CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
LAHONTAN REGION

MEETING OF NOVEMBER 13-14, 2013
SOUTH LAKE TAHOE

ITEM: **9**

SUBJECT: **LAKE TAHOE NEARSHORE UPDATE – SCIENTIFIC REPORT AND STAFF UPDATE**

CHRONOLOGY: November 16, 2010 – Lahontan Water Board adopted the Lake Tahoe TMDL to achieve the mid-lake transparency standard. The Lake Tahoe TMDL included controls and limits for the primary pollutants of fine sediment particles and nutrients (nitrogen, phosphorus). Nutrients and fine sediment also adversely affect nearshore water quality.

April 2011 – Nearshore Executive Officer's Report Item explained the importance of the nearshore water quality since it is the zone that the public interacts with most, and described the Lake Tahoe Nearshore Science Grant objectives and overall work plan.

December 2011 – Nearshore Executive Officer's Report Item informed status of researchers' continued work under the Nearshore Science Grant.

April 2012 – Nearshore Executive Officer's Report Item updated status of the Nearshore Science Team's work on the Nearshore Science Grant final deliverables and on-going efforts of the Nearshore Agency Working Group.

October 10, 2012 – Staff presentation to Lahontan Water Board on the Lake Tahoe Nearshore Science Grant and Lake Tahoe Aquatic Invasive Species Program the focus of which is to prevent, detect, and control aquatic invasive species. Infestations of aquatic invasive species at Lake Tahoe occur overwhelmingly in the nearshore.

March 2013 – Nearshore Executive Officer's Report Item that described the Nearshore Science Grant's expected deliverables and that a final report is anticipated middle to later 2013.

October 24, 2013 – The Desert Research Institute of Nevada (DRI) released its Final Nearshore Evaluation Report (Report) as approved by the US Forest Service – Pacific Southwest Research Station (PSW). Executive Summary found as Enclosure 1. The full report can be found at http://www.dri.edu/cwes. Click on "Download the Full Report."

BACKGROUND: Lake Tahoe's nearshore is the zone of relatively shallow water around the lake's perimeter that is valued for its recreational and aesthetic qualities, as well as for the biological community it supports. The nearshore is the part of the lake that visitors and residents interact with most. Changes in the nearshore over time have increased interest in managing the nearshore and the factors responsible for its progressively reduced condition. Lahontan and the other member agencies (TRPA, NDEP, US EPA) of the Nearshore Agency Working Group have received public criticism for focusing on Lake Tahoe's mid-lake water quality and transparency, as represented by the Lake Tahoe TMDL, to the perceived paucity of attention paid the nearshore.

In 2010, with funding managed by the US Forest Service PSW, the Nearshore Science Team and the Nearshore Agency Working Group set out to comprehensively evaluate the Lake Tahoe nearshore. The purpose of the project was to summarize the results of past research and monitoring efforts to improve our understanding of factors and activities affecting nearshore conditions. The Nearshore Science Team was tasked with evaluating the applicability of existing water quality standards to the nearshore and its desired condition, identifying the most meaningful indicators of nearshore conditions, and proposing a strategy for monitoring these indicators.

Since the awarding of the grant to the Nearshore Science Team, staff collaborated with our partner agencies, through participation in the Nearshore Agency Working Group, in an effort to manage the development of the Report. The Nearshore Agency Working Group met independently, in conference with the Nearshore Science Team and, on three occasions, jointly with the Nearshore Science Team and executives from the Nearshore Agency Working Group agencies (Lahontan, TRPA, NDEP, US EPA).

DISCUSSION: This item will include a presentation by Dr. Alan Heyvaert summarizing the Nearshore Evaluation Report. Dr. Heyvaert, of DRI, is the team leader for the Nearshore Science Team , a group of researchers affiliated with DRI, UC Davis and University of Nevada. Dr. Heyvaert will discuss the Report's products, methodologies and findings.

Staff will highlight the key messages of the Report, as well as our plan to evaluate how best to address the Report findings in our efforts to protect and restore the nearshore. Staff will also discuss existing agency actions that address nearshore needs identified in the Report.

RECOMMENDATION: No Action. This is an informational item only. The Water Board may provide direction to staff.

Enclosure	Description	Bates Number
1	Lake Tahoe Nearshore Evaluation and Monitoring Framework: Executive Summary – Full Report at http://www.dri.edu/cwes	**9-5**

ENCLOSURE 1

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Lake Tahoe Nearshore Evaluation and Monitoring Framework

EXECUTIVE SUMMARY

October 15, 2013

Photo Credits: E.S. Levy

Desert Research Institute

University of Nevada, Reno

UC DAVIS TAHOE ENVIRONMENTAL RESEARCH CENTER

Lake Tahoe Nearshore Evaluation and Monitoring Framework

October 15, 2013

The Nearshore Science Team (NeST) included water quality scientists and aquatic ecologists from the University of Nevada, Reno; the University of California, Davis Tahoe Environmental Research Center; and the Desert Research Institute Center for Watersheds and Environmental Sustainability.

A Nearshore Agency Work Group (NAWG) was created to communicate agency information needs and to contribute agency relevant information toward the effort. It was composed of representatives from the California Regional Water Quality Control Board, Lahontan Region (Lahontan Water Board), the Nevada Division of Environmental Protection (NDEP), the Tahoe Regional Planning Agency (TRPA), and the U.S. Environmental Protection Agency (USEPA).

Any questions regarding the Lake Tahoe Nearshore Evaluation and Monitoring Framework should be directed to:

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http://www.fs.fed.us/psw/partnerships/tahoescience/

The views in this report are those of the authors and do not necessary reflect those of the USDA Forest Service Pacific Southwest Research Station or the USDA Bureau of Land Management.

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SOUTHERN NEVADA PUBLIC LAND MANAGEMENT ACT
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Lake Tahoe Nearshore Evaluation and Monitoring Framework

Version 10.e

Date: October 15, 2013

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Abstract

Changes in nearshore conditions at Lake Tahoe have become evident to both visitors and residents of the Tahoe Basin, with increasing stakeholder interest in managing the factors that have contributed to apparent deterioration of the nearshore environment. This has led to joint implementation of a Nearshore Science Team (NeST) and the Nearshore Agency Working Group (NAWG), which together have contributed to a synthesis review of nearshore information and the development of a monitoring and evaluation plan that will track changes in nearshore conditions. A conceptual model is presented that conveys our contemporary understanding of the factors and activities that affect desired nearshore qualities. Results from review and analysis of historical data are provided, as well as an assessment on the adequacy of existing nearshore standards and associated indicators. The resulting nearshore monitoring framework will be used to guide development of an integrated effort that tracks the status and trends associated with nearshore conditions.

Recommended Citation: 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.

1.0 EXECUTIVE SUMMARY

1.1 Background

The nearshore of Lake Tahoe is an important zone of relatively shallow water around the lake perimeter that is much appreciated for the recreational and aesthetic qualities it provides, as well as for its vital biological habitat. Unfortunately, changes in nearshore conditions over time have become evident to both visitors and residents of the Tahoe Basin, along with increasing stakeholder interest in managing the factors that have contributed to apparent deterioration of the nearshore environment.

Heightened agency and public interest in understanding the nearshore environment has stimulated several independent research and monitoring efforts during this time, including nearshore studies on clarity and algae, as well as development of the Lake Tahoe TMDL (total maximum daily load) for managing pollutants that affect the pelagic (deep-water) clarity. This report is the result of a multi-year effort that for the first time summarizes available information on Lake Tahoe's nearshore condition, develops an integrated set of metrics and indicators to characterize nearshore condition, considers reference conditions and the relevance of existing thresholds and standards, and then provides recommendations for a monitoring and evaluation framework that can be used to guide the tracking of changes in nearshore condition and to support regional program planning needs.

Ultimately, the findings and recommendations of this project are expected to support several agency statutory and programmatic needs by: 1) providing baseline information to support assessment of relevant state and TRPA standards; 2) supporting the development of products for the Tahoe Monitoring and Evaluation Program; 3) tracking the effectiveness of the Tahoe TMDL Program and other EIP efforts related to nearshore condition; and 4) contributing to detection and management of aquatic invasive species in the nearshore.

1.2 Project Approach

This project represents an initial collaborative step between the science community and resource management agencies to develop a comprehensive approach for assessing and managing the nearshore ecology and aesthetics of Lake Tahoe. The Nearshore Science Team (NeST) included water quality scientists and aquatic ecologists from the University of Nevada, Reno (UNR), the University of California, Davis (UCD), and the Desert Research Institute (DRI). A Nearshore Agency Work Group (NAWG) was created to communicate agency information needs and to contribute agency relevant information toward the effort. It was composed of representatives from the California Regional Water Quality Control Board, Lahontan Region (Lahontan Water Board), the Nevada Division of Environmental Protection (NDEP), the Tahoe Regional Planning Agency (TRPA), and the U.S. Environmental Protection Agency (USEPA).

Completion of project components followed a logical sequence to inform successive steps in the process of assessing information and developing the final report, though several of these steps occurred iteratively (Figure 1-1). The initial task was to conduct a comprehensive literature review of available information relevant to the nearshore and to produce an annotated bibliography. This bibliography provided the basis for developing a conceptual model of the nearshore environment and the foundation for developing a desired condition statement and objectives, as well as a definition of the "nearshore" for monitoring and assessment purposes. It was also the source for much of the data summarized in the report for efficacy assessment of existing standards, and for developing an integrated set of metrics and indicators that were used to design the nearshore monitoring framework.

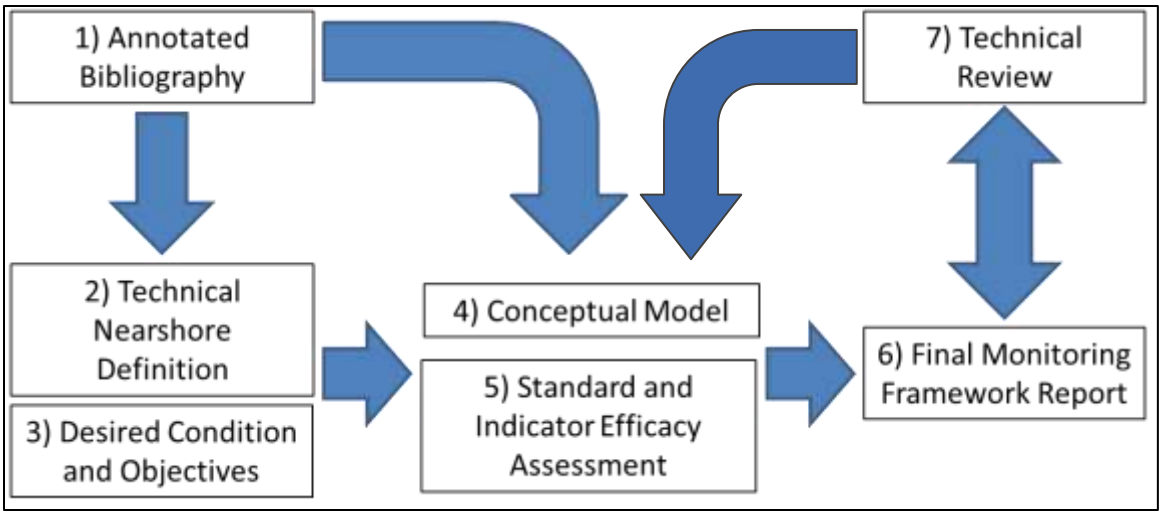


Figure 1-1. A schematic showing nearshore project tasks and sequence of workflow.

1.3 Summary of Project Components

- *Annotated bibliography* – Literature survey of data and information related to the nearshore of Lake Tahoe. Scientific journal articles as well as technical reports and academic theses/dissertations were included on topics such as water quality, ecology, algal species composition, periphyton growth and biomass, nutrients; fisheries, geology, etc.
- *Technical definition of nearshore* – Definition of the nearshore was developed for monitoring and evaluation purposes, based on existing definitions from Basin agencies, specific features of Lake Tahoe, and scientific literature.
- *Desired condition and objectives* – Developed narrative statements that summarize management objectives for a nearshore program that will guide actions taken to achieve the goal of its desired condition.

- *Conceptual model* – Summarized factors important to nearshore condition such as pollutant sources, watershed and in-lake processes, pollutants and affects, and controls within a qualitative, visual-based, format.
- *Current thresholds and standards* – Evaluated existing state and TRPA water quality-related standards and thresholds in terms of their relevance to nearshore assessment and management.
- *Indicators and metrics* – Developed a set of recommended indictors and associated metrics that would efficiently represent the complex interactions between various attributes (parameters) that constitute nearshore condition. Metrics are the measurable characteristics used in a monitoring design to evaluate the condition of specified indicators.
- *Existing nearshore data* – Available data were analyzed to provide summary assessments for each nearshore metric with regard to analysis of reference conditions, possible new or modified thresholds, and the creation of an integrated nearshore monitoring and evaluation program. Reference conditions were based on historical data, when available, otherwise on contemporary pristine, undisturbed or least disturbed conditions. Literature values were cited in the absence of Tahoe specific data. In some cases where sufficient data exist, options are discussed in consideration of different approaches.
- *Design of nearshore monitoring program* – Recommendations are provided for establishing a comprehensive monitoring program that allows nearshore condition to be evaluated for status and trends. Monitoring design is focused on the primary recommended metrics.

1.4 Nearshore Definition

This report does not recommend changes to existing state and TRPA legal or statutory definitions of the Lake Tahoe nearshore. Rather, it addresses unique aspects of the nearshore in context of framing the monitoring design through use of the following definition.

Lake Tahoe's nearshore for purposes of monitoring and assessment is considered 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; but in any case, with a minimum lateral distance of 350 feet lake ward from the existing shoreline.

The thermocline is a physical feature in lakes that represents a zone of rapid transition from warm surface water to underlying cold water. It is a seasonally dynamic stratification that strongly influences nearshore processes. The 31-year average August (maximum) thermocline depth in Lake Tahoe is 21 m (69 feet). This definition is more flexible than regulatory definitions, as is appropriate for guiding a monitoring approach that must adapt to natural variability in lake water levels and thermodynamic structure.

1.5 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 desired condition statement for Lake Tahoe's nearshore was articulated as follows.

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.

Two overarching management objective statements were developed 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.

Human experience at the lake is assumed to be equally or more strongly related to recreational interactions with the nearshore environment than it is to mid-lake clarity. Both the ability to see the bottom of the lake (transparency) and what is seen or felt on the bottom influence the nearshore aesthetic experience, which also reflects ecological conditions and processes. This report proposes that the nearshore ecology and aesthetic objective will be evaluated on the basis of three separate indicators (with associated metrics) that collectively provide assessment of:

- nearshore clarity,
- nearshore trophic status (nutrients and algal growth that indicate the degree of eutrophication), and
- nearshore community structure (biological composition).

The other 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.

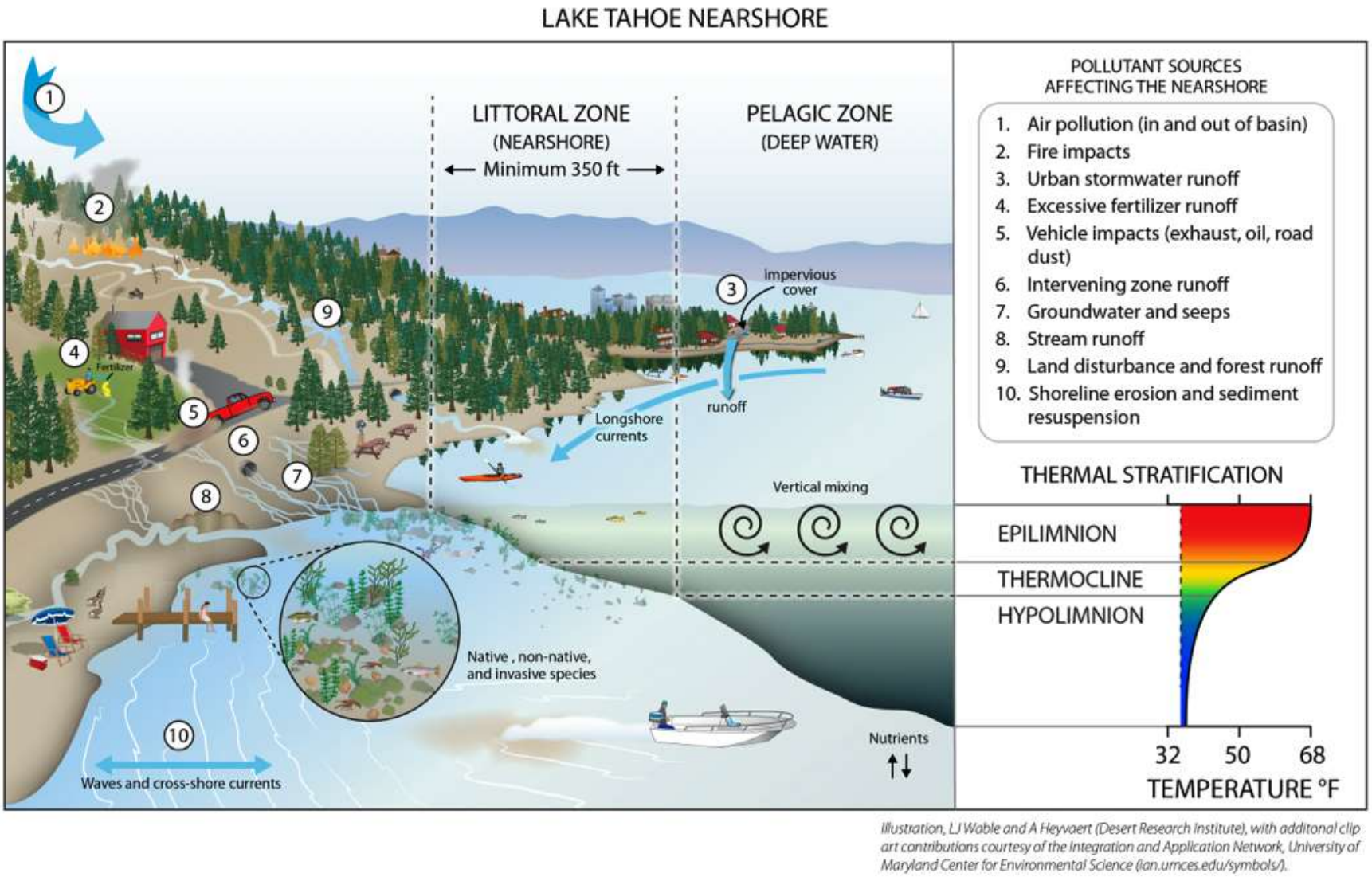
The focus for this objective is specifically on health risks associated with recreational exposure and not on attendant risks associated with water provided from the nearshore for municipal or domestic supply. Existing state and local programs enforce potable water supply standards. They also provide criteria for tracking the presence of pathogens and toxic compounds that may affect conditions for human health, which serves as the indicator for this objective.

1.6 Conceptual Model

Results from review of available literature and data indicated that nearshore condition can differ widely around the lake based on factors such as adjacent land-use and urban development, non-point pollutant inputs, vicinity to stream inputs, water movement, water depth, substrate type, and other features of the lake bottom (Figure 1-2). Variations in these factors create more localized environmental conditions compared to the open-waters of Lake Tahoe that are more uniform. The nearshore environment is inherently more complex and active than the pelagic zone and it requires a different scale of evaluation and management. Some of these requirements for evaluation are addressed in this report.

A conceptual model of the nearshore was developed 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 will eventually be mixed and diluted to some extent in the open-water, these materials can be temporarily concentrated in the nearshore zone resulting in biological responses not typically observed in Lake Tahoe's deep water. In addition to the factors listed above, there are other aspects unique to the nearshore that can contribute to environmental condition, such as greater vulnerability to increased temperature from climate change, and impacts from nearshore recreation (e.g., higher levels of boat activity), domestic animals and wildlife activity, nearshore structures and habitat, and lake level changes.

Generally, the 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 1-3). We did not conduct a quantitative linkage analysis to determine the relative contributions from each potential nearshore pollutant source, as such analysis was beyond he scope of this project, but the science team consensus is largely consistent with previous expectations (TRPA, 1982) that "watershed activities which could alter the quality of the [mid-] lake will affect the littoral zone near the watershed earlier and to a greater extent than they will the open water." Therefore, 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.



Illustration, LJ Wable and A Heyvaert (Desert Research Institute), with additonal clip art contributions courtesy of the Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/symbols/).

Figure 1-2. Illustration of important factors and processes affecting the lake nearshore environment.

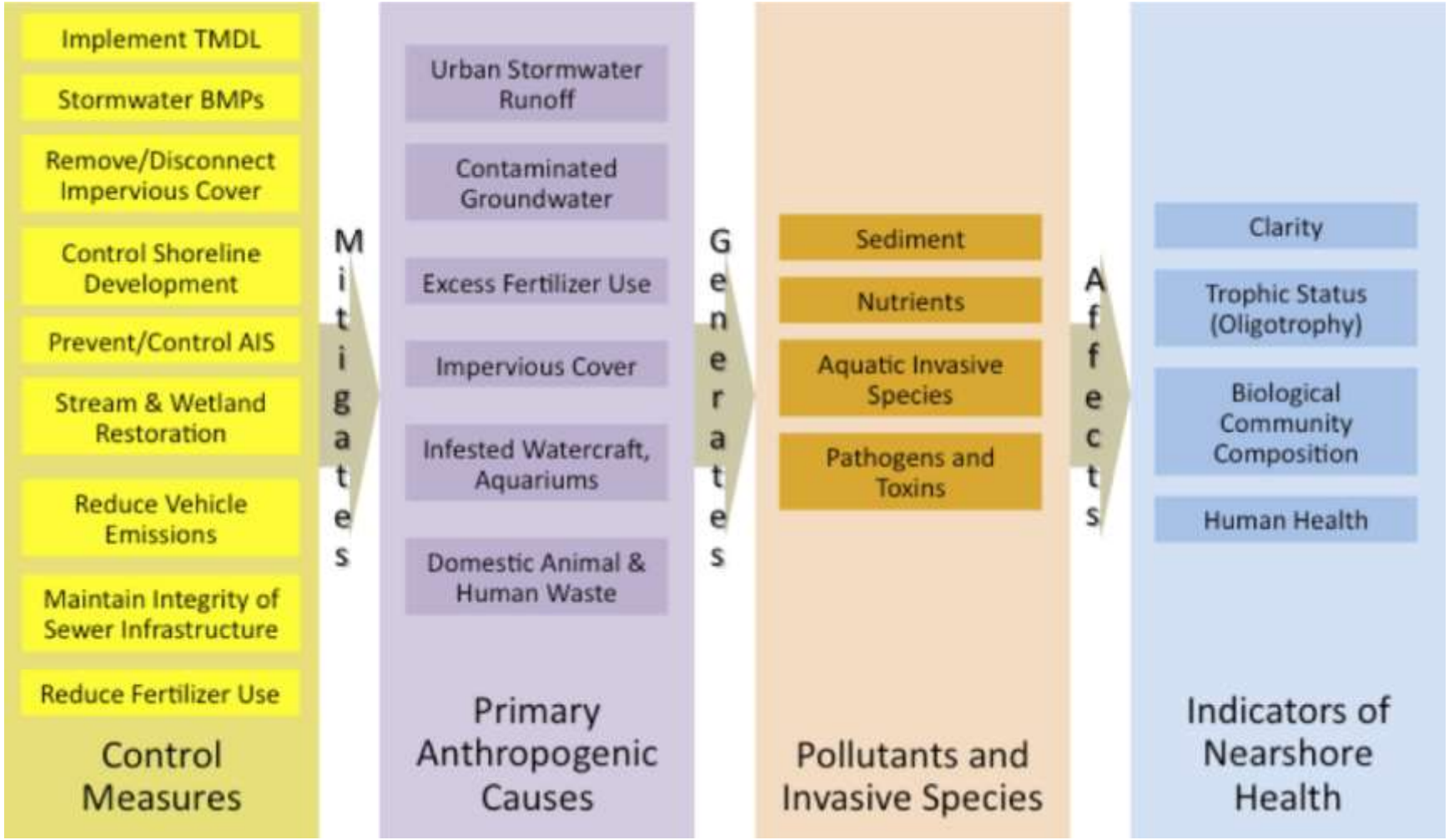


Figure 1-3. Examples from the nearshore conceptual model of progression from relevant control measures to indicators of nearshore health.

It must be acknowledged, however, that nearshore water quality is strongly influenced by localized pollutant input, so a load reduction that may improve the open-water may or may not have a directly comparable effect on all nearshore areas. For example, while load reductions along the south shore will contribute to an eventual improvement of open water clarity and a more immediate effect on that region's nearshore, its direct effect on the nearshore zone in the north lake may be delayed or attenuated. Water quality improvement projects should be selected to include those that (1) will have the most influence on both the nearshore and open water, and (2) are located in areas around the lake where measures of nearshore conditions indicate impairment.

While AIS may preferentially establish in some nearshore areas as a result of nearby watershed condition, this is not always the case, and once established they may not respond to watershed management activities. The establishment of invasive aquatic species in nearshore areas can precondition those areas for the introduction and establishment of subsequent undesired species by changing substrate and habitat conditions.

1.7 Evaluation of Existing Thresholds and Standards

An initial compilation of existing environmental standards and thresholds from California, Nevada and the TRPA consisted of 62 standards that were potentially applicable to Lake Tahoe's nearshore zone (see Report Appendix A). Some of these standards consisted of very specific numeric criteria while others were more general narrative statements. Several standards were consistent across agencies in terms of their specific characteristics and/or criteria, although some numerical criteria were not in alignment across all agencies.

The full set of 62 individual standards and thresholds was sorted into 38 categories based on related characteristics (see Report Appendix B). Then each of these categories was reviewed in terms of its relevance to monitoring and management of the nearshore at Lake Tahoe, with a brief narrative description and data assessment, as well as preliminary comments on reference conditions and whether the standard or threshold was sufficient to support desired conditions. These categories were then classified on the basis of (1) relevancy for nearshore assessment, and (2) relevancy to nearshore management for desired conditions. Nutrient loading standards, for example, are important for nearshore management since they fuel both phytoplankton and periphyton growth. Measurement of nutrient concentrations in the nearshore, however, is less relevant for assessing nearshore conditions because these concentrations can be quite ephemeral, with high input levels quickly reduced due to rapid algal uptake, sometimes yielding an apparent inverse relationship between nutrients and algal growth. The few available historic studies have not reported large and consistent differences in the spatial or temporal distribution of nutrient concentrations around the lake perimeter. Monitoring nutrient loading onshore is very important, however, and should be carried out as

part of a Tahoe regional stormwater monitoring program, in which the derived data from that program links to nearshore monitoring results.

Finally, a list of categories from nearshore standards was assembled that represented the attributes deemed as most "important" or "relevant" for assessing the achievement of nearshore desired condition. In turn, each of these categories of standards, as well as a few additional attributes, were linked to one or more of the four distinct nearshore indicators: clarity, trophic status, community structure (biological integrity), and conditions for human health. These formed the basis for design of the nearshore monitoring framework.

1.8 Design of the Nearshore Monitoring Framework

From the list of "important" or "relevant" categories for nearshore condition assessment, ten were selected to serve as primary metrics, with each metric representing a specific measurable response to anthropogenic impacts and to management actions taken to achieve objectives set forth for the nearshore desired condition. 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 (Figure 1-4).

Consistent with the desired condition statement, four nearshore indicators were selected to provide a summary assessment on unique characteristics of the system. Obviously, the exceptional clarity for which Lake Tahoe has been long renowned is one of those unique characteristics extending to clear waters in the nearshore. Trophic status represents the amount of biological growth a system supports, generally reflected by very low algal biomass and low nutrient concentrations in Lake Tahoe. 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 associated with these indicators represents a key component of the nearshore ecosystem, as described below, and contributes to an integrated perspective on the health of the system. The traditional measure of Secchi disk clarity used in deep waters at Lake Tahoe does not function for the nearshore because water transparency can extend beyond the depth limits defined as nearshore. Instead, turbidity and transmissivity (light transmittance) are recommended as appropriate metrics for evaluating the nearshore clarity. Turbidity directly relates to existing nearshore standards (TRPA, CA and NV), but is not sufficiently sensitive to document visible changes in the nearshore at low range values typical of undisturbed areas. In these cases, transmissivity is a superior metric, but it has a shorter history of measurement in Lake Tahoe and does not currently link to existing standards.

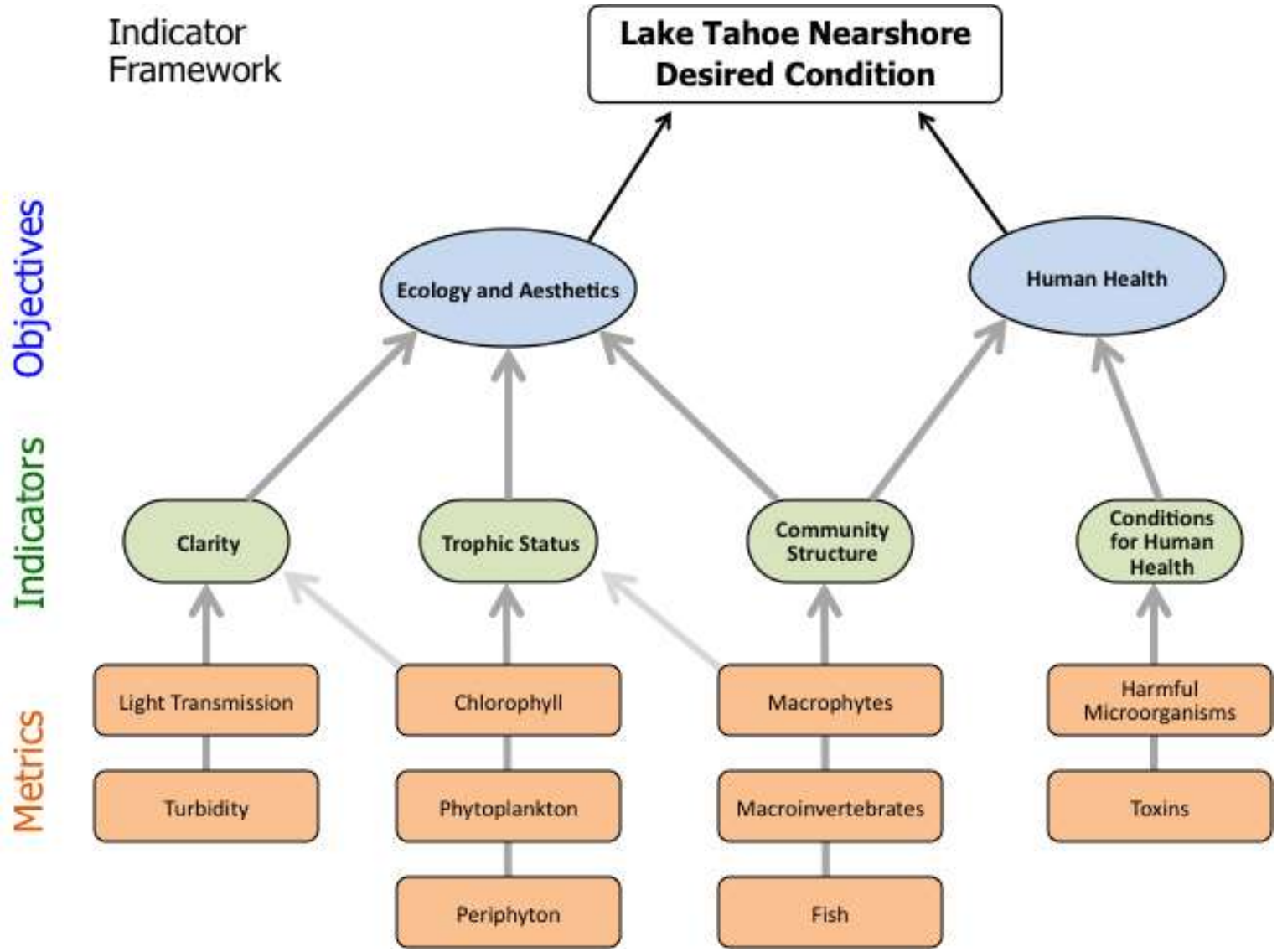


Figure 1-4. Simplified diagram of the Lake Tahoe nearshore monitoring framework, showing associations between metric data, aggregate indicators of condition, and nearshore objectives.

Chlorophyll concentration is a traditional measure of algal biomass (i.e. the concentration of algae in the water). Used in conjunction with an algal growth potential metric and phytoplankton (free-floating algae) identification, it provides a complete picture of trophic status (a measure of the biological productivity of a water body). The algal growth potential metric test uses chlorophyll measurements to determine how much algal growth can be supported by available nutrients in the water, and is more reliable than simply measuring nutrients at the very low concentrations typical in this lake. Phytoplankton counts, biomass, and algal growth potential each represent existing standards for the pelagic (deep) waters that are also consistent with evaluating nearshore conditions. Measurement of attached algae (periphyton), however, is unique to the nearshore. It is this tangible feature of the nearshore that individuals often perceive as evidence of undesirable conditions. The abundance and distribution of attached algae is variable in space and time and consequently difficult to measure in a representative manner. Fortunately, there is a long history of periphyton measurement at Lake Tahoe, which supports a robust analysis of spatiotemporal distributions and the potential development of appropriate targets or standards.

Macrophytes, macroinvertebrates, and fish are visible aquatic organisms that interact to create the habitats and diversity representative of Lake Tahoe's nearshore ecosystem. They also indirectly affect trophic status and in some cases with invasive species may contribute to diminished clarity of nearshore environments. This is one of the potential issues associated with changes in community structure resulting from the introduction of aquatic invasive species, as well as the inherent threat posed to native species and some endemic species by undesired nonnative species introductions. Nearshore surveys for each of the biological groups listed above will provide information needed for establishing suitable reference conditions and for detecting the spread or introduction of aquatic invasive species.

The proposed monitoring design includes full perimeter surveys conducted on a seasonal basis (four times per year) for turbidity, transmissivity, fluorescence (relative chlorophyll) and chlorophyll *a*, coordinated with location-based assessments of periphyton (attached algae), phytoplankton (free-floating algae), benthic macroinvertebrates, aquatic plants (macrophytes) and higher-level aquatic species that include fish and crayfish. For this initial monitoring effort, sampling four times per year should be considered a minimal effort; adjustments in sampling design may be considered as we improve our understanding of seasonal to annual variation in measurements and as funding allows over the long-term.

Measurements of turbidity, transmissivity, and relative chlorophyll are all done simultaneously, so there is minimal additional cost associated with each metric beyond the first parameter. During these perimeter circuits discrete samples will be collected for phytoplankton, absolute chlorophyll a concentration (and nutrients on occasion as secondary metrics) at

specified locations based in part on the longer-term range of responses observed in contiguous perimeter surveys. Initially, however, these discrete samples will be collected at ten locations in close proximity to established periphyton sampling sites or where some of the earliest studies were conducted from 1969–1974.

Attached algae abundance (periphyton biomass) is one of the more evident manifestations of changes in nearshore condition. It responds to lake conditions seasonally, so the sampling schedule is designed to track growth patterns that yield estimations of mean annual biomass. This sampling schedule follows existing routines and protocols, with site monitoring for periphyton biomass conducted 4-6 time per year at nine established locations and one additional spring synoptic conducted to assess biomass at forty locations around the nearshore.

Native and non-native aquatic plants would be monitored every other year on both a perimeter presence/absence and a relative abundance basis to detect changes and indicate potential effects of aquatic invasive plants on biological integrity. The macroinvertebrates would be monitored on a seasonal basis two times per year to detect shifts in community structure and impacts from environmental change. Detailed analysis of macroinvertebrate composition, distribution and abundance (CDA) obtained from samples collected at eleven sites will represent conditions over a range of substrates and including potential impacts from aquatic invasive species. This monitoring would be coordinated with efforts of the Lake Tahoe AIS Working Group.

Different fish species and crayfish migrate in and out of the nearshore seasonally, so these surveys should be conducted seasonally, four times each year, at eleven locations, and also during early summer at forty-nine spawning sites. The CDA analysis of fish and macroinvertebrate samples provides an assessment of changes in the aquatic community that will contribute to detection of AIS and evaluation of impacts on biological integrity. Again this monitoring would be integrated with efforts of the Lake Tahoe AIS Working Group.

Monitoring in the nearshore for harmful microorganisms or toxins that affect human health is proposed to be coordinated between the Lake Tahoe water quality agencies and local water purveyors. For example, samples for analysis of coliforms and E. coli are currently collected at beaches during recreational periods by regulatory agencies and some members of the Tahoe Water Suppliers Association. These programs are expected to continue in accordance with established state and federal requirements for the protection of drinking water, swimming, and other recreational activities. While chemical toxins are not generally considered an issue of concern at Lake Tahoe, any incident of localized chemical or sewage spills would require a rapid response monitoring assessment, which is outside the purview of routine monitoring.

1.9 Evaluation of Metrics for Reference Conditions and Standards Assessment

The primary metrics proposed for nearshore monitoring and condition assessment are presented and developed individually in this report. Each metric presentation begins with a brief review of its monitoring history at the lake, followed by an analysis of the available data, and then a discussion of potential standards and reference conditions (where applicable). It is important to distinguish between reference conditions and standards, because they are not necessarily synonymous.

Reference conditions represent a narrative or numeric description of a specific characteristic in the relative absence of human influence. They are used to inform a dialogue that establishes realistic targets or standards for effective management of an ecosystem to achieve desired conditions. In some cases of metric evaluation there were no available data on reference condition, or quite often the data available were too sparse to do more than provide a general sense of variation in reference condition. The following table summarizes our evaluation of data status for each of the proposed metrics (Table 1-1). The data quality itself is generally quite good, but the quantity is often insufficient to inform a detailed assessment. Given the general lack of nearshore data existing for most of these metrics, any discussion of standards and reference conditions is considered preliminary at this time. The exceptions are for periphyton and perhaps for turbidity, where longer-term nearshore monitoring has been conducted (although not as part of any regular program in the case of turbidity). The reference values presented in this report characterize conditions in the relative absence of human activities, and are considered representative of the unique attributes consistent with oligotrophic conditions in the nearshore of Lake Tahoe.

Future revision to existing standards or the development of new standards and thresholds should be linked directly to these recommended metrics and indicators. The data and the evaluations presented in this report will provide an essential scientific basis for these discussions and potential resulting actions.

Table 1-1. Summary of proposed nearshore metrics showing the relative availability of existing data for evaluation of existing state or TRPA standards, and to support linkage to specific numeric objectives.

Nearshore Metric	Associated Indicator	Data Basis	Link to Existing State or TRPA Standards
Turbidity	Clarity	Moderate	CA, NV, TRPA (Clarity)
Light Transmissivity	Clarity	Poor	CA, NV, TRPA (Clarity)
Chlorophyll	Clarity and Trophic Status	Moderate	CA (Biological Indicators)
Phytoplankton	Trophic Status	Poor	CA (Plankton Counts and AGP)
Periphyton	Trophic Status and Community Structure	Good	CA (Biological Indicators)
Macrophytes	Trophic Status and Community Structure	Poor	None
Macroinvertebrates	Community Structure	Poor	TRPA (Littoral Habitat)
Fish and crayfish	Community Structure	Poor	TRPA (Littoral Habitat)
Toxins	Human Health	Poor	CA, NV (CA Toxics Rule and Toxicity)
Pathogens	Human Health	Moderate	CA, NV (Bacteria)

1.10 Implementation of the Nearshore Monitoring Program

In designing the nearshore monitoring framework it was relevant to consider it in the context of other efforts in the Lake Tahoe Basin to reduce redundancy in monitoring efforts and to maximize monitoring investments. At Lake Tahoe, the central focus of water quality monitoring to date has been on characterizing conditions of Lake Tahoe's deep-water clarity and the nearshore periphyton. The monitoring described in this report will aid in guiding the implementation of additional nearshore monitoring efforts, while also intersecting with other monitoring programs (e.g., tributary monitoring and urban stormwater monitoring). Although these other programs were not addressed as part of the nearshore monitoring design, it is expected they will provide much of the ancillary data needed to explain variation in nearshore conditions, assuming they are concurrently implemented (Figure. 1-5).

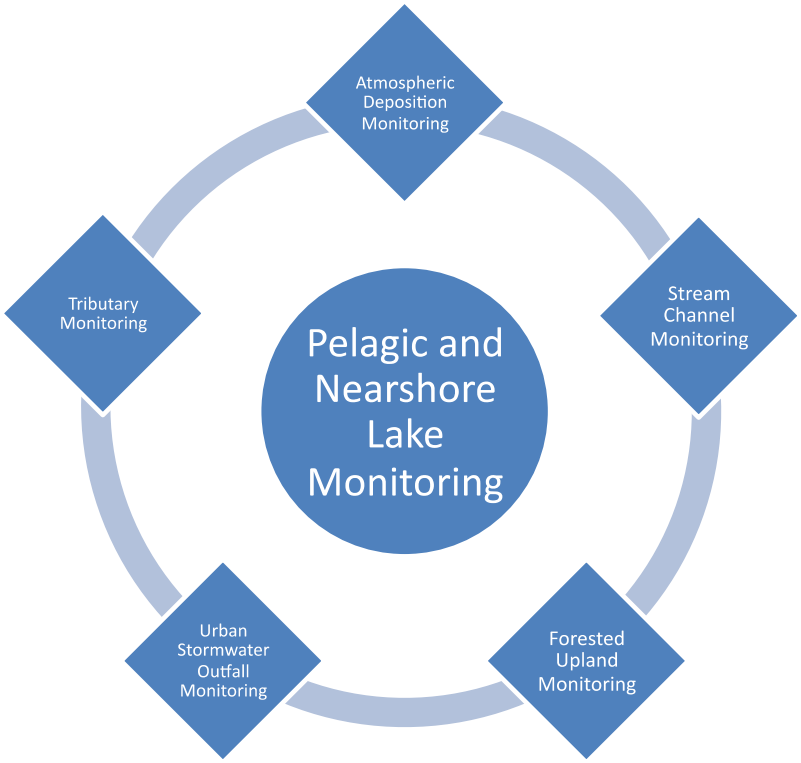


Figure 1-5. A generalized representation of other monitoring efforts anticipated in the Lake Tahoe Basin that would intersect with the nearshore monitoring program.

The nearshore monitoring framework is intended to answer key questions associated with both spatial and seasonal patterns of conditions in the lake's nearshore region. Its initial implementation will address the multiple dimensions of physical, chemical and biological characteristics in the nearshore to evaluate inherent variation within these parameters, especially in the cases of metrics and indicators for which little or no standardized monitoring data are currently available. For these indicators and metrics, subsequent data analysis and evaluation are expected to provide the basis for adjustments to initial monitoring design that will lead to improvements and a cost-efficient monitoring program (e.g., with optimal sampling frequency and locations). As a starting point, this initial monitoring framework is intended to provide the data needed to satisfy immediate management information needs for an evaluation of nearshore conditions, as well as to inform preliminary discussion on standards, and to inform progressive adjustments to the monitoring design and metric evaluation.

In most cases the metrics derive from or contain important elements of the standards reviewed in this report, although some additional attributes are to be measured as well (e.g., chlorophyll, macrophytes, and macroinvertebrates). Ultimately, it may be desirable to revise or replace existing standards with new standards that link directly to the primary nearshore

monitoring metrics. It was beyond the scope of this project, however, to provide the necessary level of analysis required by law to identify new standards, or to eliminate or modify existing standards. Rather, this report provides the scientific background that will help management agencies decide if and where they may want to address changes that would target specific features and metrics of nearshore condition.

A consistently implemented and standardized nearshore monitoring program will be essential to inform these efforts to update existing standards, including the validation of reference conditions, and for describing and confirming the spatial and temporal variation of metrics used to measure nearshore conditions. It will provide the quality and the quantity of data needed for evaluating progress in achieving management and restoration goals. It will also provide the basis for evaluating status and trends, and is designed to be flexible and scalable to accommodate available resources as well as changes in approach, information and techniques.

Taken in aggregate the ten primary metrics should provide a relatively comprehensive evaluation of status and trends for the most important and unique characteristics of the nearshore environment at Lake Tahoe. In some cases, any indication of change in status or trend would initiate an appropriate management or research initiative to address or investigate the specific causative factors and to develop suitable management or policy actions. The monitoring is focused on response variables, being the factors most sensitive and evident to changing biogeochemical conditions affecting the nearshore environment. It is not a research program, although specific questions that may arise in the context of evaluating these metrics could lead to important insights or to focused studies.

Conditions in the lake will continue to change over time as a consequence of changing patterns in land use, recreational activities, climate, species distributions, and other as yet potentially unidentified factors. A regular program of data collection allows the stakeholder community to detect and evaluate these changes in the context of natural variability and desired conditions.

Ultimately, this nearshore monitoring program will be needed to help track anticipated benefits from environmental improvement projects and from loading reductions associated with implementation of the TMDL program. The nearshore areas of lakes are responsive to changing conditions in the watershed, since most external pollutant loading must pass through the nearshore before reaching pelagic open water areas. Therefore, it is expected that nutrient and fine sediment loading reductions will provide not only better mid-lake clarity, for which the TMDL was designed, but also will provide benefits to clarity and other characteristics of the nearshore.