TECHNICAL MEMORANDUM

Results of Cyanobacteria and Microcystin Monitoring in the Vicinity of the Klamath Hydroelectric Project: August 22nd, 2011

E&S Environmental Chemistry, Inc.

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Introduction

This technical memorandum summarizes the latest results of public health monitoring during 2011 for cyanobacteria species and the associated toxin microcystin in Copco and Iron Gate reservoirs in 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), a cyanobacterium that is known to produce microcystin, with a recent history of summertime blooms in Copco and Iron Gate reservoirs. This monitoring also estimates the presence of other potentially-toxigenic cyanobacteria, including *Anabaena* spp. and *Planktothrix (Oscillatoria)* spp. 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.

The results addressed in this memorandum are specifically for samples collected on August 22nd, 2011. Subsequent memoranda will be prepared approximately every two weeks to report the results of continued monitoring.

Methods

PacifiCorp is conducting phytoplankton sampling for laboratory analysis of potentially toxigenic cyanobacteria, notably MSAE, and microcystin at four sites in Copco and Iron Gate reservoirs and one site below Iron Gate Dam (listed in Table 1), including:

- 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 the shoreline locations in the reservoirs once in May and August; and twice per month in June, July, October, and November. Samples for the river site below Iron Gate Dam are scheduled to be collected twice per month in June, July and October and weekly in August and September but may change due to river conditions. Sampling in the river would increase when the potential for blooms exists.

Phytoplankton samples from the river sites are taken as grab samples offshore according to the standard operating procedure (SOP) developed by the Klamath Blue Green Algae Working Group (http://www.kbmp.net/collaboration/klamath-hydroelectric-settlement-agreement-monitoring). Additional samples at open water sites in Copco and Iron Gate reservoirs, including a grab sample at 0.5

m depth and an integrated sample over 8 m depth, will be collected as part of the baseline water quality monitoring.

Samples for potentially toxic phytoplankton are preserved in Lugol's solution and sent to Aquatic Analysts in Friday Harbor, Washington for analysis. The laboratory analysis of phytoplankton speciation and abundance is performed on prepared microscope slides of filtered samples using phase contrast microscopy. Species are counted as algal units of cell, filament, or colony depending on the natural growth form of the species. Algal forms are identified to species or otherwise to the lowest practicable taxonomic level. Biovolumes are estimated by multiplying the cell counts by the average geometric dimensions of the cells for a given phytoplankton taxon. 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 all measurable microcystin variants.

Table 1. Sites of cyanobacteria and microcystin public health monitoring in Copco and Iron Gate reservoirs during 2011.

Location	Approximate River Mile	Site ID
Copco Reservoir at Mallard Cove ramp	201.5	CRMC
Copco Reservoir at Copco Cove ramp	200.0	CRCC
Iron Gate Reservoir at Camp Creek ramp	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

Samples of August 22nd, 2011

Five samples were collected for public health purposes on August 22nd 2011, from shoreline stations in Copco and Iron Gate reservoirs and the Klamath River below Iron Gate dam. Aliquots were sent to the EPA Region 9 laboratory for analysis for Microcystin via ELISA, to Aquatic Analysts for cyanobacteria species identification and enumeration, and held for potential subsequent analysis for microcystin via LCMS.

The results from previous public health sampling showed that cell counts at both coves in Copco reservoir and at the John Williams campground at Iron Gate reservoir exceed California's posting guidelines (SWRCB 2010). The reservoirs were and posted with public health advisory signs on August 17, 2011.

The results of cyanobacteria species identification and enumeration from the August 22 sampling event are summarized in Table 2. The reservoir cell counts continue to exceed the posting guidelines except for

Camp Creek Cove in Iron Gate reservoir. The cell counts in the Klamath River below Iron Gate dam are still below the posting guidelines.

The results of microcystin analysis from both the August 8 and 22 sampling events are summarized in Table 3.

Table 2. Summary of cyanobacteria public health monitoring August 22nd, 2011.

Date	**Sample**	**Location**	**Species**	**Biovolume (μm^3/mL)**	**Cells/mL**
8/22/2011	KR11841	CRMC	Microcystis aeruginosa	4,007,067	500,883
8/22/2011	KR11841	CRMC	Aphanizomenon flos-aquae	129,150	2,050
8/22/2011	KR11842	CRCC	Microcystis aeruginosa	39,425,446	4,928,181
8/22/2011	KR11842	CRCC	Aphanizomenon flos-aquae	1,300,595	20,644
8/22/2011	KR11843	IRCC	Microcystis aeruginosa	169,355	21,169
8/22/2011	KR11843	IRCC	Aphanizomenon flos-aquae	54,120	859
8/22/2011	KR11844	IRJW	Aphanizomenon flos-aquae	121,783,997	1,933,079
8/22/2011	KR11844	IRJW	Gloeotrichia echinulata	10,071,593	148,112
8/22/2011	KR11847	KRBI	Microcystis aeruginosa	114,649	14,331
8/22/2011	KR11847	KRBI	Aphanizomenon flos-aquae	79,756	1,266
8/22/2011	KR11847	KRBI	Anabaena flos-aquae	3,313	49

Table 3. Summary of microcystin public health monitoring on August 8th August 22nd. *Bottle was broken during shipping to analytical laboratory.

Date	Sample	Location	Result	Units
08/08/11	KR11834	CRMC	15	µg/L
08/08/11	KR11835	CRCC	*	µg/L
08/08/11	KR11836	IRCC	3.9	µg/L
08/08/11	KR11837	IRJW	180	µg/L
08/08/11	KR11840	KRBI	0.19	µg/L
08/22/11	KR11841	CRMC	74	µg/L
08/22/11	KR11842	CRCC	3,600	µg/L
08/22/11	KR11843	IRCC	4.5	µg/L
08/22/11	KR11844	IRJW	8.8	µg/L
08/22/11	KR11847	KRBI	2.3	µg/L

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 Species data for 2011 Public Health Samples.

Date	Sample	Location	Species	Biovolume, $\mu m^3/mL$	Cells/mL
05/24/11	KR11800	CRMC	None	0	0
05/24/11	KR11801	CRCC	None	0	0
05/24/11	KR11802	IRCC	None	0	0
05/24/11	KR11803	IRJW	None	0	0
05/24/11	KR11804	CRCC	None	0	0
06/06/11	KR11806	CRMC	*Anabaena flos-aquae*	9,623	144
06/06/11	KR11807	CRCC	*None*	0	0
06/06/11	KR11808	IRCC	*None*	0	0
06/06/11	KR11809	IRJW	*None*	0	0
06/06/11	KR11812	KRBI	*None*	0	0
06/22/11	KR11813	CRMC	*Aphanizomenon flos-aquae*	49,869	792
06/22/11	KR11813	CRMC	*Microcystis aeruginosa*	1,277	160
06/22/11	KR11814	CRCC	*Anabaena flos-aquae*	378,226	5,645
06/22/11	KR11814	CRCC	*Aphanizomenon flos-aquae*	201,984	3,206
06/22/11	KR11815	IRCC	*Aphanizomenon flos-aquae*	23,588	374
06/22/11	KR11815	IRCC	*Anabaena sp.*	2,572	38
06/22/11	KR11815	IRCC	*Anabaena flos-aquae*	1,267	19
06/22/11	KR11815	IRCC	*Microcystis aeruginosa*	1,210	151
06/22/11	KR11816	IRJW	*None*	0	0
07/05/11	KR11820	CRMC	None	0	0
07/05/11	KR11821	CRCC	None	0	0
07/05/11	KR11822	IRCC	Oscillatoria sp.	1,268	20
07/05/11	KR11823	IRJW	Aphanizomenon flos-aquae	2,208	35
07/05/11	KR11823	IRJW	Anabaena flos-aquae	7,044	105
07/05/11	KR11824	KRBI	Aphanizomenon flos-aquae	13,708	218
07/18/11	KR11827	CRMC	Anabaena flos-aquae	131,944	1,969
07/18/11	KR11828	CRCC	Anabaena flos-aquae	3,082,134	46,002
07/18/11	KR11828	CRCC	Aphanizomenon flos-aquae	623,338	9,894
07/18/11	KR11829	IRCC	Anabaena flos-aquae	506,274	7,556
07/18/11	KR11829	IRCC	Aphanizomenon flos-aquae	18,170	288
07/18/11	KR11829	IRCC	Anabaena sp.	2,451	36
07/18/11	KR11829	IRCC	Microcystis aeruginosa	8,652	1,082
07/18/11	KR11830	IRJW	Aphanizomenon flos-aquae	1,186,477	8,762
07/18/11	KR11830	IRJW	Anabaena flos-aquae	587,073	18,833
07/18/11	KR11830	IRJW	Anabaena sp.	20,221	297
07/18/11	KR11833	KRBI	Aphanizomenon flos-aquae	6,899	110
07/18/11	KR11833	KRBI	Anabaena flos-aquae	3,252	49
07/18/11	KR11833	KRBI	Microcystis aeruginosa	498	62

08/08/11	KR11834	CRMC	Microcystis aeruginosa	772,802	96,600
08/08/11	KR11834	CRMC	Aphanizomenon flos-aquae	94,014	1,492
08/08/11	KR11834	CRMC	Anabaena flos-aquae	27,773	415
08/08/11	KR11835	CRCC	Microcystis aeruginosa	67,717,650	8,464,706
08/08/11	KR11835	CRCC	Aphanizomenon flos-aquae	6,712,571	106,549
08/08/11	KR11835	CRCC	Anabaena flos-aquae	16,694,893	249,178
08/08/11	KR11836	IRCC	Microcystis aeruginosa	180,818	22,602
08/08/11	KR11836	IRCC	Anabaena flos-aquae	1,242,838	18,550
08/08/11	KR11836	IRCC	Aphanizomenon flos-aquae	98,828	1,569
08/08/11	KR11837	IRJW	Microcystis aeruginosa	4,510,000	563,750
08/08/11	KR11837	IRJW	Aphanizomenon flos-aquae	2,927,400	46,467
08/08/11	KR11837	IRJW	Anabaena flos-aquae	457,833	6,833
08/08/11	KR11840	KRBI	Aphanizomenon flos-aquae	43,396	689
08/08/11	KR11840	KRBI	Anabaena flos-aquae	7,082	106
8/22/2011	KR11841	CRMC	Microcystis aeruginosa	4,007,067	500,883
8/22/2011	KR11841	CRMC	Aphanizomenon flos-aquae	129,150	2,050
8/22/2011	KR11842	CRCC	Microcystis aeruginosa	39,425,446	4,928,181
8/22/2011	KR11842	CRCC	Aphanizomenon flos-aquae	1,300,595	20,644
8/22/2011	KR11843	IRCC	Microcystis aeruginosa	169,355	21,169
8/22/2011	KR11843	IRCC	Aphanizomenon flos-aquae	54,120	859
8/22/2011	KR11844	IRJW	Aphanizomenon flos-aquae	121,783,997	1,933,079
8/22/2011	KR11844	IRJW	Gloeotrichia echinulata	10,071,593	148,112
8/22/2011	KR11847	KRBI	Microcystis aeruginosa	114,649	14,331
8/22/2011	KR11847	KRBI	Aphanizomenon flos-aquae	79,756	1,266
8/22/2011	KR11847	KRBI	Anabaena flos-aquae	3,313	49

Appendix 2

Laboratory Data Sheets for August 22nd, 2011 Public Health Samples.

	Phytoplankton Sample Analysis						
	Sample:	Klamath Basin					
	Sample Site:	KR 11841					
	Sample Depth:						
	Sample Date:	22-Aug-11					
	Total Density (#/mL):	50,293					
	Total Biovolume (um^3/mL):	4,136,217					
	Trophic State Index:	60.1					
		Density	**Density**	**Biovolume**	**Biovolume**		
	Species	**#/mL**	**Percent**	**um^3/mL**	**Percent**		**Group**
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1	Microcystis aeruginosa	50,088	99.6	4,007,067	96.9		bluegreen
2	Aphanizomenon flos-aquae	205	0.4	129,150	3.1		bluegreen
	Microcystis aeruginosa cells/mL =	500,883					
	Aphanizomenon flos-aquae cells/mL =	2,050					
	Note: Toxic Algae Only						
	Aquatic Analysts			**Sample ID:**	PN24		

	Phytoplankton Sample Analysis						
	Sample:	Klamath Basin					
	Sample Site:	KR 11842					
	Sample Depth:						
	Sample Date:	22-Aug-11					
	Total Density (#/mL):	142,393					
	Total Biovolume (um^3/mL):	40,726,041					
	Trophic State Index:	76.6					
		Density	**Density**	**Biovolume**	**Biovolume**		
	Species	**#/mL**	**Percent**	**um^3/mL**	**Percent**		**Group**
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1	Microcystis aeruginosa	140,805	98.9	39,425,446	96.8		bluegreen
2	Aphanizomenon flos-aquae	1,588	1.1	1,300,595	3.2		bluegreen
	Microcystis aeruginosa cells/mL =	4,928,181					
	Aphanizomenon flos-aquae cells/mL =	20,644					
	Note: Toxic Algae Only						
	Aquatic Analysts			**Sample ID:**	PN25		

Phytoplankton Sample Analysis

Sample:	Klamath Basin
Sample Site:	KR 11843
Sample Depth:	
Sample Date:	22-Aug-11
Total Density (#/mL):	2,171
Total Biovolume (um^3/mL):	223,475
Trophic State Index:	39.1

	Species	**Density #/mL**	**Density Percent**	**Biovolume um^3/mL**	**Biovolume Percent**	**Group**
1	Microcystis aeruginosa	2,117	97.5	169,355	75.8	bluegreen
2	Aphanizomenon flos-aquae	54	2.5	54,120	24.2	bluegreen

Microcystis aeruginosa cells/mL = 21,169

Aphanizomenon flos-aquae cells/mL = 859

Note: Toxic Algae Only

Aquatic Analysts **Sample ID:** PN26

Phytoplankton Sample Analysis

Sample:	Klamath Basin
Sample Site:	KR 11844
Sample Depth:	
Sample Date:	22-Aug-11
Total Density (#/mL):	87,904
Total Biovolume (um^3/mL):	131,855,589
Trophic State Index:	85.1

	Species	**Density #/mL**	**Density Percent**	**Biovolume um^3/mL**	**Biovolume Percent**	**Group**
1	Aphanizomenon flos-aquae	87,867	100.0	121,783,997	92.4	bluegreen
2	Gloeotrichia echinulata	37	0.0	10,071,593	7.6	bluegreen

Aphanizomenon flos-aquae cells/mL = 1,933,079

Gloeotrichia echinulata cells/mL = 148,112

Note: Toxic Algae Only

Aquatic Analysts **Sample ID:** PN27

Phytoplankton Sample Analysis

Sample:	Klamath Basin
Sample Site:	KR 11847
Sample Depth:	
Sample Date:	22-Aug-11
Total Density (#/mL):	1,108
Total Biovolume (um^3/mL):	197,718
Trophic State Index:	38.2

	Species	**Density #/mL**	**Density Percent**	**Biovolume um^3/mL**	**Biovolume Percent**	**Group**
1	Microcystis aeruginosa	1,024	92.4	114,649	58.0	bluegreen
2	Aphanizomenon flos-aquae	79	7.1	79,756	40.3	bluegreen
3	Anabaena flos-aquae	5	0.4	3,313	1.7	bluegreen

Microcystis aeruginosa cells/mL = 14,331

Aphanizomenon flos-aquae cells/mL = 1,266

Anabaena flos-aquae cells/mL = 49

Note: Toxic Algae Only

Aquatic Analysts **Sample ID:** PN29