

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 2015 public health monitoring for cyanobacteria species and an associated toxin, microcystin, in Copco and Iron Gate reservoirs within PacifiCorp's Klamath Hydroelectric Project (Project) and 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 assesses the presence of other potentially-toxic cyanobacteria, including *Anabaena* sp., 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 warranted¹. 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 in Appendix 1 summarize results from all of the 2015 public health sampling events.

Methods

PacifiCorp is conducting public health sampling at five sites (Table 1) for laboratory analysis of potentially toxic 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 three 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 toxic BGA is 100,000 cells/ml or greater, or 4) if microcystin is 8 µg/L or greater.

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

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 collected for potentially toxic phytoplankton are preserved in Lugol's solution and sent to Aquatic Analysts in Friday Harbor, Washington for analysis. The samples are labeled rushed for timely analysis and only potentially toxic cyanobacteria are identified and enumerated. However, once the reservoirs are posted with health advisories signs, the reservoir samples are collected but not rushed until it visually appears that the algae bloom conditions have waned. 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.

Results

On July 1, 2015, Copco reservoir was posted with health advisories based on the public health sampling results from samples collected at Copco Cove (CRCC) on June 22, 2015, and in accordance with California posting guidelines (SWRCB 2010; see Appendix 1). Samples collected from Iron Gate reservoir on July 21, 2015 at the Camp Creek (IRCC) public health monitoring location had microcystis cell counts of 45,100 cells/mL, which exceed the posting guidelines. Public health samples from both reservoirs will continue to be collected but these samples will not be rushed for analysis since both reservoirs are now posted. Results will be available in the end of the year summary database.

The Oregon Health Authority issued a health advisory for Upper Klamath Lake and Agency Lake on July 28, 2015 and the advisory was extended to Lake Ewauna and Keno Reservoir on July 29, 2015. A health advisory was issued for JC Boyle Reservoir and the Klamath River downstream to the Oregon/California state line by the Oregon Health Authority on August 5, 2015 based on a microcystin result of 470 µg/L on July 20, 2015 from a sample collected in JC Boyle Reservoir. More specific sampling data below JC Boyle Dam was not available at the time the health advisory was extended downstream by the Oregon Health Authority.

Baseline sampling conducted on August 4 and 5, 2015 included samples collected in JC Boyle Reservoir and the Klamath River downstream. Because of the microcystis bloom occurring in Upper Klamath Lake,

Keno Reservoir, and JC Boyle Reservoir, PacifiCorp rushed the algae processing of these samples even though they were not technically part of the public health sampling effort. Results indicated that the JC Boyle Reservoir and the upstream end of the bypass reach immediately downstream of the reservoir continued to exceed the posting guidelines (Appendix 1). The samples from Klamath River downstream of the JC Boyle Powerhouse and upstream of Copco Reservoir were below the posting guidelines, although with a cell count over 32,000 cells/mL the site at the USGS gage downstream of JC Boyle Powerhouse had cell counts very close to the 40,000 cells/mL posting threshold (Appendix 1). This information was sent to the Oregon Health Authority and Oregon Department of Environmental Quality on August 10, 2015.

Available results from public health sampling on August 25, September 2, 7, 15, and 22, 2015 are shown in Table 2.

Table 2. Summary of August 25, September 2, 7, 15, and 22, 2015 laboratory algal identification and enumeration and microcystin results.

Date	Time	Location	RM	Sample ID	Depth	MSAE ⁽¹⁾	AFA ⁽²⁾	ANA ⁽³⁾	Other ⁽⁵⁾ , (6), (7), (8), (9), (10), (11), or (12)	Microcystin (µg/L)
08/25/2015	14:35	KRBI	189.7	KR15835	SG	583	583	0	0	0.42
09/02/2015	11:35	CRMC	201.5	KR15836	SG	*	*	*	*	4.3
09/02/2015	13:00	CRCC	200.0	KR15837	SG	*	*	*	*	210
09/02/2015	15:40	IRCC	192.8	KR15838	SG	*	*	*	*	17
09/02/2015	15:50	IRJW	192.4	KR15839	SG	*	*	*	*	250
09/02/2015	16:10	KRBI	189.7	KR15840	SG	*	*	*	*	0.25
09/07/2015	13:00	KRBI	189.7	KR15841	SG	*	*	*	*	0.74
09/15/2015	16:40	KRBI	189.7	KR15842	SG	*	*	*	*	0.28
09/22/2015	15:30	CRMC	201.5	KR15843	SG	*	*	*	*	4
09/22/2015	15:00	CRCC	200.0	KR15844	SG	*	*	*	*	57
09/22/2015	14:35	IRCC	192.8	KR15845	SG	*	*	*	*	64
09/22/2015	14:20	IRJW	192.4	KR15846	SG	*	*	*	*	770
09/22/2015	14:10	KRBI	189.7	KR15847	SG	*	*	*	*	0.3

¹MSAE = *Microcystis aeruginosa* (cells/mL)

²AFA = *Aphanizomenon flos-aquae* (cells/mL)

³ANA = *Anabaena flos-aquae* (cells/mL)

Other = Cells/mL of either ⁵*Planktothrix (Oscillatoria) sp.*, ⁶*Gloeotrichia echinulata*, ⁷*Anabaena sp.*, ⁸*Lyngbya sp.*, ⁹*Anabaena circinalis*, ¹⁰*Anabaena planctonica*, ¹¹*Planktothrix (Oscillatoria) limosa*, or ¹²*Pseudanabaena spp.*

“0” value indicates non-detect by analytical laboratory

* Results were not available upon the date this memo was submitted and will be included in Appendix 1 of subsequent memos

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

Cyanobacteria Species data for 2015 Public Health Samples

Table 3. Summary of 2015 laboratory algal identification and enumeration

Date	Time	Location	RM	Sample ID	Depth	MSAE ⁽¹⁾	AFA ⁽²⁾	ANA ⁽³⁾	Other ^{(5), (6), (7), (8), (9), (10), (11), or (12)}	Microcystin (µg/L)
5/18/2015	16:00	CRMC	201.5	KR15800	SG	0	0	0	0	ND
5/18/2015	17:00	CRCC	200.0	KR15801	SG	0	0	0	0	ND
5/18/2015	17:40	IRCC	192.8	KR15802	SG	0	0	0	0	ND
5/18/2015	18:05	IRJW	192.4	KR15803	SG	0	0	0	0	ND
06/08/2015	9:00	CRMC	201.5	KR15804	SG	0	139	104	0	0.20
06/08/2015	10:20	CRCC	200.0	KR15805	SG	0	0	967	0	ND
06/08/2015	11:00	IRCC	192.8	KR15806	SG	0	0	841	0	ND
06/08/2015	11:10	IRJW	192.4	KR15807	SG	0	0	324	1,060 ⁷	ND
06/08/2015	18:30	KRBI	189.7	KR15808	SG	0	0	163	0	ND
06/22/2015	10:30	CRMC	201.5	KR15809	SG	0	0	0	0	NA
06/22/2015	12:05	CRCC	200.0	KR15810	SG	2,373,318	0	218,262	0	1,000 ¹³
06/22/2015	12:29	IRCC	192.8	KR15811	SG	0	0	18,401	0	ND ¹³
06/22/2015	12:40	IRJW	192.4	KR15812	SG	0	0	678	0	ND ¹³
06/22/2015	16:30	KRBI	189.7	KR15813	SG	0	18	335	0	ND ¹³
07/08/2015	14:40	CRMC	201.5	KR15814	SG	*	*	*	*	12,000
07/08/2015	12:30	CRCC	200.0	KR15815	SG	*	*	*	*	3,300 ¹⁴
07/08/2015	11:40	IRCC	192.8	KR15816	SG	5,315	4,905	121	0	0.66
07/08/2015	11:20	IRJW	192.4	KR15817	SG	841	2,322	0	0	0.26
07/08/2015	10:35	KRBI	189.7	KR15818	SG	0	249	33	0	0.31
07/21/2015	11:25	CRMC	201.5	KR15819	SG	*	*	*	*	830
07/21/2015	13:10	CRCC	200.0	KR15820	SG	*	*	*	*	16,000
07/21/2015	13:30	IRCC	192.8	KR15821	SG	45,100	4,997	0	324 ⁶ 973 ⁷	11
07/21/2015	13:40	IRJW	192.4	KR15822	SG	13,877	10,616	0	0	3.6
07/21/2015	14:05	KRBI	189.7	KR15823	SG	12,916	0	0	0	5.6
08/04/2015 ¹⁵	8:10	Above JC Boyle	228.2	KR15212	SG	66,783	0	0	0	NS
08/04/2015 ¹⁵	11:05	JC Boyle Reservoir	224.8	KR15214	SG	1,127,500	0	0	76,875 ¹²	9.8
08/04/2015 ¹⁵	11:30	Below JC Boyle	224.6	KR15211	SG	229,707	0	0	1,515 ¹²	NS
08/04/2015 ¹⁵	10:10	USGS Gage	219.5	KR15213	SG	32,477	0	0	0	2.0
08/05/2015 ¹⁵	14:35	Above Shovel Creek	206.4	KR15219	SG	16,729	0	0	138 ¹²	0.96
08/05/2015	15:00	CRMC	201.5	KR15824	SG	*	*	*	*	2.1
08/05/2015	11:55	CRCC	200.0	KR15825	SG	*	*	*	*	14
08/05/2015	10:55	IRCC	192.8	KR15826	SG	*	*	*	*	56
08/05/2015	10:40	IRJW	192.4	KR15827	SG	*	*	*	*	38
08/05/2015	15:30	KRBI	189.7	KR15828	SG	13,423	224	0	0	1.0
08/11/2015	13:50	KRBI	189.7	KR15829	SG	3,819	0	0	0	1.8
08/17/2015	10:20	CRMC	201.5	KR15830	SG	*	*	*	*	370
08/17/2015	12:00	CRCC	200.0	KR15831	SG	*	*	*	*	3.5
08/17/2015	12:25	IRCC	192.8	KR15832	SG	*	*	*	*	1.0
08/17/2015	12:45	IRJW	192.4	KR15833	SG	*	*	*	*	3.1
08/17/2015	14:00	KRBI	189.7	KR15834	SG	6,060	559	0	0	0.64
08/25/2015	14:35	KRBI	189.7	KR15835	SG	583	583	0	0	0.42
09/02/2015	11:35	CRMC	201.5	KR15836	SG	*	*	*	*	4.3
09/02/2015	13:00	CRCC	200.0	KR15837	SG	*	*	*	*	210
09/02/2015	15:40	IRCC	192.8	KR15838	SG	*	*	*	*	17
09/02/2015	15:50	IRJW	192.4	KR15839	SG	*	*	*	*	250

09/02/2015	16:10	KRBI	189.7	KR15840	SG	*	*	*	*	0.25
09/07/2015	13:00	KRBI	189.7	KR15841	SG	*	*	*	*	0.74
09/15/2015	16:40	KRBI	189.7	KR15842	SG	*	*	*	*	0.28
09/22/2015	15:30	CRMC	201.5	KR15843	SG	*	*	*	*	4
09/22/2015	15:00	CRCC	200.0	KR15844	SG	*	*	*	*	57
09/22/2015	14:35	IRCC	192.8	KR15845	SG	*	*	*	*	64
09/22/2015	14:20	IRJW	192.4	KR15846	SG	*	*	*	*	770
09/22/2015	14:10	KRBI	189.7	KR15847	SG	*	*	*	*	0.3

¹ MSAE = *Microcystis aeruginosa* (cells/mL)

² AFA = *Aphanizomenon flos-aquae* (cells/mL)

³ ANA = *Anabaena flos-aquae* (cells/mL)

Other = Cells/mL of either ⁵*Planktothrix (Oscillatoria) sp.*, ⁶*Gloeotrichia echinulata*, ⁷*Anabaena sp.*, ⁸*Lyngbya sp.*, ⁹*Anabaena circinalis*, ¹⁰*Anabaena planctonica*, ¹¹*Planktothrix (Oscillatoria) limosa*, or ¹²*Pseudanabaena spp.*

¹³ The sample was received above the recommended temperature range

¹⁴ The reported concentration for this analyte is above the calibration range of the instrument and should be considered an estimated value

¹⁵ Baseline samples, not part of routine public health sampling protocols. Data reported because of interest in *Microcystis aeruginosa* data at sites upstream of Copco Reservoir.

“0” value indicates non-detect by analytical laboratory

“NA” value indicates sample loss

“ND” value indicates result less than quantitation limit (0.18 µg/L) by analytical laboratory

“NS” value indicates no sample provided for analysis

* Results were not available upon the date this memo was submitted and will be included in subsequent memos

Appendix 2 – Laboratory Phytoplankton Results

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR15829
Sample Depth:
Sample Date: 11-Aug-15 1350

Total Density (#/mL): 382
Total Biovolume (um³/mL): 113,199
Trophic State Index: 34.2

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent
1 Microcystis aeruginosa	255	66.7	30,552	27.0
2 Cocconeis placentula	24	6.3	11,154	9.9
3 Nitzschia palea	18	4.8	3,273	2.9
4 Rhodomonas minuta	12	3.2	242	0.2
5 Gomphonema angustatum	12	3.2	2,182	1.9
6 Gomphonema subclavatum	12	3.2	7,274	6.4
7 Fragilaria construens venter	12	3.2	873	0.8
8 Cyclotella meneghiniana	6	1.6	2,303	2.0
9 Stephanodiscus hantzschii	6	1.6	727	0.6
10 Achnanthes minutissima	6	1.6	303	0.3
11 Synedra ulna	6	1.6	24,126	21.3
12 Melosira granulata	6	1.6	20,004	17.7
13 Fragilaria crotonensis	6	1.6	10,184	9.0

Microcystis aeruginosa cells/mL = 3,819

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 15834
Sample Depth:
Sample Date: 17-Aug-15

Total Density (#/mL): 653
Total Biovolume (um³/mL): 83,721
Trophic State Index: 32.0

Species	Density #/mL	Density Percent	Biovolume um³/mL	Biovolume Percent
-	-	-	-	-
1 Microcystis aeruginosa	606	92.9	48,480	57.9
2 Aphanizomenon flos-aquae	47	7.1	35,241	42.1

Microcystis aeruginosa cells/mL = 6,060

Aphanizomenon flos-aquae cells/mL = 559

Note: Toxic Algae Only