KHSA Interim Measure 15: Water Quality Monitoring Activities Monitoring Year 2010

1. Introduction and Overview

On November 13, 2008, the United States, the states of California and Oregon, and PacifiCorp executed an Agreement in Principle (AIP) describing a framework for possible removal of several PacifiCorp's dams on the Klamath River. Interim Measure 12 of the AIP stipulated a water quality monitoring program, including on-going monitoring of blue-green algae (cyanobacteria) and associated toxins. Water quality monitoring conducted in 2009 was conducted under the plan: *AIP Interim Measure 12: Water Quality Monitoring Activities, Monitoring Year 2009*.

The Klamath Hydroelectric Settlement Agreement (KHSA) signed on February 18, 2010, supersedes the AIP. Interim Measure 15 of KHSA states that PacifiCorp shall fund long-term baseline water quality monitoring to support dam removal, nutrient removal, and permitting studies, and also will fund blue-green algae (BGA) and BGA toxin monitoring as necessary to protect public health. PacifiCorp will provide funding of $500,000 per year for this measure, and that monitoring will be performed by an entity or entities agreed upon by the parties to the KHSA and in consultation with the appropriate water quality agencies. The funding provided by PacifiCorp under Interim Measure 15 is not intended to replace existing funding for ongoing monitoring efforts by other parties and programs, but is intended to coordinate PacifiCorp's monitoring efforts with other ongoing monitoring efforts, and to involve the KHSA signatories (Parties) and the responsible water quality agencies in this coordination. Monitoring will be performed by the Parties within their areas of regulatory compliance or Tribal responsibility, or alternatively, by an entity or entities agreed upon by the Parties and in consultation with the appropriate water quality agencies.

This document, presenting the KHSA Interim Measure 15 water quality monitoring plan developed for the monitoring period from April 2010 through December 2010, is hereafter referred to as the KHSA 2010 Monitoring Plan. Separate plans will be developed for subsequent monitoring years.

In accordance with KHSA Interim Measure 15, this plan includes public health monitoring of cyanobacteria and associated toxins as necessary to protect public health, and comprehensive baseline water quality monitoring in the Klamath River. This monitoring includes monitoring of the Klamath River mainstem (including reservoirs) from Link River dam downstream through the estuary. The sampling stations are illustrated in Figure 1. This plan is being conducted as one of numerous monitoring and/or study efforts in the Klamath River Basin, including annual monitoring of: tributaries above Upper Klamath Lake, Upper Klamath Lake, and tributaries to the Klamath River including the Lost River basin. These other efforts are being captured in a basinwide plan currently being developed by the Klamath Basin Monitoring Program (KBMP). To provide the larger framework within which this KHSA Interim Measure 15

monitoring effort will occur, the scope of the larger draft KBMP basinwide monitoring effort (including monitoring activities to be done by other parties) is illustrated in Figure 2.

PacifiCorp and other parties to the KHSA agreed to a cooperative effort for the finalization of this KHSA 2010 Monitoring Plan. Through this cooperative effort, the participants have identified objectives and recommended water quality monitoring activities that meet the intent of KHSA Interim Measure 15. The work presented in this plan represents consensus amongst the following participants: PacifiCorp, California North Coast Regional Board, Oregon Department of Environmental Quality, the Karuk and Yurok Tribes, U.S. Bureau of Reclamation and the United States Environmental Protection Agency (Region 9).

Modification of the program beyond Monitoring Year 2010 is anticipated as science and monitoring program designs evolve. Planning for the KHSA 2011 Monitoring Plan will again be conducted between the Parties to the KHSA, in consultation with the appropriate water quality agencies, and in coordination with KBMP.

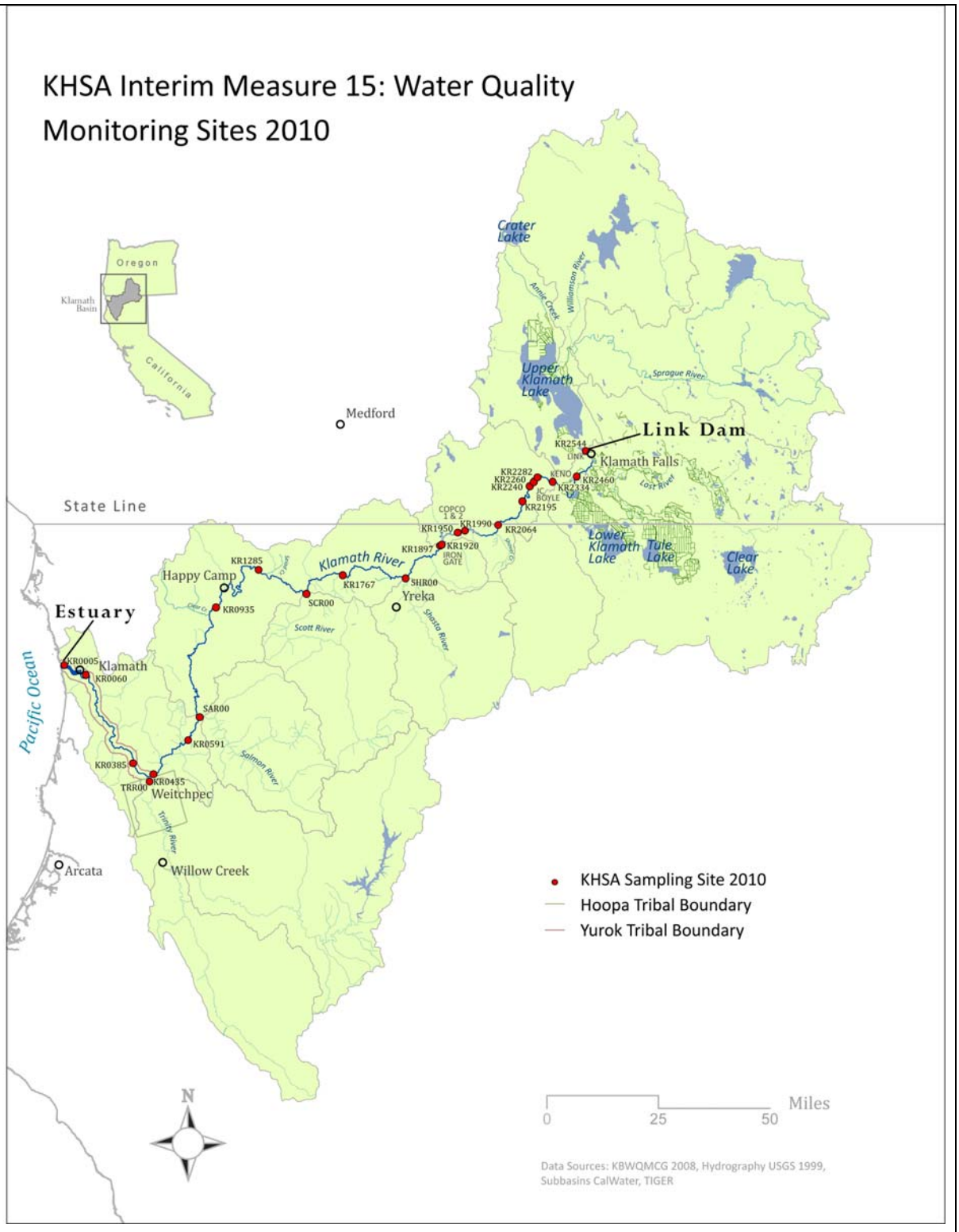

Figure 1: KHSA Monitoring Program station network locations for 2010. Stations include KHSA and joint KHSA / USBR stations. Key to locations is included in Tables 2 and 4.

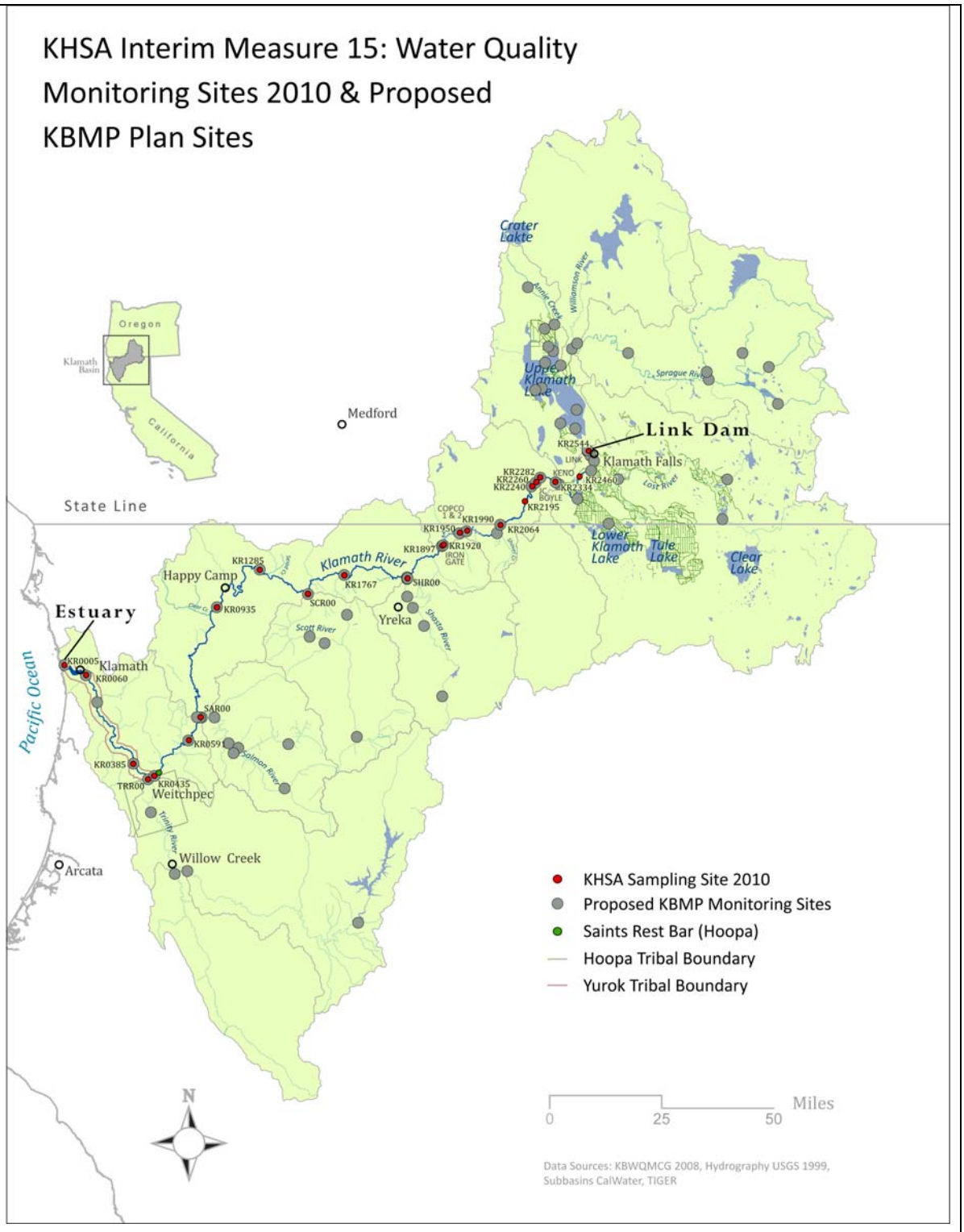

Figure 2: Monitoring stations within the KBMP framework – candidates for reporting into the Klamath Basin Water Quality Monitoring database. Not all stations are represented; recruitment is continuing.

2. Objectives

The KHSA 2010 Monitoring Plan includes both public health monitoring for cyanobacteria and toxins, and base-line monitoring. This work will be done collaboratively with several entities (state, federal, tribal, county and private). Common objectives of the KHSA 2010 Monitoring Plan and the KBMP framework include the following:

- Provide data on cyanobacteria and related toxins in a timely manner to support public health decisions.
- Support the science in the dam removal framework.
- Improve the current understanding of seasonal, annual, and long-term variations in a wide range of water quality parameters for Klamath River from Link Dam to the estuary. A system wide approach is necessary because influences from upstream sources extend downstream.
- Form a long-term program that help capture the effects of other activities in the system potentially affecting water quality in the Klamath River, regulatory actions (e.g., Biological Opinions, adjudications, etc.), potential climate change impacts, fires, and land use activities, as well as other factors.
- Provide a long-term baseline data set of water quality conditions that can be readily extended to assess impacts of management actions and restoration processes, including:
    - Clearly identifying current conditions for a wide range of hydrology, meteorology, and water quality conditions.
    - Identifying and quantifying potential water quality changes, impacts, and implementation measures.
    - Determining progress towards restoration of the river system and evaluation of possible mitigation measures to minimize long term impacts or promote/accelerate recovery
- Collect data under a consistent Quality Assurance (QA) framework
- Disseminate data in a timely fashion.

Other study priorities for the Klamath Basin were identified during the cooperative effort to plan the 2009 monitoring. These other Basin priorities (presented in Appendix A) have been referred to KBMP for consideration.

3. Monitoring Components

The KHSA 2010 Monitoring Plan includes the following two components.

3.1 Monitoring Component 1: Public health monitoring of Cyanobacteria and toxins

To assess potential risks to public health, due to exposure to cyanobacteria and their toxins occurring in the Klamath River, this monitoring component includes water column, shoreline water, and fish tissue and liver sampling within the Klamath River and reservoirs. A number of species of cyanobacteria have been documented in the Klamath River and reservoirs; the most abundant species include: *Aphanizomenon flos-aquae*, *Microcystis aeruginosa*, *Anabaena flos-aquae*, and *Oscillatoria sp*. Monitoring data from 2009 found *Anabaena flos-aquae* present at highest levels in the early summer (e.g., June/July) and in October, and large blooms of *Aphanizomenon flos-aquae* and *Microcystis aeruginosa* start in July in the Iron Gate and Copco reservoirs and continue into October (Raymond, 2008, and Kann, 2007). *Oscillatoria sp*. is found sporadically in the reservoirs and river (Raymond 2008). All four of these cyanobacteria are capable of producing cyanotoxins including variants of the microcystin toxins. *Anabaena* and *Aphanizomenon* can also produce toxins known as cylindrospermopsins and anatoxins (Graham et al 2008); however, the strain of *Aphanizomenon flos-aquae* found in Upper Klamath Lake, and presumably subsequently transported downstream to the Klamath River, has not yet been shown to produce any toxins (Carmichael et al. 2000; Li et al. 2000).

Since 2004, Klamath River monitoring has documented elevated levels of cyanobacteria including *Microcystis aeruginosa* (MSAE) and the toxin microcystin. Microcystins are a class of toxic chemicals produced by some strains of cyanobacteria including MSAE, and are released into waters when cyanobacterial cells die or cell membranes degrade. MSAE counts and microcystin concentrations found in Klamath River waters within Copco and Iron Gate Reservoirs and below Iron Gate dam have exceeded action levels defined by the World Health Organization (WHO), the California State Water Resources Control Board Blue Green Algae Work Group and the Klamath Blue Green Algae Work Group. For the reservoirs, late summer conditions are typically characterized by dense cyanobacterial blooms that form thick scums in parts of the reservoirs. The blooms at times can span much of the open water areas within the reservoirs. For the free-flowing section of the Klamath River, scums are found along shorelines and MSAE can be seen distributed throughout the water column. Since 2005, Copco and Iron Gate reservoirs have been posted with public health advisories as a result of summer blooms of MSAE; also, reaches of the Klamath River down stream of Iron Gate dam were posted in 2005, 2008, and 2009.

MSAE blooms and microcystins at elevated levels can present risks to human health and to terrestrial and aquatic species, and result in impairments to a number of beneficial uses for the waterbody. Microcystin toxins are capable of inducing skin rashes, sore throat, oral blistering, nausea, gastroenteritis, fever, and liver toxicity

(WHO, 2003). These toxins have also been shown to produce toxic effects in aquatic species (fish and mussels) and terrestrial animals, including acute liver toxicity and tumor production (de Figueiredo et al. 2004, Lehman et al. 2005, and Xie et al. 2005).

Anabaena flos-aquae has been found in water samples collected from Upper Klamath Lake and in Iron Gate and Copco reservoirs; a bloom in June of 2009 had sufficiently elevated cell counts of *Anabaena flos-aquae* to result in the reservoirs being posted, in accordance with the California State Water Resources Control Board Blue Green Algae Work Group posting guidance. While Klamath River water samples have not previously been evaluated for anatoxin-a, analytical methods are now available to assess for anatoxin-a. Anatoxin-a can act as an acute neurotoxin if consumed with water containing toxin-producing strains of *Anabena flos-aquae*, or *Aphanizomenon*, *Microcystis*, *Planktothrix* and *Oscillatoria*. Acute effects from anatoxin-a exposure can range from vomiting and diarrhea, to muscular twitching, gasping respiration, convulsions and death from paralysis of respiratory muscles.

This monitoring is intended to provide timely information that can be used to inform public health agencies if cyanobacteria are present, generating toxins of concern; and to determine the need to post warning notices and issue advisories for the reservoirs and/or areas of the river, in the event that cyanobacteria (such as MSAE) and/or cyanotoxins (e.g., microcystin) are present at levels that pose potential health risks. Additionally, analytical methods capable of detecting anatoxin are being incorporated as part of the KHSA 2010 monitoring program to assess if cyanobacteria strains present in the Klamath River and reservoirs are producing other toxins such as anatoxin-a. Monitoring is proposed to begin slightly before the bloom season (e.g., May) and continue through the period when high-risk conditions tend to prevail (e.g., when blooms are occurring and public health advisory posting decisions are likely), and to end following collapse of the bloom and after toxin levels have dropped below the public health criteria (e.g., November).

Parameters associated with Monitoring Component 1 (Public Health) are listed in Table 3. Monitoring approaches associated with Monitoring Component 1 are further described in Section 6 “Sampling Constituents and Frequency.”

3.2 Monitoring Component 2: Baseline water quality monitoring of the Klamath River

This component is designed to characterize water quality conditions, by monitoring for known impairments and related indicators of impairments. Results from this monitoring will be used to support dam removal, nutrient removal and permitting studies as necessary. Monitoring is intended to establish current data trends for the evaluation of implementation activities, and management actions and remedies.

The Clean Water Act (CWA) Section 303(d) requires the listing of impaired waterbodies. The states of Oregon and California have prepared such lists, which identify several impairments for Upper Klamath Lake and the Klamath River. Impairments to Upper Klamath Lake include dissolved oxygen (DO), chlorophyll *a*, and pH.[1] Impairments to the Oregon portion of the Klamath River include: DO, pH, ammonia toxicity, temperature, and chlorophyll *a*. Identified impairments to the California portion of the Klamath River include: nutrients, organic enrichment/low DO, temperature, microcystin, and sediment. Additionally, in the 2006 Section 303(d) listing, microcystin was listed as an impairment for Copco and Iron Gate reservoirs, and the reach of Klamath River between those reservoirs; in California's Draft 2008 303(d) list, that range has been expanded to include the Klamath River from Iron Gate dam to the Trinity River.

To address these listed impairments, together with related surrogate or indicator parameters, the proposed baseline monitoring builds on ongoing water quality monitoring programs for the Klamath River and larger basin. Proposed sampling enhances the current understanding of temporal and spatial variation in temperature, nutrients, organic matter, and algae production throughout the Klamath River system from Link River Dam to the estuary, and complements monitoring being conducted in Upper Klamath Lake by others. Data from this monitoring is intended to support ongoing and potential future studies and decisions regarding future management actions.

Parameters associated with Monitoring Component 2 are listed in Table 5.

4. Plan Adaptability

Using an adaptive management program, future KHSA Monitoring Plans will be revisited following the 2010 monitoring plan, and yearly thereafter as needed, to develop an optimized long-term KHSA monitoring program. Each year the monitoring plan sampling locations, parameters, and frequency will be reviewed to determine if changes should be made. New questions and hypotheses may arise as the program matures, thus necessitating additional sampling or modifications to the sampling program (e.g., to increase the density of sampling locations or frequency of sampling).

This annual adaptive management review of the KHSA Monitoring plan is expected to be completed in November[2] in order to identify needed updates and modifications to the following years monitoring plan. Within a sampling year, modifications to the monitoring plan should be limited to those modifications needed to address safety, access, or extraordinary events.

[1] ODEQ completed TMDLs in 2002 to address these parameters in the Sprague River, Williamson River, and Upper Klamath Lake.

[2] The monitoring year ends in December; however the majority of sampling will be completed by November. Therefore, this schedule presumes that data needed to inform this adaptive management review (e.g., laboratories have reported data) will be available to the reach monitoring entities.

5. Quality Assurance, Data Management, and Dissemination

5.1 KHSA Program Quality Assurance Strategy for 2010

The KHSA 2010 Monitoring Plan reach monitoring entities are striving to use common sample collection methods, laboratories, and data management strategy.

In the 2010 KHSA Monitoring Plan, except where otherwise specified, it is the responsibility of each monitoring entity to individually contract the services of laboratories for the analysis of water quality samples. In contracts with the laboratories, each reach monitoring entity includes requirements for a minimum level of laboratory QA procedures.

These QA requirements have been evaluated and compared, to document the analytical methods used and possible variability. The *2010 Klamath River Baseline Sampling Program QA Comparison* (see Appendix B) compares participating entity's existing QA plans and standard operating procedures. The scope of the review was to ensure that minimum standards and compatibility of methods among participants are applied for the following program elements:

- Field sampling SOPs and QA/QC requirements (e.g., duplicates, blanks)
- Laboratory and sampling accuracy and precision
    - Minimally acceptable method detection limits (MDLs) and reporting limits (RLs) for each analyte
    - Frequencies for duplicates, blanks, and sample spikes
    - Sample split requirements to evaluate comparability where multiple labs are used to evaluate a given parameter
    - Lab QA measures and reporting requirements
    - Required Actions should a lab fail to meet Lab QA measures and/or reporting requirements

The review concluded that minimum standards were met or exceeded by all reach monitoring entity's QA plans and that there was a high level of compatibility for QA procedures. The reach monitoring entity QA plans and standard operating procedures that were included in the consistency review are also included as Appendix B. A subcommittee has been formed for planning a more complete and unified KHSA QA plan for future monitoring years.

Participants in the KHSA monitoring use common laboratories where possible and practical; however, there are instances where different labs are being used. The analysis of water quality samples by multiple labs requires additional QA procedures to enable comparisons of performance by participating laboratories. To support such a comparison, a number of nutrient samples (described in the QA requirements) will be

divided into splits and those splits sent to each of laboratories doing nutrient analyses. This approach is similar to that used for the 2009 sampling effort. (The Sampling Lab Cross Comparison memo prepared for 2009 is available in Appendix C.) Specifically, triplicate samples will be collected at the Link Dam site (RM 2544) four times over the sampling season (February, May, July and September 2010). The results from this effort for 2010 monitoring will be summarized in a lab comparison memo.

Each monitoring entity will be responsible for conducting QA review of lab data results prior to disseminating data to the public. Data and laboratory QA documents from the KHSA 2010 effort will be made available to the public and interested parties in a timely manner following internal QA and quality control procedures by the reach monitoring entities. If a laboratory should fail to meet the QA requirements as set forth by the KHSA lab subgroup, and laboratories fail to adequately implement corrective actions, then contracts with that lab will cease and a new contract will be established with one of the other labs currently contracted by a monitoring entity, or, if not available, new lab(s) able to meet the QA requirements will be contracted.

5.2 Data Management and Dissemination for 2010

Data availability and dissemination are intended to be an ongoing element of future KHSA monitoring plans. In an effort to maintain continuity with the long-term basinwide water quality monitoring plan, KBMP has developed a searchable web based database for the collection and dissemination of data characterizing the Klamath River Basin (see http://www.kbmp.net/maps-data). Data from the KHSA 2010 Monitoring will be posted on this website. Funding for the data management is from an existing contract that the Regional Water Board has with the Klamath Watershed Institute to support the Klamath Basin Water Quality Monitoring Coordination Work Group.

For this 2010 Monitoring effort, each monitoring entity is responsible for maintaining all data collected, in usable spreadsheets (e.g. Excel).

For public health cyanobacteria analyses (cell count and toxin sample), each sampling entity is responsible for producing a memorandum every two weeks with the most recent analytical results and distributing that memo to regulatory agencies and interested parties including KBMP (submitted in spreadsheet format) and Klamath BGA workgroup members.

For baseline monitoring analytical results, each sampling entity is responsible for submitting data (all data received and reviewed/validated) in spreadsheet format to KBMP on a quarterly basis. Data submittals should be by the last day of the following months: April, July, October, and January. The data will be posted on the KBMP public website (see below). These data submittal and dissemination procedures may be revised pending the KBMP data reporting protocol modifications.

Additionally, a draft annual report summarizing the data will be prepared by the end of January following the sampling year, in order to guide monitoring decisions for the following season, and a final report will be completed prior to the commencement of

monitoring work for the following year (i.e., April). KHSA Monitoring Plan participants will coordinate with KBMP on the development of this annual summary report. The summary report is expected to include graphs, tables of the data, and depictions of longitudinal as well as seasonal trends of measured parameters.

5.3 Public Health Monitoring Data Dissemination

Public health monitoring of cyanobacteria and toxins requires prompt and effective communication of data to the local and state agencies to support management decisions regarding the need to post waterbodies with informational signage or issue health advisories. Thus, results from cyanobacterial cell counts and toxin analyses (e.g., MSAE counts and/or associated toxin concentrations) should be forwarded promptly to the appropriate local and state health agencies (e.g., the ODEQ, the California Regional Board and State Board, and County Health Departments). Specifically, reach monitoring entities will provide all provisional laboratory data (i.e., prior to reanalysis requests and QC review) for cyanobacterial cell counts and toxin levels, to regulatory and public health agencies (e.g., ODEQ, CA RWQCB, CDPH, EPA) **within 48 hours of receipt**, to support management decision-making. If the results of sampling suggest that cyanobacteria populations or toxin levels present a potential public health risk at any site, reach monitoring entities shall clearly identify those locations and data results when notifying the public health agencies. Public notices will be issued by the relevant authorities in accordance with regulatory requirements and guidance (e.g., California State Water Resources Control Board Blue Green Algae Work Group posting guidance document) and according to established procedures.

6. Sampling Constituents and Frequency

This section presents protocols to be used in conducting sampling for Monitoring Components 1 and 2, including sampling locations, frequency and procedures. Table 1 provides a summary of public health monitoring locations, constituents, method, and frequency. To facilitate timely shipment of samples to the various laboratories, and as a cost saving measure, PacifiCorp has established a shipping account and provided a common shipping number to the identified reach monitoring entities for use in shipping samples collected as part of this KHSA 2010 Monitoring Plan to designated laboratories

6.1 Monitoring Component 1: Public health monitoring of cyanobacteria and toxins

Risks to public health related to cyanobacteria and toxin exposure will be evaluated through water sampling, tissue sampling, and identification of the presence of scums, using the monitoring procedures described in the standard operating procedures (SOPs) presented in Appendix D. Water quality monitoring of cyanobacteria and related toxins for purposes other than public health evaluation is addressed under Monitoring Component 2, described below.

6.1.1 WATER SAMPLING

Locations

Public health monitoring for cyanobacteria and microcystin toxin in water samples will occur during 2010 at a total of 12 designated locations used for public access and recreation. These are listed in Table 1, and include:

- Four shoreline sites in coves on Copco (Mallard Cove and Copco Cove) and Iron Gate reservoirs (Camp Creek and Williams Boat Ramp). These cove sites provide public access, are known areas of likely accumulation during blooms, and have been monitored since 2005.
- Eight (8) river sites stretching from Iron Gate dam (RM 189.7) to Turwar (RM 6.0). Most of these sites have been monitored since 2005, and all represent areas of public access.

In recent years, monitoring programs have also been conducted to evaluate cyanobacteria and toxin levels in reaches of the Klamath River between Upper Klamath Lake (Link River Dam) and Copco 1 Reservoir. Cyanobacteria and cyanotoxin sampling in these reaches is addresses as part of Monitoring Component 2.

Table 1: 2010 Klamath River sampling sites for public health monitoring of cyanobacteria and cyanotoxins in surface water samples.

Location	Approx RM	Sampling Entity
Copco Reservoir and Mallard Cove	200.8	PacifiCorp
Copco Reservoir at Copco Cove	198.5	PacifiCorp
Iron Gate Reservoir at Camp Creek	192.8	PacifiCorp
Iron Gate Reservoir at Williams Boat Ramp	192.4	PacifiCorp
Klamath River below Iron Gate Dam (Hatchery Bridge)	189.7	PacifiCorp
Klamath River at I-5 Rest Area	176	Karuk
Klamath River at Brown Bear River Access	157.5	Karuk
Klamath River at Seiad Valley	128.5	Karuk
Klamath River at Happy Camp	108.4	Karuk
Klamath River at Orleans	59.1	Karuk
Klamath River at Weitchpec	43.5	Yurok
Klamath River at Turwar	6.0	Yurok

Table 2: Klamath River KHSA Monitoring Program 2010 – Summary Table of Public Health monitoring locations, constituents, method, and frequency

Site ID	Location	Phyto-plankton Species	Microcystin - EPA	LC/MS/MS water for cyanotoxins	Sampling Entity
KR2008	Copco Reservoir at Mallard Cove	BM7	BM7	BM7-mod	PacifiCorp
KR1985	Copco Reservoir at Copco Cove	BM7	BM7	BM7-mod	PacifiCorp
KR1928	Iron Gate Reservoir at Camp Creek	BM7	BM7	BM7-mod	PacifiCorp
KR1924	Iron Gate Reservoir at Williams Boat Ramp	BM7	BM7	BM7-mod	PacifiCorp
KR1897	Klamath River below Iron Gate Dam (Hatchery Bridge)	BM/W	BM/W	-	PacifiCorp
KR1760	Klamath River at I-5 Rest Area	BM/W	BM/W	-	Karuk
KR1575	Klamath River at Brown Bear River Access	BM/W	BM/W	-	Karuk
KR1285	Klamath River at Seiad Valley	BM/W	BM/W	BM5	Karuk
KR1084	Klamath River at Happy Camp	BM/W	BM/W	-	Karuk
KR0591	Klamath River at Orleans	BM/W	BM/W	-	Karuk
KR0435	Klamath River at Weitchpec	BM/W	BM/W	-	Yurok
KR0060	Klamath River at Turwar	BM/W	BM/W	-	Yurok

Frequency	# of sample events	Sampling frequency description
BM7-mod	9	1x month in May and 2x month June, July, October, and November (omits August and September)
BM7	13	1x month in May and 2x month June-November
BM/W	16	2x month in June, July, and October and weekly in August and September
BM5	10	2x month June-October

Sampling Frequency

Sampling for public health monitoring under this plan will occur at each of the identified sites as listed in Table 2:

For Copco and Iron Gate Reservoirs:

- To detect when the reservoirs should be posted and to track seasonally for the presence of cyanobacteria and cyanotoxins, sampling will start prior to the cyanobacteria blooms with one sample in May, and then continue bimonthly (2x/month) through November. Samples will be collected and submitted for analysis of toxigenic phytoplankton species and microcystin by ELISA. This data will then be used to inform regulatory agencies (e.g., California's North Coast Regional Water Quality Control Board) whether criteria have been met to warrant the posting of public health advisories.
- To determine those microcystin congeners present and assess if anatoxin-a is present, water samples for LC/MS/MS analysis will be collected concurrently with the above phytoplankton and ELISA sampling; however, samples will not be collected in August or September when reservoirs are expected to be posted and when anabaena has not been previously detected. In summary, sampling for LC/MS/MS will occur once in May and twice a month in June, July, and again twice a month in October and November at the end of the cyanobacterial bloom.

For the Klamath River below Iron Gate dam:

- To track cyanobacterial bloom conditions in the River, shoreline sampling for phytoplankton and microcystin by ELISA will be conducted bimonthly (2x/month) June, July, and October. For August and September when the bloom conditions can change rapidly in the River, sampling will be done weekly.
- To confirm ELISA results for microcystin, to see which microcystin congeners are present, and to test for the presence of anatoxin-a, water samples will be collected at one location (Seiad Valley, SV) for analysis by LC/MS/MS, on a bimonthly basis from June through October.

At all locations, as needed:

- Contingency monitoring will occur during each sampling event up until the reservoirs or the river is posted with public health advisories. For each regularly scheduled sampling event up until posting, field crews will keep a look-out for the presence of cyanobacteria. If notable densities of cyanobacteria are seen in an area other than a fixed sampling site (see Table 2), possibly approaching conditions warranting the posting of public health advisories, then the field crew will collect samples at the location for phytoplankton and microcystin by ELISA.

Sampling Procedures

Water samples will be collected, by all reach monitoring entities, for species identification/enumeration, and for toxin analysis, in accordance with the *Standard Operating Procedures, Environmental Sampling of Cyanobacteria for cell enumeration, identification and toxin analysis* (aka, Environmental Sampling SOP, see Appendix D). To address public health concerns, water samples will be collected at sampling locations and depths representative of reasonable maximum exposure by incidental ingestion exposures to sensitive populations (e.g., children).
Under the KHSA 2010 monitoring program, water samples will be collected for phytoplankton species cell identification/enumeration to determine the presence and abundance of cyanobacterial species (e.g., *Anabaena sp.*, *Aphanizomenon sp.*, *Microcystis sp.*, etc). To provide data continuity with prior years of monitoring, the river monitoring entities have agreed to have cell identification and counting be done by Aquatic Analysts laboratory, contracted by the individual monitoring entities. These analyses will be conducted to the species level at minimum. For shoreline grab samples for public health, only toxic species of phytoplankton will be counted by Aquatic Analysts. Depending on the severity (e.g., density and size) of the algal bloom and timing (e.g., pending decision to post a reach due to species and cell density) reach monitoring entities will specify whether a 48-hour rush or a 2-week turnaround will be requested for the phytoplankton sample analysis.

Water samples will also be collected for cyanotoxin analysis by two methods:

- Enzyme-Linked ImmunoSorbent Assay (ELISA) for total microcystins, analyzed by the U.S. EPA Region 9 laboratory, in accordance with the U.S. EPA Region 9 Laboratory Standard Operating Procedure (SOP 1305 for Microcystin analysis by ELISA), and

- Liquid Chromatography - tandem Mass Spectrometry (LC/MS/MS) for microcystin congeners and anatoxin-a analysis (per Mekebri et. al., 2009), at the CA Dept. of Fish and Game lab in Rancho Cordova, CA.

Sample collection and preservation will be conducted in accordance with the *Environmental Sampling SOP* (Appendix D). ELISA samples should be chilled immediately upon collection and maintained at or below 6 degrees C prior to and throughout shipping to the EPA laboratory. LC/MS/MS samples should be immediately placed on ice, frozen (standard or dry ice) as soon as possible, and maintained frozen throughout shipping to the CDFG laboratory.

Analysis and data QA/QC review and reporting should be conducted in accordance with the Quality Assurance (QA) requirements for each reach monitoring entity, as identified in Appendix B.

6.1.2 TISSUE SAMPLING

During 2010, public health monitoring will include salmon and steelhead sample collection from locations on the Klamath River below Iron Gate Dam. See Appendix E for Adult Salmonid Microcystin Study Plan for specific details. Table 3 presents an overview of sample timing and locations.

Table 3. 2010 Adult fall-run salmonid microcystin sampling overview

Species	Age	Location (approximate river mile)	Tissue type	Month			Sampling entity / Method
				Sept	Oct	Nov	
Fall Chinook	Adult	Mouth of KR (0)	fillet	5	5		Yurok fisheries / commercial harvest
			liver	1	1		
		IshiPishi (65.5)	fillet	6	6		Karuk fisheries / dip net fishery
			liver	1	1		
		Hatchery (189.7)	fillet		6		CDFG / Hatchery returns
			liver		1		
Fall Steelhead	Adult or 1/2 lb	Weitchpec (43.5)	fillet	5	5		Yurok fisheries / bycatch and/or hook and line
			liver	5	5		
		Orleans (59.1)	fillet	5	5		Karuk / Hook and line
			liver	5	5		
		Happy Camp (108.4)	fillet		5		Karuk / Hook and line
			liver		5		
		Hatchery (189.7)	fillet			5	CDFG / Hatchery returns (holding mortalities)
			liver			5	

6.1.3 Public Health Data

Water quality monitoring data (cell count, and ELISA data presenting total microcystin concentrations) for the protection of public health, will be evaluated against the following water quality criteria and guidance. Therefore, data should be of sufficient quality to fully and unquestionably meet the following criteria and guidance.

Criteria to be used for purposes of protecting public health include those presented in the California State Water Board 2008 Guidance about Harmful Algal Blooms, for Monitoring and Public Notification[3], and criteria issued by California's Office of Environmental Health and Hazard Assessment (OEHHA). Exceedance of any of these

[3] Per the posting guidelines established by the Blue Green Algae Work Group of the California State Water Resources Control Board, Department of Public Health, and Office of Environmental Health and Hazard Assessment; *Cyanobacteria in California Recreational Water Bodies; Providing Voluntary Guidance about Harmful Algal Blooms, Their Monitoring, and Public Notification*. Draft, September 2008.

criteria for the protection of human health and aquatic life may result in the posting of a waterbody by local health agencies:

- Surface scums are present containing toxigenic species[4];
- *Microcystis aeruginosa* or *Planktothrix* cell densities ≥ 40,000 cells/mL;
- Other potentially toxigenic cyanobacteria ≥100,000 cells/mL;
- Total microsystin concentrations ≥ 8 µg/L; and
- Others as specified in the California State Water Board 2008 Guidance.

To evaluate tissue samples, an exceedance threshold of the Advisory Tissue Level for one serving (8 oz uncooked, 6 oz cooked) of 26 ng of total microcystins/g will be applied to analytical results for cyanotoxin concentrations in fish fillets (OEHHA, August 6, 2008).

6.2 Monitoring Component 2: Comprehensive Baseline Water Quality Monitoring of the Klamath River

6.2.1 LOCATIONS

The baseline water quality monitoring locations are presented in both Tables 4 and 5 along with the rationale and purpose of the monitoring. Twenty mainstem sites including the estuary and the mouth of four major tributaries are identified. Reservoir sites are being sampled at multiple depths.

Additional monitoring efforts are being conducted by others and will be reported to the comprehensive Klamath Basin water quality data management system described in Section 5.2 of this document (see also KBMP website, http://www.kbmp.net/maps-data). The 2010 KHSA program will provide funding for analysis of chemical, phytoplankton, and blue-green algae related parameters for sampling at the Link Dam, Miller Island and below Keno Dam stations (collected by USBR), as well as locations from Klamath River above J.C. Boyle Reservoir down through the estuary. See Table 4 for sampling stations included in the 2010 KHSA monitoring program.

6.2.2 SAMPLING PROCEDURES

Standard operating procedures (SOPs) for cyanobacterial water and tissue sample collection methodologies are incorporated in Appendix D to this document. Other sampling methods for baseline monitoring will be conducted in accordance with river monitoring QA procedures (see Appendix B).

[4] When using the presence of scums to establish the need to post, staff trained in recognizing *Microcystis aeruginosa* scums, must compile a photographic record as part of the monitoring program.

Table 4: 2010 baseline monitoring locations and rational/purpose

Location	River Mile (RM) / Station ID	State	Rational / Purpose	Sampling Entity
Link Dam	RM 254.4 KR2544	OR	Continuous water quality monitoring of: water temperature, pH, dissolved oxygen, and specific conductance, to comply with ESA requirements.	USBR
			Blue-Green Algae (BGA) monitoring	
			Nutrient monitoring including CBOD	
			Data will be used to continue to refine UKL outflow quality understanding	
			Support UKL TMDL activities and the Klamath River TMDL	
Keno Reservoir – at Miller Island	RM 246.0 KR2460	OR	Continuous water quality monitoring at 1.0 meters below the surface and 1.0 meter above the bottom of: water temperature, pH, dissolved oxygen, and specific conductance, to comply with ESA requirements.	USBR
			Nutrient monitoring including CBOD	
			Keno reservoir experiences complex flow and water quality conditions, and a separate sampling effort should be used to quantify the individual effects of the TMDL efforts through time. For example, inputs from the Lost River diversion channel and the Klamath Straits Drain should be quantified, municipal and industrial compliance tracked, comprehensive monitoring of water quality prescriptions (e.g., return flows from treatment wetlands, non-point source control BMP's). Sampling conducted by USBR will include vertical profiles (e.g., top and bottom observations) located at two to three longitudinal locations.	
			Blue-Green Algae (BGA) monitoring	
Klamath River below Keno Dam	RM 233.4 KR2334	OR	Support TMDL activities (UKL, Lost River, and Klamath River)	USBR
			CBOD – see rationale for Link River below Link Dam	
			Blue-green algae monitoring	
Klamath River above J.C. Boyle Reservoir	RM 228.2 KR2282	OR	Implement and maintain water quality management plans for J.C. reservoir, wherein inflows, outflows, and in-reservoir sampling are desirable.	PacifiCorp
			. Support TMDL activities	
J.C. Boyle Reservoir	RM 226.0 KR2260	OR	Supports implementation and assessment of in-reservoir water quality activities associated with reservoir water quality management plans.	PacifiCorp
			Support TMDL activities – Nutrient monitoring	
			Blue-Green Algae (BGA) monitoring	

Table 4 (cont.): 2010 monitoring locations and rational/purpose

Location	River Mile (RM) / Station ID	State	Rational / Purpose	Sampling Entity
Klamath River below J.C. Boyle Dam	RM 224.0 KR2240	OR	This reservoir outflow point will support TMDL activities in Oregon regarding conditions in J.C. Boyle reservoir.	PacifiCorp
			Klamath River immediately below J.C. Boyle Dam supports implementation and assessment of in-reservoir water quality activities associated with reservoir water quality management plans.	
			Combined with the sampling point below the J.C. Boyle powerhouse, these data can be used to assess conditions in the bypass reach.	
			Dam removal baseline	
Klamath River below USGS Gage	RM 219.5 KR2195	OR	This location is below both the J.C. Boyle powerhouse and the large springs complex which enters the river in the bypass reach and represents the last point in Oregon where compliance would be assessed. Access to stateline from the Oregon side of the border is challenging.	PacifiCorp
			Blue-Green Algae (BGA) monitoring	
			Dam removal baseline	
Klamath River above Shovel Creek (above Copco Reservoir)	RM 206.4 KR2064	CA	Represents both Klamath River at Stateline and Klamath River above Copco Reservoir. ("Stateline" has been represented by agencies and other entities as the Klamath River above Shovel Creek for several years.)	PacifiCorp
			Assess TMDL activities in California.	
			CBOD – see rationale for Link River below Link Dam	
			Blue-Green Algae (BGA) monitoring	
			Dam removal baseline	
Copco Reservoir	RM 199.0 KR1990	CA	Support TMDL activities	PacifiCorp
			Support reservoir management plan activities (e.g., nutrients)	
			Blue-Green Algae (BGA) monitoring	
			Dam removal baseline	
Klamath River below Copco Dam	RM 195.0 KR1950	CA	Support reservoir management plan activities	PacifiCorp
			Blue-Green Algae (BGA) monitoring	
			Dam removal baseline	
Iron Gate Reservoir	RM 192.0 KR1920	CA	Location to support TMDL activities	PacifiCorp
			Support reservoir management plan activities	
			Blue-Green Algae (BGA) monitoring	
			Dam removal baseline	

Table 4 (cont.): 2010 monitoring locations and rational/purpose

Location	River Mile (RM) / Station ID	State	Rational / Purpose	Sampling Entity
Klamath River below Iron Gate Dam	RM 189.7 KR1897	CA	Support TMDL activities	PacifiCorp
			Support reservoir management plan activities	
			CBOD – see rationale for Link River below Link Dam	
			Blue-Green Algae (BGA) monitoring	
			Dam removal baseline	
Klamath River at Shasta River at Walker Bridge	RM 176.7 KR1767	CA	Location to support TMDL activities	Karuk
			Blue-Green Algae (BGA) monitoring	
			Dam removal baseline	
Klamath River near Seiad	RM 128.5 KR1285	CA	Location to support TMDL activities	Karuk
			Blue-Green Algae (BGA) monitoring	
			Dam removal baseline	
Klamath River near Happy Camp	RM 93.5 KR0935	CA	Location to support TMDL activities	Karuk
			Blue-Green Algae (BGA) monitoring	
			Dam removal baseline	
Klamath River near Orleans	RM 59.1 KR0591	CA	Location to support TMDL activities	Karuk
			Blue-Green Algae (BGA) monitoring	
			Dam removal baseline	
Klamath River at Weitchpec	RM 43.5 KR0435	CA	Long-term monitoring station is established at Weitchpec with relatively easier access than Saints Rest Bar. Compare representative characteristics with Saints Rest Bar to determine whether both sites are needed for 2010 – 2011 sampling season.	Yurok
			Location to support TMDL activities	
			Blue-Green Algae (BGA) monitoring	
			Dam removal baseline	
Klamath River below Trinity River (above Tully Creek)	RM 38.5 KR0385	CA	Location to support TMDL activities	Yurok
			Blue-Green Algae (BGA) monitoring	
			Dam removal baseline	
Klamath River near Klamath	RM 6.0 KR0060	CA	Location to support TMDL activities	Yurok
			Blue-Green Algae (BGA) monitoring	

			Dam removal baseline	

Table 4 (cont.): 2010 monitoring locations and rational/purpose

Location	~River Mile	State	Rational / Purpose	Sampling Entity
Klamath River Estuary	RM 0.5 KR0005	CA	Location to support TMDL activities	Yurok
			Blue-Green Algae (BGA) monitoring	
			Dam removal baseline	
Shasta River near mouth	SHR00	CA	Major tributary contribution: nutrient and sondes	Karuk
Scott River near mouth	SCR00	CA	Major tributary contribution: nutrient and sondes	Karuk
Salmon River near mouth	SAR00	CA	Major tributary contribution: nutrient and sondes	Karuk
Trinity River near mouth	TR00	CA	Major tributary contribution: nutrient and sondes	Yurok

6.2.3 SAMPLING CONSTITUENTS AND FREQUENCY

Outlined herein are constituents that are proposed for the baseline monitoring plan. The purpose, or rationale, for each constituent is briefly introduced, as is the rationale for frequency of sampling.

Data Collection Using Sondes

For each of the following parameters, capturing sub-daily variability is important to understanding the dynamics present in the system. Continuous monitoring devices will be deployed to address the period May to November, important for characterizing current conditions. Currently, planned winter deployments are minimal (December 1-March 31) with certain exceptions that would include Keno Reservoir where winter water quality conditions are poorly understood.

- **Temperature -** controls rate reactions in aquatic system and can be a stressor to aquatic life.

- **Dissolved Oxygen -** is important to aquatic ecosystem function. Low concentrations can be a stressor to certain aquatic life.

- **pH -** conditions are important for aquatic life, with typical acceptable pH concentrations in a range of 6 to 9. At elevated pH, unionized ammonia can be toxic to aquatic life, a condition exacerbated by elevated temperatures.

- **Conductance -** represents ions that are in solution. This parameter is often used as a conservative constituent and to identify inputs or affects of land use practices.

Data Collection by Sampling

For the following parameter, limited sampling (frequency and locations) is proposed:

- **CBOD -** To address TMDL and potential dam removal issues, sampling of CBOD will occur every two weeks from June to October, and approximately monthly the remainder of the year. Sampling for CBOD will occur at the following locations: Link River Dam, Keno Reservoir at Miller Island, below Keno Dam, above Copco Reservoir at Shovel Creek, and below Iron Gate Dam. Sampling for CBOD will occur monthly at Seiad Valley from June-September. Sampling procedures will be generally based on the USGS National Field Manual (2009) as part of the recently completed studies on the Keno reach (Sullivan 2008).

Sampling for the following parameters will occur from April through December at frequencies noted in Table 5, below. Capturing short term variability (biweekly or daily) may be important for several or all of these parameters, and could be added in future monitoring plans.

- **Inorganic/Organic N (ammonia, nitrate, nitrite, organic N) -** Inorganic nutrients (ammonia, nitrite, nitrate) are readily available for primary production. Total nitrogen (organic plus inorganic forms) is an indicator of overall status of an aquatic system. It is important to collect and assess/consider both organic and inorganic forms. Ammonia can be toxic (unionized ammonia) when elevated pH and temperature conditions are present. The conversion of ammonia to nitrite and nitrate consumes oxygen.

- **Inorganic/Organic P (orthophosphate, organic P) -** Inorganic nutrients (orthophosphate) are readily available for primary production. Total phosphorus (organic plus orthophosphate) is an indicator of overall status of an aquatic system. It is important to collect and assess/consider both organic and inorganic forms.

- **Particulate and Dissolved C (particulate and dissolved organic carbon) -** This is a measure of the organic matter within the system, and is necessary for the partitioning of organic matter fractions into particulate, dissolved, labile, and refractory. Organic matter consumes oxygen during decay and releases nutrients. Analysis of organic carbon is used to determine organic matter loads. Special studies will be used to identify stoichiometry of organic matter (C, N, and P fraction) and to partition particulate and dissolved matter into refractory and labile forms.

- **TSS/VSS (total and volatile suspended solids) -** TSS and VSS together define the organic (VSS) and inorganic (TSS-VSS) fraction of suspended material. This provides insight on bulk organic matter loads, and coupled with inorganic suspended solids can be used to estimate light extinction.

- **Alkalinity -** Understanding alkalinity helps to identify the buffering capacity of waters and the ability of an aquatic system to resist changes in pH (e.g., in response to primary production).

- **Water Column Chl-A/Pheo -** This measure of Chl-A and Pheo in reservoirs can be used to estimate the standing crop of phytoplankton.

- **Phytoplankton species -** Sampling is needed to identify species presence and absence. Determination of population variations can provide insight into trophic status, nutrient availability, BGA species, potential toxins and health advisories.

- **Microcystin -** The California 2006 Section 303(d) list identified microcystin as an impairment in the segment from and including the Copco Reservoirs down to Iron Gate Dam, including the segment of Klamath River between those reservoirs. California's 2008 *Public Review Draft Staff Report for the 2008 Integrated Report for the Clean Water Act Section 305(b) Surface Water Quality Assessment and the 303(d) List of Impaired Waters* (Regional Water Board 2008) recommends that the mainstem Klamath River from downstream of Iron Gate

Dam to the confluence of the Trinity River be listed as impaired for microcystin (Klamath River from Iron Gate Dam to Scott River - Middle Klamath River HA, and from Scott River to the Trinity River - Middle & Lower Klamath River HA).

Sampling in the water column occurs monthly May through October when the greatest potential for shorter term variability exists. Additional sampling may be required depending on field conditions. Additionally, the presence of scums should be documented to support listing decisions; in California, guidelines for documentation of scums to support the CWA 303(d) listing of waterbody reaches is provided in the Regional Board Guidelines for documentation.

Sampling constituents, locations, frequency, and monitoring entities are presented in Table 5.

Table 5: Klamath River KHSA Monitoring Program 2010 – Summary Table of Baseline Monitoring

Monitoring Location	**Temperature (°C)**	**Dissolved Oxygen (mg/l)**	**pH (log[H+])**	**Conductance (uS/cm)**	**Inorganic/Organic N (mg/l)**	**Inorganic/Organic P (,g/l)**	**Particulate and Dissolved C (mg/l)**	**TSS/VSS (mg/l)**	**Alkalinity (mg/l)**	**Water Column chl_a/Pheo (ug/l)**	**Phytoplankton species**	**Microcystin (ug/l)**	**LCMS confirmation**	**CBOD mg/l**	**Sampling Entity**
Sampling Method:	*T,P*	*P*	*P*	*P*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	
Link Dam (RM - 254.4)	**H**	**H**	**H**	**H**	**M/ BM**	**M/ BM**	**M/ BM**	**M/ BM**	**M/ BM**	**M/ BM**	**M/ BM**	**BM/ S**	**M/S**	**M2/ BM2**	**USBR**
Keno Reservoir at Miller Island (RM - 234.9)	**H**	**H**	**H**	**H**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M/S**	**-**	**M2/ BM2**	**USBR**
Klamath River below Keno Dam (RM -233.4) ***(see note A)***	**H**	**D**	**D**	**D**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M/S**	**-**	**M2/ BM2**	**USBR**
Klamath River above J.C. Boyle Reservoir (RM-228.2)	**H**	**D**	**D**	**D**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**-**	**-**	**-**	**PacifiCorp**
J.C. Boyle Reservoir (RM-226.0) ***(see note B)***	**VP**	**VP**	**VP**	**VP**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M/S**	**-**		**PacifiCorp**
Klamath River below J.C. Boyle Dam (RM-224.0)	**H**	**D**	**D**	**D**	**M**	**M**	**M**	**M**	**M**	**M**	**M**		**-**	**-**	**PacifiCorp**
Klamath River below USGS Gage (RM-219.5)	**H**	**D**	**D**	**D**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M/S**	**-**	**-**	**PacifiCorp**
KR above Shovel Creek (Stateline) (RM-206.4)	**H**	**H**	**H**	**H**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M/S**	**-**	**M2/ BM2**	**PacifiCorp**
Copco Reservoir (RM-199.0) ***(see note C)***	**VP**	**VP**	**VP**	**VP**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M/S**	**-**		**PacifiCorp**

Monitoring Location	Temperature (°C)	Dissolved Oxygen (mg/l)	pH (log[H+1])	Conductance (uS/cm)	Inorganic/Organic N (mg/l)	Inorganic/Organic P (,g/l)	Particulate and Dissolved C (mg/l)	TSS/VSS (mg/l)	Alkalinity (mg/l)	Water Column chl_a/Pheo (ug/l)	Phytoplankton species	Microcystin (ug/l)	LCMS confirmation	CBOD, mg/l	Sampling Entity
Sampling Method:	*T,P*	*P*	*P*	*P*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	
Klamath River below Copco Dam (RM-195.0)	**H**	**D**	**D**	**D**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M/S**	**-**	**-**	**PacifiCorp**
Iron Gate Reservoir (RM-192.0) ***(see note D)***	**VP**	**VP**	**VP**	**VP**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M/S**			**PacifiCorp**
Klamath River below Iron Gate Dam (RM-189.7)	**H**	**H**	**H**	**H**	**M/BM**	**M/BM**	**M/BM**	**M/BM**	**M/BM**	**M/BM**	**M/BM**	**BM/S**	**M/S**	**M2/BM2**	**PacifiCorp**
Klamath River at Walker Bridge (RM- 176.7)	**H**	**D**	**D**	**D**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M/S**		**-**	**Karuk**
Klamath River below Seiad (RM - 128.5)	**H**	**H**	**H**	**H**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M/S**		**M**	**Karuk**
Klamath River near Happy Camp (RM-93.5)	**H**	**D**	**D**	**D**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M/S**		**-**	**Karuk**
Klamath River at Orleans (USGS) (RM-59.1)	**H**	**H**	**H**	**H**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M/S**		**-**	**Karuk**
Klamath River at Weitchpec (RM-43.5)	**H**	**H**	**H**	**H**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M/S**	**M/S**		**Yurok**
Klamath River near Klamath (RM-6.0)	**H**	**H**	**H**	**H**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M/S**		**-**	**Yurok**
Klamath River Estuary (RM-0.5) ***(see Note A)***	**D**	**D**	**D**	**D**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M/S**		**-**	**Yurok**

Monitoring Location	Temperature (°C)	Dissolved Oxygen (mg/l)	pH (log[H+])	Conductance (uS/cm)	Inorganic/Organic N (mg/l)	Inorganic/Organic P (,g/l)	Particulate and Dissolved C (mg/l)	TSS/VSS (mg/l)	Alkalinity (mg/l)	Water Column chl_a/Pheo (ug/l)	Phytoplankton species	Microcystin (ug/l)	LCMS confirmation	CBOD mg/l	Sampling Entity
Sampling Method:	*T,P*	*P*	*P*	*P*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	
Shasta River near mouth	**H**	**H**	**H**	**H**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	-	-	-	**Karuk**
Scott River near mouth	**H**	**H**	**H**	**H**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	-	-	-	**Karuk**
Salmon River near mouth	**H**	**H**	**H**	**H**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	-	-	-	**Karuk**
Trinity River near mouth	**H**	**H**	**H**	**H**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	-	-	-	**Yurok**

NOTES:

A: A sonde is also at this location under a different program; sonde data will supplement the KHSA 2010 monitoring data.
B: Sampling at two depth intervals in J.C. Boyle reservoir (0.5 m and 8 m depths)
C: Sampling at 4 depth Intervals in Copco reservoir (0.5 m, 9, 18, and 27 m depths)
D: Sampling at 5 depth intervals in Iron Gate reservoir (0.5, 10, 20, 30, and 40 m depths)

KEY:

Sampling Method	Sampling Frequency
T – thermistor	VP – vertical profile at stated sampling frequency
P – probe or data sonde (minimum seasonal deployment – April to November)	H – hourly measurements by sondes (in some instances sub-hourly data may be desired)
G – Grab sample	M – monthly sampling
D – Discrete Sample	

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Appendix A

Klamath Basin future study priorities, as Recommended to KBMP

Other priorities identified during the cooperative effort to plan 2009 and 2010 monitoring that were not addressed by AIP 2009 or KHSA 2010 Monitoring Plans remain as candidate priorities for Klamath Basin. These have been referred to the KBMP group for future basinwide study planning, should funding become available. These other priorities include:

- Monitoring to provide time-critical information should it be needed to support monitoring when KFHAT-identified critical conditions are exceeded and monitoring entities throughout the Basin are called upon to conduct increased monitoring to characterize conditions in support of management decisions for actions. At such a time, California Department of Fish and Game (CDFG) as the KFHAT lead agency would contact monitoring entities along the River to request increased levels of monitoring (e.g., frequency and density).
- Sampling distribution, frequency and timing should be in accordance with that recommended by OEHHA.
- Monitoring to address identified data gaps, in response to interim management activities, or to address other high priority needs (e.g., extended droughts, special operations, etc.).
- Monitoring below burn areas for turbidity and sediment;
- Sampling of tributaries to better understand their contribution to the nutrient and organic matter budget within the mainstem Klamath River; and
- Biological monitoring monthly from June through September for the Klamath River mainstem below Iron Gate Dam for an improved understanding of periphyton densities, the impact of periphyton on water quality (DO, pH), and the role of natural controls on periphyton density.
- Assessing the possible linkages between water quality in the Klamath River and fish disease.
- Increase the frequency of physical and chemical monitoring in the Klamath River to improve the understanding of nutrient dynamics and seasonal and annual variability.

Appendix B

2010 Klamath River Baseline Sampling Program QA Comparison,

and

Quality Assurance Plans and Standard Operating Procedures

For Reach Monitoring Entities:

- PacifiCorp
- Karuk Tribe
- Yurok Tribe
- US Bureau of Reclamation

Posted as separate documents.

Appendix C

2009 Klamath River AIP
Sampling Lab Cross Comparison

Appendix C has been posted as a separate document.

Appendix D

Standard Operating Procedures

Environmental Sampling of Cyanobacteria for Cell Enumeration, Identification and Toxin Analysis

Cyanobacteria Sampling SOP. V6
June 24, 2009

Appendix D has been posted as a separate document.

Appendix E

Adult Salmonid Microcystin Study Plan For KHSA 2010 Monitoring

Adult Salmonid Microcystin Sampling
September-November 2010
Susan Corum
Karuk Water Quality

Background

In the mainstem Klamath River, adult salmonids are an important subsistence food for Tribal people. The Yurok fish for fall Chinook starting in August. Fall Chinook reach the Karuk fishery in September. Fall steelhead enter the Klamath River in late summer, are in the mid-Klamath River by September or October, and reach Iron Gate hatchery by November. Salmonids are also caught and consumed by recreational fishermen and sold in the Yurok commercial fishery.

Since 2005, cyanobacteria blooms consisting significantly of *Microcystis aeruginosa*. have been documented in the Klamath River Water quality sampling in the Klamath River has shown the presence of the hepatotoxin microcystin, produced by species of cyanobacteria including *Microcystis a*., during the summer and early fall. The blooms vary in duration and severity in the free flowing-section of the River but are generally present at some level in August and September (Kann and Corum 2009). Due to the overlap in the toxic algae blooms and run-timing of salmonids that serve as a food source, bioaccumulation of microcystins could be a potential public health concern.

Field sampling for salmonid fish tissue for public health has been conducted in the past. In 2005, the Yurok Tribe collected a small number of samples from the Klamath River: 5 Chinook livers, 4 Chinook fillets, 2 steelhead livers, and 2 steelhead fillets. The fish were collected from mid-September to early October (Fetcho 2006). A trace amount of microcystin was detected in the smaller steelhead and 0.54 µg/g microcystin was found in the adult steelhead liver (Fetcho 2006). In 2007, PacifiCorp collected a total of eleven (11) adult Chinook salmon and eight (8) adult steelhead from the Klamath River during their fall migration period. Four Chinook salmon and two steelhead were collected in the lower Klamath River below the Trinity River, one steelhead and one Chinook salmon were collected in the middle Klamath River, and six Chinook salmon and five steelhead were from Iron Gate Hatchery. All fish were sampled by angling in October, with the exception of the fish obtained from the hatchery. Laboratory results indicates that un-bound or "free" microcystin was not detected in any of the muscle or liver samples Skin samples were collected but not analyzed due to due to matrix effects produced by analytical interference from other non-target substances. However, the laboratory (SUNY-CESF Laboratory) indicated that the skin would be expected to contain even less microcystin relative to the liver or muscle tissues (which were all non-detect).Histological examination of liver tissues determined that lesions were present in the liver tissues from both species. (CH2M HILL 2009).

Both fish fillets and livers need to be sampled to assess public health risks for fish consumption (M. Miller 2010, pers. comm., A. Mekebri, pers. comm.). Whereas individuals most commonly consume the fillet of salmonids, Tribal members also

consume the cheeks (M. Mollier 2010, pers. comm.), eyes, and skin (A. Corum 2010, pers. comm.) of the fish. Analyzing the fillets will give amounts of direct consumption of toxins. However, if microcystin is not detected in the fillets but is detected in the livers, then there is the potential for microcystin bioaccumulation in other parts of the fish (J. Kann 2010, pers. comm.). If, for example, microcystin toxin is never found in salmon livers under a variety of bloom conditions, then there would be very low to no likelihood that other salmon tissues would pose a public health risk. On the other hand, if microcystin is documented in salmon livers, one cannot rule out the potential for accumulation in other tissues (Smith, et al 2008), and continued monitoring under a variety of bloom conditions would need to be made prior to assuming public health risk is low. Further research needs to be conducted to look at variability of microcystin in both fillets and livers of salmonids during the bloom season and different points along the Klamath River, with a focus on sampling events and locations for Tribal subsistence harvest. This sampling will help establish if there is the potential for microcystins to bioaccumulate, and thereby a potential threat to human health, in fall-running salmonids in the Klamath basin

Objectives

1. Perform a preliminary screening study to assess variability of microcystin in adult fall Chinook in the Klamath River.
    - Sample at 3 locations along the Klamath River between the mouth and upper-most point of salmon migration: mouth, Ishi-Pishi falls, and Iron Gate Hatchery (hatchery). See Table 1 for detail.
    - 5 fish will be collected from the mouth for each of 2 sample events (early September and October) by Yurok fisheries.
    - 6 fish will be collected from Ishi-Pishi falls for each of 2 sample events (early September and October) by Karuk fisheries.
    - 6 fish will be obtained from the hatchery for 1 sample event (early October; fish are not available for collection at the hatchery in September) from hatchery returns.
    - Fillet and liver samples will be sent to CDFG lab in Rancho Cordova for microcystin analysis by LCMS/MS. Liver samples will be composites and 1 composite will be done for each sampling location and event (see Table 1 for detail).
    - Liver, kidney, and gastrointestinal sections will be sent in for histological examination at a lab yet to be determined.

    Note: The sample point at the mouth of the river may serve as a control site, since the fish will have just entered the river. From stakeholder comments, they wanted to see the minimum number of fish (5) processed at the control site, but the sample size increased at the other sites. After speaking with those providing the fish and due to budget constraints, 6 fish was an attainable sample size. Due to budget constraints, the livers will be processed by composite samples. CDFG lab will hold liver samples from each fish. If samples come back positive, then money will be sought after to process the liver samples individually.

2. Perform a preliminary screening study to assess variability of microcystin in adult fall steelhead in the Klamath River.
   - Sample at 4 locations along the Klamath River where steelhead can be reasonably obtained: Weitchpec, Orleans, Happy Camp, and the hatchery. See Table 1 for detail.
   - 5 fish will be collected from Weitchpec area by Yurok fisheries for each of 2 sample events (mid-September and mid-October).
   - 5 fish will be collected from Orleans area by Karuk Natural Resources staff for each of 2 sample events (mid-September and mid-October).
   - 5 fish will be collected from Happy Camp area by Karuk Natural Resources staff for 1 sample event (mid-October).
   - Up to 5 fish will be obtained from the hatchery, if they are available.
   - Fillet and liver samples will be sent to CDFG lab in Rancho Cordova for microcystin analysis by LCMS/MS.
   - Liver sections will be sent in for histological examination at a lab yet to be determined.

   Note: A minimum sample size of 5 fish was selected for the steelhead sampling due to concerns over not being able to collect more fish than that over a couple of days of collection effort.

Funding

Sampling effort, shipping, and fillet and liver processing at CDFG lab will be paid for under the Klamath Hydro Settlement Agreement (KHSA), Measure 15. Histological examination funding will be from an additional source yet to be determined.

Table 1. Sampling schedule and quantities for adult salmonid microcystin sampling 2010

Species	Age	Location (approximate river mile)	Tissue type	Month			Sampling entity / Method
				September	October	November	
Fall Chinook	Adult	Mouth (RM 0)	fillet	5	5		Yurok fisheries/ commercial harvest
			liver	1	1		
		IshiPishi (RM 65)	fillet	6	6		Karuk fisheries/ dip net fishery
			liver	1	1		
		Hatchery (RM 189.7)	fillet		6		CDFG / Hatchery returns
			liver		1		
Fall Steelhead	Adult or 1/2 lb	Weitchpec (RM 43.5)	fillet	5	5		Yurok fisheries / bycatch and/or hook and line
			liver	5	5		
		Orleans (RM 59.1)	fillet	5	5		Karuk / Hook and line
			liver	5	5		
		Happy Camp (RM 108.4)	fillet		5		Karuk / Hook and line
			liver		5		
		Hatchery (RM 189.7)	fillet			5	CDFG / Hatchery returns (holding mortalities)
			liver			5	

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