TECHNICAL MEMORANDUM

Results of Cyanobacteria and Microcystin Monitoring in the Vicinity of the Klamath Hydroelectric Project: October 13 and 26, 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 October 13 and 26,, 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 October 13 and 26, 2009

Two samples were collected for public health purposes from open water sites in Copco and Iron Gate reservoirs on October 13, and five samples were collected on October 26 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, and to Aquatic Analysts for cyanobacteria species identification and enumeration

The results of cyanobacteria species identification and enumeration are summarized in Table 2; cumulative data are included in Appendix 1. Three cyanobacteria species were observed in these samples; *Aphanizomenon flos-aquae, Microcystis aeruginosa,* and *Anabaena* sp. *Aphanizomenon* was observed at the open water site in Copco reservoir on October 13 and near the shore in Mallard Cove and Copco Cove on October 26. *Aphanizomenon* was not observed in Iron Gate reservoir in these samples. Anabaena sp. was observed at shoreline samples in Copco reservoir, but not at other sites. Cell counts of Aphanizomenon exceeded 100,000 at both shoreline sites in Copco reservoir, and Anabaena exceeded 100,000 cells/mL at Copco Cove. *Microcystis* was observed at all reservoir sites sampled, but exceeded 40,000 cells/mL[2] – by a very small margin – only at Camp Creek in Iron Gate reservoir. No cyanobacteria were observed at the site below Iron Gate dam on October 26. 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 October 14, 2009 are presented in Appendix 3. Results from EPA for microcystin analyses for samples collected on October 26, are not yet available. Results for 111 samples are available to date. Of the 111 samples analyzed, 44 have exceeded the California guideline value of 8 µg/L. No sample prior to July 20 exceeded the guideline value. In July, August, and September 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 October 13 and 26,, 2009.

Date	Sample	Location[1]	Species	Biovolume, µm³/mL	Rank[2]	Cells/mL
10/13/09	KR9218	IR01	*Microcystis aeruginosa*	1,577	7	197
10/13/09	KR9227	CR01	*Microcystis aeruginosa*	97,976	1	12,247
10/13/09	KR9227	CR01	*Aphanizomenon flos-aquae*	274,332	3	4,354
10/26/09	KR9241	CRMC	*Aphanizomenon flos-aquae*	10,654,875	1	169,125
10/26/09	KR9241	CRMC	*Anabaena sp.*	5,606,494	2	82,448
10/26/09	KR9241	CRMC	*Microcystis aeruginosa*	9,020	9	1,128
10/26/09	KR9242	CRCC	*Aphanizomenon flos-aquae*	34,448,922	1	546,808

[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.

10/26/09	KR9242	CRCC	*Anabaena sp.*	13,339,785	2	196,173
10/26/09	KR9242	CRCC	*Microcystis aeruginosa*	3,127,556	3	390,945
10/26/09	KR9243	IRCC	*Microcystis aeruginosa*	324,950	1	40,619
10/26/09	KR9244	IRJW	*Microcystis aeruginosa*	11,465,975	1	1,433,247
10/26/09	KR9245	KRBI	*none*	0	0.0	0

[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 Cyanobacteria 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
10/13/09	KR9227	CR01	*Aphanizomenon flos-aquae*	274,332	3	4,354
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
10/13/09	KR9227	CR01	*Microcystis aeruginosa*	97,976	1	12,247
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
10/26/09	KR9242	CRCC	*Anabaena sp.*	13,339,785	2	196,173
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
10/12/09	KR 9211	CRCC	*Aphanizomenon flos-aquae*	2,768,446,154	1	43,943,590
10/26/09	KR9242	CRCC	*Aphanizomenon flos-aquae*	34,448,922	1	546,808
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
09/28/09	KR9206	CRCC	*Microcystis aeruginosa*	93,669	2	27,164,077
10/12/09	KR 9211	CRCC	*Microcystis aeruginosa*	56,479,077	2	7,059,885
10/26/09	KR9242	CRCC	*Microcystis aeruginosa*	3,127,556	3	390,945
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
10/12/09	KR 9210	CRMC	*Anabaena sp.*	224,674	11	3,304
10/26/09	KR9241	CRMC	*Anabaena sp.*	5,606,494	2	82,448
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
09/28/09	KR9205	CRMC	*Aphanizomenon flos-aquae*	928	8	9,280
10/12/09	KR 9210	CRMC	*Aphanizomenon flos-aquae*	208,154	6	3,304
10/26/09	KR9241	CRMC	*Aphanizomenon flos-aquae*	10,654,875	1	169,125
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
09/28/09	KR9205	CRMC	*Microcystis aeruginosa*	77,951	1	20,267,160
10/12/09	KR 9210	CRMC	*Microcystis aeruginosa*	6,290,872	1	786,359
10/26/09	KR9241	CRMC	*Microcystis aeruginosa*	9,020	9	1,128
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
10/13/09	KR9218	IR01	*Microcystis aeruginosa*	1,577	7	197
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
10/12/09	KR 9212	IRCC	*Aphanizomenon flos-aquae*	161,700	4	2,567
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
09/28/09	KR9207	IRCC	*Microcystis aeruginosa*	41,781	1	501,371
10/12/09	KR 9212	IRCC	*Microcystis aeruginosa*	469,333	1	58,667
10/26/09	KR9243	IRCC	*Microcystis aeruginosa*	324,950	1	40,619
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
09/28/09	KR9208	IRJW	*Aphanizomenon flos-aquae*	221	3	5,969
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
09/28/09	KR9208	IRJW	*Microcystis aeruginosa*	43,405	1	520,861
10/12/09	KR 9213	IRJW	*Microcystis aeruginosa*	82,360,060	1	10,295,008
10/26/09	KR9244	IRJW	*Microcystis aeruginosa*	11,465,975	1	1,433,247
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
09/28/09	KR9209	KRBI	*Microcystis aeruginosa*	179	4	22,371
10/12/09	KR9214	KRBI	*Microcystis aeruginosa*	4,045	6	506

[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 October 13 and 26,, 2009 Public Health Samples.

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 9245
Sample Depth:
Sample Date: 26-Oct-09

Total Density (#/mL): 1,559
Total Biovolume (um^3/mL): 887,448
Trophic State Index: 49.0

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Cocconeis placentula	348	22.3	160,077	18.0	diatom
2	Rhodomonas minuta	125	8.0	2,506	0.3	cryptophyte
3	Fragilaria construens	111	7.1	67,349	7.6	diatom
4	Fragilaria vaucheriae	111	7.1	48,107	5.4	diatom
5	Nitzschia palea	97	6.2	17,539	2.0	diatom
6	Nitzschia frustulum	84	5.4	10,022	1.1	diatom
7	Achnanthes lanceolata	70	4.5	15,033	1.7	diatom
8	Navicula cryptocephala veneta	70	4.5	6,612	0.7	diatom
9	Gomphoneis herculeana	70	4.5	375,833	42.3	diatom
10	Navicula minuscula	56	3.6	2,506	0.3	diatom
11	Nitzschia amphibia	56	3.6	5,345	0.6	diatom
12	Fragilaria construens venter	42	2.7	2,606	0.3	diatom
13	Amphora perpusilla	28	1.8	4,621	0.5	diatom
14	Synedra ulna	28	1.8	55,401	6.2	diatom
15	Amphora coffeiformes	28	1.8	2,645	0.3	diatom
16	Gomphonema angustatum	28	1.8	5,011	0.6	diatom
17	Gomphonema ventricosum	28	1.8	23,664	2.7	diatom
18	Gomphonema subclavatum	28	1.8	16,704	1.9	diatom
19	Cryptomonas erosa	28	1.8	14,477	1.6	cryptophyte
20	Rhoicosphenia curvata	14	0.9	1,629	0.2	diatom
21	Nitzschia communis	14	0.9	626	0.1	diatom
22	Denticula elegans	14	0.9	10,440	1.2	diatom
23	Nitzschia microcephala	14	0.9	1,392	0.2	diatom
24	Asterionella formosa	14	0.9	3,062	0.3	diatom
25	Navicula sp.	14	0.9	2,088	0.2	diatom
26	Diatoma vulgare	14	0.9	27,283	3.1	diatom
27	Chlamydomonas sp.	14	0.9	4,524	0.5	green
28	Ankistrodesmus falcatus	14	0.9	348	0.0	green

Aquatic Analysts

Sample ID: MM53

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 9218
Sample Depth:
Sample Date: 13-Oct-09

Total Density (#/mL): 316
Total Biovolume (um^3/mL): 93,489
Trophic State Index: 32.8

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Nitzschia palea	93	29.4	16,726	17.9	diatom
2	Asterionella formosa	46	14.7	10,221	10.9	diatom
3	Chlamydomonas sp.	23	7.3	7,550	8.1	green
4	Cocconeis placentula	23	7.3	10,686	11.4	diatom
5	Nitzschia amphibia	20	6.3	1,912	2.0	diatom
6	Rhodomonas minuta	20	6.3	398	0.4	cryptophyte
7	Microcystis aeruginosa	11	3.5	1,577	1.7	bluegreen
8	Selenastrum minutum	10	3.1	199	0.2	green
9	Ankistrodesmus falcatus	10	3.1	249	0.3	green
10	Cryptomonas erosa	7	2.1	3,451	3.7	cryptophyte
11	Melosira granulata	7	2.1	23,728	25.4	diatom
12	Gomphonema angustatum	7	2.1	1,195	1.3	diatom
13	Nitzschia frustulum	3	1.0	398	0.4	diatom
14	Nitzschia dissipata	3	1.0	893	1.0	diatom
15	Glenodinium sp.	3	1.0	2,323	2.5	dinoflagellate
16	Staurastrum gracile	3	1.0	1,792	1.9	green
17	Stephanodiscus astraea minutula	3	1.0	1,162	1.2	diatom
18	Rhoicosphenia curvata	3	1.0	2,330	2.5	diatom
19	Cocconeis klamathensis	3	1.0	929	1.0	diatom
20	Sphaerocystis schroeteri	3	1.0	1,858	2.0	green
21	Fragilaria vaucheriae	3	1.0	956	1.0	diatom
22	Fragilaria construens	3	1.0	1,487	1.6	diatom
23	Cyclotella meneghiniana	3	1.0	1,261	1.3	diatom
24	Kephyrion sp.	3	1.0	209	0.2	chrysophyte

Note: 4X count for toxic species.

Microcystis aeruginosa cells/mL = 197

Aquatic Analysts

Sample ID: MM37

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 9227
Sample Depth:
Sample Date: 13-Oct-09

Total Density (#/mL): 1,937
Total Biovolume (um^3/mL): 677,453
Trophic State Index: 47.0

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	875	45.2	97,976	14.5	bluegreen
2	Cryptomonas erosa	343	17.7	178,586	26.4	cryptophyte
3	Aphanizomenon flos-aquae	207	10.7	274,332	40.5	bluegreen
4	Nitzschia palea	162	8.4	29,159	4.3	diatom
5	Chlamydomonas sp.	97	5.0	31,589	4.7	green
6	Rhodomonas minuta	71	3.7	1,426	0.2	cryptophyte
7	Asterionella formosa	39	2.0	8,553	1.3	diatom
8	Ankistrodesmus falcatus	39	2.0	2,138	0.3	green
9	Cyclotella meneghiniana	13	0.7	4,925	0.7	diatom
10	Stephanodiscus hantzschii	13	0.7	1,555	0.2	diatom
11	Fragilaria construens	13	0.7	4,354	0.6	diatom
12	Nitzschia amphibia	13	0.7	1,244	0.2	diatom
13	Navicula rhynchocephala	6	0.3	1,912	0.3	diatom
14	Nitzschia microcephala	6	0.3	648	0.1	diatom
15	Glenodinium sp.	6	0.3	4,536	0.7	dinoflagellate
16	Sphaerocystis schroeteri	6	0.3	1,814	0.3	green
17	Stephanodiscus astraea minutula	6	0.3	2,268	0.3	diatom
18	Melosira granulata	6	0.3	28,511	4.2	diatom
19	Gomphonema angustatum	6	0.3	1,166	0.2	diatom
20	Rhoicosphenia curvata	6	0.3	758	0.1	diatom

Note: 4X count for toxic species.

Microcystis aeruginosa cells/mL = 12,247

Aphanizomenon flos-aquae cells/mL = 4,354

Aquatic Analysts

Sample ID: MM40

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 9241
Sample Depth:
Sample Date: 26-Oct-09

Total Density (#/mL): 12,149
Total Biovolume (um^3/mL): 16,346,805
Trophic State Index: 70.0

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Aphanizomenon flos-aquae	8,456	69.6	10,654,875	65.2	bluegreen
2	Anabaena sp.	3,298	27.1	5,606,494	34.3	bluegreen
3	Nitzschia amphibia	56	0.5	5,412	0.0	diatom
4	Cocconeis placentula	56	0.5	25,933	0.2	diatom
5	Nitzschia frustulum	56	0.5	6,765	0.0	diatom
6	Rhodomonas minuta	56	0.5	1,128	0.0	cryptophyte
7	Rhoicosphenia curvata	56	0.5	6,596	0.0	diatom
8	Cryptomonas erosa	56	0.5	29,315	0.2	cryptophyte
9	Microcystis aeruginosa	28	0.2	9,020	0.1	bluegreen
10	Schroderia sp.	28	0.2	1,268	0.0	green

Aphanizomenon flos-aquae cells/mL = 169,125
Aphanizomenon flos-aquae akinetes/mL = 1,268

Anabaena sp. cells/mL = 82,448

Microcystis aeruginosa cells/mL = 1,128

Note: 4X count for toxic species.

Aquatic Analysts

Sample ID: MM49

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 9242
Sample Depth:
Sample Date: 26-Oct-09

Total Density (#/mL): 41,011
Total Biovolume (um^3/mL): 51,147,606
Trophic State Index: 78.2

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Aphanizomenon flos-aquae	30,378	74.1	34,448,922	67.4	bluegreen
2	Anabaena sp.	8,529	20.8	13,339,785	26.1	bluegreen
3	Microcystis aeruginosa	1,636	4.0	3,127,556	6.1	bluegreen
4	Nitzschia palea	234	0.6	42,062	0.1	diatom
5	Gomphonema subclavatum	117	0.3	70,104	0.1	diatom
6	Fragilaria capucina mesolepta	117	0.3	119,176	0.2	diatom

Aphanizomenon flos-aquae cells/mL = 546,808
Aphanizomenon flos-aquae heterocysts/mL = 351
Aphanizomenon flos-aquae akinetes/mL = 5,725

Anabaena sp. cells/mL = 196,173

Microcystis aeruginosa cells/mL = 390,945

Note: 4X count for toxic species.

Aquatic Analysts

Sample ID: MM50

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 9243
Sample Depth:
Sample Date: 26-Oct-09

Total Density (#/mL): 5,573
Total Biovolume (um^3/mL): 1,135,957
Trophic State Index: 50.8

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	2,901	52.1	324,950	28.6	bluegreen
2	Nitzschia amphibia	661	11.9	76,113	6.7	diatom
3	Fragilaria construens	488	8.8	344,575	30.3	diatom
4	Rhoicosphenia curvata	345	6.2	48,398	4.3	diatom
5	Nitzschia palea	345	6.2	62,048	5.5	diatom
6	Fragilaria construens venter	230	4.1	79,422	7.0	diatom
7	Gomphonema subclavatum	172	3.1	103,414	9.1	diatom
8	Nitzschia frustulum	172	3.1	20,683	1.8	diatom
9	Cocconeis placentula	115	2.1	52,856	4.7	diatom
10	Gomphonema angustatum	86	1.5	15,512	1.4	diatom
11	Achnanthes lanceolata	29	0.5	5,171	0.5	diatom
12	Nitzschia paleacea	29	0.5	2,815	0.2	diatom

Microcystis aeruginosa cells/mL = 40,619

Note: 4X count for toxic species.

Aquatic Analysts **Sample ID:** MM51

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 9244
Sample Depth:
Sample Date: 26-Oct-09

Total Density (#/mL): 143,076
Total Biovolume (um^3/mL): 19,341,493
Trophic State Index: 71.2

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	119,437	83.5	11,465,975	59.3	bluegreen
2	Fragilaria construens	6,843	4.8	3,065,556	15.8	diatom
3	Fragilaria construens venter	4,354	3.0	773,356	4.0	diatom
4	Nitzschia palea	4,354	3.0	783,807	4.1	diatom
5	Cocconeis placentula	3,732	2.6	1,716,910	8.9	diatom
6	Fragilaria capucina mesolepta	1,244	0.9	793,138	4.1	diatom
7	Rhoicosphenia curvata	1,244	0.9	145,564	0.8	diatom
8	Gomphonema angustatum	1,244	0.9	223,945	1.2	diatom
9	Gomphonema subclavatum	622	0.4	373,241	1.9	diatom

Microcystis aeruginosa cells/mL = 1,433,247

Note: 4X count for toxic species.

Aquatic Analysts

Sample ID: MM52

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.

Date	SiteID	Location	RESULT	RL	NOTE	COMMENT
05/24/09	KR19874	Copco 0.5 m grab	0.15	0.18	C1, J	
05/24/09	IR01	Iron Gate Res near dam	0.15	0.18	C1, J	
05/24/09	CR01	Copco Res near dam	0.14	0.18	C1, J	
05/24/09	KR19019	Iron Gate 8 m INT	0.14	0.18	C1, J	
05/24/09	KR19874	Copco 8 m INT sample	0.13	0.18	C1, J	
05/24/09	KR19019	Iron Gate 0.5 m grab	0.13	0.18	C1, J	
05/24/09	KR18973	Hatchery bridge	0.12	0.18	C1, J	
05/25/09	KR22822	Above JCB reservoir	0.14	0.18	C1, J	
05/25/09	KR22478	JCB reservoir 8.0 m	0.14	0.18	C1, J	
05/25/09	KR22000	Spring Island	0.12	0.18	C1, J	
05/25/09	KR22478	JCB reservoir 0.5 m	0.11	0.18	C1, J	
06/08/09	CRMC	Copco Res Mallard Cove	1.5	0.18		
06/08/09	IRJW	Iron Gate Jay Williams	0.84	0.18		
06/08/09	CRCC	Copco Res Copco Cove	0.18	0.18		
06/08/09	KRBI	Hatchery bridge	0.14	0.18	C1, J	
06/08/09	IRCC	Iron Gate Camp Creek	0.14	0.18	C1, J	
06/08/09	KR18973	Hatchery bridge	0.12	0.18	C1, J	
06/22/09	CRMC	Copco Res Mallard Cove	ND	0.18	U	
06/22/09	IRCC	Iron Gate Camp Creek	2.5	0.18		
06/22/09	CRCC	Copco Res Copco Cove	0.23	0.18		
06/22/09	IRJW	Iron Gate Jay Williams	0.12	0.18	J, C1	
06/22/09	KRBI	Hatchery bridge	0.09	0.18	J, C1	
06/23/09	KR20642	Abv Shovel creek	ND	0.18	U	
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	
06/23/09	KR22000	Spring Island	0.09	0.18	C1, J	
06/24/09	KR19645	Below Copco 2 powerhouse	ND	0.18	U	
06/24/09	KR19874	Copco 8 m INT sample	ND	0.18	U	
06/24/09	KR19874	Copco 0.5 m grab	0.19	0.18		
06/24/09	KR19019	Iron Gate 0.5 m grab	0.14	0.18	C1, J	
06/24/09	KR19019	Iron Gate 8 m INT	0.11	0.18	C1, J	
06/24/09	KR18973	Hatchery bridge	0.10	0.18	C1, J	
07/06/09	CRCC	Copco Res Copco Cove	50	18		
07/06/09	IRJW	Iron Gate Jay Williams	7.2	1.8		
07/06/09	KRBI	Hatchery bridge	2.0	0.18		
07/06/09	IRCC	Iron Gate Camp Creek	1.1	1.8	C1, J	
07/06/09	KR18973	Hatchery bridge	0.45	0.18		
07/06/09	CRMC	Copco Res Mallard Cove	0.25	0.18		
07/20/09	CRCC	Copco Res Copco Cove	2,200	1800	A2, A3, J	Cracked lid
07/20/09	CRMC	Copco Res Mallard Cove	8,700	1800	A2, J	
07/20/09	KRBI	Hatchery bridge	13	1.8	A2, J	

07/20/09	IRCC	Iron Gate Camp Creek	11	1.8	A2, J	
07/20/09	IRJW	Iron Gate Jay Williams	220	180	A2, A3, J	
07/21/09	KR19874	Copco 0.5 m grab	16	1.8	A2, J	Cracked lid
07/21/09	CR01	Copco Res near dam	24	18	A2, J	Cracked lid
07/21/09	KR19019	Iron Gate 0.5 m grab	10	1.8	A2, J	Cracked lid
07/21/09	KR19645	Below Copco 2 powerhouse	6.0	1.8	A2, J	Cracked lid
07/21/09	KR19874	Copco 8 m INT sample	3.5	1.8	A2, J	
07/21/09	KR18973	Hatchery bridge	1.9	0.18	A2, J	Cracked lid
07/22/09	KR22000	Spring Island	ND	0.18	A2, J, 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	
08/03/09	CRCC	Copco Res Copco Cove	3,800	1800		
08/03/09	CRMC	Copco Res Mallard Cove	7,500	1800		
08/03/09	KR18973	Hatchery bridge	1,700	1800	C1, J	
08/03/09	IRCC	Iron Gate Camp Creek	10	1.8		
08/03/09	IRJW	Iron Gate Jay Williams	1,000	180		
08/10/09	KRBI	Hatchery bridge	5.0	1.8		
08/17/09	CRCC	Copco Res Copco Cove	62	18		
08/17/09	CRMC	Copco Res Mallard Cove	2,000	180		
08/17/09	IRCC	Iron Gate Camp Creek	15	1.8		
08/17/09	IRJW	Iron Gate Jay Williams	160	18		
08/17/09	KRBI	Hatchery bridge	2.0	0.18		
08/17/09	KR20642	Abv Shovel creek	0.17	0.18	C1, J	
08/18/09	KR19874	Copco 0.5 m grab	8.9	1.8		
08/18/09	CR01	Copco Res near dam	100	18		
08/18/09	KR19019	Iron Gate 0.5 m grab	12	1.8		
08/18/09	IR01	Iron Gate Res near dam	7.4	1.8		
08/18/09	KR19019	Iron Gate 8 m INT	5.6	1.8		
08/18/09	KR19874	Copco 8 m INT sample	4.7	1.8		
08/18/09	KR18973	Hatchery bridge	2.0	0.18		
08/18/09	KR18973	Hatchery bridge	1.3	0.18		
08/19/09	KR22478	JCB reservoir 0.5 m	0.37	0.18		Sampled date/time determined from label
08/19/09	KR22000	Spring Island	0.26	0.18		Sampled date/time determined from label
08/19/09	KR22478	JCB reservoir 8.0 m	0.24	0.18		Sampled time not listed on COC no
08/24/09	KRBI	Hatchery bridge	8.8	1.8		
08/31/09	CRCC	Copco Res Copco Cove	22,000	1800		
08/31/09	CRMC	Copco Res Mallard Cove	1,000	180		
08/31/09	IRCC	Iron Gate Camp Creek	150	18		
08/31/09	KRBI	Hatchery bridge	0.13	0.18	C1, J	
08/31/09	IRJW	Iron Gate Jay Williams	0.13	0.18	C1, J	
09/07/09	KRBI	Hatchery bridge	9.7	1.8		
09/14/09	KR20642	Abv Shovel creek	ND	0.18	U	
09/14/09	CRCC	Copco Res Copco Cove	44,000	18,000		
09/14/09	CRCC	Copco Res Copco Cove	44,000	18,000		
09/14/09	CRMC	Copco Res Mallard Cove	38,000	18,000		
09/14/09	CRMC	Copco Res Mallard Cove	38,000	18,000		
09/14/09	IRJW	Iron Gate Jay Williams	5,300	1,800		
09/14/09	IRJW	Iron Gate Jay Williams	5,300	1,800		
09/14/09	IRCC	Iron Gate Camp Creek	6.0	1.8		
09/14/09	IRCC	Iron Gate Camp Creek	6.0	1.8		
09/14/09	KRBI	Hatchery bridge	4.4	1.8		
09/14/09	KRBI	Hatchery bridge	4.4	1.8		

09/15/09	KR19874	Copco 0.5 m grab	14	1.8	
09/15/09	KR18973	Hatchery bridge	11	1.8	
09/15/09	KR18973	Hatchery bridge	8.7	1.8	
09/15/09	KR19019	Iron Gate 0.5 m grab	11	1.8	
09/15/09	CR01	Surface BGA Sample	15	1.8	
09/15/09	IR01	Surface BGA Sample	13	1.8	
09/15/09	KR19019	Iron Gate 8 m INT	7.6	1.8	
09/15/09	KR19874	Copco 8 m INT sample	6.2	1.8	
09/15/09	KR19645	Below Copco 2 powerhouse	2.0	0.18	
09/16/09	KR22478	JCB reservoir 0.5 m	ND	0.18	U
09/16/09	KR22000	Spring Island	ND	0.18	U
09/16/09	KR22478	JCB reservoir 8.0 m	0.09	0.18	C1, J
09/21/09	KR9204	Hatchery bridge	9.8	1.8	A2, J
09/28/09	KR9206	Copco Res Copco Cove	36,000	18,000	
09/28/09	KR9205	Copco Res Mallard Cove	73,000	18,000	
09/28/09	KR9209	Hatchery bridge	11	1.8	
09/28/09	KR9207	Iron Gate Camp Creek	190	18	
09/28/09	KR9208	Iron Gate Jay Williams	160	18	
10/13/09	KR19874	Copco 0.5 m grab	2.3	0.18	A2, J, Q11
10/13/09	CR01	Surface BGA Sample	1.2	0.18	A2, J, Q11
10/13/09	KR19874	Copco 8 m INT sample	0.69	0.18	A2, J
10/13/09	KR19645	Below Copco 2 powerhouse	1.8	0.18	A2, J, Q11
10/13/09	KR19019	Iron Gate 0.5 m grab	0.93	0.18	A2, J
10/13/09	IR01	Surface BGA Sample	0.39	0.18	A2, J
10/13/09	KR19019	Iron Gate 8 m INT	2.6	0.18	A2, C2, J
10/13/09	KR18973	Hatchery bridge	0.52	0.18	A2, J
10/13/09	KR18973	Hatchery bridge	0.1	0.18	A2, C1, J
10/13/09	KR20642	Abv Shovel creek	0.16	0.18	A2, C1, J
10/14/09	KR22478	JCB reservoir 0.5 m	0.19	0.18	A2, J
10/14/09	KR22478	JCB reservoir 8.0 m	0.2	0.18	A2, J
10/14/09	KR22000	Spring Island	0.24	0.18	A2, J
10/14/09	KR18973	Hatchery bridge	0.6	0.18	A2, J

J The reported result for this analyte should be considered an estimated value.
C1 The reported concentration for this analyte is below the quantitation limit.
B1 The concentration of this analyte found in this sample was less than five times the concentration found in the associated method blank.
A3 The sample was prepped/analyzed past the recommended holding time.
A2 The sample was received above the recommended temperature range.
U Not Detected
NR Not Reported
RE1, RE2, etc: Result is from a sample re-analysis.