# Lake Tahoe TMDL Pollutant Reduction Opportunity Report

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

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NEVADA DIVISION OF ENVIRONMENTAL PROTECTION
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# Executive Summary

The Lake Tahoe Basin is in a montane-subalpine setting above an altitude of approximately 1,900 meters (6,234 ft) in the Sierra Nevada Range of California and Nevada. Lake Tahoe is losing its famed clarity because of excess loading of fine sediments and nutrients. As a result, the California Regional Water Quality Control Board, Lahontan Region (Lahontan Water Board) and the Nevada Division of Environmental Protection (NDEP) initiated the Lake Tahoe Total Maximum Daily Load (Lake Tahoe TMDL). The Lake Tahoe TMDL program includes a comprehensive research component and a restoration planning effort. The Lake Tahoe TMDL is answering a set of core questions summarized in Table ES-1.

This report represents a significant step forward in the development of the Lake Tahoe TMDL. It provides a first estimate of the potential Basin-wide pollutant load reductions at several levels of effort. Targeted research will refine these initial estimates over the coming years through a continual improvement and adaptive management process.

**Table ES-1. Lake Tahoe TMDL synopsis with this work highlighted**

| TMDL phase | Questions | Products |
|---|---|---|
| **Phase One—** 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 |
| **Phase Two—** 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 TMDL |
| **Phase Three—** 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:** Periodic Milestone Reports |

## Phase One

Phase One of the Lake Tahoe TMDL answered three important questions:

1. **What pollutants are causing Lake Tahoe's clarity loss?**
2. **How much of each pollutant is reaching Lake Tahoe?**
3. **How much of each pollutant can Lake Tahoe accept and still achieve the clarity goal?**

Extensive scientific research conducted for the Lake Tahoe TMDL has identified five major sources of pollutants and estimated the annual load of pollutants that are delivered from each source. The numeric results are summarized in the pollutant budget Table ES-2. It is useful context for the results presented in this report. The Lake Clarity Model was also developed to help evaluate the load reduction necessary to meet the Lake Tahoe TMDL water clarity target of 29.7 m (97.4 ft.) annual average Secchi depth. This information is presented in detail in the Lake Tahoe TMDL Technical Report (Technical Report), which can be found on the Lahontan Water Board web site (http://www.waterboards.ca.gov/lahontan/TMDL/Tahoe/Tahoe_Index.htm).

**Table ES-2. Pollutant loading budget for Lake Tahoe from Phase One Technical Report**

| Source category | | Total nitrogen (metric tons/year) | Total phosphorus (metric tons/year) | Number of fine sediment particles ($x10^{18}$/ year) |
|---|---|---|---|---|
| Upland | Urban | 63 | 18 | 348 |
| | Non-Urban | 62 | 12 | 41 |
| Atmospheric Deposition | Wet + Dry | 218 | 7 | 75 |
| Stream Channel Erosion | | 2 | < 1 | 17 |
| Groundwater | | 50 | 7 | NA* |
| Shoreline Erosion | | 2 | 2 | 1 |
| **TOTAL** | | **397** | **46** | **481** |

*NA = Not applicable because it was assumed that groundwater does not transport fine sediment particles.

## Phase Two

Phase Two began in 2005 and is the focus of current efforts to answer two additional questions:

1. **What are the options for reducing pollutant inputs to Lake Tahoe?**
2. **What strategy should we implement to reduce pollutant inputs to Lake Tahoe?**

This report answers the first question by providing initial estimates of the potential Basin-wide pollutant load reductions at several levels of effort. This information will form the basis for the development and selection of an Integrated Water Quality Management Strategy (Integrated Strategy). During the fall of 2007 the public and stakeholders will be engaged to inform the development of potential Integrated Strategies. Load allocations, a TMDL element required by the federal Clean Water Act, will be informed by the preferred Integrated Strategy. Load allocations ultimately assign responsibility for achieving the required load reductions and may be made to watersheds, management/regulatory programs, jurisdictions, or a combination of these. In addition, water quality crediting and trading will be analyzed as a programmatic means to assist implementation of projects designed to achieve load reduction requirements. These elements will compose the Final TMDL report that is planned for completion in the winter of 2008/2009.

### Phase Three

Phase Three is the implementation phase of the Lake Tahoe TMDL restoration plan and addresses three additional questions:

1. **Are the expected reductions of each pollutant to Lake Tahoe being achieved?**
2. **Is the clarity of Lake Tahoe improving in response to actions to reduce pollutants?**
3. **Can innovation and new information improve our strategy to reduce pollutants?**

The Lake Tahoe TMDL will be implemented through projects, programs and regulations included in the Tahoe Regional Planning Agency (TRPA) Regional Plan, the USDA Forest Service (USFS) Land and Resource Management Plan, state funding agency programs, and permits issued through the Lahontan Water Board and NDEP. Load reductions related to projects and programs will be tracked and project effectiveness will be monitored. Ongoing research and monitoring will improve the scientific basis for adjusting the Lake Tahoe TMDL and Integrated Strategy over time. A formal, continual improvement and adaptive management process will be used to focus implementation on the most effective and appropriate pollutant controls.

## General Approach

This analysis estimated potential pollutant load reductions and associated costs at a Basin-wide scale. This is the first comprehensive estimate of possible load reductions based on differing levels of effort applied to the to major pollutant sources. The Lahontan Water Board and NDEP intend to use this information as a basis for discussion with stakeholders on developing a broad Basin-wide strategy to protect water quality.

The analysis was performed in three steps including an evaluation of potential pollutant controls, a site-scale analysis, and an extrapolation to the Basin-wide scale (See Figure ES-1). The steps were pursued independently by each of four groups of experts known as Source Category Groups (SCGs). The groups were overseen by a committee responsible for providing direction and maintaining consistency of results called the Source Category Integration Committee (SCIC). The approach and results were further reviewed by experts not previously involved with the Lake Tahoe TMDL program. The results of each SCG were processed by the project team and combined into two related sets of tables that are summarized in the results section of this Executive Summary.

In many cases the SCGs took necessarily individualized approaches to their analyses. The unique details of each SCG's approach are explained in their specific chapters.

**Key Participants**

**SCGs**

The Lahontan Water Board and NDEP identified and assembled respected experts into Source Category Groups (SCGs) to investigate pollutant control options for each major source of pollutants entering Lake Tahoe. Each SCG included a group lead that coordinated the technical investigations and overall staffing of the group.

**SCIC**

Review and cross-SCG coordination has been provided by a Source Category Integration Committee (SCIC). The SCIC included staff from the Lahontan Water Board, NDEP and TRPA, a Pathway Coordination Team representative, and a Science Advisor involved with long-term TMDL development experience.

## Step 1: Pollutant Control Option Evaluation

These analyses began with evaluations of pollutant control options (PCO) that could be applied. Each SCG compiled a list of potential PCOs on the basis of professional experience, local knowledge, and input from the SCIC, Pathway Technical Working Groups, the Pathway Forum, and other sources. The SCGs then screened the list of PCOs and focused investigations on PCOs that were expected to produce large Basin-wide pollutant load reductions and could be quantified well enough at this time to be used in calculations.

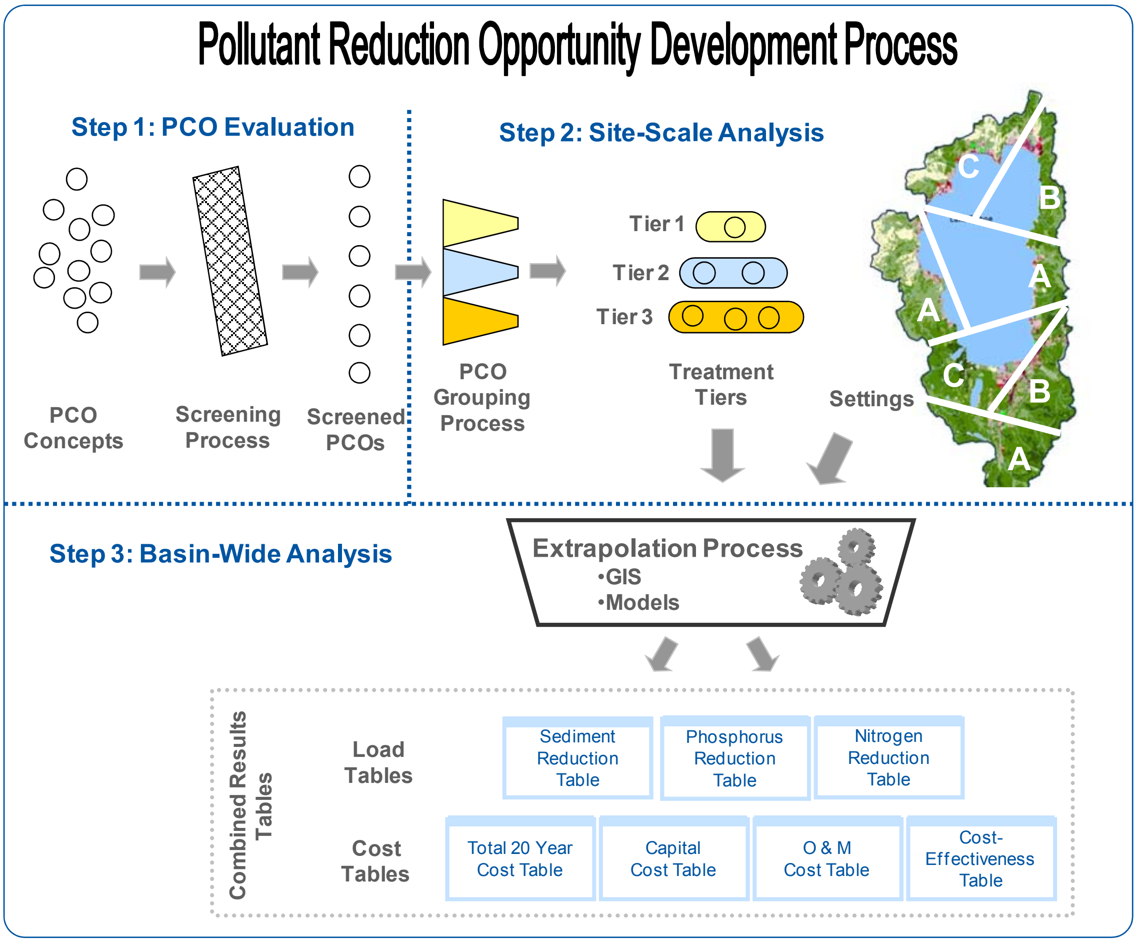


**Figure ES-1. The pollutant reduction opportunity development process showing three analysis steps. Step 1: consider wide-ranging Pollutant Control Options and select PCOs most likely to produce large load reductions and quantifiable results. Step 2: group PCOs into several Treatment Tier that could be applied to Settings representative of the landscape characteristics. Step 3: extrapolate site-scale results Basin-wide using tools such as GIS and predictive models. Combined results were captured in a set of spreadsheet tables.**

## Step 2: Site-scale Analysis

Each SCG analyzed pollutant load reductions and implementation costs of applying PCOs on a representative site scale. During this step, the SCGs defined the representative site areas, called *Settings* and packages of PCOs, called *Treatment Tiers* (Tiers) that could be applied.

### Settings

Each SCG categorized the physical area of the Lake Tahoe Basin into a number of representative Settings on the basis of several criteria. Settings were largely determined by the physical characteristics of the land such as average slope or soil type. Settings were in part determined by the applicability of PCOs. For example, water quality projects use different PCOs depending on how much impervious coverage is present. In other cases, Settings were determined by the way that they deliver pollutants to Lake Tahoe. For instance, atmospheric loads are highly affected by the distance of the source from the Lake, so the atmospheric SCG defined Settings according to distance from the Lake. Settings were selected to ensure that all treatable areas of the Lake Tahoe Basin were included while maintaining a manageable number of Setting-PCO combinations. Summary definitions of each SCG's Settings are provided in Table ES-3.

**Table ES-3. Summary definition of Settings for each source category**

| Setting name | Definition |
|---|---|
| **Atmospheric Settings** | |
| Setting 1 | The entire band of land less than 0.2 kilometer from the Lake. Pollutant emissions from this Setting will reach the Lake most readily. |
| Setting 2 | The entire band of land less than 1 kilometer from the Lake (includes Setting 1). |
| Setting 3 | The entire band of land less than 3 kilometers from the Lake (includes Settings 1 & 2) |
| Setting 4 | The entire Lake Tahoe Basin (includes Settings 1, 2, & 3) |
| **Urban and Groundwater Settings** | |
| Concentrated – Steep | Areas where impervious coverage is relatively concentrated and there is minimal space for PCOs to be constructed. Average slope of the area is *greater than* 10%. |
| Concentrated – Moderate | Areas where impervious coverage is relatively concentrated and there is minimal space for PCOs to be constructed. Average slope of the area is *less than* 10%. |
| Dispersed – Steep | Areas where impervious coverage is relatively dispersed and there is adequate area for PCOs to be constructed among the impervious coverage or downhill from it. Average slope of the area is *greater than* 10% |
| Dispersed – Moderate | Areas where impervious coverage is relatively dispersed, and there is adequate area for PCOs to be constructed among the impervious coverage or downhill from it. Average slope of the area is *less than* 10%. |
| **Forested Uplands Settings** | |
| Setting A | Highly disturbed areas with significant compaction such as unpaved roads. |
| Setting B | Areas subject to major soil disturbance such as ski runs, campgrounds, and steep bare slopes. These areas are characterized by moderate vegetative cover, little mulch or duff, and low-infiltration capacity. |
| Setting C | Typical Tahoe forested areas that are managed for forest health and defensible space. These areas are characterized by well-established plant communities, thick duff layers and high soil-hydrologic function. The large majority of the Basin land area falls into Setting C. |
| **Stream Channel Settings** | |
| Upper Truckee River | The entire restorable channel of the Upper Truckee River. |
| Blackwood Creek | The entire restorable channel of Blackwood Creek. |
| Ward Creek | The entire restorable channel of Ward Creek. |

### Treatment Tiers

The SCGs combined screened PCOs into Treatment Tiers designed to provide a spectrum of potential load reduction and effort level within each Setting. Each SCG specifically defined its own Treatment Tiers however the following descriptions provide a general understanding of the definitions that guided the SCG's work.

- Tier 1—A basic set of PCOs that represented a step forward in practices generally used for existing projects in the Lake Tahoe Basin. Constraints to implementation and cost-effectiveness of particular PCOs selection for this Tier. This Tier was often the least expensive to implement of the three Tiers and represented the lowest level of effort relative to the other Tiers.
- Tier 2—A mix of the PCOs used in Tiers 1 and 3. The Tier 2 analysis generally provided a greater load reduction and cost than Tier 1.
- Tier 3—The maximum load reduction potential evaluated by the SCG. Land ownership, cost-effectiveness and other constraints were considered less important in formulating this Tier. This Tier was generally the most expensive to implement of the three Tiers.

Treatment Tier definitions for each SCG are summarized in Table ES-4.

**Table ES-4. Summary definitions of Treatment Tiers for each source category**

| Treatment Tier name | Summary definition |
|---|---|
| **Atmospheric** | |
| Tier 1 | A baseline of existing loading from which to compare. This source category was different than others because this *Tier* does not result in load reductions. |
| Tier 2* | A set of PCOs that is deemed effective and particularly cost effective. Numeric estimates are based on average literature values. |
| Tier 3 | A set of PCOs deemed more effective and difficult to implement. Estimates based on literature values that were the most favorable for load reduction. |
| **Urban & Groundwater** | |
| Tier 1* | An upper-end use of existing practices and technologies. Spatial application within the treatment area considers typical site and funding constraints. Assumes 50% completion of residential best management practices (BMPs). |
| Tier 2 | A significantly higher-use, advanced, gravity-driven treatment technologies applied more aggressively within the treatment area. Traditional limitations on property acquisition and maintenance rates are relaxed in this Tier. Assumes 100% completion of residential BMPs. |
| Tier 3 | A composite of pumping and centralized treatment systems for concentrated settings (both moderate and steep) and Tier 2 treatments for dispersed settings (both moderate and steep). |
| **Forested Uplands** | |
| Tier 1* | Includes *standard* treatments used or required by management agencies in current practice. |
| Tier 2 | A middle level of treatment that includes *state-of-the-art* practices designed to achieve *functional* rehabilitation of hydrologic properties. |
| 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. |

(table continues next page)

| **Stream Channel** | |
|---|---|
| Tier 1 | Restoration. A set of treatments that modifies planform, increases length and sinuosity, connects floodplain and decreases slope such that a *restored* condition is eventually reached. This Tier is designed to achieve load reductions as well as other ecosystem objectives such as riparian habitat, flood control, and recreation value. |
| Tier 2* | Rehabilitation. A combination of channel restoration (Tier 1) and simple bank protection (Tier 3) that focuses on cost-effective treatments, and property ownership is considered a factor. |
| Tier 3 | Bank protection. A basic set of channel armoring and minor bank slope reductions that increase hydraulic resistance and reduce bank failure. This Tier does not achieve multiple ecosystem objectives. |

* These Tiers include pollutant controls that are most closely related to those used in the most effective EIP projects however; they do not represent a baseline or status quo condition that applies to existing projects.

### Step 3: Basin-wide Extrapolation

The SCGs used models and spatial analysis to estimate the pollutant load reduction potential and associated cost of applying each Treatment Tier to each applicable Setting within their source category. The tools and procedures used to complete the extrapolation step are described more completely within each SCG's chapter. The result of the extrapolation step is a Basin-wide estimate of potential pollutant load reductions and associated costs.

## Results

Summary results from all SCGs are combined in Figure ES-2 and Table ES-5 to describe potential load reductions and estimated costs. Additional data including results for each Setting is available in Chapter 6 (*Combined Results: Load and Cost Tables*) of this document. Review of the more detailed analysis results will be necessary to understand the subtleties of the information and select an Integrated Strategy.

Load reductions are critical to determine whether the Lake Tahoe TMDL clarity goals can be achieved while costs are a consideration for implementation of pollutant controls. Figure ES-2 summarizes the potential load reduction estimates from each SCG in relation to the Technical Report's total pollutant budget. It also includes the total 20-year cost of the Treatment Tier that could achieve the relative reductions. This cost includes all capital investment and operations & maintenance (O&M) costs necessary to ensure ongoing load reductions. No attempt has been made to separate the cost to control a particular pollutant because most controls contribute to reductions of more than one pollutant. Table ES-5 contains the data displayed in Figure ES-2 and makes it possible to compare results between different source categories or Tiers (columns) but not between the differing pollutants (rows).

These results must be viewed within the context with which they were estimated. The values assume that all pollutant controls are applied to the maximum applicable area on which they could be used. The SCGs did not consider how long it would take to achieve full implementation in their analyses. The values presented signify the total load reduction possible once the PCOs are fully installed, Basin-wide.

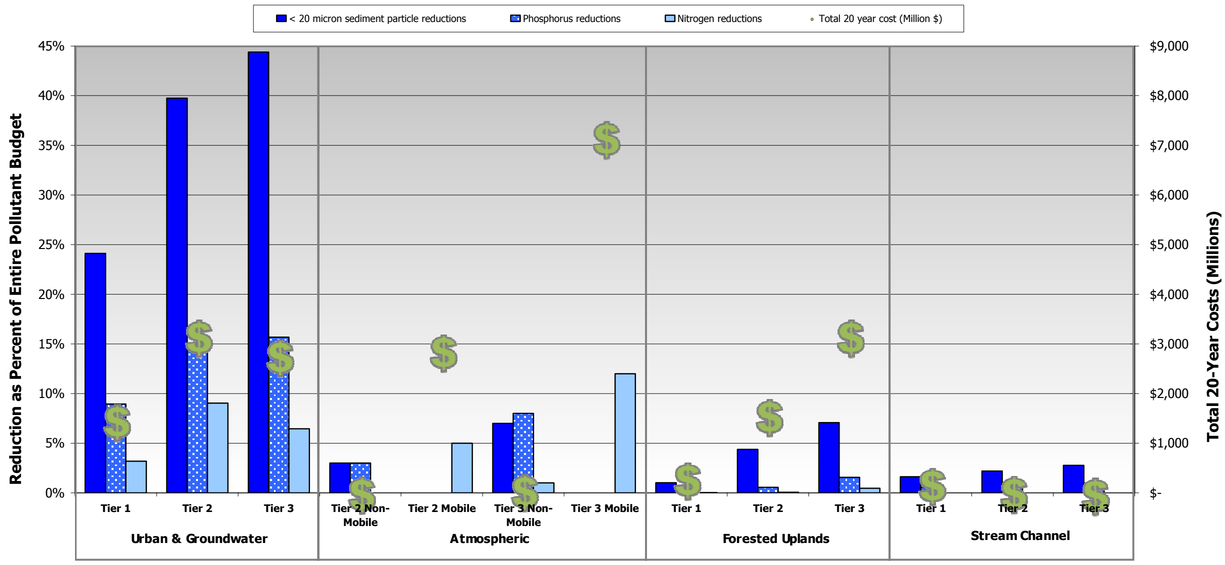


**Figure ES-2. This chart presents two separate data sets for comparison. Estimated load reductions as a percent of the entire Lake Tahoe TMDL pollutant budget are shown by vertical bars that can be read on the left axis. Total 20-year costs for each Tier are represented as dollar signs that can be read on the right axis. Each cost is associated with all three pollutant load reductions represented by the vertical bars.**

## Table ES-5. Summary table of estimated potential load reductions as a percent of the total pollutant budget and total 20-year costs

| Source Category and Tier | < 20 micron sediment particle reductions | Phosphorus reductions | Nitrogen reductions | Total 20 year cost (Million $) | 20 year capital cost (Million $) | Annual O&M cost (Million $) |
|---|---|---|---|---|---|---|
| **Atmospheric**[4] | | | | | | |
| Tier 2 Non-Mobile | 3% | 3% | 0% | $35 | $28 | $0 |
| Tier 2 Mobile | 0% | 0% | 5% | $2,900 | $280 | $130 |
| Tier 2 Sub-total | 3% | 3% | 5% | $2,900 | $300 | $130 |
| Tier 3 Non-Mobile | 7% | 8% | 1% | $88 | $74 | $1 |
| Tier 3 Mobile | 0% | 0% | 12% | $7,200 | $690 | $330 |
| Tier 3 Sub-total | 8% | 8% | 13% | $7,300 | $760 | $330 |
| **Urban & Groundwater** | | | | | | |
| Tier 1 | 24% | 9% | 3% | $1,500 | $1,400 | $3 |
| Tier 2 | 40% | 15% | 9% | $3,200 | $2,800 | $21 |
| Tier 3 | 44% | 16% | 6% | $2,800 | $2,500 | $15 |
| **Forested Uplands** | | | | | | |
| Tier 1 | 1% | 0% | 0% | $320 | $193 | $6 |
| Tier 2 | 4% | 1% | 0% | $1,600 | $1,400 | $7 |
| Tier 3 | 7% | 2% | 0% | $3,200 | $3,100 | $0 |
| **Stream Channel** | | | | | | |
| Tier 1 | 2% | 1% | N/A | $210 | $210 | $0 |
| Tier 2 | 2% | 1% | N/A | $50 | $51 | $0 |
| Tier 3 | 3% | 1% | N/A | $15 | $15 | $0 |

Notes:
1. These results are based on the assumption that controls are applied to the maximum applicable area.
2. Columns are not summed because Tiers are not additive. Only one Tier can be selected for each source category.
3. Rows are not summed because each represents a different quantity.
4. Atmospheric pollutant reduction opportunities have been split between 1) non-mobile sources, which consist of transportation infrastructure and stationary source reductions and 2) mobile sources, which consist of reductions from reduced vehicle emissions resulting from reducing vehicle miles traveled.

Figure ES-2 and Table ES-5 show the following results for loads and costs.

**Load Results**

1. Urban and groundwater sources show the largest opportunity to reduce pollutants of concern.
    a. In general, these controls show several times more load reduction potential than fine sediment particles from the three other source categories combined. Fine sediment particle load reductions come from urban runoff pollutant controls, not groundwater treatment.
    b. Nutrient loads from this source are also controllable, but to a lesser extent.
2. Atmospheric controls provide the largest opportunity (13 percent) to reduce nitrogen loads and can reduce significant amounts of the fine sediment (8 percent) and phosphorus (8 percent) loads.
3. Forest and Stream Channel sources show moderate potential for load reductions in fine sediment and limited potential for reduction of nutrients.
4. Achieving clarity goals will require implementation of controls in all source categories.

**Cost Results**

1. Urban and groundwater pollutant controls show 20 year costs ranging from $1.5-3.2 billion. These costs are similar to forest upland costs and higher than costs for other source categories but higher load reduction potentials make urban and groundwater pollutant control relatively cost effective.
2. Forested uplands costs show a broad range ($320 million to $3.1 billion) that corresponds positively with increasing load reductions. The estimates show somewhat lower cost effectiveness than urban and groundwater sources and emphasize the need to focus restoration on high priority, disturbed areas to make these controls cost effective.
3. Atmospheric cost results do not include the potential revenue that could be generated through VMT reduction incentives. Atmospheric non-mobile costs ($35-$88 million) are orders of magnitude less than mobile costs ($2.9 to $7.2 billion). Non-mobile fine sediment controls are highly cost effective.
4. Stream channel costs are lower for higher numbered Treatment Tiers, unlike other source categories. This is because Tier 3 controls involve basic bank hardening that is inexpensive and effective for reducing stream channel erosion. However, this analysis did not include the potential treatment of upland loads being transported by the stream. Tier 1 restorations are considered likely to provide water quality benefits by allowing sedimentation in flood plains, as well as other benefits such as flood control and enhanced riparian habitat. Thus, these results could be adjusted upward in the future as tools for estimating all benefits are fully developed.

## Source Category Considerations

This section presents key considerations and additional findings related to each source category that provide important context for understanding load reduction and cost results.

### Atmospheric Sources

1. Atmospheric cost results do not include the potential revenue that could be generated through VMT reduction incentives.
2. There is a significant cost difference between mobile source PCOs that target nitrogen and non-mobile controls that typically target fine sediment and phosphorus. In general, Basin-wide total costs to control nitrogen from mobile sources are two orders of magnitude higher than comparable costs to control fine sediment and phosphorus. It is possible to focus effort on stationary sources or mobile sources separately.
3. The atmospheric estimates presented in the results tables do not attempt to include entrained dust deposition to Lake Tahoe from mobile sources. After this report was complete, the SCG completed a preliminary estimate of this load and found that VMT reductions up to 25 percent resulted in fine sediment particle 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 this research need has been identified for inclusion within the Tahoe Science Consortium’s Draft Science Plan.
4. In some instances, atmospheric PCOs overlap with Urban and Forest PCOs.  As a result, Integrated Strategies that employ both atmospheric and urban or forest controls will include some double counting of costs. Integrated Strategies that do not employ both atmospheric controls, but do employ urban or forest controls will not account for the associated atmospheric pollutant reductions. Examples of such overlap include:
    - Paved roads where the atmospheric group estimated the total costs of street sweeping and the urban and groundwater group estimated the cost of PSC-1 which includes street sweeping/vacuuming.
    - Unpaved roads where atmospheric dust control strategies could potentially overlap forested uplands particulate runoff controls.

### Urban and Groundwater Sources

1. Tier 3 has the greatest estimated pollutant load reduction capabillity and is more cost effective than Tier 2. Tier 3 has the potential to reduce sediment particle loads of approximately 4% more than Tier 2 controls and it costs approximately 13% less for Basin-wide application. Additionally, as the concentration of urban development increases Tier 3 appears to become more cost effective. Source controls with both pollutant concentration and hydrologic volume effects (e.g. private property BMPs) are an important component of this tier.
2. The investment in a Tier 2 level of O&M activities is a significant cost that is at least an order of magnitude greater than the current resources devoted to water quality O&M. While, O&M cost estimates are preliminary and must be verified and compared to existing storm water utility programs, an increase in O&M activity will be needed to increase pollutant reductions.
3. The estimates of potential load reduction for the centralized pumping and treatment controls that make up part of Tier 3 have the lowest confidence among all urban Treatment Tiers because of the numerous assumptions that were made about the design of centralized treatment systems. Additional work has already begun to better characterize the feasibility of these kinds of pollutant controls.

### Forested Uplands Sources

1. Unpaved roads represent a small fraction of forested upland land-uses in the Basin, however, annual per acre fine sediment loading rates from unpaved roads are roughly double that from ski trails and 20–40 times greater than loading rates from undeveloped forested areas.
2. Obliteration of *legacy areas*—such as old logging roads, trails, abandoned landings, and other erosion *hot spots*—has the greatest potential to efficiently reduce loading from forested areas, especially if conducted in combination with planned thinning and fuels reduction treatments.
3. This analysis does not consider wildfire or controlled-burn effects on subwatershed hydrologic dynamics and subsequent stream loading. The effect of fire on runoff, sediment, and nutrient yield in the Basin is a topic that requires additional research and focused analyses beyond those considered here. The analysis framework developed here could be applied to future fire analysis and continued investigation into the water quality effects of fire should be considered a top priority.
4. Results show little nitrogen removal by forested upland controls because regression equations used in the model applied could not be adjusted to match existing datasets. Additional work has shown that estimates for nitrogen removal by the SCG were particularly conservative. Future results are expected to show larger load reductions of nitrogen for this source category.
5. There is a general need to define terms and establish clear, quantitative success criteria for different treatments and PCOs within the Basin. One important reason that costs are so difficult to generalize is that some treatments are poorly defined or defined very differently from agency to agency, and contractor to contractor.

### Stream Channel Sources

1. The total load reductions available from reducing stream channel erosion are relatively small, however, they are quite cost effective. In addition, current load reduction estimates do not account for treatment of upland loads during flood events, which would further improve the cost effectiveness of stream channel restoration. Future research is targeted to quantify the potential load reductions achievable by increasing floodplain connectivity and over-bank flows.
2. The uncertainty about PCO effectiveness for bank protection (Tier 3) is more likely to overestimate load reductions and underestimate costs than visa versa.

## Next Steps

The results of the SCG efforts will form the basis for the development and selection of Integrated Strategies. Initial Integrated Strategies will be used to stimulate discussion during the Lake Tahoe TMDL 2007 Public Participation Series. This set of workshops and discussions will solicit valuable input from the engaged public, local governments, and the Pathway Forum. Lake Tahoe TMDL decision makers including Lahontan Water Board, NDEP and TRPA will use the input gathered to select the most acceptable package of pollutant controls.

### Load Allocations

Results from the Lake Tahoe TMDL 2007 Public Participation Series and Integrated Strategy development will guide selection of the most acceptable load allocations. Load allocations are assignments of allowable loads and load reduction requirements allocated to appropriate agencies, programs, business sectors, or other legal entities. While the sum of all Tahoe Basin allocations must eventually result in attainment of the 29.7 meter clarity standard, initial milestones will be set to reach a series of achievable targets. Load allocations will be based on at least one of several methods and are expected to satisfy principles of cost-effectiveness, equitability, public acceptance, and accountability.