Lake Almanor Watershed Monitoring Plan

Prepared for

Plumas County Flood Control and Conservation District

APRIL 2007

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Acronyms and Abbreviations

COC	constituent of concern
CPUD	Chester Public Utility District
County	Plumas County
DHS	California Department of Health Services
DO	dissolved oxygen
DWR	California Department of Water Resources
EC	Electrical Conductivity
EPA	U.S. Environmental Protection Agency
Hg	mercury
LNF	Lassen National Forest
MCL	maximum contaminant limit
mg/L	milligrams per liter
ml	milliliter
MPN/100 ml	most probable number per 100 milliliters
MTBE	methyl tertiary-butyl ether
N	nitrogen
NH_3	dissolved ammonia
NO_2	dissolved nitrite
NO_3	dissolved nitrate
P	phosphorus
PCDEH	Plumas County Division of Environmental Health
PG&E	Pacific Gas and Electric Company
Project	Lake Almanor Watershed Planning and Non-point Source Control Project

RWQCB	Regional Water Quality Control Board
SWRCB	California State Water Resources Control Board
USFS	United States Forest Service
VOC	volatile organic compound

Lake Almanor Watershed Water Quality Monitoring Plan

Introduction

Background

The Lake Almanor watershed comprises more than 300,000 acres of land in northern California, approximately two thirds in Plumas County and one third in Lassen County (see Figure 1). The watershed is located at the transition between the Sierra Nevada and Cascade Ranges in Northern California, and the watershed elevation varies from nearly 10,000 feet above mean sea level (msl) on the slopes of Lassen Peak down to 4,500 feet msl at Lake Almanor.

Lake Almanor is one of the largest reservoirs in California, with a storage capacity of over 1 million acre feet. The reservoir receives runoff from the Upper North Fork Feather River and various smaller streams and springs. Lake Almanor and Mountain Meadows Reservoir, which is located upstream of Lake Almanor on Hamilton Branch, are managed by the Pacific Gas & Electric Company for power generation, recreation, and irrigation.

Lake Almanor is an important scenic, recreational, and economic resource for Plumas County (County) and the broader community of northeastern California. The County and watershed stakeholders have recognized that the generally unimpaired state of the Lake Almanor watershed resources must be protected from degradation, and that an organized planning and management effort is essential to the long-term health of the watershed.

In response to this need, the County is conducting the Lake Almanor Watershed Planning and Non-point Source Control Project (Project) to provide data to support and develop a framework for management of the Lake Almanor watershed. The Project includes several important steps to ensure that appropriate long-term management measures are implemented, including developing a stable institutional framework for coordinated planning and management; completing a comprehensive watershed assessment; improving public awareness of watershed issues; and coordinating watershed monitoring. The Project is currently funded by a grant from the California State Water Resources Control Board (SWRCB) and is being executed by Plumas County Flood Control and Conservation District.

This monitoring plan builds on previous efforts, including two reports, completed as part of this project:

- Lake Almanor Watershed Water Quality Report (CH2M HILL 2006)
- Lake Almanor Watershed Assessment Report (CH2M HILL and EARTHWORKS Restoration 2006)

The water quality report summarizes the historical water quality monitoring that has been conducted by various entities in the watershed. The watershed assessment describes current conditions in the watershed and identifies the major current and potential stressors on the natural resource conditions in the watershed, with a focus on the water quality and beneficial uses of Lake Almanor.

In general, the findings of these reports suggest that the lake and its contributing watershed are currently in good condition. The watershed assessment, however, also suggests that planned and possible changes in land use and recreational activities in the watershed could have significant impacts on the watershed and lake conditions, and that proactive management is needed to ensure that the values and benefits of Lake Almanor are protected into the future.

Purpose and Objectives

Monitoring Plan Objectives

As described in the water quality report (CH2M HILL 2006) and as summarized in the following section, considerable water quality monitoring has been conducted by various entities in the watershed over the past several decades. The purpose of this monitoring plan is to provide for a coordinated water quality and watershed monitoring effort into the future that reflects the current understanding of existing conditions and recognition of the potential water quality issues in the watershed.

This comprehensive monitoring plan responds to several needs identified in discussions among multiple stakeholder groups by:

- Providing for coordinated monitoring between multiple entities;
- Ensuring more effective use of available financial and human resources investment in monitoring;
- Providing year-to-year consistency in monitoring;
- Providing clear justification for monitoring and required investment; and
- Improving comparability across monitoring.

Monitoring Objectives

The purpose of this monitoring is to supply information to the interested stakeholders that will provide the basis for management decisions necessary to protect the resource values of Lake Almanor and the beneficial uses of the lake waters. As detailed below, there are a number of potential water quality issues that will require close attention and may warrant more active management of the lake and its watershed. The major water quality issues that the proposed monitoring will address include:

- Overall lake water quality associated with nutrient status and biological growth that reflects the cumulative effects of land condition and activities across the lake and contributing watershed;

- Bacterial issues associated primarily with human and animal waste in or near the lake; and
- Contaminants, most likely localized, from accidental spills or leaks from recreational activities on the lake or near the lake shore.

The proposed monitoring responds to the need to track the lake and watershed conditions with respect to these and other possible water quality issues. Detailed rationales for the proposed monitoring are discussed below in the section entitled "Water Quality Issues and Monitoring Rationale."

Plan Adaptability

The monitoring plan presented here is a starting point that captures the current state of knowledge about lake and watershed conditions and reflects the current vision of likely water quality stressors. The plan presented also reflects a balance of the level of concern with the anticipated availability of resources to conduct monitoring. As conditions change and new information becomes available, stakeholders may well develop a revised view of monitoring needs, in which case, appropriate modifications to the monitoring activities may be warranted. Accordingly, the monitoring plan may be updated, perhaps reducing or increasing sampling intensity, changing monitoring locations, or analyzing for additional or different constituents.

Contributors and Participants

Many organizations and individuals have contributed to the project and continue to participate in the efforts to better understand and manage the resources of the Lake Almanor Watershed. As mentioned previously, Plumas County (County), under the direction of Plumas County Flood Control and Conservation District, is responsible for executing the project, with contributing efforts from the Environmental Health Division of the Plumas County Public Health Agency (PCDEH). The project has grown largely from the work of the Plumas County Water Quality Subcommittee, an organization of interested local residents and landowners, who have been examining conditions in the watershed and posing questions about water quality conditions in the lake since 1993. In 2005, the Almanor Basin Watershed Advisory Committee (ABWAC) was formed to advise the County Supervisors on issues related to the Almanor watershed portion of Plumas County. Numerous other organizations have contributed to the water quality efforts in the Almanor watershed including:

- California State Water Resources Control Board (SWRCB), through the Central Valley Regional Water Quality Control Board (RWQCB)
- Pacific Gas and Electric (PG&E)
- Sierra Institute for Community and Environment
- California Department of Water Resources (DWR)
- U.S. Forest Service (USFS), Lassen National Forest (LNF)
- U.S. National Park Service, Lassen Volcanic National Park (LVNP)
- Chester Public Unitilities District (CPUD)

This document was reviewed by the Plumas County Water Quality Subcommittee and a technical advisory group (TAG) that has been assembled to assist the project.

Previous Water Quality Monitoring

Several entities have been involved in collecting information related to water quality in the Lake Almanor Watershed. Primary sources of data include the California Department of Water Resources (DWR) and Pacific Gas and Electric Company (PG&E), which operates the hydropower generating facilities at the reservoir. The historical water quality data from the watershed is detailed in the water quality report (CH2M HILL 2006). The following table (Table 1) is excerpted from the water quality report and identifies the major sources of historical data.

TABLE 1
Major Data Sources for Lake Almanor Watershed Water Quality Data

Data Source	Classes of Data Provided	General Sampling Locations	General Period of Record
California Department of Water Resources	Physical Minerals Nutrients Minor elements Phytoplankton and zooplankton Sediment Fish tissue Coliform Volatile organic compounds	Lake Almanor and a few tributaries; primarily at seven locations and less intense monitoring at other locations Groundwater	1989-2004; less frequent sampling 1957-1989; some individual periods of Intense sampling of parameters of interest
Pacific Gas & Electric Company	Physical Fish tissue Coliform Minerals Nutrients Minor elements	Lake Almanor and tributary/outlet streams, primarily at five locations	2000; temperature data 2000-2004
Regional Water Quality Control Board	Coliform Nitrate	Locations of interest near the lake shore	2004 and 2005
Plumas County Public Health Agency, Environmental Health Division	Coliform	High recreational use locations near the lake shore	2002-2006

Source: CH2M HILL, 2006

Water quality sampling efforts in the watershed to date have focused on Lake Almanor, with most regular sampling locations in the lake or on the North Fork of the Feather River (NFFR) in Chester, just upstream of where the river enters the lake.

General Monitoring Plan Rationale

Water Quality Conditions and Issues

Lake Almanor is a mesotrophic (clear water lakes and ponds with beds of submerged aquatic plants and medium levels of nutrients), mountain reservoir that currently supports several beneficial uses, including recreation, fisheries, and hydropower production. The data and information available to date show no evidence of long-term degradation of water quality (CH2M HILL and EARTHWORKS 2006).

The beneficial uses of the waters of Lake Almanor are important considerations in monitoring plan formulation. Also, since the outflow from Lake Almanor represents a significant portion of the flow into the NFFR, beneficial uses for that water body should also be considered. The official beneficial uses of Lake Almanor and the NFFR established by the RWQCB are listed in Table 2.

Although the current water quality in Lake Almanor fully supports these beneficial uses and no significant water quality degradation has been observed, the watershed assessment documents several conditions and activities in the watershed that have the potential to significantly affect the capacity of Lake Almanor to support all of the valued beneficial uses. Some of the more significant potential stressors are listed in Table 3.

TABLE 2
Designated Beneficial Uses for Lake Almanor and North Fork Feather River

Water Body	Designated Beneficial Uses
Lake Almanor (and Tributary Watershed)	POW
	REC-1 (CONTACT)
	FRESHWATER HABITAT (WARM OR COLD)
	SPAWNING (WARM)
	WILDLIFE HABITAT
North Fork Feather River (Below Lake Almanor)	MUN
	POW
	REC-1 (CONTACT) (CANOEING AND RAFTING)
	REC-2 (OTHER CONTACT)
	FRESHWATER HABITAT (COLD)
	SPAWNING (COLD)
	WILDLIFE HABITAT

Notes:

MUN = Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.

POW = Uses of water for hydropower generation.

REC-1 (CONTACT) = Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible.

REC-2 (OTHER CONTACT) = Uses of water for recreational activities involving proximity to water, but where there is generally no body contact with water, nor any likelihood of ingestion of water.

FRESHWATER HABITAT (WARM OR COLD) = Uses of water that support warm or cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

SPAWNING (WARM OR COLD) = Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.

WILDLIFE HABITAT = Uses of water that support terrestrial or wetland ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats or wetlands, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.

Source: (RWQCB 2004).

TABLE 3
Selected Major Potential Stressors or Issues Potentially Affecting Future Water Quality in Lake Almanor

Potential Stressor/Issue	Explanation/Notes
Increased Residential and Associated Commercial Development	Several new developments are either under construction or planned in the watershed, and others are expected. In addition, construction of new single-family residences or improvements to existing residences on current parcels continues. Increased urbanization of the lakeshore and watershed can contribute to water quality degradation through: • Increased surface erosion and associated sediment delivery to tributary streams as compared with forested landscapes or grazing lands. • Altered storm water and snowmelt runoff patterns that result in more concentrated flows over land and in stream channels, which can lead to increased channel erosion and downstream sediment delivery to tributary streams or directly to the lake. • Increased contaminant levels, including nutrients and toxics, in runoff from urbanized areas as compared with current or historic forested landscapes. The scale of current and planned development in the watershed suggests that development-related issues are the most urgent potential stressor to lake water quality.
Timber Harvest and Associated Road Building Practices	Timber harvest practices and particularly roads associated with timber harvesting have the capacity to increase sediment erosion and delivery to streams and the lake.
Unmanaged Off-road Vehicle Recreation	Unmanaged or poorly-managed use of vehicles off of established roads can result in significant erosion and delivery of sediment to streams and the lake.
Increased Recreational Use of Lake Almanor	Increased recreational use of the lake increases the potential for direct contamination of lake waters by a variety of contaminants including toxics from spills and bacteria from human waste.
Poorly Functioning Septic Systems Adjacent to the Lakeshore	Poorly functioning or inadequately maintained septic systems immediately adjacent to the lakeshore could contribute nutrients or fecal bacteria to the lake.

Source: Excerpted or summarized from: CH2M HILL and EARTHWORKS, 2006.

Major Monitoring Plan Components

In the context of these designated beneficial uses and considering the critical importance of Lake Almanor as a resource to Plumas County and the region, the considerable pressures on the watershed warrant diligence in monitoring to identify changes in lake and tributary water quality before they become significant. Further, many water quality problems, particularly those related to lake productivity or nutrient status are very difficult to correct once they have developed. Therefore it is crucial to implement monitoring to identify conditions or situations that may require management action before they result in significant water quality degradation.

To respond to this need, this proposed monitoring plan contains two major components:

1. **Water Quality Monitoring Component** – involves traditional, recurring, in-situ measurement of water quality parameters and collection of water quality samples for laboratory analysis.

2. **Watershed Condition Monitoring Component** – involves tracking certain watershed physical conditions or biologic indicators to alert stakeholders and management entities to issues that may require special attention. By tracking specific biologic indicators and watershed conditions, information that is missed by water quality sampling (which is conducted at specific moments in time) may be captured before actual changes in water quality conditions are observed or detected in water quality samples.

These two components are presented in the following sections. The water quality monitoring component, has been developed in detail since considerable background information, from a long history of monitoring, is available. Historical precedents for the watershed condition monitoring are not as well-defined, and little baseline information is available to use in designing detailed plans. Accordingly, conceptual elements of the watershed condition monitoring components are presented to provide a starting point for pursuing partnerships and funding to conduct baseline assessments of these elements and develop detailed implementation plans.

Prioritization of Monitoring Activities

During stakeholder discussion of the monitoring plan components, it became evident that the preference for more comprehensive monitoring must be balanced with the availability of funds and other resources to conduct the monitoring. However, it was concluded that a base level of monitoring was absolutely essential to adequately inform management of the watershed and to ensure that general water quality trends were adequately tracked.

Therefore, it was proposed that the overall monitoring strategy include a prioritization of proposed monitoring activities so that levels of monitoring can be adjusted in the future while still adhering to a rational comprehensive monitoring strategy. Changes in monitoring activities may be helpful in allowing managers to:

- adapt to funding availability
- respond to new information obtained from the monitoring itself or from other sources
- take advantage of unique opportunities for partnerships and public involvement

In response, components of the Monitoring Plan presented here are categorized into three priority levels:

- **Priority Level 1: Baseline/Essential** – Monitoring of these components on an annual or more frequent basis are essential to maintain long-term consistency for trend analysis and ensure that general lake conditions are healthy and stable. At a minimum, funding to support these monitoring components should be maintained at a stable level.
- **Priority Level 2: High Value/Special Needs** – Monitoring components that are a high priority to answer specific questions or to provide additional information not currently available. Also, monitoring of some of these components at less-regular intervals is acceptable without compromising their value. Funding for these components should be aggressively pursued.

- **Priority Level 3: Intermittent/Opportunistic** – Monitoring components that are high value, but whose value is not compromised by intermittent collection. These monitoring components should be pursued in combination as unique cooperative and/or synergistic opportunities present themselves, such as volunteer participation, educational forums, and public outreach needs.

Of course, the priority of a particular monitoring component may change as new information becomes available and as conditions or perceived threats to the watershed and lake water quality change over time.

Priority categories of specific monitoring activities are included in the detailed discussions in the following sections.

Water Quality Monitoring Components

This section describes the portion of the monitoring plan that involves actual measurement of the chemical or physical water quality parameters via field measurement and collection of water quality samples for laboratory analysis. Details of field methods, laboratory methods and quality assurance protocols are provided in the Quality Assurance Program Plan (QAPP) in Appendix A.

Categories of Water Quality Information Needs

Based on the most likely water quality issues and potential stressors, the proposed monitoring program is designed primarily to track water quality conditions in the following categories:

- General Water Quality Status Characterization
- Nutrient or Trophic Status Parameters
- Toxic Contaminants
- Bacterial Contaminants

These categories are described below. Some water quality parameters are important in more than one of these general categories.

General Water Quality Status Characterization

Characterization of general water quality parameters is required to appropriately interpret sampling of other constituents. General water quality parameters include water temperature (T), acidity or pH, electrical conductivity (EC) and dissolved oxygen (DO).

Nutrient or Trophic Status Parameters

Information assembled to date, combined with case histories of water quality problems at other lakes, suggest that problems associated with the nutrient or biologic productivity of the lake are some of the more likely and serious issues that could arise at Lake Almanor if appropriate precautions are not taken. Eutrophication is a condition where increased biologic productivity, often including rapid algae growth, can result in severe oxygen depletion and significant impacts to overall health and aesthetic conditions in lakes. Eutrophication is usually caused by a combination of factors and can be triggered by an increased availability of nutrients that are normally present in limited amounts in the water column.

The trophic status of a water body is measured by sampling and evaluating the abundance of and different types of organisms, including phytoplankton and zooplankton (floating plants and animals, including algae), periphyton (algae attached to stable substrates), macrophytes (larger plants), and benthic plants and animals (organism living on the lake bottom). In addition to the biological elements, monitoring of the major nutrients, primarily the different forms of nitrogen and phosphorus, also provide some insight into whether productivity conditions are changing. However the proper interpretation of results for nutrient parameters is often masked by biologic growth processes, because the biologic community can respond very quickly to changes in nutrient availability. In high clarity (low turbidity) waters such as Lake Almanor, water clarity is an easily measured (often by observing how far below the water surface a special black and white disc is visible [Secchi depth]), and useful indicator of overall water quality. In the summer months, when tributary inflows are low and mixing between lake levels is limited, the water clarity is also a fairly reliable indicator of overall productivity, since the presence of floating algae is a major contributor to turbidity (cloudiness).

If issues involving biologic productivity develop, they can affect large areas of a lake and can impact several of the beneficial uses including water clarity and fishery health.

Toxic Contaminants

Contaminants categorized as "toxics" include a suite of toxic metals and synthetic organic compounds. The potential sources of these contaminants are innumerable in developed areas, since they may be present in widely applied pesticides and are present in low concentrations in machinery parts, lubricants, fuels, paints, and cleaners.

In the case of Lake Almanor, contamination of these types could be localized, resulting from spills or local runoff from a contaminant source. However, more continuous, low levels of toxics can be introduced by dispersed runoff from developed areas. In addition to man-made sources from developed areas, the geothermal features in the upper Warner Creek drainage, which is a tributary to the NFFR upstream of the lake, may be a natural source of metals.

Bacterial Contaminants

The primary bacterial contaminant of concern at Lake Almanor is coliform contamination resulting from untreated or inadequately treated human wastes. The primary sources of potential coliform contamination are likely to be direct introduction of waste material at high-use recreation areas or possibly from faulty wastewater treatment at residences near the lakeshore. Coliform contamination is measured by sampling and analysis for total coliform or for more specific sub-categories of coliform bacteria, such as Escherichia coli (E-coli), the primary concern from a human health standpoint. Coliform or E-coli contamination, should it occur, is most likely to be a localized and short-lived contamination, but even such localized contamination is a significant health issue.

Sampling Locations

Numerous monitoring locations have been established by different entities that have conducted water quality sampling at Lake Almanor (see Figure 2). In some cases, sampling locations used by one entity are located in close proximity to stations used by other entities. Due to this overlap, some consolidation of monitoring locations is proposed for the future coordinated monitoring.

For the parameters that are monitored to track lakewide water quality trends, such as nutrient status and clarity, the vast majority of long-term historic data has been collected by DWR. Therefore, future sampling of these and related parameters will be conducted at the previously designated DWR sampling sites to maintain as much database consistency as possible.

For sampling targeting water quality issues that are most likely localized in scope, locations have been selected to best incorporate insights gained in past sampling. Some specific sampling programs that are prescribed by other guidance documents, such as the 2105 relicensing agreement (PG&E 2005), have locations that are already defined. In such cases, the prescribed location(s) will be kept in this comprehensive monitoring plan.

The sampling locations selected for future monitoring are described in the following section and are highlighted in Figure 2.

Monitoring Plan Parameters and Frequency

The monitoring plan components are detailed in Table 4. The items in the table are organized into Water Quality Components and Watershed Condition Monitoring Components as described above in the section entitled "Major Monitoring Plan Components." The prioritization of component groups as described above in the section entitled, "Prioritization of Monitoring Activities," are also indicated in the table. The following section describes the rationale supporting the plan outlined in the table.

General Physical Parameters

Issues Addressed: The measurement of general physical parameters may be related to any of the categories of water quality information but over the range of values typically expected in surface waters such as Lake Almanor and tributaries, are most important in describing the general water quality status and the nutrient/trophic state of the lake.

Frequency Rationale: DO, pH, EC and T are parameters that are easily measured in the field and are generally measured any time that other water quality samples are taken, since these measurements influence the interpretation of other water quality parameters. Secchi depth and turbidity are both measurements of the "clarity" of the water, which is an indirect indicator of the amount of suspended or non-dissolved material in the water. This suspended material may include sediment and plankton.

TABLE 4
Monitoring Plan Summary

Parameter General Category	Specific Parameters	Sampling Locations	Frequency
WATER QUALITY COMPONENTS			
Priority 1 – Baseline/Essential Components		**(Water Quality Components)**	
Physical	- Temp - pH - DO - EC - Turbidity - Secchi Depth[1]	> LA-1 (DWR) (in lake) > LA-2 (DWR) (in lake) > LA-3 (DWR) (in lake) Multiple Depth Profile at Lake Locations (approximately 3 meter intervals) > LA-4 (DWR) (NFFR) Temperature, pH & DO only	4 times/year [2]
Nutrients	- NH_3 - NO_2, NO_3 - P (ortho &Total)	> LA-1 (DWR) (in lake) > LA-2 (DWR) (in lake) > LA-3 (DWR) (in lake) Near Surface and Near Bottom Samples at Lake Locations > LA-4 (DWR) (NFFR) Temperature, pH & DO only	4 times/year [2]
Major Minerals	Ca, Cl, K, Mg, Na, SO_3, Hardness, TSS, Alkalinity	> LA-1 (DWR) (in lake) > LA-2 (DWR) (in lake) > LA-3 (DWR) (in lake) Multiple Depth Profile in lake (approx. 1 m intervals) > LA-4 (DWR) (NFFR) Temperature, pH & DO only	4 times/year [2, 4]
Metals (in water)	Ag, Al, As, B, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, Zn	> LA-1 (DWR) (in lake) > LA-2 (DWR) (in lake) > LA-3 (DWR) (in lake) Surface & Bottom in lake > LA-4 (DWR) (NFFR) Temperature, pH & DO only	4 times/year [2, 4]
Organics (Petroleum Products)	Multiple VOCs, MTBE	Selected High Use Areas -- e.g. near or at > LA-14 (DWR) > LA-16 (DWR) > LA-7 (DWR)	1 time/year (high use period)
Bacteria	E-coli Fecal Coliform	Selected High Use Areas > LA-7 (Plumas County) > LA-8 (Plumas County) > LA-12 (Plumas County) > LA-13 (Plumas County) > LA-16 (Plumas County) > Five stations near PG&E Recreation Sites[5]	1 time/year (high use period)
Plankton	Zooplankton Phytoplankton	Single Depth-integrated Net Tow > LA-1 (DWR) (in lake) > LA-2 (DWR) (in lake) > LA-3 (DWR) (in lake)	4 times/year [2]

TABLE 4
Monitoring Plan Summary

Parameter General Category	Specific Parameters	Sampling Locations	Frequency
Priority 2 – High Value/Special Needs Components (Water Quality Components)			
Metals (in water)	Ag, Al, As, B, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, Zn	> LA-1 (DWR) (in lake) > LA-2 (DWR) (in lake) > LA-3 (DWR) (in lake) Surface & Bottom in lake > LA-4 (DWR) (NFFR) Temperature, pH & DO only	4 times/year [2, 4]
Bacteria	E-coli Fecal Coliform	Selected High Use Areas > LA-7 (Plumas County) > LA-8 (Plumas County) > LA-12 (Plumas County) > LA-13 (Plumas County) > LA-16 (Plumas County) > Five stations near PG&E Recreation Sites[5]	1 time/year (high use period) – **in addition to 1 time per year priority 1.**
Priority 3 – Intermittent/Opportunistic Components (Water Quality Components)			
Stormwater Flow Spot Samples	Multiple Parameters as detailed above - Physical - Major Minerals - Nutrients - Bacteria - Metals - Organics	Selected locations draining developed areas	During large rain and/or snowmelt events as opportunities allow

WATERSHED CONDITION MONITORING COMPONENTS			
Priority 2 – High Value/Special Needs Components (Watershed Condition Components)			
Benthic Macroinvertebrates[6]	Standard CSBP taxonomic level	> Newly-selected shallow lake sites > near LA-4 (DWR) (NFFR)[6] > near LA-06 (DWR) (Hamilton Branch) [6] > Bailey Creek[6] > Warner Creek[6] > Last Chance Creek[6] > Dearheart Creek[6]	Every 5 years[3]
Macrophytes and Periphyton (Attached Algae)		> Newly-selected shallow lake sites > NFFR > Hamilton Branch	Every 5 years[3]
Stream Channel Condition Assessments[6]	- channel geometry transects - longitudinal profile - substrate characteristics - riparian	> Newly-selected shallow lake sites > near LA-4 (DWR) (NFFR)[6] > near LA-06 (DWR) (Hamilton Branch) [6] > Bailey Creek[6] > Warner Creek[6] > Last Chance Creek[6] > Dearheart Creek[6]	Every 5 years[3]

TABLE 4
Monitoring Plan Summary

Parameter General Category	Specific Parameters	Sampling Locations	Frequency
	vegetation extent and character		
GIS-based Watershed Condition Tracking	Changes in: - zoning changes - impervious area - building starts - road density - current and planned developments	Watershed-wide	Every 2 – 5 years[3]

DWR – Department of Water Resources

NFFR – North Fork Feather River

DO – Dissolved oxygen

EC – Electrical Conductivity

[1] Relevant in deep lake sampling sites only. Not applicable to shallow tributary sampling.

[2] Approximately April, June, August and October.

[3] First time baseline sampling event to be conducted as soon as possible and frequency and location of ongoing sampling to be determined based on baseline observations.

[4] Reduction in frequency may be considered in future years

[5] As prescribed in 2105 Agreement (PG&E 2005)

[6] BMI and stream channel condition assessments could be combined at same stream reaches and use the standardized method such as USFS Stream Condition Inventory (SCI) or California Stream Bioassessment Procedure (CSBP) although additional channel condition parameters may be desirable

Locations and Depths: DO, pH, EC and T will be measured in the field at all locations whenever other water quality samples are taken for analysis. For measurement of these parameters, samples are taken at 3 meter (m) intervals over the vertical depth of the lake, while only the surface sample and bottom-most samples are analyzed for nutrients, major minerals, and metals.

Secchi depth is only relevant in the deep lake environments, and given the ease of the measurement and its usefulness as a quick, general indicator of water quality, it will be measured any time other lake water quality samples are collected.

Nutrients

Issues Addressed: The sampling and analysis for nutrients is primarily of interest in determining the nutrient or trophic status of the reservoir.

Frequency Rationale: The nutrient status of the reservoir is highly dynamic and is influenced strongly by nutrient availability, temperature, sunlight, and biologic activity. The most active periods for biologic activity are from spring through fall when water temperatures are warmer and more sunlight is available. To adequately capture this dynamic behavior, multiple sampling dates are proposed throughout the year for nutrients and plankton. The target sampling times are April, June, August, and October.

Locations: Nutrient samples will be taken at three lake locations and at the NFFR location at Chester. At the lake locations, nutrient analysis will be conducted on the surface sample (1 m depth) and on the deepest sample to capture the effect of thermal stratification in the lake.

Major Minerals

Issues Addressed: The sampling and analysis for major minerals is primarily of interest in determining the general water quality status of the waterbody.

Frequency Rationale: Major minerals analysis has historically been conducted on most samples taken for nutrient and metals analysis. The highly stable nature of the major mineral character of the water in Lake Almanor suggests that the frequency of these analyses might be reduced in the future if historical trends continue.

Locations: Samples will be taken at three lake locations and at the NFFR location at Chester. At the lake locations, major minerals analysis will be conducted on the surface sample (1 m depth) and on the deepest sample to capture the effect of thermal stratification in the lake.

Organics

Issues Addressed: The sampling and analysis for organics (from petroleum products) is primarily in response to concerns of toxicity.

Frequency Rationale: Since the sources of organic contaminants are most likely to be connected to spills or leaks associated with recreational activities, the sampling strategy is to target worst-case conditions, which are thought to be high-use areas during high-use time periods. If new information, such as detection of concentrations of concern during these high use periods, suggests the issue warrants closer attention, the monitoring intensity could be increased.

Locations: Samples will be taken at three lake locations near fueling and/or boat launching facilities where leaks or spills of petroleum or organic materials associated with use of equipment are expected to be most likely.

Bacteria

Issues Addressed: The sampling and analysis for bacterial contamination is primarily a human health concern.

Frequency Rationale: Since the sources of highest levels of bacterial contamination are most likely to be associated with high-use recreational swimming areas, the monitoring strategy is to target worst-case conditions, which is thought to be high-use swimming areas during high-use times. Therefore, sampling will be conducted at five swim beaches on one of the busiest days of the fourth of July holiday period. If new information, such as detection of concentrations of concern at high use times, suggests the issue warrants more close attention, the monitoring intensity could be increased.

Locations: Samples will be taken at a total of ten Lake Almanor locations near high-use public swimming beaches, including five locations adjacent to PG&E managed recreation facilities as specified in the 2105 Relicensing Agreement (PG&E 2006).

Plankton

Issues Addressed: The sampling and analysis for plankton is primarily of interest in determining the nutrient or trophic status of the reservoir.

Frequency Rationale: As discussed above when addressing analysis for nutrients, the nutrient status of the reservoir is highly dynamic and is influenced strongly by nutrient availability, temperature, sunlight, and biologic activity. As with the nutrient status, to adequately capture this dynamic behavior, multiple sampling dates are proposed throughout the year for plankton. The target sampling times are April, June, August, and October.

Locations: Plankton samples will be taken at three lake locations.

Metals

Issues Addressed: The sampling and analysis for metals is primarily in response to concerns of toxicity. Even when present at very low concentrations where direct toxicity to humans or wildlife may not be a concern, metals can bio-accumulate to potentially toxic levels in some segments of the food chain, including fish.

Frequency Rationale: Metals analysis has historically been conducted on most samples taken for nutrient and minerals analysis. The historically low concentrations of dissolved metals encountered in Lake Almanor water suggests that the possible impacts of metals may be more effectively tracked by observing metals concentrations in sediments and/or fish tissues.

Locations: Samples will be taken at three lake locations and at the NFFR location at Chester. At the lake locations, major minerals analysis will be conducted on the surface sample (1 m depth) and on the deepest sample to capture the effect of thermal stratification in the lake.

Watershed Condition Monitoring Components

As mentioned previously, monitoring lake or watershed conditions can provide managers with important information that may be missed by the event-by-event water quality measurements. Such biologic or physical condition monitoring may highlight issues that need management attention early on, before they develop into more severe and/or expensive problems.

Several types of biological or physical watershed condition monitoring activities are described below. These descriptions are conceptual in nature at this point to prompt discussions among stakeholders and potential project partners. It is expected that the scope and extent of monitoring in each category will be refined to guide baseline efforts, and then appropriate levels of effort and sampling designs will be developed based on funding availability and baseline findings.

Aquatic Biologic Monitoring

In addition to plankton monitoring, included in the water quality sampling plan described above, other types of biologic monitoring can be useful indicators of water quality conditions. Monitoring the density and/or diversity of larger plants and animals provides an indication of the overall habitat and water quality conditions, since factors that affect their growth and survival are cumulative over longer periods of time.

Accordingly, the following biologic monitoring should be conducted:

1) Macrophytes (large aquatic plants) and attached algae (algae that is attached to stable objects or material as opposed to floating) in the lake; and

2) Benthic Macroinvertebrates (larger-sized invertebrate animals that inhabit the bottom of water bodies) in tributary streams and possibly shallow lake locations.

Macrophytes and Attached Algae

In addition to providing insight into long-term sediment and nutrient processes in the lake, macrophyte and attached algae monitoring are important in early identification of any exotic species issues. For example, watermilfoil (*Myriophyllum sp.*) has been found in Lake Almanor (CH2M HILL and EARTHWORKS 2006), although it has not been determined if the species is the invasive and problematic Eurasian milfoil (*Myriophyllum Spicatum*) or one of the two species of milfoil known to inhabit California waters. Further, the extent of the milfoil beds has not been determined. As a first step in the monitoring process, the species of the milfoil should be clarified and a more thorough documentation of the current extent of the milfoil beds should be conducted. A reconnaissance survey should also be conducted as soon as possible to clarify the need for a more comprehensive macrophyte monitoring program. The reconnaissance survey should provide a summary description of the common native and exotic species. It should also identify potential appropriate locations for established monitoring transects, if it is determined that more comprehensive monitoring is needed.

Benthic Macroinvertebrates

Monitoring of benthic macroinvertebrate (BMI) communities can provide a more comprehensive indication of stream or water body health than simple chemical measurements, since the various organisms demonstrate different sensitivities to different stressors. BMI assessment is most appropriate and informative in streams and shallow waters, where organism diversity is high, as opposed to deep water sediments, which usually have limited diversity. In order to add BMI assessment to the comprehensive monitoring plan for the Lake Almanor Watershed, a baseline survey should be conducted as soon as possible, and subsequent assessments should be conducted at intervals of approximately every 5 years. Target locations should include NFFR and Hamilton Branch just upstream of the Lake and one to three shallow lake locations, such as at the north end of the lake near the Highway 36 causeway.

BMI monitoring is combined with stream physical and riparian vegetation condition monitoring in a number of standardized monitoring protocols for assessing the condition of small and medium-sized “wadeable” streams. Two standardized methods particularly relevant in the Lake Almanor Watershed are the USFS, Pacific Southwest Region’s Stream Condition Inventory (SCI) (USFS, 2005) and the California Stream Bioassessment Procedure (CSBP) established by the California Department of Fish and Game (CDFG, 2003). However, standards for stream BMI sampling are quickly developing, and the most recent information should be considered at the time that funding for BMI sampling is obtained.

GIS-Based Watershed Condition Tracking

As discussed previously, major potential stressors to the water quality in Lake Almanor are associated with the effects of changing land use, particularly increased development, near the lake shore and throughout the watershed. Many of the effects of development are dispersed over wide areas and over long periods of time and are therefore difficult to capture with direct water quality sampling or other instantaneous measurements.

Although direct or even indirect measurement of the actual physical or chemical effects of land use changes may be difficult to quantitatively measure, documentation of landuse changes can provide information useful in assessing the size of areas impacted by various landuse conditions, how the extent of these areas change through time, and possibly help identify specific locations to monitor to determine if problems are actually occurring.

A considerable GIS database has already been assembled by the County and other agencies in the watershed. With incorporation of some additional information, regular updating, and appropriate analysis, this database could be used to highlight the progress of landuse changes that are important to consider in future management decisions and policy development. The proposed GIS analyses can provide direct quantitative information on a per square mile or subdrainage area basis, such as the number of potentially developable acres or road density in a given creek drainage. With regular updates every 3 to 5 years, the change in such variables could be calculated and mapped. Producing color-coded thematic maps would also be possible and is perhaps as valuable as the direct quantitative information.

As an example, by combining property parcel information with current aerial photography, a map showing the developed parcels or developed density could be produced, with different colors showing different development densities. With periodic updating, and possibly using historical aerial photography, the change in developed area through time could be documented using the same thematic representation. By using standardized assumptions or by incorporating satellite imagery interpretation, a similar thematic map could be produced to show percent impervious area due to road, parking lot, and building construction.

Thematic mapping such as this can provide decision-makers with visual tools for effective interpretation of general trends and in some cases more quantitative information on which to base proactive management responses in advance of actual water quality impacts. These visual tools and information would also be effective for increasing public awareness of changing landuse trends in the watershed.

Because a considerable portion of the required GIS database is already assembled, the primary need is for dedicated personnel time to formulate and execute the analysis. Some additional data acquisition or data development may also be needed according to the selection of desired themes.

Stream Channel Condition Assessments

Stream channel conditions are important indicators of sediment movement in the watershed as well as overall stream health. Therefore, a baseline assessment of major streams in the watershed and an ongoing program of stream condition monitoring is needed to provide information to identify erosion and stream degradation issues before they become significant problems. Identification of local problems through stream assessments could potentially allow management responses to be implemented before local problems become more widespread and impact Lake Almanor.

The stream channel condition assessment will involve identifying and establishing fixed monitoring reaches on selected tributaries, targeting the larger tributaries and those perennial or intermittent streams that drain the areas most likely to be impacted by anticipated landuse changes. In addition to NFFR and Hamilton Branch, Bailey Creek, Warner Creek, Benner Creek, Last Chance Creek, and Dearheart Creek are reasonable candidates for on-going monitoring. Where possible, stream monitoring reaches should coincide with BMI monitoring locations and long-term water quality monitoring. At each established monitoring reach, cross-sections would be surveyed and key conditions, such as streambed material composition and riparian vegetation type and condition, would be documented in the reach. In addition, more detailed characterization of the landuse history in the drainage upstream of the monitoring reach would be documented.

A base assessment will be planned and conducted as soon as possible, and regular assessment of the established stream reaches will be conducted approximately every 5 years thereafter.

Implementation Plan

Water Quality Sampling

For calendar year 2007, DWR expects to continue with its current level of water quality sampling, which covers the 4 times per year sampling of general physical parameters, nutrients, major minerals, metals, and plankton at the three Lake Almanor sites and the NFFR site at Chester. Similarly, the PCDEH, on behalf of the Water Quality Subcommittee, plans to continue bacterial sampling at the high-use recreational sites on the July 4th weekend.

However, the long-term funding prospects for continued DWR contributions to the monitoring program are uncertain at this time. To prepare for continuation of the routine monitoring beyond 2007 and to develop funding strategies and responsibilities for the additional proposed monitoring, the County will convene discussions with the multiple stakeholder parties to investigate options for working jointly to secure continued funding.

Database Management

As part of the Project, the historical water quality data has been assembled, and efforts are underway to incorporate the collected data into a publicly accessible database. The data collected as part of this monitoring plan will be added to the database to facilitate ongoing tracking of water quality conditions.

Discussions are currently underway to identify long-term database management responsibilities and to secure funding for database upkeep and web hosting.

Watershed Condition Monitoring

The water quality sampling components of the monitoring plan have been discussed at length among stakeholder group participants, and using the insights gained from historical sampling, the plans have been refined to the point necessary for detailed description. General consensus, however, has not yet been established on the watershed condition monitoring components. Therefore, further discussions will be required to define the level of need and to prioritize the proposed efforts, considering personnel resources, funding options, and other information.

The next steps toward implementing the watershed condition monitoring components include:

1. Discussion in stakeholder forums to refine details and general prioritization of efforts;
2. Investigation of possible funding opportunities and in-house capabilities for priority elements;
3. Development of detailed plans for each baseline assessment, along with accompanying data management, reporting, and quality assurance guidelines as required for the project QAPP (see Appendix A);
4. Upon securing funding, implement baseline assessment, develop on-going monitoring plan, and prepare baseline report; and
5. Implementation of on-going monitoring at appropriate intervals.

References

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Figure 1

Lake Almanor Watershed Extent and Features

11x17 GIS map with labeled sampling locations.

Figure 2

Lake Almanor Watershed Sampling Station Locations

8.5x11 GIS map with labeled sampling locations.

Appendix A
Quality Assurance Program Plan