Planned Water Quality Studies for Year 2007 for the Klamath Hydroelectric Project

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PacifiCorp Energy (PacifiCorp) is planning several water quality studies in the vicinity of the Klamath Hydroelectric Project (Project) to be conducted during the June-December period of 2007. These studies are described below, including study purpose, approach, and schedule. The studies described in this document will provide key information for PacifiCorp's on-going assessment of reservoir management plan (RMP) actions in support of PacifiCorp's application for water quality certification for the Project from the California State Water Resources Control Board (SWRCB) and the Oregon Department of Environmental Quality (DEQ).

There are seven proposed studies described in this document, including:

1. Engineering Analysis of Vertical Mixing in J.C. Boyle for Dissolved Oxygen Enhancement
2. Engineering Analysis of Hypolimnetic Oxygenation in Copco and Iron Gate Reservoirs
3. Field Tests of Epilimnetic Mixing for Algae Control in Project Reservoirs
4. Feasibility Assessment of Other Reservoir Management Techniques for Algae Control and Water Quality Improvements in Project Reservoirs
5. Field Study of Phytoplankton Presence and Distribution in the Klamath River System
6. Field Study of Nutrient and Organic Matter Fate and Transport in Representative Reaches in the Klamath River System
7. Basic Water Quality Monitoring

These studies, although listed as discrete elements, have considerable overlap and are intended to be complimentary where applicable. Further, the field components of these studies may be modified in response to additional information and field conditions experienced during the monitoring.

1. Engineering Analysis of Vertical Mixing in J.C. Boyle for Dissolved Oxygen Enhancement

Purpose:

Preliminary analysis has indicated that vertical mixing of J. C. Boyle reservoir in the area below the Highway 66 bridge would be a viable means to address the issue of low dissolved oxygen at depth in J. C. Boyle reservoir. Water column circulation uses the basic principle of aeration-driven circulation to mix the entire vertical water column and prevent or interrupt vertical stratification. This study will be a desk-top engineering assessment to determine the most feasible and cost effective method, and develop preliminary design criteria for a system using this technology. Although not anticipated at this point, pilot field studies may be conducted if warranted.

Approach:

PacifiCorp is considering implementation of vertical mixing in J.C. Boyle reservoir to improve dissolved oxygen and pH in the reservoir's bottom waters. The vertical mixing will be accomplished using water column circulation (also known as "destratification") techniques intended to directly introduce oxygen to the bottom waters of the reservoir. Water column circulation uses the basic principle of aeration-driven circulation to mix the entire vertical water column and prevent or interrupt vertical stratification.

The two most common techniques for water column circulation (destratification) are mechanical mixing and air injection. Mechanical mixing is accomplished using axial flow pumps in a "top-down" approach to set up a circulation pattern. A flotation platform and frame support an electric motor, gearbox, drive shaft, and large propeller (6–15 foot diameter). The propeller is suspended just a few feet below the water surface. Its rotation "pushes" water from the reservoir surface downward, setting up a vertical circulation pattern. Oxygen-poor water from the lake bottom is circulated to the reservoir surface, where oxygenation from the atmosphere can then occur.

Air injection (diffuser) systems use a compressor on shore that delivers air through lines connected to a perforated pipe(s) or other simple diffuser(s) placed near the bottom, typically in the deep area of the lake. The rising air bubbles cause water in the bottom water layer to also rise, pulling this water into the surface water layer. This aeration technique is sometimes referred to as the air-lift method of circulation, since bottom waters are "lifted" to the lake surface through the action of the injected air.

This study will include an analysis to assess effectiveness and feasibility of these techniques, including an estimate of costs (including equipment and O&M) for the techniques. Among the activities conducted for this study, PacifiCorp will seek detailed proposals from various manufacturers on optional alternative water column circulation techniques. Based on this information, a specific technique will be selected, and a design and implementation plan for a final selected technique will be developed. PacifiCorp will consult with ODEQ on this plan, and will seek ODEQ's input and concurrence on the plan. PacifiCorp anticipates conducting field tests of the selected technique during summer of 2008 to refine implementation requirements.

Schedule:

Analysis, assessment, and design: June-August 2007. Report of results: October 2007.

2. Engineering Analysis of Hypolimnetic Oxygenation in Copco and Iron Gate Reservoirs

Purpose:

Hypolimnetic oxygenation is proposed for Copco and Iron Gate reservoirs as a means to address the issue of low dissolved oxygen at depth in these reservoirs. There are two optional hypolimnetic oxygenation techniques that have been demonstrably effective in other reservoir applications – the line diffuser system (or bubble plume system) and submerged down-flow contact oxygenation (SDCO) or the Speece cone system. These technologies are proven; therefore, pilot studies are not necessary to establish feasibility. PacifiCorp plans to gather manufacturer recommendations and specification on these two techniques, and develop detailed designs to guide implementation.

Approach:

Hypolimnetic oxygenation is a technique that adds oxygen to the deeper part of the reservoirs (hypolimnion) without disrupting stratification. The addition of oxygen to the hypolimnion is used to prevent hypolimnetic anoxia (low oxygen in the bottom layer) and to reduce nutrient releases from sediments under low oxygen conditions. This technique increases the amount of oxygenated water available to organisms that use the deeper and cooler waters of the reservoir, and retards the buildup of undecomposed organic matter and compounds (e.g., ammonium) in the hypolimnion.

Hypolimnetic oxygenation uses pure oxygen that is delivered using one of two primary approaches: a bubble system or a bubble-free system. The bubble system consists of pipes with small holes laid throughout the reservoir. Gaseous oxygen is passed to the underwater pipes and fine oxygen bubbles rise, losing oxygen to the water as they do so. If the hypolimnion is greater than 100 feet deep, the bubbles will dissolve completely. Typically the efficiency of bubble plume oxygenation is about 85 percent. The method is effective for oxygenating most of the hypolimnion but may not fully oxygenate the sediment interfaces. The bubble-free system consists of a pressuring device into which the deep water is pumped to compress the oxygen for an efficiency of almost 100 percent. Oxygen is often provided as liquid oxygen and stored lake-side, and also can be generated on site by a pressure swing compressor and molecular sieve.

Two popular types of bubble oxygenators are the unconfined fine bubble diffuser and the unconfined and diffuse bubble curtain. The fine bubble diffuser sends oxygen to the bottom at a few sites using discrete diffusers. The bubble curtain uses long arrays of hoses that emit fine bubbles over the entire length of the hose. Several very large bubble curtain systems, supplying up to 100 tons of oxygen a day, are in use in reservoirs in the southeast United States.

The bubble-free oxygenator system sends oxygen into a pressurized container where the gas mixes with water pumped from the reservoir. The pressurized container can be situated at the bottom of the lake, taking advantage of the natural pressure of deep water. The oxygenated water is then dispersed over the sediments via a short manifold or sometimes with a few direct pipes.

This study will include an analysis to assess effectiveness and feasibility of hypolimnetic oxygenation techniques, including an estimate of costs (including equipment and O&M) for the techniques. Among the activities conducted for this study, PacifiCorp will seek detailed proposals from manufacturers and/or consultants with demonstrated experience in applying these techniques in similar reservoir systems. These manufacturers and/or consultants will be asked to provide design and installation requirements, installation costs, and O&M costs for their proposed techniques. Field visits and detailed analysis using existing data are assumed. Based on this information, a specific technique will be selected, and a design and implementation plan for the final selected technique will be developed. PacifiCorp will consult with SWRCB on this plan.

Schedule:

Analysis, assessment, and design: June-August 2007. Report of results: September 2007.

3. Field Tests of Epilimnetic Mixing for Algae Control in Project Reservoirs

Purpose:

Review and evaluation of potential reservoir management techniques suggests that increased turbulence or mixing of the epilimnion in Copco and Iron Gate reservoirs during summer has the potential to reduce or eliminate blooms of blue-green algae (cyanobacteria). Preliminary analysis has indicated that solar-powered reservoir circulators (such as the Pond Doctor™ or SolarBee™) have proven effective in providing epilimnetic mixing in similar applications and would be well suited to this study. Review and assessment of other epilimnetic mixing applications suggests that installation of a sufficient number of properly-sized circulators could significantly reduce or prevent the development of blue-green algae blooms in Copco and Iron Gate reservoirs. This study will involve field tests to determine the effectiveness and extent of influence of circulators installed at representative locations in Copco reservoir. PacifiCorp recognizes that the proposed field tests represent conditions in only a portion of the reservoir and that further tests may be required. Nonetheless, the planned tests will provide valuable insight on the efficacy of circulators in the reservoir environment at a localized scale, identify challenges with deployment and use of such devices, and provide important information on the possible similar use of circulators in Iron Gate or J.C. Boyle reservoirs.

Approach:

Although reservoir circulators are a proven effective technology for providing epilimnetic mixing, it is not clear how the performance or areal extent of influence of circulators might vary under actual field conditions in Copco and Iron Gate reservoirs. As such, field tests will be conducted of circulators installed at representative test locations in Copco reservoir during summer 2007. The study will document the changes in pH, dissolved oxygen, nutrients, and phytoplankton induced in the epilimnion within the zone of influence of the circulators compared to unmixed regions of the reservoir. The results of the study will provide information suitable to assess the feasibility of epilimnetic mixing as a measure for reservoir water quality management. Copco reservoir is proposed because the blue-green algae blooms seem to be more abundant there and there is less likelihood that tests will be disrupted by recreational boat traffic, which is more prevalent in Iron Gate reservoir.

For purposes of the field test, PacifiCorp plans to install solar-powered reservoir circulators in the vicinity of Mallard Cove on the south side of Copco reservoir. Mallard Cove provides a discreet area of reservoir in which to test the circulators, and an area that has experienced high concentrations of blue-green algae, including *Microcystis aeruginosa* (Kann and Corum 2006; referred to as site CRMC). During the test in Mallard Cove, nearby "untested" coves in the reservoir will serve as "controls" for water quality monitoring purposes. Such control coves may include the adjacent cove between Mallard Cove and Copco No. 1 dam (referred to as "Cove near Residences" or site CRJS in Kann and Corum (2006)) and Copco Cove on the northwest side of the reservoir (referred to as site CRCC in Kann and Corum 2006). Field reconnaissance will be completed prior to final deployment locations to ensure conditions are conducive to meeting pilot project objectives.

Three solar-powered reservoir circulators are proposed to be deployed in Mallard Cove. The circulators will operate continuously during the test period (July through September 2007) and provide a minimum DMD (Direct Mechanical Displacement) of 1.22 MGD at each unit. This flow, when combined with the induced flow created by the units should be ample to provide circulation throughout the Mallard Cove area. The circulators utilize a low horsepower gearmotor to rotate an impeller which lifts and distributes water radially outward, which provides the surface mixing action.

The test period of the circulators in Mallard Cove will occur from July through September 2007. The water quality monitoring period associated with the test will occur from June through October 2007, which will bracket the test period and provide pre-test and post-test information. After installation, but prior to start-up, measurements will be made and samples collected at various points in the reservoir to establish the water quality conditions prior to operation. During monitoring, samples will be obtained from six locations:

1. Copco reservoir in Mallard Cove
2. Copco reservoir in Copco Cove
3. Copco reservoir in southwest cove near residences
4. Copco reservoir near dam near deepest point (PacifiCorp monitoring site KR19874)
5. Klamath River above Copco reservoir (PacifiCorp monitoring site KR20642)
6. Klamath River below Copco reservoir (PacifiCorp monitoring site KR19645)

Samples will be obtained at approximately biweekly to monthly intervals during the monitoring period; i.e., samples will be taken 3 weeks and 1 week prior to start-up of circulators; 1 week, 3 weeks, 5 weeks, and 9 weeks after start up; and 1 week and 3 weeks after circulators are stopped. This sampling will include instantaneous acquisition of physical parameters (with multi-probe instrumentation) and grab samples for laboratory analysis of water chemistry and phytoplankton. The physical parameters that will be measured include water temperature, dissolved oxygen, pH, and specific conductance. These measurements will be taken at the reservoir sites as profiles at 1 meter intervals and at the river sites just beneath the surface. Secchi disk measurements will also be taken at reservoir sites.

Grab samples for laboratory analysis of water chemistry and phytoplankton will occur immediately following the physical measurements. Samples will be analyzed for ammonia, nitrate + nitrite (as N), total Kjeldahl nitrogen (TKN), total phosphorous, orthophosphate, total organic carbon (TOC), dissolved organic carbon (DOC), and chlorophyll a. Samples will also be analyzed for algae species, abundance, and biovolume. At the reservoir sites, two samples will be taken: (1) an integrated vertical sample over the photic zone (from the surface to a depth equal to twice the Secchi depth), and (2) one-half meter from the surface. If the depth at the reservoir cove sites is less than a depth equal to twice the Secchi depth, then one integrated vertical sample will be taken from the surface to a depth one meter above the bottom. Grab samples from the river sites will be taken offshore in the current just beneath the surface.

A supplemental intensive short-term water quality survey will be conducted during the start-up phase of the circulators in Mallard Cove to measure short-term changes in water quality. The more intensive short-term water quality survey will occur over the period from approximately two days before to two days after start-up of the circulators. During this period, multiple sub-daily measurements of water temperature, dissolved oxygen, pH, specific conductance, Secchi depth, and chlorophyll a will be taken at the four reservoir sampling sites and several other locations in the vicinity of the circulators during this period. The measurements of water temperature, dissolved oxygen, pH, and specific conductance will be obtained with multi-probe instrumentation. The chlorophyll a measurements will be obtained using a field fluorometer (with verification by lab analysis of a subset of samples). These measurements will be taken at the reservoir sites as profiles at 1 meter intervals (not to exceed a total depth equal to twice the Secchi depth). The additional locations in the vicinity of the circulators in Mallard Cove will be taken to characterize the extent of the zone of influence of the circulators.

Schedule:

Planning and implementation: April-June 2007. Field installation and testing period: July-September 2007. Water quality monitoring period: June-October 2007. Report of results: January 2008.

4. Feasibility Assessment of Other Reservoir Management Techniques for Algae Control and Water Quality Improvements in Project Reservoirs

Purpose:

In addition to the mixing, aeration, and oxygenation techniques described in the above studies, PacifiCorp plans to assess the feasibility of other potential techniques for controlling algae and improving water quality in Project reservoirs. For example, the use of algicides or other inhibitors (e.g., humics) are potential techniques for control of blue-green algae in the reservoirs, perhaps on a periodic or short-term basis. The use of algicides can be effective under certain circumstances, but their use is controversial. Recent research in Upper Klamath Lake has shown repressive effects of plant decomposition products (specifically humics) on the growth of blue-green algae (Geiger et al. 2005). Creation or enhancement of wetlands in the vicinity of the reservoir is another potential water quality improvement measure. Properly designed and constructed wetlands could offer a means of capturing and removing particulates and nutrients in waters of the reservoir or river inflow. Direct algae removal (e.g., using rotating microstrainers) is other potential technique for control of algae, particularly at a localized scale (e.g., in reservoir cove or shoreline area where higher accumulation of algae can occur). This study will assess the feasibility of these techniques for potential application in the Project reservoirs.

Approach:

PacifiCorp plans to assess the feasibility of other potential techniques for controlling algae and improving water quality in Project reservoirs, such as:

- Algicides
- Other algae inhibitors (e.g., humic substances, barley straw)
- Wetland creation and restoration

- Direct removal of algae (e.g., rotating microstrainers)

The work under this study will consist of a comprehensive literature review and interviews with recognized experts with specific applied experience in the use of these techniques. Advantages and disadvantages of each technique will be described with regard to application to Copco and Iron Gate reservoirs, particularly for improving water quality conditions caused by or related to loads of organic and nutrient matter from upstream sources (such as summertime algae blooms, dissolved oxygen, and pH). Preliminary design and cost information will be developed for alternatives to evaluate feasibility. Although not anticipated at this point, pilot field studies may be conducted if warranted. An implementation feasibility report will be prepared describing the results of the study.

Schedule:

Analysis and assessment: June-August 2007. Report of results: September 2007.

5. Field Study of Blue-Green Algae Presence and Distribution in the Klamath River System

Purpose:

The presence of blue-green algae in Project reservoirs has received considerable attention, particularly because of recent observations of the toxic blue-green algae *Microcystis aeruginosa* (MSAE). The purpose of this study is to provide synoptic surveys of blue-green algae presence and distribution in the Klamath River system to provide a clear context for and understanding of their distribution and abundance throughout the system.

Approach:

This field study will consist of two primary study components: (1) concurrent or synoptic bi-weekly (twice-monthly) sampling of phytoplankton and associated water quality during July through September 2007 at locations throughout the length of the Klamath River system; and (2) additional assessment of spatial and temporal heterogeneity of phytoplankton in August at Copco and Iron Gate reservoirs.

Concurrent or synoptic bi-weekly sampling of phytoplankton (during July-September 2007) will occur at 15 locations in the Klamath River system, including (from upriver to downriver):

1. Upper Klamath Lake lower end near Buck Island
2. Klamath River below Link dam (PacifiCorp monitoring site KR25312)
3. Keno reservoir lower end near log boom (monitoring site KR23360)
4. Klamath River below Keno dam (monitoring site KR23335)
5. J.C. Boyle reservoir lower end near log boom (monitoring site KR22478)
6. Klamath River below J.C. Boyle dam (monitoring site KR22460)
7. Klamath River above Copco reservoir (monitoring site KR20642; also sampled in study 3 above)

8. Copco reservoir lower end near dam (monitoring site KR19874; also sampled in study 3 above)
9. Klamath River below Copco No. 2 dam (monitoring site KR19645; also sampled in study 3 above)
10. Iron Gate reservoir lower end near dam (monitoring site KR19019)
11. Klamath River below Iron Gate reservoir (monitoring site KR18973)
12. Klamath River at Seiad Valley (monitoring site KR12850)
13. Klamath River at Orleans (monitoring site KR15900)
14. Klamath River at Weitchpec (monitoring site KR04250)
15. Klamath River at Turwar (monitoring site KR00600)

PacifiCorp might also conduct sampling in the Klamath River estuary, but this will depend on logistical and safety considerations.

Samples will be obtained at biweekly intervals (every two weeks) during the July-September 2007 monitoring period (a total of six sample events). This sampling will include grab samples for laboratory analysis of phytoplankton and chlorophyll a, along with measurements of physical parameters with multi-probe instrumentation (temperature, dissolved oxygen, pH, and specific conductance), and Secchi depth (at lake and reservoir sites). Lake and reservoir samples will consist of a composite of several grab samples collected at 0.5 m depth at intervals along a transect. Grab samples from the river sites will be taken in the current offshore just beneath the surface. Samples will be analyzed for algae species, abundance, biovolume, and chlorophyll a.

Additional assessment of spatial and temporal (sub-daily) heterogeneity of phytoplankton will occur during the two sampling events in August in Copco and Iron Gate reservoirs. Spatial heterogeneity will be assessed in the two reservoirs based on numerous chlorophyll a measurements obtained in approximate grid fashion in the reservoir during a short mid-day period. The chlorophyll a measurements will be made using a field fluorometer with verification by lab analysis of a subset of samples, and phytoplankton species density and biovolume. Concurrent color digital photographs will be taken at various sampling locations to visually document water surface conditions. In addition, aerial infrared (IR) photographs will be flown during the two sampling events at an elevation of approximately 5000 feet above Copco and Iron Gate reservoirs, providing a spatial depiction of algae distribution at a reservoir-wide scale. Blue-green algae species containing gas vacuoles (e.g., *Aphanizomenon*, *Microcystis*, *Anabaena*) reflect a specific signature in the near IR (Anderson and Horne 1975). Thus, color IR photographs can be used to show the spatial distribution of blue-green algae surface accumulations.

Temporal (sub-daily) heterogeneity of phytoplankton will be based on obtaining multiple samples per day during the two sampling events in August in Iron Gate reservoir near dam (monitoring site KR19019) and in the Klamath River below Iron Gate dam (monitoring site KR18973). The chlorophyll a measurements will be made using a field fluorometer with verification by lab analysis of a subset of samples for chlorophyll a, and phytoplankton species density and biovolume. The measurements at the reservoir site will be taken as profiles at 1 meter intervals (not to exceed a total depth equal to twice the Secchi depth). The measurements at the river site below the dam will be taken offshore just beneath the surface.

Schedule:

Planning and implementation: May-June 2007. Field sampling period: July-September 2007. Report of results: December 2007.

6. Field Study of Nutrient and Organic Matter Fate and Transport in Representative Reaches in the Klamath River System

Purpose:

Asarian and Kann (2006) claim that river reaches, such as that which occurs below Iron Gate dam on the Klamath River, provide significant instream retention or removal of nutrients. This study will perform focused sampling of nutrients in river reaches upstream and downstream of the Project reservoirs to more clearly resolve the question of nutrient and organic matter processing and retention in the river.

Approach:

Existing field data and modeling results suggest that the short residence time through the river reaches in the project area limits the processing of organic matter and sequestering of nutrients by benthic algae, and that the relatively long residence time through the reservoir reaches in the project area enhances the processing of organic matter and sequestering of nutrients (PacifiCorp 2006). This study will be specifically designed to determine the effect on nutrient concentrations of passage through two representative unimpounded river reaches in the Klamath River just upstream and downstream of the Project reservoirs, defined as follows:

1. Klamath River from Keno dam (monitoring site KR23335) to J.C. Boyle reservoir (KR22822)
2. Klamath River from Iron Gate dam (monitoring site KR18973) to Walker Road bridge (KR15750)

The four sites bracketing the two reaches as listed above will be sampled approximately monthly during the June-September 2007 period. During each sampling event, multiple samples per day will be collected over a three or four-day period at each site. Samples at these sites will be taken offshore in the current just beneath the surface. The sub-daily samples will be composited for each day, resulting in one composite sample per day per site. Each of these daily composite samples will be analyzed for ammonia, nitrate + nitrite (as N), total Kjeldahl nitrogen (TKN), total phosphorous, orthophosphate, total organic carbon (TOC), dissolved organic carbon (DOC), and chlorophyll a.

At the time of sub-daily sampling, measurement of water temperature, dissolved oxygen, pH, and conductivity will be taken with multi-probe instrumentation. For the site below Iron Gate dam (monitoring site KR18973), in addition to the daily composite sample, the individual sub-daily samples will be analyzed for the parameters listed above. This analysis of sub-daily samples will provide additional information on the temporal (sub-daily) heterogeneity of nutrients in waters released to the river from Iron Gate reservoir.

Schedule:

Planning and implementation: May-June 2007. Field sampling period: June-September 2007. Report of results: December 2007.

7. Basic Water Quality Monitoring

Purpose:

Basic water quality monitoring will be done in conjunction with the above studies as a continuation of work carried out in 2001- 2005 to describe water quality conditions in the Project area. This monitoring will occur at the following 12 locations:

1. Klamath River below Keno dam (PacifiCorp monitoring site KR23335) (same as sampled in studies 5 and 6 above)
2. Klamath River above J.C. Boyle reservoir (PacifiCorp monitoring site KR22822) (same as sampled in study 6 above)
3. J.C. Boyle reservoir lower end near log boom (PacifiCorp monitoring site KR22478) (same as in study 5 above)
4. Klamath River below J.C. Boyle dam (PacifiCorp monitoring site KR22460) (same as in study 5 above)
5. Klamath River above J.C. Boyle powerhouse (PacifiCorp monitoring site KR22040)
6. Klamath River below J.C. Boyle powerhouse (PacifiCorp monitoring site KR22020)
7. Klamath River above Copco reservoir (PacifiCorp monitoring site KR20642) (same as in studies 3 and 5 above)
8. Copco reservoir lower end near dam (PacifiCorp monitoring site KR19874) (same as in studies 3 and 5 above)
9. Klamath River below Copco No. 2 powerhouse (PacifiCorp monitoring site KR19645) (same as in studies 3 and 5 above)
10. Iron Gate reservoir lower end near dam (PacifiCorp monitoring site KR19019) (same as in study 5 above)
11. Klamath River below Iron Gate dam (PacifiCorp monitoring site KR18973) (same as in studies 5 and 6 above)
12. Klamath River at the I-5 rest area (PacifiCorp monitoring site KR17600)

Approach:

Water Temperature

To create a record of water temperature, continuously-recording thermistors (Onset Tidbits or Stowaways) will be deployed at the 12 locations listed above. A single thermistor will be used in river locations, while reservoir settings will include multiple devices suspended from the log boom to provide a profile of reservoir temperatures. Data will be collected on an hourly basis, and probes will be downloaded approximately monthly (consistent with the frequency of other sampling under this study).

Characterization of Water Quality

Water quality sampling for this study will be at a frequency of once per month from June through December 2007 (note: more frequent sampling will occur at some of the sites under studies 3, 5, or 6 as described above). This sampling will include instantaneous acquisition of physical parameters (with multi-probe instrumentation) and grab samples for laboratory analysis of water chemistry and phytoplankton. The acquisition of physical parameters will include measurements of water temperature, dissolved oxygen, pH, and specific conductance. These measurements will be taken at the reservoir sites as profiles at 1 meter intervals and at the river sites just beneath the surface (approximately 0.5 m depth). Secchi disk measurements will also be taken at reservoir sites.

Grab samples for laboratory analysis of water chemistry and phytoplankton will occur immediately following the physical measurements. Samples will be analyzed for ammonia, nitrate + nitrite (as N), total Kjeldahl nitrogen (TKN), total phosphorous, orthophosphate, total organic carbon (TOC), dissolved organic carbon (DOC), chlorophyll a, biochemical oxygen demand (BOD), and total alkalinity. Samples will also be analyzed for algae speciation, density, and biovolume. At the reservoir sites, two samples will be taken: (1) an integrated vertical sample over the photic zone (from the surface to a depth equal to twice the Secchi depth), and (2) one meter from the bottom. If the depth at the reservoir cove sites is less than a depth equal to twice the Secchi depth, then one integrated vertical sample will be taken from the surface to a depth one meter from the bottom. Grab samples from the river sites will be taken offshore just beneath the surface (approximately 0.5 m depth).

Schedule:

Planning and implementation: April-May 2007. Monitoring period: June-December 2007. Report of results: March 2008.

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