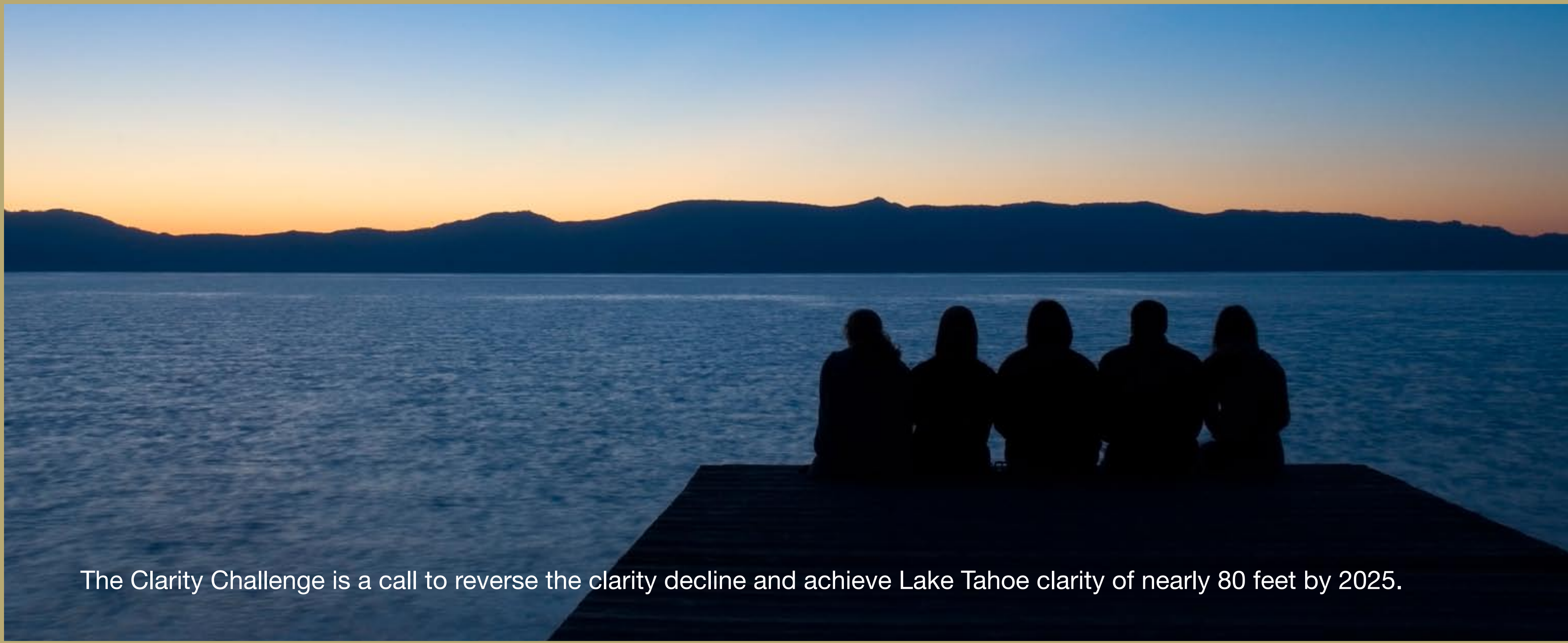
Charting the course to

The Lake Tahoe Total Maximum Daily Load

Clarity

2008 - 2009



The Clarity Challenge is a call to reverse the clarity decline and achieve Lake Tahoe clarity of nearly 80 feet by 2025.

Charting the Course to Clarity is a publication of the Lahontan Water Board and the Nevada Division of Environmental Protection.

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

Lake Tahoe's clarity can be restored. Scientific research tells us that it is possible for people to once again be able to see to depths of close to 100 feet in Lake Tahoe. The California Regional Water Board, Lahontan Region (Lahontan Water Board) and Nevada Division of Environmental Protection (NDEP) are committed to the Lake Tahoe TMDL, a strategy to return Lake Tahoe to a clarity depth of nearly 100 feet*, the clarity standard. Although Lake Tahoe clarity has been in decline for decades, recent science indicates the rate of decline has slowed. This good news is likely in response to the water quality improvement projects that are part of the Environmental Improvement Program (EIP). Science shows that an increase in the number and efficacy of these and other types of water quality improvement projects is key to achieving the clarity standard.

Charting the Course to Clarity 2008-2009 presents highlights of the strategy for restoring Lake Tahoe's clarity. If citizens and their government agencies support an effective course of action based in scientific understanding of Lake Tahoe, the clarity standard can be achieved. The strategy presented in this document is the result of decades of data collection, the work of hundreds of scientists and engineers, and the involvement of citizens. The key questions regarding Lake Tahoe clarity are:

*The Lake Tahoe clarity standard is 97.4 feet.

- 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 standard?
- What should be the strategy for reducing pollutant inputs to Lake Tahoe?
- How will the strategy be implemented?
- How will progress be assessed?

The Lahontan Water Board and NDEP propose the Clarity Challenge; a call to reverse the clarity decline and to achieve and sustain clarity nearing 80 feet by 2025. Realizing the Clarity Challenge is an essential first step toward ultimately achieving the historic clarity of nearly 100 feet. Slowing the clarity decline is an important step. *Reversing* the decline will be even bigger. The Clarity Challenge is a call to action—successful restoration of the Lake will require the sustained daily, coordinated participation of people and their governments.

Achievement of the Clarity Challenge is estimated to require 1.5 billion dollars (in 2008 dollars) in capital improvement costs over the next 20 years. Financial and participatory commitment by the people vested in the ecological, social and economic vitality of Lake Tahoe is essential to success. Coordinated commitments and resources at the private, local, state and federal level, contributing to the overall objectives of the EIP, will make the return to clarity possible.

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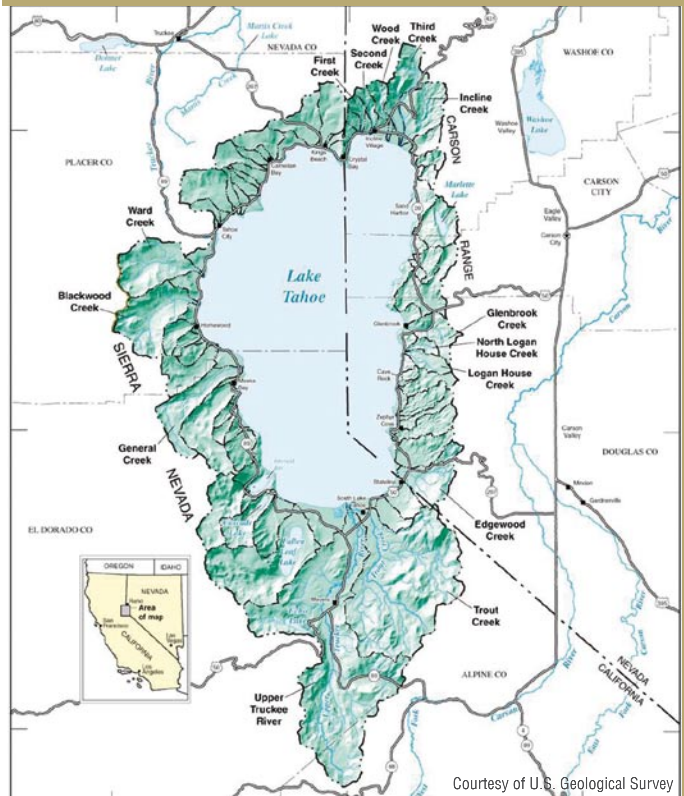
For PDF versions of technical reports for the Lake Tahoe TMDL visit: *www.waterboards.ca.gov/lahontan*



Courtesy of U.S. Geological Survey

Lake Tahoe

Spectacularly blue Lake Tahoe is situated between the crest of the Sierra Nevada mountains on the west and the Carson range on the east, with an average surface elevation of 6,225 feet above sea level. The geologic basin that cradles the lake is dominated by impressive mountains, steep slopes and erosive, nutrient-poor granitic soils as well as volcanic rocks and soils. The lake's montane subalpine watershed is predominantly vegetated by mixed conifer forests that shelter the 63 streams that flow into Lake Tahoe. The lake has one outlet, the Truckee River, which ultimately drains to Pyramid Lake, a terminal lake in Nevada.

Lake Tahoe is the eleventh-deepest lake in the world with a depth of 1,645 feet: more than a quarter of a mile. The California Nevada state line splits the Lake Tahoe watershed. Approximately one-quarter of the watershed area and one-third of the lake area are within Nevada, and the remainder is in California. At nearly 200 square miles, the surface area of the lake covers nearly three-fifths of the watershed. The lake holds about 39 trillion gallons of water.

It takes roughly 700 years for the average drop of water entering the lake to travel through and out to the Truckee River.

Lake Tahoe is prized for the remarkable blue of its waters. It is designated an Outstanding National Resource Water by the state of California and a "water of extraordinary ecological or aesthetic value" by the state of Nevada. Non-contact recreation aesthetic enjoyment of the clarity of Lake Tahoe's waters is the beneficial use that triggers the TMDL for lake clarity. The Lake Tahoe Basin is a summer and winter destination for millions of visitors annually and is home to approximately 60,000 year-round residents. The lake is prized as a recreation venue, with people swimming, fishing, kayaking, skiing and boating in and on its waters. Above all, people like to take in the view of Lake Tahoe's famed crystal clear, blue waters. The scale of the commitment to-date, to find and implement a solution to Lake Tahoe's clarity decline illustrates the importance of the lake to the people of Nevada, California, and the nation.

Acknowledgements

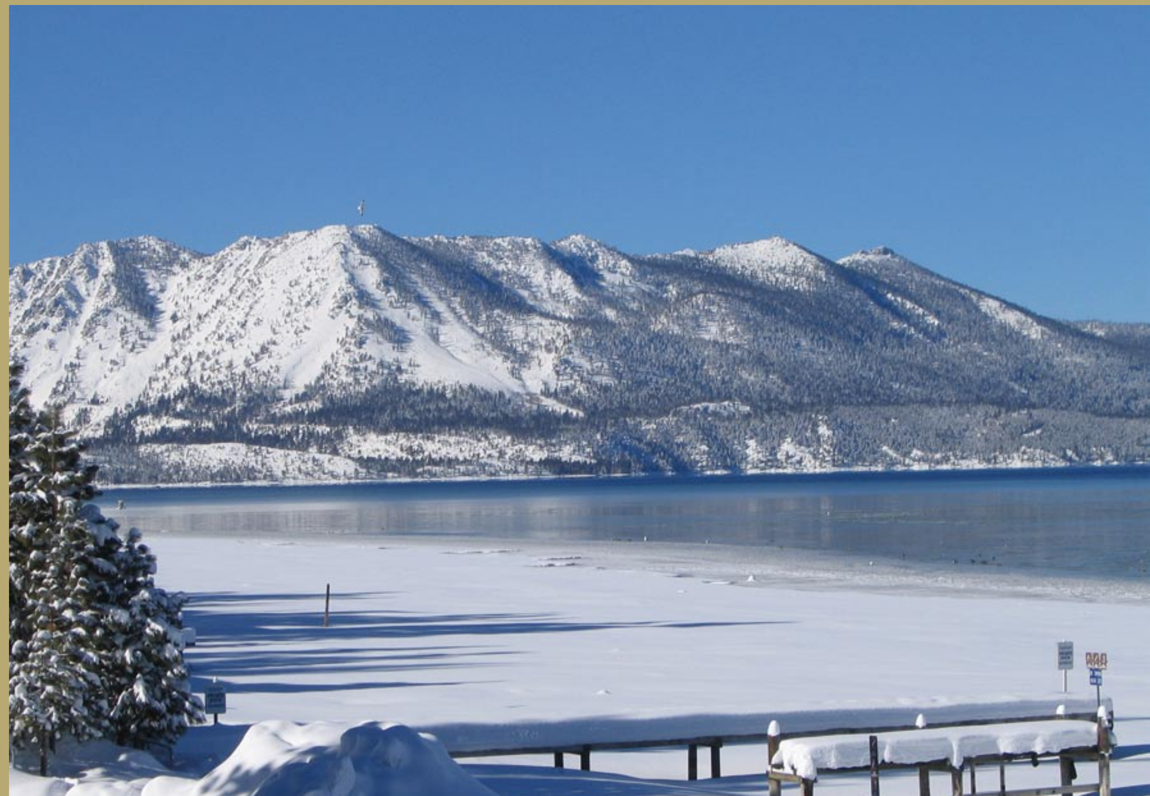
The following contributors and committees are doing the work of the TMDL:

California Air Resources Board
California Regional Water Quality Control Board, Lahontan Region
California Tahoe Conservancy
Desert Research Institute
Environmental Incentives, LLC
Lake Tahoe Interagency Monitoring Program Committee
Nevada Division of Environmental Protection (NDEP)
Nevada Division of State Lands
PATHWAY Forum members
Storm Water Quality Improvement Committee
Tahoe Regional Planning Agency (TRPA)
Tetra Tech, Inc.
TMDL Focus Team Members
U.S. Army Corps of Engineers
U.S. Department of Agriculture, National Sedimentation Laboratory
U.S. Forest Service, Lake Tahoe Basin Management Unit

U.S. Geological Survey
University of California at Davis, Tahoe Environmental Research Center (UC Davis)

The scale of effort applied to the Lake Tahoe TMDL reflects one of the most comprehensive scientific commitments applied to any TMDL, nationwide. This would not be possible without the support of U.S. Senators Harry Reid and John Ensign of Nevada, U.S. Senators Barbara Boxer and Dianne Feinstein of California, and the U.S. Environmental Protection Agency (EPA).

The TMDL would not be possible without the participation and support of PATHWAY partner agencies: The Tahoe Regional Planning Agency and the U.S. Forest Service. Nor would it be possible without local jurisdictions: Douglas County, El Dorado County, Placer County, Washoe County, Carson City rural area, and the City of South Lake Tahoe, the General Improvement Districts, the Nevada Department of Transportation and the California Department of Transportation.



Lake Tahoe Total Maximum Daily Load (TMDL)

The Lake Tahoe TMDL is the scientific effort at the forefront of the campaign to return Lake Tahoe water clarity to historic levels. The Tahoe TMDL to-date has involved:

- Research efforts by nearly 200 scientists and engineers;
- More than a $10-million investment by the federal government and the states of Nevada and California;
- Design of cutting-edge technologies to address Tahoe-specific questions;
- Cooperation and participation by Tahoe resource management agencies, local governments and the public.

This scale of effort signifies the importance of this national treasure as well as the complexity of the endeavor to create a scientifically-rigorous path to recovery of the lake.

The Clean Water Act establishes water quality standards and the TMDL program. Waters of the United States are assigned beneficial uses such as drinking water supply, water contact recreation, and aquatic life support according to the beneficial ways that these waters are used by people, animals and the environment. One of the beneficial uses of Lake Tahoe is termed “recreation (water contact and non-water contact)”. This beneficial use is also referred to as, “aesthetic enjoyment of Lake Tahoe clarity”. This aesthetic enjoyment is impaired by the declining clarity of the lake waters. When the water quality standards that describe a minimum requirement for a beneficial use are not being met, a TMDL is required by the Clean Water Act.

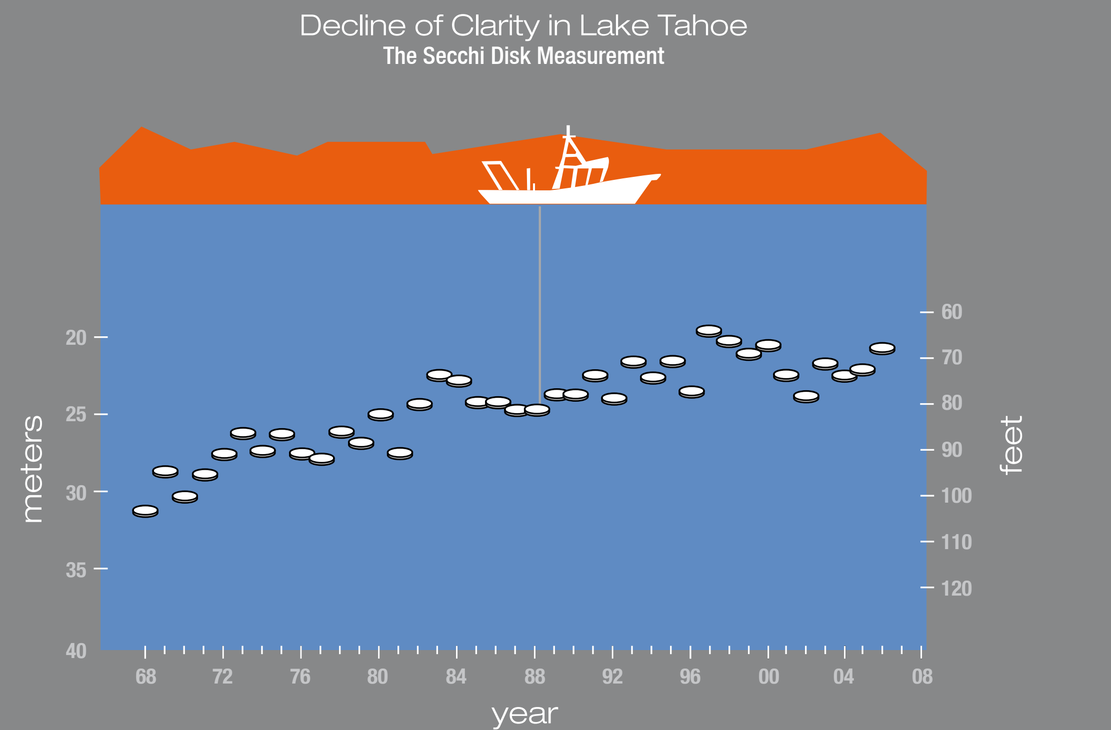
The Lahontan Water Board and NDEP are developing a sediment and nutrient TMDL that is intended to guide the implementation of projects targeted at restoring Lake Tahoe clarity. TMDL findings to-date provide an understanding of the magnitude of reduction of fine sediment and nutrients needed to achieve nearly 100 feet of clarity. TMDL findings serve as a valuable basis for focusing efforts to restore Lake Tahoe, using the most-effective and most cost-efficient mechanisms. The TMDL also helps to develop and prioritize research and monitoring efforts and focus resource management policy on results. Most importantly, the TMDL defines pollutant load reduction requirements for inclusion in permits and inter-agency agreements.

This scale of effort signifies the importance of this national treasure.

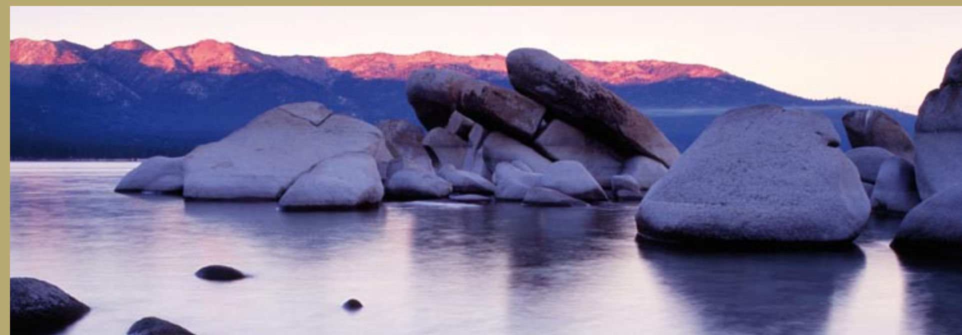
The problem: Declining clarity of Lake Tahoe waters

Lake Tahoe clarity declined at an average rate of approximately nine inches per year between 1968 and 2000. One-third of Lake Tahoe's unique clarity was lost during this period. The Lake Tahoe clarity standard of nearly 100 feet has not been achieved since the standard was adopted in 1975. However, scientific evidence indicates that the trend of decline has slowed since 2000 and can be reversed so that nearly 100 feet of clarity is possible in Lake Tahoe once again.

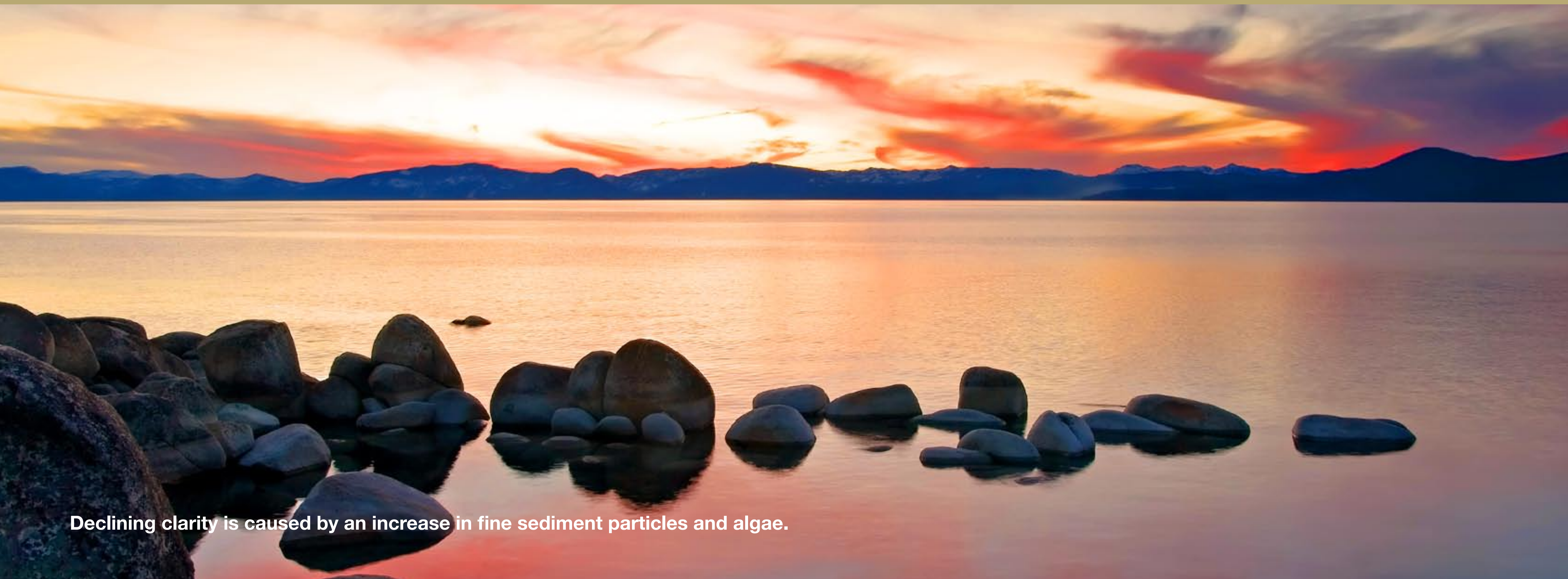
Water clarity is measured using a tool called a Secchi disk—a device resembling a dinner plate that is used to measure water transparency in open waters. It is a circular, white disk made of acrylic that is mounted on a rope and lowered slowly in the water. The depth at which the disk is no longer visible is taken as a measure of the transparency of the water. The clearer the water is, the greater the distance at which the Secchi disk can be seen. The measure is known as Secchi depth. Standardized methods for measuring Secchi depth at Lake Tahoe have been applied since the late 1960s. The Lake Tahoe transparency standard for Secchi depth—nearly 100 feet—is the annual average Secchi depth measured between 1968 and 1971.



Courtesy of UC Davis



Scientists working on the TMDL effort have developed the Lake Tahoe Clarity and Watershed Models to answer: (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 achieve the clarity standard? Computer models, based on 30 years of water quality data, have been developed to predict the likely improvement in lake clarity given the implementation of efforts to reduce fine sediment and nutrient levels in stormwater.


Declining clarity is caused by an increase in fine sediment particles and algae.

What pollutants are causing Lake Tahoe's clarity loss?

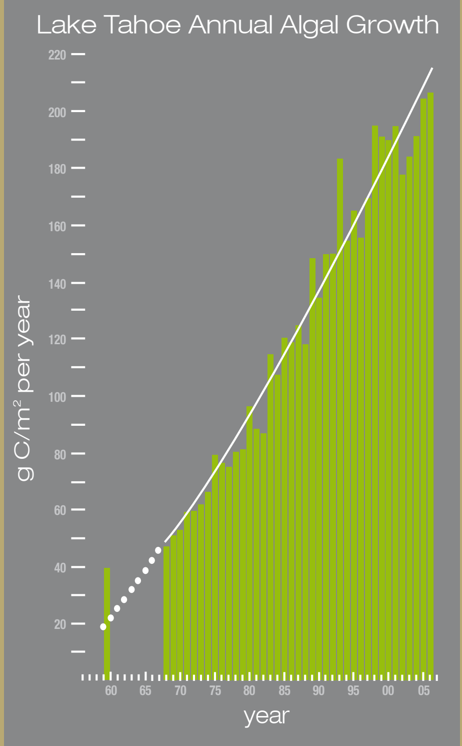
Declining clarity is attributable to both the increase in fine sediment particles and the increase in algae production from inputs of nitrogen and phosphorus. The extraordinary clarity of Lake Tahoe exists because its clean waters allow sunlight to reach depths greater than it reaches in most other water bodies. As the amount of fine sediment particles increases, these particles scatter the light, causing less light to reach deeper waters. Similarly, as the amount of algae in the lake increases, the algae adsorbs the light and less light reaches deep water. As light is scattered or adsorbed, clarity declines and Secchi depth decreases.

Fine Sediment Particles

Fine sediment particles originate in the watershed. Soil disturbance, application of road abrasives and other activities mobilize fine sediment particles. These particles are produced in and travel through streams, storm drains, and the air, into the lake. TMDL research indicates that the smallest of the fine sediment particles—those smaller than 20 micrometers in diameter (smaller diameter than a human hair)—are the primary culprit in impairing Lake Tahoe clarity.

Algae Production

Algae are water plants with no true leaves or stems. While some algae exist naturally, the amount of algae in the water increases as more nitrogen and phosphorus are added to the lake. Higher amounts of phytoplankton—free floating algae—in the water absorb more light and reduce light penetration into deeper waters. This too diminishes the clarity of the lake. The following graph illustrates how algae production in Lake Tahoe has dramatically increased in recent years.



Courtesy of UC Davis

The accumulation of attached algae on rocks, piers, boats and other hard-bottomed substrates is a striking indicator of Lake Tahoe's declining water quality. Thick expanses of periphyton biomass often coat the shoreline in portions of the lake during the spring.

How much of each pollutant is reaching Lake Tahoe?

Year 2004 levels of fine sediment particles, nitrogen and phosphorus have been utilized as baseline numbers in developing the strategy for the next 20 years. In 2004, the annual estimate for each of these pollutants was:

- Fine sediment – 481 x 10^{18} particles
- Nitrogen – 397 metric tons
- Phosphorus – 46 metric tons

Most of the pollutants reaching Lake Tahoe come from four pollutant sources-urban runoff, forest runoff, stream channel erosion and atmospheric deposition. Estimates of the amount of each pollutant entering the lake from each pollutant source are derived from scientific monitoring and modeling.

Total fine sediment particles reaching Lake Tahoe

The number of fine sediment particles in the water column affects the clarity of the lake. The majority of fine sediment particles are generated in urban areas. Commercial, residential and roadway areas all contribute. Road dust and wood burning are also sources of fine sediment particles, some of which make it to the lake from urban runoff and some of which make it to the lake from atmospheric transport and deposition.

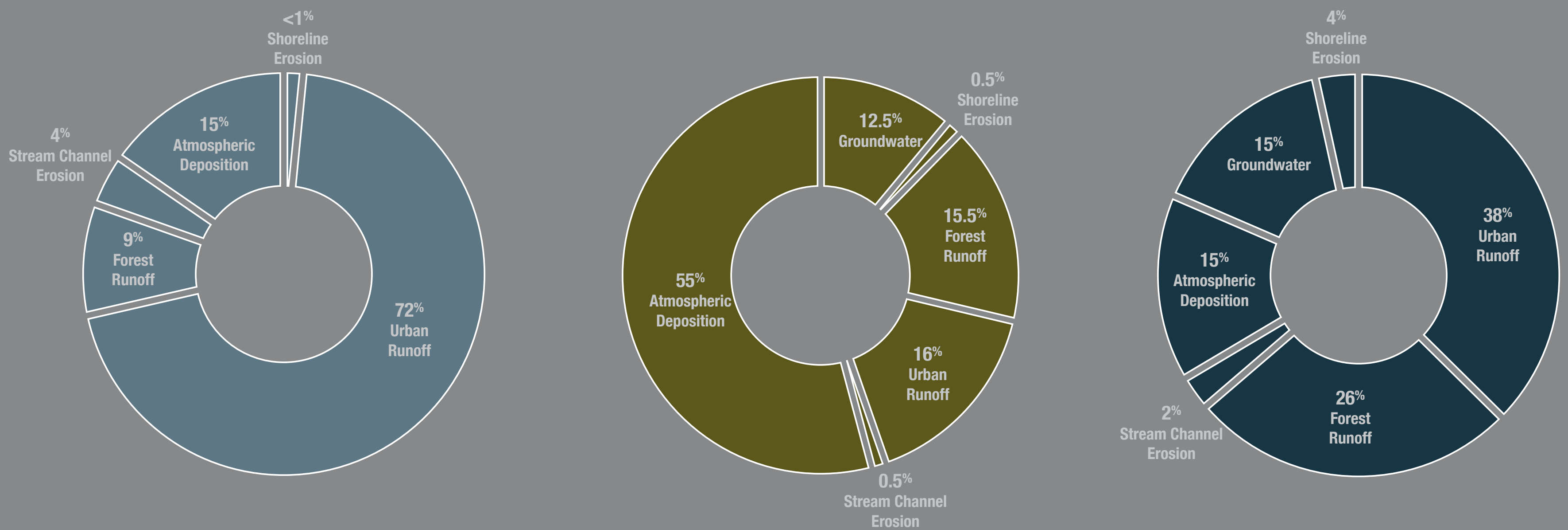
Total nitrogen reaching Lake Tahoe

The mass of nitrogen available affects the clarity of the lake. Nitrogen entering the lake is generated primarily in urban areas. Locally-generated vehicle emissions are a significant contributor of nitrogen. Nitrogen transports to the lake predominantly by atmospheric deposition.

Total phosphorus reaching Lake Tahoe

The mass of phosphorus available affects the clarity of the lake. Phosphorus entering the lake is generated primarily in urban areas. Road dust is a significant source of phosphorus. Phosphorus is also generated in the forest areas of the Tahoe Basin and transported to the lake from forest runoff. Forests (non-urbanized areas) represent more than 80% of the land within the Lake Tahoe Basin so their cumulative impact on lake clarity is important to address.

Scientific monitoring and modeling estimates of fine particle, nitrogen and phosphorus inputs to the lake.



Fine Sediment Particle Estimates
Percent Contribution per Source Category

Total Nitrogen Estimates
Percent Contribution per Source Category

Total Phosphorus Estimates
Percent Contribution per Source Category

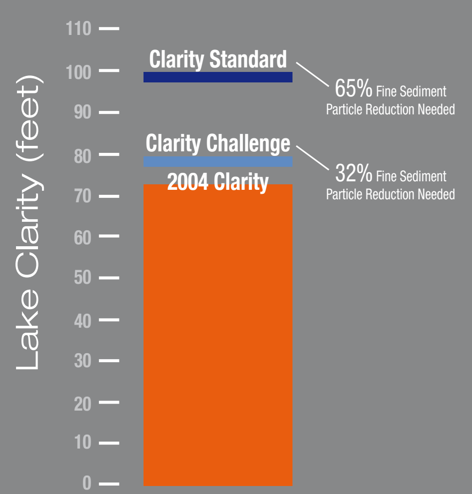
The number of fine sediment particles affects lake clarity while mass of nitrogen and phosphorus stimulates algae growth, which in turn impacts lake clarity.

How much of each pollutant can Lake Tahoe accept and meet the Clarity Challenge and the clarity standard?

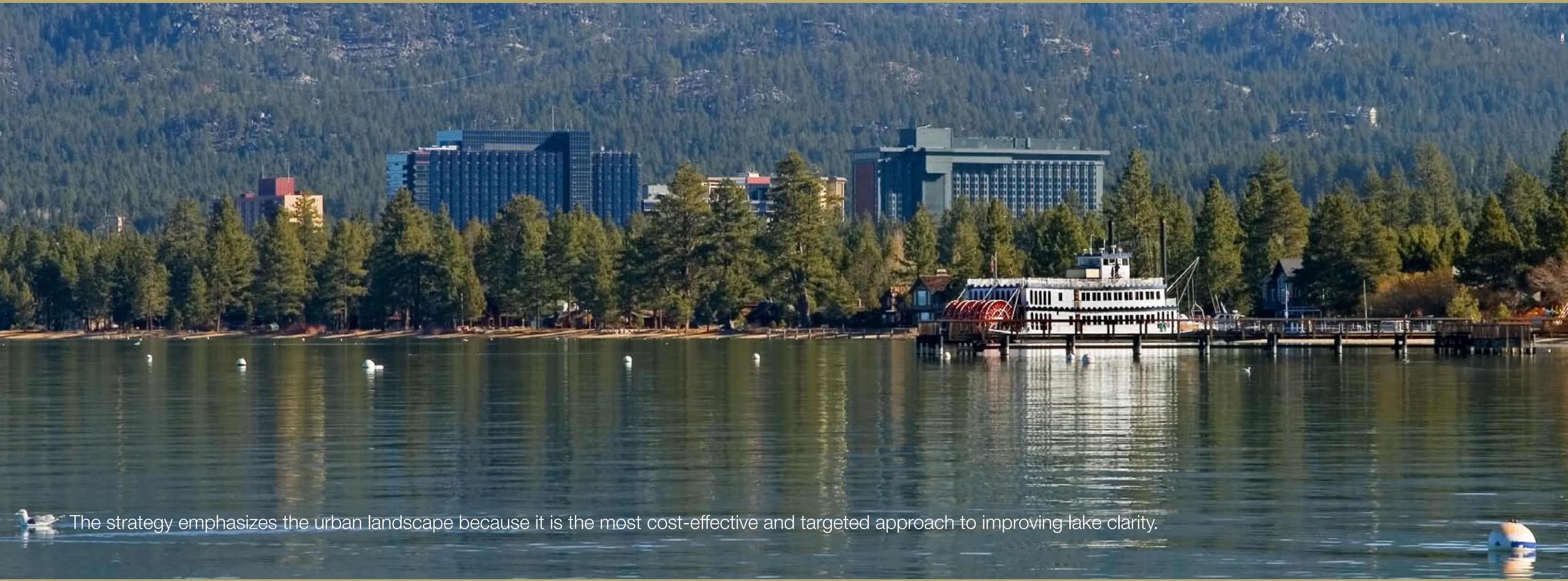
While the indication is that the decrease in clarity has been slowed, a big effort will be required to turn the tide, halt clarity decline, and actually improve clarity. Meeting the Clarity Challenge and reversing the clarity decline requires significantly reducing the inputs of fine sediment particles, nitrogen and phosphorus to the lake. Data shows that when pollutant input is reduced, Secchi depth and clarity can increase by many feet over a period of just a few years.

The Lake Clarity Model estimates that a basin-wide 32% reduction (from 2004 levels) in the input of fine sediments to the lake, and accompanying reductions of nitrogen and phosphorus, will result in meeting the Clarity Challenge. To meet the long-term clarity standard of nearly 100 feet, amounts of fine sediment particles and entering the lake will need to be reduced much further, by approximately 65% from 2004 levels.

Percent fine sediment particle reductions needed to meet the Lake Tahoe Clarity Challenge and clarity standard.



An approximate 32% reduction (from 2004 levels) in fine sediment particles is needed to reach the Clarity Challenge, about 80 feet, in the next 20 years. An approximate 65% reduction (from 2004 levels) in fine sediment particles is needed to reach the clarity standard at nearly 100 feet. Reductions of nitrogen and phosphorus (not portrayed in this graphic) accompanying the fine sediment particle reductions are also needed to reach these clarity goals.



The strategy emphasizes the urban landscape because it is the most cost-effective and targeted approach to improving lake clarity.

What should be the strategy for reducing pollutant inputs to Lake Tahoe?

The strategy for improving lake clarity emphasizes reducing fine sediment particles originating in urban areas that are transported to the lake through stormwater runoff and atmospheric deposition. The strategy also includes efforts to reduce pollutants originating in, and transporting through, forests and stream channels. The cost of strategy implementation over a twenty-year period (in 2008 dollars) is estimated at $1.5 billion.

Urban runoff

The strategy for the next 20 years includes broader application of the types of treatments utilized in the past to reduce pollutants to the lake. The strategy also calls for innovative improvements to these treatments using new technologies, materials and methods. The strategy employs area-wide stormwater treatment and erosion control projects such as: road vacuum sweeping, wetland and passive filtration basins, media filters in stormwater vaults, private property BMP implementation, and intensive maintenance of stormwater infrastructure. Engineering estimates indicate that capturing urban runoff water from the most intensively urbanized areas and treating it using advanced technologies has the potential to significantly reduce pollutant inputs to the lake. One element of the strategy is to investigate further how, when and where to apply these technologies for the best results. To meet the Clarity Challenge, fine sediment particles from urban runoff need to be reduced by 34% from 2004 levels. To meet the clarity standard, fine sediment particles from urban runoff need to be reduced by approximately 71% from 2004 levels.

Atmospheric deposition

The strategy for reducing pollutant loads to Lake Tahoe calls for reducing the amount of dust generated in the Lake Tahoe basin. This involves using technologies, materials and methods that minimize the amount of dust from parking lots, construction sites, and paved and unpaved roadways ending up in stormwater or the lake. These technologies include street sweeping with advanced vacuum sweeping equipment and graveling, paving or eliminating dirt roads. To meet the Clarity Challenge in 20 years, fine sediment particles from atmospheric deposition need to be reduced by 30% from 2004 levels. To meet the clarity standard, fine sediment particles from atmospheric deposition need to be reduced by approximately 55% from 2004 levels.

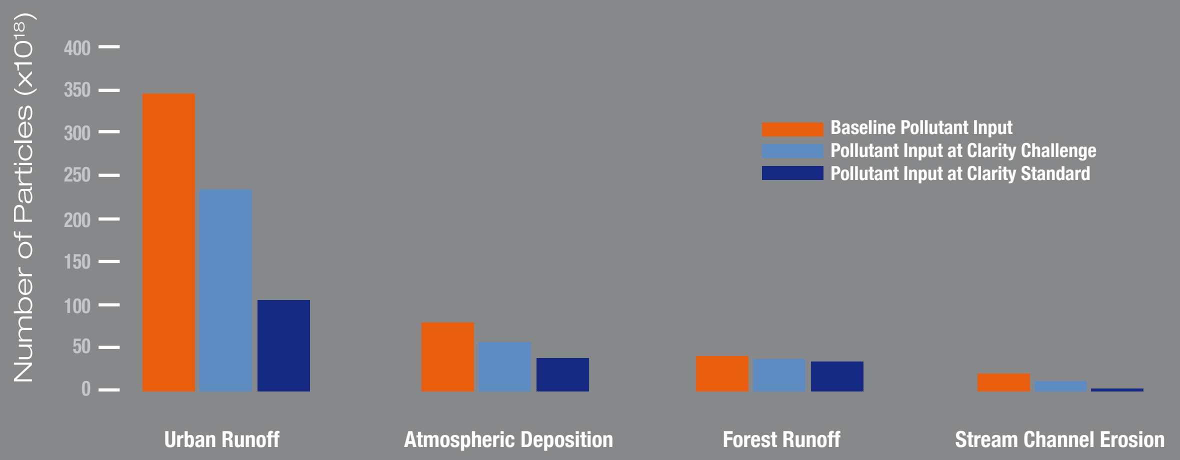
Forest runoff

The strategy calls for control of runoff from forest sources to reduce pollutants to the lake. Disturbed areas of the forest such as unpaved roads, ski runs and campgrounds yield high amounts of fine sediment particles when compared to the undisturbed forest. Relatively high sediment yields and easy access to these areas make controlling pollutants from them relatively cost-effective. Forest areas in the Tahoe Basin are managed by federal and state agencies with well-defined, multi-objective restoration programs. The TMDL strategy works in conjunction with these agencies' efforts while also accommodating forest fuels treatment projects and recreation management activities. In order to meet the Clarity Challenge in 20 years, fine sediment particles from forest runoff need to be reduced by 12% from 2004 levels. To meet the clarity standard, fine sediment particles from forest runoff need to be reduced by approximately 20% from 2004 levels.

Stream channel erosion

Stream restoration activities are an integral part of the strategy. These provide a broad array of benefits to the Lake Tahoe ecosystem and result in the most cost-effective fine particle reductions. Restoring streams reduces pollutant inputs from failing stream banks and eroding stream beds, but more significantly, enhances riparian habitat and improves floodplain function. Further, reconnecting disturbed rivers and streams with the natural floodplain allows the stream system to serve as a natural filter for pollutants coming from the upland areas. In order to meet the Clarity Challenge in 20 years, it is estimated that fine sediment particles from stream channels need to be reduced by approximately 53% from 2004 levels. To meet the clarity standard, it is estimated that fine sediment particles from stream channels need to be reduced by approximately 89% from 2004 levels.

Fine sediment particle inputs to Lake Tahoe (as of 2004) and reductions needed to meet the Clarity Challenge and clarity standard.



This chart shows the fine sediment particle inputs to Lake Tahoe as of 2004 (orange columns). In order to meet the Clarity Challenge in the next 20 years (light blue columns) and the clarity standard (dark blue columns) the number of fine sediment particles coming from urban runoff, atmospheric deposition, forest runoff and stream channels needs to be dramatically reduced.

How was the strategy developed?

The TMDL strategy is built on a foundation of science. Decades of data collection, work of hundreds of scientists and practitioners, and the findings and projections of scientific models all inform the framework of the strategy. Public opinion also figures significantly in the strategy that the Lahontan Water Board and NDEP have developed. Multiple strategies for meeting the Clarity Challenge were discussed with a forum of well-informed members of the public (stakeholders) who informed the selection of strategy elements.

The 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 objective of each was to: (1) Identify, screen and analyze opportunities to control pollutants; (2) Formulate strategies integrating opportunities to control pollutants from all pollutant sources; (3) Develop and refine a recommended strategy for consideration by the Lahontan Water Board and NDEP. During each cycle in development:

- An interim product (containing draft strategy elements) was developed to engage people in substantive discussion and review;
- Stakeholders commented on the interim product;
- Product was adjusted to address comments—resulting in a new interim product;
- Additional stakeholder questions were answered.

How will the strategy be implemented?

The strategy will be implemented by local, state and federal regulatory and land management agencies and jurisdictions through their respective programs. The distribution of allocations—pollutant load reduction requirements—to these entities will be managed by the Lahontan Water Board and NDEP. According to TMDL guidelines, the sum of all Tahoe Basin allocations must result in attainment of the nearly 100–foot clarity standard over time. Allocations are expected to satisfy principles of cost-effectiveness, equitability, public acceptance and accountability.

A pollutant reduction tracking system and regional stormwater monitoring program will inform the adaptive management of the Lake Tahoe TMDL.

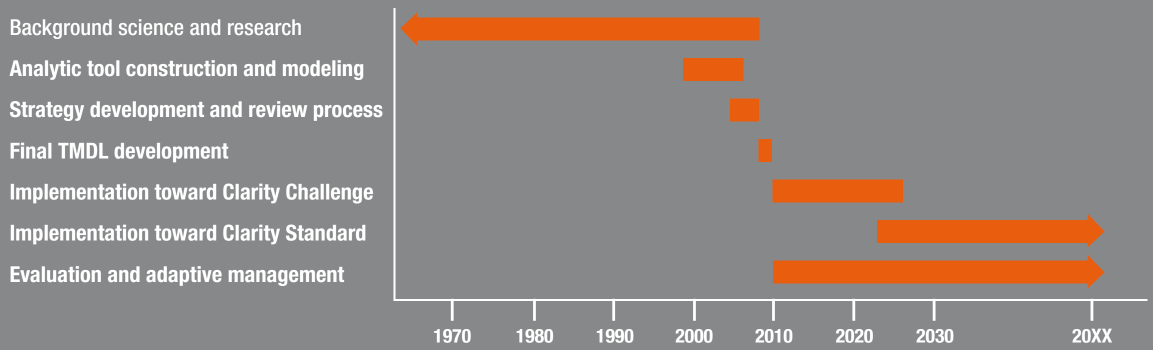
How will progress be assessed?

The Lahontan Water Board and NDEP will assess progress toward the Clarity Challenge through the regular evaluation of responses to three pivotal questions over the twenty-year timeframe: (1) Are the expected reductions of each pollutant being achieved? (2) Is the clarity of Lake Tahoe improving as models predicted in response to actions to reduce pollutants? (3) Can innovation and new information improve our strategy to reduce pollutants?

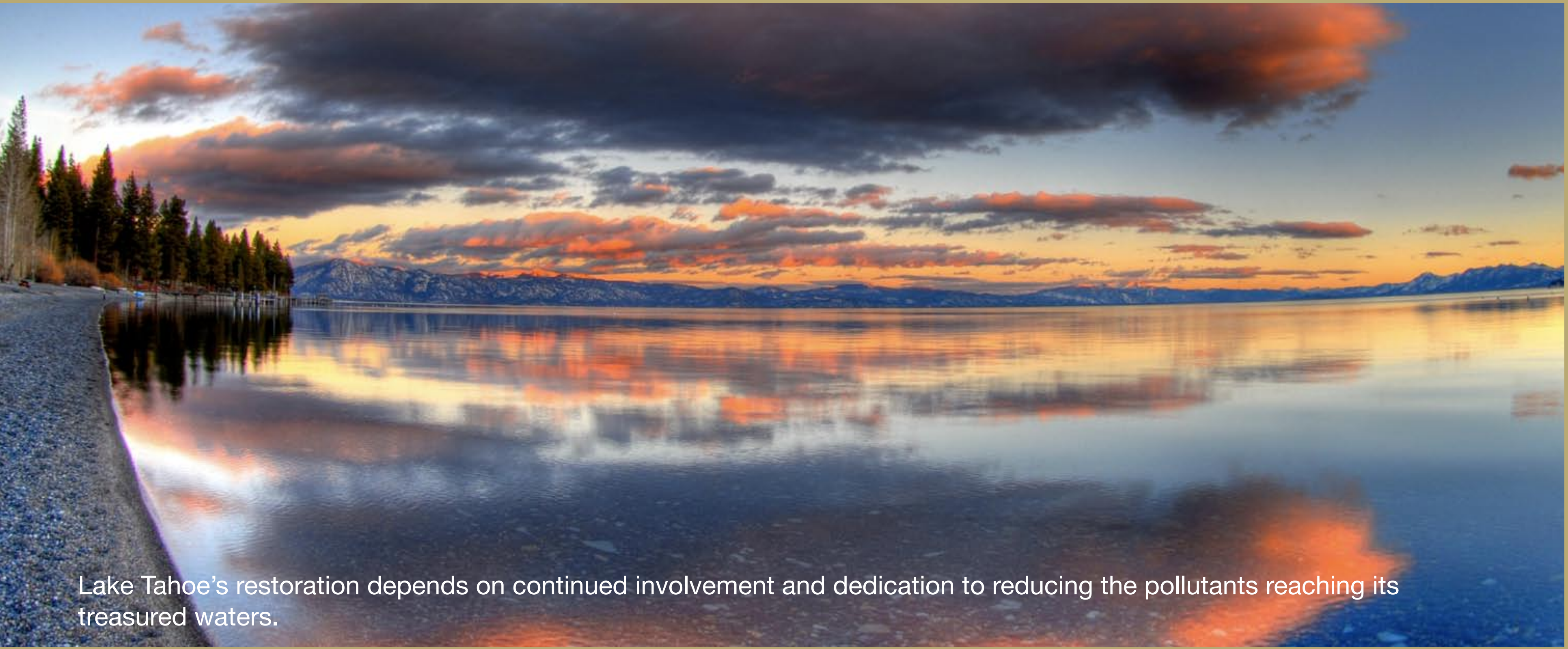
Over the 20 years of implementation these questions will be answered through load reduction tracking and lake clarity crediting. These are tools to assist the Lahontan Water Board and NDEP calculate and account for the amount of pollutant that is kept out of the lake due to specific actions on the ground. These will help agencies define the lake clarity benefit derived from investment in water clarity improvements. Together with a regional stormwater monitoring program these programs will inform the adaptive management process for the Lake Tahoe basin.

Timeline of the Lake Tahoe TMDL

Overview timeline of Lake Tahoe clarity monitoring and restoration.



Regular monitoring of Lake Tahoe clarity began in the 1960s. This monitoring documented the loss of clarity. From 1990 to the present, concerted efforts have addressed critical questions as to how to focus a strategy for restoring the lake. Also, on-the-ground projects have proven somewhat effective in slowing the trend toward decline. The strategy recommended for the next 20 years is to reverse the trend and improve clarity by emphasizing investment in broad application of effective practices to reduce fine sediment particles generated in urban areas.



Lake Tahoe's restoration depends on continued involvement and dedication to reducing the pollutants reaching its treasured waters.

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Charting the course to
Clarity

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Charting the Course to Clarity

The pristine waters of Lake Tahoe are a national and international treasure. In the past several decades a significant decline in the clarity of these waters has been caused by the addition of fine sediment particles, nitrogen and phosphorus to the lake system. Monitoring and science have illustrated the decline and pinpointed the reasons for it. Science and engineering indicate that implementation of projects that significantly reduce runoff can make it possible to once again see to depths of nearly 100 feet into Lake Tahoe. The trend of decline seems to be slowing in response to actions of the recent past. The challenge is to reverse the decline. Coordinated commitments and resources at the local, state and federal levels are essential to realizing the return to historic clarity at Lake Tahoe.

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