TECHNICAL MEMORANDUM

Results of Cyanobacteria and Microcystin Monitoring in the Vicinity of the Klamath Hydroelectric Project: August 18 and 24, 2009

E&S Environmental Chemistry, Inc.

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Date: August 27, 2009

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 August 18 and 24, 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 August 18 and 24, 2009

Three samples were collected for public health purposes on August 18 and 24, 2009. Samples were collected on August 18th from near the dam at the cable line in Cove in Copco reservoir, and from near the dam at the log boom in Iron Gate reservoir, and on August 24th from the Klamath River below Iron Gate dam near the Iron Gate hatchery bridge. Samples were sent to the EPA Region 9 laboratory for analysis for microcystin, and to Aquatic Analysts for cyanobacteria species identification and enumeration. Results for microcystin analyses for samples collected on August 18 and 24 are not yet available.

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 this set of samples. *Anabaena* sp. was observed in samples from the Klamath River below Iron Gate dam. *Anabaena* sp. numbers did not exceed 20,000 cells/mL below Iron Gate dam and *Microcytis* was not present. *Aphanizomenon flos-aquae* and *Microcystis aeruginosa* were observed in samples from near the dams in both Iron Gate and Copco reservoirs. *Aphanizomenon* and *Microcystis* exceeded 40,000 cells/mL in Copco reservoir, but not in Iron Gate reservoir. The concentration of *Aphanizomenon* and *Microcystis* in Copco reservoir near the dam exceeded the relevant guidelines for protection of individuals engaged in water contact recreation.[2]. 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 analysis for microcystin toxin for samples collected on August 18 and 24 are not yet available. Results of microcystin analysis for all sites sampled by sampling entities pursuant to the 2009 AIP Monitoring Plan through July 23, 2009 are presented in Appendix 3. Through July 23, 2009, only one sample out of 149 total samples has exceeded the relevant guideline (8 µg/L) for microcystin. One sample from Copco reservoir (CRCC, 50 µg/L) on July 6 exceeded the guideline.

[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.

Table 2. Summary of cyanobacteria and microcystin public health monitoring results in Copco and Iron Gate Reservoirs on August 3 and August 10, 2009.

Date	Sample	Location[1]	Species	Biovolume, μm^3/mL	Rank[2]	Cells/mL
8/18/2009	KR9141	IR01	*Microcystis aeruginosa*	257,008	1	32,126
8/18/2009	KR9141	IR01	*Aphanizomenon flos-aquae*	1,961,665	2	31,138
8/18/2009	KR9150	CR01	*Microcystis aeruginosa*	3,006,667	1	375,833
8/18/2009	KR9150	CR01	*Aphanizomenon flos-aquae*	7,629,417	2	121,102
8/24/2009	KR9165	KRBI	*Anabaena sp.*	1,211,687	9	17,819

[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
08/18/09	KR9150	CR01	*Microcystis aeruginosa*	3,006,667	1	375,833
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
08/03/09	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
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
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
08/18/09	KR9141	IR01	*Aphanizomenon flos-aquae*	1,961,665	2	31,138
08/18/09	KR9141	IR01	*Microcystis aeruginosa*	257,008	1	32,126
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
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
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
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
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
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

[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
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Date	**Sample**	**Location[1]**	***Species***	**Biovolume, $\mu m^3/mL$**	**Rank[2]**	**Cells/mL**
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06/08/09	KR9060	CRCC	*Anabaena flos-aquae*	1,019,824	2	15,221
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06/08/09	KR9060	CRCC	*Aphanizomenon flos-aquae*	9,471	26	150
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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
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
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
08/18/09	KR9141	IR01	*Aphanizomenon flos-aquae*	1,961,665	2	31,138
08/18/09	KR9141	IR01	*Microcystis aeruginosa*	257,008	1	32,126
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
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
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
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
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
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

[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
[2]Rank = The rank of the species in the sample based on the count of algal units.

Appendix 2

Laboratory Data Sheets for August 18 and August 24, 2009 Public Health Samples.

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 9141
Sample Depth:
Sample Date: 18-Aug-09

Total Density (#/mL): 5,159
Total Biovolume (um^3/mL): 2,433,516
Trophic State Index: 56.3

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	3,213	62.3	257,008	10.6	bluegreen
2	Aphanizomenon flos-aquae	1,297	25.1	1,961,665	80.6	bluegreen
3	Nitzschia palea	432	8.4	77,844	3.2	diatom
4	Cryptomonas erosa	62	1.2	32,126	1.3	cryptophyte
5	Gomphonema angustatum	31	0.6	5,560	0.2	diatom
6	Rhodomonas minuta	31	0.6	618	0.0	cryptophyte
7	Stephanodiscus hantzschii	31	0.6	3,707	0.2	diatom
8	Melosira granulata	31	0.6	84,949	3.5	diatom
9	Chlamydomonas sp.	31	0.6	10,039	0.4	green

Microcystis aeruginosa cells/mL = 32,126

Aphanizomenon flos-aquae cells/mL = 31,138
Aphanizomenon flos-aquae heterocysts/mL = 525

Note: 4X counts for toxic species.

Aquatic Analysts **Sample ID:** ML83

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 9150
Sample Depth:
Sample Date: 18-Aug-09

Total Density (#/mL): 47,188
Total Biovolume (um^3/mL): 12,620,066
Trophic State Index: 68.1

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Microcystis aeruginosa	37,583	79.6	3,006,667	23.8	bluegreen
2	Aphanizomenon flos-aquae	6,055	12.8	7,629,417	60.5	bluegreen
3	Nitzschia palea	1,879	4.0	338,250	2.7	diatom
4	Chlamydomonas sp.	1,253	2.7	407,153	3.2	green
5	Fragilaria crotonensis	313	0.7	1,236,492	9.8	diatom
6	Rhodomonas minuta	104	0.2	2,088	0.0	cryptophyte

Microcystis aeruginosa cells/mL = 375,833

Aphanizomenon flos-aquae cells/mL = 121,102
Aphanizomenon flos-aquae heterocysts/mL = 1,044
Aphanizomenon flos-aquae akinetes/mL = 104

Note: 4X counts for toxic species.

Aquatic Analysts **Sample ID:** ML86

Phytoplankton Sample Analysis

Sample: Klamath Basin
Sample Site: KR 9165
Sample Depth:
Sample Date: 24-Aug-09

Total Density (#/mL): 46,471
Total Biovolume (um^3/mL): 28,696,246
Trophic State Index: 74.1

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Cocconeis placentula	15,918	34.3	7,322,118	25.5	diatom
2	Fragilaria construens	5,306	11.4	4,635,219	16.2	diatom
3	Synedra ulna	3,537	7.6	7,743,051	27.0	diatom
4	Nitzschia frustulum	2,653	5.7	382,024	1.3	diatom
5	Gomphonema subclavatum	2,653	5.7	1,591,765	5.5	diatom
6	Amphora coffeiformes	2,653	5.7	252,029	0.9	diatom
7	Fragilaria construens venter	2,211	4.8	700,376	2.4	diatom
8	Nitzschia capitellata	1,769	3.8	636,706	2.2	diatom
9	Anabaena sp.	1,371	2.9	1,211,687	4.2	bluegreen
10	Amphora ovalis	1,326	2.9	766,700	2.7	diatom
11	Nitzschia palea	1,326	2.9	238,765	0.8	diatom
12	Rhoicosphenia curvata	884	1.9	103,465	0.4	diatom
13	Navicula cryptocephala veneta	884	1.9	84,010	0.3	diatom
14	Achnanthes hauckiana	884	1.9	42,447	0.1	diatom
15	Gomphoneis herculeana	442	1.0	2,387,647	8.3	diatom
16	Rhodomonas minuta	442	1.0	8,843	0.0	cryptophyte
17	Melosira varians	442	1.0	287,402	1.0	diatom
18	Nitzschia paleacea	442	1.0	43,331	0.2	diatom
19	Asterionella formosa	442	1.0	194,549	0.7	diatom
20	Nitzschia microcephala	442	1.0	44,216	0.2	diatom
21	Navicula minuscula	442	1.0	19,897	0.1	diatom

Anabaena sp. cells/mL = 17,819
Anabaena sp. heterocysts/mL = 884
Anabaena sp. akinetes/mL = 177

Note: 4X counts for toxic species.

Aquatic Analysts **Sample ID:** ML95

Appendix 3

Laboratory Results for Microcystin Analysis.

These results are provided by the EPA Region 9 laboratory. The samples were collected by the Bureau of Reclamation, PacifiCorp, Karuk Tribe Department of Natural Resources, and Yurok Tribe Environmental Program. Refer to publications of the sampling entities for information about sample names and site locations

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SAMPLENAME	SAMPDATE	RESULT	RL	UNITS	ANOTE
OR051409-OC	05/14/2009 08:00:00	0.16	0.18	ug/L	C1, J
SA051409-OC	05/14/2009 08:35:00	0.13	0.18	ug/L	C1, J
SV051409-OC	05/14/2009 10:10:00	0.11	0.18	ug/L	C1, J
SC051409-OC	05/14/2009 10:45:00	0.11	0.18	ug/L	C1, J
WA051409-OC	05/14/2009 11:15:00	0.13	0.18	ug/L	C1, J
SH051409-OC	05/14/2009 12:06:00	0.12	0.18	ug/L	C1, J
KR9031	05/23/2009 00:00:00	0.12	0.18	ug/L	C1, J
KR9033	05/23/2009 00:00:00	0.14	0.18	ug/L	C1, J
KR9034	05/23/2009 00:00:00	0.13	0.18	ug/L	C1, J
KR9035	05/23/2009 00:00:00	0.15	0.18	ug/L	C1, J
KR9040	05/23/2009 00:00:00	0.15	0.18	ug/L	C1, J
KR9041	05/23/2009 00:00:00	0.14	0.18	ug/L	C1, J
KR9042	05/23/2009 00:00:00	0.13	0.18	ug/L	C1, J
KR9044	05/23/2009 00:00:00	0.17	0.18	ug/L	C1, J
KR9045	05/23/2009 00:00:00	0.11	0.18	ug/L	C1, J
KR9052	05/23/2009 00:00:00	0.12	0.18	ug/L	C1, J
KR9053	05/23/2009 00:00:00	0.11	0.18	ug/L	C1, J
KR9054	05/24/2009 00:00:00	0.14	0.18	ug/L	C1, J
KR9055	05/24/2009 00:00:00	0.14	0.18	ug/L	C1, J
2009AIP-001	05/27/2009 06:50:00	0.16	0.18	ug/L	C1, J
2009AIP-002	05/27/2009 09:10:00	0.16	0.18	ug/L	C1, J
2009AIP-003	05/27/2009 11:50:00	0.14	0.18	ug/L	C1, J
LES052809	05/28/2009 07:33:00	ND	0.18	ug/L	U
TG052809	05/28/2009 08:20:00	ND	0.18	ug/L	U
SA052809-OC	05/28/2009 08:33:00	0.12	0.18	ug/L	C1, J
HC052809-OC	05/28/2009 09:32:00	0.14	0.18	ug/L	C1, J
SV052809-OC	05/28/2009 10:12:00	0.14	0.18	ug/L	C1, J
TC052809	05/28/2009 10:22:00	ND	0.18	ug/L	U
SC052809-OC	05/28/2009 10:42:00	0.19	0.18	ug/L	
WA052809-OC	05/28/2009 11:13:00	0.12	0.18	ug/L	C1, J
SH052809-OC	05/28/2009 12:11:00	0.16	0.18	ug/L	C1, J
KR9059	06/08/2009 12:40:00	1.5	0.18	ug/L	
KR9060	06/08/2009 13:28:00	0.18	0.18	ug/L	
KR9062	06/08/2009 14:10:00	0.14	0.18	ug/L	C1, J
KR9061	06/08/2009 14:44:00	0.84	0.18	ug/L	
KR9063	06/08/2009 15:07:00	0.14	0.18	ug/L	C1, J
KR9058	06/08/2009 15:43:00	0.12	0.18	ug/L	C1, J
2009AIP-004	06/10/2009 07:30:00	0.16	0.18	ug/L	C1, J
OR061109-OC	06/11/2009 07:50:00	ND	0.18	ug/L	U
OR061109-SG	06/11/2009 07:50:00	0.10	0.18	ug/L	J, C1
LES061109-OC	06/11/2009 07:52:00	ND	0.18	ug/L	U

SA061109-OC	06/11/2009 08:21:00	ND	0.18	ug/L	U
TG061109-OC	06/11/2009 08:35:00	ND	0.18	ug/L	U
TG061109-SG	06/11/2009 08:35:00	ND	0.18	ug/L	U
HC061109-SG	06/11/2009 09:15:00	0.11	0.18	ug/L	J, C1
SV061109-OC	06/11/2009 10:05:00	ND	0.18	ug/L	U
SV061109-SG	06/11/2009 10:05:00	ND	0.18	ug/L	U
SB061109-OC	06/11/2009 10:20:00	ND	0.18	ug/L	U
SD061109-OC	06/11/2009 10:30:00	ND	0.18	ug/L	U
TC061109-OC	06/11/2009 10:34:00	ND	0.18	ug/L	U
SC061109-OC	06/11/2009 10:50:00	0.09	0.18	ug/L	J, C1
BB061109-SG	06/11/2009 11:10:00	ND	0.18	ug/L	U
WE061109-OC	06/11/2009 11:24:00	0.09	0.18	ug/L	C1, J
WE061109-SG	06/11/2009 11:24:00	ND	0.18	ug/L	U
TR061109-OC	06/11/2009 11:40:00	ND	0.18	ug/L	U
IG061109-OC	06/11/2009 12:41:00	ND	0.18	ug/L	U
SH061109-OC	06/11/2009 13:30:00	ND	0.18	ug/L	U
KR9064	06/22/2009 10:56:00	ND	0.18	ug/L	U
KR9065	06/22/2009 11:35:00	0.23	0.18	ug/L	
KR9067	06/22/2009 12:20:00	2.5	0.18	ug/L	
KR9066	06/22/2009 12:54:00	0.12	0.18	ug/L	J, C1
KR9068	06/22/2009 13:18:00	0.09	0.18	ug/L	J, C1
KR9075	06/23/2009 15:52:00	0.09	0.18	ug/L	C1, J
KR9072	06/23/2009 20:15:00	ND	0.18	ug/L	U
KR9071	06/23/2009 20:30:00	ND	0.18	ug/L	U
KR9080	06/24/2009 12:25:00	0.19	0.18	ug/L	
KR9079	06/24/2009 12:30:00	ND	0.18	ug/L	U
KR9086	06/24/2009 14:15:00	0.14	0.18	ug/L	C1, J
KR9085	06/24/2009 14:20:00	0.11	0.18	ug/L	C1, J
KR9076	06/24/2009 15:05:00	ND	0.18	ug/L	U
KR9084	06/24/2009 16:40:00	ND	0.18	ug/L	U
KR9078	06/24/2009 20:30:00	0.10	0.18	ug/L	C1, J
KR9088	06/24/2009 20:30:00	ND	0.18	ug/L	U
KR9093	06/24/2009 20:30:00	0.10	0.18	ug/L	C1, J
LES062509	06/25/2009 07:41:00	ND	0.18	ug/L	U
OR062509-OC	06/25/2009 08:15:00	0.11	0.18	ug/L	C1, J
OR062509-SG	06/25/2009 08:20:00	ND	0.18	ug/L	U
SA062509-OC	06/25/2009 08:52:00	ND	0.18	ug/L	U
TG062509-OC	06/25/2009 08:53:00	ND	0.18	ug/L	U
KBW062509-SG	06/25/2009 09:05:00	ND	0.18	ug/L	U
HC062509-SG	06/25/2009 09:20:00	ND	0.18	ug/L	U
TG062509-SG	06/25/2009 09:40:00	ND	0.18	ug/L	U
HC062509-OC	06/25/2009 10:00:00	ND	0.18	ug/L	U
HC062509-SG	06/25/2009 10:10:00	0.09	0.18	ug/L	C1, J
TC062509	06/25/2009 10:38:00	0.10	0.18	ug/L	J, C1
SV062509-OC	06/25/2009 11:20:00	ND	0.18	ug/L	U
SV062509-SG	06/25/2009 11:20:00	ND	0.18	ug/L	U
WE062509-SG	06/25/2009 11:24:00	ND	0.18	ug/L	U
SD062509-OC	06/25/2009 11:50:00	ND	0.18	ug/L	U
SD062509-SG	06/25/2009 11:50:00	ND	0.18	ug/L	U
SB062509-OC	06/25/2009 12:00:00	ND	0.18	ug/L	U
SC062509-OC	06/25/2009 12:05:00	0.09	0.18	ug/L	C1, J
BB062509-SG	06/25/2009 12:24:00	ND	0.18	ug/L	U

WA062509-OC	06/25/2009 12:35:00	ND	0.18	ug/L	U
SH062509-OC	06/25/2009 14:15:00	ND	0.18	ug/L	U
2009AIP-011	06/30/2009 07:05:00	ND	1.8	ug/L	U
2009AIP-014	06/30/2009 08:40:00	ND	1.8	ug/L	U
2009AIP-015	06/30/2009 09:50:00	ND	1.8	ug/L	U
KR9095	07/06/2009 10:40:00	0.25	0.18	ug/L	
KR9096	07/06/2009 11:40:00	50	18	ug/L	
KR9098	07/06/2009 13:05:00	1.1	1.8	ug/L	C1, J
KR9097	07/06/2009 13:45:00	7.2	1.8	ug/L	
KR9099	07/06/2009 14:20:00	2.0	0.18	ug/L	
KR9094	07/06/2009 14:30:00	0.45	0.18	ug/L	
LES070909	07/09/2009 07:46:00	ND	0.18	ug/L	A2, J, U
OR070909-SG	07/09/2009 07:55:00	ND	0.18	ug/L	A2, J, U
OR070909-OC	07/09/2009 08:00:00	ND	0.18	ug/L	A2, J, U
TG070909-OC	07/09/2009 08:41:00	ND	0.18	ug/L	A2, J, U
TG070909-SG	07/09/2009 08:41:00	ND	0.18	ug/L	A2, J, U
SA070909-OC	07/09/2009 08:45:00	ND	0.18	ug/L	A2, J, U
HC070909-SG	07/09/2009 09:38:00	ND	0.18	ug/L	A2, J, U
SV070909-OC	07/09/2009 10:36:00	0.19	0.18	ug/L	A2, J
TC070909	07/09/2009 10:39:00	ND	0.18	ug/L	A2, J, U
SV070909-SG	07/09/2009 10:40:00	0.14	0.18	ug/L	A2, C1, J
SC070909-OC	07/09/2009 11:08:00	ND	0.18	ug/L	A2, J, U
WE070909-SG	07/09/2009 11:20:00	0.10	0.18	ug/L	A2, C1, J
WE070909-OC	07/09/2009 11:27:00	0.10	0.18	ug/L	A2, C1, J
BB070909-SG	07/09/2009 11:33:00	0.79	0.18	ug/L	A2, J
TR070909	07/09/2009 11:45:00	ND	0.18	ug/L	A2, J, U
WA070909-OC	07/09/2009 11:50:00	0.39	0.18	ug/L	A2, J
IG070909-OC	07/09/2009 12:48:00	1.1	0.18	ug/L	A2, J
SH070909-OC	07/09/2009 14:00:00	ND	0.18	ug/L	A2, J, U
WE071009-OC	07/10/2009 12:42:00	0.14	0.18	ug/L	A2, C1, J
KASR072009-OC	07/20/2009 09:02:00	0.22	0.18	ug/L	A2, J
OR072209-OC	07/22/2009 08:14:00	0.22	0.18	ug/L	A2, J
HC072209-OC	07/22/2009 10:00:00	0.14	0.18	ug/L	A2, C1, J
SV072209-OC	07/22/2009 11:56:00	0.12	0.18	ug/L	A2, C1, J
BB072209-OC	07/22/2009 12:42:00	0.12	0.18	ug/L	A2, C1, J
IB072209-OC	07/22/2009 14:00:00	0.64	0.18	ug/L	A2, J
LES072309-OC	07/23/2009 07:10:00	0.19	0.18	ug/L	A2, J
TG072309-SG	07/23/2009 08:06:00	0.26	0.18	ug/L	A2, J
OR072309-OC	07/23/2009 08:08:00	0.13	0.18	ug/L	A2, C1, J
OR072309-SG	07/23/2009 08:10:00	0.11	0.18	ug/L	A2, C1, J
TG072309-OC	07/23/2009 08:10:00	0.15	0.18	ug/L	A2, C1, J
SA072309-OC	07/23/2009 08:45:00	0.09	0.18	ug/L	A2, C1, J
HOM072309-SG	07/23/2009 09:06:00	0.15	0.18	ug/L	A2, C1, J
KBW072309-SG	07/23/2009 09:30:00	0.12	0.18	ug/L	A2, C1, J
HC072309-OC	07/23/2009 09:45:00	0.16	0.18	ug/L	A2, C1, J
HC072309-SG	07/23/2009 09:50:00	0.72	0.18	ug/L	A2, J
TC072309-OC	07/23/2009 10:24:00	0.16	0.18	ug/L	A2, C1, J
SV072309-OC	07/23/2009 10:45:00	0.18	0.18	ug/L	A2, J
SV072309-SG	07/23/2009 10:50:00	0.56	0.18	ug/L	A2, J
WE072309-SG	07/23/2009 11:12:00	0.30	0.18	ug/L	A2, J
SC072309-OC	07/23/2009 11:25:00	0.12	0.18	ug/L	A2, C1, J
SD072309-SG	07/23/2009 11:25:00	0.31	0.18	ug/L	A2, J

BB072309-SG	07/23/2009 11:47:00	1.8	1.8	ug/L	A2, J
SD072309-OC	07/23/2009 11:50:00	0.15	0.18	ug/L	A2, C1, J
WA072309-OC	07/23/2009 12:05:00	0.17	0.18	ug/L	A2, C1, J
SH072309-OC	07/23/2009 12:50:00	1.0	1.8	ug/L	A2, C1, J