TECHNICAL MEMORANDUM

Results of Cyanobacteria and Microcystin Monitoring in the Vicinity of the Klamath Hydroelectric Project: September 14, 15, and 21 2009

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Introduction

This technical memorandum summarizes the latest results of monitoring during 2009 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 with a recent history of summertime blooms in Copco and Iron Gate reservoirs that is known to produce microcystin. 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 12, Water Quality Monitoring, contained in the Klamath Hydroelectric Project Agreement in Principle (AIP) executed between the United States Department of Interior, the States of California and Oregon, and PacifiCorp.

The results specifically addressed in this memorandum are for samples collected on September 14, 15, and 21, 2009. Subsequent memoranda such as this will be prepared every two weeks to report the results of continued monitoring. PacifiCorp plans to prepare a final report of the results and interpretation of the complete set of collected data after the conclusion of the sampling effort in winter 2009.

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:

- 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 2009 AIP Measure 12 water quality monitoring plan. The plan is available on the Regional Board's website.[1]

- Four shoreline sites in coves in Copco and Iron Gate reservoir (i.e., two cove sites in each reservoir).

- One Klamath River site below Iron Gate Dam near the hatchery bridge.

Sampling will occur at the two open-water monitoring sites once per month in June through December. 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.

[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 2009 AIP Measure 12 water quality monitoring plan. At the open-water reservoir sites public health samples will be collected according to the published SOP. Additional samples, 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 phytoplankton speciation, density, and biovolume are preserved in Lugol's solution and sent to Aquatic Analysts in Milwaukie, Oregon for analysis. The laboratory analysis of phytoplankton speciation and density 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.

Table 1. Sites of Cyanobacteria and Microcystin Public Health Monitoring in Copco and Iron Gate reservoirs during 2009.

Location	Approximate River Mile	Site ID
Copco Reservoir at Mallard Cove ramp	201.5	CRMC
Copco Reservoir at Copco Cove ramp	200.0	CRCC
Copco Reservoir near dam at cable line	198.6	CR01
Iron Gate Reservoir at Camp Creek ramp	192.8	IRCC
Iron Gate Reservoir at Williams campground	192.4	IRJW
Iron Gate Reservoir near dam at log boom	190.2	IR01
Klamath R. at Iron Gate Hatchery bridge	189.7	KRBI

Results

Samples of September 14, 15, and 21, 2009

Eight samples were collected for public health purposes on September 14, 15, and 21, 2009 from shoreline and open water 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, and to Aquatic Analysts for cyanobacteria species identification and enumeration. Results from EPA for microcystin analyses for samples collected on September 14, 15, and 21 are not yet available.

The results of cyanobacteria species identification and enumeration are summarized in Table 2; cumulative data are included in Appendix 1. Two cyanobacteria species were observed in these samples; *Aphanizomenon flos-aquae* and *Microcystis aeruginosa*. On September 14 *Aphanizomenon* exceeded 40,000 cells/mL[2] where dense scums had accumulated at the shoreline sites in Copco reservoir and near the Jay Williams campground in Iron Gate reservoir. Samples at Camp Creek in Iron Gate reservoir and below Iron Gate dam were well below 40,000 cells/mL. Surface samples collected on September 15 in the reservoirs near the dams were also less than 40,000 cells/mL. *Microcystis* abundance exceeded 40,000 cells/mL at all reservoir sites on September 14 and 15. Abundance was especially high where samples were collected from thick scums accumulated near the shore. Samples collected below Iron Gate dam were well below the relevant guidelines for both species on both September 14 and September 21. Laboratory data sheets for phytoplankton are included as Appendix 2.

Microcystis has been observed to produce microcystin, a potentially dangerous liver toxin (Codd et al 2005), and could pose a potential health risk to persons or pets engaged in water contact recreation when cell abundance exceeds the relevant guidelines. Iron Gate and Copco reservoirs and the Klamath River from Iron Gate dam to Happy Camp have been posted with Public Health advisory signs.

Results of microcystin analysis by EPA for all sites sampled by PacifiCorp pursuant to the 2009 AIP Monitoring Plan through August 31, 2009 are presented in Appendix 3. Eight-four samples have been analyzed to date. Of the 84 samples analyzed, 25 have exceeded the California guideline value of 8 µg/L. No sample prior to July 20 exceeded the guideline value. In July and August several samples, mostly from shoreline sites in Copco and Iron Gate reservoirs exceeded the guideline value. The highest values observed to date have come from shoreline samples taken from thick accumulated scum in Copco reservoir.

Table 2. Summary of cyanobacteria public health monitoring on September 14, 15, and 21, 2009.

Date	Sample	Location[1]	Species	Biovolume, µm³/mL	Rank[2]	Cells/mL
09/21/09	KR9204	KRBI	*Aphanizomenon flos-aquae*	214,977	6	3,412
09/21/09	KR9204	KRBI	*Microcystis aeruginosa*	40,757	14	5,095
09/15/09	KR9189	CR01	*Microcystis aeruginosa*	1,312,647	1	164,081
09/15/09	KR9189	CR01	*Aphanizomenon flos-aquae*	1,216,899	2	19,316
09/15/09	KR9180	IR01	*Microcystis aeruginosa*	392,174	1	49,022
09/15/09	KR9180	IR01	*Aphanizomenon flos-aquae*	1,791,254	2	28,433
09/14/09	KR9176	KRBI	*Microcystis aeruginosa*	72,160	6	9,020
09/14/09	KR9176	KRBI	*Aphanizomenon flos-aquae*	198,692	7	3,154

[2]The World Health Organization (WHO) has recommended guidelines for safe recreational water environments based on a low, moderate, or high probability of adverse health effects from exposure to concentrations of cyanobacterial cells and microcystin toxins in recreational waters (WHO 2003). The WHO guideline values for low and moderate probability of adverse health in recreational waters are 20,000 and 100,000 cyanobacterial cells/mL, respectively. WHO equates these cell count values to microcystin toxin concentrations of 4 µg/L and 20 µg/L, respectively (WHO 2003). The WHO guideline for high probability of adverse health effects is a narrative; i.e., "Cyanbacterial scum formation in areas where whole-body contact and/or risk of ingestion/aspiration occur". No specific cyanobacterial cell or microcystin concentrations are provided by WHO for high probability of adverse health effects. The WHO (2003) guidance values were derived from calculations based on a 20 kg child that would swim for up to two hours (in a day) and would accidentally ingest 0.05 L of water per hour.

The California State Water Resources Control Board (SWRCB 2007) and Oregon Department of Health Services (ODHS 2005) provide guidelines for posting advisories in recreation waters. These guidelines were developed using information provided in WHO (2003). Both SWRCB (2007) and ODHS (2005) recommend 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 toxigenic BGA is 100,000 cells/ml or greater. Based on WHO (2003) information, SWRCB (2007) and ODHS (2005) indicate that cell counts of 40,000 cells/mL and 100,000 cells/mL equate to microcystin toxin concentrations of 8 µg/L and 20 µg/L, respectively.

09/14/09	KR9175	IRJW	*Microcystis aeruginosa*	100,514,635	1	12,564,329
09/14/09	KR9175	IRJW	*Aphanizomenon flos-aquae*	6,016,871	4	95,506
09/14/09	KR9174	IRCC	*Microcystis aeruginosa*	515,233	1	64,404
09/14/09	KR9174	IRCC	*Aphanizomenon flos-aquae*	119,284	3	1,893
09/14/09	KR9173	CRCC	*Microcystis aeruginosa*	35,018,824	2	4,377,353
09/14/09	KR9173	CRCC	*Aphanizomenon flos-aquae*	19,984,606	3	317,216
09/14/09	KR9172	CRMC	*Microcystis aeruginosa*	978,706,080	1	122,338,260
09/14/09	KR9172	CRMC	*Aphanizomenon flos-aquae*	31,254,300	3	496,100

[1]CRMC = Copco reservoir at Mallard Cove ramp, CRCC = Copco reservoir at Copco Cove ramp, IRCC = Iron Gate reservoir at Camp Creek ramp, IRJW = Iron Gate reservoir at Williams campground, KRBI = Klamath R. at Iron Gate Hatchery bridge, IR01=Iron Gate reservoir at log boom, CR01 = Copco reservoir at cable line
[2]Rank = The rank of the species in the sample based on the count of algal units.

References

Codd, G. A., J. Lindsay, F. M. Young, L. F. Morrison, and J. S. Metcalf. 2005. Harmful cyanobacteria: from mass mortalities to management measures. In Harmful Cyanobacteria, J. Juisman, H. C. P. Matthijs, and P. M. Visser eds. Springer 2005.

ODHS. 2005. Public Health Advisory Guidance for Toxigenic Cyanobacteria in Recreational Waters. Oregon Department of Human Services, Environmental Toxicology Program.

PacifiCorp. 2008. Agreement in Principle to address issues pertaining to the resolution of certain litigation and other controversies in the Klamath Basin, including a path forward for possible Facilities removal. U.S. Secretary of the Interior, November 18, 2008.

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 (OEHHA).

World Health Organization (WHO). 2003. Guidelines for safe recreational waters, Volume 1 – Coastal and fresh waters, Chapter 8: Algae and cyanobacteria in fresh water. WHO Publishing, Geneva, pp. 136-158.

Appendix 1

Cumulative Data for 2009 Public Health Samples.

Date	Sample	Location [1]	Species	Biovolume, µm3/mL	Rank [2]	Cells/mL
08/18/09	KR9150	CR01	*Aphanizomenon flos-aquae*	7,629,417	2	121,102
09/15/09	KR9189	CR01	*Aphanizomenon flos-aquae*	1,216,899	2	19,316
08/18/09	KR9150	CR01	*Microcystis aeruginosa*	3,006,667	1	375,833
09/15/09	KR9189	CR01	*Microcystis aeruginosa*	1,312,647	1	164,081
06/08/09	KR9060	CRCC	*Anabaena flos-aquae*	1,019,824	2	15,221
06/22/09	KR9065	CRCC	*Anabaena flos-aquae*	61,364	4	916
06/08/09	KR9060	CRCC	*Aphanizomenon flos-aquae*	9,471	26	150
06/22/09	KR9065	CRCC	*Aphanizomenon flos-aquae*	1,262,193	1	20,035
07/06/09	KR9096	CRCC	*Aphanizomenon flos-aquae*	422,813	8	6,711
07/20/09	KR9100	CRCC	*Aphanizomenon flos-aquae*	799,116	11	12,684
08/03/09	KR9134	CRCC	*Aphanizomenon flos-aquae*	1,183,875	11	18,792
08/17/09	KR9178	CRCC	*Aphanizomenon flos-aquae*	15,452,684	2	245,281
08/31/09	KR9168	CRCC	*Aphanizomenon flos-aquae*	10,332,000	3	164,000
09/14/09	KR9173	CRCC	*Aphanizomenon flos-aquae*	19,984,606	3	317,216
08/03/09	KR9134	CRCC	*Gloeotrichia echinulata*	76,670,000	8	1,127,500
07/06/09	KR9096	CRCC	*Microcystis aeruginosa*	25,950,397	1	3,243,800
07/20/09	KR9100	CRCC	*Microcystis aeruginosa*	50,589,145	1	6,323,643
08/03/09	KR9134	CRCC	*Microcystis aeruginosa*	64,893,889	2	8,111,736
08/17/09	KR9178	CRCC	*Microcystis aeruginosa*	6,370,968	1	796,371
08/31/09	KR9168	CRCC	*Microcystis aeruginosa*	498,560,000	1	62,320,000
09/14/09	KR9173	CRCC	*Microcystis aeruginosa*	35,018,824	2	4,377,353
07/20/09	KR9100	CRCC	*Oscillatoria sp.*	229,951	20	3,709
06/08/09	KR9059	CRMC	*Anabaena flos-aquae*	271,627,386	1	4,054,140
06/22/09	KR9064	CRMC	*Aphanizomenon flos-aquae*	826,007	1	13,111
07/06/09	KR9095	CRMC	*Aphanizomenon flos-aquae*	7,941	13	126
07/20/09	KR9101	CRMC	*Aphanizomenon flos-aquae*	191,548	8	3,040
08/17/09	KR9177	CRMC	*Aphanizomenon flos-aquae*	3,790,167	5	60,161
08/31/09	KR9167	CRMC	*Aphanizomenon flos-aquae*	1,732,500	6	27,500
09/14/09	KR9172	CRMC	*Aphanizomenon flos-aquae*	31,254,300	3	496,100
07/06/09	KR9095	CRMC	*Microcystis aeruginosa*	1,471	26	184
07/20/09	KR9101	CRMC	*Microcystis aeruginosa*	26,147,865	1	3,268,483
08/03/09	KR9133	CRMC	*Microcystis aeruginosa*	65,031,611	2	8,128,951
08/17/09	KR9177	CRMC	*Microcystis aeruginosa*	22,253,821	1	2,781,728
08/31/09	KR9167	CRMC	*Microcystis aeruginosa*	326,106,000	1	40,763,250
09/14/09	KR9172	CRMC	*Microcystis aeruginosa*	978,706,080	1	122,338,260
08/31/09	KR9167	CRMC	*Oscillatoria limnetica*	618,750	4	13,750
08/18/09	KR9141	IR01	*Aphanizomenon flos-aquae*	1,961,665	2	31,138
09/15/09	KR9180	IR01	*Aphanizomenon flos-aquae*	1,791,254	2	28,433
08/18/09	KR9141	IR01	*Microcystis aeruginosa*	257,008	1	32,126
09/15/09	KR9180	IR01	*Microcystis aeruginosa*	392,174	1	49,022
06/08/09	KR9062	IRCC	*Anabaena flos-aquae*	83,936	2	1,253
06/22/09	KR9067	IRCC	*Anabaena flos-aquae*	1,303,884	1	19,461
07/06/09	KR9098	IRCC	*Anabaena sp.*	36,222	8	533
08/17/09	KR9180	IRCC	*Anabaena sp.*	982,949	17	14,455
06/22/09	KR9067	IRCC	*Aphanizomenon flos-aquae*	406,734	2	6,456
08/03/09	KR9136	IRCC	*Aphanizomenon flos-aquae*	617,248	3	9,798
08/17/09	KR9180	IRCC	*Aphanizomenon flos-aquae*	127,494	23	2,024

09/14/09	KR9174	IRCC	*Aphanizomenon flos-aquae*	119,284	3	1,893
07/06/09	KR9098	IRCC	*Microcystis aeruginosa*	227,276	2	28,409
07/20/09	KR9103	IRCC	*Microcystis aeruginosa*	320,366	1	40,046
08/03/09	KR9136	IRCC	*Microcystis aeruginosa*	352,506	1	44,063
08/17/09	KR9180	IRCC	*Microcystis aeruginosa*	346,923	20	43,365
08/31/09	KR1970	IRCC	*Microcystis aeruginosa*	62,456,198	1	7,807,025
09/14/09	KR9174	IRCC	*Microcystis aeruginosa*	515,233	1	64,404
07/20/09	KR9102	IRJW	*Anabaena flos-aquae*	112,414	12	1,678
06/08/09	KR9061	IRJW	*Anabaena flos-aquae*	18,829,827	1	281,042
06/22/09	KR9066	IRJW	*Anabaena flos-aquae*	22,136	12	330
06/22/09	KR9066	IRJW	*Aphanizomenon flos-aquae*	272,567	3	4,326
07/06/09	KR9097	IRJW	*Aphanizomenon flos-aquae*	417,838	13	6,632
07/20/09	KR9102	IRJW	*Aphanizomenon flos-aquae*	42,281	13	671
09/14/09	KR9175	IRJW	*Aphanizomenon flos-aquae*	6,016,871	4	95,506
07/06/09	KR9097	IRJW	*Microcystis aeruginosa*	8,312,549	1	1,039,069
07/20/09	KR9102	IRJW	*Microcystis aeruginosa*	6,550,238	1	818,780
08/03/09	KR9135	IRJW	*Microcystis aeruginosa*	46,612,848	1	5,826,606
08/17/09	KR9179	IRJW	*Microcystis aeruginosa*	6,402,431	1	800,304
08/31/09	KR1969	IRJW	*Microcystis aeruginosa*	2,890,393	1	361,299
09/14/09	KR9175	IRJW	*Microcystis aeruginosa*	100,514,635	1	12,564,329
07/20/09	KR9102	IRJW	*Oscillatoria sp.*	24,966	14	403
06/08/09	KR9063	KRBI	*Anabaena flos-aquae*	9,306	27	139
06/22/09	KR9068	KRBI	*Anabaena flos-aquae*	14,238	10	213
08/17/09	KR9181	KRBI	*Anabaena sp.*	1,572,790	1	23,129
08/24/09	KR9165	KRBI	*Anabaena sp.*	1,211,687	9	17,819
06/08/09	KR9063	KRBI	*Aphanizomenon flos-aquae*	12,353	26	196
06/22/09	KR9068	KRBI	*Aphanizomenon flos-aquae*	83,305	2	1,322
07/06/09	KR9099	KRBI	*Aphanizomenon flos-aquae*	10,005	20	159
08/03/09	KR9132	KRBI	*Aphanizomenon flos-aquae*	3,381,592	4	53,676
08/10/09	KR9137	KRBI	*Aphanizomenon flos-aquae*	179,165	4	2,844
08/31/09	KR9166	KRBI	*Aphanizomenon flos-aquae*	495,936	1	7,872
09/07/09	KR9171	KRBI	*Aphanizomenon flos-aquae*	968,625	6	15,375
09/14/09	KR9176	KRBI	*Aphanizomenon flos-aquae*	198,692	7	3,154
09/21/09	KR9204	KRBI	*Aphanizomenon flos-aquae*	214,977	6	3,412
07/06/09	KR9099	KRBI	*Microcystis aeruginosa*	4,065	21	508
07/20/09	KR9104	KRBI	*Microcystis aeruginosa*	406,316	1	50,790
08/03/09	KR9132	KRBI	*Microcystis aeruginosa*	37,431,991	1	4,678,999
08/10/09	KR9137	KRBI	*Microcystis aeruginosa*	129,268	7	16,158
08/17/09	KR9181	KRBI	*Microcystis aeruginosa*	20,964	11	2,620
08/31/09	KR9166	KRBI	*Microcystis aeruginosa*	611,501	3	76,438
09/07/09	KR9171	KRBI	*Microcystis aeruginosa*	50,738	19	6,342
09/14/09	KR9176	KRBI	*Microcystis aeruginosa*	72,160	6	9,020
09/21/09	KR9204	KRBI	*Microcystis aeruginosa*	40,757	14	5,095

[1]CRMC = Copco reservoir at Mallard Cove ramp, CRCC = Copco reservoir at Copco Cove ramp, IRCC = Iron Gate reservoir at Camp Creek ramp, IRJW = Iron Gate reservoir at Williams campground, KRBI = Klamath R. at Iron Gate Hatchery bridge, IR01=Iron Gate reservoir at log boom, CR01 = Copco reservoir at cable line
[2]Rank = The rank of the species in the sample based on the count of algal units.

Appendix 2

Laboratory Data Sheets for September 14, 15, and 21, 2009 Public Health Samples.

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 9172
Sample Depth:
Sample Date: 14-Sep-09

Total Density (#/mL): 565,253
Total Biovolume (um^3/mL): 1,081,338,647
Trophic State Index: 100.2

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	411,913	72.9	978,706,080	90.5	bluegreen
2	Nitzschia palea	51,113	9.0	9,200,400	0.9	diatom
3	Aphanizomenon flos-aquae	33,073	5.9	31,254,300	2.9	bluegreen
4	Gomphonema subclavatum	18,040	3.2	14,071,200	1.3	diatom
5	Nitzschia amphibia	18,040	3.2	1,731,840	0.2	diatom
6	Gomphonema ventricosum	9,020	1.6	7,667,000	0.7	diatom
7	Gomphoneis herculeana	6,013	1.1	32,472,000	3.0	diatom
8	Rhoicosphenia curvata	6,013	1.1	703,560	0.1	diatom
9	Cocconeis placentula	6,013	1.1	2,766,133	0.3	diatom
10	Nitzschia capitellata	3,007	0.5	1,082,400	0.1	diatom
11	Fragilaria construens	3,007	0.5	1,683,733	0.2	diatom

Microcystis aeruginosa cells/mL = 122,338,260

Aphanizomenon flos-aquae cells/mL = 496,100

Note: 4X count for toxic species.

Aquatic Analysts

Sample ID: MM02

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 9173
Sample Depth:
Sample Date: 14-Sep-09

Total Density (#/mL): 171,115
Total Biovolume (um^3/mL): 75,937,030
Trophic State Index: 81.1

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Nitzschia palea	102,328	59.8	18,418,992	24.3	diatom
2	Microcystis aeruginosa	41,689	24.4	35,018,824	46.1	bluegreen
3	Aphanizomenon flos-aquae	17,623	10.3	19,984,606	26.3	bluegreen
4	Nitzschia amphibia	3,790	2.2	363,832	0.5	diatom
5	Cocconeis placentula	1,895	1.1	871,681	1.1	diatom
6	Chlamydomonas sp.	1,895	1.1	615,861	0.8	green
7	Stephanodiscus astraea minutula	1,895	1.1	663,235	0.9	diatom

Microcystis aeruginosa cells/mL = 4,377,353

Aphanizomenon flos-aquae cells/mL = 317,216
Aphanizomenon flos-aquae heterocysts/mL = 1,895

Note: 4X count for toxic species.

Aquatic Analysts

Sample ID: MM03

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 9174
Sample Depth:
Sample Date: 14-Sep-09

Total Density (#/mL): 6,292
Total Biovolume (um^3/mL): 853,070
Trophic State Index: 48.7

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	5,367	85.3	515,233	60.4	bluegreen
2	Nitzschia palea	399	6.3	71,750	8.4	diatom
3	Aphanizomenon flos-aquae	100	1.6	119,284	14.0	bluegreen
4	Cryptomonas erosa	71	1.1	37,014	4.3	cryptophyte
5	Cocconeis placentula	71	1.1	32,743	3.8	diatom
6	Rhodomonas minuta	71	1.1	1,424	0.2	cryptophyte
7	Chlamydomonas sp.	43	0.7	13,880	1.6	green
8	Fragilaria construens	43	0.7	38,267	4.5	diatom
9	Nitzschia frustulum	28	0.5	3,417	0.4	diatom
10	Nitzschia amphibia	28	0.5	2,733	0.3	diatom
11	Asterionella formosa	14	0.2	3,132	0.4	diatom
12	Rhoicosphenia curvata	14	0.2	1,666	0.2	diatom
13	Fragilaria capucina mesolepta	14	0.2	3,630	0.4	diatom
14	Ankistrodesmus falcatus	14	0.2	356	0.0	green
15	Gomphonema subclavatum	14	0.2	8,542	1.0	diatom

Microcystis aeruginosa cells/mL = 64,404

Aphanizomenon flos-aquae cells/mL = 1,893
Aphanizomenon flos-aquae heterocysts/mL = 14

Note: 4X count for toxic species.

Aquatic Analysts

Sample ID: MM04

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 9175
Sample Depth:
Sample Date: 14-Sep-09

Total Density (#/mL): 193,665
Total Biovolume (um^3/mL): 124,783,741
Trophic State Index: 84.7

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	98,159	50.7	100,514,635	80.6	bluegreen
2	Nitzschia palea	76,935	39.7	13,848,353	11.1	diatom
3	Chlamydomonas sp.	5,306	2.7	1,724,412	1.4	green
4	Aphanizomenon flos-aquae	5,306	2.7	6,016,871	4.8	bluegreen
5	Gomphonema subclavatum	2,653	1.4	1,591,765	1.3	diatom
6	Nitzschia frustulum	1,326	0.7	159,176	0.1	diatom
7	Asterionella formosa	1,326	0.7	291,824	0.2	diatom
8	Rhodomonas minuta	1,326	0.7	26,529	0.0	cryptophyte
9	Cocconeis placentula	1,326	0.7	610,176	0.5	diatom

Microcystis aeruginosa cells/mL = 12,564,329

Aphanizomenon flos-aquae cells/mL = 95,506

Note: 4X count for toxic species.

Aquatic Analysts

Sample ID: MM05

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 9176
Sample Depth:
Sample Date: 14-Sep-09

Total Density (#/mL): 3,643
Total Biovolume (um^3/mL): 1,891,708
Trophic State Index: 54.4

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Cocconeis placentula	915	25.1	420,723	22.2	diatom
2	Amphora ovalis	694	19.0	401,043	21.2	diatom
3	Nitzschia palea	410	11.3	73,800	3.9	diatom
4	Nitzschia frustulum	315	8.7	41,631	2.2	diatom
5	Amphora coffeiformes	221	6.1	20,973	1.1	diatom
6	Microcystis aeruginosa	205	5.6	72,160	3.8	bluegreen
7	Aphanizomenon flos-aquae	158	4.3	198,692	10.5	bluegreen
8	Rhodomonas minuta	126	3.5	2,523	0.1	cryptophyte
9	Navicula minuscula	126	3.5	5,677	0.3	diatom
10	Synedra ulna	63	1.7	125,523	6.6	diatom
11	Gomphoneis herculeana	63	1.7	340,615	18.0	diatom
12	Nitzschia amphibia	63	1.7	6,055	0.3	diatom
13	Diatoma vulgare	63	1.7	123,631	6.5	diatom
14	Navicula cryptocephala veneta	63	1.7	5,992	0.3	diatom
15	Cryptomonas erosa	32	0.9	16,400	0.9	cryptophyte
16	Chlamydomonas sp.	32	0.9	10,250	0.5	green
17	Gomphonema angustatum	32	0.9	5,677	0.3	diatom
18	Gomphonema subclavatum	32	0.9	18,923	1.0	diatom
19	Schroderia sp.	32	0.9	1,419	0.1	green

Microcystis aeruginosa cells/mL = 9,020

Aphanizomenon flos-aquae cells/mL = 3,154
Aphanizomenon flos-aquae heterocysts/mL = 16

Note: 4X count for toxic species.

Aquatic Analysts

Sample ID: MM06

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 9180
Sample Depth:
Sample Date: 15-Sep-09

Total Density (#/mL): 7,647
Total Biovolume (um^3/mL): 2,504,913
Trophic State Index: 56.5

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	4,902	64.1	392,174	15.7	bluegreen
2	Aphanizomenon flos-aquae	1,422	18.6	1,791,254	71.5	bluegreen
3	Nitzschia palea	882	11.5	158,830	6.3	diatom
4	Rhodomonas minuta	123	1.6	2,451	0.1	cryptophyte
5	Cryptomonas erosa	98	1.3	50,983	2.0	cryptophyte
6	Chlamydomonas sp.	49	0.6	15,932	0.6	green
7	Schroderia sp.	25	0.3	1,103	0.0	green
8	Synedra rumpens	25	0.3	3,432	0.1	diatom
9	Ulothrix sp.	25	0.3	19,609	0.8	green
10	Ankistrodesmus falcatus	25	0.3	613	0.0	green
11	Sphaerocystis schroeteri	25	0.3	54,904	2.2	green
12	Cocconeis placentula	25	0.3	11,275	0.5	diatom
13	Nitzschia amphibia	25	0.3	2,353	0.1	diatom

Microcystis aeruginosa cells/mL = 49,022

Aphanizomenon flos-aquae cells/mL = 28,433
Aphanizomenon flos-aquae heterocysts/mL = 294

Note: 4X count for toxic species.

Aquatic Analysts

Sample ID: MM10

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 9189
Sample Depth:
Sample Date: 15-Sep-09

Total Density (#/mL): 18,129
Total Biovolume (um^3/mL): 2,675,201
Trophic State Index: 56.9

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	16,408	90.5	1,312,647	49.1	bluegreen
2	Aphanizomenon flos-aquae	920	5.1	1,216,899	45.5	bluegreen
3	Nitzschia palea	445	2.5	80,112	3.0	diatom
4	Rhodomonas minuta	89	0.5	1,780	0.1	cryptophyte
5	Nitzschia amphibia	59	0.3	5,697	0.2	diatom
6	Chlamydomonas sp.	30	0.2	9,643	0.4	green
7	Cocconeis placentula	30	0.2	13,649	0.5	diatom
8	Rhoicosphenia curvata	30	0.2	3,472	0.1	diatom
9	Asterionella formosa	30	0.2	6,528	0.2	diatom
10	Cryptomonas erosa	30	0.2	15,429	0.6	cryptophyte
11	Scenedesmus quadricauda	30	0.2	7,714	0.3	green
12	Cyclotella stelligera	30	0.2	1,632	0.1	diatom

Microcystis aeruginosa cells/mL = 164,081

Aphanizomenon flos-aquae cells/mL = 19,316
Aphanizomenon flos-aquae heterocysts/mL = 119

Note: 4X count for toxic species.

Aquatic Analysts

Sample ID: MM13

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 9204
Sample Depth:
Sample Date: 21-Sep-09

Total Density (#/mL): 18,481
Total Biovolume (um^3/mL): 7,717,636
Trophic State Index: 64.6

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Cocconeis placentula	14,914	80.7	6,860,450	88.9	diatom
2	Navicula minuscula	835	4.5	37,583	0.5	diatom
3	Nitzschia palea	477	2.6	85,905	1.1	diatom
4	Achnanthes hauckiana	358	1.9	17,181	0.2	diatom
5	Nitzschia frustulum	358	1.9	42,952	0.6	diatom
6	Aphanizomenon flos-aquae	262	1.4	214,977	2.8	bluegreen
7	Fragilaria construens	239	1.3	93,541	1.2	diatom
8	Amphora ovalis	239	1.3	137,925	1.8	diatom
9	Amphora coffeiformes	239	1.3	22,669	0.3	diatom
10	Nitzschia acicularis	119	0.6	33,407	0.4	diatom
11	Melosira varians	119	0.6	77,553	1.0	diatom
12	Rhoicosphenia curvata	119	0.6	13,960	0.2	diatom
13	Chlamydomonas sp.	119	0.6	38,776	0.5	green
14	Microcystis aeruginosa	84	0.5	40,757	0.5	bluegreen

Aphanizomenon flos-aquae cells/mL = 3,412

Microcystis aeruginosa cells/mL = 5,095

Note: 4X count for toxic species.

Aquatic Analysts

Sample ID: MM23

Appendix 3

Laboratory Results for Microcystin Analysis.

These results are provided by the EPA Region 9 laboratory for samples collected by PacifiCorp in the vicinity of the Klamath Hydroelectric Project through August 10, 2009.

Results (µg/L) of Microcystin Sampling for Public Health and Water Quality Monitoring in the Klamath Hydroelectric Project during 2009.

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Date	SiteID	Location	RESULT	RL	NOTE
05/24/09	CR01	Copco 0.5 m grab	0.15	0.18	C1, J
05/24/09	CR01	Copco Res near dam	0.14	0.18	C1, J
05/24/09	CR01	Copco 8 m INT sample	0.13	0.18	C1, J
06/24/09	CR01	Copco 8 m INT sample	ND	0.18	U
06/24/09	CR01	Copco 0.5 m grab	0.19	0.18	
07/21/09	CR01	Copco Res near dam	24	18	A2, J
07/21/09	CR01	Copco 0.5 m grab	16	1.8	A2, J
07/21/09	CR01	Copco 8 m INT sample	3.5	1.8	A2, J
08/18/09	CR01	Copco Res near dam	100	18	
08/18/09	CR01	Copco 0.5 m grab	8.9	1.8	
08/18/09	CR01	Copco 8 m INT sample	4.7	1.8	
06/08/09	CRCC	Copco Res Copco Cove	0.18	0.18	
06/22/09	CRCC	Copco Res Copco Cove	0.23	0.18	
07/06/09	CRCC	Copco Res Copco Cove	50	18	
07/20/09	CRCC	Copco Res Copco Cove	2200	1800	A2, A3, J
08/03/09	CRCC	Copco Res Copco Cove	3800	1800	
08/17/09	CRCC	Copco Res Copco Cove	62	18	
08/31/09	CRCC	Copco Res Copco Cove	22000	1800	
06/08/09	CRMC	Copco Res Mallard Cove	1.5	0.18	
06/22/09	CRMC	Copco Res Mallard Cove	ND	0.18	U
07/06/09	CRMC	Copco Res Mallard Cove	0.25	0.18	
07/20/09	CRMC	Copco Res Mallard Cove	8700	1800	A2, J
08/03/09	CRMC	Copco Res Mallard Cove	7500	1800	
08/17/09	CRMC	Copco Res Mallard Cove	2000	180	
08/31/09	CRMC	Copco Res Mallard Cove	1000	180	
05/24/09	IR01	Iron Gate Res near dam	0.15	0.18	C1, J
08/18/09	IR01	Iron Gate Res near dam	7.4	1.8	
06/08/09	IRCC	Iron Gate Camp Creek	0.14	0.18	C1, J
06/22/09	IRCC	Iron Gate Camp Creek	2.5	0.18	
07/06/09	IRCC	Iron Gate Camp Creek	1.1	1.8	C1, J
07/20/09	IRCC	Iron Gate Camp Creek	11	1.8	A2, J
08/03/09	IRCC	Iron Gate Camp Creek	10	1.8	
08/17/09	IRCC	Iron Gate Camp Creek	15	1.8	
08/31/09	IRCC	Iron Gate Camp Creek	150	18	
06/08/09	IRJW	Iron Gate Jay Williams	0.84	0.18	
06/22/09	IRJW	Iron Gate Jay Williams	0.12	0.18	J, C1
07/06/09	IRJW	Iron Gate Jay Williams	7.2	1.8	

07/20/09	IRJW	Iron Gate Jay Williams	220	180	A2, A3, J
08/03/09	IRJW	Iron Gate Jay Williams	1000	180	
08/17/09	IRJW	Iron Gate Jay Williams	160	18	
08/31/09	IRJW	Iron Gate Jay Williams	0.13	0.18	C1, J
05/24/09	KR01	Iron Gate 8 m INT	0.14	0.18	C1, J
05/24/09	KR01	Iron Gate 0.5 m grab	0.13	0.18	C1, J
06/24/09	KR01	Iron Gate 0.5 m grab	0.14	0.18	C1, J
06/24/09	KR01	Iron Gate 8 m INT	0.11	0.18	C1, J
07/21/09	KR01	Iron Gate 0.5 m grab	10	1.8	A2, J
08/18/09	KR01	Iron Gate 0.5 m grab	12	1.8	
08/18/09	KR01	Iron Gate 8 m INT	5.6	1.8	
06/24/09	KR19645	Below Copco 2 powerhouse	ND	0.18	U
07/21/09	KR19645	Below Copco 2 powerhouse	6	1.8	A2, J
06/23/09	KR20642	Abv Shovel creek	ND	0.18	U
08/17/09	KR20642	Abv Shovel creek	0.17	0.18	C1, J
05/25/09	KR22000	Spring Island	0.12	0.18	C1, J
06/23/09	KR22000	Spring Island	0.09	0.18	C1, J
07/22/09	KR22000	Spring Island	ND	0.18	A2, J, U
08/19/09	KR22000	Spring Island	0.26	0.18	
05/25/09	KR22478	JCB reservoir 8.0 m	0.14	0.18	C1, J
05/25/09	KR22478	JCB reservoir 0.5 m	0.11	0.18	C1, J
06/23/09	KR22478	JCB reservoir 0.5 m	ND	0.18	U
06/23/09	KR22478	JCB reservoir 8.0 m	ND	0.18	U
07/22/09	KR22478	JCB reservoir 0.5 m	0.11	0.18	A2, B1, C1, J
07/22/09	KR22478	JCB reservoir 8.0 m	0.09	0.18	A2, B1, C1, J
08/19/09	KR22478	JCB reservoir 0.5 m	0.37	0.18	
08/19/09	KR22478	JCB reservoir 8.0 m	0.24	0.18	
05/25/09	KR22822	Above JCB reservoir	0.14	0.18	C1, J
05/24/09	KRBI	Hatchery bridge	0.12	0.18	C1, J
06/08/09	KRBI	Hatchery bridge	0.14	0.18	C1, J
06/08/09	KRBI	Hatchery bridge	0.12	0.18	C1, J
06/22/09	KRBI	Hatchery bridge	0.09	0.18	J, C1
06/24/09	KRBI	Hatchery bridge-blank	ND	0.18	U
06/24/09	KRBI	Hatchery bridge	0.1	0.18	C1, J
06/24/09	KRBI	Hatchery bridge-dup	0.1	0.18	C1, J
07/06/09	KRBI	Hatchery bridge	2	0.18	
07/06/09	KRBI	Hatchery bridge	0.45	0.18	
07/20/09	KRBI	Hatchery bridge	13	1.8	A2, J
07/21/09	KRBI	Hatchery bridge	1.9	0.18	A2, J
08/03/09	KRBI	Hatchery bridge	1700	1800	C1, J
08/10/09	KRBI	Hatchery bridge	5	1.8	
08/17/09	KRBI	Hatchery bridge	2.0	0.18	
08/18/09	KRBI	Hatchery bridge	ND	0.18	U
08/18/09	KRBI	Hatchery bridge	2.0	0.18	
08/18/09	KRBI	Hatchery bridge	1.3	0.18	
08/24/09	KRBI	Hatchery bridge	8.8	1.8	
08/31/09	KRBI	Hatchery bridge	0.13	0.18	C1, J