KHSA Interim Measure 15: 2016 Water Quality Monitoring Study Plan

1. Introduction and Overview

On February 18, 2010, the United States, the States of California and Oregon, PacifiCorp, Indian tribes, and a number of other stakeholders signed the Klamath Hydroelectric Settlement Agreement (KHSA). The KHSA lays out the process for additional studies, environmental review, and a determination by the Secretary of the Interior regarding whether removal of four dams owned by PacifiCorp on the Klamath River (i.e., Iron Gate, J.C. Boyle, Copco 1, and Copco 2 dams) will advance restoration of the salmonid fisheries of the Klamath Basin, and is in the public interest (which includes effects on local communities and tribes).

The KHSA includes provisions and detailed actions for the interim operation of the dams and mitigation activities prior to removal of the dams or the termination of KHSA. One of these measures titled: *Interim Measure 15 - Water Quality Monitoring* states that PacifiCorp shall fund ($500,000 per year) long-term baseline water quality monitoring to support water quality improvement activities, dam removal studies, permitting studies (as necessary), and form a long-term record to assess trends and other potential changes in the basin. This includes funding for blue-green algae (BGA; cyanobacteria) and BGA toxin monitoring, as necessary to protect public health. This plan addresses the eighth year of monitoring under Interim Measure 15 (hereafter referred to as IM 15). Since the goals and objectives of IM 15 remain the same and the sampling entities and locations are unchanged since monitoring began in 2009, this document provides a brief summary of the of IM 15 goals and objectives, sampling strategies, and any updates and/or changes to the sampling from previous plans (Note: In 2009, sampling was done under an interim settlement agreement). Detailed discussions on goals, objectives and the rationale for the parameters sampled can be found in the previous study plans, available on the Klamath Basin Monitoring Program (KBMP) website (http://www.kbmp.net under the Collaboration tab on the Home page). This website hosts all of the IM 15 study plans and results.

This study plan outlines the parameters to be sampled, their frequency and location by sampling entity for the monitoring period from February 2016 through December 2016. The IM 15 monitoring includes monitoring of the Klamath River mainstem (including reservoirs) from Upper Klamath Lake downstream through the estuary (Figure 1). The long-term baseline water quality monitoring includes 24 monitoring sites that have been sampled under this planning process since 2009. The cyanobacteria and toxin monitoring includes 17 monitoring sites, of which 5 new sites have been added in 2016 to obtain data related to potential public health concerns upstream of J.C. Boyle dam. Site coordinates are presented in Appendix A.

The water quality parameters, locations, sampling frequency, and sampling methods for the 2016 IM 15 sampling represents consensus amongst the following participants:

PacifiCorp, North Coast Regional Water Quality Control Board (NCRWQCB), Oregon Department of Environmental Quality (ODEQ), the Karuk and Yurok tribes, U.S. Bureau of Reclamation, and the United States Environmental Protection Agency, Region 9 (EPA).

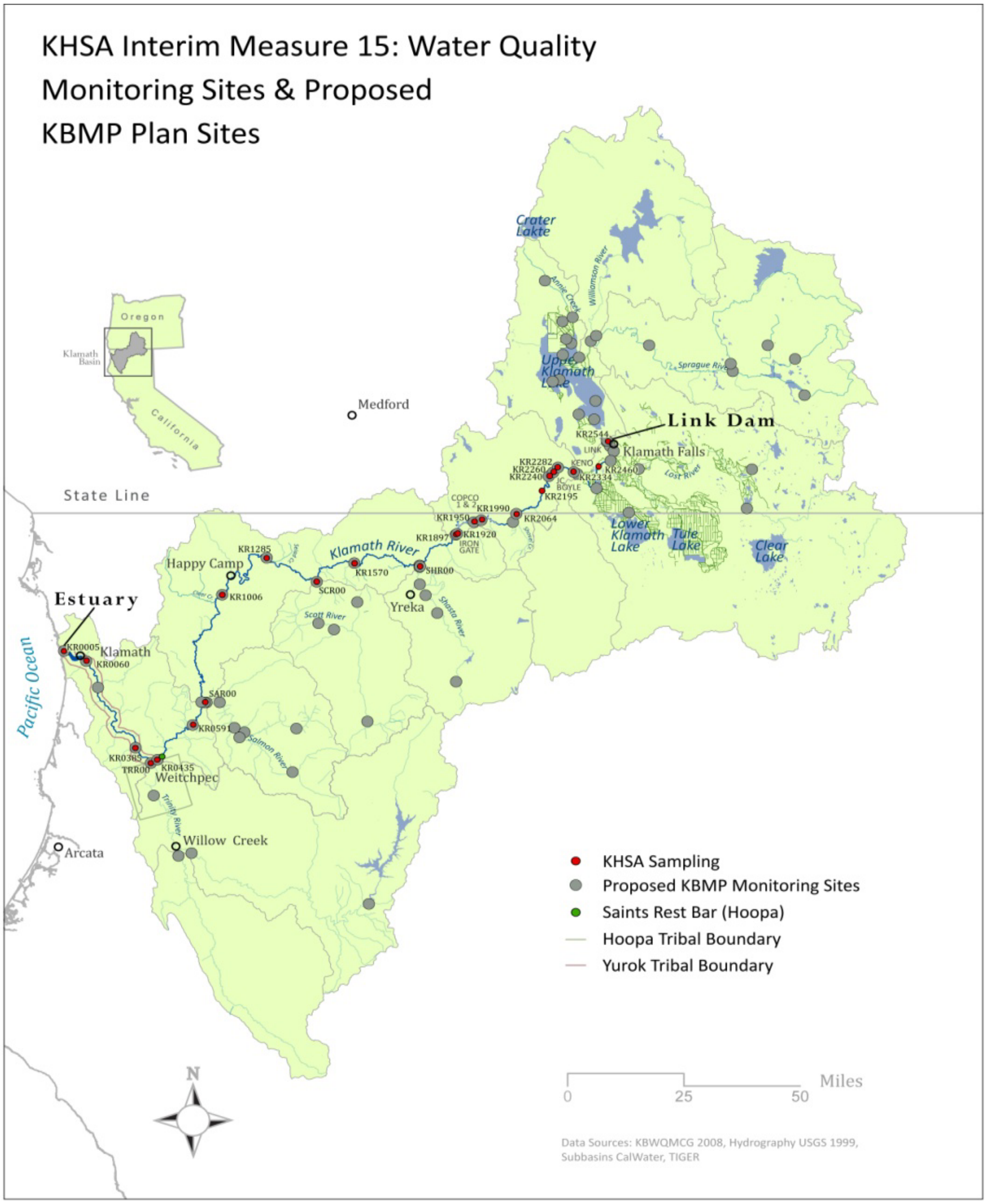

Figure 1.KHSA IM 15 Monitoring stations within the KBMP framework.

2. Objectives

The IM 15 monitoring objectives remain the same as previous years and include both public health monitoring for cyanobacteria and toxins and baseline monitoring. These key objectives are:

- 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 Upper Klamath Lake to the estuary. A system wide approach is necessary because influences from upstream sources extend downstream.
- Support a long-term monitoring program that helps capture the effects of other activities in the system potentially affecting water quality in the Klamath River, including those related to: regulatory actions (e.g., Biological Opinions, Total Maximum Daily Load (TMDL) implementation, adjudications, etc.), potential climate change, 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 baseline water quality data in a timely fashion.

3. Monitoring Components

The 2016 IM 15 monitoring activities include public health and baseline monitoring components.

3.1 Public health monitoring of Cyanobacteria and toxins

This monitoring component provides data to assess potential risks to public health, from exposure to cyanobacteria and their toxins occurring in the Klamath River and is based on water column and/or shoreline water sampling within Upper Klamath Lake, the Klamath River, and Copco and Iron Gate reservoirs. A number of species of cyanobacteria have been documented in Upper Klamath Lake, the Klamath River, and reservoirs; the most abundant species include: *Aphanizomenon flos-aquae*, *Microcystis aeruginosa* (MSAE), *Dolichospermum* (formerly *Anabaena*) *flos-aquae*, *Gloeotrichia* sp., and *Oscillatoria* sp. Since 2004, Klamath River monitoring has documented elevated levels of toxin-producing cyanobacteria, primarily MSAE and the toxin microcystin. Microcystins are a class of toxic chemicals produced by some strains of cyanobacteria including MSAE that are released into waters during early bloom development and when cyanobacterial cells die or cell membranes degrade. MSAE blooms and microcystins at elevated levels can present risks to human health and to terrestrial and aquatic species, and can 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; OEHHA 2012).

The locations, parameters, and frequency associated with public health monitoring are listed in Tables 1 and 2, respectively.

3.2 Baseline water quality monitoring of the Klamath River

This component is designed to characterize water quality conditions by monitoring for basic water quality parameters (temperature, dissolved oxygen (DO), pH, and conductance) as well as a suite of nutrients and other related indicators. Results from baseline monitoring will be used to support water quality improvement activities, dam removal studies, permitting studies (as necessary), and ultimately form a long-term record to assess trends and other potential changes in basin water quality.

The locations, parameters, frequency and sampling entity associated with baseline monitoring are listed in Appendix B.

4. Quality Assurance, Data Management, and Dissemination

4.1 KHSA Program Quality Assurance Strategy for 2016

Similar to previous years, the IM 15 sampling entities have developed common sample collection methods, addressed the use of different laboratories, and refined data management and dissemination strategies.

4.1.1 Quality Assurance

Quality Assurance (QA) requirements have been evaluated, compared and documented through the 2010 Klamath River Baseline Sampling Program QA Comparison (on the KBMP website http://www.kbmp.net), which compares the existing QA plans and standard operating procedures of participating entities. In contracts with the laboratories, each reach monitoring entity includes requirements for a minimum level of laboratory QA procedures.

Water samples for public health monitoring are collected in accordance with the Standard Operating Procedures (SOP), Environmental Sampling of Cyanobacteria for cell enumeration, identification and toxin analysis (Cyanobacteria SOP; KBGAWG 2009). This SOP, developed for the Klamath River by the Klamath BGA Workgroup, is posted on the KBMP website.

Participants in the KHSA monitoring use common laboratories (labs) 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 labs. In previous years, to support such a comparison a number of nutrient samples (described in the QA requirements) were divided into splits and those splits sent to each of the labs doing nutrient analyses. The lab comparison memos prepared for 2009 through 2014 are available on the KBMP website. The comparison of 2015 data is in preparation. This comparison was dropped from the 2016 program.

4.1.2 Data Management and Dissemination

All long-term baseline monitoring data are provided to KBMP for inclusion in the California Environmental Data Exchange Network (CEDEN). Final reports are posted on both the KBMP (www.kbmp.net) and PacifiCorp web sites (http://www.pacificorp.com/es/hydro/hl/kr.html).

Public Health Sampling. Public health monitoring of cyanobacteria and algal 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 site-specific health advisories. Thus, results from cyanobacteria cell count and toxin analyses are forwarded promptly to the appropriate local and state water quality and public health agencies (e.g., ODEQ, Oregon Health Authority, NCRWQCB, and State Water Resource Control Board). For public health cyanobacteria analyses (cell count and toxin levels), each sampling entity is responsible for producing a memorandum every 2 weeks with the most recent analytical results and distributing that memo to regulatory agencies and interested parties including KBMP. In 2016, all lab results for microcystin will be included in these public health memos regardless of the source of the sampling (baseline or public health sampling programs); if algae cell count information from baseline sites is available in a timely manner it will also be incorporated into the public health memos but it will not be added to the public health memos if it is not available in a timely manner. To facilitate this process, PacifiCorp, Reclamation, and ODEQ will provide a sample list spreadsheet within a week of sampling that allows a complete cross-walk between collected samples and locations. This preserves the integrity of the laboratory analysis process by keeping the lab blind to the sample locations while allowing rapid identification of sites when laboratory results are available.

Public health memos prepared by PacifiCorp are posted on the PacifiCorp and KBMP websites and memos from other participating sampling organizations (Karuk Tribe and Yurok Tribe) are posted on the KBMP site. An interactive map of algae bloom conditions is also available on the KBMP website. A final summary of all public health sampling will be included in the baseline water quality report (see below).

Baseline Sampling. The frequency and locations for baseline nutrient sampling are generally not changing for 2016. The frequency of sampling for phytoplankton in the baseline program has been reduced in 2016 (Appendix B). In 2016, a single report and associated data file will be created that contains the final data from both the public health and baseline monitoring components. This water quality monitoring report and associated data file will document the year’s results for both monitoring components and present the inter-lab comparison findings. The final report and data file will be posted on the PacifiCorp and KBMP websites.

5. Sampling Constituents and Frequency

The 2016 sampling locations for public health monitoring are listed in Table 1, and the sampling constituents and frequency can be found in Table 2. The baseline monitoring is summarized in Appendix B where the sampling entity, the parameters sampled, and the sampling frequency are listed by location.

5.1 Public health monitoring of cyanobacteria and toxins

Decisions about whether to post and issue public health notifications related to cyanobacteria and toxin exposure will be evaluated through toxin analysis, identification and enumeration of cyanobacteria, and the identification of the presence of scums formed by aggregations of cyanobacteria.

5.1.1 Locations

Public health monitoring for cyanobacteria and microcystin toxin in water samples will occur during 2016 at a total of 18 designated locations used for public access and recreation (Table 1). These 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 river sites stretching from downstream of Iron Gate dam (river mile (RM) 189.7) to Turwar (RM 6.0). Most of these sites have been monitored since 2005, and all represent areas of public access.
- Five new sites have been added in 2016 to obtain additional data related to public health concerns upstream of J.C. Boyle dam. One is in J.C. Boyle reservoir at Topsy Campground and another site is in Keno reservoir at Keno Park. Three sites are in Upper Klamath Lake (Eagle Ridge County Park, Howard’s Bay Park, and Moore Park) that will allow monitoring of conditions within the lake and in the discharge from the lake into Lake Ewauna and Keno reservoir. Monitoring data from these sites was not available in years past.
- One new site was added in the Klamath River estuary, Klamath River at South Slough (LSS), because this is an important public access and use area with a history of BGA blooms.

5.1.2 Sampling Frequency

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

Upper Klamath Lake and Keno, J.C. Boyle, Copco, and Iron Gate reservoirs
Public health sampling in Upper Klamath Lake and Keno, J.C. Boyle, Copco, and Iron Gate reservoirs will begin in May, and continue until a waterbody is posted with a health advisory. Once an advisory is issued and the waterbody posted, public health cyanobacteria samples will still be collected, but phytoplankton analysis will not be rushed and these data will not be available for the bi-weekly BGA memos. Bi-weekly memos will include the microcystin toxin

data as it is received from the EPA laboratory. Monitoring data from previous annual public health sampling efforts (2005-2015) indicates that MSAE cell counts and/or microcystin levels in non-river samples (Iron Gate and Copco reservoirs and likely Upper Klamath Lake) typically remain elevated until cooler weather and shorter days terminate the blooms. Upper Klamath Lake and reservoir cyanobacteria cell count samples may again be rushed starting in October to provide the data needed to lift an advisory and de-post the waterbody(ies).

Table 1. 2016 Klamath River sampling sites for public health monitoring of cyanobacteria and cyanotoxins in surface water samples, approximate river mile, and sampling entity.

Location (Site ID)	River Mile	Sampling Entity
Upper Klamath Lake at Eagle Ridge County Park (UKEP)	N/A	ODEQ
Upper Klamath Lake at Howard's Bay Park (UKHP)	N/A	ODEQ
Upper Klamath Lake at Moore Park (UKMP)	N/A	ODEQ
Keno Reservoir at Keno Park (KEKP)	234.0	ODEQ
J.C. Boyle Reservoir at Topsy Campground (BRTC)	225.0	ODEQ
Copco Reservoir and Mallard Cove (CRMC)	200.8	PacifiCorp
Copco Reservoir at Copco Cove (CRCC)	198.5	PacifiCorp
Iron Gate Reservoir at Camp Creek (IRCC)	192.8	PacifiCorp
Iron Gate Reservoir at Williams Boat Ramp (IRJW)	192.4	PacifiCorp
Klamath River below Iron Gate Dam (Hatchery Bridge) (KRBI)	189.7	PacifiCorp
Klamath River at I-5 Rest Area (IB)	179.0	Karuk
Klamath River at Brown Bear River Access (BB)	157.5	Karuk
Klamath River at Seiad Valley (SV)	128.5	Karuk
Klamath River at Happy Camp (HC)	108.4	Karuk
Klamath River at Orleans (OR)	59.1	Karuk
Klamath River at Weitchpec (WE)	43.5	Yurok
Klamath River at Turwar (TU)	6.0	Yurok
Klamath River at South Slough (LSS)	tbd	Yurok

Following the schedule in Table 2, samples will be collected and submitted for identification and enumeration of toxigenic phytoplankton species and analysis of total microcystins by Enzyme-Linked ImmunoSorbent Assay (ELISA). This data will then be provided to regulatory agencies (e.g., NCRWQCB, ODEQ, and Oregon Health Authority) to inform whether criteria have been met to warrant the issuing of a public health advisory for a specific water body and to provide the necessary information and data to lift public health advisories once in place.

Although anatoxin-a has not been detected in reservoir samples analyzed to date, up to four samples will be analyzed for anatoxin-a if elevated cell count levels of *Dolichospermum* are present (Table 2). These samples will be collected and frozen, and those samples with enumeration results exceeding 40,000 *Dolichospermum* cells per milliliter (mL) will be submitted for anatoxin-a analysis.

Klamath River below Iron Gate dam

Between 13 and 16 shoreline samples will be collected for cyanobacteria identification, enumeration, and microcystin (ELISA) analysis at each of nine monitoring sites to track cyanobacterial bloom conditions in the Klamath River downstream of Iron Gate dam (Table 2). Ten water samples will be collected at the I-5 Rest Area station (Table 2) for analysis by LC/MS/MS on a bimonthly basis from June through October. These analyses will be used to confirm ELISA results for microcystin, to determine the type of congeners present, and to verify the presence or absence of anatoxin-a.

Table 2. Klamath River IM 15 Monitoring Program 2016 –Public health monitoring locations, constituents, method, and frequency.

Site ID	Location	Phyto-plankton Species	Microcystin - EPA	LC/MS/MS water for cyanotoxins	Sampling Entity
UKEP	Upper Klamath Lake at Eagle Ridge County Park	BM7-mod	BM7-mod	-	ODEQ
UKHP	Upper Klamath Lake at Howard’s Bay Park	BM7-mod	BM7-mod	-	ODEQ
UKMP	Upper Klamath Lake at Moore Park	BM7-mod	BM7-mod	-	ODEQ
KEKP	Keno Reservoir at Keno Park	BM7-mod	BM7-mod	-	ODEQ
BRTC	J.C. Boyle Reservoir at Topsy Campground	BM7-mod	BM7-mod	-	ODEQ
CRMC	Copco Reservoir at Mallard Cove	BM7-mod	BM7-mod	S	PacifiCorp
CRCC	Copco Reservoir at Copco Cove	BM7-mod	BM7-mod	S	PacifiCorp
IRCC	Iron Gate Reservoir at Camp Creek	BM7-mod	BM7-mod	S	PacifiCorp
IRJW	Iron Gate Reservoir at Williams Boat Ramp	BM7-mod	BM7-mod	S	PacifiCorp
KRBI	Klamath River below Iron Gate Dam (Hatchery Bridge)	BM7-mod	BM7-mod	-	PacifiCorp
IB	Klamath River at I-5 Rest Area	BM/W	BM/W	BM5	Karuk
BB	Klamath River at Brown Bear River Access	BM/W	BM/W	-	Karuk
SV	Klamath River at Seiad Valley	BM/W	BM/W	-	Karuk
HC	Klamath River at Happy Camp	BM/W	BM/W	-	Karuk
OR	Klamath River at Orleans	BM/W	BM/W	-	Karuk
WE	Klamath River at Weitchpec	BM/W	BM/W	-	Yurok
TG	Klamath River at Turwar	BM/W	BM/W	-	Yurok
LSS	Klamath River at South Slough	BM/W	BM/W	-	Yurok

Frequency	# of sample events	Sampling frequency description
BM7-mod	13	1x month in May and at least 2x month June through November
BM/W	16	Timing of public health monitoring will be at the discretion of the sampling entity; however, weekly sampling usually occurs from July through September during peak algae bloom season.
BM5	10	2x month June-October
S	4	Analysis for anatoxin-a will be tied to the temporal and density distribution of *Dolichospermum* in the reservoirs however; four test analysis are budgeted.

5.1.3. Sampling Procedures

Under the IM 15 monitoring program, water samples will be collected for phytoplankton species cell identification/enumeration to determine the presence and abundance of cyanobacterial species (e.g., *Dolichospermum* sp., *Aphanizomenon* sp., *Microcystis* sp., etc.). Depending on the severity (e.g., density and size) of a cyanobacterial bloom and timing, (e.g., pending decision to post a reach because of species and cell density) sampling entities will specify whether a 48-hour rush turnaround will be requested for the phytoplankton sample analysis.

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

- 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).

- Liquid Chromatography - tandem Mass Spectrometry (LC/MS/MS) for microcystin congeners and anatoxin-a analysis (per Mekebri et. al., 2009).

Sample collection and preservation will be conducted in accordance with the Cyanobacteria SOP (KBGAWG 2009).

5.2 Comprehensive Baseline Water Quality Monitoring of the Klamath River

5.2.1 Locations

The baseline water quality monitoring locations, constituents, and sampling frequency are presented in Appendix B. As in previous years, baseline monitoring will occur at 24 sites; 20 sites on the Klamath River from Link River Dam to the estuary; and 4 sites at the mouths of each of 4 major tributaries.

5.2.2 Sampling Constituents and Frequency

Listed below are constituents sampled for the baseline monitoring plan. The baseline monitoring will begin in February 2016 and continue through December 2016.

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, with probes for the following parameters, at a minimum, will be deployed during the period May to November.

- Temperature
- Dissolved Oxygen
- pH
- Conductance

Sample-based Data Collection. Sampling locations and frequency for all baseline monitoring are detailed in Appendix B. The following parameters will be sampled during 2016 at least monthly, with a few exceptions.

- Inorganic/Organic Nitrogen (ammonia, nitrate, nitrite, organic N) and Total Nitrogen
- Inorganic/Organic Phosphorus (orthophosphate, organic P)
- Particulate and Dissolved Carbon
- Total and Volatile Suspended Solids (TSS / VSS)

- Alkalinity
- Water Column Chlorophyll-*a*/pheophytin
- Microcystin
- Phytoplankton
- Particulate and Dissolved Organic Carbon
- Particulate Nitrogen
- Particulate Phosphorous and Particulate Inorganic Phosphorus
- Dissolved Organic Nitrogen and Phosphorus

Most of the parameters listed above have been part of the baseline monitoring program since 2009. Slight modifications have been made through the years (e.g. particulate and dissolved organic carbon, particulate N, and turbidity were added to the parameters sampled in 2012). Physical parameters for temperature, dissolved oxygen, pH, and conductance are collected with a hand-held sonde coincidentally with grab sample collection at each location.

Modifications to the sampling are anticipated as management actions change and the monitoring program evolves.

5.2.3 Program Changes and Updates

This sampling program has been in place with relatively few changes since 2009. Review of the study plan for 2016 revealed some changes that had not been captured in previous iterations of the study plan. In 2013, specific tests from samples collected 1 m from the bottom in Copco and Iron Gate reservoirs were dropped from the analysis. These parameters include chlorophyll-a, pheophytin, particulate carbon, and particulate nitrogen. At about the same time, an integrated sample was added for Copco and Iron Gate reservoirs and analyzed for chlorophyll-a, pheophytin, particulate carbon, phytoplankton species, and microcystin from the surface to 8 m in depth. These changes are not documented in previous study plans and the sampling specifics were not included in previous sampling tables (Appendix B in this report). Appendix B has been revised to clarify the specific samples collected from various depths in Copco and Iron Gate reservoirs. There is no change being proposed for any reservoir sampling in 2016, this is simply a clarification of what has been happening since 2013.

This program has been successful at operating under the fixed IM 15 budget in previous years. In planning for 2016 it became clear that cost were going to exceed the IM 15 budget. To address cost over-runs, the KSHA water quality monitoring group met via conference call on January 28, 2016. The goal of the call was to look for areas of the IM 15 program where changes in sampling frequency, parameters, or other efficiencies could generate cost savings. The following changes were made as a result of that discussion:

1. ODEQ volunteered to collect all public health samples at new sites in Oregon (Table 2).
2. Alkalinity was dropped from the QA program because it is relatively stable and an expensive spike.
3. The frequency of the public health side downstream of Iron Gate dam (KBRI) was changed to BM7-Mod (once in May, twice a month June-November).

4. The interlab comparison was dropped.
5. Carbonaceous biological oxygen demand (CBOD) was dropped from the program.
6. Shifted the frequency of baseline phytoplankton sampling as follows: All M sites changed to M- and all M- sites changed to M/S. The site at Link Dam and Below Iron Gate Dam stayed at the same frequency (M/BM).
7. Shifted the anatoxin-a analysis from the CDFW lab to GreenWater Labs
8. Requested that sampling crews bundle and bulk-ship baseline phytoplankton samples to save on shipping costs.

These changes resulted in cost savings, but not enough to bring the entire program back to the $500,000 budget that is available. To address the over-run in 2016 PacifiCorp is reallocating funds from IM 11 *Interim Water Quality Improvements* to IM 15. This reduces the amount of money available for IM 11 studies in 2016, but allows IM 15 to continue. The KSHA water quality group will need to consider substantial changes to the IM 15 program in 2017 to reduce costs to the funding available.

6.0 Additional Public Health Sampling

PacifiCorp had proposed a special study intended to evaluate new sample analysis techniques. Because of the funding concerns, PacifiCorp is funding this study independently of the IM 15 program.

7.0 References

KBGAWG (Klamath Blue Green Algae Working Group). 2009. Cyanobacteria Sampling SOP, Standard Operating Procedures Environmental Sampling of Cyanobacteria for Cell Enumeration, Identification and Toxin Analysis; Developed for the 2009 AIP Interim Measure 12, Water Quality Monitoring Activities, Klamath River, V6, June 24, 2009

Mekebri, A., G.J. Blondina, and D.B. Crane. 2009. Method validation of microcystins in water and tissue by enhanced liquid chromatography tandem mass spectrometry. Journal of Chromatography A. 1216 (2009) 3147-3155.

OEHHA (California Office of Environmental Health Hazard Assessment) 2012. Toxicological Summary and Suggested Action Levels to Reduce Potential Adverse Effects of Six Cyanotoxins. Final Report-May 2012. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Sacramento, California 95812-4010

WHO (World Health Organization). 2003. Cyanobacterial Toxins: Microcystin-LR in Drinking Water. Background document for the development of WHO Guidelines for Drinking-Water Quality. World Health Organization. Geneva.

Appendix A

2016 KHSA Interim Measure 15 Coordinates

Appendix A
Site ID, Location, and longitude and lattitude information for both baseline and public health program sampling sites.

Program	SiteID	Location	Longitude	Lattitude	Coordinate System
Baseline	KR254.4	Link Dam (RM 254.44)	42.233611	-121.8025	WGS84
Baseline	KR246.0	Keno Reservoir at Miller Island (RM 245.3)	42.148107	-121.848646	WGS84
Baseline	KR233.4	KR below Keno Dam near a USGS gage (RM 233.4)	42.134525	-121.948071	WGS84
Baseline	KR22822	KR above J.C. Boyle Reservoir (RM 228.22)	42.149770757	-122.014881282	NAD83
Baseline	KR22478	J.C. Boyle Reservoir (RM 224.78)	42.122204454	-122.047292577	NAD83
Baseline	KR22460	KR below J.C. Boyle Dam (RM 224.60)	42.121216272	-122.049258541	NAD83
Baseline	KR21950	KR below USGS Gage (RM 219.50)	42.084779584	-122.073102465	NAD83
Baseline	KR20642	KR near Stateline (RM 206.42)	41.972428556	-122.201586816	NAD83
Baseline	KR19874	Copco Reservoir (RM 198.74)	41.980385184	-122.331208998	NAD83
Baseline	KR19645	KR below Copco Dam (RM 196.45)	41.972889774	-122.364389084	NAD83
Baseline	KR19019	Iron Gate Reservoir (RM 190.19)	41.938214229	-122.432227627	NAD83
Baseline	KR18973	KR below Iron Gate Dam (RM 189.73)	41.930994108	-122.442067789	NAD83
Baseline	WA	KR at Walker Bridge (RM 156.26)	41.837411	-122.864806	WGS84
Baseline	SV	KR below Seiad (RM 128.5)	41.842331	-123.220106	WGS84
Baseline	HC	KR near Happy Camp (RM 93.5)	41.729708	-123.429811	WGS84
Baseline	OR	KR at Orleans (USGS) (RM 59.1)	41.307133	-123.5311	WGS84
Baseline	WE	KR at Weitchpec (RM 43.5)	41.18575	-123.708525	WGS84
Baseline	TC	KR below Trinity River (RM 38.5)	41.226617	-123.772406	WGS84
Baseline	TG	KR near Klamath (RM 6.0)	41.509492	-123.981292	WGS84
Baseline	LES	KR Estuary (RM 0.5)	41.545308	-124.072956	WGS84
Baseline	SH	Shasta River near mouth	41.823	-122.595	WGS84
Baseline	SC	Scott River near mouth	41.766631	-123.024386	WGS84
Baseline	SA	Salmon River near mouth	41.377331	-123.477297	WGS84
Baseline	TR	Trinity River near mouth	41.179581	-123.706067	WGS84
Public Health	UKEP	Upper Klamath Lake at Eagle Ridge County Park			
Public Health	UKHP	Upper Klamath Lake at Howard's Bay Park			
Public Health	UKMP	Upper Klamath Lake at Moore Park			
Public Health	KEKP	Keno Reservoir at Keno Park			
Public Health	BRTC	J.C. Boyle Reservoir at Topsy Campground			
Public Health	CRCC	Copco Reservoir at Copco Cove	41.983507773	-122.330997237	NAD83
Public Health	CRMC	Copco Reservoir at Mallard Cove	41.973997254	-122.299017388	NAD83
Public Health	IGJW	Iron Gate Reservoir at John Williams Boat Ramp	41.962181466	-122.440236014	NAD83
Public Health	IGCC	Iron Gate Reservoir at Camp Creek	41.972659383	-122.436119002	NAD83
Public Health	KRBI	Klamath River below Iron Gate Dam (Hatchery Bridge)	41.930585692	-122.441960299	NAD83
Public Health	IB	Klamath River at I-5 Rest Area	41.856947	-122.57085	WGS84
Public Health	BB	Klamath River at Brown Bear River Access	41.823067	-122.961967	WGS84
Public Health	SV	Klamath River at Seiad Valley	41.842331	-123.220106	WGS84
Public Health	HC	Klamath River at Happy Camp	41.774018	-123.39635	WGS84
Public Health	OR	Klamath River at Orleans	41.307133	-123.5311	WGS84
Public Health	WE	Klamath River at Weitchpec	41.18575	-123.708525	WGS84
Public Health	TG	Klamath River at Turwar	41.509492	-123.981292	WGS84

Appendix B

2016 KHSA Interim Measure 15 Baseline Water Quality Monitoring Table

Appendix B

2016 KHSA Interim Measure 15 baseline water quality monitoring. REVISED Jan 28, 2016

Location	Temperature (oC)	Dissolved Oxygen (mg/l)	pH (log[H+])	Conductance (uS/cm)	Total N (mg/l)	Ammonia N (mg/l)	Nitrite+Nitrate (mg/l)	Total P (mg/L)	Ortho P (mg/L)	Particulate P and Particulate Inorganic P (mg/l)	Dissolved Organic N & P (mg/l)	Particulate and Dissolved C (mg/l)	Particulate N (mg/l)	TSS/VSS (mg/l)	Alkalinity (mg/l)	Water Column chl_a/Pheo	Phytoplankton species	Microcystin (ug/l)	LCMS confirmation	turbidity, (NTU)	Sampling Entity
Sampling Method:	*T,P*	*P*	*P*	*P*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	
Link Dam (RM 254.44)	H	H	H	H	M/BM	M/BM	M/BM	M/BM	M/BM	M/BM	M/BM	M/BM	M/BM	M/BM	M/BM	M/BM	M/BM	BM/S		M2/BM2**	**USBR**
Keno Reservoir at Miller Island (RM 245.3)	H	H	H	H	M	M	M	M	M			M		M	M	M	M-	M/S		M	**USBR**
KR below Keno Dam near a USGS gage (RM 231.77)	H	D	D	D	M2/BM2	M2/BM2	M2/BM2	M2/BM2	M2/BM2	M		M	M	M	M2/BM2**	M	M-	M/S		M2/BM2**	**USBR**
KR above J.C. Boyle Reservoir (RM 228.22)	H	D	D	D	M	M	M	M	M			M		M	M	M	M/S	M/S			**PacifiCorp**
J.C. Boyle Reservoir[a] (RM 224.78)	VP	VP	VP	VP												M/S	M/S	M/S			**PacifiCorp**
KR below J.C. Boyle Dam (RM 224.60)	H	D	D	D	M	M	M	M	M			M		M	M	M	M/S	M/S			**PacifiCorp**
KR below USGS Gage (RM 219.50)	H	D	D	D	M	M	M	M	M			M		M	M	M	M-	M/S		M	**PacifiCorp**
KR near Stateline[b] (RM 206.42)	H	D	D	D	M2/BM2	M2/BM2	M2/BM2	M2/BM2	M2/BM2	M		M	M	M	M	M	M-	M/S		M	**PacifiCorp**
Copco Reservoir (RM 198.74)	VP	VP	VP	VP																	**PacifiCorp**
Copco Res 0.5 m from Surface					M	M	M	M	M			M		M	M	M	M/S	M/S			**PacifiCorp**
Copco Res Thermocline					M	M	M	M	M			M		M	M	M					**PacifiCorp**
Copco Res 1 m from Bottom					M	M	M	M	M			M		M	M						**PacifiCorp**
Copco Res 0-8 m Integrated																M	M/S	M/S			**PacifiCorp**
KR below Copco Dam[c] (RM 196.45)	H	D	D	D	M	M	M	M	M			M		M	M	M	M/S	M/S			**PacifiCorp**
Iron Gate Reservoir (RM 190.19)	VP	VP	VP	VP																	**PacifiCorp**
Iron Gate Res 0.5 m from Surface					M	M	M	M	M			M		M	M	M	M/S	M/S			**PacifiCorp**
Iron Gate Res Thermocline					M	M	M	M	M			M		M	M	M					**PacifiCorp**
Iron Gate Res 1 m from Bottom					M	M	M	M	M			M		M	M						**PacifiCorp**
Iron Gate Res 0-8 m Integrated																M	M/S	M/S			**PacifiCorp**
KR below Iron Gate Dam (RM 189.73)	H	H	H	H	M/BM	M/BM	M/BM	M/BM	M/BM	M/BM		M/BM	M/BM	M/BM	M/BM	M/BM	M/BM	BM/S		M/BM	**PacifiCorp**
KR at Walker Bridge (RM 156.26)	H	D	D	D	M	M	M	M	M			M		M	*	M	M/S	M/S	S2		**Karuk**
KR below Seiad (RM 128.5)	H	H	H	H	M	M	M	M	M	M		M	M	M	*	M	M-	M/S		M	**Karuk**
KR near Happy Camp (RM 93.5)	H	D	D	D	M	M	M	M	M			M		M	*	M	M/S	M/S			**Karuk**
KR at Orleans (USGS) (RM 59.1)	H	H	H	H	M	M	M	M	M			M		M	M	M	M-	M/S		M	**Karuk**
KR at Weitchpec (RM 43.5)	H	H	H	H	M	M	M	M	M			M		M	*	M	M/S	M/S	S2		**Yurok**
KR below Trinity River (RM 38.5)	H	H	H	H	M	M	M	M	M			M		M	*	M	M/S	M/S			**Yurok**
KR near Klamath (RM 6.0)	H	H	H	H	M	M	M	M	M	M		M	M	M	*	M	M-	M/S		M	**Yurok**
KR Estuary[d] (RM 0.5)	HP	D	D	D	M	M	M	M	M			M		M	*	M	M/S	M/S			**Yurok**
Shasta River near mouth	H	H	H	H	M	M	M	M	M			M		M	*	M	*			M	**Karuk**
Scott River near mouth	H	H	H	H	M	M	M	M	M			M		M	*	M	*			M	**Karuk**
Salmon River near mouth	H	H	H	H	M	M	M	M	M			M		M	*	M	*			M	**Karuk**
Trinity River near mouth	H	H	H	H	M	M	M	M	M			M		M	*	M	*			M	**Yurok**

[a] Sampling at one depth in J.C. Boyle reservoir (0.5 m depth = surface)

[b] Site actually located at Shovel Creek confluence with Klamath River

[c] Site actually located downstream of Copco 2 Powerhouse

[d] Hourly sampling in the estuary at four locations (two in lower estuary, one in mid estuary and one in upper estuary) at two depths (0.5 m and bottom)

KEY

Sampling Method
T – thermistor
P – probe or data sonde
G – grab sample
D – discrete sample

Sampling Frequency
VP – Vertical profile at stated sampling frequency
H – Hourly measurements by sondes (in some instances sub-hourly data may be desired)
M – Monthly sampling, excluding January
M/S – Monthly sampling, seasonally from May through October
M/BM – Bimonthly sampling May - October and monthly sampling the remainder of the year
M2/BM2 – Bimonthly sampling June-September and monthly the remainder of the year
BM/S – Bimonthly sampling July-Oct
S2 – Monthly sampling July - Oct
* - Not sampled This parameter is covered M/S by Tribal WQ Workgroup
M- – Monthly Sampling with exception of December, January and February
M2/BM2 ** – Bimonthly sampling June-September and monthly the remainder of the year
HP - Hourly measurements in a profile