
# UPDATED LAKE TAHOE NEARSHORE WATER QUALITY PROTECTION PLAN

## STATE WATER RESOURCES CONTROL BOARD
## LAHONTAN REGION

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

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## Executive Summary

The California Regional Water Quality Control Board, Lahontan Region (Lahontan Water Board) and its partners are committed to understanding the complex and dynamic set of factors influencing Lake Tahoe's nearshore, and when sufficient data and information are available to inform resource management decisions, to implementing appropriate changes to existing or proposed rules and regulations to address specific issues and concerns.

Guided by the Nearshore Water Quality Protection Plan (2014), most recent efforts have focused on monitoring nearshore conditions and evaluating the drivers of various nearshore health indicators (e.g., clarity, algal growth, biological community structure, and human health metrics) to support resource management decisions.

**What is new**

Since the 2014 Plan was adopted, a broad agency and academic partnership has conducted a series of pilot monitoring projects to begin gathering basic nearshore condition information.

The *Pilot Implementation of the Lake Tahoe Nearshore Monitoring Framework for Clarity Metrics* (Heyvaert et al., May 2016*),* led by the Desert Research Institute, documented nearshore clarity metric status. University of Nevada, Reno partners conducted the *Lake Tahoe Nearshore Community Structure Pilot Monitoring* project (Chandra, Ngai-Ryan, 2015) to assess the composition, distribution, and abundance of nearshore biological indicators at Lake Tahoe. Researchers with the University of California, Davis Tahoe Environmental Research Center continue critical nearshore periphyton monitoring. The United States Geological Survey led a targeted study to evaluate periphyton growth drivers on Lake Tahoe's west shore and continues to manage tributary monitoring efforts.

The Nearshore Agency Working Group, made up of Lahontan Water Board, Tahoe Regional Planning Agency, Nevada Division of Environmental Protection, United States Environmental Protection Agency, and Tahoe Resource Conservation District staff, developed a unique decision support system known as the Nearshore Resource Allocation Program to prioritize ongoing research and monitoring investment.

To share nearshore program knowledge, the region-wide Lake Tahoe Info online platform now includes a Nearshore Resource Allocation Program page describing recent and current work.

**What we have learned**

Evaluating potential impacts to Lake Tahoe's nearshore environment and assessing appropriate resource management responses is challenging. Conditions vary greatly, both spatially and temporally, and the biological, chemical, and physical properties are more complex than (more commonly considered) deep-water clarity.

The Tahoe: State of the Lake Report (2018), produced annually by University of California, Davis Tahoe Environmental Research Center, continues to document ongoing warming of the lake waters, extended periods of lake stratification, and increased frequency of warm, wet storms as clear evidence of climate change impacts at Lake Tahoe. These impacts are believed responsible for the lowest average annual clarity level on record, measured in 2017, and are likely influencing nearshore conditions ranging from clarity, periphyton growth, and cyanobacteria outbreaks.

Introduced fish and macroinvertebrate species have substantively altered Lake Tahoe's delicate ecological balance, further complicating algal growth patterns. Aquatic invasive species threaten further nearshore impairment.

**Where we are going**

Further research and monitoring is critical for guiding resource management decisions. In 2018, the Lahontan Water Board has invested in lake-wide invasive plant and bacteria surveys to guide plant control and ensure public safety protection. Program resources are also dedicated to ongoing tributary monitoring to better understand nearshore inputs, and planned studies will further evaluate climate change and biological factors influencing algal growth. The Lahontan Water Board is also investing in new technologies, including real-time Nearshore Network monitoring stations, to more effectively and efficiently gather needed information.

The Lahontan Water Board continues Lake Tahoe Total Maximum Daily Load (TMDL) program efforts to reduce fine sediment and nutrient loading while further evaluating the efficacy of nearshore water quality standards Basin Plan objectives at maintaining desired nearshore conditions.

**Key Recommendations**

This report follows the same five-point organization strategy outlined in the Nearshore Water Quality Protection Plan (2014). Each of the five plan strategy sections provides specific recommendations to support future work related to Lake Tahoe's nearshore environment. Select key recommendations include:

- Support paired watershed studies that assess conditions at undeveloped alpine lake systems (e.g., Castle Lake, CA; Crater Lake, OR) in comparison to Lake Tahoe to determine the relative influence of climate change variables on nearshore environment.
- Support ongoing nearshore monitoring to continue to assess nearshore conditions and better understand condition drivers with an emphasis on identifying those variables under management control.
- Engage with marina operators and beach management agencies to ensure harmful algal blooms are identified quickly and notifications posted.

Additional program recommendations are described throughout the report, and listed in the Recommendations Summary section, starting on page 19.

## Background

The Lake Tahoe nearshore is the portion of the lake in close proximity to the shoreline. It is the area that people interact with when viewing the lake from the shore, wading, swimming, enjoying paddle sports, and boating. Nearshore conditions differ widely around the lake based on adjacent land-use, non-point pollutant inputs, proximity to stream inputs, water movement, water depth, substrate type, and other features. Variations in these factors create more heterogeneous conditions compared to the more uniform open waters. Consequently, the nearshore environment is inherently more complex and active than deeper waters, requiring a different scale of evaluation and management.

Appendix A includes a detailed nearshore definition, established desired condition statements, and a conceptual model describing nearshore condition drivers.

In 2013, a Nearshore Science Team comprised of water quality scientists and aquatic ecologists from the University of Nevada, Reno, the University of California, Davis, and the Desert Research Institute developed the Lake Tahoe Nearshore Evaluation and Monitoring Framework Report (NeST Report) (NeST 2013). The NeST Report synthesized available nearshore information and established a comprehensive monitoring approach to assess nearshore physical, chemical, and biological variables. The report framework (Appendix B) provides a valuable structure for organizing nearshore environment research, monitoring, and resource management considerations.

**Lake Tahoe Nearshore Water Quality Protection Plan (2014)**

In June 2014, the Lahontan Water Board prepared the Lake Tahoe Nearshore Water Quality Protection Plan (Plan). The Plan was developed in response to the Budget Act of 2012 (Assembly Bill 1464, Chapter 21, Statues of 2012) that required the Lahontan Water Board, upon receipt of the NeST Report (NeST 2013), to establish a schedule responding to nearshore water quality concerns.

Since the Plan was developed and adopted, the Lahontan Water Board and its partners have leveraged available resources to invest in targeted research and monitoring to better understand nearshore dynamics. The complexity of the nearshore, coupled with relatively sparse long-term data, obligated the Lahontan Water Board and its partners to simultaneously focus on identified areas of concern while developing a comprehensive research and monitoring prioritization approach to guide future work.

The Plan recommended a five-point strategy:

(1) Continue implementing programs that benefit nearshore water quality.
(2) Establish a nearshore monitoring program to assess nearshore conditions.
(3) Evaluate the cause of “hotspots” were nearshore change has been identified.
(4) Investigate climate change influence on Lake Tahoe’s nearshore.
(5) Assess the need to revise or update water quality standards to protect nearshore water quality.

The Plan has guided nearshore program activities to date, and continues to provide a framework for future work.

2018 Plan Update

This Plan update provides a status report of nearshore conditions and available information within the context of the established conceptual model (Appendix A) and indicator framework (Appendix B). The updated Plan follows a similar format to the 2014 report. Sections describe Lahontan Water Board progress in implementing the Plan's five strategy points, broadly outlining recent program efforts by describing resource expenditures, project findings, and outstanding information gaps.

**Funding**

California Senate Bill 630 (Chapter 762, Statutes of 2013) established the Lake Tahoe Science and Improvement Account (Account) to support Lake Tahoe nearshore program management and to establish the Lake Tahoe Science Council. The Lahontan Water Board is charged with investing Account funds in Lake Tahoe nearshore research and monitoring.

To date, approximately $1M has been spent assessing nearshore conditions and monitoring tributary inflows. The Lahontan Water Board is working on contracting another $800,000 to further evaluate climate change influences and conduct further research on the biological drivers of algal growth.

Agency and academic partners provide critical funding support to enhance Account investments. The California State Water Resources Control Board invested $200,000 from Cleanup and Abatement Account resources to evaluate hotspot conditions, while the State of Nevada has matched nearshore program investments to ensure various projects effectively gather lake-wide data.

**Agency Partnership and Public Engagement**

The Lahontan Water Board, Nevada Division of Environmental Protection (NDEP), Tahoe Regional Planning Agency (TRPA), Tahoe Resource Conservation District (TRCD), and United States Environmental Protection Agency (USEPA) staff regularly meet as the Nearshore Agency Working Group (NAWG) to guide Lake Tahoe nearshore policy and program investment. The NAWG tracks and prioritizes outstanding nearshore information needs, assesses how best to monitor change, and collectively evaluates resource management options for the nearshore environment.

Lake Tahoe resource management agencies continue to provide the public with opportunities to learn about Lake Tahoe's nearshore and associated monitoring efforts. NAWG members have provided regular updates to various decision makers, and agency staff have drafted a number of brief documents describing nearshore program progress. Presentations to TRPA's Advisory Planning Commission and Governing Board were open to the public, as were presentations to the Lahontan Water Board. Lahontan Water Board staff annually distributed Executive Officer's reports that provide concise summaries of nearshore program activities.

## Plan Strategy 1 - Continue implementing established programs

The Lahontan Water Board and NDEP developed the Lake Tahoe TMDL to establish a science-based plan to restore Lake Tahoe's historic transparency. The TMDL, based on more than ten years and ten million dollars of targeted research and monitoring, provides pollutant load reduction targets to guide water quality implementation actions.

TMDL research found the bulk of the fine sediment particles (72 percent) and total phosphorus 47 percent) reaching Lake Tahoe originate in the urban landscape. Consequently, the TMDL program emphasizes actions to reduce urban storm water pollution. The TMDL program relies on multi-objective land management programs implemented by regional, state, and federal partners to reduce fine sediment and nutrient loading from undeveloped lands, stream channels and the atmosphere.

Current Status

The NeST Report asserted "nutrient and fine sediment loading reductions resulting from Tahoe TMDL implementation will provide not only better mid-lake clarity, for which the TMDL was designed, but also will provide benefits to clarity and related characteristics in nearshore conditions" (NeST 2013). Consequently, the Lahontan Water Board has maintained focus on motivating and tracking actions to remove fine sediment particles, total phosphorus, and total nitrogen from pollutant sources documented in the Lake Tahoe TMDL.

Recent Work

In 2017, the program documented substantive fine sediment and nutrient reductions, exceeding the first five-year TMDL targets. In addition to ongoing steam restoration efforts and load reduction work in forested areas, local governments have demonstrated fine sediment particle, total phosphorus, and total nitrogen loads of 10 percent, eight percent, and seven percent, respectively.

The Lake Tahoe Info Stormwater Tools describe actions taken by urban implementing partners to meet required load reduction targets. Learn more at https://stormwater.laketahoeinfo.org/.

Similarly, TMDL program managers updated the online system for tracking overall TMDL progress and incorporated it into the web-based Lake Tahoe Info platform: https://clarity.laketahoeinfo.org/

Recommendations

Lake Tahoe TMDL research noted potential water quality improvements from roadways and storm water infrastructure maintenance. Operations and maintenance funding has historically lagged behind infrastructure investment.

To reduce further achieve TMDL program goals, ***the greatest outstanding need is for dedicated and continuous storm water facility and roadway operations and maintenance funding.*** Such investment is not only critical for restoring Lake Tahoe's clarity, it is fundamentally needed to ensure Lake Tahoe nearshore protection.

## Plan Strategy 2 - Establish monitoring to assess nearshore conditions

Given the lack of available data related to nearshore conditions, the heterogeneous nature of nearshore variables, and the interrelated complexity of nearshore drivers, monitoring and assessment remains the primary focus of the Lake Tahoe nearshore program.

The NeST Report outlined a comprehensive monitoring approach to evaluate and track all aspects of Lake Tahoe nearshore conditions. Implementing the proposed monitoring approach, however, greatly exceeds available resources, creating the need to prioritize monitoring needs to target limited available resources. To meet this need, the Lahontan Water Board first invested in developing a process that would guide funding decisions.

The Nearshore Resource Allocation Program (NRAP) directs nearshore science and monitoring investment through a systematic framework to better understand nearshore conditions and processes, and reduce uncertainty about management actions. The NRAP provides a unique structure to effectively tackle complex nearshore research and monitoring questions in a systematic and iterative process to ensure wise investment of limited funds. Using the NRAP structure, resource managers (1) evaluate the state of the knowledge for each focus area and summarize available research findings; (2) broadcast priority information needs to research partners as project solicitations; (3) rank and select research and monitoring projects; and (4) integrate new findings into future information need and project selection processes.

The NAWG has successfully used the NRAP approach to organize nearshore research and monitoring needs and select projects to fill identified gaps.

**Tributary Monitoring**

In developing the TMDL, the Lahontan Water Board and NDEP leveraged the multi-year Lake Tahoe Interagency Monitoring Program (LTIMP) tributary data to assess historic sediment and nutrient loads and calibrate numeric watershed modelling tools. To maintain this critical data source and track tributary inputs to the nearshore, the Lahontan Water Board is annually contributing resources to maintain LTIMP in select streams.

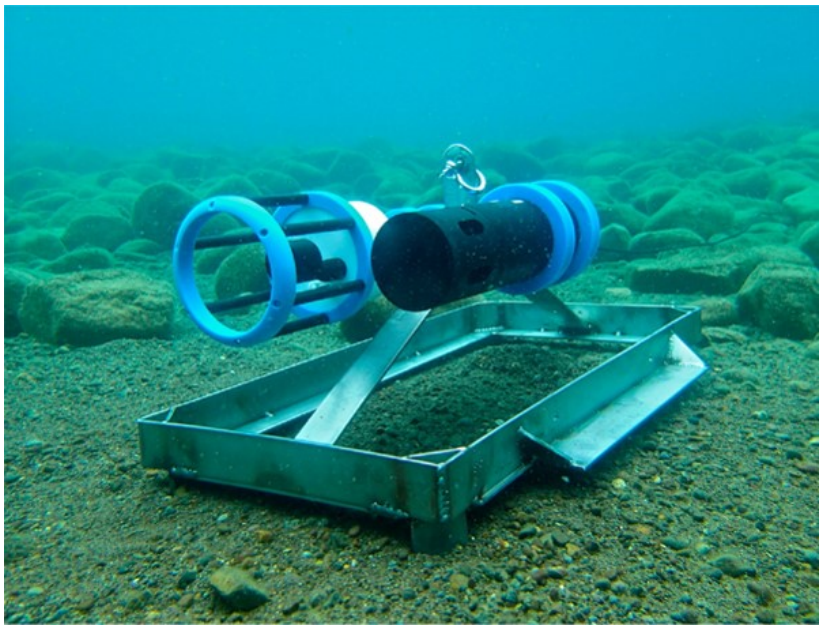
**Nearshore Clarity**

Water clarity represents one of the most important characteristics of Lake Tahoe. Water clarity is an integrative indicator of lake condition, for both nearshore and mid- lake environments. Historically, nearshore clarity has been measured with grab samples of turbidity and/or snapshot boat-based surveys of turbidity and light transmissivity.

Current Status

The most recent boat-based lakeshore survey was conducted by Heyvaert et al. in 2014 and 2015 (*Pilot Implementation of the Lake Tahoe Nearshore Monitoring Framework for Clarity Metrics*, Heyvaert et al., May 2016). The project was implemented to evaluate nearshore clarity metrics by conducting five complete nearshore surveys from November 2014 through November 2015, using flow-through sensors mounted on a boat that followed a consistent path-line around the entire nearshore at approximately the 7-meter depth contour.

No single turbidity measurement in the Hayvaert et al. study exceeded the state and regional clarity standard of one nephelometric turbidity unit (NTU). These measurements were necessarily conducted during non-storm periods, however, so nearshore monitoring closer to outfall points during storm runoff events could yield values exceeding 1 NTU. The range of turbidity values measured throughout the year spanned 0.081 to 0.999 NTU. The average of interquartile ranges (representing the bulk of collected data during each circuit) extended from 0.107 to 0.128 NTU. Higher turbidity was typically found near urban areas along the south shore, the northeast shore and northwest shore of Lake Tahoe.



**Real-time nearshore monitoring station (UD Davis TERC)**

Recent Work

In 2014, the University of California, Davis Tahoe Environmental Research Center (TERC) began establishing a network of continuous water quality monitoring stations at various points on the shoreline around the lake. The program, known as the Nearshore Network, aims to provide essential data needed to track and evaluate real-time nearshore conditions, including turbidity.

As of early 2018, TERC has established eleven stations in the Lake Tahoe basin.
Although not yet fully distributed around the lake, the Nearshore Network has already provided valuable insight into nearshore clarity conditions. Using turbidity measurements from the Nearshore Network together with a model of wind-generated waves, researchers have been able to estimate wave-induced turbidity at any point around the shoreline. The results showed how frequently a particular turbidity value is exceeded in the nearshore region due to waves. It is evident that the eastern shore, because of its exposure to winds, has the highest number of standard exceedances, particularly during the Fall cooling period from October-December,

demonstrating the elevated turbidity measurements are often due to natural wind and wave action (*Tahoe: State of the Lake Report 2017*, UC Davis).

The Lahontan Water Board funded the installation and maintenance of two additional Nearshore Network stations, both installed on Lake Tahoe's south shore.

Recommendations

The NAWG supports full Nearshore Network buildout and will continue to explore data assessment opportunities to leverage collected datasets. Ideally, the network will include approximately twenty stations distributed around the lake to continuously assess nearshore condition variables. The Water Board and its partners should ***support Nearshore Network build-out and further network data assessment work.***

**Nearshore Trophic Status (Algae)**

The term "trophic" refers to the ability of a waterbody to support life such as plants, fish and wildlife. "Trophic state" defines where a lake lies along a spectrum from one that is pristine to one that is choked with excessive plant growth. While lakes exist along a spectrum of trophic conditions, three basic categories are commonly recognized: oligotrophic, mesotrophic and eutrophic. Lake Tahoe is classified as oligotrophic with clear water, containing few nutrients, low levels of phytoplankton, rich in dissolved oxygen, and supporting a healthy diversity of fish and other aquatic animals.

Although the NeST indicator framework includes phytoplankton and chlorophyll concentration metrics, nearshore trophic status is primarily characterized by indicators that assess both attached and free-floating algal growth (e.g. periphyton and macrophytes).

Periphyton - Current Status

The accumulation of periphyton (attached algae) on natural rock surfaces, piers, boats and other hard-bottomed substrates is perhaps the most visible indicator of Lake Tahoe's nearshore condition. The Lahontan Water Board has funded UC Davis to perform attached algae (periphyton) monitoring for nearly 30 years. The program includes routine sampling at a series of sites distributed around the lake and an annual lake perimeter (synoptic) survey to evaluate conditions during the spring period of maximum.

Select photographs of nearshore periphyton in Lake Tahoe (NeST 2013)

Periphyton - Recent Work

A trend analysis of synoptic and routine UC Davis sites conducted in 2016 identified no significant trends in periphyton growth. Approximately 30 years of routine data were analyzed at nine locations, and the analysis identified slight increases of periphyton at the Pineland and Incline West sites. Review of twelve years of data from synoptic sites and all other lake wide and regional analyses indicated declining periphyton abundance. UC Davis researchers advise caution regarding the synoptic data review, as that survey is conducted only once per year. UC Davis is currently reviewing sampling methods to ensure they are appropriate to capture periphyton status and trends.

Following extensive NAWG input in the context of the NRAP framework, the Lahontan Water Board is also investigating how introduced macroinvertebrates and the changing climate are influencing periphyton growth.

Periphyton – Recommendations

The periphyton monitoring program needs review to ensure the sampling and analysis can assess changes in attached algae growth and long-term data trends. The Lahontan Water Board and TRPA should ***evaluate contracted monitoring review products, consider submitting those products to the Tahoe Science Council for peer review, and assess the need to adjust future monitoring agreements to implement the most effective periphyton monitoring protocols to inform management decisions.***

Metaphyton - Current Status

Metaphyton is the algae that is unattached to any substrate and is not truly planktonic. In some areas such as shallow sandy areas along the south shore, variable metaphyton levels have been observed as large clumps of algae hovering above or rolling along the bottom in the mid-summer to early fall. Bright green metaphyton can be quite apparent and visually unappealing to

users of the shorezone. It may also collect near the shoreline and eventually wash up along shore to create rather foul-smelling accumulations of decaying algae.

Metaphyton – Recent Work

There has never been coordinated data collection for metaphyton at Lake Tahoe. Occasionally thick blooms of metaphyton have been reported in some locations, including in Marla Bay in 2008 and at some south shore locations in recent years. UC Davis researchers have noted metaphyton growth in areas with significant Asian Clam presence.

Metaphyton - Recommendations

Within the NRAP funding prioritization framework, the Lahontan Water Board and its partners should ***invest in metaphyton condition monitoring and metaphyton growth driver research.***

**Nearshore Community Structure**

Community structure reflects the ecological conditions that affect diversity, distribution, and interactions among producers and consumers able to survive in nearshore environment. Macroinvertebrates (including crayfish), fish, and macrophytes (aquatic plants) are visible aquatic organisms that interact to create the community structure representative of Lake Tahoe's nearshore ecosystem. Detection of community structure change can more broadly reflect Lake Tahoe's nearshore condition, which has experienced changes in external factors over time due to recreational activities, climate, species distributions, and other factors.

Most management issues related to nearshore community structure pertain to aquatic invasive species (AIS). Consequently, there is close linkage with the AIS Program and nearshore management at Lake Tahoe and most community structure monitoring efforts are coordinated and supported as part of the Lake Tahoe AIS Program.

A 2014-15 study led by the University of Nevada, Reno (*Lake Tahoe Nearshore Community Structure Pilot Monitoring,* Chandra, Ngai-Ryan, 2015) provides the most recent information regarding the composition, distribution, and abundance of nearshore biological indicators at Lake Tahoe.

Macrophytes - Current Status

Lake Tahoe's nearshore area contains few aquatic plants with the exception of a native water milfoil species (*Myriophyllum quintense*). The Eurasian watermilfoil (*Myriolphyllum spicatum*) is the main invasive plant to establish in Lake Tahoe. Plant fragments and fragment propagules can colonize and grow when attached to substrate. To date many locations of this nonnative plants are largely within marinas or other waters where there is little mixing. Diver-assisted targeted control efforts at Emerald Bay and other locations have proven successful at eliminated watermilfoil infestations in discrete areas.

In 2003, a more aggressive plant was noted in the Tahoe Keys: curly leaf pondweed (*Potomageton crispus*). This macrophyte can colonize open water areas and is rapidly moving to new locations in the South Shore. The curly leaf pondweed has established within certain fingers of the Tahoe Keys, dominating the biomass while in other locations it is not dominant. It is not clear if the lack of establishment or dominance results from time or other factors.

**Invasive milfoil (Tahoe Resource Conservation District)**

Macrophytes - Recent Work

In 2018, the Lahontan Water Board contracted with the TRPA to develop and demonstrate effective and efficient monitoring protocols for tracking both native and non-native macrophyte species at Lake Tahoe. Once complete, the project will provide an up-to-date, lake-wide macrophyte survey to guide future control efforts. The resulting protocol development will allow future surveys to continue monitoring macrophyte status and trends.

Macrophytes – Recommendations

The NAWG will ***review 2018 macrophyte survey findings and associated monitoring plan submittals, and consider the appropriate frequency for future macrophyte surveys.*** The program also needs resources to fund future surveys and to respond to identified invasive plant control needs.

Fish and macroinvertebrates - Current Status

Lake Tahoe's nearshore biological community has changed considerably from historical conditions. Habitat alteration or lost due to shorezone development (e.g. constructions of marinas), overharvesting (of native Lahontan cutthroat trout), intentional and unintentional introduction of nonnative aquatic species (e.g. plants, fish and macroinvertebrates), and other nearshore disturbance have caused substantive changes to the nearshore fish community.

The lake's fishery is dominated by introduced species and the macroinvertebrates (signal crayfish and mysid shrimp) that were introduced to support the sport fishery. Comparison between historical and contemporary snapshot studies suggests that the health of Lake Tahoe's nearshore fishery is deteriorating. Given potential expansion of suitable habitat for nonnative fishes by the increasing spread of aquatic invasive plants, elevated lake water temperatures, reduction in transparency, and other related threats, the future of Lake Tahoe's nearshore native fishery may be in trouble. Furthermore, introduced macroinvertebrates influences on native invertebrate species may impact nearshore periphyton and mid-lake clarity conditions.

**Signal Crayfish**

Fish and macroinvertebrates – Recent Work

The impact of the different web and trophic structure on Lake Tahoe's nearshore and mid-lake clarity conditions remains unknown. The Lahontan Water Board is contracting with the University of Nevada, Reno to perform initial studies to assess crayfish impacts on periphyton growth by establishing a series of exclusion plots. Researchers will install barriers in select areas to prevent crayfish access and will compare periphyton growth and other metrics to control areas subject to crayfish grazing.

Fish and macroinvertebrates – Recommendations

Growing evidence suggests introduced macroinvertebrates may have a significant effect on Lake Tahoe's nearshore condition. As resources allow, the NAWG should consider ***investing in targeted study to better understand the interrelated dynamics between Lake Tahoe's biological, chemical, and physical variables.*** As with other monitoring framework metrics, additional funding is needed to better understand these complex linkages and evaluate what, if any, management options can be pursued to reduce the impact of introduced species.

**Nearshore Conditions for Human Health**

Oligotrophic lakes like Lake Tahoe do not generally have issues with toxicity or harmful micro-organisms, unless there are discharges of sewage, grazing impacts, or other waste. Sewage and industrial discharges are not allowed into Lake Tahoe, and grazing operations in the

watershed ceased in the 1990s. Storm water runoff to the lake from urban areas and some recreational activities could conceivably contribute toxic chemicals or pathogens.

Contamination in the nearshore of Lake Tahoe can arise from sources such as sewer malfunctions, contaminated storm drains, animal pastures, pet waste, wildlife, and other sources. During rainfall, snowmelt, and other types of precipitation, coliform bacteria may be washed into the lake. Human illness and infections can result from contact with or ingestion of contaminated water. Beach sands and sediments present a favorable environment for the persistence and transfer of microorganisms to adjacent waters.

Harmful micro-organisms – Current Status

In recent years, the agencies have monitored coliforms and E. coli at 23 nearshore/beach locations, including, Kings Beach, Lake Forest, Tahoe City Commons, McKinney-Chambers Landing, Sugar Pine Point-Shoreline, Sugar Pine Point-Boat Area, Meeks Bay, D.L. Bliss-Shoreline, D.L. Bliss- Boat Area, Emerald Bay Shoreline, Emerald Bay Boat Camp, Ski Beach, Baldwin Beach, Kiva Beach, Camp Richardson, El Dorado Beach near boat ramp, Timber Cove, Lakeside Beach, Nevada Beach, Zephyr Cove, Sand Harbor, and near the mid-lake monitoring buoy, with the latter included for reference. This monitoring was primarily done during the summer and early fall in coordination with public use of the beaches. The bacteria levels were generally lower than state and federal standards.

Harmful micro-organisms – Recent Work

The Lahontan Water Board has contracted with the TRPA to revisit previously-sampled sites to reassess bacteria levels at those popular lake access locations.

Harmful micro-organisms – Recommendations

The NAWG ***will review 2018 bacteria survey findings and associated recommendations, and consider the appropriate frequency for future bacteria surveys.*** The program needs resources to fund future surveys and to respond to identified bacteria problems.

Harmful algal blooms – Current Status

Cyanobacteria are naturally present in waterbodies. The cyanobacteria are an integral part of the ecosystem and food web and help maintain the health of most freshwater and marine ecosystems. Warmer air and water temperatures, high nutrient levels, and slow and stagnant water have caused cyanobacteria (also known as blue-green algae) to rapidly multiply into harmful algal blooms (HABs). HABs can consist of both toxic and non-toxic algae. Toxic HABs can produce cyanotoxins (e.g., microcystins, Anatoxin-a) potent enough to threaten the safety of humans, wildlife, and pets. Non-toxic algal blooms have impacted beneficial uses of water by reducing the aesthetics, imparting unpleasant tastes and odors to water and fish, and by reducing dissolved oxygen levels.

Harmful algal blooms – Recent Work

The first documented HAB at Lake Tahoe was observed in the Lake Tahoe Keys in August 2017. Field visits verified the presence of cyanobacteria indicators (blue-green color, floating scum, visible algal mats) throughout the Tahoe Keys West Lagoons. Additionally, low levels of cyanotoxins (Anatoxin-a and microcystins) were confirmed by an independent genetics laboratory in samples collected by staff and the Tahoe Keys Property Owners Association (TKPOA).

Based on these triggers, Lahontan Water Board staff recommended the TKPOA and the El Dorado County Public Health Department inform people who may be recreating in the impacted water of the potential health risk. The recommendation to post a "Caution" level advisory was consistent with health triggers for recreational lakes.

As part of the 2018 nearshore human-health assessment project, bacteria monitoring at public-access sites will include a general cyanobacteria survey to evaluate the potential for HABs.

Harmful algal blooms – Recommendations

The Lahontan Water Board and its partners should ***actively engage with marina partners and beach management agencies to ensure potential harmful algal blooms are identified quickly and any necessary warning notifications are posted.***

## Plan Strategy 3 - Evaluate the cause of identified hotspots

Part of the Plan strategy is to respond when nearshore problem areas are been identified. TERC has monitored Lake Tahoe nearshore periphyton growth for nearly thirty years. While the data does not show clear trends of in most periphyton monitoring sites, the Pineland sampling location on Lake Tahoe's west shore was identified as a "hotspot" of elevated attached algal growth.

Current Status

In response to increased periphyton growth at Pineland, the Lahontan Water Board contracted with the United States Geological Survey to conduct a detailed nutrient assessment and algal growth study to evaluate the cause of observed conditions. The study revealed that, in that location, precipitation events occasionally drive groundwater pulses with elevated nutrient concentrations into the nearshore that are correlated to observed periphyton growth trends.

Recent Work

The Pineland study findings have led to additional inquiry regarding the source of elevated groundwater nutrient concentrations, and further research into the impact of groundwater nutrient inputs in other portions of Lake Tahoe's nearshore. The NAWG selected two separate projects that will use isotopic analysis to better understand groundwater nutrient sources.

Recommendations

The Lahontan Water Board and its partners should ***review and assess the findings of recently contracted projects and determine what, if any, additional work is needed to full understand Periphyton growth drivers at Pineland.***

## Plan Strategy 4 - Investigate climate change influence

Climate change refers to a change in global or regional climate patterns evidenced by shifts in weather phenomena and an increase in average temperatures. The planet's average surface temperature has risen more than 1.5 degrees Fahrenheit since the late 19th century, driven largely by increased carbon dioxide and other human-made emissions. (https://www.ncdc.noaa.gov/indicators/)

Current Status

Research partners continue efforts to assess established climate change impacts Lake Tahoe, and work is underway to evaluate how record high water temperature and uncommon lake mixing patters may influence nearshore conditions. More broadly, agency partners are actively assessing climate change impacts on the Lake Tahoe watershed and developing climate change resiliency plans.

Recent Work

The Lahontan Water Board held a series of workshops and outreach meetings to solicit public and agency feedback on climate change adaptation and resilience projects. The process included a survey, offering stakeholders the opportunity to share detailed comments and suggestions. Following that effort, Lahontan Water Board staff has been preparing a draft Climate Change Mitigation and Adaptation Strategy that outlined a series of policy goals to guide agency work in coming years. It has not been determined whether the strategy document will have proposed recommendations or actions directly related to Lake Tahoe nearshore protection. For more information, see the Lahontan Water Board climate change website:

https://www.waterboards.ca.gov/lahontan/water_issues/programs/climate_change_adaptation/

The Tahoe: State of the Lake Report (2018), produced annually by University of California, Davis Tahoe Environmental Research Center (UC Davis TERC), continues to document ongoing warming of the lake waters, extended periods of lake stratification, and increased frequency of warm, wet storms as clear evidence of climate change impacts at Lake Tahoe.

The Lahontan Water Board will also be contracting with UC Davis TERC to perform a series of experiments that will evaluate the effect of warming lake water on carbon and nutrient cycling at the sediment-water interface and assess how those changing dynamics may be fueling periphyton growth in the nearshore

Recommendations

Like most nearshore condition concerns, the influence of the changing climate on nearshore metrics is complex. ***The NAWG should support a paired watershed study that assess***

***conditions at undeveloped alpine lake systems (e.g., Castle Lake, CA; Crater Lake, OR) in comparison to Lake Tahoe could help determine the relative influence of climatic variables on nearshore variables.*** Additional resources are needed to evaluate the relationship between increased water and air temperature, differing precipitation patterns, and nearshore dynamics.

## Plan Strategy 5 - Assess the need to revise standards

Water quality standards are set by policy makers to maintain desired conditions consistent with defined objectives. The individual standards in some cases may be less stringent than reference values for pristine conditions, but must be adequate to protect resources at a level that will maintain desired conditions. In general, standards are set by values taken directly from the scientific literature, numeric value(s) based on historic conditions, statistically-based values, modeling results, values on the public/agency perception of acceptable conditions.

The NeST Report noted there are more than sixty existing numeric and narrative standards related to aquatic conditions at Lake Tahoe that have been adopted by the TRPA and the states of California and Nevada (NeST 2013). Many of these standards, including those that reference clarity, trophic status, and chemical constituents, apply to Lake Tahoe nearshore conditions.

Recent Work

The NeST Report reviewed available data for individual metrics and standards and provided assessments of both existing conditions and potential reference points (or ranges) for those metrics. As noted previously in this report, nearshore condition data are quite sparse (or not even available), thus complicating the evaluation of suitable reference conditions. Despite this challenge, the NeST Report provides a comprehensive assessment of existing conditions in relation to established standards and, where possible, provides descriptions of relevant historical conditions (NeST 2013).

Recommendations

Given uncertainty in nearshore condition trends and unknown pre-disturbance conditions, there is no information at this time to support additional nearshore water quality standards beyond those already established.

Considering concerns and perceptions related to algal growth, ***further assessment of the established periphyton standards is a logical next step***. Currently, there is no numeric periphyton standards at Lake Tahoe. The Lahontan Water Board standard, as described by the Water Quality Control Plan, states "*for Lake Tahoe, algal productivity and biomass of phytoplankton, zooplankton, and periphyton shall not be increased beyond the levels recorded during the period 1967-71, based on statistical comparison of seasonal and annual means."* Additional resources are needed to evaluate this standard in the context of updated data and methods to consider what, if any, change is warranted.

## Recommendation Summary

Plan Strategy 1- Continue implementing established programs

- Support efforts to establish dedicated storm water facility and roadway operations and maintenance funding.

Plan Strategy 2- Continue nearshore condition monitoring efforts

- Support Nearshore Network build-out and further network data assessment work.
- Evaluate contracted monitoring review products, consider submitting those products to the Tahoe Science Council for peer review, and assess the need to adjust future monitoring agreements to implement the most effective periphyton monitoring protocols to inform management decisions.
- Within the NRAP funding prioritization framework, invest in metaphyton condition monitoring and metaphyton growth driver research.
- Review 2018 macrophyte and bacteria survey findings and associated monitoring plan submittals, and consider the appropriate frequency for future surveys.
- Consider investing in targeted study to better understand the interrelated dynamics between Lake Tahoe's biological, chemical, and physical variables.
- Engage with marina partners and beach management agencies to ensure potential harmful algal blooms are identified quickly and any necessary warning notifications are posted.

Plan Strategy 3- Evaluate the cause of identified hotspots

- Review and assess the findings of recently contracted projects and determine what, if any, additional work is needed to full understand Periphyton growth drivers at Pineland.

Plan Strategy 4- Investigate climate change influence

- Support a paired watershed study that assess conditions at undeveloped alpine lake systems (e.g., Castle Lake, CA; Crater Lake, OR) in comparison to Lake Tahoe could help determine the relative influence of climatic variables on nearshore variables.

Plan Strategy 5- Assess the need to revise standards

- Further assess the established periphyton standards in the Water Quality Control Plan.

## Learn More

TRPA has incorporated nearshore activities into the broad "Lake Tahoe Info" platform, offering an online location to track the state-of-the-knowledge for nearshore indicators and house current research reports and associated summaries. With additional resources, the site will grow to link nearshore implementation actions, research findings, and raw data with the

Environmental Improvement Program Tracker, Monitoring Dashboard, and other relevant portions of Lake Tahoe Info. This site will serve as a living, real-time program management tool and outreach center to track Lake Tahoe's nearshore conditions. Please visit: https://laketahoeinfo.org/Initiative/NRAP

## Citations

Heyvaert, A.C., Reuter, J.E., Chandra, S., Susfalk, R.B., Schaldow, S.G. Hackley, S.H. 2013. Lake Tahoe Nearshore Evaluation and Monitoring Framework. Final Report prepared for the USDA Forest Service Pacific Southwest Research Station.

Tahoe: State of the Lake Report 2018. Regents of the University of California, Davis Tahoe Environmental Research Center.

Hayvaert, A.C., Fiszgerald, B., Morton, C. McGwire, R., Susfalk, R.B. 2016. Pilot Implementation of the Lake Tahoe Nearshore Monitoring Framework for Clarity Metrics. Final Report prepared for the Nevada Division of State Lands.

Chandra, S., Caires, A., Ngai-Ryan, K.L. 2015. Lake Tahoe Nearshore Community Structure Pilot Monitoring. Final Report prepared for the Lahontan Regional Water Quality Control Board, Nevada Division of Environmental Protection and the Tahoe Regional Planning Agency.

# Appendix A - Nearshore Definition

The Lahontan Water Board Basin Plan (1995) references TRPA's definition of the nearshore, which states: "the nearshore of Lake Tahoe extends lake ward from the low water elevation to a depth of 30 feet, or to a minimum width of 350 feet." Neither the NDEP US EPA specify a definition relating to the nearshore environment at Lake Tahoe.

For monitoring and assessment purposes, academic researchers consider Lake Tahoe's nearshore to extend from the low water elevation of Lake Tahoe (6223.0 feet Lake Tahoe Datum) or the shoreline at existing lake surface elevation, whichever is less, to a depth contour where the thermocline intersects the lake bed in mid-summer, with a minimum lateral distance of 350 feet lake ward from the existing shoreline (Figure 1).

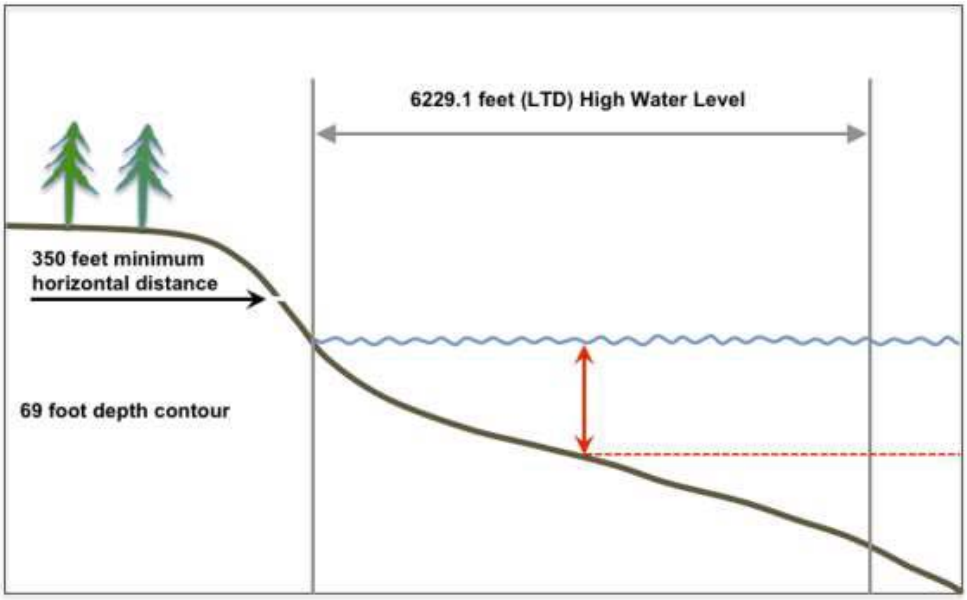



Figure 1. Definition of Lake Tahoe nearshore for purposes of monitoring and assessment (NeST 2013)

**Desired condition statement and objectives**

A desired condition statement provides the focus for management and monitoring activities needed to achieve and maintain a preferred level of ecosystem quality. The 2013 NeST framework articulated the following desired condition statement for Lake Tahoe's nearshore:

> *Lake Tahoe's nearshore environment is restored and/or maintained to reflect conditions consistent with an exceptionally clean and clear (ultra-oligotrophic) lake for the purposes of conserving its biological, physical and chemical integrity, protecting human health, and providing for current and future human appreciation and use.*

The 2013 NeST framework also established overarching management objective statements to support achieving the desired condition. The first is for preserving ecological and aesthetic characteristics of the nearshore:

*Maintain and/or restore to the greatest extent practical the physical, biological and chemical integrity of the nearshore environment such that water transparency, benthic biomass and community structure are deemed acceptable at localized areas of significance.*

Recreational experiences at Lake Tahoe more likely occur at the nearshore than at deeper waters. Consequently, the second objective is for sustaining conditions suitable for human health in the nearshore zone:

*Maintain nearshore conditions to standards that are deemed acceptable to human health for purposes of contact recreation and exposure.*

The focus for this objective is specifically on health risks associated with recreational exposure and not on risks associated with water provided from the nearshore for municipal or domestic supply.

**Conceptual model**

The Nearshore Science Team developed a conceptual model of the nearshore to illustrate relevant interactions between the natural and anthropogenic factors that affect important features and conditions of the nearshore. In many respects this nearshore conceptual model is quite similar to the mid-lake conceptual model, but with additional elements that emphasize how pollutants and other material that enter the lake from the watershed or groundwater can be temporarily concentrated in the nearshore zone resulting in biological responses not typically observed in Lake Tahoe's deep water. Other aspects unique to the nearshore that can contribute to environmental condition include greater vulnerability to increased temperature from climate change, impacts from nearshore recreation (e.g., higher levels of boat activity), domestic animal and wildlife activity, nearshore structures and habitat, and lake level changes.

Some pollutant sources that affect nearshore conditions are the same as those identified in the Lake Tahoe TMDL, so the control measures to address those factors should be similar (Figure 2). It is anticipated that nutrient and fine sediment loading reductions that result from implementation of the Lake Tahoe TMDL will not only provide improved mid- lake clarity, but also will provide benefits for clarity and related characteristics in nearshore condition.

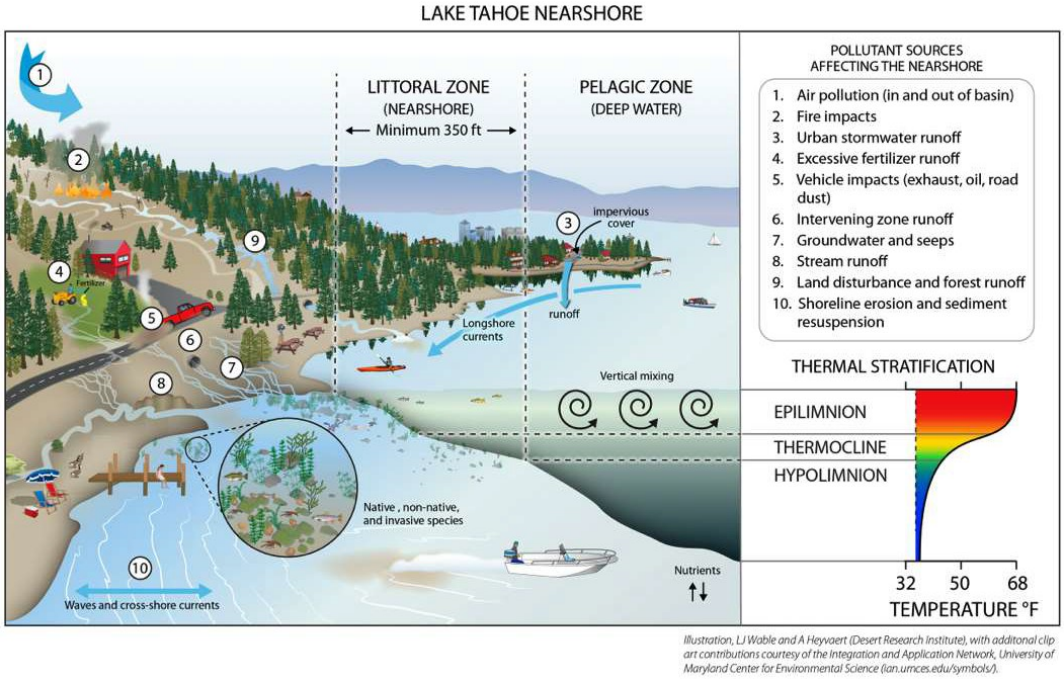



**Figure 2. Nearshore Conceptual Model (NeST 2013)**

## Appendix B - Indicator Framework

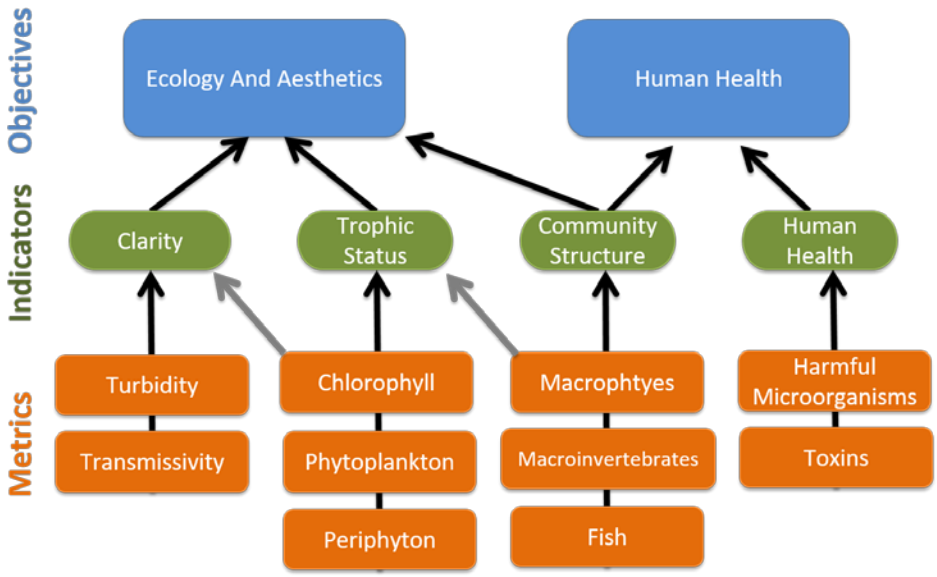



**Figure 3. Nearshore environmental indicator framework (NeST 2013)**

The framework identifies four primary indicators as essential for nearshore condition evaluation: *clarity, trophic status, community structure,* and *human health*. These broad indicators represent the interpretation of aggregate data from a set of individual metrics. Lake Tahoe has long been renowned for its exceptional *clarity*, and those unique characteristics extend to clear nearshore waters. *Trophic status* represents the amount of biological growth a system supports, while *community structure* characterizes the aquatic species composition (richness), abundance and distribution. Nearshore conditions for *human health* are directly relevant to maintaining expected standards for safety and healthy recreational use of the lake.

Each metric reflects a key component of the nearshore ecosystem and contributes to an integrated perspective on system health. The benefit of this approach is that nearshore condition is not viewed as a series of individual standards subject to attainment determination, but rather as an interacting system of interdependent environmental factors evaluated on the basis of ecologically integrative response variables.