TECHNICAL MEMORANDUM

Results of Cyanobacteria and Microcystin Monitoring in the Vicinity of the Klamath Hydroelectric Project:

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Introduction

This technical memorandum summarizes the results for the public health monitoring conducted during 2014 for cyanobacteria species and the associated toxin, microcystin, in Copco and Iron Gate reservoirs within PacifiCorp's Klamath Hydroelectric Project (Project) and at one monitoring station in the Klamath River below Iron Gate Dam. This monitoring is particularly focused on *Microcystis aeruginosa* (MSAE), which is known to produce microcystin. This monitoring also estimates the presence of other potentially-toxigenic cyanobacteria, including *Anabaena* spp., *Planktothrix (Oscillatoria)* spp. and others. This monitoring is being conducted pursuant to Interim Measure 15, Water Quality Monitoring Activities, contained in the Klamath Hydroelectric Settlement Agreement (KHSA) executed between the United States Department of Interior, the states of California and Oregon, PacifiCorp, and other parties.

Results from the public health sampling are used to determine if public health advisories are warranted[1]. In addition to PacifiCorp's website (www.pacificorp.com/es/hydro/hl/kr.html#), these memos are also posted on the Klamath Basin Monitoring Program's (KBMP) website (www.kbmp.net) and inform the Blue Green Algae tracker on the KBMP website

The data summarized in this memorandum include results from the November reservoir public health sampling as well as the results from all the 2014 public health sampling events (see Appendix 1).

Methods

PacifiCorp is conducting public health sampling at 5 sites (Table 1) for laboratory analysis of potentially toxigenic cyanobacteria, notably MSAE, and microcystin at:

- Four shoreline sites in coves in Copco and Iron Gate reservoirs (i.e., two cove sites in each reservoir).
- One Klamath River site below Iron Gate Dam near the hatchery bridge.

Samples are planned to be taken at shoreline locations in the reservoirs once in May; and twice per month in June, July, August, September, October, and November. Samples to be collected from the river site below Iron Gate Dam are scheduled to be collected according to the discretion of the sampling entity (PacifiCorp) based on river conditions.

[1] The California State Water Resources Control Board provides guidelines for posting advisories in recreation water (SWRCB 2010). SWRCB recommends posting advisories in recreation waters under four circumstances: (1) if "scum is present associated with toxigenic species"; (2) if scum is not present, but the density of *Microcystis* or *Planktothrix* is 40,000 cells/ml or greater; and (3) if scum is not present, but the density of all potentially toxigenic BGA is 100,000 cells/ml or greater, or 4) if microcystin is 8 µg/L or greater.

Public health samples are taken as grab samples offshore according to the standard operating procedure (SOP) developed by the Klamath Blue Green Algae Working Group (www.kbmp.net/collaboration/klamath-hydroelectric-settlement-agreement-monitoring). Samples for potentially toxic phytoplankton are preserved in Lugol's solution and sent to Aquatic Analysts in Friday Harbor, Washington for analysis. Results for cyanobacteria species are reported as individual cells per milliliter.

Samples for determination of microcystin toxin are placed in a cooler on ice and shipped to the EPA Region 9 Laboratory in Richmond, California. The samples are analyzed using the competitive Enzyme-Linked ImmunoSorbent Assay (ELISA) method based on the EnviroLogix QuantiPlate Kit for microcystins. The quantitation limit is 0.18 µg/L or parts per billion (ppb). This test method does not distinguish between the specific microcystin congeners, but detects their presence to differing degrees. That is, ELISA test results yield one value as the sum of measurable microcystin variants.

Table 1. Sites of cyanobacteria and microcystin public health monitoring in Copco and Iron Gate reservoirs and the Klamath River during 2014.

Location	Approximate River Mile	Site ID
Copco Reservoir at Mallard Cove	201.5	CRMC
Copco Reservoir at Copco Cove	200.0	CRCC
Iron Gate Reservoir at Camp Creek	192.8	IRCC
Iron Gate Reservoir at John Williams campground	192.4	IRJW
Klamath River below Iron Gate dam near hatchery bridge	189.7	KRBI

Results

The Klamath River station below Iron Gate dam (KBRI) was posted with a public health advisory on July 28th, and the advisory was lifted on October 22, 2014. Health advisories were posted at Copco reservoir on June 20th, and at Iron Gate reservoir on July 25th. The reservoir public health samples were rushed in November to determine if health advisories were still warranted and are presented below (Table 2). Both the microcystin and MSAE cell counts met the criteria for lifting the health advisories, and the postings have been removed. It should be noted that both reservoirs are currently drawn down and the public boat ramps are not suitable for access, further reducing any potential health risk. In addition, Mallard Cove in Copco Reservoir (CRMC) is currently a mud flat and cannot be sampled.

Public health samples (including algae cell counts and toxin) have been collected at both reservoir coves sites (Table1) throughout the summer however; those samples were not rushed and the results from these samples are still pending. Once these results are available, all the data will be presented in a final memo.

Table 2. Summary of laboratory identification and enumeration

Date	Time	Location	RM	Sample ID	Depth	MSAE[1]	AFA[2]	ANA[3]	Other [5], [6], [7], [8], [9], or [10]	Microcystin (µg/L)
11/02/14	12:05	CRCC	200.0	KR14875	SG	352	22,360	0	0	ND
11/03/14	11:05	IRCC	192.8	KR14876	SG	33,519	0	0	0	1.6
11/03/14	11:15	IRJW	192.4	KR14877	SG	0	0	0	123[5]	ND
11/19/14	12:55	CRCC	200.0	KR14879	SG	0	247,979	0	0	0.16
11/19/14	12:35	IRCC	192.8	KR14880	SG	1,538	0	0	0	0.19
11/19/14	12:25	IRJW	192.4	KR14881	SG	0	0	0	0	ND

[1]MSAE = *Microcystis aeruginosa* (cells/mL)
[2]AFA = *Aphanizomenon flos-aquae* (cells/mL)
[3]ANA = *Anabaena flos-aquae* (cells/mL)
Other = either [5]*Planktothrix (Oscillatoria) sp.* or [6]*Gloeotrichia echinulata* or [7]*Anabaena sp.* or [8]*Lyngbya sp.* (cells/mL) or [9]*Anabaena circinalis* (cells/mL) or [10]*Anabaena planctonica* (cells/mL)
"0" value indicates non-detect by analytical laboratory
"*" value indicates results were not available upon the date this memo was submitted and will be included in subsequent memos as availability allows

References

SWRCB. 2010. Cyanobacteria in California Recreational Water Bodies: Providing Voluntary Guidance about Harmful Algal Blooms, Their Monitoring, and Public Notification. July 2010. Document provided as part of Blue-green Algae Work Group of State Water Resources Control Board (SWRCB) and Office of Environmental Health and Hazard Assessment (OEHHA).

Appendix 1

Cumulative Cyanobacteria Species data for 2014 Public Health Samples

Table 3. Summary of public health monitoring: 2014

Date	Time	Location	RM	Sample ID	Depth	MSAE[1]	AFA[2]	ANA[3]	Other [6], [7], [8], [9], or [10]	Microcystin (µg/L)
5/20/2014	9:40	CRMC	201.5	KR14800	SG	0	0	0	0	ND
5/20/2014	11:15	CRCC	200.0	KR14801	SG	0	0	0	87[5]	ND
5/20/2014	10:45	IRCC	192.8	KR14802	SG	0	0	0	0	ND
5/20/2014	10:30	IRJW	192.4	KR14803	SG	0	0	0	0	ND
6/10/2014	11:35	CRMC	201.5	KR14806	SG	0	0	253	0	0.23
6/09/2014	12:00	CRCC	200.0	KR14807	SG	0	0	256,920	0	ND
6/09/2014	11:20	IRCC	192.8	KR14808	SG	0	0	1,756	165[5]	ND
6/09/2014	10:50	IRJW	192.4	KR14809	SG	0	0	433	0	ND
6/09/2014	15:45	KRBI	189.7	KR14810	SG	0	0	0	0	ND
6/18/2014	11:25	CRMC	200.0	KR14812	SG	7,996	24	516	0	0.18
6/18/2014	15:15	CRCC	192.8	KR14813	SG	6,213	0	73,449	0	0.44
6/18/2014	14:50	IRCC	192.4	KR14814	SG	132	0	1,202	185[10]	0.15
6/18/2014	14:35	IRJW	189.7	KR14815	SG	0	0	5,117	0	0.17
6/23/2014	14:10	KRBI	189.7	KR14816	SG	23	70	258	120[7]	0.22
6/24/2014	7:50	CRMC	201.5	KR14817	SG	0	0	0	0	0.32
6/24/2014	12:00	CRCC	200.0	KR14818	SG	66,452	0	396,368	0	9.00
6/24/2014	11:40	IRCC	192.8	KR14819	SG	6,085	0	6,116	123[10]	0.30
6/24/2014	11:25	IRJW	192.4	KR14820	SG	0	0	1,273	0	0.16
7/08/2014	13:00	CRMC	189.7	KR14821	SG	2,818,750	854	0	0	210
7/09/2014	12:45	CRCC	201.5	KR14822	SG	12,402,500	0	0	0	230
7/09/2014	15:15	IRCC	200.0	KR14823	SG	25,287	344	2,091	0	2.4
7/09/2014	15:30	IRJW	192.8	KR14824	SG	5,891	0	0	0	0.63
7/09/2014	13:30	KRBI	192.4	KR14825	SG	135	65	0	0	0.18
7/22/2014	18:00	IRCC	200.0	KR14828	SG	125,836	2,323	0	1,743[6]	6.3
7/22/2014	18:10	IRJW	192.8	KR14829	SG	35,633,333	654,500	0	0	1,400
7/22/2014	18:35	KRBI	189.7	KR14830	SG	6,146	543	0	0	1.5
8/05/2014	13:50	KRBI	189.7	KR14836	SG	8,559	40	0	0	1.3
8/12/2014	11:15	KRBI	189.7	KR14837	SG	*	*	*	*	0.76
8/19/2014	12:40	KRBI	189.7	KR14842	SG	20,246	0	0	0	0.72
8/25/2014	11:50	KRBI	189.7	KR14844	SG	18,311	363	0	0	0.25
9/01/2014	15:40	KRBI	189.7	KR14845	SG	3,409	0	0	0	0.18
9/08/2014	14:05	KRBI	189.7	KR14850	SG	2,974	0	0	0	0.16
9/15/2014	9:15	KRBI	189.7	KR14851	SG	4,102	0	0	0	0.27
9/22/2014	16:30	KRBI	189.7	KR14856	SG	11,778	0	0	0	0.27
10/07/2014	11:40	KRBI	189.7	KR14862	SG	44	18	0	0	ND
10/20/2014**	17:30	IRCC	189.7	KR14865	SG	1,277,833	0	0	0	28.0
10/20/2014**	17:15	IRJW	189.7	KR14866	SG	0	0	0	0	0.29
10/20/2014**	14:30	KRBI	189.7	KR14867	SG	0	0	0	0	0.16
10/27/2014	15:00	IRCC	189.7	KR14870	SG	83,242	0	0	0	*

Date	Time	Location	RM	Sample ID	Depth	MSAE[1]	AFA[2]	ANA[3]	Other [6], [7], [8], [9], or [10]	Microcystin (µg/L)
10/27/2014	15:15	IRJW	189.7	KR14871	SG	0	0	0	0	*
11/02/2014	12:05	CRCC	200.0	KR14875	SG	352	22,360	0	0	ND
11/03/2014	11:05	IRCC	192.8	KR14876	SG	33,519	0	0	0	1.6
11/03/2014	11:15	IRJW	192.4	KR14877	SG	0	0	0	123(5)	ND
11/19/2014	12:55	CRCC	200.0	KR14879	SG	0	247,979	0	0	0.16
11/19/2014	12:35	IRCC	192.8	KR14880	SG	1,538	0	0	0	0.19
11/19/2014	12:25	IRJW	192.4	KR14881	SG	0	0	0	0	ND

[1]MSAE = *Microcystis aeruginosa* (cells/mL)
[2]AFA = *Aphanizomenon flos-aquae* (cells/mL)
[3]ANA = *Anabaena flos-aquae* (cells/mL)
Other = either [5]*Planktothrix (Oscillatoria) sp.* or [6]*Gloeotrichia echinulata* or [7]*Anabaena sp.* or [8]*Lyngbya sp.* (cells/mL) or [9]*Anabaena circinalis* (cells/mL) or [10]*Anabaena planctonica*
"0" value indicates non-detect by analytical laboratory
"*" value indicates results were not available upon the date this memo was submitted and will be included in subsequent memos as availability allows
"**" indicates value was incorrectly reported on a former memo

Appendix 2

Laboratory Data Sheets: November 2nd, 3rd, and 19th, 2014

Phytoplankton Sample Analysis

Sample:	Klamath Basin
Sample Site:	KR 14875
Sample Depth:	
Sample Date:	2-Nov-14
Total Density (#/mL):	1,191
Total Biovolume (um^3/mL):	1,411,482
Trophic State Index:	52.3

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Aphanizomenon flos-aquae	1,177	98.8	1,408,663	99.8	bluegreen
2	Microcystis aeruginosa	14	1.2	2,819	0.2	bluegreen

Aphanizomenon flos-aquae cells/mL = 22,360

Microcystis aeruginosa cells/mL = 352

Note: Toxic Algae Only

Aquatic Analysts **Sample ID:** SD95

Phytoplankton Sample Analysis

Sample:	Klamath Basin
Sample Site:	KR 14876
Sample Depth:	
Sample Date:	3-Nov-14 1105
Total Density (#/mL):	1,197
Total Biovolume (um^3/mL):	268,150
Trophic State Index:	40.4

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	1,197	100.0	268,150	100.0	bluegreen

Microcystis aeruginosa cells/mL = 33,519

Note: Toxic Algae Only

Aquatic Analysts **Sample ID:** SD92

Phytoplankton Sample Analysis

Sample:	Klamath Basin
Sample Site:	KR 14877
Sample Depth:	
Sample Date:	3-Nov-14 1115
Total Density (#/mL):	4
Total Biovolume (um^3/mL):	7,598
Trophic State Index:	15.5

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Oscillatoria sp.	4	100.0	7,598	100.0	bluegreen

Oscillatoria sp. cells/mL = 123

Note: Toxic Algae Only

Aquatic Analysts **Sample ID:** SD93

Phytoplankton Sample Analysis

Sample:	Klamath Basin
Sample Site:	KR 14879
Sample Depth:	
Sample Date:	19-Nov-14 1255
Total Density (#/mL):	11,272
Total Biovolume (um^3/mL):	15,622,653
Trophic State Index:	69.7

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Aphanizomenon flos-aquae	11,272	100.0	15,622,653	100.0	bluegreen

Aphanizomenon flos-aquae cells/mL = 247,979

Note: Toxic Algae Only

Aquatic Analysts **Sample ID:** SD00

Phytoplankton Sample Analysis

Sample:	Klamath Basin
Sample Site:	KR 14880
Sample Depth:	
Sample Date:	19-Nov-14 1235
Total Density (#/mL):	128
Total Biovolume (um^3/mL):	12,300
Trophic State Index:	18.7

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	128	100.0	12,300	100.0	bluegreen

Microcystis aeruginosa cells/mL = 1,538

Note: Toxic Algae Only

Aquatic Analysts **Sample ID:** SE01

Phytoplankton Sample Analysis

Sample:	Klamath Basin
Sample Site:	KR 14881
Sample Depth:	
Sample Date:	19-Nov-14 1225
Total Density (#/mL):	<3
Total Biovolume (um^3/mL):	
Trophic State Index:	

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	No Toxic Algae Present	<3				

Note: Toxic Algae Only

Aquatic Analysts **Sample ID:** SE02