Integrated Water Quality Management Strategy Project Report

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v1.0

CALIFORNIA
Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

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Acronyms and Abbreviations

BMP	Best management practice
BSTEM	Bank Stability and Toe Erosion Model
CalTrans	California Department of Transportation
CARB	California Air Resources Board
CICU	Commercial/Institutional/Communications/Utilities
CONCEPTS	Conservational Channel Evolution and Pollutant Transport System
CTC	California Tahoe Conservancy
EIP	Environmental Improvement Program
EPA	U.S. Environmental Protection Agency
GIS	Geographic information system
IWQMS	Integrated Water Quality Management Strategy (Integrated Strategy)
LSPC	Loading Simulation Program C++ (Watershed Model)
LTBMU	Lake Tahoe Basin Management Unit, (U.S. Forest Service)
NDEP	Nevada Division of Environmental Protection
NDOT	Nevada Department of Transportation
NTCD	Nevada Tahoe Conservation District
O&M	Operations and maintenance
PAT	Packaging and Analysis Tool
SEZ	Stream environment zone
SNPLMA	Southern Nevada Public Land Management Act
SWQIC	Storm Water Quality Improvement Committee
TMDL	Total Maximum Daily Load
TN	Total nitrogen
TP	Total phosphorus
TRPA	Tahoe Regional Planning Agency
UCD	University of California at Davis
USFS	U.S. Forest Service
VBA	Visual Basic for Applications
VMT	Vehicle Miles Traveled

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1. Introduction

The California Regional Water Quality Control Board, Lahontan Region (Lahontan Water Board) and the Nevada Division of Environmental Protection (NDEP) are developing the Lake Tahoe Total Maximum Daily Load (Lake Tahoe TMDL)—a plan for achieving a reduction of fine sediment and nutrients to restore Lake Tahoe's clarity to 97.4 feet. The Lake Tahoe TMDL is organized around a series of questions:

- **What pollutants are causing Lake Tahoe's clarity loss?**
- **How much of each pollutant is reaching Lake Tahoe?**
- **How much of each pollutant can Lake Tahoe accept and still achieve the clarity goal?**
- **What are the options for reducing pollutant inputs to Lake Tahoe?**
- **What strategy should we implement to reduce pollutant inputs to Lake Tahoe?**
- **Are the expected reductions of each pollutant to Lake Tahoe being achieved?**
- **Is the clarity of Lake Tahoe improving in response to actions to reduce pollutants?**
- **Can innovation and new information improve our strategy to reduce pollutants?**

As these questions are answered, the plan for restoring the clarity of Lake Tahoe is developed. Additional background of the Lake Tahoe TMDL is in two separate reports; (1) the *Lake Tahoe TMDL Pollutant Reduction Opportunity Report* v2.0 (PRO Report v2.0) (Lahontan and NDEP 2007b), and (2) the *Draft Lake Tahoe Total Maximum Daily Load Technical Report* (Technical Report) (Lahontan and NDEP 2007a).

1.1. Integrated Water Quality Management Strategy Project

The Integrated Water Quality Management Strategy Project (Integrated Strategy Project) is part of the larger Lake Tahoe TMDL effort and answers the questions: **What are the options for reducing pollutant inputs to Lake Tahoe?** and **What strategy should we implement to reduce pollutant inputs to Lake Tahoe?** The Integrated Strategy Project provides the California and Nevada water quality regulatory agencies technically viable, publicly discussed recommendations to inform the development of the implementation plan for the *Final Lake Tahoe TMDL*.

These recommendations begin with answers to the question, **What are the options for reducing pollutant inputs to Lake Tahoe?** Groups of technical experts analyzed potential pollutant reduction opportunities and associated costs. These analyses and findings are provided by groups of experts in the PRO Report v2.0.

An *integrated strategy* combines selected pollutant controls from each of the four primary sources of fine sediment and nutrients to Lake Tahoe. The four primary sources are: (1) urban uplands (urban), (2) forested uplands (forest), (3) atmospheric deposition (atmospheric) and (4) stream channel erosion (stream). Several candidate integrated strategies provided the basis for engaging project implementers and public stakeholders during an extensive public input process. Input and comments from this series of communications helped to guide agency decision makers in development of a *Recommended Strategy*; answering the question, **What strategy should we implement to reduce pollutant inputs to Lake Tahoe?** Table 1-1 provides a perspective on the Integrated Strategy Project's relationship to the larger Lake Tahoe TMDL.

The Recommended Strategy incorporates the best available science and extensive stakeholder input to describe a Basin-wide, non-prescriptive strategy to inform the Lake Tahoe TMDL implementation plan. It provides a plausible and efficient approach to achieve the Clarity Challenge. The *Clarity Challenge* is an interim water quality milestone established by the Lahontan Water Board and NDEP to focus planning efforts on achieving a measurable improvement of lake clarity based on meaningful load reductions. The Clarity Challenge is proposed as a Basin-wide 32 percent fine sediment (of less than 20 microns in diameter) load reduction and is expected to result in 77 to 80 feet of clarity.

The Recommended Strategy is intended to guide implementing agencies in their efforts to achieve necessary load reductions. The Recommended Strategy does not directly translate to recommendations for project-scale application, and implementing agencies are not required to implement the specific pollutant controls contained within the Recommended Strategy. It is intended that more-detailed, geographically specific analyses be pursued for site-scale implementation and budget planning.

Table 1-1. TMDL Questions and Products with Current Effort Highlighted

TMDL phase	Questions	Products
Pollutant Capacity and Existing Inputs	**What pollutants are causing Lake Tahoe's clarity loss?**	Research and analysis of fine sediment, nutrients and meteorology
	How much of each pollutant is reaching Lake Tahoe?	Existing pollutant load to Lake Tahoe from major sources
	How much of each pollutant can Lake Tahoe accept and still achieve the clarity goal?	Linkage analysis and determination of needed pollutant load reduction
		Document: TMDL Technical Report
Pollutant Reduction Analysis and Planning	**What are the options for reducing pollutant inputs to Lake Tahoe?**	Estimates of potential pollutant load reduction opportunities **Document:** Lake Tahoe TMDL Pollutant Reduction Opportunity Report
	What strategy should we implement to reduce pollutant inputs to Lake Tahoe?	Integrated Strategies to control pollutants from all sources
		Load reduction allocations and implementation milestones
		Implementation and Monitoring Plans
		Document: Final Lake Tahoe TMDL
Implementation and Operation	**Are the expected reductions of each pollutant to Lake Tahoe being achieved?**	Implemented projects & tracked load reductions
	Is the clarity of Lake Tahoe improving in response to actions to reduce pollutants?	Project effectiveness and environmental status monitoring
	Can innovation and new information improve our strategy to reduce pollutants?	Lake Tahoe TMDL continual improvement and adaptive management system, targeted research
		Document: Future Periodic Milestone Reports

1.2. Using This Report

This report is intended to be a reference to support agency staff in their development of the Final Lake Tahoe TMDL and a source document for technical reviewers and interested stakeholders. It is one of four documents produced by the Lake Tahoe TMDL program to date. Throughout this document, pollutant loads are assumed to be annual averages unless otherwise specified.

Lake Tahoe TMDL document suite

- *Charting a Course to Clarity*, The Lake Tahoe Total Maximum Daily Load
- The *Draft Lake Tahoe Total Maximum Daily Load Technical Report*
- The *Lake Tahoe TMDL Pollutant Reduction Opportunity Report v2.0*
- The *Integrated Water Quality Management Strategy Report* (this report)

The Integrated Strategy Project report does three things:

1. Describes the Recommended Strategy
2. Describes the process for developing the Recommended Strategy
3. Provides results of analyses conducted to support load allocation development

Extensive appendices provide supporting documentation detailing the work described in the main body of the report. The following are chapter summaries of the report's content:

***Chapter 2: Recommended Water Quality Management Strategy* –** The key result of the Integrated Strategy Project including charts describing estimated effects of the strategy on pollutant inputs to Lake Tahoe and estimated costs to implement and maintain recommended pollutant controls.

***Chapter 3: Development of the Recommended Strategy* –** A complete description of the process used to arrive at the Recommended Strategy including descriptions of alternative strategies considered and synthesized input from contributors including stakeholders, researchers and the TMDL team.

***Chapter 4: Analyses Supporting Load Allocations* –** The Results of Geographic Information System (GIS) analyses that combine the Recommended Strategy with existing land uses and jurisdictions. These results are intended to support the establishment of load allocations for the Final TMDL.

Information on the U.S. Environmental Protection Agency's (EPA's) TMDL program is at www.epa.gov/owow/tmdl. Information on the Lake Tahoe TMDL, including the reports noted above, is at http://www.waterboards.ca.gov/lahontan/water_issues/programs/tmdl/lake_tahoe/index.shtml or http://ndep.nv.gov/bwqp/tahoe.htm.

2. Recommended Water Quality Management Strategy

The Recommended Strategy incorporates the best available science and extensive stakeholder input to describe a Basin-wide, non-prescriptive strategy to inform agencies as they create TMDL load allocations and develop an implementation plan. The Recommended Strategy also serves to estimate a practical distribution of potential reductions from each source category. The Recommended Strategy combines pollutant controls from all four major categories of pollutant sources while focusing on reducing fine sediment particles delivered by urban runoff. Implementing the Recommended Strategy is estimated to involve a $1.5 billion capital investment and will achieve the Clarity Challenge, which calls for approximately 32 percent reduction in the Basin-wide fine sediment particle load.

This chapter presents the Recommended Strategy by describing suggested actions for each of the major pollutant source categories and then describes the estimated results of implementing the Recommended Strategy. Chapter three explains the process of technical analysis and stakeholder input used to formulate the Recommended Strategy.

Non-Prescriptive Strategy

The Recommended Strategy is intended to guide implementing agencies in their efforts to achieve required load reductions. The Recommended Strategy does not directly translate to recommendations for project-scale application, and implementing agencies are not required to implement the specific pollutant controls contained within the Recommended Strategy. It is intended that more-detailed, geographically specific analyses be pursued for site-scale implementation and budget planning.

2.1. Source Category Recommendations

The Recommended Strategy incorporates recommendations tailored to each source category because they deposit pollutants into Lake Tahoe via differing mechanisms and at different rates. For each source category, three key elements define the actions within the Recommended Strategy. *Treatment tiers* are groups of pollutant controls that were screened by technical experts to be broadly applicable to the Tahoe Basin. Each source category's treatment tiers can be applied to a portion of the potential opportunities available within the Tahoe Basin. Thus, *Application level* is expressed as a percent of total possible application. For instance, a 75 percent application level of a particular urban treatment tier would mean that three- quarters of the Tahoe Basin's urban areas would be treated with that group of pollutant controls and one- quarter would remain untreated. The treatment tiers can be applied at various application levels to several different *Settings* that are based on Basin-wide physical characteristics and applicable pollutant controls. The Recommended Strategy is based on several assumptions that are described at the end of the section.

Comments and observations about the relative confidence related to each source category's analysis are discussed at the end of each source category section. These comments are based on the TMDL team's interpretation of technical confidence ratings provided by source category experts combined with confidence ratings of the TMDL pollutant budget (Lahontan and NDEP 2007a, p. 5-164).

Urban Runoff Focus

The majority of pollutant loading, and also estimated potential pollution control, come from urban runoff. Thus, this is the area of focus for the Recommended Strategy (Lahontan and NDEP 2007a and 2007b). The Recommended Strategy focuses on advanced practices and innovative technology to control fine sediment particles from the urban runoff source category.

Pollutant Controls Included

Urban pollutant controls are categorized into three treatment tiers that are targeted to four settings. The names of the treatment tiers and example controls include the following:

- **Best Current Practices (Tier 1)** – Detention and retention basins, stormwater vaults, road shoulder stabilization, vacuum sweeping on heavily sanded roads, limited impervious coverage removal and 50 percent completion of private property best management practices (BMPs)
- **Advanced, Intensive Practices** (**Tier 2**) – Wetland and passive filtration basins, media filters in stormwater vaults, deicing compounds or advanced abrasive (sand) recovery, intensive maintenance of stormwater infrastructure, 100 percent completion of private property BMPs
- **Innovative Technology** (**Tier 3**) – Active pumping and filtration systems for stormwater applied to urban areas with concentrated impervious coverage (such as *downtown* areas) and Tier 2 treatment applied to urban areas with dispersed impervious coverage (such as many residential areas)

The Recommended Strategy includes these pollutant controls at different application levels in four settings based on configuration of impervious coverage and slope. The areas with concentrated impervious coverage, such as commercial land uses with extensive streets and rooftops, involve a greater application level of the higher treatment tiers. The land uses with more dispersed impervious coverage, such as residential land uses with less pavement and more open space, require less advanced treatments at a lower application level. For each of these settings, Table 2-1 provides the application level included in the Recommended Strategy. Additional information about the mix of pollutant controls included in each treatment tier and the process for deriving these numbers is in Appendix C.

Table 2-1. Application Level for Urban Pollutant Controls Used in the Recommended Strategy

Pollutant controls	Concentrated impervious coverage areas on steep slopes	Concentrated impervious coverage areas on moderate slopes	Dispersed impervious coverage areas on steep slopes	Dispersed impervious coverage areas on moderate slopes
Best Current Practices (Tier 1)	20%	20%	30%	40%
Advanced, Intensive Practices (Tier 2)	–	–	–	40%
Innovative Technology (Tier 3)	50%	50%	–	–
% of Total Area Treated	**70%**	**70%**	**30%**	**80%**

Note: percentages represent the amount of urban area treated with pollutant controls. Hyphens indicate that these controls are not included in the Recommended Strategy for this source category. These percentages are not project-level recommendations; they represent percentages of the entire urban area within the Lake Tahoe Basin.

Table 2-1shows that Basin-wide, 20 percent of the urban area with concentrated impervious coverage on steep slopes would be treated with best current practices (Tier 1). 50 percent of these areas would be treated with innovative technology (Tier 3) pollutant controls. The remaining 30 percent of these areas would remain untreated. Taken together, the treatment tiers and their application levels to each urban setting compose the Recommended Strategy for the urban source category.

Relative Confidence

The analyses of urban runoff controls are considered of high enough confidence to use for management decisions at the Basin-wide scale. However, an analysis of confidence revealed that the centralized pumping and stormwater treatment systems included in the innovative technology (Tier 3) pollutant controls will benefit from additional analysis future efforts. In particular, many of the design assumptions made in determining the cost and effectiveness of innovative technology treatments such as pumping and filtering stormwater are subject to adjustment as new information becomes available from testing of different designs. In some cases, Tier 3 results are sensitive enough to the assumptions made that sediment removal rates or costs could be adjusted up or down significantly.

Atmospheric Deposition Focus on Stationary Sources

Lower, but significant, pollutant loads and cost-effective treatments are available by controlling stationary atmospheric dust sources. The cost-effective fine sediment load reduction available through enhanced maintenance and operation of nonmobile dust sources leads to recommendations that focus on controls for both paved and unpaved roadways, as well as parking lots and construction sites. Pollutant controls include street sweeping with advanced vacuum sweeping equipment, graveling dirt roads, other dust control efforts for construction and reducing residential wood burning.

The Recommended Strategy focuses on nonmobile sources of dust particles within the atmospheric source category because these sources provide the bulk of fine particles within this source category and because mobile sources predominantly produce nitrogen, not fine particles. Nonmobile sources of fugitive dust, such as both paved and unpaved roads are responsible for more than 88 percent of atmospheric fine particle emissions in the Lake Tahoe Basin (Lahontan and NDEP 2007b, p. 52). Mobile sources, such as vehicles, produce a relatively large amount of Lake Tahoe's nitrogen load but only 1.3 percent of fine particles (Lahontan and NDEP 2007b, p. 52). Nitrogen is one nutrient that can enhance algae growth. But the TMDL Technical Report showed that light absorption by algae is responsible for approximately one-third of lake clarity loss as demonstrated by the Lake Tahoe Clarity Model (Clarity Model) (Lahontan and NDEP 2007a, pp. 3-13 through 3-14). Finally, stationary source controls for fine particles and their associated phosphorus are three orders of magnitude less expensive per ton than mobile sources according to expert analysis provided in the PRO Report v2.0.

Pollutant Controls Included

The Recommended Strategy for atmospheric deposition sources includes controls for paved and unpaved roads, as well as parking lots, construction areas and residential wood burning. They are classified into two treatment tiers by treatment intensity. The *Increased Intensity* treatment tier is generally applied more intensively or extensively than current efforts. This group of pollutant controls was referred to as *Tier 2* in the PRO Report v2.0 and includes the following:

- Every other week street sweeping with vacuum equipment that captures 10 micron particles
- Pave dirt roads at access points
- Speed limits on unpaved roads
- Gravel 50 percent of unpaved roads, including forest roads
- Require adequate soil moisture during earth-moving operations
- Use dust suppressants on exposed soil at road-building projects
- 20 percent reduction in residential wood burning emissions

The second group of controls, called *High Intensity,* is applied more intensively and pollutant load reduction effectiveness is higher. In the PRO Report v2.0, this group of pollutant controls was referred to as *Tier 3*, and it includes the following:

- Weekly street sweeping with vacuum equipment that captures 10 micron particles
- Pave all unpaved roads
- Limit speeds on unpaved roads
- Require adequate soil moisture during earth-moving operations
- Use dust suppressants on roadway and construction projects
- 50 percent reduction in residential wood burning emissions

Table 2-2. Application Level of Pollutant Controls for Atmospheric Sources of Fine Particles Used in the Recommended Strategy

Pollutant control	Basin-wide application level
Increased Intensity (Tier 2)	30%
High Intensity (Tier 3)	50%
Total % Application	**80%**

Note: values represent the percent of total, Basin-wide road length or bare area treated with pollutant controls.

Relative Confidence

The atmospheric science behind these recommendations is an area of lower confidence than other source categories because it has not been studied as long or thoroughly. Water quality studies of the urban and forested uplands in the Lake Tahoe Basin have a long history and excellent body of research that supports the estimates of potential load reduction and costs associated with fine particle controls. The body of research is less well developed in the atmospheric sciences. For instance, the Tahoe Basin's first study relating vehicles and the entrained fine particles they generate was completed in 2005. The results of this work have influenced the Lake Tahoe TMDL, but additional study is necessary to numerically link Vehicle Miles Traveled (VMT) to the fine sediment particle load to Lake Tahoe. An improved understanding of this linkage would allow greater confidence in the Recommended Strategy's recommendation to focus efforts on nonmobile sources such as paved and unpaved roads.

Stream Channel Erosion and Stream Restoration

Multi-objective stream channel restoration programs are well established, and methods do not offer wide latitude in treatment options. Thus, the recommendations for this source category are based on current plans and approaches. The analysis focuses only on fine sediment particles released from stream banks and beds, and does not consider the other potential benefits available from stream or wetland restoration. The analysis is based on the top three fine sediment particle producing streams in the Basin, which are responsible for 96 percent of the fine sediment particle load in this source category (Lahontan and NDEP 2007b, p. 212). These streams, in order of load production, are as follows:

- Upper Truckee River
- Blackwood Creek
- Ward Creek

The Recommended Strategy includes stream restoration because it is very cost-effective and follows the lead of stream management agencies because they are pursuing a broad scope of ecosystem benefits. The TMDL program focuses exclusively on the clarity of Lake Tahoe and should not disturb the multi-objective scope of existing stream restoration programs. The relative contribution to the Basin-wide fine sediment particle load for this source category is relatively small at 4 percent (Lahontan and NDEP

2007a, p. 4-164). The estimated maximum load reduction of the potential pollutant controls fall into a range of 1.7 to 2.7 percent of Basin-wide load (Lahontan and NDEP 2007b, p. 261). However, stream channel restoration provides very cost-effective fine sediment particle reductions (Lahontan and NDEP 2007b, p. 267). The Recommended Strategy includes pollutant controls that match current approaches and objectives.

Pollutant Controls Included

The evaluation of potential load reductions and costs involved with stream channel sources defined two kinds of restoration or treatment approaches. *Unconstrained restoration* of the stream includes a set of treatments that modify planform, increases length and sinuosity, connect floodplain and decrease slope such that a restored condition is eventually reached. These treatments are designed to achieve load reductions as well as other ecosystem objectives such as riparian habitat enhancement, flood control and recreation value. Estimates for these treatments assumed ideal construction access and project sequencing. Typical limitations on property acquisition are not considered in the analysis of unconstrained restoration. The second kind of restoration, *Bank protection,* is a basic set of channel armoring and minor bank slope reductions that increases hydraulic resistance and reduce bank failure. This kind of project does not achieve multiple ecosystem objectives but is very cost-effective in reducing fine sediment particles.

The current and planned future projects under consideration in the Tahoe Basin generally involve a *mixed approach* of unconstrained restoration where possible and simple bank protection on constrained stream reaches. The Recommended Strategy would implement the mixed approach in projects to include 80 percent of the potentially treatable stream channels for the three streams (i.e. an 80 percent application level). The mixed approach and 80 percent application limit recognize that certain project areas could be overly costly or difficult to address.

For the purposes of this analysis, pollutant controls were assumed to include the following distribution *within a project*:

- 45 percent bank protection
- 35 percent unconstrained restoration
- 10 percent bank strengthening
- 5 percent toe stabilization
- 5 percent bank lowering or angle reduction

Relative Confidence

The analysis of stream channel pollutant controls is considered to be of high enough confidence to support Basin-wide management decisions. However, improvements are suggested based on the model applied in the analysis. Load reductions are estimated using the Bank Stability and Toe Erosion Model (BSTEM) by the National Sedimentation Lab. This model is deemed reliable in determining the loading effects for bank protection, but it is less able to accurately estimate the effects of unconstrained restoration. Future, scheduled efforts will use an improved model, Conservational Channel Evolution and Pollutant Transport System (CONCEPTS), to estimate the effects of unconstrained restoration.[1] In addition, the load reductions do not consider the potential for streams and associated wetlands to provide treatment for urban and forest fine sediment particle loads from overbank flows. Tahoe's science organizations have already begun to study the potential water quality benefits of reconnecting floodplains.

[1] For additional discussion of stream channel modeling approaches, see Lahontan and NDEP 2007b, pp. 228 & 248.

Forested Uplands Planned Activities

Federal, state, and some of the larger local management agencies have well-defined, multi-objective restoration programs with established funding and established restoration plans. The TMDL program is focused on the clarity of Lake Tahoe and should not adversely affect the multi-objective scope of existing forest restoration programs. The Recommended Strategy incorporates load reductions from planned or expected activities of multi-objective forest restoration programs. However, these considerations do not include some of the expedited fuels reduction approaches being discussed following the June 2007 Angora Fire, which may have lasting impacts on fuels reduction plans.

Estimates of the potential load reductions available from forested uplands showed a maximum of 7 percent reduction of the overall Basin-wide fine sediment budget (Lahontan and NDEP 2007b, p. 257). The majority of this reduction comes from applying controls at a very large scale on low sediment-yielding forests. Treatment of an area this extensive increases capital costs of forest treatments alone to approximately $3 billion (Lahontan and NDEP 2007b, p. 257). However, there are small, disturbed areas (e.g., unpaved roads, campgrounds and ski runs) where relatively high sediment particle yields and easy access make pollutant controls cost-effective. Therefore, the Recommended Strategy focuses its efforts on disturbed areas and planned activities including restoration and mitigation of impacts.

Pollutant Controls Included

The Recommended Strategy for forested uplands focuses the most effort on easy-access, high pollutant yielding disturbed areas and some additional effort on implementing advanced water quality improvements on small portions of the less-disturbed parts of the forest. The forested uplands were divided into two categories on the basis of a gradient of disturbance. *Moderate to highly disturbed* areas have significantly compacted soils, little to no duff layer and moderate vegetative cover. Examples of these areas can include unpaved roads and trails, ski runs, campgrounds, cut and fill slopes or steep, exposed areas. *Typical Tahoe forested* areas have good soil hydrologic function, well-established plant communities and thick mulch or duff layers. These areas include most places that appear undisturbed, such as areas managed for forest health and second or third growth areas, but that could have legacy impacts from past activity.

Pollutant controls can be specialized to particular land uses (e.g., unpaved roads, campgrounds or ski runs) but can generally be divided into two categories of their own. *Standard BMP treatments* are planned by federal and state land management agencies for their roads, trails and fuels reduction projects. These treatments are referred to as *Tier 1* treatments in the PRO Report v2.0. Examples of these treatments include the following:

- Full, unpaved roadway BMPs (waterbars, armored ditches, rut stabilization) and annual maintenance
- Hydro-seeding and tackifier for ski runs
- Forest treatments implemented with ground-based equipment and required BMPs

Advanced treatments designed to achieve a range of effects from better hydrologic function to complete restoration that will mimic natural conditions as time progresses. These treatments are referred to as *Tier 2* or *Tier 3* treatments in the PRO Report v2.0. Examples of these treatments can include those found under standard BMP treatments, plus the following:

- Mulching and revegetating with seeding or transplanted seedlings on ski runs
- Road re-contouring, tilling, organic soil amendments, mulch, and revegetation with seedlings and seeding
- Urban sediment capture BMP for paved roadways (e.g., stormwater vaults, settling basins)

- Full restoration of legacy roads and trails

The Recommended Strategy applies the pollution controls at different application levels for each of the settings described above. Table 2-3 displays the application level for each treatment tier to each category of forested land. Efforts focus on moderate to highly disturbed areas, and the majority of treatments follow existing requirements. A small fraction of the typical forested area is recommended for treatment. This area is based on rough estimates of the area planned for fuels reduction treatment within the current planning horizon of approximately 20 years.

Table 2-3.Application Level of Pollutant Controls for Forested Upland Sources of Fine Particles Used in the Recommended Strategy

Pollutant control	Moderate to highly disturbed	Typical Tahoe forested
Standard BMP Treatments (Tier 1)	60%	–
Advanced Treatments (Tiers 2 & 3)	20%	5%
% of Total Area Treated	**80%**	**5%**

Note: values represent the percent of total Basin-wide area treated with pollutant controls. A hyphen indicates that this treatment is not included in the Recommended Strategy.

Relative Confidence

The analysis of forest upland pollutant controls is considered to be of high enough confidence to warrant management decisions at a Basin-wide scale. However, some finer points of the modeling analysis and understanding of fire effects have been identified for additional research. The technical experts who provided these analyses have recommended additional research regarding watershed modeling that would include soil properties at a finer spatial scale, additional quantitative analysis of advanced water quality pollutant controls, and exploration of the long-term costs of standard BMPs versus full restoration. This analysis specifically did not attempt to quantify the effects or costs of wildfire or controlled burns. Current efforts both inside and outside the Lake Tahoe TMDL are focused on gaining a better understanding of the pollutant loading effects of fire.

Assumptions

Several assumptions are necessary to develop the Recommended Strategy. The assumptions described below are the most immediate and defining assumptions of this analysis, but the Recommended Strategy also relies on additional assumptions that are captured in the PRO Report v2.0 and in Chapter 3:Development of the Recommended Strategy. Some of the assumptions apply universally, while others are applicable to a specific source category and are marked as such. The assumptions are numbered for reference purposes only and are not ranked in order of importance.

1. The maximum application level for pollutant controls to any given area is 80 percent. This reflects the understanding that project-scale implementation issues occur that cannot be determined at a Basin-wide planning scale. In particular, some areas might not be accessible or are unable to achieve the estimated load reductions. Site-specific challenges such as high groundwater, utility line interference, or bedrock intrusions could also make projects excessively costly in some areas.
2. **Urban:** The minimum application level for the urban Tier 1 pollutant controls is 20 percent. This assumption is necessary because implementers have already completed or are planning projects that will achieve this level within the next few years. While Tier 1 pollutant controls might be retrofitted in the future, they are assumed to be more cost-effective for addressing untreated runoff during this planning horizon.

3. **Forest sources:** As currently planned, approximately15 percent of the Basin's federal- and state-owned forest lands will be treated to reduce forest fuel loads during the next 20 years. Roughly two-thirds of the treated areas will receive standard BMPs for water quality, while the other one-third (5 percent of Basin-wide area) will receive advanced pollutant controls.
4. Street sweeping costs will be distributed between urban and atmospheric source categories. Roadway fine sediment controls are included in both urban and atmospheric source categories because they control fine sediment particle delivery to the Lake via entrained dust deposition and urban runoff. The costs of these pollutant controls are redundantly included in both source categories for this analysis. During implementation these costs will only be necessary once and the overall cost of the Recommended Strategy will be reduced.

2.2. Results

Implementation of the Recommended Strategy is estimated to result in the necessary pollutant load reductions to achieve the Clarity Challenge. The overall pollutant reductions, costs and clarity effects are described in this section. The results account for the combined effect of all controls described in Section 2.1.

Reductions in Fine Sediment Particles

The Recommended Strategy focuses on pollutant controls for fine sediment particles because these particles are responsible for roughly two-thirds of the clarity loss Lake Tahoe has exhibited. Figure 2-1 shows that the Recommended Strategy is estimated to reduce fine sediment particle (smaller than 20 micron) loads to Lake Tahoe by a total of 32 percent relative to the Lake Tahoe pollutant budget presented in the Technical Report (Lahontan and NDEP, p. 4-164).

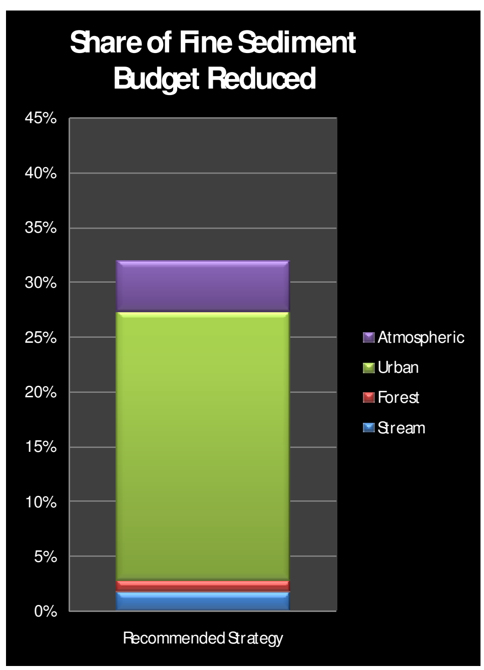

Figure 2-1. Analytic results for total percent reduction of the entire Lake Tahoe fine sediment budget for the Recommended Strategy.

Implementation of the Recommended Strategy controls is projected to achieve fine sediment particle load reductions from all the source categories; however, only a small minority of fine particles is from the forest or stream categories. Urban stormwater pollutant controls account for the large majority of these reductions, providing approximately 25 percent of the Basin-wide total fine sediment particle budget. Atmospheric controls focused on nonmobile sources are estimated to account for 5 percent of the Basin-wide total fine sediment particle budget. Forested upland and stream channel source controls are estimated to produce 1 percent and 2 percent of the Basin-wide load reduction, respectively.

These results are not intended to discount the importance of forested upland treatments or stream channel restoration as approaches for improving the environment of Lake Tahoe. The PRO Report v2.0 shows that the load reduction available from stream channel erosion is the second most cost-effective way to control fine sediment (Lahontan and NDEP 2007b, p. 272). In addition, stream channel reductions do not include the potential of streams and associated wetlands to capture and control sediment from urban or other upland sources. The 1 percent forested runoff estimate reflects that a relatively low fine sediment particle yield (per acre) and forested lands are generally difficult to access for cost-effective treatments. The fine sediment particle producing land uses within forested areas, such as unpaved roads, ski runs and burn areas provide important opportunities to achieve cost-effective load reductions. For these reasons, the Recommended Strategy includes continued treatment of forest and stream channel sources according to the plans laid out by management and funding agencies such as the Lake Tahoe Basin Management Unit (LTBMU), the California Tahoe Conservancy (CTC) and Nevada Division of State Lands (NDSL).

Lake Clarity Effects

The pollutant load reductions resulting from implementation of the Recommended Strategy are predicted to bring Secchi depth measurements of lake clarity to approximately 78 feet, achieving the Clarity Challenge laid out in chapter one. Figure 2-2 illustrates results obtained using a liner-regression of the Clarity Model results assuming fine sediment particle reductions only. These results demonstrate arrested clarity loss and a 13-foot improvement over the 2006 average Secchi depth of 67.7 feet (TERC 2007, p. 10.2). Achievement of this milestone would be a significant waypoint on the path to eventual attainment of the long-term clarity goal of 97.4 feet (Lahontan and NDEP 2007a, p. 2-8).

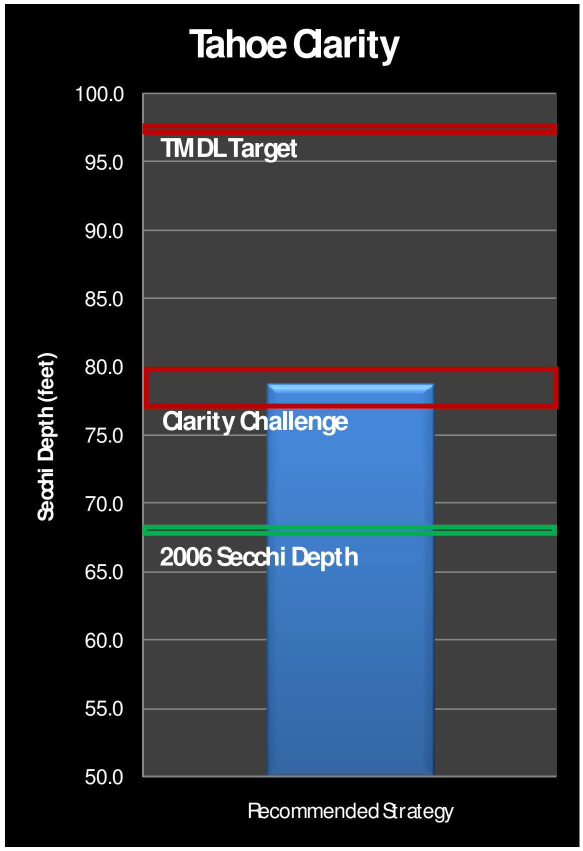

Figure 2-2. The Clarity Model predicts that implementing the Recommended Strategy will achieve the Clarity Challenge of 77-80 feet of Secchi depth as Lake Tahoe's clarity measurement moves from the 2006 value toward the overarching TMDL Target.

This result is calculated using a linear regression of outputs from the Clarity Model as reported in the TMDL Technical Report. The resulting Secchi depths are considered to be a conservative estimate because they do not include the benefits of reducing nutrients that would be associated with any pollutant controls that reduce fine sediment particles. Key sources of uncertainty in this estimate result from assumptions necessary for the Clarity Model and potential non-linearity in lake response to fine sediment inputs.

Costs

The 20-year capital and annual operations and maintenance (O&M) costs of implementing the Recommended Strategy are estimated by groups of experts on a control-by-control basis and then aggregated into totals for each major source category. Capital costs include all implementation costs such as planning, design, acquisition and replacement costs when the useful life of the controls is shorter than 20 years. More detailed analysis is necessary for budgeting and project level planning; these estimates are provided only as rough approximations.

Implementing the entire Recommended Strategy as analyzed would involve an estimated capital investment of approximately $1.5 billion. Figure 2-3 shows a breakdown of the costs associated with each of the major source categories in addition to the total amount. All values are in 2007/2008 equivalent dollars. The majority of costs, $1.3 billion, are for urban runoff pollutant controls. Pollutant controls for other sources estimated are $120 million, $48 million and $40 million for forest runoff, atmospheric and stream channel pollutant controls, respectively. The relatively high investment in urban runoff controls is reflective of the importance of this source category in reducing fine sediment particle loads. Both types of costs are important because state and federal funding has historically been available for capital investments, while local jurisdictions have been responsible for O&M costs.

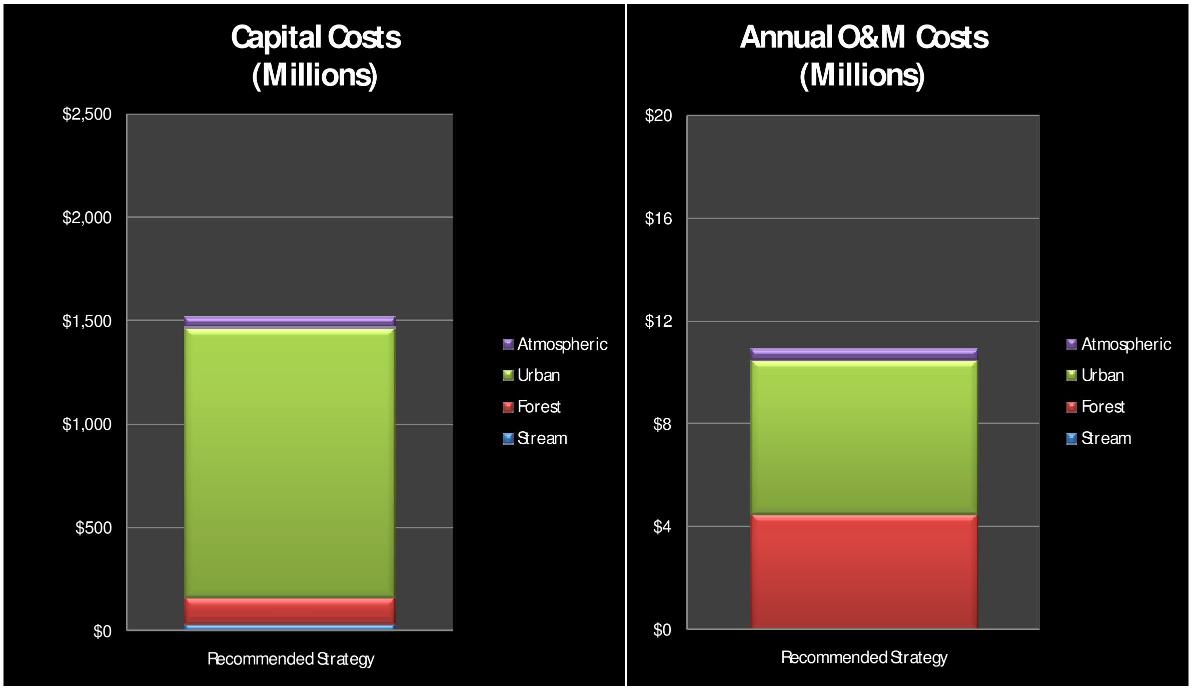

Figure 2-3. An estimated $1.5 billion in capital costs and $11 million in annual O&M costs would be needed to initiate and maintain effectiveness of the Recommended Strategy.

Figure 2-3 above, shows estimates of funding needed annually to operate and maintain recommended pollutant controls including a breakdown of the cost by major source category. These costs are reasonably evenly divided between urban runoff controls and forested runoff controls at $6.0 million and $4.5 million, respectively. Atmospheric controls are estimated to cost approximately half a million dollars annually, while stream channel controls are estimated to be self-sustaining for the life of the project. The average annual O&M costs include all requirements to maintain effectiveness of the pollutant controls at the efficiency used in load-reduction estimates for the expected life of the project.

2.3. Milestone Analysis

The Lake Tahoe TMDL must establish *milestones* along the path toward achieving the Clarity Challenge and, eventually, the Lake Tahoe TMDL's overarching numeric target for Secchi depth. The Recommended Strategy's pollutant controls and application levels define one of the milestones. The current best available science finds that achievement of the load reductions associated with the Recommended Strategy are possible by the third milestone and will accomplish the Clarity Challenge. *Implementation periods* (periods) are the intervals between milestones in which a level of effort (represented by $500 million dollars) is focused on effectively implementing the recommended pollutant controls. Specific application levels of pollutant controls and resulting costs and benefits are calculated using the Packaging and Analysis Tool[2]. The milestones may be used to guide allocations and permitting decisions as the Lake Tahoe TMDL moves forward.

Pollutant Controls Included

The pollutant controls included in the milestone analysis are based on the Recommended Strategy and include the same selection of pollutant controls. At each milestone, application levels for the treatment tiers are adjusted. Thus, the pollutant control table for this analysis includes values for each source category's settings and treatment tiers at each milestone. The table is included for reference as Table C-2 in Appendix C.

General trends within the table show increasing pollutant control application levels until the third milestone. During the fourth period, many of the current best practices (Tier 1 controls) are projected to be retrofitted or replaced with advanced practices or innovative technologies (Tier 2 and 3 controls). The advanced and innovative technologies are not widely applied during the first two periods because they are assumed to be under development. However, they are assumed to be widely applied during the third and fourth periods, when they are expected to be available for broad application.

Overview Milestone Results

The milestones incorporate load reductions and costs from each of the source categories, but an overview should provide the clearest picture of the important trends that result from the milestone analysis before looking at source category specifics. Figure 2-4 depicts the capital costs and percent of the entire Basin-wide pollutant budget for fine sediment at each of the milestone periods. The center of each bubble is at the potential percent reduction of the overall Basin-wide fine sediment budget at each milestone. The size of the bubble represents the estimated capital cost (in millions) of implementing controls and is rounded to two significant figures. These costs are estimates of the cumulative total needed to reach each milestone.

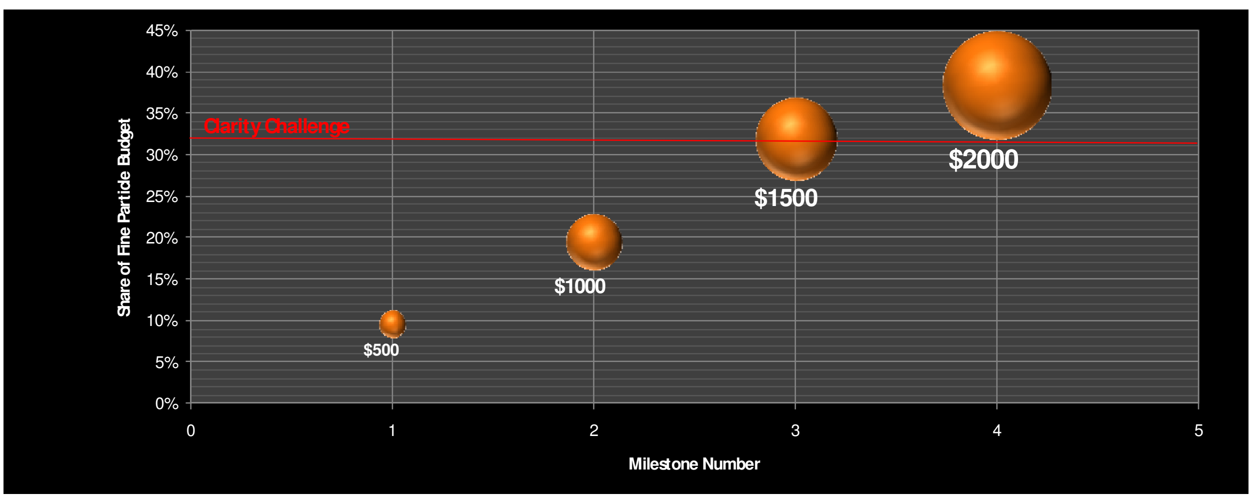

Figure 2-4. Milestones showing estimated fine particle load reductions and cumulative costs (millions) surrounding the Recommended Strategy. Milestone number three is the Recommended Strategy.

One of several important features of the milestone analysis is the ability to achieve the estimated load reductions needed for Clarity Challenge by the end of the third period. This analysis also shows potential

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[2] For an additional description of the PAT and its use during creation of the Recommended Strategy, see Section 3-2 and Appendix A.

to move beyond the Clarity Challenge by achieving a 38 percent reduction of fine sediment particle loads by the fourth milestone. The results also show different load reduction rates during each period.

> ***First Period –*** Initial load reductions are 10 percent because the implementers are focused on employing current best practices as the only available pollutant controls.
>
> ***Second Period –*** Marginal[3] load reductions of 9 percent reflect growing implementation capacity with development of new and advanced technologies for fine sediment particle treatment.
>
> ***Third Period –*** Marginal load reductions of 13 percent reflect acceleration from applying advanced fine sediment control technologies and increased implementation capacity.
>
> ***Fourth Period –*** Marginal load reduction of 6 percent because of a slowing rate of reduction as load reduction opportunities become limited and retrofitting Tier 1 projects is necessary.

The overview results show that the Clarity Challenge can be met and exceeded, but additional planning and strategy adjustments will be necessary before the overarching TMDL target of 97.4 feet can be reached. This planning should be performed before the fourth milestone is reached so that implementers can fill their project pipelines with well-targeted projects before the current planning horizon ends.

Source Category Results

At each milestone, expenditures and load reductions are contributed by each source category. Table 2-4 provides load reduction and costs for each of the source categories. The information provided is the cumulative total at each milestone.

This analysis assumes that all reductions for atmospheric, forest and stream channel sources are complete by the third milestone. Additional work on urban sources would continue through the fourth period, but the area available for applying pollutant controls becomes so constrained during this period that load reduction decelerates. In addition, O&M of most pollutant controls would have to be carried beyond this planning horizon to maintain the load reductions.

[3] Marginal change is defined as the incremental change from the previous milestone.

Table 2-4. Estimated Pollutant Reduction and Costs by Source Category for Four Milestones[4,5]

Source category	Milestone #1			Milestone #2			Milestone #3[6]			Milestone #4		
	% Fine particle reduction[7]	Capital costs (millions)	O&M costs (millions)	% Fine particle reduction	Capital costs (millions)	O&M costs (millions)	% Fine particle reduction	Capital costs (millions)	O&M costs (millions)	% Fine particle reduction	Capital costs (millions)	O&M costs (millions)
Atmospheric	1%	$12	$0.12	2%	$23	$0.24	5%	$46	$0.48	5%	$50	$0.49
Forest Upland	0%	$42	$2.6	1%	$77	$3.9	1%	$120	$4.5	1%	$120	$4.6
Stream Chan.	0%	$10	$0.0	1%	$20	$0.00	2%	$40	$0.00	2%	$40	$0.00
Urban Upland	7%	$440	$1.7	15%	$910	$3.7	25%	$1,300	$6.0	31%	$1,700	$11
Total	10%	$500	$4.5	19%	$1,000	$7.8	32%	$1,500	$11	38%	$2,000	$16

4 **Rounding:** Displayed values have been rounded to two significant figures. Totals were calculated using all available decimal places, then rounded. This causes the apparent errors in column totals.

5 **Milestone Totals:** The numeric results presented in this table are cumulative totals for each milestone.

6 **Milestone #3:** The third milestone corresponds to the Recommended Strategy. Load reductions associated with the Recommended Strategy (and thus the third milestone) are expected to achieve the Clarity Challenge.

7 **Percent of Total Load:** Fine sediment particle reductions are shown as a percent of the entire Basin-wide pollutant budget

Assumptions

The results of the milestone analysis depend on challenging assumptions about funding availability, pollutant control implementation rates and availability of new technologies. The primary assumptions are captured below.

1. The minimum application level for current best practices (Tier 1) controls on urban areas in the third period is 20 percent. This assumption is necessary because implementers have already completed or are planning projects that will achieve this level before innovative practices (Tier 2) or new technologies (Tier 3) are available.
2. The maximum application level for pollutant controls to any given area is 80 percent. This reflects the understanding that implementation issues occur that cannot be determined at a Basin-wide planning scale. In particular, some areas might not be accessible, or pollutant reductions might not be achievable at certain sites. Site-specific challenges such as high groundwater, utility line interference, or bedrock intrusions could also make projects excessively costly in some areas.
3. For the purposes of quantitative analysis, the periods were assumed to be 5 years. This assumption allows the load reductions necessary to reach the Clarity Challenge to be achieved in 15 years. However, the Recommended Strategy and the milestones do not need to be tied to any particular number of years.
4. Funding in the amount of $500 million is available and expendable in each 5-year period. This assumption is considered challenging but reasonable because committed funding was reported as $1.123 billion during the first 8 years of the Lake Tahoe Environmental Improvement Program (EIP) (TRPA 2006, p. 2). Approximately 50 percent of this funding was expended on projects and research for water quality purposes (TRPA 2006, p. 7). Although the EIP's 8-year period is longer than the 5 years assumed for this analysis, the assumption is plausible given the implementation capacity that the Basin has gained during the first round of the EIP. This is the extent of the feasibility analysis that was considered for this assumption. The Recommended Strategy's cost estimates are above and beyond the previous funding of the EIP.
5. Advancements in atmospheric pollutant control technology can be implemented more quickly than advancements in urban pollutant controls. Urban control advancements necessitate new technology that must be researched, demonstrated and pilot tested. Higher technology controls for atmospheric sources, such as fine sediment-effective sweepers used in concrete manufacturing plants, are currently available.
6. The lag between the achievement of necessary load reductions and lake clarity response is assumed to be 10 years. The TMDL Technical Report includes an analysis using the Clarity Model that shows lake clarity achieving the clarity target within 15 years if all urban pollutant loads are reduced at a rate of 4.5 percent per year (Lahontan and NDEP 2007a, p. 5-56). At the outer limit, this implies that lake clarity lag could not be longer than 15 years. Another study of precipitation rates and their effect on Secchi depth measurements showed that the majority of clarity effects were noted within 2 years of precipitation extremes. Thus, it is reasonable to assume that the lake's clarity lag will be between 2 and 15 years.
7. Technology limitations determine early ability to produce advanced practices and new technology (Tiers 2 and 3, respectively) projects in the urban source category. This understanding results in three assumptions for the milestone analysis.
    - **First Period:** Research into new technology and general applicability of advanced practices

- **Second Period:** Limited application of advanced practices and pilot implementation of new technologies
- **Third Period:** Widespread availability of advanced practices and innovative technology

These assumptions are reflected in the milestone analysis constraints that allow only 10 percent of urban areas to be treated with new technology by the third milestone. Cost and opportunity constraints determine the ability to implement projects in later time periods.

3. Development of the Recommended Strategy

The Recommended Strategy was developed through a cyclic process of design and adjustment in which scientists and engineers, stakeholders, and TMDL staff and consultants participated. There were three cycles in the process. The cycles are referred to in terms of their objectives:

- Identify, screen and analyze pollutant controls
- Formulate integrated strategies
- Develop and refine the Recommended Strategy

In each cycle of the process, four activities took place:

- An interim product was developed to engage people in substantive discussion and review.
- Stakeholders commented on the interim product.
- The product was adjusted to address comments—resulting in a new interim product.
- Additional stakeholder questions were answered

The product more closely resembled the Recommended Strategy with each cycle, and the product of the third cycle *is* the Recommended Strategy.

Using the Content of This Chapter

Chapter 3 is an overview of the process of development of the Recommended Water Quality Management Strategy (Recommended Strategy). Because this is a record of process, the tables, graphs and information contained herein are not final products. These are draft materials that were subsequently refined or outmoded as the Recommended Strategy came into form. For final versions of tables, charts and information, see Chapter 2: Recommended Water Quality Management Strategy and the PRO Report v2.0. Content of this chapter should not be cited except as it pertains to the *process* of developing the Recommended Strategy.

Contributors

Stakeholder participation informed development of the Recommended Strategy. The stakeholders included the Pathway Forum (Forum), the Focus team and Implementers (staff of Basin agencies).[8] Stakeholder contributions to the Integrated Strategies project included consideration, discussion and evaluation of options and strategies at strategic decision points in the process.

Source category groups provided evaluation and technical review of pollutant control options. The source category groups were composed of scientists and engineers independent of the TMDL team and agencies.[9] The source category groups screened pollutant controls and then provided estimates of potential load reductions and costs for the selected pollutant controls. These estimates are the building blocks of the Recommended Strategy.

[8] See Appendix B/Rosters/Stakeholder Roster
[9] See Appendix B/Rosters/Source Category Group Roster

TMDL team participation informed development of the Recommended Strategy. The TMDL team was composed of TMDL staff and consultants.[10] TMDL team contributions to development of the Recommended Strategy included analysis, discussion, design, evaluation and decisionmaking regarding options and strategies throughout the process.

Overview

The Recommended Strategy was developed through iterative interaction of stakeholders, source category groups, and TMDL team contributions in a cyclic process. These interactions are described in terms of cycles to facilitate comprehension of the progression and results of the project. While each cycle involved interim product development, stakeholder comment and product adjustment, any of these activities could have taken place in multiple venues and in varying sequence during one cycle. Table 3-1 is provided to assist project participants identify which stakeholder meetings contributed to realizing each cycle's objective.

Table 3-1. Project Development Cycles and Associated Meetings

Cycle objective	Meeting date/period	Participants
Cycle 1: Identify, screen and analyze pollutant controls	▪ July 27, 2006 ▪ September 28–29, 2006 ▪ September 10–11, 2007 ▪ September 27, 2007	▪ Forum ▪ Forum ▪ Focus team ▪ Forum
Cycle 2: Formulate integrated strategies	▪ October 11, 2007 ▪ October 25, 2007 ▪ November 14, 2007	▪ Focus team ▪ Forum and Focus team ▪ Implementers
Cycle 3: Develop and refine the Recommended Strategy	▪ December 6, 2007 ▪ January 29, 2008	▪ Forum ▪ Implementers

[10] See Appendix B/Rosters/TMDL Team Roster

3.2. Cycle 1: Identify, Screen and Analyze Pollutant Controls

Pollutant controls are the means for reducing pollutant inputs to Lake Tahoe. At the outset of the Integrated Strategies project, the stakeholders, source category groups and the TMDL team all contributed to identifying pollutant control concepts through a series of discussions in which suggested pollutant controls were noted and a broad list of potential options was compiled. Next, the TMDL team and source category groups created screening criteria. Pollutant controls that met these criteria were designated for further analysis. Finally, the source category groups analyzed the pollutant controls to quantitatively estimate their potential for reducing pollutant input to Lake Tahoe. Analysis was done at both site and Basin scales.

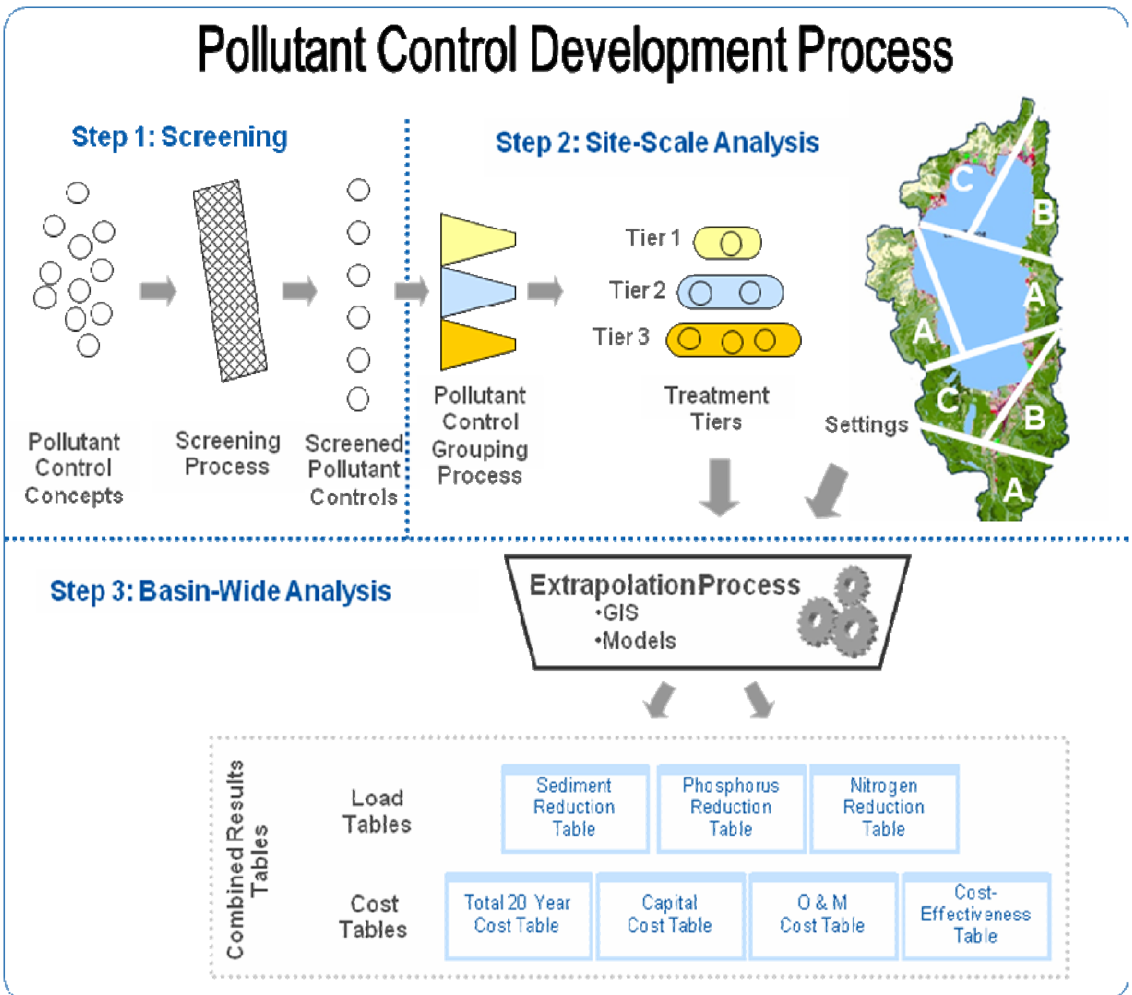


Figure 3-1. After identifying an initial set of pollutant control concepts, the analysis involved (1) Screening—Selecting pollutant controls that are widely applicable at Lake Tahoe and most likely to produce quantifiable load reductions. (2) Analyzing at the site scale—Grouping pollutant controls into Treatment Tiers that can be applied to Settings representative of landscape characteristics. (3) Analyzing at the Basin-wide scale—Extrapolating site-scale results Basin-wide using GIS and predictive models.[11]

[11] Additional background on the scope and objectives of this effort is available in the *PRO Report v2.0* (Lahontan and NDEP 2007b).

Highlights from Cycle 1: Identify, Screen and Analyze Pollutant Controls

Interim product: Viable pollutant controls with analyses of load reduction potential and associated costs (*PRO Report v2.0*)

Review & input venues:

Meeting date/period	Participants
July 27, 2006	Forum and water quality group
September 28–29, 2006	Forum and water quality group
Winter, 2007	Implementers
September 10–11, 2007	Focus team
September 27, 2007	Forum

Adjustments of note:

- Urban Tier 3
- Integrated PRO results chart & tables
- Separate atmospheric mobile and non-mobile pollutant controls
- Recommendations to focus on fine sediment, focus on urban opportunities, implement forest and stream projects as planned
- Progress toward integrated strategies

Identifying Pollutant Controls

Responses to, **"What are the options for reducing pollutant inputs to Lake Tahoe?"** were collected in a series of interactions with the stakeholders, the source category groups and the TMDL team in the period from July 2006 through February 2007. Participants were asked to suggest pollutant controls in terms of the pollutant source categories that the TMDL uses in the Watershed Model. These source categories are urban[12], forest, stream channel, and atmospheric. Highlights of stakeholder input into identifying pollutant controls are summarized in the following table.[13]

[12] The phase "urban" and "urban source category" is used in this document to refer to urban uplands runoff and its effects on groundwater. This is an adjustment from the terminology used in the PRO Report v2.0 in which the phrase "urban & groundwater" was used.

[13] See Appendix B/Identify, Screen and Analyze Pollutant Controls/Stakeholder Contribution to Identification of Pollutant Controls, 2006 (Inputs from the source category groups and TMDL team are not called out in a stand-alone table as these are reflected in the PRO Report v2.0.)

Table 3-2. Highlights from Stakeholder Pollutant Control Identification

Stakeholder-Suggested Pollutant Controls
Urban
▪ Focus on urban area creeks and meadows
▪ Use stormwater utilities for urban areas
▪ Create regional stormwater treatment sites
▪ Use porous parking surfaces
▪ Use vegetated roofs
▪ Research gray water use application and roof runoff collection for Tahoe-specific application
▪ Increase incentives for ecosystem improvements
▪ Use public urban lots for recreation and water quality
Atmospheric
▪ Use parking fees (to offset vehicle use and encourage public transit)
Forest
▪ Reduce forest fuels while improving water clarity
▪ Use recreation improvement opportunities to make water clarity improvements
Stream Channel
▪ Restore stream channels
▪ Restore meander to Upper Truckee River
▪ Restabilize banks
▪ Reduce nutrient flow
General Comment
▪ Use a watershed-based approach
▪ Reduce sediment and nutrient inputs to the Lake
▪ Focus on urban areas
▪ Shift to a macro-results oriented system (and away from micro-regulation)
▪ Address these while reducing pollutant inputs: social and economic benefits, wildlife benefits, soil, defensible space, public access
▪ Formalize education programs in all management efforts
Funding Comment
▪ Consolidate programs across the Basin
▪ Create a stormwater utility tax
▪ Fund research and development
▪ Create private sector incentives
▪ Encourage public–private partnerships
▪ Use mitigation projects
▪ Implement downstream water user surcharges

Source: Stakeholder meetings, July and September 2006

Screening Pollutant Controls

Screening of pollutant controls involved screening and evaluating pollutant controls against set criteria.

The source category groups and TMDL team together finalized the set of pollutant controls for analysis. The screening process is described in full in the PRO Report v2.0. Controls were selected for analysis on the basis of two criteria: (1) ability to demonstrate quantifiable reductions in pollutant inputs, and (2) broad applicability in the Tahoe Basin. The pollutant controls were screened on the basis of existing data whenever possible and best professional judgment of experts from the source category groups, when necessary.

Analyzing Pollutant Controls

Analysis of pollutant controls involved the following:

- Analyzing at site scale
- Extrapolating to Basin-wide scale

The source category groups analyzed pollutant controls at a site scale estimating (1) expected pollutant reduction, and (2) cost of application on a representative site scale. This involved defining representative site areas called *Settings* and groups of pollutant controls representing different approaches to reducing pollutants called *Treatment Tiers*. Subsequently, they extrapolated to a Basin-wide scale estimating (1) pollutant input reduction potential (using models), and (2) cost of application of each Treatment Tier to each applicable Setting. The result of the extrapolation is a Basin-wide estimate of potential pollutant load reductions and associated costs. The analysis process is described in full in the PRO Report v2.0.[14]

Findings of the Pollutant Control Analysis

Scientists and engineers of the source category groups articulated their answers to, **"What are the options for reducing pollutant inputs to Lake Tahoe?"** in the PRO Report v1.01 published in September 2007. This report indicates the following:

- Urban uplands are the source of pollutant inputs that have the greatest and most cost-effective potential to reduce pollutant inputs to Lake Tahoe.
- Stream channel erosion is the source with the least potential for reducing fine sediment particles, but the potential that is available is at relatively low cost and floodplain reconnection has great potential to offer additional ecosystem benefits.
- Forest uplands are the source of pollutant inputs with a small potential to reduce fine sediment particles. Opportunities are cost-effective in some areas, but sediment reductions greater than a few percent of the Basin-wide pollutant budget become very expensive.
- Atmospheric deposition is the source of pollutant inputs showing the best potential to reduce nitrogen and showing good potential to reduce fine sediment particles.

Following is a table providing example pollutant controls used by the source category groups in calculating pollutant input reductions and cost estimates. These pollutant controls are grouped into *Treatment Tiers*—groups of pollutant controls representing different approaches to reducing pollutants.

[14] See Appendix B/Tables __: Pollutant Controls on which Screening and Analysis were to be Performed
  - Assessment of Pollutant Controls for Atmospheric Sources of Fine Sediments and Nutrients
  - Initial Evaluation of Pollutant Controls for Urban Uplands and Groundwater
  - Initial Pollutant Controls Assessment for Forested Uplands Settings
  - Assessment of Pollutant Controls for Stream Erosion Sources of Fine Sediments and Nutrients

Table 3-3. Summary of Options for Reducing Pollutant Inputs to Lake Tahoe, TMDL Treatment Tiers and Example Pollutant Controls

Tier name	Summary definition	Example Controls
Atmospheric		
Tier 2* Transportation Infrastructure & Stationary	A set of PCOs for stationary sources of fine sediment and phosphorous that effectively removes pollutants, deemed cost effective. Numeric estimates based on average literature values.	• Vacuum sweep streets (bi-weekly, fine-sediment-effective) • Pave dirt roads at access points • Limit speed on unpaved roads • Gravel 50% of unpaved roads, including forest roads • Require adequate soil moisture during earth moving operations • Suppress dust on road building projects • Reduce residential wood burning emissions by 20%
Tier 2* Vehicle Emissions	A set of PCOs for mobile sources of nitrogen that effectively removes pollutants and is considered cost effective. Numeric estimates based on average literature values.	• Reduce Vehicle Miles Traveled (VMT) by 10% through incentives/disincentives • Comprehensive transit service
Tier 3 Transportation Infrastructure & Stationary	A set of PCOs for stationary sources of fine sediment and phosphorous, deemed highly effective in removing pollutants and may be more costly than Tier 2. Numeric estimates based on high literature values.	Tier 2 controls plus: • Vacuum sweep streets (weekly, fine-sediment-effective) • Pave all unpaved roads • Suppress dust on construction projects • Reduce residential wood burning emissions by 50%
Tier 3 Vehicle Emissions	A set of PCOs for mobile sources of nitrogen, deemed highly effective in removing pollutants and may be more costly than Tier 2. Numeric estimates based on high literature values.	• Reduce VMT by 25% through incentives/disincentives • Comprehensive transit service
Urban & Groundwater		Note: each tier is defined differently for each setting. These descriptions are representative of controls used.
Tier 1*	An upper-end use of existing practices and technologies. Spatial application within the treatment area considers typical site and funding constraints.	• Stabilize and re-vegetate road shoulders • Vacuum sweep streets (in heavily sanded areas) • Upgrade fertilizer / turf management to reduce nutrient application and provide optional education • Remove impervious and soft coverage (increase infiltration) • Re-route runoff for additional treatment • Install and maintain infiltration trenches • Install and maintain prefabricated infiltration systems • Install and maintain detention basins • Install and maintain prefabricated stormwater vaults
Tier 2	A significantly more intense application of advanced, gravity-driven treatment technologies applied aggressively within the treatment area. Traditional limitations on property acquisition and maintenance rates are relaxed in this Tier.	• Apply advanced deicing strategies (possibly eliminate sand) • Upgrade infrastructure operation and maintenance • Further enhance fertilizer / turf management to reduce nutrient application and require education for turf managers • Control retail fertilizer sales within the Basin • Recommend landscaping practices that reduce nutrient mobilization • Install and maintain wet basins / infiltration basins • Install and maintain constructed wetland • Install and maintain media filters in stormwater vaults
Tier 3	A collection, pumping, and centralized treatment system (Pump & Treat) in concentrated settings with large contiguous areas. Tier 2 controls in dispersed settings.	• Install and maintain stormwater collection and conveyance infrastructure and apply advanced stormwater treatment technologies to address the concentrated impervious area (60% of the urban watersheds) • Apply Tier 2 controls on the remaining 40% of dispersed impervious urban areas

Tier name	Summary definition	Example Controls
Forested Uplands		Note: each tier is defined somewhat differently for each Forested Setting (e.g. unpaved roads, ski runs, and "undisturbed" forested areas). These describe representative activities.
Tier 1*	Includes standard treatments used or required by management agencies in current practice.	• Install and maintain (annually) full unpaved roadway BMPs (e.g. waterbars, armored ditches, rut stabilization) • Hydro-seed and tackify ski runs • Implement forest treatments with ground-based equipment and required BMPs
Tier 2	A middle level of treatment that includes state-of-the-art practices designed to achieve functional rehabilitation of hydrologic properties.	Tier 1 controls plus: • Capture on-site, unpaved roadway sediment • Mulch and revegetate with seedlings on ski runs • Install and maintain "full BMPs" (to increase infiltration and reduce runoff on landings, trails and roads) in forested areas
Tier 3	Treatments designed to develop site conditions that will mimic undisturbed, natural conditions after a period of time. This Tier represents the maximum load reduction possible in the setting and assumes runoff volume and quality similar to natural background conditions.	• Decommission and re-contour existing roads (plus tilling, organic soil amendments, mulch, and functional revegetation) • Fully restore legacy roads and trails • Results in return to native forest conditions with natural hydrologic function
Stream Channel		
Tier 1	**Unconstrained Restoration.** A set of treatments that increases length and sinuosity, connects floodplain, and decreases slope such that a restored condition is eventually reached. Designed to achieve load reductions as well as other ecosystem objectives such as riparian habitat, flood control, and recreation value. Assumes ideal construction access and sequencing. Traditional limitations on property ownership and acquisition are relaxed in this Tier.	• Lower stream channel banks and reduce angle to accommodate more frequent over-bank flow and reduce erosion / slumping of channel banks • Increase channel length and sinuosity which will over-time decrease channel bed slope • Restore riparian vegetation • Reconnect floodplains (remove infrastructure) • Remove any infrastructure (e.g. bridges) that restrict stream channel flow
Tier 2*	**Rehabilitation.** A combination of channel restoration (Tier 1) and simple bank protection (Tier 3) that focuses on cost-effective treatments. Property ownership is considered a factor.	• Apply channel restoration techniques where feasible to mitigate identified channel erosion problems • Protect stream banks and apply grade control where restoration is constrained • The result is a rehabilitated condition of mixed treatments
Tier 3	**Bank protection.** A basic set of channel armoring and minor bank slope reductions that increase hydraulic resistance and reduce bank failure. Does not achieve multiple ecosystem objectives.	• Install rip rap on channel banks • Install grade controls • Remove overhanging banks • (No additional floodplain connection)

* These Treatment Tiers represent current best practices most closely.
Source: Reproduced from October 25, 2007 handout

Focus Team Comments on Pollutant Controls

The source category groups presented pollutant controls to the Focus team on September 10 and 11, 2007.[15] On this occasion, groups of members with expertise in each of the four source categories met with a focus on only one source category (urban, forest, atmospheric or stream channel). In subsequent meetings, all source category topics were discussed together. Topics introduced and discussed included:

Information presented to the Focus team, September 10 and 11, 2007

Primary question: What are the options for reducing pollutant inputs to Lake Tahoe?

Focus of discussion: Pollutant controls (highlights of the PRO Report v1.01)

Discussion topics:

- The approach to screening and analysis of pollutant controls
- The pollutant controls from each of the four source category analyses (see Table 3-3 above)
- Pollutant reduction estimates associated with pollutant controls in each source category
- Cost estimates associated with pollutant controls in each source category
- The planned approach to creating the strategy to reduce pollutant inputs to Lake Tahoe

Citable versions of the information presented are in the PRO Report v2.0.

The materials for the first Focus team meeting presented each source category group's results separately. Focus team responses to this information helped refine the pollutant controls and their presentation. This feedback, summarized in the following table, informed the TMDL team's subsequent refinement and combining of the pollutant controls. [16]

Table 3-4. Focus Team Feedback Regarding the Pollutant Controls

Urban
▪ Further understanding of the ramifications of Pump & Treat are needed
▪ Benefits of existing BMPs and projects implemented need to be quantified and acknowledged
Atmospheric
▪ Atmospheric sources of phosphorus are associated with atmospheric sources of fine particles
▪ Do not assume that a mass transit system would produce fewer pollutant inputs than the cars it would replace
▪ Frame the pollutant controls in terms of *reducing car use* rather than expanding mass transit or visitor fees
Forest
▪ *Legacy road* definition and level of effort to be applied toward these needs to be coordinated between U.S. Forest Service (USFS) and the Lake Tahoe TMDL
▪ USFS and TMDL estimations of cost need to be better-integrated so that the agencies share mutual understanding of level of effort required to achieve desired results
▪ Model analysis has difficulty accommodating *unpredictable* events such as wildfire; therefore, this topic needs to be incorporated into considerations using a different approach.

[15] See Appendix B/Identify Screen and Analyze Pollutant Controls/Focus Team September 10 &11, 2007, Meeting Materials.
[16] See Appendix B/Identify Screen and Analyze Pollutant Controls/Focus Team Meeting Notes September 11, 2007.

Stream Channel
▪ Be very clear that this analysis is limited to stream channel work as opposed to full stream system restoration
▪ Address limitations to understanding of flood plain connection benefits for water quality as comprehensively and as soon as possible
General Comment
▪ Focus effort in areas that will realize benefits to diverse resources
▪ Align cost-benefit numbers to facilitate comparison among source category groups
▪ Seek to achieve water quality benefit in several source categories at once wherever possible
▪ Basin agencies should agree on a standard definition of *cost-effective* for pollution reduction opportunities

Source: Focus Team Notes, September 10 and 11, 2007

Table 3-5. Focus Team Suggested Future Studies

Suggested Future Studies/Efforts
General
▪ Study the short- and long-term cost tradeoffs of the various approaches to resource management including analysis of O&M versus Capital costs
▪ Study ways to integrate water quality improvement efforts with efforts benefiting other resource areas
▪ Establish a long-term plan for housing/staffing the Watershed/Loading Stimulation Program C++ (LSPC) model at the end of the Tetra Tech contract
Urban
▪ Conduct a Pump & Treat feasibility study
▪ Expand consideration of Pump & Treat to include decentralized treatment
▪ Use the Clarity Model to determine the impact of the integrated strategies
▪ Assess the implications of increased defensible space and other fire risk reduction measures
▪ Further consider climate change impacts
▪ Determine how to assess and consider the *non-quantifiable* pollutant controls
▪ Verify/support the conclusion that groundwater loads will decrease even with increased hydrologic loading (due to an emphasis on infiltration)
▪ Follow through on/invest further in the Storm Water Quality Improvement Committee (SWQIC) assessment of effectiveness of existing BMPs
Atmospheric
▪ Research other locations (i.e., Yosemite) regarding visitor fee revenue/vehicle reduction programs and ramifications
▪ Research legalities regarding visitor fee revenue/vehicle reduction programs
▪ Analyze break-even point of nitrogen and resuspended road dust from increased number of buses of a mass transit system and the subsequent reduction in number of cars
▪ Study socioeconomic potential for reducing visitor and resident car usage in the Basin
▪ Analyze underlying assumptions in TRPA/California Air Resources Board (CARB) boat emissions inventory
▪ Analyze potential increase in boat emissions related to proposed changes in shore zone ordinance
▪ Analyze potential ramifications of increasing forest fuels management
▪ Analyze potential ramifications of future growth/build out

Suggested Future Studies/Efforts
▪ Assess what percentage of phosphorous is associated with atmospheric sources of fine sediment
Forest
▪ Account for economies of scale of combined landscape management practices (fuels/water quality)
▪ Research further how pollutant inputs will be affected by increases in mechanical removal of fuels in stream zones
▪ Research further how pollutant inputs will be affected by increases in forest fuels reduction in general
▪ Use the Lake Tahoe TMDL model to help inform future forest management by the USFS
▪ Develop a fuels reduction/water quality working group to examine trade-offs associated with increased forest management related to wildfire
▪ Incorporate the potential impacts of increased fuels reduction activities and catastrophic wildfire, as feasible, into the Watershed Model to address decreased risk of pollutants resulting from catastrophic events
▪ Study the short- and long-term cost trade-offs of varying approaches to forest management including analysis of O&M versus Capital costs
▪ Use the Angora fire as an opportunity for study. (Incorporate the impacts of catastrophic wildfire into model and calculations, as feasible. Incorporate findings of the USFS study.)
▪ Develop consistent interagency information/understanding regarding legacy roads; agree on how many legacy roads currently affect soil hydrology
▪ Develop criteria for erosion control project implementation—splitting forest and upland
▪ Develop/clarify proximity to waterbody analysis
▪ Determine where/how wildfire prevention enters into an all-agency management equation; specify the role of the Lake Tahoe TMDL in this process; identify factors that need to be considered using models; determine whether a related working group should be established
Stream Channel
▪ Ensure that potential reductions of pollutants—originating from upland sources and eliminated by stream channel work—are captured in the Lake Tahoe TMDL analysis and reporting
▪ Improve stream restoration project monitoring
▪ Include *non-water quality* benefits in estimating *value* of stream environment restoration
▪ Expand evaluation to include stream environment restoration as opposed to only stream channel restoration
▪ Apply Southern Nevada Public Land Management Act (SNPLMA) funding to further evaluate benefits of increased connectivity to the floodplain

Source: Focus Team Notes, September 10 and 11, 2007

Adjustments of Note from Focus Team Communication about Pollutant Controls

In response to concerns over marginalization of the importance of stream restoration and forest health treatments, the TMDL team adjusted the approach to these source categories. These projects are important and should be managed under multi-objective plans. The Lake Tahoe TMDL agencies support the approaches promoted by the appropriate management agencies and recognizes that the fine sediment and nutrient reductions available from these projects will contribute to achieving water quality goals. TMDL staff plan to work with management agencies to synchronize plans and proceed with appropriate assumptions.

Several Focus team members noted that the Pump & Treat Tier defined for urban sources was not comparable to the other urban tiers, so the TMDL team defined an additional tier for urban sources. Tier 3 is a composite of the Pump & Treat Tier for all concentrated impervious subwatersheds, supplemented by advanced practices (Tier 2) on subwatersheds that have dispersed impervious coverage. This adjustment allows innovative and advanced pollutant controls for the entire urban area of the Basin, making this tier comparable to Tier 1 and Tier 2. The TMDL team also expanded the scope of thinking about the meaning of Tier 3 to include additional forms of centralized treatment through advanced methods. Although previous estimates were based on filtration technology, the TMDL team felt that the numeric estimates would provide a reasonable first-order estimate of costs and effectiveness of other advanced treatments such as cultured ecologies, flocculation and electrostatic treatment.

Focus team members also asked that atmospheric treatments for mobile sources not be limited to a park and ride transit system as the sole approach to achieving the goals of the Tier 1 pollutant controls. They suggested that paid parking and other incentive/disincentive programs could also be effective for achieving reductions in VMT. This shifted the thinking among TMDL team members and is a consideration for further planning development.

The TMDL team also converted atmospheric results provided as inorganic nitrogen to total nitrogen using a factor of 1.5. This conversion allowed atmospheric results to be compared to nitrogen reduction results from other source categories and is consistent with this species conversion in the Lake Tahoe TMDL pollutant budget (Lahontan and NDEP 2007b, Section 2.8).

Forum Comments on Pollutant Controls

The TMDL team presented to the Forum on September 27, 2007, the findings of the pollutant controls analysis and source category combinations.[17] Context for the information provided was essential because it had been a year since there had been communication with the Forum on this topic. Also, the Clarity Challenge put the new information in the context of the next 20-year planning horizon. Main points of the September 27 communication are bulleted below. The full record of the meeting is in Appendix B.

Information presented to the Forum, September 27, 2007

Primary question: How are we going to restore Lake Tahoe's famed clarity?

Focus of discussion: Pollutant controls (highlights of the PRO Report v1.01)

Documents distributed: PRO Report v1.01, *Charting a Course to Clarity* and the Technical Report

Discussion topics:

- Pollutants causing Lake Tahoe's clarity loss
- How much of each pollutant is reaching Lake Tahoe
- How much of each pollutant Lake Tahoe can accept and still achieve the clarity goal
- Introduction to options for reducing pollutant inputs to Lake Tahoe
    - Overview of pollutant control reduction and cost estimates
- The Clarity Challenge—an interim milestone to assist in managing toward Lake clarity for 20 years
- The planned approach to creating the strategy to reduce pollutant inputs to Lake Tahoe

Citable versions of the information presented are in the PRO Report v2.0.

[17] See Appendix B/Identify Screen and Analyze Pollutant Controls/Forum September 27, 2007, Meeting Materials.

Pathway Forum responses to this information helped to refine thinking about ways to combine the pollutant controls and their presentation as the project advanced. [18]

Table 3-6. Forum Feedback Regarding the Pollutant Controls

Forum Feedback Regarding the Pollutant Controls
Urban
▪ In subsequent TMDL analysis differentiate between levels of urban development
▪ Investigate alternative pavement materials as a means to alleviate the need to sand roads
▪ Emphasize pervious pavement (especially on low traffic surfaces like bike lanes, paths, sidewalks, small commercial parking lots, residential driveways, and the like)
▪ Use monitored demonstration projects as a means to improve knowledge about road design, infiltration design, sweepers, and such.
Atmospheric
▪ Incorporate into calculations the future development and resulting VMT (and/or second homeowners converting to full-time homeowners) over the baseline
▪ Adjust the cost analysis for the atmospheric category so that the results read consistently with the others
Forest
▪ In subsequent TMDL analysis separate the trail system from roads (separate issues and uses)
▪ The way in which the trails system is accounted for has implications for future trails improvement funding
Stream Channel
▪ Explain stream channel erosion better: appears from the description of Tiers 1 and 3 that they should be the same percent load (based on treatments)
▪ If (as believed) stream zone restoration has significant, non-quantifiable benefits at low cost ,it seems we must have at least a ballpark estimate of load reduction. (Otherwise we could spend a lot for small benefit just to meet the Clarity Challenge.) For example, Forest Upland Runoff has a very high unit cost—floodplain restoration could make that unnecessary.
Other Comment
▪ Clarify whether there is a *point of diminishing return* with regard to the Clarity Challenge. How do benefits change when you are considering an improvement of 28–29 meters as opposed to 25–26 meters of clarity?
▪ Estimate the cost of reduction that achieves the best environmental results
▪ Identify potential funding sources to inform the feasibility discussion
▪ Expand consideration of Pump & Treat to include decentralized treatment
▪ Consider incorporating *ecosystem services* into the approach for funding the new EIP (state and national)
▪ Include control of development as a pollutant control opportunity for investigation

Source: Forum Notes, September 27, 2007

[18] See Appendix B/Identify Screen and Analyze Pollutant Controls/ Forum Pollutant Controls September 27, 2007 Meeting Notes.

Table 3-7. Forum Suggested Future Studies

Forum Suggested Future Studies/Efforts
General
▪ Clarify the pollutant loading difference between urban development with BMPs versus those without
▪ Clarify the pollutant loading difference anticipated from better street sweepers
▪ Investigate the contribution to nitrogen from goose droppings: Is it enough to be considered a source?
▪ Investigate fire effects on fine sediments and nutrients. (Increase monitoring to assess the effects of wildfire, pile burning, controlled burns; smoke from distant fires; and pollen)

Source: Forum Notes, September 27, 2007

Adjustments of Note from Forum Communication about Pollutant Controls

In response to comments about the atmospheric source category results, the TMDL team separated revenues and costs that could be generated from public transport incentives and divided the pollutant controls into mobile and non-mobile sources. Separating revenues from the costs associated with using incentives to reduce VMT by 10 percent made costs for this source category comparable to the others. It also significantly reduced the cost-effectiveness of mobile source controls. It became clear that non-mobile sources needed to be divided out of the total atmospheric controls because the extreme costs associated with the VMT reduction were not shared by the non-mobile pollutant controls. Non-mobile pollutant controls for fine sediment particles became much more economically attractive after the division was made.

In response to stakeholder suggestions to analyze behavior-changing or social strategies that could result in pollutant reductions, the TMDL team considered available data on VMT and private-property BMPs. These two pollutant controls were the best available proxies of changeable behavior. This analysis was complicated by private property BMPs being quantified separately from other pollutant controls within the urban Treatment Tiers. The effects of VMT changes were available, but they were focused on nitrogen instead of fine sediment. (Later in the project, additional estimates of VMT reductions revealed small effect on fine sediment particle loads.) The analysis did not show that behavior change could achieve the Clarity Challenge without large projects reducing impacts from existing infrastructure.

3.3. Cycle 2: Formulate Integrated Strategies

Integrated strategies are combinations of pollutant controls from each of the source categories, employed at varying application levels throughout the Basin to reduce pollutants. Pollutant controls from each source category were combined in varying ways in the effort to find the combination that maximizes pollutant reduction, with cost effectiveness considered.

The TMDL team formulated integrated strategies through a two-step process. The first step resulted in draft integrated strategies known as *integrated packages*. The second step resulted in a second draft set of integrated strategies known as *Scenarios* that replaced the integrated packages. These intermediate steps allowed stakeholders to comment during the formulation process of a Recommended Strategy.

Highlights from Cycle 2: Formulate Integrated Strategies

Interim products: Integrated packages (of pollutant controls) and scenarios

Review & input venues:

Meeting date/period	Participants
October 11, 2007	Focus team
October 25, 2007	Forum and Focus team
November 14, 2007	Implementers

Adjustments of note:

- Packaging and Analysis Tool becomes available
- Adjust forest treatments
- Create four Integrated Packages including *Extension of Current Practice*
- Recommendations to focus on non-mobile atmospheric sources

TMDL Team Drafts Integrated Packages

Using results of the pollutant controls analysis, the TMDL team and stakeholders undertook to answer the question, "**What strategy should we implement to reduce pollutant inputs to Lake Tahoe?**" This involved analyzing integrated strategies and comparing them to one another for effectiveness in maximizing pollutant reduction in an efficient and acceptable manner.

New Materials

During this cycle, the TMDL team produced a spreadsheet tool to facilitate aggregation of pollutant controls, load reductions and costs, and used it to formulate three integrated packages based on pollutant reduction themes. The spreadsheet tool allows a user to scale back the *application level*[19] of each Treatment Tier. The spreadsheet tool was built using Microsoft Excel and uses a lookup table and linear scaling to calculate the estimated load reduction and cost of each tier for each source category. The spreadsheet tool does not allow the user to consider spatial or land use considerations (Settings—as defined by the source category groups) except in the special case of the forest source category. Additional resolution is necessary for the forest source because small areas (e.g., unpaved roads, ski runs) produce higher yields of fine sediment, and pollutant controls are much more cost effective in these areas. Additional explanation of the forest source category is provided in the Integrated Packages Overview section below. Table 3-8 shows a sample of the spreadsheet tool. Adjustable inputs are shown as blue numbers, and net results of package are totaled on the bottom line.[20]

[19] *Application level* is expressed as a percent of total possible application. For instance, a 75 percent application level of an urban Treatment Tier would mean that three-quarters of the Tahoe Basin's urban areas would be treated with that group of pollutant controls and one-quarter would remain untreated.

[20] The underlying load reduction to the version of the spreadsheet tool used to create the integrated packages were subsequently changes to address technical issues discovered during the initial review. This resulted from the desire to engage stakeholders in discussion before a full technical review could be completed. These adjustments were made before developing the scenarios that the Forum reviewed on October 26th.

Table 3-8. Example of Spreadsheet Tool Used to Create Integrated Packages

Integrated Packages Overview

The integrated packages are composed of pollutant controls from all four source categories. Urban and atmospheric components of the integrated packages were adjusted significantly according to the theme of the package. Forest and stream channel source contributions did not vary across the three integrated packages that were presented. This is because of the narrow band of pollutant reduction opportunity and existing multi-objective management plans that are in place for these source categories. For these reasons, the forest and stream channel contributions to the integrated packages presented were known as *base packages*.

The stream channel base package is relatively straightforward, while the forest base package requires some understanding. The stream channel base package is modeled after current and planned stream restoration projects within the Basin. These typically involve a mix of complete restoration and bank armoring. The stream channel base package includes applying this mix to 80 percent of the stream channels of Blackwood Creek, the Upper Truckee River and Ward Creek. The forest base package includes a 70 percent application level of required BMPs (Tier 1), and 10 percent application of complete restoration (Tier 3) to unpaved roads, trails, ski runs, campgrounds and bare slopes. This package would also include 10 percent application of hydrologic restoration (Tier 2) and 10 percent application of complete restoration (Tier 3) to typical Tahoe forests. (It is important to note that this base package evolved slightly before it became part of the Recommended Strategy.)

The integrated package themes and a few of their differentiating features are as follows:

> ***Extension of Current Best Practice* –** Implementing an aggressive version of existing best practices focused on wide application of controls for urban stormwater and atmospheric fine particles. This integrated package would result in 18 percent reduction in fine sediment particles and require capital investment of $1.69 billion.

> ***Focus on Innovation* –** Investing in development and implementing innovative practices and new technology such as conveying and treating stormwater with mechanical or chemical systems. This

scenario would reduce fine sediment particle loads by 21 percent and require capital investment of $1.86 billion.

All Out Push – Developing new technologies that would be more effective in removing pollutants and applying these pollutant controls to the greatest area possible given certain constraints. This scenario would achieve 31 percent fine sediment particle load reduction and require capital investment of $2.65 billion.

The integrated packages were presented as handouts to stakeholders. These handouts described the integrated packages using four elements. These elements are described below and are followed by a series of three figures that replicate the handouts for each integrated package.

Package Theme – A general description of the unifying quality of the pollutant controls included and the objectives of the integrated package. This element was in the upper-left corner of the handout.

Spreadsheet Tool Inputs/Outputs – The application levels, pollutant reductions and costs of each integrated package. This element was in the upper-right corner of the handout.

Results Charts – A graphic depiction of the fine sediment reductions, capital costs, annual O&M costs and estimated resulting clarity measurement. These charts are colored black and use stacked, colored bars to depict the contribution of each source category to the total.

Example Pollutant Controls – A set of bullets that note many of the major pollutant controls that are included in the integrated package. These lists do not include the complete set of pollutant controls that could be used within the package but are provided to facilitate understanding of the types of pollutant controls contributing to load reductions.

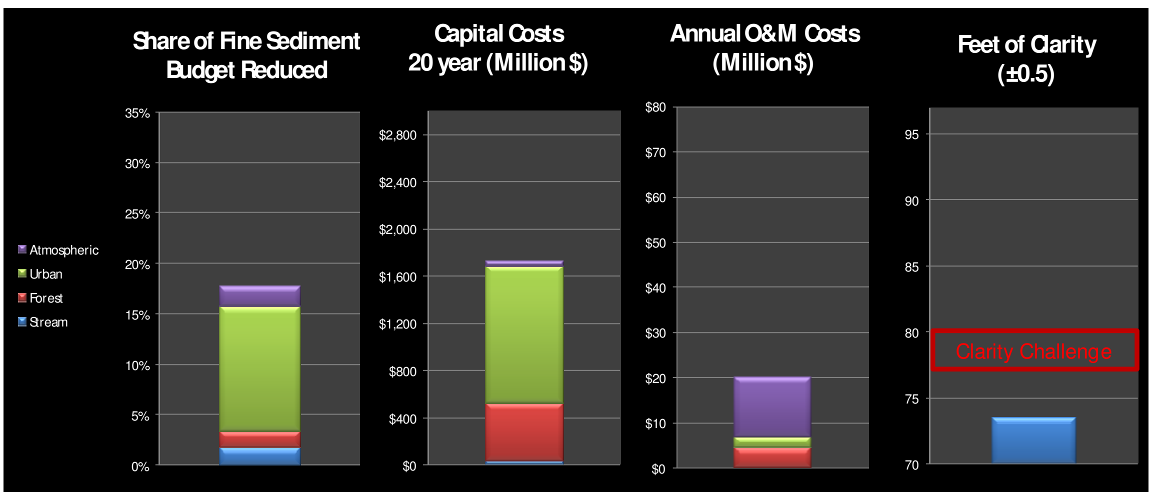
Integrated Package: Extension of Current Practice

Integrated Package Description

This package is an aggressive implementation of current best practices, emphasizing broad implementation of pollutant controls for reducing atmospheric fine sediment and treating urban runoff. Controls focus on treating stationary atmospheric sources of fine sediment and phosphorus, extension of current residential and forest BMPs, and a combination of stream channel rehabilitation and restoration.

	Percent Application (%)	< 20 micron sediment particle reductions	Phosphorus reductions	Nitrogen reductions	Capital cost 20 year (Million $)	Annual O&M cost (Million $)	Total 20 year cost (Million $)
Atmospheric							
Tier 2 FS&P/Stationary	**70%**	2%	2%	0%	$20	$0	$25
Tier 2 Mobile	**10%**	0%	0%	0%	$28	$13	$290
Tier 3 FS&P/Stationary	**0%**	0%	0%	0%	$0	$0	$0
Tier 3 Mobile	**0%**	0%	0%	0%	$0	$0	$0
Total	*OK*	*2%*	*2%*	*1%*	*$48*	*$13*	*$315*
Urban & Groundwater							
Tier 1	**80%**	12%	5%	2%	$1,120	$2	$1,200
Tier 2	**0%**	0%	0%	0%	$0	$0	$0
Tier 3	**0%**	0%	0%	0%	$0	$0	$0
Total	*80%*	*12%*	*5%*	*2%*	*$1,120*	*$2*	*$1,200*
Forested Uplands							
Base Package		*2%*	*0%*	*0%*	*$482*	*$4*	*$549*
Stream Channel							
Tier 1	**0%**	0%	0%	N/A	$0	$0	$0
Tier 2	**80%**	2%	1%	N/A	$40	$0	$40
Tier 3	**0%**	0%	0%	N/A	$0	$0	$0
Total	*80%*	*2%*	*1%*	*0%*	*$40*	*$0*	*$40*
Scenario Total		**18%**	**9%**	**3%**	**$1,690**	**$20**	**$2,103**

Results



Example Pollutant Controls

- Bi-weekly PM-effective street sweeping
- Pave dirt roads at access points
- Gravel 50% of unpaved roads
- Sweeping in intensive traction abrasive areas
- 50% completion of residential best management practices

- Detention & retention basins
- Coverage removal
- Forest treatments done with ground-based equipment and required BMPs focusing on unpaved roads, disturbed areas and fuels treatment areas
- Stream channel restoration and bank protection

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Figure 3-2. A reproduction of the handout describing the *Extension of Current Practice* integrated package from October 11, 2007.

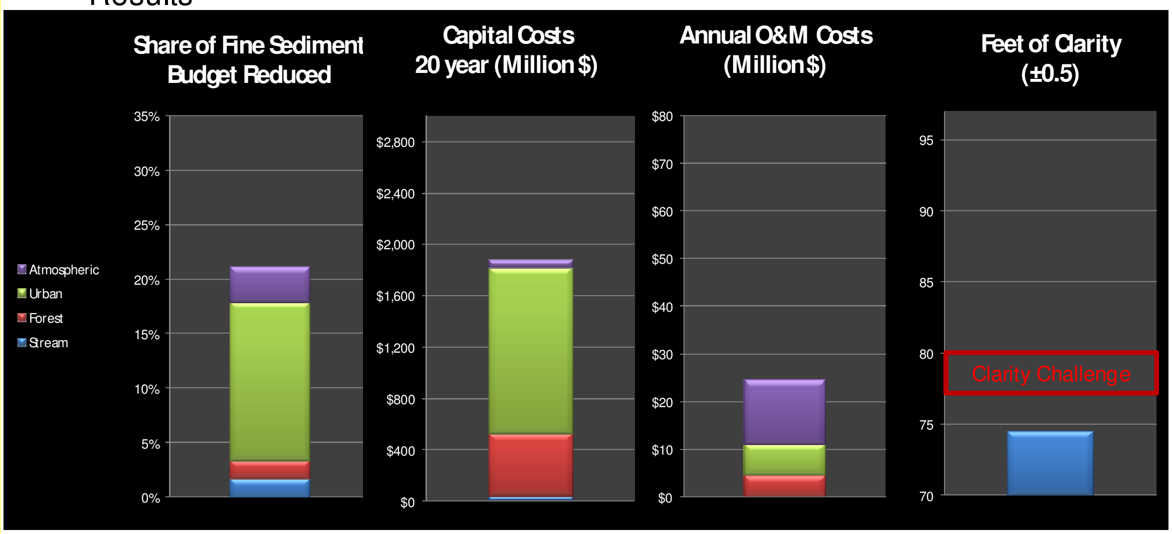
Integrated Package: Focus on Innovation

Integrated Package Description

This integrated package involves an investment of time and resources in developing new technologies to more effectively reduce pollutants, and implementation of these new technologies to the degree possible once they have been developed. Efforts include significant deployment of pollutant controls to reduce stationary sources of atmospheric pollutants, development and application of urban stormwater pump and treat technologies, extension of current forest BMPs, and a combination of stream channel rehabilitation and restoration.

	Percent Application (%)	< 20 micron sediment particle reductions	Phosphorus reductions	Nitrogen reductions	20 year capital cost (Million $)	Annual O&M cost (Million $)	Total 20 year cost (Million $)
Atmospheric							
Tier 2 FS&P/Stationary	**10%**	0%	0%	0%	$3	$0	$4
Tier 2 Mobile	**10%**	0%	0%	0%	$28	$13	$290
Tier 3 FS&P/Stationary	**40%**	3%	3%	0%	$30	$0	$35
Tier 3 Mobile	**0%**	0%	0%	0%	$0	$0	$0
Total	*OK*	*3%*	*4%*	*1%*	*$60*	*$13*	*$329*
Urban & Groundwater							
Tier 1	**20%**	3%	1%	1%	$280	$1	$300
Tier 2	**0%**	0%	0%	0%	$0	$0	$0
Tier 3	**40%**	11%	5%	2%	$1,000	$6	$1,120
Total	*60%*	*14%*	*6%*	*3%*	*$1,280*	*$7*	*$1,420*
Forested Uplands							
Base Package		*2%*	*0%*	*0%*	*$482*	*$4*	*$549*
Stream Channel							
Tier 1	**0%**	0%	0%	N/A	$0	$0	$0
Tier 2	**80%**	2%	1%	N/A	$40	$0	$40
Tier 3	**0%**	0%	0%	N/A	$0	$0	$0
Total	*80%*	*2%*	*1%*	*0%*	*$40*	*$0*	*$40*
Scenario Total		**21%**	**11%**	**4%**	**$1,862**	**$24**	**$2,337**

Results



Example Pollutant Controls

- Weekly street sweeping
- Aggressively reduce residential wood burning emissions
- Collection and conveyance infrastructure for private property and public impervious areas
- Control or retail fertilizer sales
- Media filters in stormwater vaults
- Forest treatments done with ground-based equipment and required BMPs focusing on unpaved roads, disturbed areas and fuels treatment areas
- Stream channel restoration and bank protection

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Figure 3-3. A reproduction of the handout describing the *Focus on Innovation* integrated package from October 11, 2007.

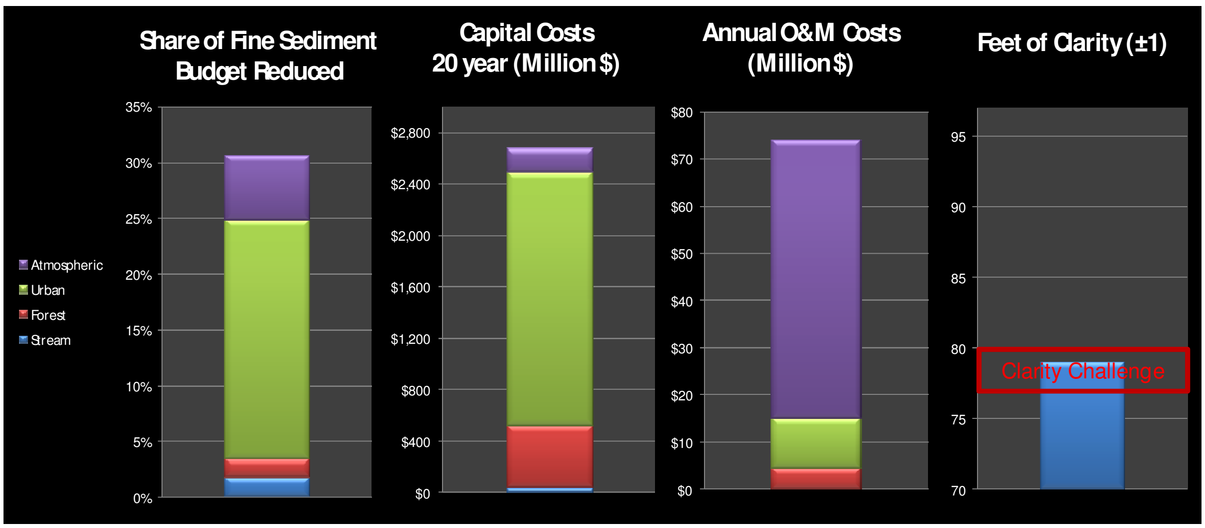
Integrated Package: All Out Push

Integrated Package Description

This integrated package includes development of new technologies to more effectively reduce pollutants and implementation of these new approaches over the greatest area possible. Efforts include maximum implementation of pollutant controls to reduce stationary sources of atmospheric pollutants, development and application of urban stormwater pump and treat technologies, extension of current forest BMPs, and a combination of stream channel rehabilitation and restoration.

	Percent Application (%)	< 20 micron sediment particle reductions	Phosphorus reductions	Nitrogen reductions	Capital cost 20 year (Million $)	Annual O&M cost (Million $)	Total 20 year cost (Million $)
Atmospheric							
Tier 2 FS&P/Stationary	**20%**	1%	1%	0%	$6	$0	$7
Tier 2 Mobile	**20%**	0%	0%	1%	$56	$26	$580
Tier 3 FS&P/Stationary	**70%**	5%	6%	1%	$52	$0	$62
Tier 3 Mobile	**10%**	0%	0%	1%	$69	$33	$720
Total	*OK*	*6%*	*6%*	*3%*	*$182*	*$60*	*$1,369*
Urban & Groundwater							
Tier 1	**30%**	5%	2%	1%	$420	$1	$450
Tier 2	**10%**	3%	1%	1%	$280	$2	$320
Tier 3	**50%**	14%	6%	3%	$1,250	$8	$1,400
Total	*90%*	*21%*	*9%*	*4%*	*$1,950*	*$11*	*$2,170*
Forested Uplands							
Base Package		*2%*	*0%*	*0%*	*$482*	*$4*	*$549*
Stream Channel							
Tier 1	**0%**	0%	0%	N/A	$0	$0	$0
Tier 2	**80%**	2%	1%	N/A	$40	$0	$40
Tier 3	**0%**	0%	0%	N/A	$0	$0	$0
Total	*80%*	*2%*	*1%*	*0%*	*$40*	*$0*	*$40*
Scenario Total		**31%**	**16%**	**7%**	**$2,654**	**$75**	**$4,127**

Results



Example Pollutant Controls

- Weekly street sweeping
- Collection and conveyance infrastructure for private property and public impervious areas
- Control of retail fertilizer sales
- Media filters in stormwater vaults
- Reduce vehicular emissions and travel
- Forest treatments done with ground-based equipment and required BMPs focusing on unpaved roads, disturbed areas and fuels treatment areas
- Stream channel restoration and bank protection

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Figure 3-4. A reproduction of the handout describing the *All Out Push* integrated package from October 11, 2007.

Focus Team Comments on Integrated Packages

The TMDL team presented the integrated packages (above) to the Focus team on October 11, 2007.[21] The TMDL team informed the Focus team of the intent to set interim clarity goals and articulated the goal of this session as "discussing strategies which integrate controls from all sources at once." Additional highlights of the information presented are as follows:

Information presented to the Focus Team October 11, 2007

Focus of discussion: Integrated packages (see the preceding three pages):
- Extension of Current Practice
- Focus on Innovation
- All out Push

Discussion topics:
- Focus on fine sediment particle reductions
- Focus on the largest opportunity for pollutant reductions—urban runoff
- Implement forest and stream restoration programs for multiple benefits as planned

Citable versions of this information are in Chapter 2: Recommended Water Quality Management Strategy

The recommendation to focus on fine sediment particle reductions sprung from three pieces of key information: (1) fine sediment is responsible for the majority of clarity loss; (2) the difference in clarity benefits between fine sediment and nutrient load reductions versus fine sediment reductions alone is very similar within the percent reductions that appear possible (Lahontan and NDEP 2007a p. 5-55), and (3) while the current focus for implementation will be fine sediment particles, phosphorus and nitrogen are also removed by fine sediment particles controls. The Lake Tahoe TMDL will continue to track nutrient reductions and the responsible agencies recognize the importance of nutrients in restoring Lake Tahoe's clarity.

The recommendation to focus on the largest opportunity for pollutant reductions—urban sources—was made because of the following (1) it produces the largest load of fine sediment particles, (2) it has more than four times the potential for load reductions than the next-best source category, and (3) it is cost-competitive with other source categories for fine sediment particle reduction.

The recommendation to implement forest programs as planned by the management and funding agencies that are leading these efforts evolved for several reasons. Forests are currently managed for multiple objectives (e.g., fuels reduction, recreation, habitat) which could take priority over the goals of Lake Tahoe TMDL's water quality objective. In addition, the source category group analysis showed that these projects, when completed using current best practices, provide a net benefit to water quality by reducing fine sediment particle loads.

Multi-objective stream channel erosion programs are well established, and existing conditions do not offer wide latitude in treatment options. The Lake Tahoe TMDL analysis focuses only on fine sediment

[21] See Appendix B/Formulate Integrated Strategies/Focus Team October 11, 2007 Meeting Materials.

particles released from stream banks and does not consider the other potential ecosystem benefits available from stream restoration or potential water quality benefits of reconnecting floodplains.

The Focus team asked questions and provided comment during the meeting. These comments are captured and synthesized in Table 3-9.

Table 3-9. Focus Team Feedback Regarding the Integrated Packages

Urban

- Evaluation of road projects will be easier with the TMDL methodology as it reflects "reasoned prioritization"
- Gut check the assumption that 60% of urban areas (as opposed to 80%) can be treated
- Look at Tier 2 as much as possible; focus on advanced BMPs other than Pump & Treat
- Continue to expand the Pump & Treat inquiry and research further the cost effectiveness of different approaches. Is there a certain approach that would be more effective given local conditions?
- Consider moving snow and then treating it elsewhere
- Funding could be more of an issue than human capacity

Atmospheric

- Maintain a focus on addressing mobile as well as stationary sources because VMT affects multiple sources—not only nitrogen emissions in the air, but also the amount of fine sediment and phosphorus that gets resuspended or ends up as runoff from the roads
- Package the recommendations in a way that encourages behavioral change
- Traction materials and de-icers are important to study further
- Try Tier 2 over Tier 3 in urban areas

Forest and Stream Channel

Meeting participants supported the TMDL team's approach to

- Pursue a strategy for forest sources that builds on existing practices
- Pursue a strategy for stream channels that builds on existing practices
- Using this consistent strategy for both forests and streams under all 3 packages
- Focusing more intense efforts on atmospheric deposition and urban runoff (bigger load reduction potentials)

New Ideas from the Focus Team

- Include actions focused on sociological fixes/behavior change to complement the technological fixes
- Improve quantification of benefits; quantify benefits of collaboration; for instance project permitting and business interests; SWQIC process a good example of this
- Credit source control measures including those that cannot be easily quantified; this would increase source control efforts
- Attempt to develop some packages that disaggregate settings in urban and other source categories
- Include some trade-off analysis
- Identify a certain amount of money and then run the Clarity Model to optimize actions

Future Research Suggestions from Focus Team

- Pursue a system for central tracking and quantification of existing clarity achievements that link to specific projects
- Conduct Pump & Treat feasibility study
- Connect strategy/packages with the Clarity Model
- Consider the impacts of greater implementation of defensible space practices

▪ Consider the impacts of future growth (U.S. Geological Survey)
▪ Consider the impacts of climate change
▪ Study further the time over which lake clarity change is expected (using the Clarity Model)
▪ Study the long-term impacts of the existing sewage system
▪ Incorporate the benefits of stream channel restoration into other sources
▪ Characterize and include other non-water quality benefits of stream channel restoration
▪ Include fine sediment reduction benefits of overbanking and increasing floodplain connectivity of streams
▪ Quantify the benefits of a water quality project
▪ Conduct a natural resource economic analysis
▪ Spatial and temporal challenges make funding this data collection difficult
▪ Quantify nutrient cycling on the floodplain
▪ More stream data is needed in general

Source: Focus Team Notes, October 11, 2007

Adjustments of Note from Focus Team Input on Integrated Strategies—Scenarios

The TMDL team synthesized feedback from the Focus team and developed scenarios—refinements of the integrated packages.[22]

Forest

Interest from the LTBMU and a new analysis tool encouraged the TMDL team to make adjustments to the forest pollutant controls. The new analysis tool (explained in the following paragraphs) allowed for better cost/benefit analysis that made it apparent that more cost-effective pollutant reductions were available with modified pollutant controls and application levels. The adjustment resulted in several changes in the results pertaining to the forest strategy:

- Fine sediment particle reductions decreased somewhat, from 2 percent to 1 percent
- 20-year capital costs decreased significantly, from $482 million to $120 million
- Annual O&M costs rose slightly, from $4 million to $4.5 million

Stream Channel

Some stakeholders identified that the stream channels could provide treatment of upland sources and that this potential was not analyzed in the pollutant control analysis. The TMDL team attempted to gain an understanding of this potential by using design reports from the Upper Truckee River Marsh Restoration project in combination with average particle fluxes from general research done by University of California Davis (UCD). The analysis did show some potential for the restoration to increase fine sediment particle capture during flooding on the order of the reductions from stream channel erosion overall. This calculation was very preliminary and additional analysis will be necessary before these load reduction estimates can be included in the Lake Tahoe TMDL.

Atmospheric

The TMDL team did additional analysis into mobile sources of fine sediment. The initial analysis of mobile sources did not include VMT reductions as a pollutant control for fine sediment particles. A rough quantitative estimate revealed that VMT reductions up to 25 percent resulted in fine sediment particle

[22] See Appendix B/Formulate Integrated Strategies/Focus Team Integrated Strategies Meeting Notes October 11, 2007.

load reductions less than half of one percent. This result supported the initial assumption that VMT reductions do not provide a significant opportunity for significant fine sediment particle load reductions. However it is important to note that current scientific understanding of the linkage between VMT and fine sediment loading to Lake Tahoe is not well characterized and additional research is included within the Tahoe Science Consortium's research plan.

Scaling

The TMDL team determined that scaling factors were necessary to match the source category groups' results with the Basin-wide pollutant budget. This scaling allowed each source category group to use the best available information and methodologies from its source category while they performed their estimates. Once these estimates were complete, they were scaled to the baseline pollutant budget used by the Lake Tahoe TMDL. The scaling factors needed were different for each source category and ranged from 1.561 to 1. Atmospheric source category results were not scaled because this source category group rectified the California Air Resources Board emission inventory with the TMDL pollutant budget. Appendix C provides a table with all the scaling factors used. The most notable change in the values was an increase in the estimated load reduction potential from the urban source category.

New Discussion Materials

A new tool designed to enhance the TMDL team's ability to create and analyze integrated packages of pollutant controls became operational at this point in the project. The Packaging and Analysis Tool (PAT) allowed the TMDL team to delve more deeply into the integrated packages by allowing them to apply application levels to specific settings, as opposed to aggregated source categories. PAT also included features to minimize costs within given constraints and seek goals for pollutant reduction or costs. The PAT was built using Visual Basic for Applications (VBA) on a Microsoft Excel platform. It incorporates a scatter search version of a genetic algorithm to find *best solutions* subject to user-defined constraints. In this case, best solutions are defined by the product of cost and pollutant reduction. Appendix A further describes the functions and technology used in PAT.

The PAT was used to explore the most efficient ways that a given budget could be invested in pollution control. This analysis resulted in a curve describing the best clarity that could be reached for a given investment, subject only to the constraint that no more than 80 percent of a given setting can be treated with pollutant controls and the predetermined forest and stream pollutant controls. Figure 3-5 is the slide that was discussed with stakeholders. It shows that $1.1-$1.5 billion dollars are needed to achieve the Clarity Challenge under these idealized conditions. It should be noted that all integrated packages and scenarios were subject to some additional constraints and were always somewhat less optimal than this curve.

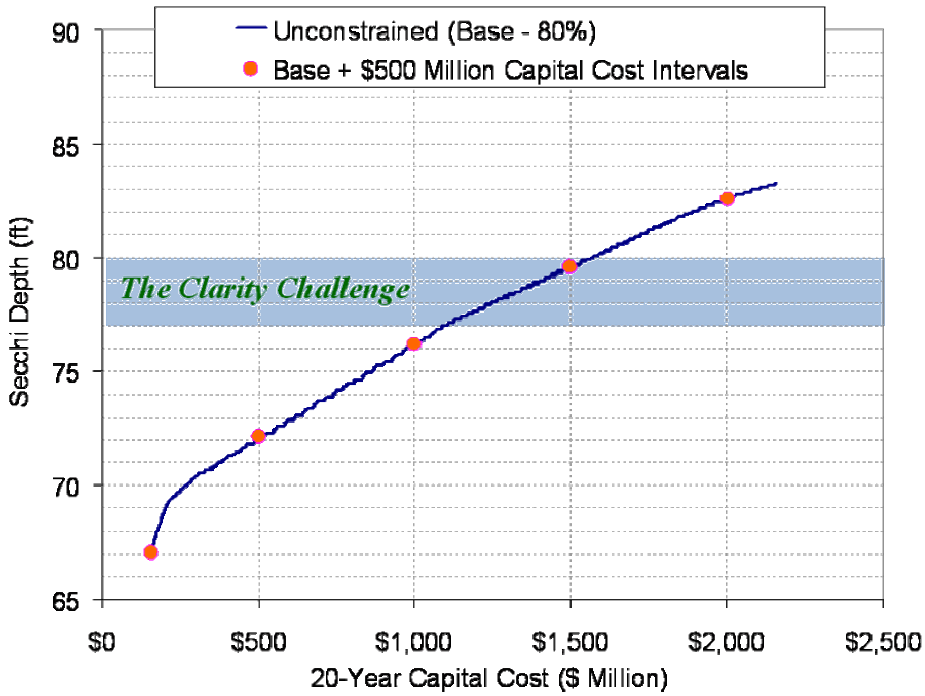


Figure 3-5. An optimal cost curve relating investment to Secchi depth.

Scenarios

The PAT was also used to enhance the integrated packages by analyzing more cost-effective ways of applying pollutant controls to particular Settings. The advancements made through this analysis and comments by the Forum Planning Committee prompted the TMDL team to rename the integrated packages to scenarios. This was particularly important because the new scenarios were built on the same themes as their integrated package predecessors. Although their names are usually similar, they have slightly different application levels for many of the pollutant controls. In some cases, significant changes in cost and pollutant removal resulted from the new analysis.

Three scenarios and an analysis of current best practices were presented to stakeholders with a series of handouts like the integrated packages handouts. This handout series included similar categories of information as the integrated package handout, except the PAT equivalent of the "Spreadsheet Tool Inputs/Outputs" was much more extensive and was summarized via a narrative. The handouts for each of the four scenarios are reproduced in the following figures. The extensive PAT Inputs/Outputs page for each scenario is in Appendix B.[23]

The scenarios and a few of their differentiating features are as follows:

> ***Scenario A: Retrofit & Enhanced Best Practices –*** Implementing existing best practices augmented with more advanced and intensive treatment of urban stormwater and atmospheric fine particles. This scenario would meet the Clarity Challenge and require capital investment of $1.8 billion.
>
> ***Scenario B: Focus on Innovation & Advanced Practices –*** Developing and implementing innovative practices such as conveying and treating stormwater with mechanical or chemical

[23] See Appendix B/Formulate Integrated Strategies/Forum & Focus Team October 25, 2007 Meeting Materials.

systems. This scenario would meet the Clarity Challenge and require capital investment of $1.5 billion.

Scenario C: All Out Push – The maximum, potentially practical load reduction, given applicability constraints of the proposed pollutant controls. This scenario would exceed the Clarity Challenge and require capital investment of $2.0 billion.

Scenario A: Retrofit & Enhanced Best Practices

Meets Clarity Challenge

Theme

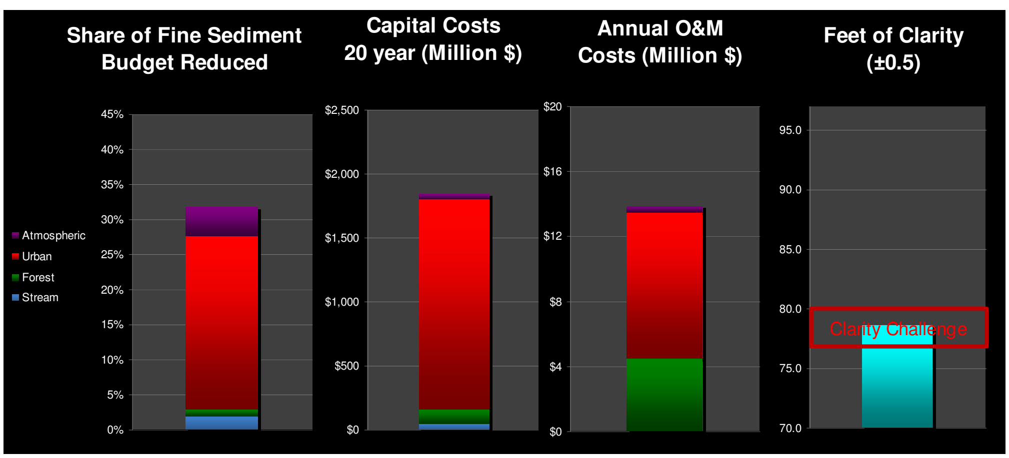
This scenario focuses on continuing to implement existing best practices -- augmenting these with more-advanced and intensive treatment of urban stormwater and atmospheric fine sediment -- to meet the Clarity Challenge. A maximum of 80% of the land area for any particular setting is treated.

Atmospheric: Focus on reducing fine sediment and phosphorus from roadways by: sweeping streets weekly or bi-weekly (using fine-particle-effective technologies); paving dirt roads at access points; graveling or paving portions of 80% of the unpaved roadways in the Basin; and reducing use of woodburning stoves.

Urban and Groundwater: Extending **current practice** for residential, commercial and roadway areas on approximately 40% of the urban area; employing advanced passive treatment technologies on an additional 40% of the urban area; and achieving implementation of a majority of private property BMPs.

Forest: Treating 60% of unpaved roads, ski runs, campgrounds and other disturbed forested areas, using current best practices; employing intensive treatments such as on-site sediment capture on 10% of the area; and restoring an additional 10% of unpaved roads and disturbed areas. Assumes treating 15% of the forest to reduce fuels loads (2/3 of which will receive standard pollutant controls and the other 1/3 treated using more intensive treatment approaches).

Streams: Combining stream channel rehabilitation and restoration on 80% of the potential project areas on each of the Upper Truckee River, Ward Creek and Blackwood Creek.



Example Pollutant Controls

• Bi-weekly augmented by some weekly fine particle-effective street sweeping • Gravel or pave unpaved roads • Reroute runoff for additional treatment • Road shoulder stabilization & revegetation • Additional operations & maintenance of infrastructure • Fertilizer management	• Wet basin and constructed wetlands • Extensive implementation of private property BMPs • Impervious and soft coverage removal • Forest treatments done with ground-based equipment and required BMPs focusing on unpaved roads, disturbed areas and fuels treatment areas • Stream channel restoration and bank protection

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Figure 3-6. A reproduction of the handout describing *Scenario A - Retrofit & Enhanced Best Practices from October 25, 2007.*[24]

[24] See Appendix B/Formulate Integrated Strategies/Retrofit & Enhanced Best Practices (details).

Scenario B: Focus on Innovation & Advanced Practices

Meets Clarity Challenge

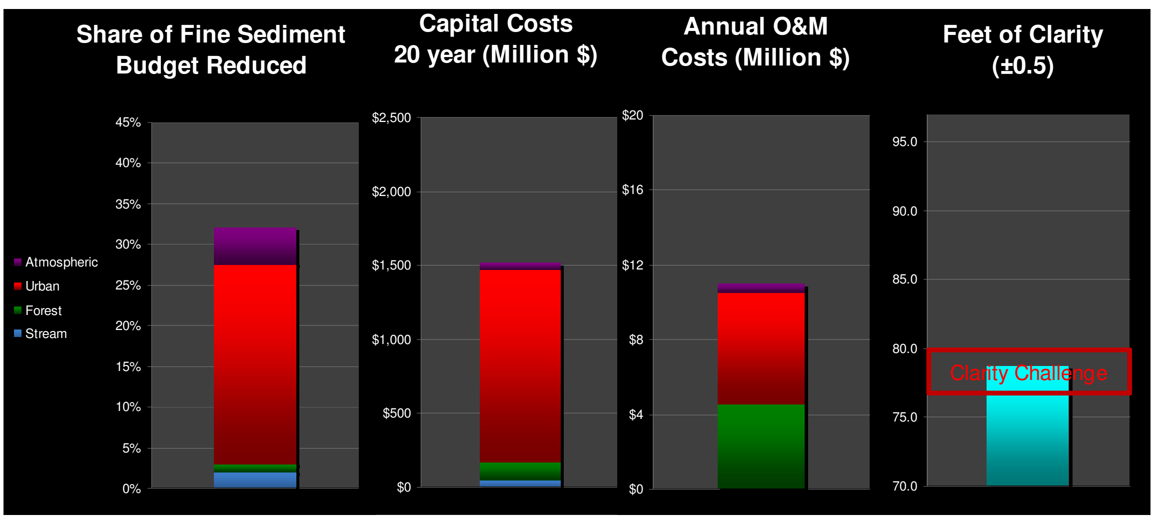
This scenario focuses on implementing innovative practices to meet the Clarity Challenge. In this scenario, less land area is treated than in the "Retrofit & Enhanced Best Practice scenario". This scenario assumes urban stormwater collection and treatment and intensive effort to control atmospheric fine sediment. A maximum of 80% of the land area for any particular setting is treated.

Atmospheric: Intensive effort to reduce fine sediment and phosphorus from roadways by: sweeping streets weekly or bi-weekly (using fine-particle-effective technologies); paving dirt roads at access points; paving and graveling significant portions of 80% of the unpaved roadways in the Basin; and reducing use of woodburning stoves.

Urban and Groundwater: Implementing **advanced controls** including: conveying and treating stormwater on approximately 50% of areas with concentrated impervious surfaces, in combination with using current best-practices on approximately 30% of all urban areas, and advanced passive controls in select areas; and achieving a moderate-level of implementation of private property BMPs.

Forest: Treating 60% of unpaved roads, ski runs, campgrounds and other disturbed forested areas using current best practices; employing intensive treatments such as on-site sediment capture on 10% of the area; and restoring an additional 10% of unpaved roads and disturbed areas. Assumes treating 15% of the forest to reduce fuels loads (2/3 receiving standard pollutant controls and the other 1/3 treated using more intensive treatment approaches).

Streams: Combining stream channel rehabilitation and restoration on 80% of the potential project areas on each of the Upper Truckee River, Ward Creek and Blackwood Creek.



Example Pollutant Controls

• Weekly or bi-weekly fine-particle-effective street sweeping • Pave dirt roads at access points • Pave or gravel significant portions of unpaved roads • Collect and treat urban stormwater with advanced mechanical or chemical treatments	• Detention & retention basins • Increased implementation of private property BMPs • Forest treatments done with ground-based equipment and required BMPs focusing on unpaved roads, disturbed areas and fuels treatment areas • Stream channel restoration and bank protection

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Figure 3-7. A reproduction of the handout describing *Scenario B - Focus on Innovation & Advanced Practices from October 25, 2007.*[25]

[25] See Appendix B/Formulate Integrated Strategies/Focus on Innovation & Advanced Practices (details).

Scenario C: All Out Push

Exceeds Clarity Challenge

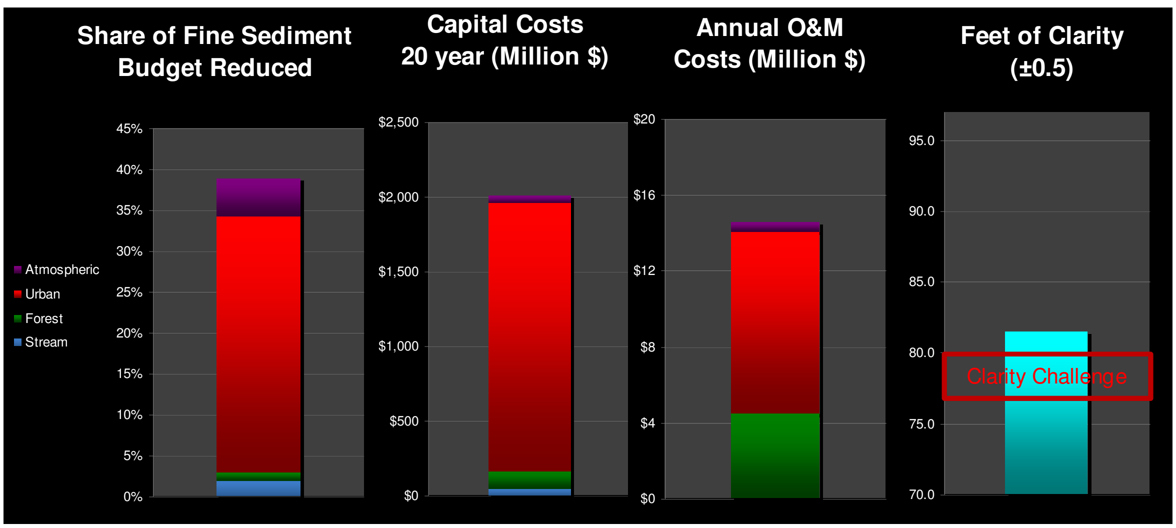
This scenario represents the maximum potentially practical load reduction that can be achieved considering the set of pollutant reduction opportunities analyzed. Treatment areas are restricted to a maximum implementation of 80% of the land area for any particular setting and 20% of the treated urban area will use current best-practices rather than advanced treatment. This scenario exceeds the Clarity Challenge.

Atmospheric: Intensive effort to reduce fine sediment and phosphorus from roadways through: weekly fine-sediment-effective street sweeping of a majority of roads; paving 80% of dirt roads at access points; paving or graveling significant portions of unpaved roads; and reducing use of woodburning stoves.

Urban and Groundwater: Implementing **advanced controls** including: conveying and treating stormwater from 60% of the dense urban areas, and using advanced passive treatment controls on dispersed urban areas. Employing current practices on a 20% of urban areas. Achieving a high level of private property BMP implementation.

Forest: Treating 60% of unpaved roads, ski runs, campgrounds and other disturbed forested areas using current best practices; employing intensive treatments such as on-site sediment capture on 10% the area; restoring an additional 10% of unpaved roads and disturbed areas. Assumes 15% of the forest will be treated to reduce fuels loads (2/3 of which will receive standard pollutant controls and the other 1/3 will be treated using more intensive treatment approaches).

Streams: Combining stream channel rehabilitation and restoration on 80% of the potential project areas on each of the Upper Truckee River, Ward Creek and Blackwood Creek.



Example Pollutant Controls

• Weekly fine particle-effective street sweeping • Pave dirt roads at access points • Gravel unpaved roads • Collect and treat urban stormwater with advanced mechanical or chemical treatments • Advance deicing and reduced use of road sands • Fertilizer management & sales restrictions	• High degree of implementation of private property BMPs in dispersed urban areas • Impervious and soft coverage removal • Forest treatments done with ground-based equipment and required BMPs focusing on unpaved roads, disturbed areas and fuels treatment areas • Stream channel restoration and bank protection

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Figure 3-8. A reproduction of the handout describing *Scenario C - All Out Push from October 25, 2007.*[26]

[26] See Appendix B/Formulate Integrated Strategies/All Out Push (details).

Forum and Focus Team Comment on Scenarios

The scenarios were presented to the Focus team and the Forum together on October 25, 2007.[27] Highlights of the information presented are as follows:

Information presented to the Focus Team and Forum October 25, 2007

Focus of discussion: Three scenarios (see preceding pages)
- Scenario A - Retrofit and Enhanced Best Practices
- Scenario B - Focus on Innovation and Advanced Practices
- Scenario C - All Out Push

Discussion topics:
- Reiteration of recommendation to focus on fine sediment removal
- Recommendation to focus effort in the atmospheric category on non-mobile sources
- Finding that continuation of current practice would not achieve the Clarity Challenge

Citable versions of this information are in Chapter 2: Recommended Water Quality Management Strategy.

The TMDL team recommended that the strategy for reducing pollutant inputs to Lake Tahoe emphasize fine sediment removal because it is responsible for the majority of the clarity condition, and the Clarity Model shows that lake response from fine sediment particle reduction alone is similar to reductions available from a combination of fine sediment particles, nitrogen and phosphorus.

Splitting non-mobile and mobile sources of atmospheric pollutants and the advanced PAT analysis led the TMDL team to recommend focusing efforts exclusively on non-mobile sources of atmospheric pollutants. Non-mobile sources such as roads produce 88 percent of the fine sediment particles from this source category (Lahontan and NDEP 2007b, p. 52) and available pollutant controls such as fine particle street sweepers are cost effective. The recommendation particularly noted street sweeping, using advanced traction compounds, and restoring or surface treatment of unpaved surfaces as focus areas. This recommendation was further supported by accepting the earlier recommendation to focus on fine sediment particle reductions and continue to track nutrient reductions.

The TMDL team completed an analysis showing that continuing current practices would not achieve the Clarity Challenge. The PAT provided a venue to input assumed application levels from each source category and produce estimates of total costs and benefits. The assumed application levels for each source category were as follows:

- Urban Tier 1: 70%
- Stream Channel Tier 2: 80%
- Forest Tier 1: 80%
- Atmospheric non-mobile sources Tier 2: 70%

This analysis estimated capital investment at $1.1 billion, annual O&M at $7.4 million. The benefit of implementing these practices was estimated at 22 percent fine sediment particle reductions and 75 feet of clarity.

[27] See Appendix B/Formulate Integrated Strategies/Forum & Focus Team October 25, 2007, Meeting Materials.

The TMDL team presented forest management pollutant reduction recommendations. On the basis of the pollutant's total percentage of input to Lake Tahoe, forest sources account for significantly less impact than do atmospheric deposition and urban runoff sources. Therefore, the TMDL team recommended that the current multi-objective approach to forest management continue; including aggressive implementation of BMPs wherever forest fuels treatments could cause an impact and mitigation of impacts from highly disturbed areas such as unpaved roads, ski runs and campgrounds.

The TMDL team recommended continuing current and planned stream restoration activities and supported monitoring and research in this source category. Stream restoration is highly cost-effective and provides water quality and ecosystem benefits beyond what just stream channel work would achieve. However, the quantifiable fine sediment particle load reductions are not as large as load reductions from other source categories such as urban and atmospheric. More information and additional studies will be available in the near future, and crediting and tracking for stream restoration projects will be updated accordingly.

The TMDL team presented urban runoff pollutant reduction recommendations. Urban upland runoff accounts for 72 percent of the pollutant input to Lake Tahoe. The TMDL team recommended that to meet the Clarity Challenge (1) consider Tier 1 applications for dispersed coverage areas; (2) apply substantially more Tier 2 treatments (filtration and O&M); and (3) consider and research Pump & Treat applications for some areas.

As the Forum and Focus team were combined for this interaction, their feedback was gathered from combined small groups in discussion about the topics presented. The feedback received subsequently helped inform development of the Recommended Strategy.[28] This feedback is presented in Table 3-10.

[28] See Appendix B/Formulate Integrated Strategies/Forum & Focus Team Scenarios Meeting Notes October 25, 2007.

Table 3-10. Forum and Focus Team Feedback Regarding Scenarios

Feedback on Scenarios

Scenario A - Retrofit Enhanced Best Practice
- Like scenario B as a means to get to scenario C
- Like scenario A as a means to get to C (go with what we can do before try to run)—make sure progress is being made while innovation is being pursued
- Some skepticism of A as a scenario

Scenario B - Innovation & Enhanced Best Practice
- Scenario B is good because of value and applicability for achieving 100-foot clarity
- Combine Scenario A and B
- Scenario B—Issues of return relative to expectation
- Be realistic about the time it will take to get Pump & Treat pollutant controls underway
- Lean toward innovation, history shows it will be to good end; account for *creative breakthroughs* in the time frame of the project
- Use scenario B and ask for the full amount required – say "Here is what we need to make the Clarity Challenge"
- Develop a scenario using maximum implementation of all current best practices. Then apply a realistic filter to work backward from there.

Scenario C - All Out Push
- Pursue the All out push
- Like scenario C
- Go with C, okay to pull in some aspects of B
- What is the incentive to exceed the clarity challenge (why would anyone want to go to scenario C?)
- Aim high—all out push—do whatever it takes to save the Lake
- Momentum is there for A to B to C
- Make sure not to make us stop the progress
- May be better off to do as much work early as possible—because it will be cheaper overall
- Consumer action seems least likely to make a difference in this scenario

New Scenario Ideas Proposed

- High-confidence scenario
- Incentive-based scenario
- Un-development scenario
- Sustainability scenario (sustainable clarity over time)
- Stormwater export out of Basin scenario
- Compliance with everything already on the books scenario

Transportation
- Transportation-focus scenario
- Need a scenario that covers transportation—take things that are in other scenarios but craft in terms of transportation—calculate emissions per person, per mile. A transportation scenario is more compelling when it comes to raising funds than other scenarios might be.

Cost
- Distribute cost equitably
- Prioritize by cost-benefit before bundling at source category level; use most effective and least costly pollutant controls
- Target best bang for the buck from each source
- Emphasize least cost that will get to Clarity Challenge

Feedback on Pollutant Controls within the Scenarios

Private property BMPs
- Caution on ever including 100% private property BMP implementation
- Pull back on reliance on private property BMP
- Combine defensible space and erosion control efforts
- Enforcement an agency issue
- Question residential BMP effectiveness
- Do not drop residential BMPs—tie to incentives like defensible space and insurance credits
- People would rather pay long term into public system than put down a bunch of cash for private BMPs
- Remove impervious coverage (purchase for-sale lots with homes on them to retire coverage)

Sweeping
- Fine as a pollutant control
- Make sure frequency and effort are fine-tuned for maximum effectiveness, least nuisance
- Needs regional effectiveness measuring/adjusting

Residential wood combustion
- Not a good pollutant control
- Too little gain for the trouble
- A health and safety issue
- Just focus on incentives (rebates and EPA-compliant stoves)
- Use education as a pollutant control for raising awareness about good/bad times for wood stove use
- Don't mess with woodstoves—too little gain for the price you will pay with the public
- De-emphasize residential wood burning reduction—complement with incentives (especially for low-income households)

Pump & Treat
- Fine as a pollutant control
- Test further before putting too much emphasis here
- Use existing infrastructure
- Look into localizing efforts over regionalizing efforts
- Pump & Treat—early stage, introduce it, but don't rely on it…introduce slowly
- Pump & Treat scenic and noise issues—can publicly fund
- Stormwater fees as a way to pay for Pump &Treat
- Fine as pollutant control to consider… need to know more
- Pump & Treat—if you've got to do it, you've got to do it.
- Is there any redundancy between private property BMPs and the Pump & Treat controls?

Focus on transportation
- Keep VMT and look at ecosystem benefits
- RE: VMT—Don't let it drop because the benefits would be so great
- VMT is out-dated way of looking at transportation
- Don't de-emphasize transportation efforts, fine to let VMT specifically go
- Use less salt, sand, looking into alternatives favorable
- Maintain safety but look to alternatives to road sanding

Themes

Pursue a course in which you have a high degree of certainty

- Certainty and ability to reach expectation that you are setting out to achieve needs to be an explicit part of the equation
- If we are going to put our faith in these things, let's make sure we have confidence they will work
- Invest in effectiveness and best chance of success

Pursue incentives

- Incentives a good way to redistribute burden
- Are there ways to switch to incentivizing?
- Move from stick to carrot…If we are going to ask folks to change behavior, make it more incentive based and focus on education

Set up a system that is accountable

- Demonstrate progress
- Make sure monitoring is factored into any future scenario
- Emphasize the public visibility of progress in each source category
- Emphasize accountability and follow through
- Require payment into public program for those who do not do private BMPs—that takes the burden for them
- Document costs and benefits, including social

Pursue benefits to water clarity mutual with other ecosystem benefits

- Highlight collateral benefit to the other thresholds
- Emphasize those that benefit other thresholds
- Social: To get buy-in on TMDL need to put it in context of Regional Plan and don't neglect other thresholds
- Keep an eye out for synergistic effects with other thresholds

Pursue public solutions (as opposed to private)

- Increase emphasis on government action (as opposed to individual action)
- Look to opportunities that don't involve social change (more expeditious)
- Try to keep away from putting burden on the individual
- Must have a plan for a local source of revenue
- Pursue centralized authority and aggregated funding (CA/NV, joint-funding authority and so on.)
- Use a large public works approach "like a sewage treatment plant" if lake clarity is the agreed upon priority
- Public borrowing much cheaper than private borrowing
- Create organizational infrastructure that supports investment in new technology. Designate that certain amount of total funds will go to innovation, improving technology and such

Public Sentiment

- We'll do what makes sense
- We trust Lahontan and NDEP to give us their best judgment regarding what makes sense
- Emphasize incentives over regulation
- Emphasize effectiveness

Messaging

- Use patience and good humor
- Put messages in positive light to fuel energy and innovation
- Message positively for most public support and progress
- Acknowledge (or better, account for) what has already been done
- Market the concept and the target—sell the general public on this
- Be honest
- Do not try to convey that there is consensus
- The *big* conversation is about a package that we can sell
- Provide context—relate the 2030 ask to the 1990–2010 amount actually spent
- Be careful with messaging—Don't give impression "we don't care about anything but water clarity"
- At an individual level, people need to buy in to the need for these controls

Other

- Concern with unpaved road numbers (too high), costs for forest source control seems high
- Focus on Upper Truckee River area—set up incremental goals
- Streams—have a good public image, keep highly visible
- Is the Lake Tahoe TMDL Is the target even attainable?
- Make sure cost distribution is equitable and can be handled

Adjustments of Note from Focus Team and Forum Communication about Scenarios

In response to comments, the TMDL team adjusted the estimate of the forest fuels treatments planned and reevaluated the recommendation not to focus on VMT reductions until science can more adequately quantify the linkage between VMT and particle deposition to Lake Tahoe. During the meeting with the LTBMU and other land managers, the planned treatment of forested lands was lowered from 20 percent to 15 percent. Although not confirmed in current official plans, this estimate is considered a conservative estimate on the basis of projected resource availability. The TMDL team also reevaluated its initial recommendation on the importance of VMT reductions. Current estimates of the fine sediment particle load reductions available might be too rough to use as a basis for significant management decisions. The team performed additional analysis, as described in the next section, and acknowledges that VMT reductions are extremely important for achieving objectives in other resource areas such as air quality, as well as contributing to fine sediment load reductions.

3.4. Cycle 3: Develop and Refine the Recommended Strategy

The Recommended Strategy is the final product of the development process—the combination of pollutant controls combined into a strategy for reducing pollutant inputs into Lake Tahoe to achieve the maximum feasible clarity at an acceptable cost. The Recommended Strategy is explained in Chapter 2 of this report.

Highlights from Cycle 3: Develop and Refine the Recommended Strategy

Products: Responses to stakeholder questions, Recommended Strategy, Refined Recommended Strategy

Review & input venues:

Meeting date/period	Participants
▪ December 6, 2007	▪ Forum
▪ January 29, 2008	▪ Implementers

Adjustments of note:

- Responses to stakeholder questions sought and presented
- Time-series created
- The effects of the timing of innovation are analyzed and compared
- Fuels treatment assumptions are adjusted
- Terminology adjusted

Forum and Focus Team Hear Responses to Questions Posed and Comment on the Recommended Strategy

The TMDL team presented the Recommended Strategy and responses to specific hypothetical questions to the Forum on December 6, 2007.[29] Following are highlights of the information presented.

Information presented to the Forum December 6, 2007

Focus of discussion: Responses to stakeholder questions
The Recommended Strategy

Discussion topics:

- High-confidence pollutant controls
- Effects of increased impervious cover
- Effects of lowering VMTs
- Technology and the Clarity Challenge
- Pollutant controls' potential effect on other resource areas

Citable versions of this information are in Chapter 2: Recommended Water Quality Management Strategy.

Responses to Stakeholder Questions

Stakeholders posed several hypothetical questions earlier in the development process. The TMDL team used all available tools and data to provide quantitative answers whenever possible. In many cases, the answers were specific and quantitative, while in other cases, data limitations allowed only qualitative answers. In a few cases, the tools and data were not adequate to provide a specific response. Questions that were analyzed but not answered in public meetings are included for reference here. Questions that were answered are summarized here and explanatory slides are included in Appendix B.

Can we focus on high-confidence pollutant controls? – The TMDL team considered two kinds of confidence in this analysis: *analytic confidence* was provided by the source category groups, while *implementation feasibility* was judged by members of the TMDL team. Pollutant controls that did not score high in these ratings were eliminated from Scenario B. These criteria eliminated all atmospheric controls, eliminated Tier 3 urban controls, and reduced the application of Tier 2 urban controls.

Results: High-confidence pollutant controls do not achieve the Clarity Challenge. They reduce fine sediment particle loads by 27 percent instead of the necessary 32 percent. These include capital costs of $1.7 billion.

What are the effects of increased impervious cover? How much will fine sediment particle loads increase at full build out? – The TMDL team used the Watershed Model and a series of development simulations to estimate the additional fine sediment particle load that would result under existing development rules. In a separate trial, the Watershed Model was tested for sensitivity to 10 percent increase and a 10 percent decrease in impervious cover after full build out. The 10 percent change in impervious cover was achieved by increasing coverage equally in

[29] See Appendix B/Develop and Refine the Recommended Strategy/Forum December 6, 2007, Meeting Materials.

all subwatersheds.

Results: Fine sediment particle loads are estimated to increase by just over 2 percent at full build out. A 10 percent change in coverage is estimated to change fine sediment particle loads by 8 percent.

What are the effects of investing in pollutant controls on mobile atmospheric sources (lowering VMT)? – The TMDL team created an additional scenario that supplemented Scenario B with maximum effectiveness mobile controls applied at the maximum intensity (80 percent, Tier 3).

Results: When lowering VMT, nitrogen reductions increase from four to 15 percent, fine sediment particle reductions increase less than 1 percent, capital costs increase from $1.5 billion to $2.1 billion, and annual O&M costs increase from $11 million to $271 million. Note that the atmospheric source category group estimated offsetting O&M revenues from mobile source controls.

How far could a maximum technology scenario take us beyond the Clarity Challenge? – The TMDL team created another hypothetical scenario that maximized the application level of the most advanced pollutant controls. This maximization was still subject to the constraint that only 80 percent of a setting could be treated. Stream channel and forest pollutant controls were not changed from their Scenario B values. The maximum technology scenario was compared to Scenario B.

Results: In a maximum technology scenario, fine sediment particle reductions increase from 32 percent to 44 percent, capital costs rise from $1.5 billion to $2.2 billion, and annual O&M costs rise from $11 million to $17 million.

How will the pollutant controls affect other resource areas? – It is expected that any significant implementation of the pollutant controls will affect other resource areas. For instance, the stream channel erosion pollutant controls would be expected to enhance fish spawning habitat and atmospheric dust controls would increase air quality by decreasing particulate matter and increasing visibility. In another example, it is conceivable that centralized treatment pumps for urban stormwater could create noise that may affect sound levels in their vicinity. There was insufficient data to provide quantitative results to this question. Table 3-11 was presented to indicate expected interactions. Overall, pollutant controls are generally believed to have predominantly beneficial effects on other resource areas and their implementation is consistent with attainment of TRPA thresholds for these resource areas.

Table 3-11. Expected Positive (blue) and Negative (red "X") Effects of Pollutant Controls, Expected Magnitude of Effect is Depicted by Symbol Size

Scenario B	Wild/ Fish	Soil	AQ	Veg	Noise	Scenic	Rec
Urban & GW	•	•	●	•	x		
Atmospheric	•		●	•	•	●	
Streams	●	●		●		●	•
Forest	●	●		●		•	

What are the effects of climate change on the Lake Tahoe TMDL? – The Lake Tahoe TMDL includes a targeted study of 84 climate change simulations. This generated 11 precipitation and temperature scenarios that were considered a reasonable estimate of the possibilities for the future Tahoe Basin climate. These scenarios were used as inputs to the Watershed Model, and new hydrology results were generated. Resource limitations have not permitted application of the new hydrology results to pollutant transport subroutines.

Results: The hydrology results vary, but central tendencies point to more precipitation as rain, 9 inches less peak snow pack, 10-day later snowpack, and a 73-day reduction in presence of the snowpack.

Time-Series Analysis

The Lake Tahoe TMDL must consider the path to achieve the Clarity Challenge and the overarching numeric target. The time-series analysis was built using a series of PAT runs based on Scenario B, stakeholder input, and a series of assumptions about funding availability, pollutant control implementation rates and lake response lag. The analysis resulted in four sets of data that defined estimated potential load reductions and costs for four milestones. Each milestone was based on a uniform level of effort measured by a capital cost of $500 million invested between each milestone. Milestones were expected to be achieved every fifth year during stakeholder discussions. The specific timing may vary and does not affect the analysis. This analysis is more completely described in Section 2.3: Milestone Analysis.

Innovation Timing Analysis

Stakeholders raised questions about the need to invest scarce funds in innovation that prompted an analysis of the effects of a 10-year delay in implementation of innovative pollutant controls. To answer this question, the TMDL team made adjustments to technology assumptions and compared the numeric results to the Recommended Strategy milestones.

Delayed innovation was represented by limiting the application level for advanced practice and new technology (Tier2 and Tier 3) pollutant controls for the first two milestones. During the later time periods, application levels were controlled by funding available. These assumptions are represented in Table 3-12. These assumptions should be compared to the baseline Recommended Strategy assumptions presented at the end of Section 2.3: Milestone Analysis. In particular, assumption number 7 is related.

The complete set of PAT inputs used for this analysis is provided in Table C-1 of Appendix C.

Table 3-12. Assumptions Limiting Innovation*

Pollutant controls	Milestone #1	Milestone #2	Milestone #3	Milestone #4
Advanced Practices (Tier 2)	10%	20%	$	$
New Technology (Tier 3)	0%	10%	$	$

*Percentages are maxima; dollars represent limitations based only on resource availability

The results of delayed innovation are considerable and graphically depicted in Figure 3-9. The center of each bubble is located at the potential percent reduction of the overall Basin-wide fine sediment budget for each time step. The size of the bubble represents estimated capital cost (in millions) of implementing controls and is rounded to two significant figures. The Clarity Challenge is shown by the horizontal red line.

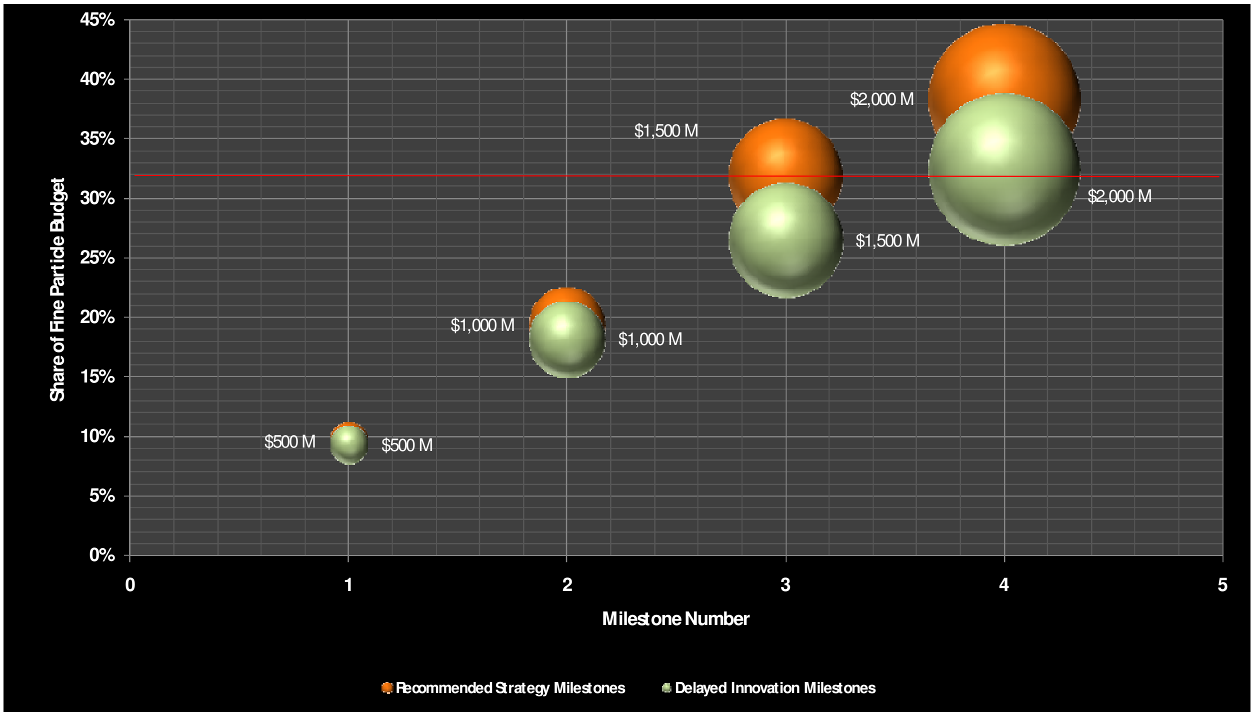

Figure 3-9. A comparison of the Recommended Strategy milestone analysis (orange bubbles) versus a delayed innovation analysis representing a 10-year delay in innovative pollutant controls (green bubbles).

Although capital investment is identical, the delayed innovation results in fine sediment reductions of only 27 percent by the third milestone and 32 percent by the fourth milestone. These fine sediment particle load reductions begin to lose pace with the Recommended Strategy by the second milestone. The overall finding is that achieving the Clarity Challenge is delayed by one milestone and that the maximum potential for fine sediment particle reductions are 6 percent less at the fourth milestone.

Forum and Implementers Feedback Regarding the Recommended Strategy

The December 6, 2007, Forum meeting[30] was structured to encourage open discussion about anything that forum members wanted to address. Themes of the day's discussion echoed those heard throughout the series of communications with the Forum in the year of the project. Where applicable, these themes had already influenced the Recommended Strategy. Those themes that do not directly influence the Recommended Strategy are noted that they could inform implementation efforts for the Lake Tahoe TMDL.

Table 3-13. Forum Feedback Regarding the Recommended Strategy and Other Topics

Feedback on Funding
▪ Competition for funds at the state and federal levels is increasing—set goals accordingly
▪ Increase organizational capacity for securing funding for the Tahoe Basin including ▪ Regional revenue source ▪ Private, local, county, regional, state and federal coordination ▪ Strategize and coordinate communications with funding sources—convey confidence in ability to achieve goals
▪ Apply similar rigor for creating a funding strategy as has been applied to defining the Lake clarity problem
Feedback on Innovation
▪ Innovate with regard to the way regulation plays out in the Tahoe Basin
▪ Increase organizational capacity and effectiveness for monitoring at a Basin-wide level ▪ Monitor effects of innovation to ensure best-possible performance and quality
▪ Market Tahoe as a national center for research and demonstration for innovation to encourage private investment in innovative techniques on-the-ground
▪ Incentivize innovation
▪ Evaluate regulations to remove those that inhibit innovation
Feedback on Pollutant Controls
▪ Look for opportunities to maximize benefit to ecosystem functions beyond water clarity
▪ Emphasize transportation strategies (VMT and infrastructure)
Feedback on Other Topics
▪ Tie clarity improvements to other thresholds
▪ Focus on activities at the subwatershed level, eliminating coverage model

[30] See Appendix B/Develop and Refine the Recommended Strategy/Forum Recommended Strategy Meeting Notes December 6, 2007.

3.5. Refine the Recommended Strategy

To complete the project, the TMDL team made minor changes to application levels, adjusted the terminology used and provided additional data that could be used for load allocations in the *Final Lake Tahoe TMDL* document. Application levels for atmospheric and urban tiers of Scenario B were adjusted slightly to better incorporate stakeholder feedback. During the December Forum meeting, the TMDL team presented the "time-series analysis" of "Scenario B". Subsequent discussions resulted in realization that the results of this analysis would be more appropriately called the "Recommended Strategy" and "milestone analysis." This terminology change will be useful when the Lake Tahoe TMDL agencies produce the *Final Lake Tahoe TMDL* document.

The TMDL team did additional GIS analysis of the Recommended Strategy to provide data that could be used in load allocations. The analysis applied the estimated potential load reductions from the Recommended Strategy in several ways;

- Designating jurisdictions as either forest or urban, then applying the relevant percent load reduction to the jurisdiction's baseline load
- Categorizing land uses as either forest or urban, then applying the relevant percent load reduction and aggregating the land uses by jurisdiction
- Representing all the urban and forest pollutant controls in the Watershed Model and then aggregating the outputs by jurisdiction

The analysis also explored an approach to establishing allocations through equal reduction of the anthropogenic loads of each jurisdiction. A description of this analysis and the resulting data are available in Chapter 4: Analyses Supporting Load Allocations.

4. Analyses Supporting Load Allocations

This chapter presents an estimate of baseline annual pollutant loads by jurisdiction and five approaches to establishing allowable loads for upland sources. Results for each of the methods are provided along with discussion about the potential implications for load allocation associated with each of the approaches. The Lake Tahoe TMDL agencies may use this information to inform discussions with the implementing community and determine the approach that will be included in the Final Lake Tahoe TMDL document.

This chapter focuses on upland pollutant sources and does not present information about potential load allocations to atmospheric or stream channel sources. The urban and forest upland sources will be covered by permits, memoranda of understanding or other regulatory requirements that will directly relate to upland loads and load reductions. The Recommended Strategy does include stream channel load reductions, which will be achieved through other programmatic efforts.

This chapter also describes an analysis of how to appropriately express loads in the TMDL and presents *load duration curves* that can be used to express the *annual* allowable load allocations as *daily* loads. The load duration curves are based on evaluation of EPA guidance document *Options for Expressing Daily Loads in TMDLs* (EPA 2007).

4.1. Distributing Baseline Loads to Jurisdictions

Establishing estimates of how much of the baseline load is attributable to each of the management jurisdictions is a two-step process that involves (1) spatially referencing jurisdictional boundaries in a GIS relative to subwatershed and land use locations, and (2) database aggregation of the original Watershed Model results according to the referenced jurisdictional boundaries.

Methods

Four data sets were used to develop the baseline load estimates by jurisdiction: (1) the results of the Watershed Model baseline run; (2) an aggregated GIS layer of jurisdictions; (3) the Watershed Model land use grid; and (4) the Watershed Model subbasin boundaries. The starting point for the analysis was the Watershed Model baseline loading outputs.

As described in the Technical Report, the Watershed Model results for the baseline run were based on a calibration period from 1995 to 2004. The upland areas results were summarized in a master table of annual average surface and subsurface loads for each pollutant of concern for each subbasin and land use combination. This master table contains results for the 223 modeled subbasins, 20 land uses, and 5 pollutants of concern (Surface TSS, Surface Fines, Surface Particles, Total Nitrogen, and Total Phosphorus), for a total of 22,300 records. The format of this table is presented in Table 4-1. This master table, however, does not include information regarding the jurisdictional boundaries. The table is too large to be included as an appendix of this report, but it is stored within the Lake Tahoe TMDL project records at the Lahontan Water Board and NDEP.

Table 4-1. Example Table Format of Watershed Model Baseline Results

Pollutant	Subbasin ID	Land use ID	Baseline load
Surface Fines (tonne)	1001	1	…
Surface Fines (tonne)	1001	2	…
…	…	…	…
Surface Particles (count)	1001	1	…
Surface Particles (count)	1001	2	…
…	…	…	…
Surface TSS (tonne)	1001	1	…
Surface TSS (tonne)	1001	2	…
…	…	…	…
Total TN (kg)	1001	1	…
Total TN (kg)	1001	2	…
…	…	…	…
Total TP (kg)	1001	1	…
Total TP (kg)	1001	2	…
…	…	…	…

Spatially Referencing Jurisdictional Boundaries in a GIS

The following GIS layers were collected and compiled for this effort. Data sources are listed in parentheses.

1. City of South Lake Tahoe limits (TRPA)
2. USDA Forest Service Lands (TRPA)
3. California Tahoe Conservancy (CTC, TRPA)
4. Nevada State Lands (TRPA)
5. California State Parks (TRPA)
6. Counties (TRPA)
7. General Improvement Districts for Douglas County (Douglas County, NDEP)

An aggregated jurisdiction GIS layer was created by merging the various component layers and dissolving features within within unique jurisdictional boundaries. In those instances where an area was shared by two or more jurisdictions, the order of precedence for jurisdiction assignment was as follows: (1) USDA Forest Service, (2) California Tahoe Conservancy, (3) State Parks, (4) State Lands, (5) Cities, and (6) Counties. Douglas County is further subdivided into General Improvement Districts. Since the all-inclusive county boundaries was last in the order of precedence, any area not previously assigned to one of the preceding jurisdictions was automatically included as general county land. Because primary roads were already distinguished within the TMDL land use layer, CALTRANS and NDOT jurisdiction areas were assigned directly from this land use category by state.

The aggregated jurisdictional layer was intersected with the subbasin layer to obtain a composite layer containing both subbasin and jurisdictional information, as illustrated in Figure 4-1. This new layer was overlaid upon the Watershed Model land use grid, and the attributes tabulated according to the new jurisdiction and subbasin combinations. The result was a table of subbasins, jurisdictions, and land use areas.

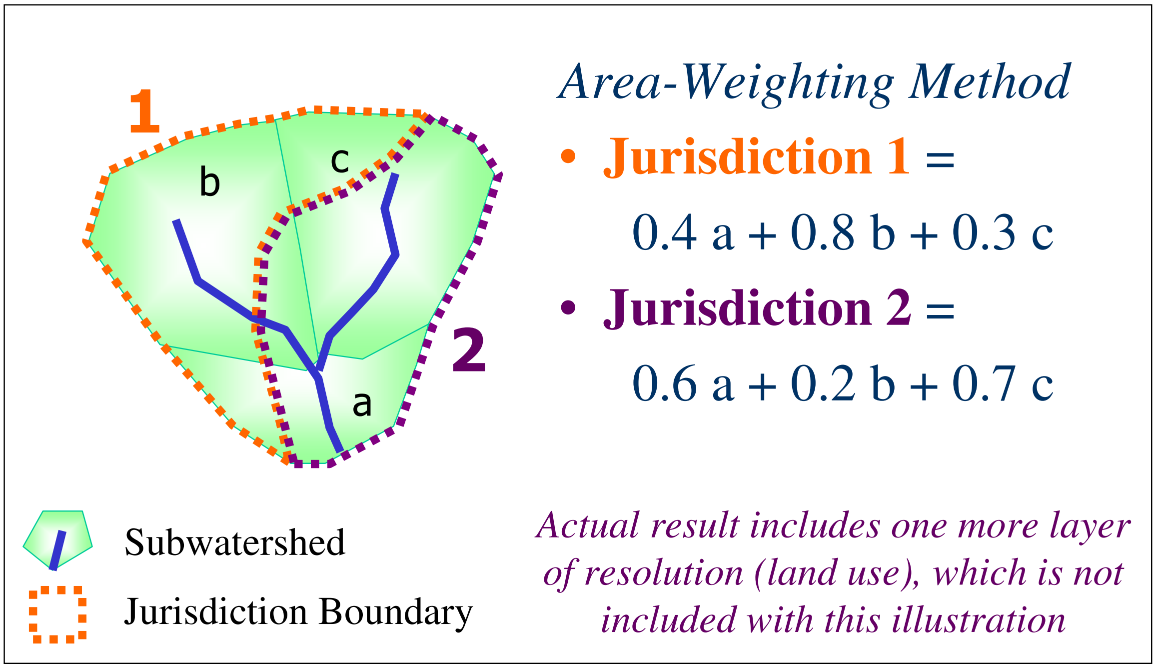

Figure 4-1. Area-weighting method used to build a composite subbasin-jurisdiction layer

Figure 4-2 presents a summary of the land uses by jurisdiction as a percent of its area obtained from the process described here. To simplify presentation, two jurisdictional consolidations have been made. First, the Douglas County General Improvement Districts (GIDs) have been grouped as Douglas County, NV. The second consolidation includes the forested jurisdictions: CTC; USFS; Nevada State Lands; California and Nevada State Parks; and Carson City, Nevada. Detailed summaries for each of the individual jurisdictions are presented in Appendix C.

The composite jurisdiction-and-subwatershed layer was used to resample the numerical results. For each jurisdiction, the percent area of each subbasin and land use combination served as a weighting factor for the jurisdictional roll-up. An example excerpt of this table is shown in Table 4-2. In this case, 25 percent of the Veg_EP3 land use (Vegetated Erosion Potential 3) of subbasin 1001 falls within the US Forest Service jurisdiction, while 10 percent is part of the Nevada State Lands, and the remaining 65 percent is part of Washoe County.

Table 4-2. Example Table of Percent of Area by Jurisdiction

Subbasin	Land use ID	Land use description	Jurisdiction	State	Percent of area
1001	7	Veg_EP3	US Forest Service	NV	24.71%
1001	7	Veg_EP3	NV State Lands	NV	9.92%
1001	7	Veg_EP3	Washoe County	NV	65.36%

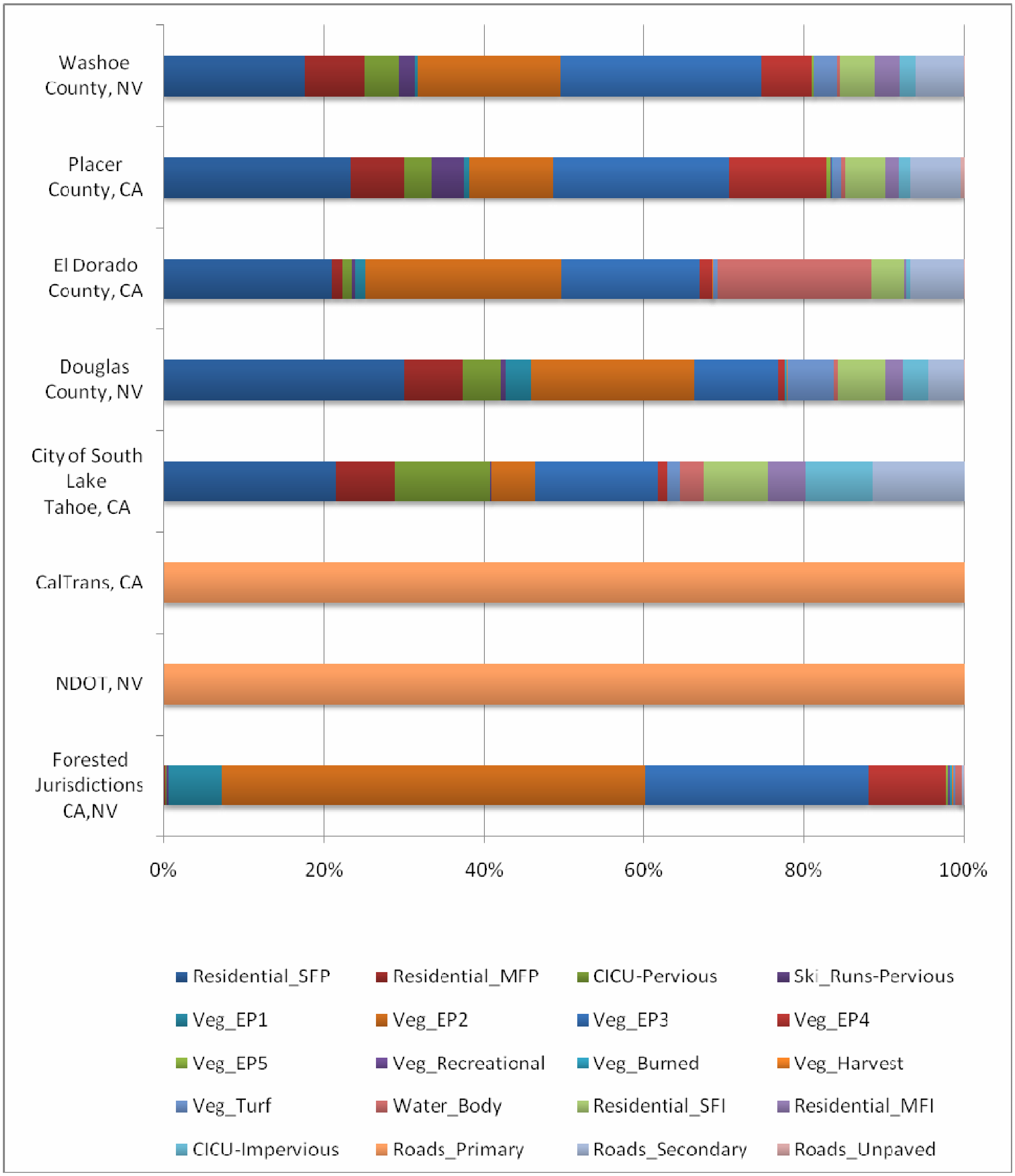

Figure 4-2. A comparison of land use composition among aggregated jurisdictions.

Database Aggregation of Results Based on Jurisdictional Boundaries

The table of subbasin, land use, and percent area by jurisdiction was combined with the model results in the master baseline table. Loads for each jurisdiction were calculated by distributing the land use load for each subbasin according to the resampled jurisdiction percent areas previously described.

In the example started above, the average annual total particles load for the Veg_EP3 land use of subbasin 1001 is approximately 10.37×10^{15}. Table 4-3shows how this amount is split among the three jurisdictions according to their percent distribution. Table 4-4 is an example of how the estimated load by subbasin, land use, *and* jurisdiction are summarized. This exercise was performed for all subbasins, land uses, jurisdictions, and pollutants of concern.

Table 4-3. Example Table of Subbasin Loads Split by Jurisdiction

Subbasin	Land use ID	Land use name	Jurisdiction	State	Fine sediment load (particle #)
1001	7	Veg_EP4	US Forest Service	NV	2.56×10^{14}
1001	7	Veg_EP4	NV State Lands	NV	1.03×10^{14}
1001	7	Veg_EP4	Washoe County	NV	6.78×10^{14}

Table 4-4. Final Baseline Master Table Including Jurisdictions

Pollutant	Subbasin ID	Land use ID	Jurisdiction	Baseline load
Surface Particles (count)	1001	1	Jurisdiction A	…
Surface Particles (count)	1001	1	Jurisdiction B	…
Surface Particles (count)	1001	…	…	…
Surface Particles (count)	1001	2	Jurisdicton A	…
Surface Particles (count)	1001	2	Jurisdicton B	…
Surface Particles (count)	1001	2	Jurisdicton C	…
Surface Particles (count)	…	…	…	…
…	…	…	…	…

Jurisdictional baseline loads were summed for each pollutant from the new table of pollutant, subbasin, land use, and jurisdictions.

Results

Table 4-5 presents the baseline annual average loads of fine sediment particles by jurisdiction along with the associated percentage relative to the basin-wide total. The jurisdictions with the largest total surface fine sediment particles loads are CalTrans and the City of South Lake Tahoe.

Table 4-5. Baseline Fine Sediment Particle Loads by Jurisdiction

Jurisdiction	Baseline (particles x 10^{18})	% of total urban baseline load
Forest Jurisdictions	51.7	13%
CalTrans, CA	76.4	20%
City of South Lake Tahoe, CA	74.6	19%
Douglas County, NV	10.2	3%
El Dorado County, CA	37.6	10%
NDOT, NV	32.8	8%
Placer County, CA	56.9	15%
Washoe County, NV	48.8	13%

4.2. Load Allocation Approaches

The TMDL Team explored five approaches for determining load allocations. The first two approaches applied the Recommended Strategy's source category load reductions directly to each jurisdiction's baseline loads, the third approach applied the Recommended Strategy's load reductions by setting before summarizing by jurisdiction, the fourth approach explicitly represented Recommended Strategy controls within the watershed model to spatially distribute associated level of application relative to the baseline run, and the fifth approach directly applied the required load reduction to a watershed model estimate of anthropogenic loading.

Table 4-6 presents a summary of the allocation approaches. The *Basic map unit* column is the starting point for the analysis. The *Basis for assigning load reduction* column explains how the reductions are calculated. The *Load reduction aggregation to* column shows that all load reductions are summed by jurisdictions for all approaches. The methods and results for each approach are described in the following sections.

Table 4-6. Summary of Allocation Approaches

	Basic map unit	Basis for assigning load reduction	Load reduction aggregated to
Approach I: Predominant Load Source	26 Jurisdictions	Baseline loading reduced by the source category % reductions from the Recommended Strategy	26 Jurisdictions
Approach II: Load Source Weighted	20 TMDL Land Uses Aggregated to Forest or Urban	Baseline loading reduced by the source category weighted % reductions from the Recommended Strategy by land use	26 Jurisdictions
Approach III: Setting Specific	4 Urban Settings plus 3 Forested Settings (Groupings of the 20 Land Uses)	Baseline loading reduced by the setting-specific % reductions from the Recommended Strategy by setting	26 Jurisdictions
Approach IV: Watershed Model	Watershed Models' subbasins and land uses	Watershed model's estimates of HSC, PSC, and SWT effects. Application levels from the Recommended Strategy by setting and tier are modeled	26 Jurisdictions
Approach IV: Anthropogenic Loading	Basin-wide	Uniform % reduction of anthropogenic load	26 Jurisdictions

Load Reduction Milestones and the Load Target

The milestone analysis, described in Chapter 2: Recommended Water Quality Management Strategy was the basis for setting load reduction milestones. The four milestones provide a path to reaching the Clarity Challenge. An additional, *Lake Tahoe TMDL final load target* (load target) is necessary to estimate the additional load reductions to achieve the *Lake Tahoe TMDL numeric target* of 97.4 feet of clarity (Lahontan and NDEP 2007a, pp.2–8). The pollutant load reductions for the load target were calculated by linearly extrapolating the average load reduction rates through the fourth milestone to achieve the numeric target defined by using the Lake Clarity Model.

Approach I: Predominant Load Source

Approach I: Predominant Load Source categorized each *jurisdiction* as urban or forested based on the type of land use, urban or forest, which causes the predominant load from the jurisdiction. The corresponding percent load reduction for the predominant source category determined by the Recommended Strategy milestones analysis was then applied to the jurisdiction's baseline load. For instance, if 20 percent of a county's load comes from forest land uses and 80 percent comes from urban land uses, the county would be expected to achieve a 34 percent reduction from baseline loading to meet the third (Clarity Challenge) milestone. The 34 percent reduction corresponds to the load reduction expected from all urban uplands.

Methods

Table 4-7 shows the Basin-wide average load reductions corresponding to each of the milestones and the load target for forest and urban sources. The percent reductions are from the source category specific baseline pollutant budget. They were calculated using Equation #1 with the necessary percent reduction at each milestone taken from the Basin-wide load reduction milestones presented in Chapter 2: Recommended Water Quality Management Strategy.

Equation #1:

$$\%\ \textit{Reduction from Source Category Baseline} = 100 \times \frac{\textit{Necessary \% Reduction at Milestone}}{\textit{Source Category \% of Baseline Load}}$$

Table 4-7. Average Fine Sediment Percent Reductions at Each Milestone for Forest and Urban Source Categories

Pollutant	Milestone	Forest reduction*	Urban reduction*
Fine Sediment Particles	#1	6%	10%
	#2	9%	21%
	#3	12%	34%
	#4	12%	42%
	Load Target	20%	71%

*All values provided are percentages of the forest or urban specific source category baseline pollutant budget.

The resulting designations for each jurisdiction are presented in Table 4-8, with the loading source shown in Figure 4-3. Even though the area for some counties was a majority forested, the predominant load source for all counties, primary road jurisdictions and the City of South Lake Tahoe was urban.

Table 4-8. Predominant Load Source of Jurisdictions (Approach I)

Jurisdiction	Forest/Urban category
California Tahoe Conservancy, CA	Forest
CalTrans, CA	Urban
Carson City (Rural Area), NV	Forest
City of South Lake Tahoe, CA	Urban
Douglas County, NV	Urban
El Dorado County, CA	Urban
USFS, CA	Forest
USFS, NV	Forest
NDOT, NV	Urban
Placer County, CA	Urban
State Lands, NV	Forest
State Parks, CA	Forest
State Parks, NV	Forest
Washoe County, NV	Urban

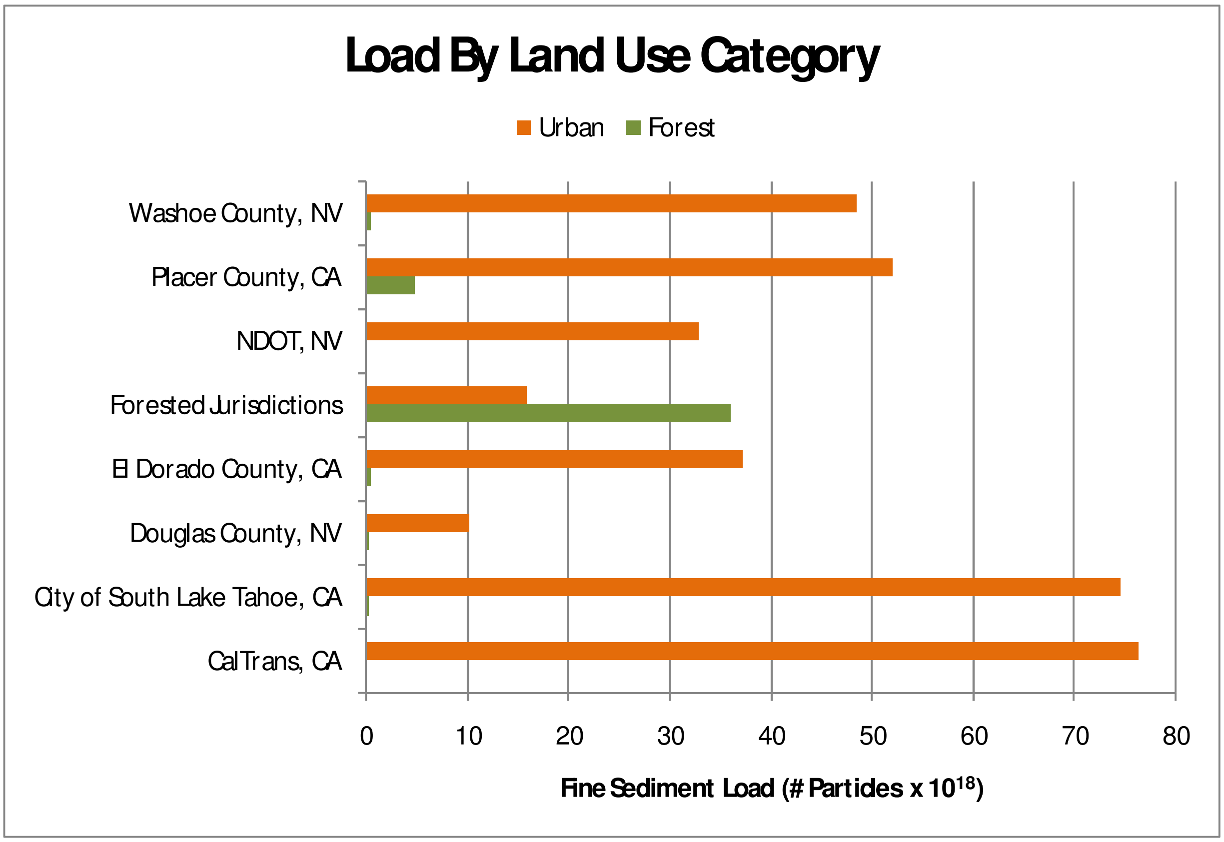

Figure 4-3. The portion of each major jurisdiction's fine sediment particle load categorized as forested or urban.

Analysis Assumptions

This analysis assumes that load reduction capability is primarily determined by the dominant loading source and that other loading sources within a jurisdiction will not significantly change the jurisdiction's ability to reduce overall loads. This assumption is valid in cases where forested land uses make up a small proportion of loading within a predominantly urban area. This assumption is less valid when urban land uses make up a small part of a forested area because there is a larger potential for urban areas to reduce fine sediment particles.

Results

The results of the Predominant Load Source approach are presented in Table 4-9. Allowable loads were calculated using Equation #2. Urban jurisdictions had higher load reduction percentages than forested jurisdictions, and all urban percent reductions were the same.

Equation #2:

$$\text{Allowable Load} = \text{Baseline Load} - \text{Baseline Load} \times \frac{\%\ \text{Reduction}}{100}$$

Table 4-9. Fine Sediment Particle Jurisdictional Percent Reductions and Allowable Loads at Each Milestone for Approach I: Predominant Load Source Approach[31]

Jurisdiction	% Reduction from jurisdiction baseline[32]					Allowable load (particles x10^{18})					
	Milestone #1	Milestone #2	Milestone[33] #3	Milestone #4	Load target	Baseline load	Milestone #1	Milestone #2	Milestone #3	Milestone #4	Load target
Forested Jurisdictions[34]	6%	9%	12%	12%	20%	51.7	48.8	47.2	45.7	45.6	41.4
CalTrans, CA	10%	21%	34%	42%	71%	76.4	68.5	60.2	50.5	44.2	22.0
City of South Lake Tahoe, CA	10%	21%	34%	42%	71%	74.6	66.9	58.8	49.3	43.2	21.5
Douglas County, NV	10%	21%	34%	42%	71%	10.2	9.2	8.0	6.7	5.9	2.9
El Dorado County, CA	10%	21%	34%	42%	71%	37.6	33.7	29.6	24.9	21.8	10.8
NDOT, NV	10%	21%	34%	42%	71%	32.8	29.4	25.9	21.7	19.0	9.4
Placer County, CA	10%	21%	34%	42%	71%	56.9	51.0	44.8	37.6	32.9	16.4
Washoe County, NV	10%	21%	34%	42%	71%	48.8	43.8	38.5	32.3	28.3	14.1

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[31] Similar tables for total nitrogen and total phosphorus are included in Appendix C.
[32] These percent reductions are based on the jurisdictional baselines, not the Basin-wide values presented in Table 4-7.
[33] The third milestone corresponds to the Recommended Strategy. Load reductions associated with the Recommended Strategy (and thus the third milestone) are expected to achieve the Clarity Challenge.
[34] Forested jurisdictions include CTC; USFS; State Lands, Nevada; California and Nevada State Parks; Carson City, Nevada. For the results of each of these individual jurisdictions, see Appendix C.

Approach II: Load Source Weighted

Approach II: Load Source Weighted categorized each of the 20 TMDL *land uses* as either urban or forested and determined the amount of pollutant load coming from each category of each jurisdiction. The corresponding source category percent load reduction from the Recommended Strategy was applied to the urban and forested loads independently and summed to determine the total jurisdictional load reduction. For example, if 20 percent of a county's load comes from forest land uses and 80 percent comes from urban land uses, the county would be expected to achieve a 12 percent load reduction from the forest load and a 34 percent load reduction from the urban load to meet the Clarity Challenge milestone. This corresponds to an overall jurisdictional weighted load reduction of 30 percent.

Methods

This approach used the baseline loads distributed to jurisdictions and the relative source category load reductions resulting from the milestone analysis. Table 4-10 shows which land uses were categorized as urban versus forest, and Figure 4-4 summarizes the distribution of urban and forested land use classifications for each jurisdiction. Figure 4-3 above, shows the fine sediment particle loads, summarized by forest and urban land use categories, for each jurisdiction.

Table 4-10. Categorization of Land Uses as Urban or Forest

Land use ID	Land use name	Land use category
1	Residential_SFP	Urban
2	Residential_MFP	Urban
3	CICU-Pervious	Urban
4	Ski_Runs-Pervious	Urban
5	Veg_EP1	Forest
6	Veg_EP2	Forest
7	Veg_EP3	Forest
8	Veg_EP4	Forest
9	Veg_EP5	Forest
10	Veg_Recreational	Forest
11	Veg_Burned	Forest
12	Veg_Harvest	Forest
13	Veg_Turf	Urban
14	Water_Body	Waterbody
15	Residential_SFI	Urban
16	Residential_MFI	Urban
17	CICU-Impervious	Urban
18	Roads_Primary	Urban
19	Roads_Secondary	Urban
20	Roads_Unpaved	Forest

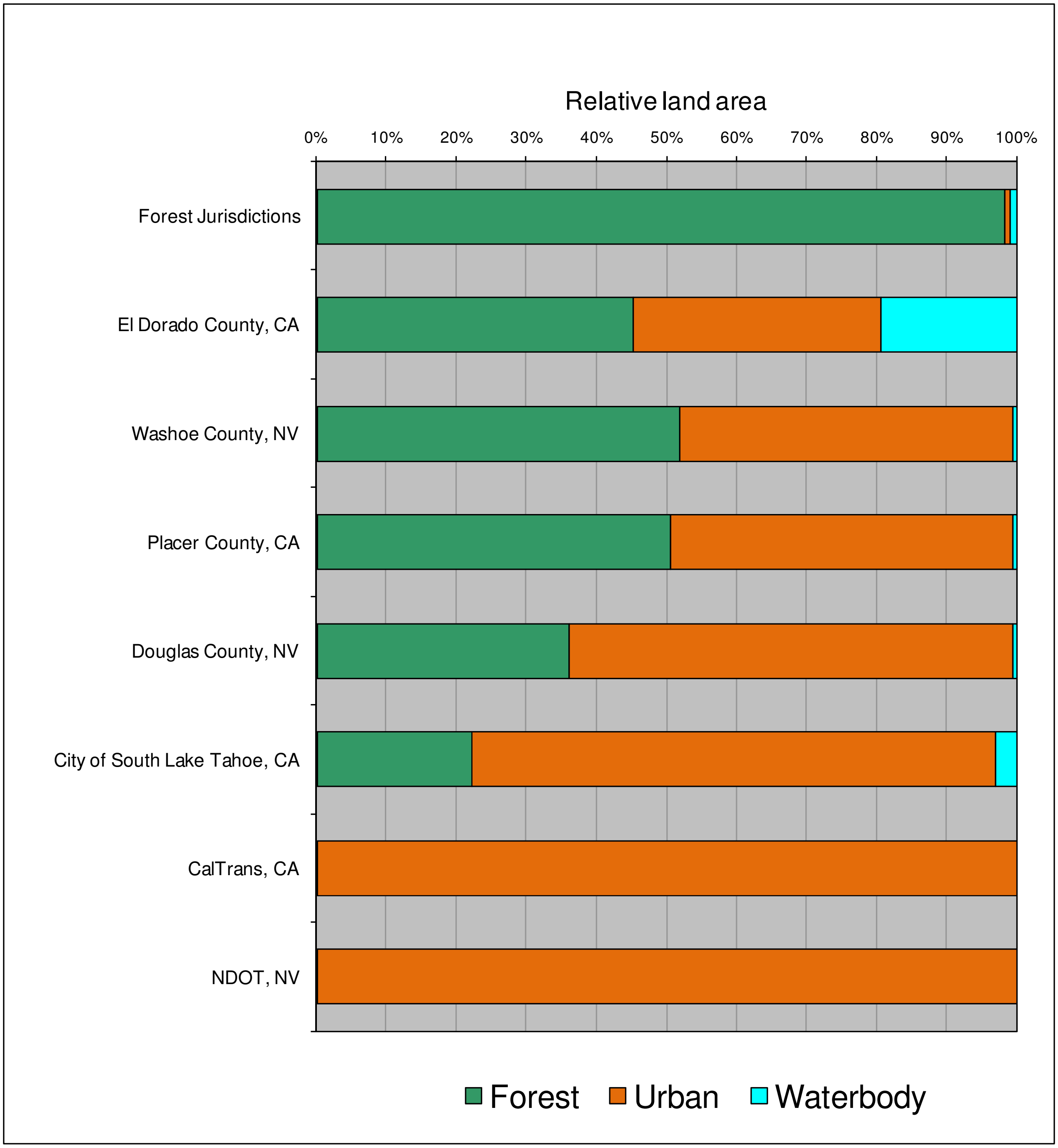

Figure 4-4. The relative portion of each major jurisdiction's land use, categorized as forest, urban, and waterbody.

Analysis Assumptions

This analysis assumes that load reductions at the jurisdictional scale can be achieved in urban and forested land uses similar to the average reductions for urban and forest land uses developed in the Recommended Strategy. It does not differentiate between load reduction potential among the various urban and forest land use categories. It also does not consider any spatially variability in load patterns associated with climate and hydrologic variability around the basin.

Results

The results of the Load Source Weighted approach are presented in Table 4-11. Allowable loads were calculated using Equation #2. Percent load reductions from urban jurisdictions are somewhat similar to each other despite differences in the percent area of urban and forested land uses. This is because the dominance of the urban load (see Figure 4-3). The impact of the urban load allocation is evident even when the fraction of urban land area is less than 50 percent.

Placer County's forested land is considerably higher than the other counties as a result of a greater area of highly erosive forested land uses and the high level of precipitation and runoff in the northwest portion of the Basin. Placer County is the only urban jurisdiction where the forest load notably reduces the load reduction requirement compared to a purely urban area.

Table 4-11. Fine Sediment Particle Jurisdictional Percent Reductions and Allowable Loads at Each Milestone for Approach II: Load Source Weighted Approach[35]

Jurisdiction	% Reduction from jurisdiction baseline[36]					Allowable load (particles x 10^{18})					
	Milestone #1	Milestone #2	Milestone[37] #3	Milestone #4	Load Target	Baseline Load	Milestone #1	Milestone #2	Clarity Challenge #3	Milestone #4	Load Target
Forested Jurisdictions[38]	7%	13%	18%	21%	36%	51.7	48.1	45.2	42.2	40.8	33.3
CalTrans, CA	10%	21%	34%	42%	71%	76.4	68.5	60.2	50.5	44.2	22.0
City of South Lake Tahoe, CA	10%	21%	34%	42%	71%	74.6	66.9	58.8	49.3	43.2	21.5
Douglas County, NV	10%	21%	34%	42%	71%	10.2	9.2	8.0	6.8	5.9	3.0
El Dorado County, CA	10%	21%	34%	42%	71%	37.6	33.7	29.7	24.9	21.9	11.0
NDOT, NV	10%	21%	34%	42%	71%	32.8	29.4	25.9	21.7	19.0	9.4
Placer County, CA	10%	20%	32%	40%	67%	56.9	51.2	45.4	38.7	34.4	18.8
Washoe County, NV	10%	21%	34%	42%	71%	48.8	43.8	38.5	32.4	28.4	14.3

[35] Similar tables for total nitrogen and total phosphorus are included in Appendix C.
[36] These percent reductions are based on the jurisdictional baselines, not the Basin-wide values presented in Table 4-7.
[37] The third milestone corresponds to the Recommended Strategy. Load reductions associated with the Recommended Strategy (and thus the third milestone) are expected to achieve the Clarity Challenge.
[38] Forested jurisdictions include CTC; USFS; State Lands, Nevada; California and Nevada State Parks; Carson City, Nevada. For the results of each of these individual jurisdictions, see Appendix C.

Approach III: Setting Specific

Approach III: Setting Specific used the individual percent reductions by setting from the Recommended Strategy, and applied them to the baseline loads of each setting.

Methods

For this approach, urban upland areas throughout the basin were categorized into 4 settings (either Concentrated Moderate, Concentrated Steep, Dispersed Moderate, or Dispersed Steep). Forest upland areas were split between 3 settings (Setting A, Setting B, and Setting C). The baseline loads from each one of these settings received the average percent reduction by setting from the Recommended Strategy shown in Table 4-12. Finally, the reduced loads were summed by jurisdiction, and the overall jurisdiction percent reduction from baseline was calculated.

Table 4-12. Fine Sediment Particles Percent Reduction by Setting

Pollutant	SCG	Setting	Reduction %
Fine Sediment Particles	Forest	Setting A	75%
		Setting B	66%
		Setting C	2%
	Urban	Conc.-Moderate	42%
		Conc.-Steep	36%
		Disp.-Moderate	43%
		Disp.-Steep	7%

Assumptions

This analysis assumes that load reductions at the jurisdictional scale can be achieved in urban and forested settings similar to the average reductions for those settings developed in the Recommended Strategy. It does not differentiate between load reduction potential *within* settings; however, it begins to factor in differences in load reduction potential *between* settings. Because similar settings are fairly well distributed around the basin, Approach III also does not explicitly consider any spatial variability in load patterns associated with climate and hydrologic variability around the basin.

Results

The results of the Setting Specific approach are presented in Table 4-13. Allowable loads were calculated using Equation #2, and the percent reductions for each setting from Table 4-12. This analysis was completed for the third milestone only.

Table 4-13. Fine Sediment Particle Jurisdictional Percent Reductions and Allowable Loads at Each Milestone for Approach III: Setting Specific[39]

	% Reduction from jurisdiction baseline[40]					Allowable load (particles x 10^{18})					
Jurisdiction	**Milestone #1**	**Milestone #2**	**Milestone[41] #3**	**Milestone #4**	**Load Target**	**Baseline Load**	**Milestone #1**	**Milestone #2**	**Clarity Challenge #3**	**Milestone #4**	**Load Target**
Forested Jurisdictions[42]			18%			51.7			42.7		
CalTrans, CA			31%			76.4			52.9		
City of South Lake Tahoe, CA			42%			74.6			43.0		
Douglas County, NV			29%			10.2			7.2		
El Dorado County, CA			32%			37.6			25.7		
NDOT, NV			24%			32.8			24.8		
Placer County, CA			34%			56.9			37.4		
Washoe County, NV			35%			48.8			32.0		

[39] Similar tables for total nitrogen and total phosphorus are included in Appendix C.
[40] These percent reductions are based on the jurisdictional baselines, not the Basin-wide values presented in Table 4-7.
[41] The third milestone corresponds to the Recommended Strategy. Load reductions associated with the Recommended Strategy (and thus the third milestone) are expected to achieve the Clarity Challenge.
[42] Forested jurisdictions include CTC; USFS; State Lands, Nevada; California and Nevada State Parks; Carson City, Nevada. For the results of each of these individual jurisdictions, see Appendix C.

Approach IV: Watershed Model

Approach IV: Watershed Model used the Watershed Model to simulate the effects of proposed pollutant controls in reducing upland source loads. This approach required a unique run of the Watershed Model and incorporated the hydrologic effects of pollutant controls. It can be thought of as a spatially relevant disaggregation of the Recommended Strategy. In contrast to approaches I, II, and similar to approach III, this approach explicitly accounts for the level of application for the different settings determined in the Recommended Strategy. While approach III averages the model response by setting, the Watershed Model approach reveals different responses for areas of the same setting, but in different locations of the basin. For this reason, the associated allocations by jurisdiction are reflective of spatially variable loading patterns in the watershed.

Methods

For this approach, the Watershed Model was configured to simulate the hydrologic and water quality effects of the application of pollutant controls for the different settings and tiers selected as part of the Recommended Strategy.

The application level of each tier of pollutant control determined in the Recommended Strategy was applied to each watershed according to the appropriate urban setting for urban watersheds or the mix of settings for forest watersheds. The Watershed Model results provided pollutant loads associated with Recommended Strategy application level by subbasin, which are then summed to jurisdictions similarly to the method described in Section 4.1 for distributing baseline loads.

Assumptions

This analysis assumes that pollutant controls will be implemented in every subbasin according to the Recommended Strategy application levels for Tiers 1, 2, and 3. While actual pollutant controls are likely to be implemented more intensively in certain subbasins and others will receive less treatment, this analysis approximates the load reductions possible from implementing pollutant controls throughout the watershed.

Results

The results of the Watershed Model approach are presented in Table 4-14. Allowable loads were provided directly from the Watershed Model outputs, and percent reductions were calculated using Equation #3.

Equation #3:

$$\%\ \text{Reduction from Jurisdiction Baseline} = 100 \times \frac{\text{Baseline Load} - \text{Allowable Load}}{\text{Baseline Load}}$$

This analysis was completed for the third milestone load reductions only.

Table 4-14. Fine Sediment Particle Allowable Loads and Jurisdictional Percent Reductions at Each Milestone for Approach IV: Watershed Model[43]

Jurisdiction	% Reduction from jurisdiction baseline[44]					Allowable load (particles x10^{18})					
	Milestone #1	Milestone #2	Milestone[45] #3	Milestone #4	Load target	Baseline load	Milestone #1	Milestone #2	Milestone #3	Milestone #4	Load target
Forested Jurisdictions[46]			17%			51.7			43.1		
CalTrans, CA			36%			76.4			48.6		
City of South Lake Tahoe, CA			38%			74.6			45.9		
Douglas County, NV			21%			10.2			8.1		
El Dorado County, CA			38%			37.6			23.5		
NDOT, NV			28%			32.8			23.7		
Placer County, CA			34%			56.9			37.5		
Washoe County, NV			33%			48.8			32.5		

[43] Similar tables for total nitrogen and total phosphorus are included in Appendix C.
[44] These percent reductions are based on the jurisdictional baselines, not the Basin-wide values presented in Table 4-7.
[45] The third milestone corresponds to the Recommended Strategy. Load reductions associated with the Recommended Strategy (and thus the third milestone) are expected to achieve the Clarity Challenge.
[46] Forested jurisdictions include CTC; USFS; State Lands, Nevada; California and Nevada State Parks; Carson City, Nevada. For the results of each of these individual jurisdictions, see Appendix C.

Approach V: Anthropogenic Loading

Approach V: Anthropogenic Loading first calculated the *difference* in pollutant loading between the *baseline loads* on the basis of current land uses and *background loads* determined by Watershed Model estimates of pollutant loading from a completely forested watershed. A uniform percent reduction sufficient to meet Basin-wide load reduction milestones was applied to the resulting anthropogenic load. Total allowable loads were determined for each jurisdiction by adding the background load and allowable anthropogenic load at each milestone according to Equations #4.

Equation #4:

$$\text{Total Allowable Load} = \text{Background Load} + \text{Allowable Anthropogenic Load}$$

Where

$$\text{Allowable Antropogenic Load} = \text{Antropogenic Load} - \text{Antropogenic Load} \times \frac{\%\ \text{Reduction}}{100}$$

The following discussion and Figure 4-5 illustrate this approach with the actual values further described below.

- The sum of forest and urban Basin-wide *baseline* load is 389 x 10^{18} particles.
- The sum of forest and urban Basin-wide *background* load is 35 x 10^{18} particles.
- The sum of forest and urban Basin-wide *anthropogenic* load is 354 x 10^{18} particles.
- The sum of forest and urban loading at the third milestone is 266 x 10^{18}. Thus, the allowable anthropogenic load is 231 x 10^{18} (266 x 10^{18} less the background load of 35 x 10^{18}). This corresponds to a 35 *percent anthropogenic load reduction*.

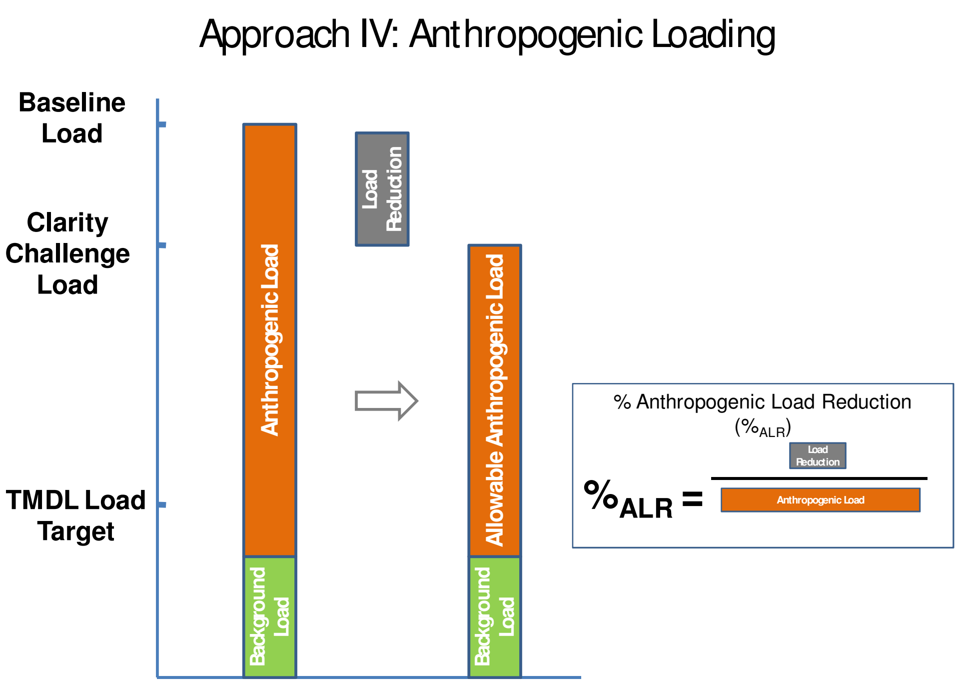

Figure 4-5. A diagram of the key concepts used in Approach IV: Anthropogenic Loading for establishing allowable loads.

This 35 percent reduction was applied to each jurisdiction's anthropogenic load, giving an allowable anthropogenic load at the third milestone. [47] A jurisdiction's total allowable load is the sum of the allowable anthropogenic load and the background load as shown in Equation #5.

Methods

Background loads were determined by running the Watershed Model with all developed land uses replaced by forested land uses: Vegetated EP1 through EP5. The forested land use areas were determined from the erosion potential GIS coverage intersected with the subbasin coverage. Table 4-15 shows the Basin-wide allowable upland load at each milestone, which corresponds to the sum of forest and urban particles at each milestone. The corresponding Basin-wide allowable anthropogenic load was computed by subtracting the background load from the allowable load. The percent anthropogenic load reduction was computed by dividing the allowable anthropogenic load by the total anthropogenic load.

Table 4-15. Basin-wide Allowable Loads and Anthropogenic Load Reductions at Each Milestone

Pollutant	Milestone	Basin-wide allowable upland load (particles x10^{18})	Background load (particles x10^{18})	Allowable anthropogenic load (particles x10^{18})	Anthropogenic load reduction
	Baseline	389	35	354	0%
Fine Sediment Particles	#1	351	35	315	11%
	#2	312	35	276	22%
	#3	266	35	231	35%
	#4	238	35	202	43%
	Load target	162	35	97.5	72%

*All values provided are percentages of the forest and urban upland specific source category baseline pollutant budget.

The jurisdiction specific background loads were determined using the same method described in Section 4.1 above for summing baseline loads by jurisdiction. Jurisdiction specific anthropogenic loads are computed as the difference between the background load and the baseline load. The jurisdiction specific allowable loads were calculated using Equation #4 with the jurisdiction specific baseline and background loads and the percent anthropogenic load reduction from Table 4-16. Results are presented in Table 4-17**.**

Assumptions

This approach assumes that the undeveloped load can be approximated in the watershed model by converting all areas to Vegetated, according to the five established erosion potential groups. This approach is also based on the assumption that anthropogenic loads of pollutants are controllable for all sources with the same effectiveness regardless of their spatial location in the watershed.

Results

The jurisdiction-specific baseline, background and anthropogenic loads are presented in Table 4-16. Allowable loads and percent reductions at each milestone for the Anthropogenic Loading approach are presented in Table 4-17. The results show that a vast majority of anthropogenic loading comes from urban jurisdictions, and the commensurate majority of the load reductions are expected from the urban jurisdictions. Results also show that 40 percent of the load from the forest jurisdictions is anthropogenic from urban or other developed land uses within the forest jurisdictions.

[47] The third milestone is established by the Recommended Strategy and is estimated to achieve the Clarity Challenge.

Table 4-16. Fine Sediment Particle Loads by Jurisdiction[48]

Jurisdiction	Fine sediment particle load (particles $x10^{18}$)			
	Baseline load	Background load	Anthropogenic load	Anthropogenic load % of baseline[49]
Forested Jurisdictions[50]	51.7	30.9	20.9	40.4%
CalTrans, CA	76.4	0.02	76.3	100%
City of South Lake Tahoe, CA	74.6	0.12	74.5	99.8%
Douglas County, NV	10.2	0.05	10.2	99.5%
El Dorado County, CA	37.6	0.29	37.3	99.2%
NDOT, NV	32.8	0.01	32.8	100%
Placer County, CA	56.9	3.6	53.2	93.6%
Washoe County, NV	48.8	0.42	48.4	99.1%

48 Similar tables for total nitrogen and total phosphorus are included in Appendix C.
49 All values have been rounded to three significant figures.
50 Forested jurisdictions include CTC; USFS; State Lands, Nevada; California and Nevada State Parks; Carson City, Nevada. For the results of each of these individual jurisdictions, see Appendix C.

Table 4-17. Fine Sediment Particle Allowable Loads and Jurisdictional Percent Reductions From Baseline Load at Each Milestone for Approach V: Anthropogenic Loading[51]

Jurisdiction	% Reduction from jurisdiction baseline[52]					Allowable load (particles x10^{18})				
	Milestone #1	Milestone #2	Milestone[53] #3	Milestone #4	Load target	Milestone #1	Milestone #2	Milestone #3	Milestone #4	Load target
Forested Jurisdictions[54]	4%	9%	14%	17%	29%	49.5	47.2	44.5	42.8	36.6
CalTrans, CA	11%	22%	35%	43%	72%	68.1	59.6	49.9	43.7	21.1
City of South Lake Tahoe, CA	11%	22%	35%	43%	72%	66.6	58.3	48.8	42.7	20.7
Douglas County, NV	11%	22%	35%	43%	72%	9.1	8.0	6.7	5.9	2.9
El Dorado County, CA	11%	22%	34%	42%	72%	33.6	29.4	24.6	21.6	10.6
NDOT, NV	11%	22%	35%	43%	72%	29.3	25.6	21.4	18.8	9.1
Placer County, CA	10%	20%	32%	40%	68%	51.1	45.2	38.4	34.1	18.3
Washoe County, NV	11%	22%	34%	42%	72%	43.6	38.2	32.0	28.1	13.8

[51] Similar tables for total nitrogen and total phosphorus are included in Appendix C.
[52] These percent reductions are based on the jurisdictional baselines, not the Basin-wide values presented in Table 4-7.
[53] The third milestone corresponds to the Recommended Strategy. Load reductions associated with the Recommended Strategy (and thus the third milestone) are expected to achieve the Clarity Challenge.
[54] Forested jurisdictions include CTC; USFS; State Lands, Nevada; California and Nevada State Parks; Carson City, Nevada. For the results of each of these individual jurisdictions, see Appendix C.

Approach Comparison

Each of the approaches provides load reductions from the baseline load. Figure 4-6 shows the baseline load and the allowable loads at the third (Clarity Challenge) milestone for each jurisdiction using the five different load reduction approaches. Figure 4-7 shows the percent reduction from the jurisdiction's baseline load to the Clarity Challenge milestone for each jurisdiction using the five different load reduction approaches.

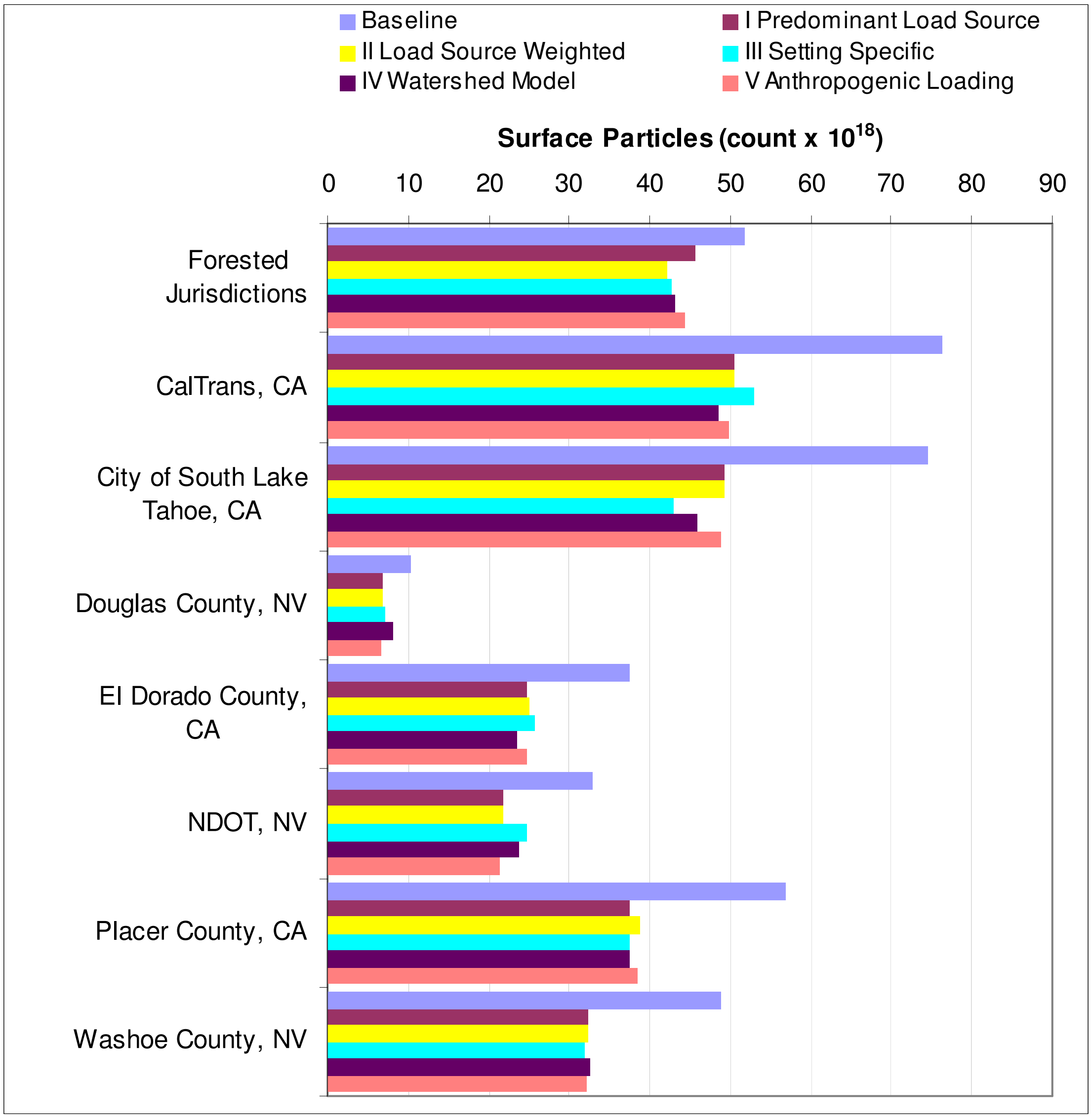

Figure 4-6. Fine sediment particle load by jurisdiction for baseline and at the Clarity Challenge Milestone for five allocation approaches

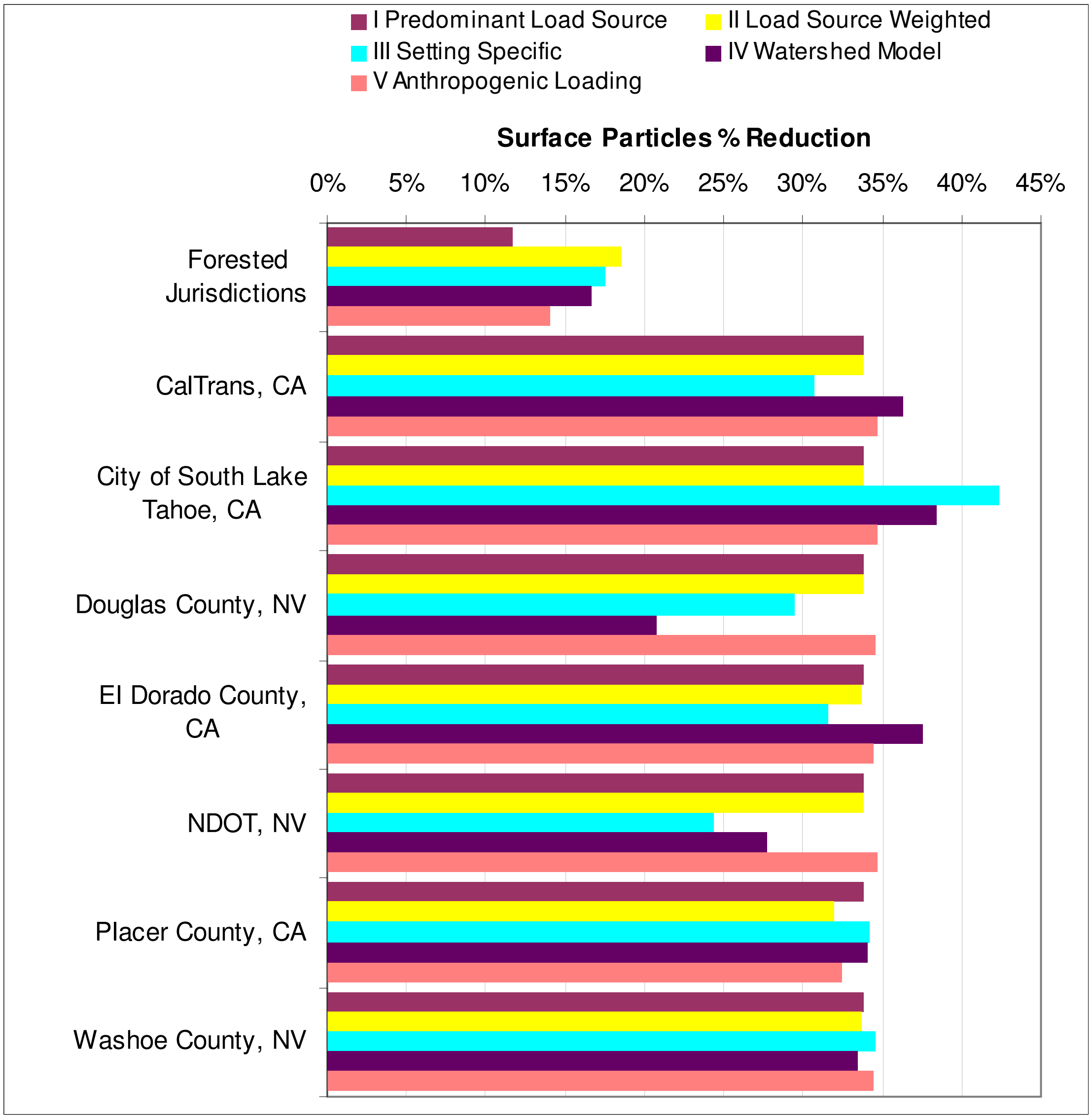

Figure 4-7. Percent reductions of fine sediment particles at the Clarity Challenge Milestone for five allocation approaches

Approach I: Predominant Load Source & Approach II: Load Source Weighted

Approaches I and II provide very similar results for all urban jurisdictions but a notable difference for the forested jurisdictions. This is a result of the dominance of urban loading sources within urban areas, even when a significant proportion of the area is forest uplands. Likewise, the relative strength of urban over forest pollutant loading results in the small proportional urban land area in the forested jurisdictions having a noticeable impact of loading, and associated load reduction, in Approach II.

Approach III: Setting Specific

Approach III takes the analysis a step further in that it differentiates between source category settings. The Recommended Strategy development focused on overall cost and relative contributions from each source category. Within a source category a constrained optimization approach lead to the selection of different levels of application for different settings based on relative cost effectiveness. The influence of cost optimization shows that the load reductions from individual jurisdictions vary as a result of different proportions of specific settings between jurisdictions. The following discussion illustrates this point using the Recommended Strategy application levels for urban pollutant controls presented in Table 2-1.

Treating dispersed impervious coverage areas on *steep* slopes is estimated to be relatively less cost effective than treating other settings. As a result:

- Only a 30 percent application level of best current practices (Tier 1) is defined for dispersed impervious coverage areas on *steep* slopes. The result is approximately 7 percent load reduction from dispersed impervious coverage areas on steep slopes.
- A 40 percent application level of best current practices (Tier 1) and an additional 40 percent application level of advanced, intensive practices (Tier 2) are defined for dispersed impervious coverage areas on *moderate* slopes. The result is approximately a 43 percent load reduction from dispersed impervious coverage areas on moderate slopes.

Therefore, a county with a low proportion of dispersed impervious coverage areas on *steep* slopes and a high proportion of dispersed impervious coverage areas on *moderate* slopes is expected to reduce more pollutant load than a county with a high proportion of the dispersed impervious coverage areas on *steep* slopes. This influence can be seen by the City of South Lake Tahoe's higher load reduction and Douglas County's lower load reduction from this approach when compared to Approach II.

Approach IV: Watershed Model

Approach IV takes the analysis one step further than Approach III, in that it differentiates watershed response within areas of the same type setting that are located in different parts of the basin. It uses the Recommended Strategy application levels and controls as direct inputs to the watershed model. The Recommended Strategy was developed using Basin-wide average cost effectiveness figures with no distinction made between east and west during the optimization exercise. Because of a West to East rain shadow effect and other physical features, greater loading, load reduction potential and cost effectiveness is found on the western side of the Basin. As a result, had a spatial distinction been made during the optimization exercise, the selected application levels for the Recommended Strategy would have been heavily biased towards controls in California over Nevada.

Approach IV highlights the difference in the opportunities and limitations for load reductions in different jurisdictions depending on their location and land characteristics. Weather patterns, hydrology, and soils can change the effectiveness of pollutant controls. The Watershed Model is necessary to account for all of these effects.

Approach V: Anthropogenic Loading

Approach V uses the same percent reduction from the estimated anthropogenic load to achieve the overall load reduction required. This approach does not differentiate among sources or reduction potential for different locations and land characteristics.

Sensitivity Analysis

It is also useful to quantify the spatial influence of a selected application level among the various pollutant controls. A sensitivity analysis was performed based on using 80% application level for urban areas as the maximum theoretical treatable area. Forest areas were maintained at the application levels specified in the Recommended Strategy. The goal of the analysis was to estimate the effects of treating at 80% application level using the most potent urban Tiers for all locations. This represents a "theoretical maximum" scenario. Using the Watershed Model allows us to assess the performance of this scenario under natural spatial climate and hydrologic variability.

Methods

For this approach, the Watershed Model is configured to simulate the hydrologic and water quality effects of the application of pollutant controls for the different settings and tiers using 80% application level as the maximum theoretical treatable area.

An 80% application level for the most potent urban Tiers was used for all settings. The Watershed Model results provide pollutant loads by subbasin and land use, which are then summed to jurisdictions similarly to the method described in Section 4.1 for distributing baseline loads.

Results

The results of the sensitivity analysis compared with the 5 allocation approaches are presented in Table 4-18. The analysis shows that even when the same application level is applied uniformly around the Basin, the model shows spatial variability in the potential for load reduction. Spatially variable influences of climate and hydrology around the watershed may be significant to consider in definition of load allocations.

State Comparison

Another interesting observation is the difference in overall percent reduction for the urban jurisdictions in California and Nevada.

Table 4-19 shows the total loads and percent reductions in three groups: urban jurisdictions in California, urban jurisdictions in Nevada and forested jurisdictions. For approach II, urban jurisdictions in the state of California receive a 33% reduction, while the urban jurisdictions in Nevada receive 34%. The reductions for the urban jurisdictions in California increase for Approach III, while they decrease in Nevada. Furthermore, the percent reductions for Approach IV show a greater difference between states by increasing to 37% reduction in California while remaining at 30% in Nevada.

Table 4-18. Sensitivity Analysis for Fine Sediment Particle Allowable Loads and Jurisdictional Percent Reductions From Baseline Load at the Third Milestone for All Five Allocation Approaches

Jurisdiction	% Reduction from jurisdiction baseline[55]						Allowable load (particles x10^{18})						
	I	II	III	IV	V	80% Max. LOA[56]	Baseline	I	II	III	IV	V	80% Max. LOA
Forested Jurisdictions[57]	12%	18%	18%	17%	14%	**24%**	51.7	45.7	42.2	42.7	43.1	44.5	**39.4**
CalTrans, CA	34%	34%	31%	36%	35%	**83%**	76.4	50.5	50.5	52.9	48.6	49.9	**13.0**
City of South Lake Tahoe, CA	34%	34%	42%	38%	35%	**66%**	74.6	49.3	49.3	43.0	45.9	48.8	**25.5**
Douglas County, NV	34%	34%	29%	21%	35%	**58%**	10.2	6.7	6.8	7.2	8.1	6.7	**4.3**
El Dorado County, CA	34%	34%	32%	38%	34%	**85%**	37.6	24.9	24.9	25.7	23.5	24.6	**5.7**
NDOT, NV	34%	34%	24%	28%	35%	**80%**	32.8	21.7	21.7	24.8	23.7	21.4	**6.5**
Placer County, CA	34%	32%	34%	34%	32%	**63%**	56.9	37.6	38.7	37.4	37.5	38.4	**20.9**
Washoe County, NV	34%	34%	35%	33%	34%	**66%**	48.8	32.3	32.4	32.0	32.5	32.0	**16.5**

55 These percent reductions are based on the jurisdictional baselines, not the Basin-wide values presented in Table 4-7.
56 LOA is an abbreviation for application level.
57 Forested jurisdictions include CTC; USFS; State Lands, Nevada; California and Nevada State Parks; Carson City, Nevada. For the results of each of these individual jurisdictions, see Appendix C.

Table 4-19. State Comparison of Fine Sediment Particle Allowable Loads and Summarized Jurisdictional Percent Reductions From Baseline Load at Each Milestone for All Five Allocation Approaches

Jurisdiction	% Reduction from jurisdiction baseline[58]						Allowable load (particles x10[18])						
	I	II	III	IV	V	80% Max. LOA	Baseline	I	II	III	IV	V	80% Max. LOA
Forested Jurisdictions[59]	12%	18%	18%	17%	14%	24%	51.7	45.7	42.2	42.7	43.1	44.5	39.4
Urban Jurisdictions, CA	34%	33%	35%	37%	34%	73%	245.4	162.3	163.5	159.0	155.5	161.7	65.0
Urban Jurisdictions, NV	34%	34%	30%	30%	35%	70%	91.9	60.8	60.9	64.0	64.4	60.2	27.3

[58] These percent reductions are based on the jurisdictional baselines, not the Basin-wide values presented in Table 4-7.
[59] Forested jurisdictions include CTC; USFS; State Lands, Nevada; California and Nevada State Parks; Carson City, Nevada. Urban Jurisdictions in California include CalTrans, City of South Lake Tahoe, El Dorado County and Placer County. Urban Jurisdictions in Nevada include Douglas County, NDOT and Washoe County.

4.3. Expressing Allowable Pollutant Loads

Throughout the TMDL analysis and this report, loads have been expressed as annual loads. In the *Final Lake Tahoe TMDL* document, allowable load allocations must be expressed as *daily* loads. This section describes options that EPA recommends for expressing jurisdictional loads in this form.

The EPA document *Options for Expressing Daily Loads in TMDLs* (EPA 2007) recommends guidelines for expressing daily loads in TMDLs from the following assumptions:

1. Methods and information used to develop the daily load should be consistent with the approach used to develop the loading analysis.
2. The analysis should avoid added analytical burden without providing added benefit.
3. The daily load expression should incorporate terms that address acceptable variability in loading under the long-term loading allocation. Because many TMDLs are developed for precipitation driven parameters, one number will often not represent an adequate daily load value. Rather, a range of values might need to be presented to account for allowable differences in loading due to seasonal or flow-related conditions (e.g., daily maximum and daily median).
4. The specific application (e.g., data used, values selected) should be based on knowledge and consideration of site-specific characteristics and priorities.
5. The TMDL analysis on which the daily load expression is based fully meets the EPA requirements for approval, is appropriate for the specific pollutant and waterbody type, and results in attainment of water quality criteria.

When making the decision of how to express allowable loads as daily loads, the practitioner should maintain consistency with assumptions from the non-daily TMDL analysis and consider (1) pollutant source types, (2) critical loading conditions, (3) pollutant source behavior, and (4) waterbody type. Tables 4-20 to 4-23(taken from EPA 2007) show recommended options for daily load expressions based on these considerations and highlight the most appropriate option for the Lake Tahoe TMDL. The three daily load expression options described in the tables include the following:

- **Static** – one load applicable to all times and flow conditions
- **Flow range variable** – defining acceptable loads related to corresponding flows
- **Temporally variable** – defining acceptable loads for different seasons or critical periods during the year

Table 4-20. Target Option and Pollutant Source Type Considerations

Pollutant source types	Daily load expression option		
	Static	Flow range variable	Temporally variable
Point source-dominated ▪ Water quality problems often related to discharge that overwhelms receiving stream's dilution capacity ▪ Critical conditions generally occur during low flows	**High**—Could be appropriate for steady state analysis TMDLs or when dynamic modeling output is used in conjunction with the TSD approach for identifying the maximum daily load (e.g., nutrient loads from a wastewater treatment plant)	**Medium**—Consider when discharges are related to precipitation and critical conditions occur at a particular flow range (e.g., municipal separate storm sewer systems [MS4s], stormwater, combined sewer overflows [CSOs], surface mines)	**Low**—Might be appropriate if discharges are seasonal in nature (e.g., power plants, wastewater treatment plants [WWTPs] in a summer vacation area where population increases)
Nonpoint source-dominated ▪ Water quality problems often related to precipitation/runoff events ▪ Critical conditions generally occur during high flows	**Medium**—Could be appropriate to apply TSD approach to long-term average load to develop corresponding maximum daily value. Consider if parameters are relatively constant but from nonpoint sources (e.g., septics, abandoned mine land seeps, sediment oxygen demand, sediment as in-stream source of metals)	**High—**Might be appropriate when problem conditions occur with varying intensity across different flow ranges (e.g., streambank erosion)	**Medium**—Could be appropriate when sources are seasonal in nature (e.g., agricultural, summer season campground package plants)
Mixed point source and nonpoint source ▪ Water quality problems associated with precipitation/runoff events (nonpoint source) and dry-weather point source discharges ▪ Different sources impact stream at different flow ranges	**Medium**—Could be appropriate to apply TSD approach to long-term average load to develop corresponding maximum daily value	**High**—Could be appropriate for problem conditions that occur with varying intensity across different flow ranges	**Medium**—Could be appropriate when sources are seasonal in nature (e.g., agricultural, summer season campground package plants)

Source: EPA 2007.

Lake Tahoe is nonpoint source-dominated. The highest recommended option for the daily expression of the TMDL is the flow range variable. Temporally variable expressions could also be used, given the seasonal pattern of flows and loadings.

Table 4-21. Target Option and Critical Condition Considerations

Critical condition	Daily load expression option: Static	Flow range variable	Temporally variable
Low flow	**High**—Consider when steady-state analysis was used for non-daily TMDL; point source dominated with little nonpoint source influence; critical conditions occur at multiple flow ranges	**Low**	**Medium**—Consider when problem conditions occur seasonally (e.g., nuisance algal growth in-stream due to summer low flows, slow flow rate, lack of shading)
High flow	**Low**	**High—**Consider when critical conditions are associated with precipitation/runoff events and sources include multiple source types	**Medium**—Consider when critical conditions are associated with precipitation/runoff events and occur seasonally
Seasonal	**Low**	**Low**	**High**—Consider when critical conditions are driven by seasonal factors (e.g., seasonal water quality criteria)

Source: EPA 2007.

Lake Tahoe's critical condition is high flow. The highest recommended option for the daily expression of the TMDL is the flow range variable. Temporally variable expressions could also be used, given the seasonal pattern of flows and loadings.

Table 4-22. Target Option and Source Behavior Considerations

Source behavior	Daily load expression option: Static	Flow range variable	Temporally variable
Seasonal (e.g., agricultural nonpoint loading)	**Low**	**Medium**—Might be appropriate if seasonal source is also associated with specific flow regimes	**High—**Could be appropriate when seasonal sources dominate the waterbody response
Constant (e.g., atmospheric mercury)	**High**—May be appropriate to consider when source is fairly constant in nature or when the TMDL approach assumes a constant loading rate	**Medium**—Might be appropriate if impact of constant source is more critical during certain flow regimes (e.g., low flows) than others	**Low**
Precipitation driven	**Medium**—Might be appropriate to apply the TSD approach to develop single maximum associated with long-term average derived by dynamic or general watershed model	**High—**Might be appropriate when major sources are precipitation driven	**Medium**—Consider using if seasonal considerations are significant

Source: EPA 2007.

Lake Tahoe is both seasonal and precipitation driven. The highest recommended options for the daily expression of the TMDLs are the temporally variable and the flow range variable.

Table 4-23. Target Options and Waterbody Considerations

Waterbody type	Daily load expression option		
	Static	Flow range variable	Temporally variable
Lake/Impoundment	**Medium**—Consider when major sources are point sources or with dynamic model output and the TSD approach	**High—Consider when loads are driven by surface washoff in the watershed**	**Medium**—Consider for situations where long-term and seasonal control of nutrients/sediment is important for meeting lake targets
Free-flowing river/stream	**Medium**—Consider for point sources; dynamic model output/TSD	**High**—Consider when loads are driven by surface washoff in the watershed.	**Medium**—Consider when major sources are seasonal in nature or if critical conditions occur seasonally
Tidal/estuarine	**Medium**	**Medium**—Consider when loads are driven by surface washoff in the watershed	**High**—Consider when major sources are seasonal in nature or if critical conditions occur seasonally

Source: EPA 2007.

Finally, the highest recommended option for the daily expression of the TMDL for lakes is the flow range variable.

Following the guidelines, it is apparent that the most appropriate daily load expression for the Lake Tahoe TMDL is the flow range variable. The temporally variable option is also appropriate. The Watershed Model analysis already provides daily output of simulated daily loads, supplying the needed daily data set.

To establish the dependency of the daily loading on flow and seasons, the daily load expression for Lake Tahoe's TMDL can be established with flow-variable targets. Modeled daily loads can be arranged with increasing flows, and grouped in percentiles of flow. In the figures presented here, the flows are arranged into 10-percentile increments, and the min, max and average loads for those percentile ranges shown. In addition, the same exercise is performed grouping the flows and loads by month of the year, instead of percentile of flow, to show the seasonal variability of the daily loads.

Flow-Associated Assessment

Lake Tahoe Baseline
Flow: Sum of Inputs to Lake Tahoe (L/s)
Pollutant: Particles
Data from: 1/1/1990 to 12/31/2004

Flow Range	Associated Flow			Conc. (count/L)		Load (count/day)	
Percentile	Mean	Min	Max	Mean	Max	Mean	Max
0-10	1,375	1,013	1,587	1.1E+08	9.4E+08	1.4E+16	1.1E+17
10-20	1,754	1,587	1,936	1.6E+08	1.2E+09	2.4E+16	1.8E+17
20-30	2,195	1,937	2,504	3.2E+08	1.6E+09	6.0E+16	3.1E+17
30-40	2,842	2,505	3,240	4.6E+08	2.1E+09	1.1E+17	5.1E+17
40-50	3,848	3,243	4,593	5.8E+08	3.2E+09	1.9E+17	1.1E+18
50-60	5,546	4,594	6,706	7.4E+08	3.2E+09	3.6E+17	1.5E+18
60-70	8,642	6,707	10,977	8.9E+08	5.7E+09	6.7E+17	4.3E+18
70-80	14,274	10,999	18,158	9.2E+08	3.5E+09	1.1E+18	4.4E+18
80-90	24,386	18,160	34,477	9.3E+08	3.3E+09	2.0E+18	7.0E+18
90-100	60,450	34,613	167,090	1.1E+09	4.5E+09	6.0E+18	2.3E+19

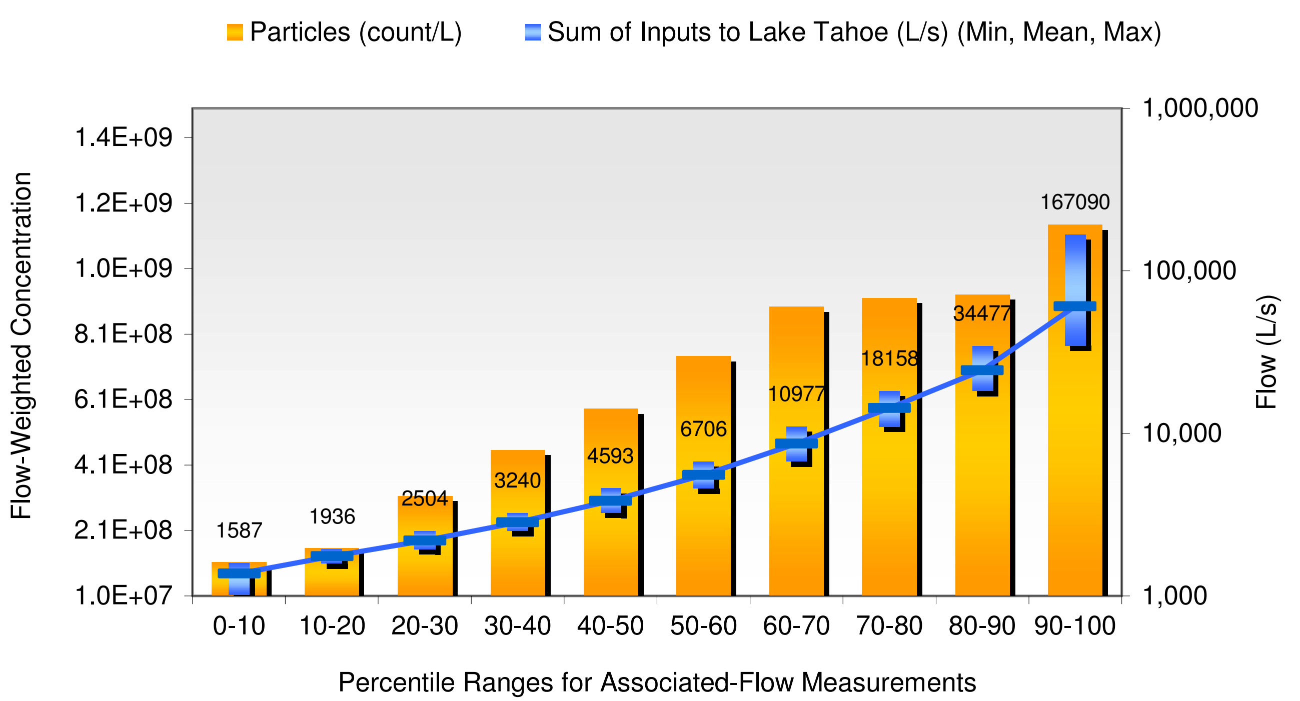

Figure 4-8. Analysis of daily maximum and average particle loads (displayed as flow-weighted concentrations) for baseline conditions.

Seasonal Assessment

Lake Tahoe Baseline
Flow: Sum of Inputs to Lake Tahoe (L/s)
Pollutant: Particles
Data from: 1/1/1990 to 12/31/2004

Time Period	Associated Flow			Conc. (count/L)		Load (count/day)	
Month	Mean	Min	Max	Mean	Max	Mean	Max
Jan	7,433	1,165	351,220	1.4E+09	3.8E+09	8.9E+17	2.4E+18
Feb	8,488	1,202	111,944	1.1E+09	3.6E+09	8.1E+17	2.6E+18
Mar	17,566	3,252	160,296	1.2E+09	5.7E+09	1.8E+18	8.7E+18
Apr	28,637	7,044	113,921	9.9E+08	3.1E+09	2.4E+18	7.6E+18
May	37,196	3,590	167,090	9.9E+08	2.7E+09	3.2E+18	8.7E+18
Jun	26,726	2,701	164,164	9.0E+08	2.1E+09	2.1E+18	4.7E+18
Jul	9,229	1,825	72,088	5.4E+08	1.3E+09	4.3E+17	1.0E+18
Aug	3,241	1,407	12,789	1.8E+08	2.4E+09	5.1E+16	6.6E+17
Sep	2,165	1,213	14,509	2.5E+08	2.2E+09	4.7E+16	4.1E+17
Oct	2,117	1,117	16,401	5.7E+08	3.5E+09	1.1E+17	6.4E+17
Nov	3,383	1,064	76,312	1.3E+09	3.4E+09	3.7E+17	9.9E+17
Dec	4,829	1,013	137,458	1.4E+09	4.1E+09	5.9E+17	1.7E+18

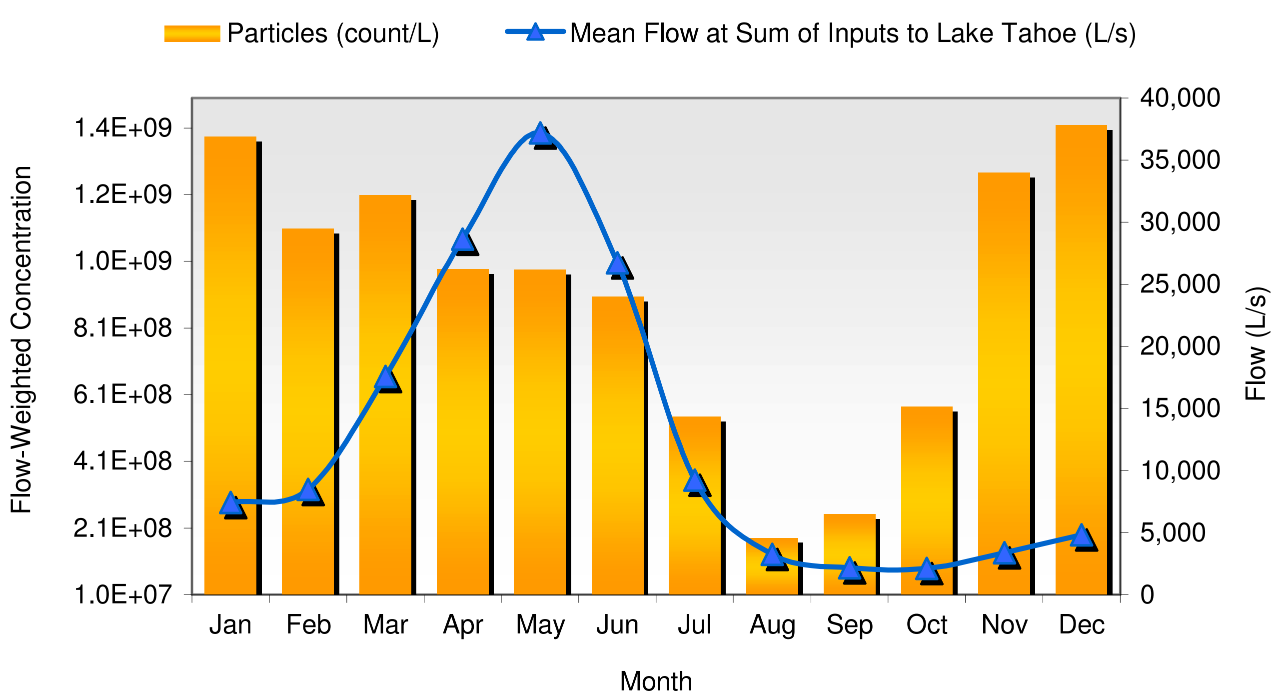

Figure 4-9. Analysis of daily maximum and average particle loads (displayed as flow-weighted concentrations) for baseline conditions.

Glossary

Advanced treatments (Tier 2). A forested source category treatment tier that includes pollutant controls designed to achieve restoration close to natural conditions over time. These include Standard BMP Treatments as well as revegetation, sediment capture BMPs, trail restoration, and the like.

Advanced, Intensive Practices (Tier 2). An urban treatment tier that includes wetland and passive filtration basins, media filters in stormwater vaults, deicing compounds or advanced abrasive (sand) recovery, intensive maintenance of stormwater infrastructure, 100 percent completion of private property BMPs. This treatment tier was named Tier 2 in the PRO Report v2.0.

Analytic Confidence. Numeric confidence ratings provided by each source category group for each of their treatment tiers. These ratings were based on guidance criteria provided by the TMDL team and used a 1 to 5 scale. These ratings were used in an analysis of high-confidence controls.

Application Level. The portion of the potential opportunities that a treatment tier is applied to; expressed as a percent. For instance, a 75 percent application level of a particular urban treatment tier would mean that three-quarters of the Tahoe Basin's urban areas would be treated with that group of pollutant controls and one- quarter would remain untreated. The treatment tiers can be applied at various application levels to several different *Settings* that are representative land uses based on Basin-wide physical characteristics.

Bank Protection. A treatment tier from the stream source category that established one end of a spectrum of potential treatments. This treatment tier represents stream restoration that retains the original course of the stream but reduces bank failure through channel armoring and bank slope reduction.

Base Package. Pollutant controls and application levels of the integrated packages that represent current multi-objective management strategies and are consistent across all the integrated strategies. Only the stream channel and forest upland source categories included base packages.

Basin. An abbreviation of Lake Tahoe Basin. This concept includes Lake Tahoe's watershed and airshed.

Best Current Practice (Tier 1). A treatment tier established for the urban source category that includes a set of techniques or pollutant controls that have been applied to areas of Lake Tahoe in recent, high-quality restoration projects. Pollutant controls include detention and retention basins, stormwater vaults, road shoulder stabilization, vacuum sweeping on heavily sanded roads, limited impervious coverage removal and 50 percent completion of private property best management practices (BMPs).

Best Solutions. The solutions found using PAT that achieve the highest quality of cost and pollutant reduction.

Capital Costs. Capital costs provided for pollutant controls include all implementation costs such as planning, design, acquisition and replacement costs when the useful life of the controls is shorter than 20 years.

Clarity Challenge. A water quality milestone established by the Lahontan Water Board and NDEP to focus planning efforts on achieving a meaningful load reduction that is projected to result in a measurable improvement of lake clarity. The Clarity Challenge is proposed as a Basin-wide 32 percent fine sediment (of less than 20 microns in diameter) load reduction and is expected to result in 77 to 80 feet of clarity.

Cost-effectiveness. A treatment tier's cost divided by the mass of emissions reduced (most typically expressed in terms of *dollars per ton* or *dollars per particle*).

Final Lake Tahoe TMDL. The legal document required by the Clean Water Act that is produced by the Lake Tahoe TMDL for the EPA and state government approval. This document will contain the required TMDL elements including allowable load allocations. The Final Lake Tahoe TMDL will be peer reviewed.

High Intensity (Tier 3). A group of the highest level of atmospheric pollutant controls. This treatment tier includes vacuum sweeping, unpaved road treatments, dust suppressants on construction areas and wood burning controls. These controls are applied more intensively and pollutant load reduction effectiveness is higher than increased intensity controls. This treatment tier was called Tier 3 in the PRO Report v2.0.

Innovative Technology (Tier 3). An urban treatment tier that includes active pumping and filtration systems for stormwater applied to urban areas with concentrated impervious coverage (such as *downtown* areas) and Advanced, Intensive Practices (Tier 2) pollutant controls applied to urban areas with dispersed impervious coverage (such as many residential areas).

Integrated packages. Thematically generated packages of pollutant controls and associated application levels from all four source categories. Each integrated package included Basin-wide estimates of pollutant load reduction and cost. Three integrated packages were initially created and then adjusted based on stakeholder comment to become three scenarios. One of the scenarios formed the basis for the Recommended Strategy.

Urban and atmospheric components of the integrated packages were adjusted significantly according to the theme of the package. Forest and stream channel source contributions did not vary across the three integrated packages that were presented.

Integrated Water Quality Management Strategy (Integrated Strategy). A plan to help stakeholders understand ways in which the necessary TMDL load reductions could be achieved using pollutant controls from all four major pollutant source categories.

Implementation Periods (Periods). The intervals between milestones in which a level of effort (represented by $500 million dollars) is focused on effectively implementing the recommended pollutant controls.

Increased Intensity (Tier 2). This atmospheric treatment tier includes a set of pollutant controls that is generally applied more intensively or extensively than current efforts but less intensively than the high intensity treatment tier. Pollutant controls are similar to high intensity treatment tier and include: vacuum sweeping, unpaved road treatments, dust suppressants on construction areas and wood burning controls.

Milestones. The Lake Tahoe TMDL must establish *milestones* along the path toward achieving the Clarity Challenge and, eventually, the Lake Tahoe TMDL's overarching numeric target for Secchi depth. The milestones may be used to guide allocations and permitting decisions as the Lake Tahoe TMDL moves forward. The Recommended Strategy's pollutant controls and application levels establish the third milestone. A pollutant reduction, cost and lake clarity result have been estimated for each milestone.

Mixed Approach (Tier 2). A stream source category treatment tier that includes unconstrained restoration where possible and simple bank protection on constrained stream reaches. This treatment tier best represents the current and planned future projects under consideration in the Tahoe Basin. The mixed approach was used to formulate the Recommended Strategy and all integrated packages.

Moderate to highly disturbed. Forested areas that have compacted soils, minimal vegetation and poor soil hydrology.

Operating and Maintenance Costs (O&M). Expenses associated with personnel, materials, consumables, equipment repair and other types of continuing expenses that would allow a pollutant controls to maintain load reductions as estimated.

Packaging and Analysis Tool (PAT). A spreadsheet model used to application pollutant controls to specific settings, and calculate resulting load reductions and costs. The PAT was built using Visual Basic for Applications (VBA) on a Microsoft Excel platform. It incorporates a scatter search version of a genetic algorithm to find *best solutions* subject to user-defined constraints. The PAT was used to explore the most efficient ways that a given budget could be invested in pollution control.

Pollutant Control. A general term to describe the physical and nonphysical methods that can reduce pollutant loads to Lake Tahoe. Examples could include residential BMPs, a commuter shuttle system or a fertilizer education program.

PRO Report. The *Lake Tahoe TMDL Pollutant Reduction Opportunity Report v2.0* that provides the underlying analysis of the cost and pollutant loading effects of pollutant controls. The results in the PRO Report v2.0 were produced by groups of experts called source category groups.

Recommended Strategy. The Recommended Strategy incorporates the best available science and extensive stakeholder input to describe a Basin-wide, non-prescriptive strategy to inform the TMDL load allocations and implementation plans. The Recommended Strategy is intended to guide implementing agencies in their efforts to achieve necessary load reductions. The Recommended Strategy does not directly translate to recommendations for project-scale application, and implementing agencies are not required to implement the specific pollutant controls contained within the Recommended Strategy.

Restored. Defined in the Forest Source Category Group as treatment to an area that eventually will replicate natural conditions. This not only achieves load reductions, it achieves other ecosystem objectives.

Scenario. A thematically generated set of pollutant controls and associated application levels from all four source categories. Each scenario included Basin-wide estimates of pollutant load reduction and cost. Three scenarios were created from stakeholder input and the Packaging Analysis Tool analysis of the integrated packages. One of the scenarios formed the basis for the Recommended Strategy.

Urban and atmospheric components of the scenarios were adjusted significantly according to the theme of the package. Forest and stream channel source contributions did not vary across the three scenarios that were presented.

Scenario B. A set of pollutant controls and associated application levels from all four source categories based on the theme "Focus on Innovation & Advanced Practices." This scenario focuses on developing and implementing innovative practices such as conveying and treating stormwater with mechanical or chemical systems and high intensity atmospheric treatments such as weekly vacuum sweeping of roadways. This scenario is estimated to meet the Clarity Challenge and require capital investment of $1.5

billion. The Recommended Strategy evolved from Scenario B but the two are substantially different and these terms should not be used interchangeably.

Setting. Representative areas of the Lake Tahoe Basin that could include similar physical characteristics, pollution controls applicability or loading effects. In general, settings strongly influence the planning, design and construction of pollutant controls in the Lake Tahoe Basin.

Source Category Groups (SCGs). Groups of technical experts that screened pollutant controls and then provided estimates of potential load reductions and costs for the selected pollutant controls. These estimates are the building blocks of the Recommended Strategy.

Source Category. A set of sources that provide a significant portion of the pollutant loads to Lake Tahoe. The Lake Tahoe TMDL has established five source categories including urban uplands, forested uplands, atmospheric deposition, stream channel erosion and groundwater.

Standard BMP Treatments. A forest treatment tier that includes pollutant controls planned by federal and state land management agencies for their roads, trails and fuels reduction projects. Examples of these controls include waterbars, culverts, road grading, hydroseeding and planting.

Stream. As used in this study, it refers to the mainstem channel of tributary watersheds to Lake Tahoe.

Technical Report. The *Draft Lake Tahoe Total Maximum Daily Load Technical Report* that provides details of the scientific research underlying the Lake Tahoe TMDL. See Lahontan and NDEP 2007a for full citation.

TMDL Team. The TMDL agency staff and supporting consultants from private companies and educational institutions who contributed to the Lake Tahoe TMDL. TMDL team contributions to development of the Recommended Strategy included analysis, discussion, design, evaluation and decisionmaking regarding options and strategies throughout the process.

Transportable Fraction (TF). Fraction of a source’s mass emissions that remain airborne and available for transport away from the source after localized removal has occurred.

Treatment Tier. A group of pollutant controls that can be applied to each setting and demonstrate the broad spectrum of potential load reduction effectiveness and effort possible. Pollutant reductions and costs were estimated for each combination of treatment tier and setting. Application level refers to the portion of the potential Basin-wide area on which treatment tiers are applied.

Typical Tahoe forested. Forested areas that have healthy vegetation and/of thick layers of duff. These areas have good soil hydrology and appear undisturbed to most observers.

Unconstrained Restoration. A stream treatment tier that includes treatments to modify planform, increase length and sinuosity, connect floodplains and decrease slope such that a restored condition is eventually reached. These treatments are designed to achieve load reductions as well as other ecosystem objectives such as riparian habitat enhancement, flood control and recreation value. Load reduction and cost estimates for these treatments assumed ideal construction access and project sequencing.

References Cited

EPA. 2007. *Options for Expressing Daily Loads in TMDLs.* Draft of June 22, 200. U.S Environmental Protection Agency Office of Wetlands, Oceans & Watersheds. Washington, D.C.

Lahontan and NDEP (Lahontan Water Board and the Nevada Division of Environmental Protection). 2007a. *Lake Tahoe TMDL Technical Report*. Lahontan Water Board and the Nevada Division of Environmental Protection, South Lake Tahoe, CA and Carson City, NV.

Lahontan and NDEP (Lahontan Water Board and the Nevada Division of Environmental Protection). 2007b. *Lake Tahoe TMDL Pollutant Reduction Opportunity Report*. Lahontan Water Board and the Nevada Division of Environmental Protection, South Lake Tahoe, CA and Carson City, NV.

TERC (Tahoe Environmental Research Center). 2007. *Tahoe State of the Lake Report 2007*. University of California, Davis, Incline Village, NV.

TRPA (Tahoe Regional Planning Agency). 2006. *Environmental Improvement Program Accomplishments Summary*. Tahoe Regional Planning Agency, Stateline, NV.

Appendix Contents

Appendix A:

Packaging and Assessment Tool Description

Appendix B: Information Supporting Discussion of the Development of the Recommended Water Quality Management Strategy

Part 1: Rosters
- Stakeholders
- Source Category Groups
- TMDL Team

Part 2: Identify, Screen and Analyze Pollutant Controls
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- Meeting Notes

Part 3: Formulate Integrated Strategies
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- Meeting Notes

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- Meeting Notes

Appendix C: Additional Tables

Tables Supporting Chapter 2 and 3

Tables and Figures Supporting Chapter 4