

TECHNICAL MEMORANDUM

Results of Cyanobacteria and Microcystin Monitoring in the Vicinity of the Klamath Hydroelectric Project: September 13, 2010

Prepared for: Tim Hemstreet (PacifiCorp)
Linda Prendergast (PacifiCorp)

Prepared by: Richard Raymond

Date: September 17, 2010



Introduction

This technical memorandum summarizes the latest results of monitoring during 2010 for cyanobacteria species and the associated toxin microcystin in Copco and Iron Gate reservoirs in PacifiCorp's Klamath Hydroelectric Project (Project) and in 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 September 13, 2010. Subsequent memoranda such as this will be prepared 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 six sites in Copco and Iron Gate reservoirs and one site below Iron Gate Dam as 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.
- Two open-water reservoir sites in the lower ends of Iron Gate and Copco reservoirs (near the log booms). These sites are part of the basic water quality monitoring that is being performed under the 2010 KHSA Measure 15 water quality monitoring plan. The plan is available on the Regional Board's website.¹

Samples will be taken at the shoreline locations in the reservoirs twice per month in June through October. Samples for the river site below Iron Gate Dam will be collected twice per month in June, July and October and weekly in August and September. Sampling will occur at the two open-water monitoring sites once per month in April through December.

¹ http://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/klamath_river/

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. This SOP is an appendix to the 2010 KHSA Measure 15 water quality monitoring plan. Additional samples at open-water sites in Copco and Iron Gate reservoirs, including a grab sample at 0.5 m depth and an additional sample integrated 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 taxa. 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 0.16 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. Samples are also sent to the California Department of Fish and Game laboratory in Rancho Cordova, California for analysis for microcystin congeners and other toxins by liquid chromatography and mass spectrometry (LC/MS).

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 Williams campground	192.4	IRJW
Klamath River below Iron Gate dam near hatchery bridge	189.7	KRBI

Results

Samples of September 13, 2010

Five samples and one replicate, plus one blank for microcystin, were collected for public health purposes on September 13, 2010 from shoreline stations in Copco and Iron Gate reservoirs and the Klamath River below Iron Gate dam. An additional sample was collected on September 7 from below Iron Gate dam. Aliquots were sent to Aquatic Analysts for cyanobacteria species identification and enumeration, to the EPA Region 9 laboratory for analysis for microcystin by ELISA methodology, and to the California Fish and Game laboratory for microcystin analysis by LC/MS.

The results of cyanobacteria species identification and enumeration are summarized in Table 2. Two cyanobacteria species capable of producing potentially harmful toxins were observed in the samples collected on September 7 and 14. *Microcystis aeruginosa* and *Aphanizomenon flos-aquae* were observed at every location sampled. *Microcystis aeruginosa* exceeded 40,000 cells/mL all samples collected on both dates. *Aphanizomenon flos-aquae* exceeded 40,000 cells/mL in the samples from Copco reservoir at Copco Cove, and in the duplicate sample – but not the primary sample – below Iron Gate dam on September 13th.

Results from microcystin analyses for samples collected on September 13 are not yet available. Results for ELISA analysis of microcystin through September 7 are provided in Appendix 1. In samples collected on July 19 and analyzed by LC/MS for nine congeners of microcystin, anatoxin a, domoic acid, and okadaic acid all results have been below the method reporting limit (0.500 ppb for microcystin, 2.00 ppb for anatoxin-A, and 1.00 ppb for domoic acid) with the exception of MC-LA which was measured at 3.27 ppb at IRCC, 0.722 ppb at IRJW, and 0.778 ppb at CRMC.

Table 2. Summary of cyanobacteria public health monitoring on September 13, 2010.

Date	Sample	Sample Site	Species	Biovolume µm ³ /mL	Cells/mL
9/7/10	KR10214	KRBI	<i>Microcystis aeruginosa</i>	447,733	55,967
			<i>Aphanizomenon flos-aquae</i>	228,199	3,622
9/13/10	KR10215	KRBI	<i>Microcystis aeruginosa</i>	515,792	64,474
			<i>Aphanizomenon flos-aquae</i>	192,088	3,049
9/13/10	KR10216	CRMC	<i>Microcystis aeruginosa</i>	23,812,800	2,976,600
			<i>Aphanizomenon flos-aquae</i>	511,946	8,126
9/13/10	KR10217	CRCC	<i>Microcystis aeruginosa</i>	101,616,618	12,702,077
			<i>Aphanizomenon flos-aquae</i>	142,065,000	2,255,000
9/13/10	KR10218	IRCC	<i>Microcystis aeruginosa</i>	902,000	112,750
			<i>Aphanizomenon flos-aquae</i>	42,093	668
9/13/10	KR10219	IRJW	<i>Microcystis aeruginosa</i>	2,672,927	334,116
			<i>Aphanizomenon flos-aquae</i>	130,226	2,067
9/13/10	KR10220	KRBI (dup)	<i>Microcystis aeruginosa</i>	789,559	98,695
			<i>Aphanizomenon flos-aquae</i>	446,629	7,089

References

SWRCB. 2007. Cyanobacteria in California Recreational Water Bodies: Providing Voluntary Guidance about Harmful Algal Blooms, Their Monitoring, and Public Notification. June 2007. 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 (OEHA).

Appendix 1

Cumulative Species data for 2010 Public Health Samples.

Date	Sample	Location	Species	Biovolume, $\mu\text{m}^3/\text{mL}$	Cells/mL	Microcystin, $\mu\text{g/L}$ (ELISA)
05/27/10	KR10070	KRBI	NA	0	0	
05/27/10	KR10072	CRMC	NA	0	0	
05/27/10	KR10073	CRCC	<i>Anabaena flos-aquae</i>	8,324	124	
05/27/10	KR10074	IRJW	NA	0	0	
05/27/10	KR10075	IRCC	NA	0	0	
06/07/10	KR10076	KRBI	NA	0	0	0.26
06/07/10	KR10078	CRMC	NA	0	0	0.25
06/07/10	KR10079	CRCC	<i>Anabaena flos-aquae</i>	4,700	70	0.47
06/07/10	KR10080	IRJW	NA	0	0	ND
06/07/10	KR10081	IRCC	NA	0	0	ND
06/21/10	KR10112	KRBI	<i>Anabaena flos-aquae</i>	13,021	164	
06/21/10	KR10110	CRMC	<i>Anabaena flos-aquae</i>	3,672,205	54,809	0.44
06/21/10	KR10109	CRCC	<i>Anabaena flos-aquae</i>	7,408,676	110,582	0.46
06/21/10	KR10107	IRJW	<i>Anabaena flos-aquae</i>	343,999	5,134	0.16
			<i>Anabaena sp.</i>	35,906	643	
			<i>Anabaena planctonica</i>	117,661	528	
06/21/10	KR10108	IRCC	<i>Anabaena flos-aquae</i>	97,509	1,455	0.21
			<i>Anabaena planktonica</i>	28,535	156	
07/06/10	KR10117	KRBI	<i>Anabaena flos-aquae</i>	230,529	3,441	ND
			<i>Aphanizomenon flos-aquae</i>	108,049	1,715	
			<i>Microcystis aeruginosa</i>	2,117	256	
			<i>Anabaena planctonica</i>	9,687	53	
07/06/10	KR10118	IRJW	<i>Anabaena flos-aquae</i>	498,696	7,443	ND
			<i>Anabaena planctonica</i>	136,085	744	
07/06/10	KR10119	IRCC	<i>Anabaena flos-aquae</i>	643,510	9,605	ND
			<i>Aphanizomenon flos-aquae</i>	19,731	313	
			<i>Anabaena sp.</i>	16,565	244	
07/06/10	KR10120	CRCC	<i>Anabaena flos-aquae</i>	76,049	568	ND
			<i>Aphanizomenon flos-aquae</i>	35,755	1,135	
07/06/10	KR10121	CRMC	<i>Oscillatoria sp.</i>	23,644	381	ND
			<i>Aphanizomenon flos-aquae</i>	3,482	55	
			<i>Anabaena flos-aquae</i>	7,406	111	
07/06/10	KR10123	KRBI (blank)	NA	NA	NA	ND
07/06/10	KR10123	KRBI (dup)	<i>Anabaena flos-aquae</i>	166,633	2,487	ND
			<i>Aphanizomenon flos-aquae</i>	74,370	1,180	
			<i>Microcystis aeruginosa</i>	1,816	227	
07/19/10	KR 10151	KRBI	<i>Aphanizomenon flos-aquae</i>	3,748	59	0.25
07/19/10	KR 10152	IRCC	<i>Anabaena flos-aquae</i>	1,498,364	22,364	1.7
			<i>Microcystis aeruginosa</i>	35,285	4,411	
			<i>Aphanizomenon flos-aquae</i>	11,741	186	
07/19/10	KR 10153	IRJW	<i>Aphanizomenon flos-aquae</i>	47,626	756	0.50
			<i>Anabaena flos-aquae</i>	31,656	472	

			<i>Anabaena sp.</i>	10,077	148	
07/19/10	KR 10154	CRMC	<i>Microcystis aeruginosa</i>	18,080	2,260	1.0
			<i>Anabaena flos-aquae</i>	33,800	504	
			<i>Aphanizomenon flos-aquae</i>	5,085	81	
			<i>Oscillatoria sp.</i>	2,502	40	
07/19/10	KR 10155	CRCC	<i>Anabaena flos-aquae</i>	91,080	1,359	0.51
			<i>Aphanizomenon flos-aquae</i>	57,431	912	
			<i>Microcystis aeruginosa</i>	1,279	160	
07/19/10	KR10156	KRBI (dup)	No toxic algae present			0.33
07/19/10	KR10157	KRBI (blink)	Toxic algae not measured			ND
08/02/10	KR10161	IRJW	<i>Microcystis aeruginosa</i>	6,676,874	834,609	280
			<i>Aphanizomenon flos-aquae</i>	17,635,655	279,931	
			<i>Anabaena flos-aquae</i>	12,989,837	193,878	
08/02/10	KR10159	KRBI	<i>Aphanizomenon flos-aquae</i>	13,319	211	0.82
08/02/10	KR10160	IRCC	<i>Aphanizomenon flos-aquae</i>	4,582,742	72,742	4.7
			<i>Microcystis aeruginosa</i>	209,497	26,187	
			<i>Anabaena flos-aquae</i>	268,054	4,001	
08/02/10	KR10162	CRMC	<i>Microcystis aeruginosa</i>	18,766	2,346	0.68
			<i>Aphanizomenon flos-aquae</i>	33,371	530	
			<i>Anabaena flos-aquae</i>	48,165	719	
08/02/10	KR10163	CRCC	<i>Microcystis aeruginosa</i>	2,573,707	321,713	200
			<i>Aphanizomenon flos-aquae</i>	10,437,042	165,667	
			<i>Anabaena flos-aquae</i>	10,152,912	151,536	
08/02/10	KR10164	KRBI (dup)	<i>Aphanizomenon flos-aquae</i>	52,254	829	0.97
			<i>Anabaena sp.</i>	33,841	498	
			<i>Anabaena flos-aquae</i>	6,946	104	
08/09/10	KR10167	KRBI	<i>Microcystis aeruginosa</i>	3,723	465	1.3
			<i>Aphanizomenon flos-aquae</i>	1,074	17	
			<i>Anabaena sp.</i>	1,159	17	
			<i>Anabaena flos-aquae</i>	2,284	34	
08/16/10	KR10168	KRBI	<i>Microcystis aeruginosa</i>	39,975	4,997	ND
			<i>Aphanizomenon flos-aquae</i>	137,222	2,178	
			<i>Anabaena sp.</i>	11,617	171	
08/16/10	KR10169	IRCC	<i>Microcystis aeruginosa</i>	721,600	90,200	21
			<i>Aphanizomenon flos-aquae</i>	2,859,631	45,391	
			<i>Gloeotrichia echinulata</i>	41,550,194	611,032	
			<i>Anabaena sp.</i>	49,465	727	
08/16/10	KR10170	IRJW	<i>Microcystis aeruginosa</i>	257,714	32,214	4.0
			<i>Aphanizomenon flos-aquae</i>	956,764	15,187	
			<i>Gloeotrichia echinulata</i>	93,882	1,381	
			<i>Anabaena sp.</i>	79,799	1,174	
08/16/10	KR10171	CRMC	<i>Aphanizomenon flos-aquae</i>	633,420,480	10,054,293	1500
			<i>Microcystis aeruginosa</i>	62,238,000	7,779,750	
			<i>Anabaena flos-aquae</i>	16,015,010	239,030	
08/16/10	KR10172	CRCC	<i>Aphanizomenon flos-aquae</i>	86,817,500	1,378,056	28
			<i>Microcystis aeruginosa</i>	641,422	80,178	
08/16/10	KR10173	KRBI (dup)	<i>Microcystis aeruginosa</i>	72,962	9,120	1.9
			<i>Aphanizomenon flos-aquae</i>	252,560	4,009	
			<i>Anabaena sp.</i>	13,630	200	
8/23/10	KR10204	KRBI	<i>Microcystis aeruginosa</i>	300,088	37,511	7.0
			<i>Aphanizomenon flos-aquae</i>	1,557,251	24,718	

8/30/10	KR10205	KRBI	<i>Microcystis aeruginosa</i>	267,490	33,436	8.4
			<i>Aphanizomenon flos-aquae</i>	465,385	7,387	
8/30/10	KR10206	CRMC	<i>Aphanizomenon flos-aquae</i>	165,512,621	2,627,184	670
			<i>Microcystis aeruginosa</i>	11,769,786	1,471,223	
8/30/10	KR10207	CRCC	<i>Microcystis aeruginosa</i>	4,414,905	551,863	230
			<i>Aphanizomenon flos-aquae</i>	14,536,884	230,744	
8/30/10	KR10208	IRJW	<i>Microcystis aeruginosa</i>	42,240,000	5,280,000	2300
			<i>Gloeotrichia echinulata</i>	28,611,000	420,750	
8/30/10	KR10209	IRCC	<i>Microcystis aeruginosa</i>	300,435	37,554	12
			<i>Gloeotrichia echinulata</i>	11,795	173	
8/30/10	KR10210	KRBI (dup)	<i>Microcystis aeruginosa</i>	149,943	18,743	12
			<i>Aphanizomenon flos-aquae</i>	531,360	8,434	
8/30/10	KR10211	KRBI (blnk)	<i>Toxic algae not measured</i>			ND
9/7/10	KR10214	KRBI	<i>Microcystis aeruginosa</i>	447,733	55,967	8.2
			<i>Aphanizomenon flos-aquae</i>	228,199	3,622	
9/13/10	KR10215	KRBI	<i>Microcystis aeruginosa</i>	515,792	64,474	
			<i>Aphanizomenon flos-aquae</i>	192,088	3,049	
9/13/10	KR10216	CRMC	<i>Microcystis aeruginosa</i>	23,812,800	2,976,600	
			<i>Aphanizomenon flos-aquae</i>	511,946	8,126	
9/13/10	KR10217	CRCC	<i>Microcystis aeruginosa</i>	101,616,618	12,702,077	
			<i>Aphanizomenon flos-aquae</i>	142,065,000	2,255,000	
9/13/10	KR10218	IRCC	<i>Microcystis aeruginosa</i>	902,000	112,750	
			<i>Aphanizomenon flos-aquae</i>	42,093	668	
9/13/10	KR10219	IRJW	<i>Microcystis aeruginosa</i>	2,672,927	334,116	
			<i>Aphanizomenon flos-aquae</i>	130,226	2,067	
9/13/10	KR10220	KRBI (dup)	<i>Microcystis aeruginosa</i>	789,559	98,695	
			<i>Aphanizomenon flos-aquae</i>	446,629	7,089	
9/13/10	KR10221	KRBI (blnk)	<i>Toxic algae not measured</i>			

Appendix 2

Laboratory Data Sheets for September 13, 2010 Public Health Samples.

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 10214
Sample Depth:
Sample Date: 7-Sep-10

Total Density (#/mL): 4,877
Total Biovolume (um³/mL): 675,932
Trophic State Index: 47.0

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent	Group
1 Microcystis aeruginosa	4,664	95.6	447,733	66.2	bluegreen
2 Aphanizomenon flos-aquae	213	4.4	228,199	33.8	bluegreen

Microcystis aeruginosa cells/mL = 55,967
 Aphanizomenon flos-aquae cells/mL = 3,622

Note: Toxic Algae Only

Aquatic Analysts

Sample ID: NQ34

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 10215
Sample Depth:
Sample Date: 13-Sep-10

Total Density (#/mL): 6,617
Total Biovolume (um³/mL): 707,879
Trophic State Index: 47.4

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent	Group
1 Microcystis aeruginosa	6,447	97.4	515,792	72.9	bluegreen
2 Aphanizomenon flos-aquae	169	2.6	192,088	27.1	bluegreen

Microcystis aeruginosa cells/mL = 64,474
Aphanizomenon flos-aquae cells/mL = 3,049

Note: Toxic Algae Only

Aquatic Analysts

Sample ID: NQ35

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 10216
Sample Depth:
Sample Date: 13-Sep-10

Total Density (#/mL): 271,006
Total Biovolume (um³/mL): 24,324,746
Trophic State Index: 72.9

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent	Group
1 Microcystis aeruginosa	270,600	99.9	23,812,800	97.9	bluegreen
2 Aphanizomenon flos-aquae	406	0.1	511,946	2.1	bluegreen

Microcystis aeruginosa cells/mL = 2,976,600
 Aphanizomenon flos-aquae cells/mL = 8,126

Note: Toxic Algae Only

Aquatic Analysts

Sample ID: NQ36

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 10217
Sample Depth:
Sample Date: 13-Sep-10

Total Density (#/mL): 675,411
Total Biovolume (um³/mL): 243,681,618
Trophic State Index: 89.5

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent	Group
1 Microcystis aeruginosa	577,367	85.5	101,616,618	41.7	bluegreen
2 Aphanizomenon flos-aquae	98,043	14.5	142,065,000	58.3	bluegreen

Microcystis aeruginosa cells/mL = 12,702,077

Aphanizomenon flos-aquae cells/mL = 2,255,000

Note: Toxic Algae Only

Aquatic Analysts

Sample ID: NQ37

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 10218
Sample Depth:
Sample Date: 13-Sep-10

Total Density (#/mL): 11,308
Total Biovolume (um³/mL): 944,093
Trophic State Index: 49.4

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent	Group
1 Microcystis aeruginosa	11,275	99.7	902,000	95.5	bluegreen
2 Aphanizomenon flos-aquae	33	0.3	42,093	4.5	bluegreen

Microcystis aeruginosa cells/mL = 112,750
Aphanizomenon flos-aquae cells/mL = 668

Note: Toxic Algae Only

Aquatic Analysts

Sample ID: NQ38

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 10219
Sample Depth:
Sample Date: 13-Sep-10

Total Density (#/mL): 33,506
Total Biovolume (um³/mL): 2,803,153
Trophic State Index: 57.3

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent	Group
1 Microcystis aeruginosa	33,412	99.7	2,672,927	95.4	bluegreen
2 Aphanizomenon flos-aquae	94	0.3	130,226	4.6	bluegreen

Microcystis aeruginosa cells/mL = 334,116
Aphanizomenon flos-aquae cells/mL = 2,067

Note: Toxic Algae Only

Aquatic Analysts

Sample ID: NQ39

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 10220
Sample Depth:
Sample Date: 13-Sep-10

Total Density (#/mL): 10,287
Total Biovolume (um³/mL): 1,236,188
Trophic State Index: 51.4

Species	Density #/mL	Density Percent	Biovolume um ³ /mL	Biovolume Percent	Group
1 Microcystis aeruginosa	9,869	95.9	789,559	63.9	bluegreen
2 Aphanizomenon flos-aquae	417	4.1	446,629	36.1	bluegreen

Microcystis aeruginosa cells/mL = 98,695
Aphanizomenon flos-aquae cells/mL = 7,089

Note: Toxic Algae Only

Aquatic Analysts

Sample ID: NQ40