb)	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max
	27.5 9.1	28.4 49.6	27.5 34.6	10.1 2.4	0.9 1.4	0.0 0.0	5.5 2.9
	30-66	31-358	30-250	11-17	1.0-10	NA	6.0-21
Mercury (Hg)	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max
	76.6 52.2	9.6 29.6	1.7 2.6	11.5 13.9	0.6 1.7	0.0 0.0	0.0 0.0
	1.2-3.0	0.15-1.7	0.026-0.15	0.18-0.8	0.01-0.1	NA	NA
Nickel (Ni)	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max
	76.3 62.6	0.0 0.0	0.0 0.0	21.6 22.1	2.1 15.3	0.0 0.0	0.0 0.0
	74-82	NA	NA	21-29	2.0-20	NA	NA
Organochlorines (PCBs)	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max
	0.0 0.0	0.0 0.0	4.7 34.6	0.0 0.0	0.5 0.6	0.0 0.0	94.7 64.8
	NA	NA	0.006-0.4	NA	0.00067-0.0067	NA	0.12-0.75
Selenium (Se)	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max
	68.9 71.8	0.0 0.0	0.0 0.0	30.4 24.3	0.6 3.9	0.0 0.0	0.0 0.0
	4.3-7.4	NA	NA	1.9-2.5	0.04-0.4	NA	NA
Silver (Ag)	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max
	43.9 77.2	0.0 0.0	0.0 0.0	55.7 22.3	0.3 0.6	0.0 0.0	0.0 0.0
	2.6-26	NA	NA	3.3-7.5	0.02-0.2	NA	NA
Tributyltin	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max
	NA	NA	NA	NA	NA	NA	NA
	NA	NA	NA	NA	NA	NA	NA
Zinc (Zn)	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max	Min Max
	52.2 13.4	24.2 67.7	6.5 12.5	13.4 3.4	0.6 1.4	0.0 0.0	3.1 1.5
	272-288	126-1,453	34-268	70-74	3.0-30	NA	16-32

* Measurements in metric tons (tonnes) per year unless otherwise indicated.
* Summation of mins. for each pollutant = 100%
* Summation of maxs. for each pollutant = 100%
NA = Not available or not dectected.

Figure 2

POLLUTANT LOADINGS

TO THE BAY–DELTA ESTUARY



However, pollutants other than trace metals are also discharged from point sources. Examples include volatile and semi-volatile organics, hydrocarbons and other synthetic organic chemicals.

Their load estimates were not presented by the AHI because available concentration data do not provide a sound basis for the calculations. If these data were to be used in loading calculations, it is estimated that the relative contribution for point sources would be significantly larger.
The toxicity or potential for adverse effects from the same constituent may also differ between point and non-point sources. For example, some parties to the hearings believe that trace metals from point sources usually enter the receiving water in dissolved form. The bioavailability potential to aquatic organisms may in this way be increased. Trace metals from nonpoint sources are usually adsorbed to soil or other inorganic particles and may therefore not be as immediately available. Absorbed nonpoint trace metals continue, however, to pose a significant problem because they accumulate and can redissolve and re-enter the water column in the dissolved form.

As shown in Table 1, point sources contribute significant amounts (greater than 10 percent) of cadmium, mercury, nickel, silver and selenium when compared to all other sources. POTWs are the major contributor to the total point source loading of copper, lead, zinc and arsenic. The eight largest POTWs contributed most of the flow (about 70 percent) and point source loading in the Estuary. Of those, five treatment plants are located in the South Bay. As a result, during the dry season effluent from treatment plants contribute the greatest volume of freshwater into the South Bay. The eight largest plants and the average discharge flow rates (1,000 gallons per day) of their effluent are listed in Table 2.

Industrial dischargers contribute on the average about 15 percent of the total point source loads of the metals listed in Table 1. Notable exceptions to this are chromium and selenium where about 1/3 of the total chromium load to the Bay-Delta was released by one discharger during the period 1984-1986. Selenium loadings from petroleum refineries are comparable to combined loads from the San Joaquin and Sacramento Rivers. Industrial dischargers also release organic and inorganic chemicals in the manufacturing process.

2.2.2 Urban Runoff

Urban runoff refers to the flow of pollutants into the Bay-Delta due to runoff from urban areas. Like point sources, which are already under the NPDES permit program, urban runoff will soon be placed under that program. Urban stormwaters contain toxic pollutants such as trace metals, and synthetic organic chemicals. Much of this pollution is due to man's activities: accidental spills, deliberate dumping, emissions from automobiles (including oil drippings) and tire wear. Pollutants from this source, typically as a result of first storm events, are discharged over very brief periods of time at high concentrations and with little dilution into nearshore waters.

Estimates for pollutant loads from urban runoff are far less accurate than point source estimates. Accurate urban runoff loads depend on reliable contaminant concentrations and flow volumes from urban areas. Available data of this type for the Bay-Delta basin is scarce and of poor quality. Therefore, data from studies conducted elsewhere have been used to estimate the pollutant loads to the Bay-Delta Estuary. The method used by the AHI for estimating the loading of pollutants from urban runoff is found in AHI Exhibit No. 302.

TABLE 2--THE EIGHT LARGEST POTWs IN THE BAY-DELTA REGION, AND AVERAGE FLOWS -- 1984-1986
(From Aquatic Habitat Institute Exhibit No. 302)

	Segment of Estuary Receiving Effluent	Flow -- 1,000 Gallons Per Day
Sacramento Regional	Sacramento River	134,214
Central Contra Costa Sanitary District (CCCSD)	Suisun Bay	38,573
East Bay Municipal Utility District (EBMUD)	South Bay	86,922
San Francisco: Southeast Water Pollution Control Plant (SWPCP)	South Bay	73,712
Union Sanitary District (USD)	South Bay	21,400
South Bayside System Authority (SBSA)	South Bay	21,400
Palo Alto Sub-regional Water Quality Control Plant	South Bay	27,477
San Jose-Santa Clara Water Pollution Control Plant	South Bay	117,569

As shown in Figure 2, it is estimated that urban runoff may contribute the greatest pollutant loads to the Bay-Delta Estuary, ranging from a maximum of 11,628 tonnes to a minimum of 1,221 tonnes of pollutants (also see Table 1). The large difference between the maximum and minimum values shows the uncertainty of estimates that are made with a lack of reliable data. As estimated, the majority (about 95 percent) of the pollutant load from urban runoff consists of a category called "Total Hydrocarbons". This category includes a variety of toxic (PCBs) and non-toxic (oil and grease) compounds. As shown in Table 1, it is estimated that urban runoff still contributes significant loads of toxic pollutants to the Bay-Delta. These pollutants include polynuclear aromatic hydrocarbons, lead, cadmium, copper, zinc and polychlorinated biphenyls.

2.2.3 Nonurban Runoff

Nonurban runoff refers to runoff from agricultural lands, pasturelands and forests within the Bay-Delta. Toxic pollutants from this source are usually derived from soil erosion, leaching of trace elements and the introduction of synthetic compounds such as pesticides.

Nonurban runoff and other nonpoint sources have not received the degree of regulatory control required for point sources. However, some control measures for these activities have been required; they include regulatory measures for silviculture activities, subsurface agricultural drainage and for control of rice herbicides.

Estimating loads from nonurban regions is a very complex procedure that is dependent upon a number of variables requiring accurate data. Accordingly, only one estimate of the loading of toxic substances into the Bay-Delta has been made to date. This study was conducted by the National Oceanographic and Atmospheric Administration (NOAA,1987 a) as part of the National Coastal Pollutant Discharge Inventory, an assessment of the loading of pollutants into estuaries and coastal ocean waters from different sources.

An explanation and critique of this study (AHI,302) points out that, because of the significant uncertainties associated with the estimates made in the study, the loading results should be considered to be of the most preliminary nature. Also, a number of toxic organic chemicals applied to non-urban lands within the Bay-Delta were not considered by NOAA.

The estimates of NOAA shown in Table 1 indicate that nonurban runoff could be a significant source of toxic substances to the Bay-Delta Estuary. The bar graph in Figure 2 shows nonurban runoff as the second largest loading source to the Estuary after urban runoff.

It is estimated that nonurban runoff contributes significant loadings of arsenic, chromium, copper, lead, cadmium and mercury to the Estuary. However, it should once again be emphasized that significant uncertainty is associated with these estimates. The data are preliminary and only indicate the need for additional research into this potentially important loading source.

2.2.4 Riverine Sources

Riverine sources of pollutant loads refer to pollutant inputs into the major rivers flowing to the Bay-Delta from all point and nonpoint sources outside the geographical boundary of the Bay-Delta Estuary. Pollutant concentrations are obtained at sampling sites located at Bay-Delta boundary points on these rivers. The sampling stations are at Freeport on the Sacramento River, Woodbridge on the Mokelumne River and Vernalis on the San Joaquin River. Water quality data on the rivers are collected by the Department of Water Resources, U.S. Geological Survey, and the U.S. Bureau of Reclamation.

Riverine mass loading estimates are calculated based on water quality and flow data for each major river. These rivers contribute large volumes of water compared to point source and nonpoint source discharges. Therefore, although a pollutant may make up a small fraction of an entire river flow, it may constitute a major component of the total loading to the Bay-Delta. Accurate measurements of very low concentrations of riverine pollutants is needed to reliably compare the loads from riverine sources with those from more concentrated, more readily quantified point discharges. Given the difficulty of accurately determining the concentration in river inflow, and given the relatively few and limited sampling programs, it is emphasized that the estimation of riverine loads is highly uncertain.

As shown in Figure 2, riverine sources are a major contributor of pollutant loads to the Bay-Delta Estuary. When compared to other major sources, the rivers contribute the greatest loads of cadmium, copper, mercury, nickel, selenium and silver. They also contribute significant loads of arsenic, chromium and zinc. The Sacramento River generally contributes larger trace element metal loads than the San Joaquin River, but, because of its large flows[1/], in dilute amounts that are difficult to assess.

Sampling programs on the San Joaquin, Sacramento and Mokelumne rivers have not addressed hydrocarbons. Because sampling programs were not designed or timed to intercept peak pulse flows when hydrocarbons are likely to be mobilized, accurate estimates would probably not have been possible even if the data had been collected. A flow-weighted sampling system would be needed to address the sources and volumes of hydrocarbons entering the Bay from riverine flow. Studies of pesticide and organochlorine contamination in the Sacramento and San Joaquin rivers have been carried out by DWR and the "Municipal Water Quality Investigation Program", formerly called the Delta Health Aspects Monitoring Program, as required by the 1978 Delta Plan. Compounds detected include the rice herbicides, bentazon, atrazine, molinate and thiobencarb, the latter two having been found in the Sacramento River during the spring when flooded rice fields treated with these materials are drained.

The San Joaquin River, comprised for the most part of irrigation return flows during the summer growing season, drains an agricultural area on which as much as 23 million kilograms of pesticides are applied annually. Measurable amounts of some of these pesticides are washed into the River. Consistently detected are 2,4-D, atrazine, simazine, dacthal and diazinon. Concentrations and loads are difficult to estimate based on current data because of the inability of laboratories to detect these chemicals accurately. Improved analytical techniques and sampling procedures, along with increased attention to the effects of pulse flows are needed to evaluate properly the release of toxic contaminants from riverine inflow to the Bay-Delta Estuary.

1/ The Sacramento River contributes 70 percent, the San Joaquin River contributes 15 percent of total inflow to the Bay.

2.2.5 Other Sources (Atmospheric Deposition, Spills and Dredging)

2.2.5.1 Atmospheric Deposition

Toxic substances may be transported to the Bay-Delta as dust or aerosols and enter the Bay via diffusion and gravitational settling. Because the local database is very poor, loading estimates for atmospheric deposition were made using information from the Great Lakes Region where extensive studies have been previously conducted. To minimize double-counting of pollutants from the other nonpoint sources, estimates for pollutant loading from atmospheric sources were computed for the Bay surface area only.

Based on the loading estimates, it is believed that atmospheric deposition is a relatively small source of toxic pollutants to the Bay-Delta, with the possible exception of PAHs and PCBs. As shown in Table 1, it is estimated that atmospheric deposition contributes anywhere from 0.8 to 4.8 tonnes per year of PAHs and 0.12 to 0.75 tonnes per year of PCBs. PAH input is on the same order of magnitude as input from urban runoff.

2.2.5.2 Spills

The source of data on spills in the Bay-Delta Estuary is the United States Coast Guard. All spills in the Bay-Delta are reported to the Coast Guard and are included in their national database. Coast Guard records on spills and potential spills indicate that inorganic chemicals, crude oil, refined petroleum products, animal and plant oils and other organic liquids have entered the Bay-Delta. Petroleum hydrocarbons are the largest component of these spills.

As shown in Figure 2, it is estimated that spills contribute relatively minor loads of toxic pollutants to the Bay-Delta. The majority of these loads are in the form of hydrocarbons. As shown in Table 1, it is estimated that spills may contribute anywhere from 72 to 110 tonnes per year of hydrocarbons to the Bay-Delta Estuary. This is orders of magnitude below the contributions estimated for urban runoff.

2.2.5.3 Dredging

Dredging the channels to improve navigation in the Bay-Delta Estuary moves five to ten million cubic meters of sediment annually. In San Francisco Bay, dredge sediment is disposed of by dumping at one of three open-water disposal sites.

Toxic substances which may be in the sediments dredged are largely dispersed and may become available to biota. During dredging and sediment disposal, water turbidity at the disposal site may increase, bottom organisms may be smothered by the sediment pile, or dissolved oxygen may be chemically removed. As shown in Table 1, materials which may be made available during dredging and sediment disposal are arsenic, cadmium, chromium, copper, hydrocarbons (particularly PAHs), lead, mercury, nickel, organochlorines (particularly DDT metabolites and PCBs) selenium, silver, and zinc. In dredging of harbors and marinas for maintenance, it is likely that tributyltin would also be liberated or redistributed.

As with the other loading sources, no reliable data exist upon which to base accurate estimates for the release of contaminants from dredging activities. However, it is certain that dredging activities remobilize pollutants bound in the sediments. Estimates of this remobilization indicate that the proportion of pollutants remobilized is relatively minor compared to the total amounts in dredged materials, when based on the assumption that remobilization rates range from 1 to 10 percent of the total contaminants in dredge sediments. As shown in Figure 2, it is estimated that dredging activities contribute from 12 to 123 tonnes of pollutants per year. As previously mentioned, the wide range between the minimum and maximum values is a reflection of the uncertainty associated with the estimates.

3.0 PROBLEM ASSESSMENT

This chapter addresses the toxicological effects of the previously identified pollutants on human health and aquatic biota. Pollutant concentrations in water, sediment and organisms are compared with available regulatory guidance and nonregulatory alert levels to determine whether a particular pollutant warrants concern.

Selected criteria include regulatory guidance such as:

- EPA water quality criteria,
- FDA criteria levels,
- DHS maximum contaminant levels,
- Ocean Plan objectives, and the
- Water Quality Control Plans of Regions 2 and 5.

Selected criteria, when available, are established levels above which a pollutant is known to cause harmful effects on human health and aquatic biota. Regulatory action is often required (FDA and DHS) or recommended (EPA and NAS) if these levels are exceeded. Therefore, greater concern is given to any pollutant concentrations that approach or exceed these guidelines. (See the Glossary (Appendix B) for specific definitions of criteria and alert levels).

Alert levels include nonregulatory references such as:

- The median international standard (MIS),
- Elevated data levels (EDL 85 and EDL 95),
- The maximum allowable residue level (MARL), and
- The lowest effect level (LEL).

Alert levels, in themselves, provide no indication of particularly harmful effects. Alert levels do indicate that, when pollutants approach or exceed certain concentrations, further investigation is warranted: They provide initial points of reference in the process of determining whether or not a pollutant found at certain concentrations should be of concern; that is, they help in establishing if, for example, the pollutant is one part of a larger, more general problem or if it is only a local irregular occurrence. Often, a specific alert level is the only information about a pollutant that is available. While no cause for concern can securely be established when this is the case, the information is nonetheless valuable because it points out the need for more studies of the pollutant's effects.

Generally speaking, in fact, more data are needed on all of these pollutants and their effects, both as single constituents and in combination with other compounds. For instance, a differential analysis should be established for organic and inorganic arsenic in aquatic biota.

Further, there are almost no data on the synergistic and additive effects of pollutants found together, as they always are in aquatic systems. Only when the total effects of these pollutants have been clearly established will it be possible to determine whether their elevated levels in Bay-Delta fish and shellfish warrant concern.

In some sections of the following assessment, standards based on fish tissue (e.g., median international standards) are compared to fish liver data collected by the Toxic Substances Monitoring Program. Some reviewers have suggested that such a comparison is inappropriate because fish livers often concentrate trace elements (probably related to the livers function of eliminating these elements) and because fish livers are not considered edible tissues. However, fish tissue/fish liver comparisons were not being made for the purpose of setting objectives for the protection of public health (It should be noted that some people eat the liver and the whole fish (Pete Phillips, DFG, pers. comm., April 4, 1990)). Fish tissue/fish liver comparisons were made for primarily two reasons: (1) other sources of information concerning concentrations of pollutant levels in fish tissues are not available, and (2) the comparisons are being used to determine if further investigation is warranted. Fish tissue data were used for comparison to the MIS when they were available.

A problem assessment matrix summarizing data on the pollutants being discussed can be found in Appendix A.

With the exception of hydrocarbons, chlorinated dibenzo-p-dioxins, chlorinated dibenzofurans and organchlorines, pollutants are addressed in alphabetical order in three subsections: (1) Public Health, (2) Aquatic Toxicity to Biota, and (3) Conclusions. Other issues examined are trihalomethanes and dredging sediments.

Unless stated otherwise, pollutant concentrations in fish reported in the following sections refer to a wet weight analysis of their liver tissues.

3.1 ARSENIC

3.1.1 Public Health

Because the highest observed arsenic levels in freshwater fish from tributaries to the Estuary are all below the median international standards (MIS) and calculated no significant risk levels[1/] (NSRL) (see matrix, Appendix A), arsenic is not considered to be a significant health concern in these waters. However, arsenic levels in some shellfish tissues have exceeded the MIS, calculated NSRL, EDL 85 and EDL 95 levels. Finfish tissue data from waters of Suisun Bay and the San Joaquin River at Old River have also exceeded the EDL 85 and EDL 95 levels.

1/ Calculated from DHS no significant risk levels (NSRL) using EPA assumptions of average consumption of water of 2 liters per day and average ingestion of fish of 6.5 grams per day.

The maximum arsenic levels detected in any fish from Central Valley waters are: 0.8 parts per million (ppm) in 1980, 0.7 ppm in 1981, and 0.5 ppm in 1984 in samples from the O'Neill Forebay on the California Aqueduct; 0.8 and 1.1 ppm in 1984 samples from Black Butte Reservoir on Stony Creek near Orland; and 0.6 ppm in Old River in the Delta taken in 1984; and lesser amounts found in 1981 in samples from Folsom Lake and American River (0.4 ppm) and Shasta Lake's Squaw Creek Area (0.3 ppm) (SWRCB,TSM Program).

The chemical form in which arsenic occurs greatly affects its toxicity. Past analyses have not distinguished between the relative amount or toxicity of inorganic forms of arsenic (arsenic (III) and arsenic (V)) and the various organic forms (methylated forms, arseno-lipids, arseno-sugars, arseno-betaine and arseno-choline). Because of the number of chemical species involved, differential analysis of the organic and inorganic forms of the element is needed to estimate their toxicity (AHI,304,201).

3.1.2 Aquatic Toxicity To Biota

Arsenic has been identified in sediment and biota of the Estuary, but it is not known whether these levels pose a threat to biota. Known polluted sites include the ASARCO slag pile near Carquinez and the Point Isabel battery disposal site near Richmond (CBE,1,F13).

3.1.3 Conclusions

The toxicity of arsenic to biota of the Bay-Delta Estuary has not been quantified due to the number of chemical species involved and because past analyses have not made the differentiation between the species. There is a need for differential analysis of organic and inorganic arsenic in aquatic biota. With these analyses as references, it may be possible to estimate whether the elevated levels of arsenic in Bay-Delta finfish and shellfish warrant concern.

3.2 CADMIUM

3.2.1 Public Health

Cadmium concentrations in San Francisco Bay mussels and oysters exceed alert levels and warrant further investigation.

The median international standard for cadmium is 0.3 ppm ww in fish and 1.0 ppm ww in shellfish (SWRCB,TSM 1985). As shown in the problem assessment matrix, both native Bay mussels (Mytilus edulis) and Olympic oysters (Ostrea lurida) have been found with concentrations approaching or exceeding 1 ppm wet weight which is equal to the median international standard for shellfish (AHI,304,141). A summary of mussel watch data over a ten-year period also indicates that tissue level burdens approach and often exceed the median international standard for shellfish, and often exceed the EDL 85 and EDL 95.

Finfish data indicate a slightly better picture. Occasionally elevated levels of cadmium have been found in fish tissue from the watershed (for example, 2.6 ppm in fish liver from the Sacramento River near Keswick) (SWRCB,TSM Program) and anadromous species using the Bay and Delta may be exposed as a result of cadmium contamination in mine wastes from upstream areas (AHI,304,146). However, a summary of Toxic Substance Monitoring Program data concerning Delta waters over a ten-year period indicates levels that occasionally approach the 0.3 parts per million median international standard for fish but have rarely exceeded it. A review of these same data also show that they only rarely approach the EDL 85.

3.2.2 Aquatic Toxicity to Biota

Cadmium is considered to be an important pollution hazard in the aquatic environment. It strongly bioaccumulates and is of significant direct toxicity to biota; it is exceptionally toxic to mammals (AHI,304:133-134;CBE,1,33).

The lack of unusually high concentrations in water and sediment at any location in the Bay-Delta Estuary (range of 0.78 to 1.66 ppm dw in sediment) and, in contrast, the fairly high levels of cadmium seen in biota of the Bay-Delta Estuary (range of 0.03 ppm to 27 ppm wet weight) indicates that cadmium may be particularly bioavailable in this ecosystem; cadmium could therefore constitute a problem if an increase in loading occurred (AHI,304,146,147). Cadmium is a problem in the Sacramento River near Keswick where it has averaged 2.5 ppb, and exceeded both the Region 5 Basin Plan objective of 0.2 ppb and the median lethal level for salmonids of 1.1 ppb (RWQCB 5,5c).

Cadmium is highly bioaccumulated in and highly toxic to aquatic organisms (AHI,304,134). Cadmium levels are somewhat higher in the South Bay than elsewhere, with maximum dissolved concentrations of 0.25 ppb, as compared to 0.1 ppb in Central San Francisco Bay (AHI,304,129). This is over an order of magnitude below the EPA water quality criterion for marine water of 9.3 ppb as a 4-day average, or 43 ppb as a one-hour average (AHI,304,134,135). It should be noted, however, that these EPA marine water criteria may not be protective of locally sensitive species such as striped bass (EPA Quality Criteria for Water--1986). Concentrations in San Francisco Bay mussels and oysters approach or exceed the shellfish MIS of 1 ppm wet weight which is a concern for public health as well as predatory animals which feed on molluscs. Uptake of cadmium by mussels is related to salinity, with uptake inversely correlated with salinities (AHI,304,141).

3.2.3 Conclusions

Cadmium concentrations in San Francisco Bay mussels and oysters exceed alert levels and warrant further investigation. Though dissolved cadmium concentrations in waters reported from the Bay and Delta do not appear to warrant concern, they are known to be a problem for aquatic life especially in the northern drainage of the Sacramento River. Sources of these high levels are the abandoned mines within the watershed. No data are available concerning cadmium levels in waters of the northern reach of the Bay-Delta.

3.3 CHROMIUM

3.3.1 Public Health

Other than for some locally contaminated sites, chromium does not appear to be a public health problem in the Estuary (AHI,304,T24). Although chromium is mutagenic, teratogenic and carcinogenic in high dosages (AHI,304,182), the SWRCB Toxic Substance Monitoring Program has found levels only as high as 0.16 ppm ww in fish tissue from the Estuary watershed. Many finfish chromium values approach but few exceed the EDL 85 level of 0.03 ppm and EDL 95 level of 0.11 ppm. However, the U.S. Fish and Wildlife Service has reported chromium concentrations in whole-body samples of juvenile striped bass from the San Joaquin River system up to 7.1 ppm dw (1.8 ppm ww) (Saiki and Palawski, 1990). The Mussel Watch Program has found chromium levels of 7.4 ppm dry weight in the native mussel *Mytilus edulis* at Mare Island near Vallejo. (Dry weight can approximately be converted to wet weight by dividing the dry weight by seven; the above case indicates a level of around 1.1 ppm wet weight) (M. Stephenson, pers. comm., June 7, 1988). At another site near Antioch, concentrations of chromium in the clam *Corbicula* were reported reaching 13 ppm dry weight or nearly 1.8 ppm ww (AHI,304,180). These sites are close to military or industrial point sources and suggest local contamination of shellfish by chromium (AHI,304,180). The majority of shellfish samples in the State Mussel Watch Program are well below 1 ppm ww (average is under 0.5 ppm).

3.3.2 Aquatic Toxicity to Biota

Elevated chromium levels in the Sacramento and San Joaquin watersheds are a cause for concern for aquatic life in Bay-Delta waters.

Chromium in the Bay-Delta Estuary may be from both upstream and local sources. Acid mine waste from Spring Creek, Squaw Creek, and Little Backbone Creek near Shasta Dam carries significant concentrations of chromium to the Sacramento River (AHI,304,172). The San Joaquin River also carries chromium from mine runoff. Reported levels for total chromium from the San Joaquin River Drainage Study range from 4 to 30 ppb in the San Joaquin at Vernalis and 6 to 55 ppb in San Joaquin at Mud Slough. These reported levels are significantly higher than the 2.5 ppb lowest effect level for hexavalent chromium which affects the development and survival of *Daphnia magna* (Mount, 1982). Unfortunately, due to lack of monitoring, the amount reaching the Bay-Delta Estuary from upstream sources in dissolved and particulate form is not known from direct measurement (AHI,304,173).

The distribution of chromium in biota from the San Francisco Bay is not clearly defined. One study by Risebrough et al. (1978) indicates that certain local sources have increased concentration levels in molluscs taken from the South San Francisco Bay; a second did not indicate such a gradient (AHI,178). Chromium levels of 13 ppm dry weight (1.8 ppm wet weight) have been detected in clams from the Antioch area, which suggests a major point source there, while a second point source is considered likely in the vicinity of Pittsburg. These are thought to be industrial in origin because several metal finishing and manufacturing plants are located there (AHI,34,180). Because chromium can be harmful in high doses, and because substantial point sources appear to be introducing chromium in some quantity, additional monitoring in water and biota is needed.

3.3.3 Conclusions

Because of the fairly low chromium levels generally found in fish and shellfish from the Bay-Delta region (other than for some locally contaminated sites), chromium does not appear to warrant a public health concern. However, elevated chromium levels in the Sacramento and San Joaquin watersheds above the Bay-Delta Estuary are a cause for concern of aquatic life in Bay-Delta waters. Currently, no direct measurements of chromium, particularly of chromium VI, the most toxic component of total chromium, exist for Bay-Delta receiving waters. Due to lack of monitoring, the amount reaching the Bay-Delta Estuary from these upstream sources in dissolved and particulate form is not known.

3.4 COPPER

3.4.1 Public Health

Although it is apparent that copper levels in Estuary biota approach or exceed median international standards, it is not clear that copper presents a threat to human health. The median international standard for copper in fish and shellfish is 20 ppm ww (SWRCB,TSM Program, 1986). Copper in finfish and shellfish has been detected at elevated levels at several locations in the Central Valley (up to 330 ppm dw in liver tissue from rainbow trout at Keswick) and fish from these upstream areas may migrate through the Estuary (AHI,304,63). Waterfowl (greater scaup and surf scoter) from the South Bay have copper levels in the liver of 96.8 $\pm$ 7.6 ppm and 49.8 $\pm$ 3.6 ppm dw, respectively (AHI,304,65). These levels compute to nearly 20 ppm and 10 ppm when converted to wet weight. The prevalence of organisms showing tissue concentrations of copper above the median international standard does not necessarily imply a threat to human health. Copper is less toxic to mammals than to aquatic biota and common foodstuff contain up to 10 ppm (SWRCB,1978). There is no evidence that human poisoning has ever occurred as a result of human consumption of copper in water, but doses of 60 to 100 mg of copper taken by mouth cause nausea and intestinal irritation (SWRCB,1978).

3.4.2 Aquatic Toxicity to Biota

Elevated levels of copper in the water column, sediment and biota within some areas are a biological concern. Copper, considered to be relatively toxic to aquatic life, is chronically toxic in concentrations as low as 10 ppb (AHI,304,F13).

After mercury and silver, copper is generally ranked as the third most toxic of the common trace metal contaminants to aquatic biota (AHI,304,40). The 1986 EPA recommendation is that the one-hour average concentration not exceed 2.9 ppb more than once every three years on the average (AHI,304,40).

South San Francisco Bay dissolved copper levels range from 2.5 to 4.0 ppb and appear to be elevated compared to local ocean concentrations of 0.25 to 0.6 ppb (AHI,304,42). In the northern reach of the Estuary, copper concentrations in receiving waters generally decrease in proportion to increasing salinity, suggesting that riverine loads of copper are important. Elevated levels of dissolved copper of 2.0 to 2.5 ppb, which do not correlate with the salinity gradient in the southern San Pablo Bay or northern Central San Francisco Bay regions, indicate a likely copper-containing discharge in these two areas (AHI,304,42,44,F15). Copper-enriched sediments are present at the Carquinez Straits near Mare Island, at Islais Creek and Mission Creek near San Francisco, near Coyote Point, at the east end of the San Mateo Bridge, near Palo Alto and Redwood Creek, and at near shore areas of the southern extreme of the South San Francisco Bay (AHI,304,46,F16).

Although local discharges appear to be responsible for elevated copper levels in San Francisco Bay biota, the rivers entering the Delta also contain elevated copper levels, with mine wastes in Spring Creek near Keswick affecting copper levels in the upper Sacramento River (RWQCB,#5,5A). The Mokelumne, McCloud, and Cosumnes rivers, O'Neil forebay near San Luis, and Black Butte Reservoir on Stony Creek all show elevated levels of copper compared to those statewide (SWRCB,TSM Program). Levels in the Sacramento River near Keswick exceed EPA 1980 freshwater criteria (average of 24 ppb compared to standard of 5.6 ppb at a hardness of 40 mg/l) (EPA Water Quality Criteria Nov. 20, 1980; 45 Fed. Reg., 79318). This condition is aggravated when local rainfall causes a spill from a debris dam on Spring Creek which retains acid mine drainage at a time when river flows are low because Shasta Dam is storing Sacramento River water (T,XLIV,169).

Acute toxic effects on freshwater and marine organisms have been shown to occur at concentrations in the range between about 0.05 ppb and 10.0 ppb (AHI,304,F13). The ambient concentrations of dissolved copper in tributaries and Bay-Delta waters at some times and locations exceed current EPA standards, and the acute toxic effects threshold (AHI,304,66).

3.4.3 Conclusions

Although current copper levels in biota of the Bay-Delta are not considered to be a human health problem, it is clear that elevated levels in the water column, sediment and in biota within some areas are a biological concern. As such, discharged loads of copper to receiving waters should be further reduced.

Available data indicate that Bay-Delta water and sediments contain moderately elevated copper concentrations. Some areas, in particular Palo Alto, Redwood Creek, San Leandro Bay, Islais Creek and Mission Creek contain high sediment levels. In addition, high copper concentrations have also been found in biota from some areas of the Bay-Delta suggesting that copper may be highly bioavailable within the Bay-Delta. Although available copper data suggest significant sources of the metal within San Francisco Bay (sewage treatment plant discharges are one documented source) (AHI,304,64), riverine sources particularly from the upper Sacramento River as a result of mine wastes contribute a significant load.

3.5 LEAD

3.5.1 Public Health

Lead is a powerful neurological toxin in humans (AHI,304,143). As shown in the problem assessment matrix, lead levels in water, sediments and biota of the Bay-Delta Estuary are, in general, not highly elevated; only occasionally do levels exceed the mussel watch and toxic substance monitoring EDL 85 and 95 levels and the median international standard of 2.0 ppm ww for both fish and shellfish. Although no widespread lead pollution or contamination problem exists within the watershed, some localized areas within the Bay do exhibit elevated lead levels. These areas appear to be associated with local sources (e.g., urban runoff or industrial pollution) rather than an indication of San Francisco Bay-wide contamination (AHI,304,156). High tissue levels in mussels (10 to 40 ppm dry weight, 1.43-5.71 ppm ww) are reported at Tara Hill, Carquinez, Albany Hill, and Sausalito, Treasure Island, Islais Creek and Redwood Creek (AHI,304,159,160). Data on lead in other organisms and from upstream areas indicate little cause for concern.

3.5.2 Aquatic Toxicity to Biota

Lead levels in sediments of the Estuary do not indicate particular problem.

Lead is only moderately toxic to aquatic organisms (AHI,304,144). The EPA standard for lead in marine water is 5.6 ppb as a 4-day average and 140 ppb as a 1-hour average (AHI,304,149). Lead in San Francisco Bay waters is, for the most part, apparently particulate-associated rather than dissolved; it appears to be derived mainly from urban runoff (AHI,304,151). The lower South Bay exhibits relatively higher levels of dissolved lead (0.3 ppb) compared to the Central San Francisco Bay (0.01 ppb) (AHI,304,152-153).

Sediments in near shore areas and creek mouths exhibit elevated lead levels (as compared to offshore areas) with Mission Creek sediments near San Francisco reaching 2580 ppm dry weight (AHI,304,151). This finding is consistent with the belief that lead pollution is associated primarily with urban runoff. Sediment lead levels range from 13-62 ppm dw in Suisun Bay and 30-38 ppm dw in the lower San Joaquin River (AHI,304,154-156).

3.5.3 Conclusion

Based on the available data, lead does not appear to be a problem with respect to Bay-Delta biota. It is only of moderate toxicity in aquatic environments and generally speaking has not been found in elevated levels in the water, sediment and biota of the Bay-Delta. However, elevated lead levels were found in the sediment and tissues of shellfish in certain local sites where they may be of concern. Currently, little information is available on detrimental effects to human health related to lead concentration in sediment and biota. The State Board will request the information necessary for regulatory decision making from the Department of Health Services (DHS) (see Chapter 4, Section 4.3.3.4). Because these localized sites with elevated levels of lead are exposed to urban runoff or industrial pollution and not used for shellfish harvesting, human lead exposure is not considered to be a major problem throughout the estuary.

3.6 MERCURY

3.6.1 Public Health

The Food and Drug Administration has set a mercury action level of 1.0 ppm ww for fish and molluscs. In 1985, DHS published an advisory level (since rescinded) of 0.5 ppm ww for protection of human health. The guideline for predator protection recommended by the National Academy of Sciences has also been set at 0.5 ppm ww; this is the same level as the median international standard for fish and shellfish.

The Toxic Substance Monitoring Program reported mercury concentrations exceeding 1.0 ppm wet weight in fish tissue both at Clear Lake and the Guadalupe River, a tributary to the South San Francisco Bay (SWRCB,TSM Program). DHS has issued health advisories regarding mercury in several fish species from Clear Lake and for striped bass from the San Francisco Bay (AHI,304,356).

Mercury concentrations in mussels of San Francisco Bay tend to be higher in the northern and southern extremities of the Bay than in the Central Bay. Levels of total mercury in native Bay mussels (*Mytilus edilis*) range from 0.25 ppm dw to 0.74 ppm dw (0.03 ppm ww -- 0.11 ppm ww) in the northern section of San Pablo Bay to 0.25 ppm dw to 3.49 ppm dw (0.03 ppm ww--0.5 ppm ww) in the southern section of the South Bay (AHI,304,F46) (SWRCB,SMW Report, 1987). Some sites within the Bay suggestive of local contamination. These sites include the Islais Creek/Mission Creek area and between Coyote Point and Redwood Creek. Total mercury concentrations in Pacific Oysters (Crassostrea gigas) at Redwood Creek approach and exceed the 0.5 ppm ww level for protection of public health (AHI,304,122).

3.6.2 Aquatic Toxicity to Biota

Mercury is very toxic in aquatic environments; its effects on biota are evident at the part per billion level (AHI,304,111). However, limited data exist to assess the impacts of the various forms of mercury on the biota. Most studies have measured total mercury without identifying the chemical form it takes. Methylmercury is most toxic and most highly bioavailable, and is the form predominantly found in finfish muscle samples (AHI,304,121). The National Academy of Sciences (NAS) guideline for predator protection is 0.5 ppm wet weight of total mercury (AHI,304,120). Mercury in mussels and Pacific oysters from Redwood Creek exceeds this level. Ducks which feed on shellfish in the San Francisco Bay have liver mercury levels of 12.5 ppm dry weight, which it is speculated may offer some protection from selenium toxicity since concentrations from both elements are antagonistically correlated in some species (AHI,304,130). Animals or humans which feed extensively on molluscs, fish or birds in the Bay-Delta would appear to be exposed to a risk of mercury contamination because of levels in tissue above NAS or FDA guidelines. However, there are no available data assessing that risk or identifying losses and community effects (AHI,304,132).

Soluble mercury concentrations in southeast San Pablo Bay range from .006 to .011 parts per billion (ppb), with total levels (particulate plus dissolved) of .009 to .028 ppb, which is greater than the open ocean concentration and approaches or exceeds slightly the EPA's recommended standard for marine life protection of 0.025 ppb (AHI,304,114). Elevated levels of mercury occur in sediments of San Pablo Bay (1.0 to 7.0 ppm dw) and South San Francisco Bay (1.0 to 7.0 ppm dw) compared to the 0.25 to 0.49 ppm of Central Bay (AHI,304,F42). This pattern may be explained by mercury input derived from fossil fuels and urban runoff. The generalized enrichment in mercury of the Central Valley watershed, derived from mercury mine wastes, and mercury used and lost in gold ore extraction affects the upper estuary sediments (AHI,304,119). Dredging and dumping redistributes these enriched sediments and may render them more bioavailable (AHI,304,119-120).

Mercury is directly toxic; it is also converted to its methylated form by microorganisms. This methylated form is particularly toxic and important in food chains (AHI,304,121). There is a wide range of acute and chronic toxicity values for various forms of mercury to aquatic biota, and uncontaminated sea water closely approaches the lower toxic concentrations (AHI,304,112). EPA recommends criteria for chronic exposure to mercury of 0.012 ppb (4-day average) or 2.4 ppb (one-hour average) for freshwater aquatic life and 0.025 ppb (4-day average) or 2.1 ppb (1-hour average) for marine biota based upon the propensity of methylmercury to bioconcentrate (AHI,304,114).

3.6.3 Conclusions

Because of mercury's tendency to exist in high concentrations in biota, and because of the toxicity of organic mercury (methylmercury) to humans, its presence in the Estuary is of serious concern. The State Board will request the Department of Health Services to review available mercury data in light of human health impacts.

Mercury is very toxic in aquatic environments; its effects on biota are evident at the part per billion level (AHI,304,111). A majority of the element originates from the drainage upstream of the Bay and Delta. Sources include the deposits from the Coast Range and wash down of mercury used in historical gold mining activities in the Sierra Nevada. Mercury, however, is also present in significant quantities in urban runoff which has led to elevated levels in localized areas (AHI,304,117). Levels of mercury in the biota from these areas approach and exceed the NAS and FDA guidelines. Unfortunately, very little reliable information is available on mercury levels in Bay-Delta waters (AHI,304,114).

3.7 NICKEL

3.7.1 Public Health

The available information for nickel in Bay-Delta biota does not convincingly reflect a threat to human health.

Different species of benthic biota appear to have different abilities to concentrate nickel from the environment, so that two species from the same site may have different concentrations (AHI,304,188). Japanese littleneck clams (Tapes japonica) appear to respond to nickel loads in the South San Francisco Bay at Coyote Point, Foster City and Redwood Creek, indicating elevated levels, while other molluscs at these sites show no such concentrations (AHI,304,188).

It should be noted, however, that mussels in certain localized areas contain elevated nickel levels. These areas include Mare Island Strait, Carquinez Strait, Islais Creek and Redwood Creek, with mussels showing levels of 5.0 to 16.9 ppm dry weight (0.7-2.4 ppm ww) (Risebrough et al., 1978).

A median international standard is not available for nickel.

3.7.2 Aquatic Toxicity to Biota

Nickel concentrations in freshwater are of concern to the biota because measured concentrations (1.0-2.0 ppb) approach levels which have resulted in toxic responses to test organisms as indicated by national data base information. The reported lowest effect level (see problem matrix) in freshwater is 4.1 ppb which has resulted in mortality to the narrow-mouthed toad embryo. Elevated nickel levels occur upstream of the Delta and are associated with discharges from mines, urban runoff, agriculture and NPDES discharges. Currently, there is no existing numerical objective for nickel in the Delta for protection of aquatic species.

Data from fish and wildlife of the Bay-Delta also do not show consistent patterns of nickel contamination. The very small amount of TSM data on nickel that is available shows only occasional high nickel values in fish livers from the Bay-Delta basin (SWRCB, TSM Program, 1985, 1986). Higher levels have been reported in samples elsewhere in California (AHI,304,191). Waterfowl tissue data (Ohlendorf et al., 1986) from surf scoters and greater scaups from the South Bay do not indicate significant contamination. Levels above the detection limit of 0.1 ppm ww were found in only 27 percent of surf scoters and 22 percent of the scaups examined (AHI,304:190-193).

Nickel shows a north-south gradient in the waters of San Francisco Bay with a high concentration (8 ppb) of nickel in the extreme South San Francisco Bay and lower concentrations in the Delta (2 ppb). Concentrations of 8 ppb in solution in the South San Francisco Bay approach the EPA criterion of 8.3 ppb for a four-day average in marine waters (AHI,304,185). Delta outflow carries some nickel into the San Francisco Bay, but levels average only 2 ppb (AHI,304,185). Nickel distribution in sediments follows a similar pattern to nickel in solution (AHI,304,187). Nickel appears to be tightly bound to sediments and thus of low bioavailability (AHI,304,188).

3.7.3 Conclusions

Nickel does not appear to represent a public health problem in the Bay and Delta. However, very little information is available on detrimental effects to human health related to nickel concentrations in sediment and biota. Median international standards are not available for this element nor are state or federal guidelines.

The waters of South San Francisco Bay have shown somewhat elevated levels of dissolved nickel, up to 8 ppb, which approaches EPA's 4-day average water quality criterion of 8.3 ppb. Delta waters show dissolved nickel concentrations of 2.0 ppb. Elevated levels occur higher in the watershed and are associated with point sources, mines, agriculture, and urban runoff. Currently, there is no existing numerical water quality objective for nickel in the Delta for protection of aquatic species. Because Delta levels approach the reported lowest effect levels (4.1 ppb, which causes mortality to the narrow-mouthed toad embryo), water quality objectives should be established.

3.8 SELENIUM

3.8.1 Public Health

Selenium is a complex element which can exist in several oxidation states and different chemical forms within an oxidation state. It is an essential element (required for the maintenance of health) and a toxic element. The toxicity of selenium is affected by its chemical form (USBR,105,1;AHI,304,68).

Selenium in the Bay-Delta Estuary has received close attention in the last five years, and despite its complex bio- and geochemistry, considerable understanding has been gained. Seleniferous soils in the coast range contribute loads of about 6.91 kg daily from the Delta to the Bay (AHI,304,85). Agricultural drainage carried by the San Joaquin River results in selenium loads of from less than 2 kg to 59.9 kg/day at Vernalis (USBR,107,T1). Because of diversion and reverse flows in the lower San Joaquin River, much of the selenium load from agricultural drainage does not reach the lower estuary (AHI,304,77). There are indications of 6.18 kg/day of selenium input in mid-estuary from refineries in the region of the Carquinez Straits (AHI,304,85). Other, less well-defined sources of selenium apparently enter the South San Francisco Bay because elevated levels of 0.12 to 0.36 ppb of dissolved selenium occur there, in comparison to levels of 0.14 to 2.26 ppb (USBR,107,15) in the San Joaquin River. Few data are available on selenium in Bay-Delta Estuary sediments, but evidence indicates that selenium loads from particulates and sediment constitute only ten percent or less of the selenium load reaching the Estuary in solution (USBR,107,F5).

For human health protection, DHS has in the past used a threshold of 2.0 ppm ww in fish (edible portion) for issuing health advisories, although this concentration is not formally adopted or codified in the regulations. DHS staff also recommended a maximum allowable residue level (MARL) of 1.0 ppm ww (edible flesh) for the protection of sportfish and aquatic birds. The 1.0 ppm level is intended by DHS to "prevent bioaccumulation in the food chain and to protect the public who consume the sportfish" (SWRCB memorandum, 7/16/86). The median international standard for selenium is 2.0 ppm ww for fish and 0.3 ppm ww for shellfish (SWRCB, TSM Program, 1986).

Levels of selenium in Bay-Delta Estuary shellfish are at higher levels in the northern reach of San Francisco Bay (mean of 0.9-1.2 ppm ww) and in the southern reaches of south San Francisco Bay (mean of 1.0-1.3 ppm ww) than in the Central Bay (mean of 0.3-0.5 ppm ww) (AHI,304,F37). Regardless of the area, these and other reported levels approach and often exceed the MIS of 0.3 ppm for shellfish.

Additionally, reported shellfish levels often approach and exceed the Mussel Watch EDL 85 level of 0.6 ppm ww and EDL 95 level of 0.8 ppm ww (SWRCB,SMW Program,1987).

The Toxic Substances Monitoring Program only recently (1983) started analyzing fish samples for selenium. Largemouth bass sampled in 1985 from Alameda Creek south of South Bay and Lake Herman near San Pablo/Suisun bays showed elevated selenium levels of 1.2 and 1.6 ppm ww in their livers (AHI,304,93). TSM sampling in 1987 of fillet portions of starry flounder from Suisun Bay indicated elevated selenium levels of 1.10 ppm ww; white sturgeon and striped bass there contained 0.69 ppm ww and 0.48 ppm ww, respectively (SWRCB,TSM Program,1987). There is evidence that food chains concentrate selenium and benthic food chains appear to do so to a greater degree than pelagic chains (selenium concentrations in benthic-feeding sturgeon and flounder tissue exceed those in pelagic feeding striped bass tissue)(AHI,304,95).

3.8.2 Aquatic Toxicity to Biota

Reports on the biota and waters of the Bay-Delta by various authors (Risebrough et al., 1978; Girvin et al., 1975; Cutter, 1987) indicate that elevated concentrations of selenium exist in the northern reach of San Francisco Bay (within the Carquinez Strait area) and to some extent in the southern extremities of the South Bay. Major sources of selenium in the northern Bay include the San Joaquin River (and to a lesser extent the Sacramento River) and effluents from oil refineries within the Carquinez Straits. Sources of selenium in the South Bay are thought to be caused by either weathering of the Almaden Hills sulfide deposits or sewage treatment plants in the South Bay or both (AHI,304,80-83,85,110;USBR,105,37).

Selenium concentrations in water measured in 1987-88 at Vernalis on the San Joaquin River were reported with a median value of 1.7 ppb and a maximum of 4 ppb. Upstream in the San Joaquin basin (but still downstream from Salt and Mud sloughs) concentrations are higher with median values ranging from 2.0 to 6.4 ppb (RWQCB,5). An analysis of selenium water concentration data measured at Vernalis and reported on STORET for the period 1960-1987 indicates a mean value of 1.1 ppb, a median 1.0 ppb and a maximum value of 5 ppb.

Studies of diving ducks (scaup and scoters) in the South Bay and Suisun Bay show levels of selenium in their liver tissue ranging from 19.3 to 34.4 ppm dw (5.5-9.8 ppm ww) (AHI,304,T17). Levels of selenium in these San Francisco Bay ducks are comparable to levels in dabbling ducks from Kesterson (25-34 ppm dw) which had reproductive problems, although different food habits among these species and possibly different susceptibility may be involved (AH1,304,107). Nonetheless, selenium levels in the South Bay and Suisun Bay diving ducks exceed DHS' MARL of 1.0 ppm ww. It should be noted however, that DHS' MARL is based on selenium levels in the edible portions (fillets) of the organism. The data presented above are based on liver tissue.

Selenium is associated with embryonic abnormalities in birds from Kesterson National Wildlife Refuge (NWR). This refuge, which received agricultural drainage water from the San Luis Drain, showed elevated levels of selenium and other trace elements (boron, silver) in local biota when compared to a similarly operated nearby wildlife area (Volta) supplied with fresh surface water rather than subsurface drainage (AHI,304,102). The concern is that this drainage water, which can no longer be disposed of at Kesterson, might reach the San Joaquin River and Bay-Delta Estuary, and add to the impacts of local discharges.

Few data on selenium concentrations in the sediments of the Bay-Delta are available. It has been noted that selenium concentrations in mussels were generally higher than those in sediments and that selenium has a low affinity for suspended particulates. Sediments could act as either a source or sink for the element (AHI,304,85,87).

As discussed in Section 3.8.1 (Public Health), elevated levels of selenium have been found in shellfish and finfish of the North and South bays. Waterfowl (scaup and scoters) in the South Bay and Suisun Bay showed detectable levels of selenium in their liver tissue comparable to levels in dabbling ducks from Kesterson which had reproductive problems. No such problems however, have been documented in scaup and scoters from the Bay-Delta because they do not nest locally.

3.8.3 Conclusions

Elevated levels of selenium have been found in shellfish, fin fish, and waterfowl particularly of the North and South bays. When compared to the various alert levels in the Problem Assessment Matrix (including DHS's MARL, MIS and EDL levels), a public health concern for individuals who might consume a quantity of these organisms is warranted. Available data on selenium concentrations in the biota of the Bay-Delta have been and will continue to be forwarded to the DHS for their review and consideration of human potential health impacts.

Because of the strong tendency of selenium to bioaccumulate, the levels measured in the waters of the Bay-Delta are cause for concern. Currently, Regional Water Quality Control Board 2 has not established water quality objectives for selenium in the Bay-Delta Estuary. Regional Board 5 has adopted selenium water quality objectives for the San Joaquin River and its tributaries. However, these objectives have been recently rejected by the EPA.

3.9 SILVER

3.9.1 Public Health

Human health does not seem likely to be affected by levels of silver found in San Francisco Bay.

A median international standard is not available for silver. The existing maximum contaminant level drinking water standard set in 1962 establishes a limit of 50 ppb for silver (SWRCB, 1978). EPA's calculated level which is protective of human health against the ingestion of contaminated water and contaminated aquatic organisms is also 50 ppb (EPA Quality Criteria for Water, 1986).

Based on concentrations found in the most highly enriched organisms anywhere in the Estuary, eastern softshell clams from near Redwood Creek would provide dietary silver at about 28 ppm wet weight of hepatopancreas tissue (AHI,304,T2). This would require a human to consume 36 kilograms of clam hepatopancreas to obtain one gram of silver, which if all absorbed would produce argyria, a bluish, permanent darkening of the skin, but no other known ill effects (SWRCB,1978).

Silver levels in shellfish tissue show the same gradient in concentrations as found in the sediment. Generally, very low silver levels of 0.061 to 0.332 ppm dw were found in clam tissue (Corbicula sp.) from Suisun Bay and the Delta. These are the same kind of levels found in clams from areas considered pristine. The TSM program also reported low levels of silver in fish tissue from the Sacramento-San Joaquin basin, with the exception of higher levels reported in the upper watershed of the Sacramento River. It is thought that mining activities are the source of these levels. Apparently little of the silver, or greatly diluted forms of it, reach the Delta and Bay (AHI,35-38).

Levels of silver in shellfish tissue from the Bay increase in a north to south gradient with maximum levels occuring at Palo Alto. Silver in clam tissue from the most-enriched site near Palo Alto fluctuates seasonally, with a maximum approaching 200 ppm dry weight (AHI,304,28). The seasonal fluctuation is correlated with Delta outflow, and it is hypothesized by AHI that enhanced mixing and reduced residence time of water in the South San Francisco Bay during times of high outflow allow clams to excrete accumulated silver (AHI,304,28).

3.9.2 Aquatic Toxicity to Biota

Despite evidence of silver contamination in the South San Francisco Bay, little information exists on food chain effects or population impacts resulting from these silver levels. Ducks show elevated levels of silver in their tissue in South San Francisco Bay compared to values reported in the literature for waterfowl from Vancouver and Chesapeake Bay. No data exist to show whether the levels they have constitutes a hazard (AHI,304,39).

Silver is extremely toxic to freshwater and marine biota; detectable effects are found with dissolved concentrations as low as 0.36 to 0.57 ppb. These concentrations retarded larval growth in two species of sea urchins. Lethal effects have been seen in oyster and clam embryos at 6 and 13 ppb, respectively (AHI,304,7). Rainbow trout, including the migratory sea-run strain known as steelhead, experience mortality or reduced growth in silver concentrations of 0.18 ppb (T,XLV,145:1-4) (USFWS,43,2). Stickleback fish are reported to exhibit a 96-hour LC50 of 10 ppb (AHI,304,8). The EPA standards for total recoverable silver are 2.3 ppb in marine waters and 1.2 ppb in freshwater; these are also the San Francisco Bay Basin Water Quality Control Plan objectives (AHI,304,11). Maximum dissolved silver levels in the Central and South bays were 0.31 ppb in 1976-77 and had a mean of 0.042 ppb.

Silver also occurs in sediments in the Bay-Delta Estuary. Except for some sites with higher levels, the range of silver found in Bay sediments is from 0.1 to 4.9 ppm, dry weight (AHI,304,13). A site on Islais Creek in San Francisco on the Bay shoreline was reported at 9.0 ppm and two sites on nearby Mission Creek were reported at 9.5 and 16 ppm dry weight. These levels, according to AHI indicate "severe local contamination" with silver (AHI,304,13,14). ("Average", "background", or "typical" silver concentrations in coastal sediments were reported ranging from 0.01-0.5 ppm dw). A small area near the Palo Alto sewage treatment plant, which AHI states was "known to be heavily contaminated with silver" was identified. It was detected as a result of metal studies on a deposit-feeding clam (Macoma balthica) which showed total silver concentration in the sediment near the outfall of 2.5 to 4 ppm dw (AHI,304,23).

Studies by various authors (Thomson et al., 1984; Chapman et al., 1986; and Luoma et al., 1984, and in press) indicate a gradient of sediment silver concentrations increasing from north of San Francisco Bay to the central and especially southern reaches of the Bay. In general, silver levels are low in sediments from Suisun Bay and the Delta (0.028-0.389 ppm dw), and gradually increase along a southern gradient (0.4-1.8 ppm dw Central Bay; 2.5-4.0 ppm dw Palo Alto area). Additionally, as previously mentioned, certain locations within the Central and South bays have high silver levels in the sediments. These locations include Islais and Mission Creeks and the Palo Alto area (AHI,304,13-16).

3.9.3 Conclusions

Silver levels in the water, sediments and biota of the Bay-Delta do not appear to represent a threat to public health. Elevated silver levels, however, do appear to represent a threat to aquatic biota, particularly in areas of Central and South bays. Silver is known to be extremely toxic to freshwater and marine biota.

Data on silver concentrations in the sediment and biota of the Central and South bays indicate elevated levels, particularly with regard to bioavailability. However, currently there is very little information regarding the transfer of silver through the food web or on the toxic effects of such a transfer.

3.10 TRIBUTYLTIN

3.10.1 Public Health

The limited data available on tin in San Francisco Bay are those of Goldberg (1987) conducted for the State Water Resources Control Board. In these studies, samples of water and sediment were collected from locations in the Central Valley and San Francisco Bay (mostly harbors and marinas) and analyzed for organic species (tributyltin, dibutyltin, monobutyltin). Tributyltin was present at higher concentrations than the other species at most sites (AHI,304,195-196). The hearing record has virtually no information available to suggest a human health hazard associated with tributyltin.

3.10.2 Aquatic Toxicity to Biota

Tin in inorganic forms is of generally low toxicity (approximately 10,000 times less toxic than equal concentrations of silver or mercury) in its elemental or inorganic form (AHI,304,198); the median international standard for tin in fish flesh is 150 ppm and for shellfish, 199 ppm (CBE,8,C6). However, the recent development of organo-tin compounds for anti-fouling coatings has raised tin toxicity as an area of concern (AHI,304,49-194). The most common organo-tin, for example, tributyltin, is extremely toxic to molluscs and other marine phyla. Known harmful effects occur at levels of less than 0.1 ppb (AHI,304,198); tributyltin, for example, is toxic to oysters at water concentrations as low as 0.050 ppb (AHI,304,195). The reported lowest effect level for tributyltin (see "Alert Level" column in the problem assessment matrix) is 0.08 ppb (80 ppt) in freshwater and 0.047 ppb (47 ppt) in saltwater. The standards for tin are clearly inadequate for tributyltin.

Reported effects at these levels are decreased growth in the embryo/fry stage of _Pimephales promelas_ (fathead minnow) and blocked oviducts in the juvenile life stage of the mud snail, _Nucella lapillus_, respectively. Levels as low as 0.057 ppb (57 ppt) and 0.095 ppb (95 ppt) in marine water had reported effects of decreased growth in 100 percent of the samples of the oyster _Ostrea edulis_ (spat) and 50 percent mortality in the larval stage of the ussel _Mytilus edulis_ (Tributyltin Priority Chemical Study, SWRCB, 1987).

Tributyltin is present at elevated concentrations in harbors and marinas; e.g., levels of 0.230 ppb at Oxbow Marina in the Delta and 0.350 ppb at the Antioch Yacht Club (AHI,304,196) (also see Problem Assessment Matrix, p. 4b). Levels of tributyltin and other butyltins are sufficiently high in semi-enclosed, poorly flushed marinas to pose a threat to sensitive non-target species (those which do not grow on boat hulls) including algae, crustaceans, molluscs, and fish.

3.10.3 Conclusions

Inorganic tin is of low toxicity to biota in aquatic environments. Butylated forms of the element, however, such as tributyltin, are of high toxicity. No information is available to suggest that tributyltin or similar species are of concern to public health within the Bay-Delta.

Elevated tributyltin levels within poorly flushed waters of harbors and marinas within the Bay-Delta are of serious concern in terms of their possible effects on aquatic biota. Available data (Goldberg, 1987) suggest that the compound is present in sufficient concentrations to produce toxic effects in sensitive species. Currently, no water quality objectives are available in the Bay-Delta by either Regional Boards 2 or 5 for protection of aquatic life from tributyltin. Such objectives are necessary as are any other methods which can effectively regulate usage and control of this highly toxic element.

3.11 ZINC

3.11.1 Public Health

Zinc concentrations in the biota of the Bay-Delta are considered to be only moderately elevated with no unusually high contamination apparent, and are therefore not a threat to the public health within the Bay-Delta.

The median international standard for zinc is 45 ppm in fish and 70 ppm in shellfish. The Mussel Watch elevated data level for the 85 and 95 percentile (EDL 85 and EDL 95) is 33.07 ppm wet weight and 38.54 ppm, wet weight, respectively (SWRCB,SMW Program, 1984-85).

Data from the State Mussel Watch Program from 33 sites in the San Francisco Bay for the years 1980-1987 were reviewed for zinc concentrations in transplanted mussels *Mytilus californianus* and bay mussels *Mytilus edulis* (SWRCB,SMW Program, 1987). Except for some elevated levels at localized sites (Central Bay, Alameda Yacht Harbor--64.5 ppm ww; South Central Bay, San Mateo Bridge--37.2 ppm ww; South Bay, Dumbarton Bridge--47.5 ppm ww), the majority of the data for this review period consistently falls below the median international standard and EDL 85 and 95 levels; it is therefore considered only moderately elevated with no unusually high contamination (SWRCB,SMW Program, 1987). This finding is supported by work done by other researchers who studied zinc concentrations in Bay-Delta biota (Girvin et al., 1975; Risebrough et al., 1978; Bradford and Luoma, 1980). It should be noted, however, that these researchers did find evidence of elevated zinc levels in the biota at localized sites including Mare Island Strait, Albany Hills, Tara Hills, Islais Creek and Redwood Creek. However, concentration levels found at these sites are not considered to be "greatly elevated" nor are they "exceptional" when compared to locations elsewhere, such as Tomales Bay or Half Moon Bay (AHI,304,167- 168).

3.11.2 Aquatic Toxicity to Biota

Zinc is less toxic to aquatic organisms than copper. EPA's 1986 standards propose a four-day average concentration of 86 ppb in marine waters and a one-hour average concentration not exceeding 95 ppb (AHI,304,163). Dissolved zinc is found throughout the Bay-Delta Estuary, with the highest levels of about 2 ppb in the extreme South San Francisco Bay and about 1.5 ppb near the Bay Bridge. The latter site is thought by AHI to be possibly associated with a discharge from the East Bay Municipal Utility District (EBMUD) sewage treatment plant (AHI,304,163). However, much higher values have been observed in the extreme South Bay with a maximum of 84 ppb recorded south of the Dumbarton Bridge in July 1986 (BADA,7).

Zinc is of concern in the Delta because concentrations measured in the Delta and upstream waters approach levels that result in a toxic response to test organisms (30 ppb--also refer to the "Alert Level" column in the problem assessment matrix). Elevated zinc levels upstream from the Delta are associated with mine discharges, which, it is estimated, account for more than 70 percent of the zinc loads in the Sacramento River (RWQCB,5).

Substantial concern has been raised by high zinc levels in acid mine waste near Keswick on the upper Sacramento River (RWQCB-5,5B). Cadmium, copper and zinc levels from the Keswick area are synergistic and acutely toxic to young salmonid fish which support a major Central Valley and Estuary fishery (RWQCB-5,5C). Riverine loads of zinc from this and other locations contribute to the moderately high levels in sediments mentioned earlier.

In the Bay-Delta Estuary generally, zinc levels are unexceptional, with only localized areas showing levels sufficiently elevated to affect biota (AHI,304,170;302,307). In general, zinc concentrations in the sediments of the Bay-Delta are at about 100 ppm dry weight.

These levels are not considered high when compared to other coastal embayments and are only slightly higher when compared to average shale. The majority of the zinc within Bay-Delta sediments also appears to be tightly bound within the sediment matrix. Some sites within the Bay, such as those close to the Palo Alto sewage treatment plant outfall, sediments in Albany Hill, Islais Creek and Mission Creek, exhibit high zinc concentrations in sediments (AHI,304,166-167).

3.11.3 Conclusions

Zinc concentrations in the biota of the Bay-Delta are considered to be only moderately elevated with no unusually high contamination apparent, and are therefore not a threat to the public health within the Bay-Delta.

High zinc levels in acid mine waste on the upper Sacramento River are of concern, particularly with respect to the synergistic effects of zinc, copper and cadmium to young salmonid fish. Zinc concentrations in Bay and Delta waters and on the upper Sacramento River occasionally approach levels that are known to cause effects on test organisms. Existing Bay and Delta water quality objectives for zinc set by Regional Boards 2 and 5 should be reviewed for their adequacy in protecting aquatic species.

3.12 HYDROCARBONS

3.12.1 Public Health

Hydrocarbons are of concern because they can enter the Bay, a major seaport involved in oil refining and transport, in potentially large volumes as a result of spills. Rates of depuration range from a few hours to three or four days.

The impacts of hydrocarbons on biota and human health, however, are not adequately defined. Because hydrocarbons are often composed of complex mixtures of chemicals for which adequate analytical techniques and toxicological data do not always exist, interpretation of the toxic problems caused by hydrocarbons is difficult (AHI,304,281). Available data often lump hydrocarbon pollutants into a single category identified as "oil and grease" which frequently reaches the estuary in urban runoff, sewage effluent and industrial discharge.

Some data exist regarding mononuclear hydrocarbons (MAHs) and polyaromatic hydrocarbons (PAHs). MAHs are not considered to be a human health problem in the Bay-Delta Estuary. They do not tend to accumulate in sediments and most aquatic organisms metabolize and depurate MAH's rapidly. PAHs include compounds which are carcinogenic to laboratory animals (e.g., benzo-a-pyrene and benzo-a-anthracene). Many of the PAHs found in San Francisco Bay sediments are known to be present in urban runoff (AHI,304,286) and atmospheric deposition (T,XLV,89). These chemicals are at high levels in the San Francisco Bay compared to other central California coastal locations (AHI,304,305) but the human health implications are not clear.

3.12.2 Aquatic Toxicity to Biota

Hydrocarbons in San Francisco Bay biota occur as complex mixtures making it difficult to trace them to a particular source; petroleum compounds from municipal and industrial discharges are considered a major source (AHI,304,293). The effects on biota are not well defined, with possible population impacts of pollutants obscured by natural variation caused by fluctuating outflows, high tidal exchange, ocean temperature changes and other perturbations (AHI,304,316).

MAHs are a component of crude oil (0.2 to 7.4 percent), particularly of the water soluble fraction (20 to 50 percent) (AHI,304,282). These compounds are generally accumulated by organisms directly from the water column, and excreted rapidly in uncontaminated conditions (AHI,304,282). MAHs possess high vapor pressures, relatively high water solubilities and relatively low octanol/water partition coefficients (indicating low potential for bioaccumulation). Environmental fate studies indicate that MAHs have a very short residence time in surface waters due to rapid volatilization. Almost complete volatilization from surface waters can be expected six to eight hours after entry. MAHs are characterized by low bioconcentration values and therefore do not tend to accumulate in aquatic organisms or to be biomagnified in food chains (de Vlaming, December, 1988, SWRCB Report).

The few monitoring data available indicate that MAH concentrations in California's surface waters do not exceed 1 ppb. During March, April and May, 1987, MAHs were below the detection limit (i.e., -0.5 ppb) in water samples collected at several locations in the Bay-Delta Estuary. A SWRCB report concluded that MAHs do not pose a widespread, chronic contamination problem in the San Francisco Bay-Delta; and they are not likely to be impacting, either in terms of bioaccumulation or adverse health effects, the striped bass population or other aquatic organism populations in this system (de Vlaming, December, 1988, SWRCB Report).

PAHs have been found in elevated levels in San Francisco Bay sediments, with particularly high levels in Islais Creek (total PAH in excess of 10 mg/kg dry weight) and lesser amounts in Oakland Harbor and San Pablo Bay (AHI,304,286). Materials identified included phenanthrene, chrysene, benzopyrenes, benzo-a-anthracene, fluoranthene and pyrenes, some of which (benzo-a-pyrene and benzoz-a-athracene) are found to be carcinogenic in laboratory mammals (AHI,304,286). The distribution of PAHs is spatially heterogeneous in the San Francisco Bay over distances as small as a mile or two (e.g., Berkeley to Oakland), perhaps reflecting a considerable number of discrete sources (AHI,304,281).

Work done by the National Oceanographic and Atmospheric Administration (NOAA) reported data for hydrocarbons in Bay-Delta sediments as "total aromatics". The results of their 1984 Benthic Surveillance Project for Pacific coast sediment samples indicate that sediments from these sites in the Bay show elevated total aromatic levels exceeding 1,000 ppb dw. Of the sites sampled throughout the nation by NOAA for aromatic hydrocarbons, 34 percent (15 of 44) showed higher levels (AHI,304,286-289).

3.12.3 Conclusions

Most studies on hydrocarbons to date have focused on two types, the mononuclear (MAHs) and polyaromatics (PAHs). Conclusions in a State Water Resources Control Board report (de Vlaming, December, 1988) indicate that MAHs, because of their rapid volatilization rate and tendency not to accumulate in aquatic organisms, do not pose a threat to human health through ingestion of aquatic organisms; they also do not seem to be having an adverse impact on aquatic organisms in the Bay-Delta.

PAHs, on the other hand, have been found in elevated levels in Bay sediments, and have been detected in biota of the Bay (starry flounder and mussels, *Mytilus edulis*). Unfortunately only limited information on Bay-Delta biota exists because hydrocarbons are not routinely analyzed for in the State Mussel Watch Program (AHI,304,293). Nonetheless, based on the available data, PAHs are moderately to highly elevated in Bay-Delta sediments and organisms compared to other areas. The human health implications of this finding are unclear.

3.13 POLYCHLORINATED BIPHENYLS (PCBs)

3.13.1 Public Health

While the human health implications of elevated levels of PCBs within the Bay-Delta are not thought to be threatening, these elevated levels are of concern; monitoring should be continued and additional studies are needed.

Organochlorine compounds, or chlorinated hydrocarbons occur in the waters of San Francisco Bay, and these compounds include pesticides and industrial chemicals such as PCBs. Effects range from toxicity to phytoplankton, to food chain biomagnification and diminished reproductive success in birds (AHI,304,204). In May 1983, a State

Water Resources Control Board report (PCBs--SWRCB, Report No. 83-1 sp 1983) concluded that PCBs are toxic substances that are hazardous to humans and aquatic life. The report advised that human contact with PCBs should be minimized and further dissemination of these compounds into the environment should be prevented.

Before 1970, 60 percent of PCB uses were for "closed" systems (electrical and heat transfer systems); the remaining 40 percent were for "open" uses (carbonless copying, hydraulic fluids and lubricants). By 1972 all PCB production was for closed systems. In 1976 the Toxic substances Control Act banned the manufacture of new PCBs and prohibited the use of PCBs except in "totally enclosed" systems. Today, about 750 million pounds (over half of the 1.4 billion pounds of PCBs produced in the U.S.) are still in service (SWRCB--Report No. 83-1 sp, 1983).

No median international standards for PCBs in fish or shellfish are available. However, the National Academy of Sciences has issued a guideline for predator protection of 500 ppb wet weight and the Food and Drug Administration has issued a tolerance level for PCBs of 2,000 ppb wet weight (AHI,304,221). In addition, the Toxic Substance Monitoring Program's elevated data levels are 160 ppb ww for the 85 percentile and 475 ppb ww for the 95 percentile (TSM 1985; Report No. 87-1 WQ). Elevated data levels from the Mussel Watch Program are as follows: EDL 85=200 ppb ww; EDL 95=283 ppb ww. Both levels are approximate as a result of conversion from dry weight to wet weight by dividing by 7 (CMW 1984-85; Report No. 86-3 WQ).

Work done by Risebrough et al. (1978) on the bay mussel Mytilus edulis indicates that relatively high levels of PCBs are present in mussels from the South Bay, particularly from Islais Creek south to Redwood Creek. PCB levels in mussels from this area ranged from 400 to 1,500 ppb dw (approximately 57 to 214 ppb ww). Elevated concentrations of PCBs were also found in mussels off Richmond, Albany and Oakland (AHI,304,216). Results of PCB concentrations from the Mussel Watch Program for the years 1979 through 1986 also indicate that the Bay still contains PCBs despite restrictions imposed on their usage in 1976 (AHI,304,216); their presence can partly be explained by the fact that these compounds, like DDT, are particularly long-lived in the environment. Recently, however, low concentrations of PCBs in sturgeon, striped bass and flounder have been found (SWRCB, SMW Report, 1986 and 1987). It should be noted, however, and the AHI points out, that while local contamination of PCBs is evident in San Francisco Bay, concentrations found in mussels are considerably lower than those found in certain polluted locations elsewhere, including New Bedford Harbor in Buzzards Bay, Massachusetts, and Newport Harbor, San Pedro and San Diego Harbors in California. It is thought that PCBs in the Bay are diluted and dispersed by the high tidal prism and high sediment mobility (AHI,304, 219-220).

Concerning finfish of the Bay-Delta, NOAA (1987) has documented that PCBs in the livers of starry flounder from Southampton Shoal and Hunters Point in San Francisco Bay are highly elevated when compared to flounders from the Columbia River, Coos Bay and Bodega

Bay (Southampton Shoal -- 3,734 ppb dw; San Pablo Bay -- 1,191 ppb dw; Hunters Point -- 6,990 ppb dw; vs. Columbia River -- 734 ppb dw; Coos Bay -- 555 ppb dw; Bodega Bay -- 548 ppb dw). Work by various researchers (Stevens, 1980; Whipple, 1984; Crosby et al., 1983; Brown et al., 1987) has indicated that the local striped bass population exhibits high levels of organochlorines, including PCBs. These concentrations are not as elevated as in highly contaminated areas (e.g., Hudson River) but they are elevated compared to areas such as the Coos Bay or Chesapeake Bay (AHI,304,223-226).

3.13.2 Aquatic Toxicity to Biota

Available data from all levels of the Bay-Delta Estuary food chain suggest that PCBs are still in the ecosystem despite controls on use, and they may be exerting a variety of detrimental biological effects (AHI,304,231).

PCBs are significant organochlorines in the Bay-Delta Estuary because of their very great persistence, widespread use and considerable aquatic toxicity (AHI,304,205). This family of chemicals, which were produced as mixtures of isomers or homologues, differ from one another in persistence, toxicity and biological availability (AHI,304,206). The sophisticated detailed analysis needed to characterize PCB contamination is expensive; in general, data have not been developed to show precisely which individual PCBs are of greatest concern at local sites (AHI,304,206).

PCBs enter the Bay from wastewater, atmospheric deposition and urban runoff (AHI,304,208). Dredging and dredge sediment disposal may mobilize PCBs which are present in sediments (AHI,304,208).

During the 1970s, several streams which entered the San Francisco Bay contained PCB-contaminated sediments, including San Rafael Creek and the Napa River in the North Bay, and San Francisquito, Stevens, Los Gatos and Alamitos creeks in the South Bay. The Guadalupe River in the extreme South San Francisco Bay was contaminated with polychlorinated napthalenes which are similar in properties and uses to PCBs (AHI,304,208). The distribution of PCBs in the Francisco Bay sediments appeared patchy, as could be seen in the spatial variability of PCB residues in starry flounder (AHI,304,209).

Data from NOAA's Benthic Surveillance Project (1987) indicate that San Francisco Bay is one of three general areas with significant PCB levels on the west coast. PCB levels in sediments of the following Bay locations are: San Pablo Bay -- 9 ppb dw; Southampton shoal -- 12 ppb dw; Oakland -- 61 ppb dw; and Hunter's Point -- 40 ppb dw. In comparison, the Bodega Bay reference site sediment contained only 4 ppb dw (AHI,304,209-213).

State Mussel Watch Program results for PCBs indicate that the entire San Francisco Bay from San Pablo to South Bay is generally contaminated, suggesting that multiple sources are involved (AHI,304,216). A sudden increase in general PCB levels found by the Mussel Watch Program in the San Francisco Bay in 1981 suggests a spill or release of some magnitude occurred in late 1980 or early 1981, but none was reported during that period (AHI,304,219).

There appear to be multiple sources of PCBs to the Bay, because different mixtures of isomers have been detected in molluscs at different times and locations (AHI,304,218,T29). The effects of PCBs in fish have been shown to induce hepatic mixed function in oxidase enzyme activity, and alter hormonal levels and interfere with reproduction (AHI,304,220). Levels of PCBs in fish and effects induced by PCBs are complex integrations of total exposure, because fish move through broad regions of the Bay (AHI,304,220). The starry flounder has been shown to have higher levels of PCB contamination in the San Francisco Bay than in other West Coast estuaries. Liver tissues of flounders from the Columbia River mouth and Coos Bay have total PCBs well under 1,000 ppb dw, while flounder from Hunter's Point and Southhampton Shoal in San Francisco Bay exceed 3,000 ppb in total PCBs. Striped bass show similarly elevated tissue PCB levels in the Bay-Delta tributaries (nearly 20 ppm lipid weight) compared to Coos Bay, Oregon and Chesapeake Bay (2.0 to 5.0 ppm) (AHI,304,223). PCBs have been detected in bay shrimp in both North and South San Francisco Bay samples with tissue levels ranging from 100 to 2,500 ppb dry weight; the highest levels occurred in the North San Francisco Bay population (BADA,7,57,58, T1-37) and suggest an unreported discharge of PCBs in late 1983 or 1984.

Marine mammals have rarely been examined for PCBs in the Bay-Delta Estuary; the data available come from individuals which were found dead and thus may not accurately reflect the distribution of contaminants in the population (AHI,304,228). One seal was more contaminated than others, with PCB levels of 500 ppm of lipid in blubber, 12,000 ppm in liver and 31,000 ppm in muscle (AHI,304,228). Other seals contained PCBs at concentrations of about 100 ppm lipid weight. Comparable levels of PCBs (100 ppm lipid weight) are believed to affect reproduction in ringed seals in Bothnian Bay, Scandinavia, but no local marine mammal reproductive information is available (AHI,304,208).

Birds from the San Francisco Bay have been reported to have experienced reproductive impairments characteristic of organochlorine toxicity; eggshell breakage, hatching failure and chick mortality in Caspian terns (Sterna caspia) also occurred. Reproductive problems in great blue heron (Ardea herodias) and black-crowned night herons (Nycticorax nycticorax) were also reported (AHI,304,229,230). Elevated PCB and DDE levels, compared to levels in control eggs from Patuxent, Maryland, were present in the eggs of night herons from Bair Island in the San Francisco South Bay. It is suspected that elevated PCB levels were responsible for a reduction in the embryonic growth of these birds (AHI,304,230).

3.13.3 Conclusions

While the human health implications associated with contamination of the aquatic biota are not thought to be threatening, the elevated levels evidenced in the biota are of concern. Additionally, it is suspected that the PCB levels currently found in the Bay sediments and biota may be exerting a variety of detrimental biological effects on the aquatic biota.

Though few data are available on PCBs in Bay-Delta waters it is evident from the available data on the sediment and biota that influent streams and the Bay contain generally elevated levels of PCBs. Sources of PCB contamination appear to be localized and multiple and also include the Central Valley Basin and South Bay catchment. There is little evidence of PCB reduction since restrictions were introduced in 1976.

3.14 DDT AND OTHER CHLORINATED HYDROCARBON PESTICIDES

3.14.1 Public Health

Although DDT, chlordane and PCBs are no longer legally used, large amounts are still evident in some places, and could enter the human food chain. DDT and other chlorinated hydrocarbon pesticides are found at elevated levels in several parts of San Francisco Bay, in part due to historic use on crops and structures, as well as manufacturing and formulating activities (packaging and processing for subsequent sale and use) (AHI,304,244). USFDA action levels for DDT and metabolites have not been exceeded by fish from the Central Valley or San Francisco Bay (AHI,304,251). Fish from the Central Valley exceed the USFDA action level for a number of pesticides including:

- o chlordane (San Joaquin River at Vernalis) (AHI,304,F78,266);
- o endosulfan (San Joaquin River at Vernalis and the Tuolumne River) (AHI,304,F80,268);
- o lindane (Sacramento River at Hood) (AHI,304,F81,269); and
- o toxaphene (San Joaquin River at Vernalis) (AHI,304,F83,271) (SWRCB,TSM Program).

In the San Francisco Bay proper, PCBs and DDT and its metabolites are the most significant organochlorine contaminants with potential public health effects, while dieldrin, chlordane and toxaphene are also commonly identified at elevated levels. Although DDT, chlordane and PCBs are no longer legally used, large amounts are still evident in some places, and could enter the human food chain. The Lauritzen Canal near Richmond is a source of several of these contaminants (AHI,304,272).

3.14.2 Aquatic Toxicity to Biota

Although DDT usage has been banned since 1970 in California (AHI,304,233), its persistence and ability to pass through the food chain seem to assure it will continue to be found in susceptible biota. Current data on DDT in San Francisco Bay sediments show levels have dropped (1986 maximum of 3.60 ppb dry weight) in comparison to those seen in the mid-1970's (up to 200 ppb in 1974) shortly after the chemical was prohibited in agricultural use (AHI,304,T30 vs. T31,235-236).

Residues in biota have shown similar declines in DDT and metabolites since the ban (AHI,304,242), but the decline has been slight in recent years; significant sources like the Lauritzen Channel near Richmond remain (AHI,304,244). Because of contamination from the former United Heckathorn pesticide formulation and packaging plant, the Channel has from 6,800 to 22,470 ppb of DDT and metabolites in biota, as well as residues of chlordane and dieldrin (AHI,304,244). Mussels throughout the Bay have DDT metabolite concentrations of about 50 to 90 ppb (AHI,304,244). Fish in the Bay-Delta Estuary and its catchment area continue to show higher DDT and metabolite residues than the same species in uncontaminated areas elsewhere. If residue declines exist, they are not dramatic because individual-to-individual variance obscures any slight trend (AHI,304,254). Little evidence of DDT-related toxicity is available for marine mammals and birds in the Bay-Delta Estuary, although a single harbor seal found dead in Richardson Bay had elevated levels of DDT and PCBs (AHI,304,255).

Other chlorinated hydrocarbons pesticides continue to be present in the San Francisco Bay. Chlordane, for example, a chemical more acutely toxic than DDT, is apparently nearly as abundant as PCBs in sediments and is found in higher concentration than DDT and its metabolites (AHI,304,259). Some other organochlorines detected include chlordane congeners (trans-chlordane, cis-chlordane, and trans-nonachlor) from Islais Creek, and hexachlorobenzene from Oakland sediments.

Biota from the Bay-Delta and its catchment show a wider variety of organochlorine compounds than sediments. Dieldrin, for example, is sometimes found in Pacific oysters, asiatic clams and mussels. In the San Joaquin River, samples of clams (Corbicula fluminea) show contamination by chlordane, chlorpyrifos, dieldrin, endosulfan, and toxaphene (AHI,304,261). Compared to other regions, fish from the Central Valley rivers show elevated levels of chlordane, aldrin, dieldrin, endosulfan, isomers of HCH, hexachlorobenzene and toxaphene (AHI,304,272), despite those chemicals being banned or restricted in California. Fish from the Central Valley exceed National Academy of Sciences (NAS) guidelines for protection of predatory species, or FDA action levels in many cases (AHI,304,264). For example, chlordane exceeded the NAS guideline of 100 ppb in fish from the lower American River, the Sacramento River at Hood, and the San Joaquin River at Twitchell Island, as detected by the State Board's Toxic Substances Monitoring Program (SWRCB, TSM Program, 1986). Other NAS guidelines exceeded in the

Central Valley are 100 ppb for endosulfan, which fish exceeded in the San Joaquin at Vernalis and the Tuolumne River. The NAS guideline of 100 ppb for toxaphene was exceeded in fish from 15 Central Valley streams (SWRCB,1986). Many of these chemicals are highly toxic to fish, with 96-hour LC50 values below 10 ppb and some below 1 ppb (AHI,304,272).

Pesticide use in the Central Valley results in contaminants reaching the estuary. The Lauritzen Canal in Richmond represents a continuing source of residual organochlorines pesticides from past manufacturing (AHI,304,273). Levels near the Canal are not all seriously toxic; however, persistence and bioaccumulation effects, as well as locally high concentrations, are all cause for concern.

3.14.3 Conclusions

Based on the limited available data, it appears that levels of DDT and its metabolites in Bay-Delta organisms have remained relatively stable since the late 1970s. The current relatively low levels of DDT and metabolites within the Bay-Delta are not causing significant adverse effects on biota. Though levels throughout the Bay-Delta are relatively low when compared to other contaminated embayments, local areas, such as the Lauritzen Canal near Richmond, contain elevated levels and may act as a source of these contaminants. Other sources undoubtedly include soils from the hydrologic basin of the Bay-Delta.

Organochlorines other than PCBs and DDT found most commonly within the Bay-Delta include dieldrin, chlordane, and toxaphene. As with DDT, the Lauritzen Canal acts as a source of these contaminants, which are believed to have come from the United Heckathorn Company plant that manufactured a number of pesticides in the past. Other sources include agricultural soils from the Bay-Delta basin. It is believed, however, that except for some local contamination, organochlorine levels are relatively minor; they are therefore having no significant adverse effects on the biota in the Bay-Delta (AHI,304,272-273).

3.15 CHLORINATED DIBENZODIOXINS AND DIBENZOFURANS

During the Water Quality Phase's hearings on the PPD, the Department of Fish and Game recommended that the State Board add chlorinated dibenzodioxin and dibenzofurans to the list of pollutants of greatest biological significance (T,I,84:18-20). The following narrative on public health impacts and toxicity of these pollutants supports the Department's recommendation.

3.15.1 Public Health

Chlorinated dibenzofurans (CDFs) and dibenzodioxins (CDDs) include one of the most toxic substances known: 2,3,7,8 -- tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), commonly called dioxin.

These compounds occur as byproducts of chemical synthesis, from electrical equipment fires, and from municipal solid waste incinerators. CDFs and CDDs share three characteristics that make them long-lived in the environment: They have very low water solubility, high affinity for soil and sediment and are resistant to breakdown (SWRCB,Report No. 88-5WQ,1988).

CDDs and CDFs are absorbed and concentrated by humans and laboratory animals. The half-life of the most toxic CDD is estimated to be over five years in humans. Laboratory studies with animals indicate that dioxin causes teratogenic and fetotoxic defects at very low exposure levels. They are also known to be strong animal carcinogens. EPA has rated dioxin as the most potent animal carcinogen tested (SWRCB,Report No. 85-5,WQ,1988).

In 1983, the U.S. Food and Drug Administration set a safe level of 25 ppt (parts per trillion) in fish for human consumption, as long as fish were not consumed more than twice a month (SWRCB, Report, No. 85-5 WQ, 1988). The EPA criterion in water for protection of human health from potential carcinogenic effects of dioxin through ingestion of contaminated water and aquatic organisms is 0.013 parts per quadrillion (ppq) at a 10^{-6} (one in a million) risk level. For bays and estuaries, exposure is limited to contaminated seafood and the criterion is slightly higher at 0.014 ppq (SWRCB, draft FED for Inland Surface Waters and Bays and Estuaries, 1/1990).

Only two facilities are confirmed dischargers of dioxin compounds to California inland waters. These are the Simpson Paper Company Mill on the Sacramento River near Anderson, and the Gaylord Container Corporation Mill at Antioch on the Delta . Effluent from the Simpson Paper Company has contained 100 to 250 ppq 2,3,7,8 TCDD, and at least 330 ppq of TCDD equivalents (TCDD equivalents are the toxic equivalent concentrations of a mixture of chlorinated dibenzodioxins and dibenzofurans) (Central Valley Regional Water Quality Control Board, Order No. 89-057). Recent measurements (March-September, 1989) have been lower, about 50 ppq TCDD equivalents. Fish and shellfish from the Sacramento River near the mill contain CDDs and CDFs at levels high enough (38 ppt equivalents in rainbow trout) that the Department of Health Services issued a health advisory in November 1988, warning against consumption of fish caught between Keswick Dam and Red Bluff (SWRCB,draft FED for Inland Surface Waters and Bay and Estuaries, 1/1990). The advisory advises people not to eat resident trout, sucker or bottomfish, such as carp or catfish, taken from the Sacramento River between Keswick Dam and Red Bluff. In May 1989, squawfish were added to the list of fish not to be eaten. This advisory was included in the Department of Fish and Game's California Sport Fishing Regulations for 1989 and will be included through 1992 (pers. comm.; Al Cordoni, DFG). Since the health advisory, subsequent samples of fish, taken both by the Simpson Paper Company and Regional Water Quality Control Board 5, have confirmed the presence of 2,3,7,8,TCDD.

The Gaylord Container Corporation Mill at Antioch on the San Joaquin River on the Delta discharges wastewater at concentrations of 129 ppq TCDD equivalents. Fish caught near the outfall contain concentrations of 2,3,7,8-TCDD estimated at 49 ppq. This concentration exceeds the EPA ambient water quality criterion for protection of human health by a factor of 3,800 at the 10^{-6} (one in a million) risk level (SWRCB Staff Report, Candidate Waterbodies for the Clean Water Act Section 304(l) Short List). However, according to comments received from the Gaylord Container Corporation, since the implementation of their chlorine minimization program, recent measurements show an average concentration of 18 ppq TCDD equivalents (12 ppq of 2,3,7,8 TCDD and 58 ppq of 2,3,7,8, TCDF) (letter to Leo Winternitz from Gaylord Container Corporation dated June 5, 1990).

CDDs and CDFs have also been detected in fish from the Sacramento River at Clarksburg, the San Joaquin River at Stockton, and the Delta near Antioch (Draft FED, Inland Surface Waters and Bay and Estuaries 1/1990). The sources of contamination are unknown.

3.15.2 Aquatic Toxicity to Biota

In addition to toxic effects occurring at very low concentrations (parts per trillion range (ppt)) the effects of CDD and CDFs on aquatic life do not appear until 5 to over 100 days after exposure. Amounts as low as 5.6 ppt have been lethal to salmon. Other toxic effects have been observed as low as 0.1 ppt (SWRCB,Report No. 88-5 WQ, March 1988).

The results of a chronic study published in January 1988 indicate that over a 56-day period, levels as low as 38 ppq of CDD had significant adverse effects on survival and growth on rainbow trout. The trout were exposed to 38 ppq of CDD for 28 days, and nearly half the trout died after an additional 20 days. CDF levels as low as 0.9 ppt reduced growth and 4 ppt reduced survival (SWRCB,Report No. 88-5 WQ, March 1988).

3.15.3 Conclusions

The presence of CDDs and CDFs, in sources of drinking water and in the tissues of organisms consumed by the public, are a source of serious concern. This concern is reflected by the health advisory issued by the Department of Health Services in November 1988, warning against consumption of fish caught between Keswick Dam and Red Bluff in the Sacramento River.

The adverse effects of CDDs and CDFs on the aquatic biota are also a serious cause of concern. These compounds are long-lived in the environment, are absorbed and bioaccumulated by humans and other organisms, and are known to be strong animal carcinogens; they also cause teratogenic and fetotoxic defects (Dioxin). In addition, adverse effects of these compounds are found at very low concentrations, in the part per trillion to part per quadrillion range.

The State Board is currently considering adopting a human health objective for 2,3,7,8-TCDD equivalents of 0.013 ppq for inland surface waters and 0.014 ppq for bays and estuaries. The rationale for this objective is discussed in the January 29, 1990 draft Functional Equivalent Document for Inland Surface Waters and Enclosed Bays and Estuaries of California.

Additional recommendations concerning this issue are found in Chapter 4, Section 4.4.1.

3.16 TRIHALOMETHANES

Trihalomethanes (THMs), a subset of chemicals known as disinfection by -products (DBPs), are single carbon, halogenated organic compounds produced when naturally occurring substances in water come in contact with chlorine during the process of disinfection (T,VI,38:3-5). The significance of THMs in a drinking water supply is reported in two national surveys which indicate that chloroform and bromoform, two of the THMs, are animal carcinogens and are suspected human carcinogens (T,VI,38:12-16).

The THM precursors present in Delta Waters are a significant water treatment issue to users who divert water from the Delta for municipal purposes. Because of the statewide effect of THM precursors in Delta waters, detailed discussion of THMs and DBPs is being included in the Water Quality Control Plan for Salinity. That document will also address State Board policy concerning the control of THMs and other DBPs.

3.17 DREDGING SEDIMENTS

Pollutants released during dredging and disposal of sediment were identified in the hearings and in exhibits as a potentially major contributor to pollution of the Sacramento-San Joaquin Delta, and particularly of San Francisco Bay.

During the Phase I hearings, parties who expressed concern about dredging sediments included Citizens for a Better Environment (CBE), Bay Institute of San Francisco (BISF), Aquatic Habitat Institute (AHI) (T,XLVIII,77:7-8;T,XLIV,37:1-13;T,XLIX,205:18-20,210:4-9) and the Department of Fish and Game (DFG) (T,XLV,192-194).

During the Water Quality Phase's hearings on the PPD, parties again expressed concern and provided recommendations on the dredging issue. These parties are the Bay Planning Coalition, DFG, Contra Costa Water District (CCWD), AHI, and the Save the San Francisco Bay Association (Save SF Bay). Other parties which commented are the U.S. Army Corps of Engineers (U.S. Corps) and EPA. Serious concerns about the deposition of dredged sediments on Delta levees have been expressed by Sacramento and San Joaquin counties, and by the CCWD, subsequent to the Phase I hearings.

3.17.1 Discussion

Those parties who addressed the effects of dredging and dredge sediment disposal during Phase I and the Water Quality Phase hearings point out that the dredging process:

1. Causes turbidity, high oxygen demand and sedimentation which harm benthic organisms by acute chemical and mechanical effects (T,XLIII,193,rg);

2. Mobilizes and/or makes biologically available pollutants and toxicants which were formerly bound or buried out of reach of benthic organisms (T,XLIX,223:5-13);

3. Occurs in areas such as harbors and channels where elevated levels of toxic materials may exist (T,XLIX,213,12-17; T,XLII,19210-20); and

4. Reduces water visibility and fish catch during the summer months (May-October) in Central San Francisco Bay (T,II,100; 15-19).

Dredging thus may harm the Bay's finfish, shellfish and other bottom-dwelling organisms by reintroducing previously unavailable toxicants into the food chain. Dredging may not only harm fish and wildlife but also recreational uses such as hunting and fishing when habitat is degraded by the introduction of dredged materials resulting in turbid waters, and when areas are closed or health warnings have to be issued by DHS. Commerce and navigation uses which depend on dredging must be balanced against the damage by dredging to other beneficial uses.

3.17.2 Alternative Recommendations

Testimony on dredging addressed the balance between the harm to other beneficial uses and the public interest in commerce and navigation. DFG recommended that Regional Board 2 reconsider its position on dredge sediment disposal activities, in which disposal of dredge sediment were routinely certified as meeting state water quality standards. DFG's recommendation specifically cites the problems of substantially increased turbidity, smothering of benthos, and acute toxicity of disposed sediments (T,XLIII,193: 17-25;226:14-23) (T,I,97:7-12;100:3-10;100:15-19). CBE proposed that, while taking economic considerations into account, toxic pollution and sediment effects from dredging could be alleviated by disposal offshore of the Golden Gate (T,XLVIII,95:8-19; T,XLVIII,100:14-16). CBE also proposed the use of a dump site which would be operated so that subsequent deposits covered previously placed sediments, thereby rendering the buried material unavailable (T,XLVIII,84:1-13). In sites with very contaminated sediments, CBE recommended that comprehensive remedial actions be evaluated before performing dredging, and that burial in place with a clay cap be considered (T,XLVIII,101:11-19). Detoxifying or removing contaminants from the aquatic environment were also identified as possible ways of dealing with contaminated dredging sites (T,XLVII,102:1-6).

AHI identified coastal or open ocean disposal of dredged material as being worthy of consideration as an alternative to disposal in the Bay (T,XLII,161:14). CBE proposed that the method of dredging be chosen to minimize dispersal of sediments into the water column (T,XLOX,223:2-9). CBE proposed that, in other situations where toxic materials in sediments were safely buried under relatively clean sediment layers, the materials should be left undisturbed (T,XLIX,223:16-21). CBE also identified as an option land disposal of sediments as hazardous wastes when contaminant levels are so high that it is inappropriate to return them to an aquatic environment (T,XLOX,214:6-18). Other options identified included capping pollutants in areas where they would likely remain undisturbed (T,XLIX,213:7-11) and deep ocean disposal beyond the continental shelf (T,XLIX,213:21-25;214:1-5).

The following recommendations were presented during the Water Quality Phase on the PPD:

DFG provided several long and short-term recommendations. The long-term recommendations include designation of a deep water ocean disposal site, and selected upland sites where fish and wildlife habitats will not be affected (T,I,101:7;102:1-10). Short-term recommendations include the development of specific criteria for assessing the suitability of sediments for in-Bay disposal, and the development of interim limits for the volume and frequency of disposal of in-Bay sites (T,I,102:11-26). In addition, DFG recommends that new projects, capable of generating large volumes of dredge sediments, should be postponed until alternate disposal sites are developed (T,I,103:1-7).

CCWD has recommended that the State and Regional Boards prohibit the deposition of dredged material on levees or elsewhere in the Delta until it is scientifically established that there will be no significant increase of pollutants in the waters of the Bay-Delta Estuary, and that the stability of the Delta levees will not be compromised (T,II,155:1-6).

While not negating the need for the designation of an ocean disposal site, the AHI has recommended that the State Board require studies be conducted to determine whether there is sufficient cause and effect between dredged material disposal and biological impacts to warrant ocean disposal (T,II,218:12-18). AHI also recommends that the State Board direct the U.S. Corps to develop a model for predicting the transport and distribution of deposited and suspended sedimentary material in the Bay (T,II,219:14-26;220:1-3).

The U.S. Corps testified that designation of an ocean disposal site prior to 1991 (as proposed in an earlier draft) is unlikely due to federal budgetary constraints, and that a new schedule is being developed (T,II,313:24-26). EPA expressed a similar comment in a letter to the State Board.

Some of the recommendations made by the Save SF Bay Association are similar to those made by other parties. These include evaluating upland disposal sites, investigating impacts of dredging and limiting bay disposal of dredged materials during the recreational fishing season (T,II,325:7-19). However, they also recommended that pollution prevention to reduce contamination of dredge sediments be required, and that the U.S. Corps investigate alternate methods of reducing dredging needs, such as coordination of past operations (T,II,325:12-23).

3.17.3 Conclusion

Dredging and dredge sediment disposal represent substantial point sources of pollutants to the Bay-Delta Estuary. The record indicates there is widespread contamination of Bay sediments by a variety of toxic contaminants, and that dredging makes formerly isolated contaminants available.

The U.S. Corps of Engineers, EPA, the San Francisco Bay Regional Water Quality Control Board and the San Francisco Bay Conservation and Development Commission all have responsibility for regulation of the use of certain waters for disposal of dredged material. Therefore, these agencies have jointly developed a long-term management strategy (LTMS) for dredging and disposal of dredged materials from San Francisco Bay. The objective of the LTMS is to develop economically reasonable and environmentally acceptable long range solutions to the dredging and disposal needs of San Francisco Bay. Specific recommendations concerning this issue are found in Chapter 4, Section 4.4.3.

4.0 POLLUTANT POLICY ACTIONS

4.1 Introduction

The problem assessment described in the preceding chapters resulted in a list of actions for Regional Board implementation. These actions fall into categories which are discussed in the following sections:

4.2 Water Quality Objectives

4.3 Mass Emissions Strategy

4.4 Site or Pollutant-Specific Actions

4.2 Water Quality Objectives

4.2.1 Introduction

Pollutants, for which information indicates that ambient concentrations are at levels posing a potential hazard for aquatic life, may be regulated through adoption of water quality objectives and plans to implement those objectives. For many pollutants of concern, water quality objectives do not exist and there is little information on toxicity. For others, either objectives have been developed (California Ocean Plan and Regional Water Quality Control Plans), or information exists in the form of EPA Ambient Water Quality Criteria (Clean Water Act Section 304(a); 33 USCA Section 1314(a)).

4.2.2 Water Quality Objective Development

Objectives for specific pollutants should be adopted where necessary. The State Board believes, however, that the pollutants in question, as well as a number of others, are not a local problem unique to the Bay-Delta Estuary but are a problem throughout the state and that a statewide approach to their control should be taken. The rigorous development of information on water quality and the full involvement of the public throughout California will best ensure the reasonable protection of the waters of the Bay-Delta Estuary. The State Board has therefore decided to remove consideration of water quality objectives from the PPD and to develop objectives to be adopted in statewide plans. Specifically, for the eight pollutants in the draft PPD (November,1988), review and implementation of objectives will be included in the Statewide Water Quality Control Plans for Inland Surface Waters and for Enclosed Bays and Estuaries of California. Workshops and hearings on these plans began in the fall of 1989.

4.3 Mass Emissions Strategy

4.3.1 Introduction

Limitations on the mass emissions of toxic persistent pollutants (e.g., lbs/day or tons/year) should be established to control pollutant accumulation in sediments and biota. Such limitations should be established as part of a strategy which includes the most effective control measures on point and nonpoint sources of the pollutant and supplements existing control measures. The mass emission strategy (MES) includes the following major elements:

1. Identify pollutants and locations of concern.

2. Identify sources of pollutants.

3. Develop and implement a program to regulate mass emissions based upon an assessment of reductions in loadings for principal sources.

4. Develop tissue alert levels and sediment quality objectives.

4.3.2 Discussion

A number of pollutants identified in previous chapters were documented to have accumulated in the tissues of fish and shellfish, as well as bottom sediments. Concentrations in fish and shellfish for some of the pollutants identified in previous sections have been measured at levels which warrant concern with respect to human health. These pollutants and others also pose potential adverse impacts on the health of aquatic communities. Accumulation in sediment represents a potential long-term problem as well, since sediment may act not only as a sink but also as a continuous source of pollutants.

Water quality objectives limit pollutant concentrations in the water column. The development of these objectives, however, often only considers protection of aquatic life from the toxic effects of direct exposure through water, and protection of human health from the toxic effects of ingesting water or consuming fish. In some cases, the concentrations of toxic substances in the sediment and biota reach levels that are potentially harmful to aquatic life and to human health while concentrations in the water column are below detection limits.

Certain EPA water quality criteria consider accumulation of toxics in aquatic organisms, thereby minimizing the threat to human health due to ingestion of fish. These criteria may be useful in limiting bioaccumulation.

Toxic pollutants, including the heavy metals, DDT, and PCBs, have very low solubilities in water, but are persistent in the aquatic system for a long time bound to sediments and biota. These substances are not readily transported from the system nor are they readily broken down since the physical, chemical, and biological processes affecting them are so slow. Bioaccumulating substances must be controlled by a program which considers the mass loading rate, the residual in the sediment and the transport of the pollutant from the waterbody.

The regulatory programs at the State and Regional Boards have been focused on discharges which come from a pipe. Programs aimed at permitted discharges such as POTWs and industry have been in place for many years, have received a great deal of regulatory attention, and have resulted in significant reductions in the discharge of certain pollutants, including heavy metals.

Further reductions from these point sources needs to be balanced with water quality conditions that could be reasonably achieved through the coordinated control of all sources. The water quality which can be achieved through additional treatment at a sewage treatment plant may also be achieved through reductions in storm water discharge. The mass emission strategy proposed here is intended to address pollution on a waterbody approach, not an individual discharge approach. This approach is being employed as part of the State Board's Clean Water Strategy and Statewide Water Quality Assessment.

The mass emissions strategy is intended to delineate a waterbody or segment of a waterbody and determine the sources of specific pollutants and the seasonal loadings from these sources. The objective is to institute additional control measures on specific toxic pollutants which pose the greatest threat to beneficial uses. The specific pollutant, the waterbody and the potential control measures are to be identified in future updates of the Statewide Water Quality Assessment. The Assessment will be used to establish priorities for implementing individual mass emission strategies.

A strategy for limiting mass emissions is warranted under the specific conditions present in the San Francisco Bay and Delta. The Bay and Delta have multiple and varied sources of pollutants discharged under hydrodynamic and water chemistry conditions favoring long-term accumulation of pollutants in sediments and organisms.

The ultimate goal of a mass emissions regulatory program is to provide reasonable protection of the beneficial uses of the estuary based upon:

- Water column, tissue and sediment objectives designed to protect the beneficial uses of the Bay and Delta. Tissue objectives would be designed to protect aquatic life as well as predator species such as man. Sediment objectives must be based upon an understanding of the physical transport and fate of the pollutants.

- An accurate and comprehensive characterization of toxic pollutant sources, loads, and concentrations in the estuary.

- A knowledge of the technical and economic feasibility of control measures for reducing toxic pollutant loads.

Actions are underway which will begin to address these elements. It will take time and money before we will have comprehensive scientific and technical knowledge. At present, there are few specific limits for metals and trace elements in fish tissue. The State Department of Health Services has issued health advisories for mercury and selenium in Bay-Delta waters for consumption of fish and waterfowl respectively. The problem is that there is a general lack of specific limits for sediment and tissue which protect aquatic life and human health. Given the absence of adequate limits, it is prudent to take measures to prevent impacts by controlling potentially toxic pollutants while considering social and economic effects. The mass emissions strategy proposed here is intended to provide a means to initiate actions within existing limitations of data and resources.

4.3.3 Actions

4.3.3.1 Identify Pollutants and Locations of Concern

Pollutants of primary concern are those which exceed specific limits, standards or objectives. Present water quality objectives alone are inadequate to identify pollutants and locations of concern where there has been a build up of toxic pollutants in sediments or tissue. Therefore, the Regional Boards will have to evaluate many sources of information to determine which areas of the Bay-Delta warrant the highest priorities. Some of these sources are Department of Health Services Maximum Acceptable Residue Levels (MARL), Elevated Data Levels (e.g., EDL 85), Median International Standards (MIS), toxicity tests, published scientific information and testimony submitted by experts in the field of resource management. Using evaluation techniques acceptable to the Regional Boardand best professional judgment, Regional Boards are to review the existing data on toxic pollutants to identify candidate pollutants for the MES which have potential impacts on the beneficial uses. These pollutants and their locations will be prioritized through the State Water Quality Assessment. The Regional Boards will complete individual mass emissions strategies for the highest priority waterbodies which will include the elements outlined below.

4.3.3.2 Identify Sources of Pollutants

Existing data should be used for initial source identifications and mass load estimates. A monitoring program for pollutant concentrations in tissues and sediments will be necessary to determine the extent and sources of substances that accumulate. Preliminary indications show that elevated levels of toxics occur in sediment and biota upstream of the Delta in the San Joaquin and Sacramento Rivers and in some of their major tributaries.

The major sources of pollutants to the Bay-Delta can be broken down into three categories: point sources, nonpoint sources, and riverine sources. Point source loadings can be determined from NPDES and monitoring reports. Nonpoint source loading is much more difficult to assess, but has been determined to be a major source of many of the pollutants of concern. Because nonpoint sources are a significant pollutant source, it is important to estimate the loadings from these sources.

Estimates can be made by examining land use or by measuring cumulative changes in receiving waters. In some cases, the discharge point of nonpoint sources is discrete and loading can be measured directly. Nonpoint sources such as agricultural drainage and urban runoff, however, vary significantly by season, both in amount and kinds of pollutants, further complicating estimates of annual loading. There is a need to evaluate this variability.

The first step in identifying sources will be to quantify loadings from point and nonpoint sources discharging directly into the locations of concern. However, the impacts of upstream sources must also be assessed. Fractions of the loadings from any given source may travel downstream dissolved in the water column, or suspended in sediments, or with the bedload. These fractions vary according to the substance and to conditions in the receiving waters. Some substances from upstream sources may never reach the Bay-Delta. For example, substances associated with suspended sediments settle out behind dams. Other substances are transported through the Bay-Delta and out to the ocean in dissolved form.

New areas and techniques for measurement will be needed. Cumulative loadings from point and nonpoint sources could be measured by determining riverine loadings at the boundaries of the Bay-Delta. Special analytical techniques will be required to monitor water concentrations below the detection limits of traditional technology. Techniques such as passing large volumes of water through resin columns are available to concentrate pollutants for low-level detection.

Each Regional Board must develop a program for identifying the major sources of loadings of the substances included in the mass emissions strategy. This list of substances is subject to change as more data become available. Evaluation of the degree of impairment and the potential for reducing mass emissions from identified sources will assist in setting priorities.

4.3.3.3 Establish a Program to Regulate Mass Emission

The goal of the MES is to attain the highest water quality reasonable considering the specific conditions affecting each waterbody. The waterbodies identified through the Water Quality Assessment process are considered of highest priority in the Estuary. Each waterbody or segment identified will have a specific sequence of measures designed to regulate and reduce the concentrations of toxic pollutants in the water column and in sediments and tissue.

The Regional Boards are to develop regulatory strategies for pollutants of concern. The implementation plan for these strategies shall be included in the basin planning process described in the Porter-Cologne Act. In adopting these strategies, the Regional Board should consider the following factors: the total loads on the waterbody; the significant sources of those loads, including point sources, urban runoff, nonurban runoff, riverine sources and atmospheric sources.

Further, for significant sources, the Regional Board shall consider estimated load reductions which can be achieved by alternative control measures and the economic, social and environmental consequences of implementing the measures. The process of selecting a strategy is to involve a balancing of these and other factors consistent with the Porter-Cologne Act.

The mass emissions strategy will implement one of the following approaches:

1. A staged program to reduce total loads to the waterbody;

2. A program to freeze loads at existing levels; or

3. A controlled program of increased loads with measures to assure continued protection of beneficial uses.

The approaches described below should include a monitoring program and reporting schedule to track progress in controlling loads and to track the resulting sediment and biota concentrations. Monitoring reports will serve to indicate whether the major sources are being targeted in an effective manner.

Since nonpoint sources appear to be a very significant source of pollutant loading, this program should include BMPs and any other method of control that can be developed for loadings from nonpoint sources. The State Board will assist the Regional Boards in developing a regulatory framework to monitor and regulate nonpoint sources.

For point sources such as POTWs and industries, the individual strategies shall include a vigorous waste minimization program which includes source control measures and considers pollution prevention audits for pollutants of concern whenever these actions are applicable. Implementation of these programs will be applicable whenever point sources are considered by the Regional Boards to be significant contributors to the mass loadings of pollutants of concern.

Waste minimization is the reduction of the generation, and subsequent need for treatment and disposal of toxic materials. The pollution prevention audit will delineate the mass emission of the pollutant of concern and identify the mass loadings from all the major contributors to the waste stream. Each major contributor shall provide an analysis of alternative measures to reduce or eliminate the discharge of the pollutant of concern. The strategy will incorporate the selected best measures and track the results in the mass emissions.

Waste minimization programs for major contributors of pollutant load might include the following elements:

o Identification of pollutants of concern targeted for reduction based on input from the Regional Boards. Other pollutants which may cause violation of water quality objectives may also be included.

- Identification of the significant sources of the targeted pollutants through extensions of present pollutant monitoring of POTW treatment plant influent and industrial sources.

- Evaluation of alternative measures for reducing the targeted pollutants.

- Formulation of a comprehensive program which might include all practical control measures, both structural and nonstructural, to reduce the discharge of the targeted pollutants.

- Development of a public education/outreach program to educate the community about the need to properly dispose of toxic materials.

- Development of a monitoring and inspection program to document compliance with and benefits of source reduction controls.

For point and nonpoint sources, all practical control measures both structural and nonstructural shall be analyzed to select a cost-effective measure to attain the greatest control of the pollutants of concern.

In some cases it may be necessary to work with other Federal and State agencies toward the longer-term objective of reduced emissions. For example, in order to reduce atmospheric deposition, the most significant source of PAHs, it may be necessary to work with the State Air Resources Board and other agencies to initiate long-term programs to reduce air emissions of PAHs.

1. Program to Reduce Loads

For those waterbodies where reductions in pollutant loads are warranted, the strategy should include a pollutant reduction program. A reduction is warranted when the Regional Board determines that the necessary measures are reasonable and such reduction would result in a greater degree of protection for beneficial uses. A reduction is required if the existing uses as defined in federal regulations are not being protected, or if higher than existing water quality is required pursuant to 40 CFR 131.10. Once the major sources have been identified, each Regional Board should develop and implement a program of reductions. Total load limits designed to prevent impairment to beneficial uses through toxic effects or accumulation in tissue or sediments will be developed. Total load limits shall be based on an appropriate time period (e.g., daily, monthly, annual) considering pulse loadings from nonpoint sources. The program should initially target the major sources. As more information becomes available, and additional loading sources and objectives for tissue and sediment levels are identified, the reduction program can address a wider range of sources.

2. Program to Freeze Loads

This alternative should be considered if the Regional Board determines that a reduction in loads is unreasonable and not required. The freezing of loads is required if it is necessary to protect existing beneficial uses. This alternative must also be given serious consideration when the Regional Board suspects that the waterbody is at risk and there exist unknowns with regard to its allowable loadings.

Current loading levels may be defined using the average loading over a representative previous three-year period. Point sources can be limited through NPDES permits. Nonpoint sources may be limited by appropriate best management practices (BMPs) and in appropriate cases by waste discharge requirements.

Under either of the above programs, increases in loading from one source may be permitted if there is a reduction in loads from other sources that is equal to or greater than the proposed increase. Of course, where the program requires a reduction in loadings, the amount of the reduction from other sources which may be credited to the source seeking an increased loading must be based upon reductions over and above any reductions which would be necessary under the program in the absence of the proposed tradeoff. Appropriate targets for reduction are, for example, nonpoint sources such as urban runoff entering the Bay-Delta. The discharger seeking an increase in loading must demonstrate to the Regional Board the ability to implement a program to reduce loads at other sources and must establish a monitoring program to ensure that the reduction takes place.

3. Controlled Program of Increased Loads

In some cases it may be determined that a program of reduction or maintenance of levels is not reasonable because of economic and social considerations. Under these conditions, it may be warranted to allow increased loadings of pollutants to accommodate specific future economic or social development. These circumstances may occur under the following two conditions.

The first is that the water quality is better than that which is necessary to maintain and protect existing beneficial uses. The Regional Board has discretion to determine that diminution of water quality and additional loading is warranted if it receives evidence which permits these findings:

a. That allowance for lower water quality is necessary to accommodate important economic or social development [40 CFR 131.12(a)(2)], is consistent with maximum benefit to the people of California, and such a change otherwise complies with State Board Resolution No. 68-16, "Statement of Policy with Respect to Maintaining High Quality Waters in California". For example, this finding could be supported by a show of consistency with the adopted general plan and supporting environmental documentation. Such documentation should include analysis of alternative actions and an analysis of projected annual loadings of candidate MES pollutants of concern over a twenty-year period. The analysis should show that all feasible actions will be undertaken to minimize such loadings.

Proof of social or economic necessity requires an economic and social impact analysis. At a minimum this analysis must show that a significant adverse impact would result from maintaining existing water quality and that the community will be adversely affected if water quality is not lowered. EPA provides guidance in the Water Quality Standards Handbook (Chapter 2) on performing an economic impact analysis .

b. That "(i)n allowing such degradation or lower water quality, the State shall assure water quality adequate to protect existing uses fully" 40 CFR 131.12(a)(2).

   This may be demonstrated through analysis of available information on the effects of the pollutants of concern on the beneficial uses. This analysis must include the effects of projected loadings. If the available scientific information is inadequate to assure the site-specific protection of beneficial uses, the Regional Board shall require that appropriate studies be undertaken by the regulated entities.

c. That ongoing protection of beneficial uses will be assured through a monitoring program to measure loads from all sources and to measure the changes in accumulative levels in sediments and biota. Such monitoring programs must have adequate sampling to provide a statistically valid trend analysis. Such analysis shall be reviewed at least biennially to assure compliance with the individual strategy.

   The second case for allowing increases in loadings because of economic and social considerations is provided for where water quality is not fully supporting designated uses, but existing uses as defined in 40 CFR 131.3(e) would be protected [40 CFR 131.10(g)(6)]. (Other bases for removing a designated use are listed in 40 CFR 131.10(g).) In this case it would be necessary to demonstrate that the designated uses are not existing [Sections 131.3(e) and 131.10(h)]. This is demonstrated through a use attainability analysis [Sections 131.3(g) 131.10(j)]. A change in designated beneficial uses would require a Basin Plan amendment supported by a finding that controls to protect such uses would be "...more stringent than those required by section 301(b) and 306 of the Clean Water Act, "and...would result insubstantial and widespread economic and social impact" [Section 131.10(g)(6)]. Additionally, before the Regional Board removes a designated use which allows increased loadings, it must have the evidence described in b. and c. above (40 CFR 131.10(h)).

4.3.3.4 Development of Methodology--Tissue Alert Levels, and Sediment Quality Objectives

The State Board will consult with DHS to determine what maximum tissue residue levels are protective of human health and preferably what tissue residue levels should trigger State and Regional Board action to prevent levels from reaching maximum allowable concentrations for human consumption. DHS will also be requested to provide information concerning synergistic, antagonistic or additive effects when more than one contaminant is accumulated in an organism. Tissue residue levels protective of aquatic life must also be determined. These levels will be used to establish priorities for State and Regional Board regulatory programs, including the mass emissions strategy.

Sediment quality criteria are virtually nonexistent. Several approaches are currently under evaluation for the development of sediment quality objectives. As sediment quality objectives are developed they will be incorporated into the program. In the interim, statistically-based screening criteria, such as the apparent effects threshold method could be used in the MES.

The apparent effects threshold (AET) method is a statistically based empirical approach which attempts to establish quantitative relationships between sediment pollutants and iological effects. This approach involves the analysis of paired chemical and biological data from numerous sites in a specific waterbody. Statistical analysis of the paired data allows the ranking of observed effects. The AET method allows the ranking of relative degradation of aquatic sites, but does not provide a safe level for the protection of aquatic species or human health. It is recommended that AETs be developed for the San Francisco Bay and Delta Estuary. The AETs could be used to track the progress of the MES and define areas where detrimental concentrations of pollutants are occurring. Initial development of sediment AETs for the San Francisco Bay is underway through a contract managed by the State Board.

4.3.3.5 Implementation of the Mass Emissions Strategy

The Regional Boards will identify the pollutants and waterbodies for the development of mass emission strategies. The Regional Board will submit draft workplans to develop these strategies no later than December 1, 1990. The workplan shall include a schedule for adopting the MES implementation measures into the Basin Plan. The workplan shall also be the basis for a Budget Change Proposal to complete any required work during calendar year 1992. San Francisco Bay, south of the Dumbarton Bridge, will be included in these workplans.

During this interim period and before adoption of these implementation measures, the Regional Boards will require all dischargers of the pollutant of concern to the identified waterbody to develop and implement a program of short-term measures which may include waste minimization and best management practices. The goal of the program would be to minimize the discharge of the pollutant of concern. If, in the opinion of the Regional Board, an increase in loading of the pollutant of concern is considered necessary, even after implementation of all practical measures, the discharger must show that these increases will not cause a violation of Basin Plan requirements including water quality objectives and protection of beneficial uses.

4.4 Site or Pollutant-Specific Actions

4.4.1 Chlorinated Dibenzodioxins and Dibenzofurans

The most certain way to eliminate discharge of CDDs and CDFs from pulp mills is to reduce or eliminate the use of chlorine in the production of finished pulp. This requires substitution of other bleaching chemicals, such as peroxide, ozone, nitrogen dioxide or sulfur dioxide. None of these methods are established technologies and their development has been limited due to their costs which can be significantly higher than chlorine bleaching (Draft FED, Inland Surface Waters and Enclosed Bays and Estuaries, January 1990).

The State Board is considering the adoption of numerical human health objectives for 2,3,7,8--TCDD equivalents: these objectives are 0.013 ppq for inland surface waters and 0.014 ppq for bays and estuaries. The Ocean Plan limit, which have been adopted by the State Board, is: 0.0039 ppq for 2,3,7,8 -- TCDD equivalents.

Due to the extreme toxicity and persistence of these compounds and their implications for public health, it is the goal of the State Board to eliminate the discharge of these compounds to waters of the Bay-Delta by the year 2000.

The State Board, therefore, directs the Regional Boards to develop plans of implementation which will achieve the goal of elimination. Further, the Regional Boards shall establish monitoring programs to track the decreased concentrations of these compounds in fish tissues that result from implementation of this program.

4.4.2 Antifouling Compounds

Tributyltin, a component of anti-fouling paint used on boat hulls, is highly toxic (at the low parts per trillion level) to a wide variety of aquatic organisms. Because of its use, it is regulated as a pesticide, and is therefore subject to the jurisdiction of the Department of Food and Agriculture (DFA). The discharge of tributyltin is now being regulated by DFA which has restricted its use to vessels over 84 feet in length.

The accumulation of tributyltin or other anti-fouling chemicals, such as copper, in harbors and marinas is likely a result of the practice of in-water paint stripping of vessels and discharges from drydock facilities. In-water cleaning of vessels may also contribute to pollutant loads. Regional Boards 2 and 5 are directed to address the need for regulation of these toxic pollutants by the following:

- Prohibit the direct discharge of tributyltin which results from in-water stripping operations performed for the purpose of repainting a vessel hull or bottom.

- Evaluate the impacts of in-water cleaning of vessels.

- Require NPDES permits for boat and shipyards to regulate the discharge of tributyltin and copper.

4.4.3 Dredging Sediments

Dredging and sediment disposal operations can potentially release contaminants bound to sediment. Sediment-bound contaminants potentially become bioavailable through physical, chemical and biological processes. Further evaluation is necessary to assess the impacts of dredging and sediment disposal.

Disposal of dredge sediments in San Francisco Bay is regulated under Section 404 of the Clean Water Act (CWA). This program is administered at the federal level by the U.S. Army Corps of Engineers (COE). The State has water quality certification regulatory authority through Section 401 of the CWA. The State and Regional Boards must find that the proposed activity (i.e., dredge sediment disposal) will not violate existing water quality objectives before a project is certified. The California Coastal Commission and the Bay Conservation and Development Commission, under Section 307(c) of the Coastal Zone Management Act, are responsible for making a determination that a proposed dredging activity is consistent with the Act.

Currently, all dredge sediment disposal occurs at three COE-designated in-Bay sites within Region 2. Apart from the channel bar site, an ocean disposal site for sand only from the Golden Gate Entrance Channel, there are no designated ocean disposal sites. There are no open water disposal sites within Region 5.

Ocean disposal of dredge sediments is regulated under the Marine Protection and Sanctuaries Research Act (MPSRA). Dredge disposal (MPRSA Sect. 103) is administered by COE with final approval by EPA. Under MPRSA Section 102, EPA has authority to allow spoil disposal in an ocean site. EPA has assigned a final target date of January 1994 for designation of an ocean disposal site.

There are differences between the two regulatory programs which make ocean disposal more environmentally restrictive than in-Bay disposal. In addition, MPRSA regulations call for monitoring of the disposal site to assess environmental impacts. There is no parallel requirement in regulations implementing the CWA. Ocean disposal, if a site were approved, would be managed by EPA while the in-Bay disposal sites are currently managed by COE. Each regulatory program, though mandated by different legislation, has developed a gradual process for making decisions. The process and testing requirements are outlined in guidance documents issued either separately or jointly by EPA and COE. Regional Board 2 has recently helped develop a tiered testing approach which provides information concerning the suitability, as well as the impacts on aquatic life, of dredge sediments for unconfined aquatic (open water) disposal.

Sediment chemistry, bioassays and bioaccumulation tests are used to evaluate the suitability of proposed dredged material for aquatic disposal. Solid phase bioassays assess long-term benthic impacts, while suspended particulate phase bioassays address water column effects. Protocols exist for the assessment of marine sediment toxicity, but are generally lacking for freshwater assessments. Interpretation of the sediment bioassay data is a subject of discussion. The federal regulations provide guidance in the interpretation of these data for regulation of dredging and disposal. For suspended particle phase bioassays, the limiting permissible concentration states that, outside a limited mixing zone, the concentration of the material will not exceed 1 percent of a concentration shown to be toxic to appropriate sensitive marine organisms in a bioassay. Analysis of solid phase bioassays is based on the difference in toxicity between the excavation site and the reference site. If significant differences are detected (at the 95 percent confidence level), then disposal of the proposed dredged material may be denied or further chronic testing may be required.

Actions

1. The State Board requests EPA to proceed with the designation of a permanent ocean disposal site. An ocean disposal site should be designated no later than January 1994.

   In the interim, the U.S. Corps, working with EPA through the LTMS program (See Chapter 3, Section 3.17), should consider the use of interim disposal sites, such as the chemical munitions disposal sites off the continental shelf.

   The State Board requests that the U.S. Corps submit a proposal listing potential interim disposal sites and the feasibility of use of those sites for new work projects. The proposal is to be submitted to the State Board and San Francisco Bay Regional Board within six months of the date of adoption of this document.

   For purposes of this policy, new work includes any modification that expands the character, scope or size of the existing authorized project. Activities which constitute new work include excavation below current design depth and excavation of channels or berths to accommodate larger vessels.

2. The State Board requests that, as part of the LTMS process, the U.S. Army Corps of Engineers and the San Francisco Bay Region Board make available to the State Board an assessment of the impacts of in-Bay disposal of dredge sediments on the beneficial uses of the waters of San Francisco Bay.

   This assessment shall include at least: (1) identification of toxic constituents in dredge sediments from San Francisco Bay; and (2) assessment of the potential bioavailability, bioaccumulation and toxicity of toxic constituents in such dredge sediments. This assessment should also include important ecological considerations, such as the effects of increased turbidity on important fish species.

   The State Board also requests that, as part of the LTMS process, the U.S. Corps develop a functional model for predicting the fate and transport of sediment in San Francisco Bay. The sediment transport model should be made available to the State Board and the San Francisco Bay Regional Board by July 1993.

3. The U.S. Corps, as part of the LTMS process, shall develop criteria for assessing the suitability of dredged sediment for in-Bay disposal.

4. Region 2 shall adopt disposal policy consistent with these and other available criteria and shall consider further limitations to in-Bay disposal. For implementation of both the policy and the limitations, it is assumed that an ocean disposal site will be designated by EPA in a timely fashion.

5. Region 2 shall continue to consider and communicate with Region 5 on the appropriateness of disposing of dredging sediments; a recent example is the consideration of the disposal of Oakland Harbor dredging sediments on Delta levees. No land disposal of dredged material should be deposited on levees or elsewhere on land in the Delta until it is established by the Regional Water Quality Control Boards that there will be no significant increase in pollutants in the waters of the Bay-Delta Estuary resulting from that practice.

6. If the assessments specified above are not produced in a timely manner, the State Board will consider requesting the San Francisco Regional Board to use its enforcement authority to obtain them.

5.0 BAY-DELTA POLLUTANT MONITORING AND ASSESSMENT PROGRAM

5.1 Introduction

In the development of this document, the State Board has concluded that:

- o Inadequate monitoring data hamper both problem identification and the ability to respond to specific circumstances;
- o The quality and quantity of some existing data are poor;
- o Lack of coordination of existing monitoring efforts has led to inefficient programs and underutilization of data; and
- o Little information is available on the potential detrimental effects to human health and biological communities as a consequence of elevated pollutant concentrations in sediment and biota.

Parties to the Bay-Delta Phase I hearing arrived at essentially the same conclusions as the AHI concluded in their Exhibit No. 304:

> "The quality of the existing database which may be employed to elucidate the abundance of contaminants in the Bay-Delta ecosystem is poor. Few contaminants have been studied in sufficient detail to adequately characterize their distribution in the Bay-Delta on regional or local scales, and the temporal trends therein. This is the case with respect to toxicant levels in water, sediments and biota of the estuary. Data on the biota rely largely on the analysis of bivalve molluscs. The transfer of contaminants through Bay-Delta food chains has been ignored to date." (AHI,304,377)

BADA and EPA also make the point that the Bay-Delta pollutant database is poor, and that current monitoring programs do not provide information to assess temporal and spatial trends of water quality in the Bay and Delta. Subsequently, parties to the Bay-Delta hearing have recommended that the State Board initiate a coordinated regional monitoring program for the Bay-Delta to characterize the spatial and temporal trends of pollutants in the water column, sediment and tissues of biota.

5.2 Discussion

5.2.1 Recommendation for a Monitoring Program

State and Regional Board staff have reviewed the comments and recommendations concerning pollutant monitoring made by parties to the Bay-Delta proceedings. Considering assessments by these parties, coupled with its experience in dealing with the available database, the State Board has concluded that a comprehensive monitoring program is needed. It should include:

- o Multiple media, such as water, sediment and organisms;
- o Fixed stations;

- Effective coordination with other controlling agencies and the public; and

- Information on the spatial and temporal trends of pollutants in the Bay-Delta.

The monitoring program to be developed will address the regulatory needs of the State Board and Regional Boards 2 and 5; it also will address questions facing the various resource managers representing other agencies, both federal and state, local government, water associations and industry. Examples of resource management questions are shown in Table 3.

Table 3
RESOURCE MANAGEMENT QUESTIONS
(Adopted from Phillips and Baumgartner, 1987).

- In which areas of the Bay-Delta are water quality objectives being violated, and what are the principle causes of violations?

- What are the existing locations of hot-spots of contamination in the Bay-Delta?

- How do alterations in freshwater inflow rates and regimes affect the abundance and distribution of pollutants in the Bay-Delta?

- How important is nonpoint runoff as a source of pollutants to the Bay-Delta?

- What major temporal changes in the abundance and distribution of pollutants have occurred and are occurring in the Bay-Delta?

- Are there potable waters of adequate quality in the Bay-Delta?

- Is public health at risk from toxicants in fish and shellfish harvested from the Bay-Delta?

- To what extent have toxic pollutants contributed to the decline of fish populations in the Bay-Delta?

- What are the impacts of sediment-borne pollutants on biological resources of the Bay-Delta? Can sediment-based regulatory criteria or standards be developed?

- Are wetland habitats and their associated wildlife at risk from pollutants in point source and non-point source effluents discharged directly to (or close to) wetlands?

The establishment of a monitoring program oriented to spatial and temporal trends will help provide information specific to the management questions listed here. It will also provide data necessary to establish a foundation for studies of pollutant effects specific to the Bay-Delta.

Because many of the aspects of this monitoring program are related to other State and Regional Board activities, its development will have to be coordinated with the Clean Water Strategy, Basin Planning, Statewide Planning, and the Nonpoint Source Program. Initially, for example, overall monitoring of the Bay will have to be coordinated with the Bay Protection and Toxic Cleanup (BPTC) Program (Water Code Sections 13390-96; SB 475 Torres). Ongoing funding for the BPTC Program, however, has yet to be identified.

In addition to the State and Regional Board activities, development of this monitoring program will also be coordinated with monitoring activities currently being conducted by other state and federal agencies. Examples include activities currently being conducted by DWR and USBR for D-1485, and the Municipal Water Quality Investigation Program, a combination of two programs formerly called the Delta Health Aspects Monitoring Program and the Delta Agricultural Drainage Program.

5.2.2 Cost Sharing

Establishment of a long-term comprehensive monitoring program will require the commitment of long-term funding. All users of Bay-Delta waters can be expected to benefit from the information developed; accordingly, all users should share in the cost of the program. Therefore, it is the intent of the State Board to establish, perhaps by recommending legislation, a procedure whereby users of Bay-Delta waters will contribute an equitable and reasonable share towards the total cost of development and maintenance of this monitoring program for as long as it is needed. Users of Bay-Delta waters include Bay-Delta and tributary dischargers of waste (municipal, stormwater, industrial and agricultural) and upstream and Bay-Delta water diverters.

5.2.3 Program Elements

Elements of the comprehensive monitoring program are to include program design, program monitoring and data storage and retrieval.

- Program Design

  One objective of this monitoring program is to provide an assessment of the waters, sediments and biota of the Bay-Delta as a whole. Therefore, the design and implementation of this monitoring program will be conducted in a cooperative framework with other responsible and interested parties. Current, ongoing pollutant and hydrodynamic studies and those that may be proposed will be considered in the program design; this will allow site specific monitoring programs to be integrated in a regional context.

  Current studies include the Regional Boards' effluent and ambient toxicity testing programs. Hydrodynamic studies include those currently being worked on by the U.S. Geological Survey and the Interagency Program.

In the design of this program, the programmatic goals and objectives of the comprehensive monitoring will also need to be developed and defined. Recommendations from resource and regulatory agencies, dischargers and the public will be considered (e.g., recommendations of AHI on PAHs (AHI,207:23-26;208:1-7;AHI,2)). In addition, review of quality assurance procedures for the collection and analysis of the samples will be an integral element of the design and will have to conform to rigorous new EPA guidance on quality assurance and quality control.

- Program Monitoring

  The program will incorporate long-term fixed station regional monitoring to determine the spatial and temporal trends of pollutants of concern within the Bay-Delta Estuary. The program will monitor the water column, sediments and biota of the Bay -Delta. It is anticipated that sediment and water column toxicity studies will also constitute an integral part of the comprehensive program.

- Data Storage and Retrieval

  It is essential that data developed by this program are readily available to researchers, dischargers, regulators and others that have an interest. Such accessibility will greatly contribute to the understanding of regional problems that cannot be addressed by local individual monitoring programs. Therefore, data generated will be stored in a system such as STORET, EPA's national storage and retrieval system, currently operated by the State Board in California. Appropriate quality assurance control procedures will be applied in the storage of data.

5.2.4 Tasks to be Accomplished

Development of this monitoring program involves two major tasks. The first will be to prepare a report to the State and Regional Boards identifying the important regulatory questions to be answered and recommending a coordinated monitoring strategy which includes programmatic goals and objectives, station locations, frequency of monitoring, constituents to be monitored and associated costs. This report will provide recommendations on changes to current programs under State and Regional Board jurisdiction (e.g., Mussel Watch and Toxic Substance Monitoring) and to those not under that jurisdiction (e.g., DWR and USBR sampling programs in the Bay and Delta) with the goal of developing the most cost-effective and efficient program possible. In developing this report, State and Regional Board staff will have to work with all interested parties, including industrial and discharger groups, federal and state agencies, such as the

Interagency Program, San Francisco Estuary Project and Aquatic Habitat Institute. To accomplish this task, the State and Regional Boards will establish a scientific advisory and review panel. The panel will assist the State and Regional Boards in reviewing the program's goals and objectives, in developing the monitoring program, and in developing quality assurance.

The second step will be the preparation of a report delineating a cost-sharing proposal for administration of the program. The report will recommend fair-share obligations for users of Bay-Delta waters.

Time Schedules

The first report is to be made available to the State and Regional Boards and the public in final form twelve (12) months after adoption of the PPD.

The second report is to follow six (6) months later.

5.3 Use of the Monitoring Program

The monitoring program, in its most basic form, would be used by the State and Regional Boards to assess the effectiveness of regulatory water quality activities in protecting beneficial uses in the Bay and Delta; it would include current on-going activities and those proposed in this document (e.g., mass emissions strategy and site-specific actions). In addition, the program would also provide:

- A trend analysis of pollutant levels and biological effects in the water column, sediments and biota, as well as set priorities for specific locations within the Bay-Delta for implementing the mass emissions strategy and other corrective actions;
- Needed data for the development of site-specific water quality objectives for the Bay-Delta;
- Data for studies determining how different water volumes affect the abundance and distribution of pollutants in the Bay-Delta; and
- Data for related cause and effect studies.

APPENDICES