

## TECHNICAL MEMORANDUM

Results of Cyanobacteria and Microcystin Monitoring in the Vicinity of the Klamath Hydroelectric Project: August 17, 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 August 17, 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.<sup>1</sup>
- 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.

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<sup>1</sup> [http://www.waterboards.ca.gov/northcoast/water\\_issues/programs/tmdls/klamath\\_river/](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.

<b>Table 1. Sites of Cyanobacteria and Microcystin Public Health Monitoring in Copco and Iron Gate reservoirs during 2009.</b>		
<b>Location</b>	<b>Approximate River Mile</b>	<b>Site ID</b>
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 17, 2009

Five samples were collected for public health purposes on August 17, 2009. Samples were collected from Mallard Cove and Copco Cove in Copco reservoir, from Jay Williams campground and Camp Creek campground in Iron Gate reservoir, and 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 17 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 Iron Gate reservoir at Camp Creek and in the Klamath River below Iron Gate dam. *Anabaena* sp. numbers exceeded 20,000 cells/mL below Iron Gate dam. *Aphanizomenon flos-aquae* was observed in samples from Copco reservoir at Mallard Cove and Copco Cove, and in Iron Gate reservoir at Camp Creek. *Aphanizomenon* exceeded 40,000 cells/mL at Copco Cove and Mallard Cove.. The concentration of *Aphanizomenon* at other locations did not exceed the relevant guidelines for protection of individuals engaged in water contact recreation.<sup>2</sup>

*Microcystis aeruginosa* was observed in samples collected from all the sites. *Microcystis* has been observed to produce microcystin, a potentially dangerous liver toxin (Codd et al 2005). The abundance of *Microcystis* cells exceeded WHO and California guidelines at all the reservoir sites on August 17,, and could pose a potential health risk to persons or pets engaged in water contact recreation. *Microcystis* cell abundance did not exceed the relevant guidelines on August 17 at the site below Iron Gate dam (KRBI). Laboratory data sheets for phytoplankton are included as Appendix 2. 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 17 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.

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<sup>2</sup>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., "Cyanobacterial 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 <sup>1</sup>	Species	Biovolume, µm <sup>3</sup> /mL	Rank <sup>2</sup>	Cells/mL
08/17/09	DR9177	CRM C	<i>Microcystis aeruginosa</i>	22,253,821	1	2,781,728
			<i>Aphanizomenon flos-aquae</i>	3,790,167	5	60,161
08/17/09	KR9178	CRCC	<i>Microcystis aeruginosa</i>	6,370,968	1	796,371
			<i>Aphanizomenon flos-aquae</i>	15,452,684	2	245,281
08/17/09	KR9179	IRJW	<i>Microcystis aeruginosa</i>	6,402,431	1	800,304
08/17/09	KR9180	IRCC	<i>Anabaena sp.</i>	982,949	17	14,455
			<i>Microcystis aeruginosa</i>	346,923	20	43,365
			<i>Aphanizomenon flos-aquae</i>	127,494	23	2,024
08/17/09	KR9181	KRBI	<i>Anabaena sp.</i>	1,572,790	1	23,129
			<i>Microcystis aeruginosa</i>	20,964	11	2,620

<sup>1</sup>CRM C = 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

<sup>2</sup>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 <sup>1</sup>	Species	Biovolume, µm <sup>3</sup> /mL	Rank <sup>2</sup>	Cells/mL
06/08/09	KR9060	CRCC	<i>Anabaena flos-aquae</i>	1,019,824	2	15,221
06/22/09	KR9065	CRCC	<i>Anabaena flos-aquae</i>	61,364	4	916
06/08/09	KR9060	CRCC	<i>Aphanizomenon flos-aquae</i>	9,471	26	150
06/22/09	KR9065	CRCC	<i>Aphanizomenon flos-aquae</i>	1,262,193	1	20,035
07/06/09	KR9096	CRCC	<i>Aphanizomenon flos-aquae</i>	422,813	8	6,711
07/20/09	KR9100	CRCC	<i>Aphanizomenon flos-aquae</i>	799,116	11	12,684
08/03/09	KR9134	CRCC	<i>Aphanizomenon flos-aquae</i>	1,183,875	11	18,792
08/17/09	KR9178	CRCC	<i>Aphanizomenon flos-aquae</i>	15,452,684	2	245,281
08/03/09	KR9134	CRCC	<i>Gloeotrichia echinulata</i>	76,670,000	8	1,127,500
07/06/09	KR9096	CRCC	<i>Microcystis aeruginosa</i>	25,950,397	1	3,243,800
07/20/09	KR9100	CRCC	<i>Microcystis aeruginosa</i>	50,589,145	1	6,323,643
08/03/09	KR9134	CRCC	<i>Microcystis aeruginosa</i>	64,893,889	2	8,111,736
08/17/09	KR9178	CRCC	<i>Microcystis aeruginosa</i>	6,370,968	1	796,371
07/20/09	KR9100	CRCC	<i>Oscillatoria sp.</i>	229,951	20	3,709
06/08/09	KR9059	CRMC	<i>Anabaena flos-aquae</i>	271,627,386	1	4,054,140
06/22/09	KR9064	CRMC	<i>Aphanizomenon flos-aquae</i>	826,007	1	13,111
07/06/09	KR9095	CRMC	<i>Aphanizomenon flos-aquae</i>	7,941	13	126
07/20/09	KR9101	CRMC	<i>Aphanizomenon flos-aquae</i>	191,548	8	3,040
08/17/09	KR9177	CRMC	<i>Aphanizomenon flos-aquae</i>	3,790,167	5	60,161
07/06/09	KR9095	CRMC	<i>Microcystis aeruginosa</i>	1,471	26	184
07/20/09	KR9101	CRMC	<i>Microcystis aeruginosa</i>	26,147,865	1	3,268,483
08/03/09	KR9133	CRMC	<i>Microcystis aeruginosa</i>	65,031,611	2	8,128,951
08/17/09	KR9177	CRMC	<i>Microcystis aeruginosa</i>	22,253,821	1	2,781,728
06/08/09	KR9062	IRCC	<i>Anabaena flos-aquae</i>	83,936	2	1,253
06/22/09	KR9067	IRCC	<i>Anabaena flos-aquae</i>	1,303,884	1	19,461
07/06/09	KR9098	IRCC	<i>Anabaena sp.</i>	36,222	8	533
08/17/09	KR9180	IRCC	<i>Anabaena sp.</i>	982,949	17	14,455
06/22/09	KR9067	IRCC	<i>Aphanizomenon flos-aquae</i>	406,734	2	6,456
08/03/09	KR9136	IRCC	<i>Aphanizomenon flos-aquae</i>	617,248	3	9,798
08/17/09	KR9180	IRCC	<i>Aphanizomenon flos-aquae</i>	127,494	23	2,024
07/06/09	KR9098	IRCC	<i>Microcystis aeruginosa</i>	227,276	2	28,409
07/20/09	KR9103	IRCC	<i>Microcystis aeruginosa</i>	320,366	1	40,046
08/03/09	KR9136	IRCC	<i>Microcystis aeruginosa</i>	352,506	1	44,063
08/17/09	KR9180	IRCC	<i>Microcystis aeruginosa</i>	346,923	20	43,365
07/20/09	KR9102	IRJW	<i>Anabaena flos-aquae</i>	112,414	12	1,678
06/08/09	KR9061	IRJW	<i>Anabaena flos-aquae</i>	18,829,827	1	281,042
06/22/09	KR9066	IRJW	<i>Anabaena flos-aquae</i>	22,136	12	330
06/22/09	KR9066	IRJW	<i>Aphanizomenon flos-aquae</i>	272,567	3	4,326

07/06/09	KR9097	IRJW	<i>Aphanizomenon flos-aquae</i>	417,838	13	6,632
07/20/09	KR9102	IRJW	<i>Aphanizomenon flos-aquae</i>	42,281	13	671
07/06/09	KR9097	IRJW	<i>Microcystis aeruginosa</i>	8,312,549	1	1,039,069
07/20/09	KR9102	IRJW	<i>Microcystis aeruginosa</i>	6,550,238	1	818,780
08/03/09	KR9135	IRJW	<i>Microcystis aeruginosa</i>	46,612,848	1	5,826,606
08/17/09	KR9179	IRJW	<i>Microcystis aeruginosa</i>	6,402,431	1	800,304
07/20/09	KR9102	IRJW	<i>Oscillatoria sp.</i>	24,966	14	403
06/08/09	KR9063	KRBI	<i>Anabaena flos-aquae</i>	9,306	27	139
06/22/09	KR9068	KRBI	<i>Anabaena flos-aquae</i>	14,238	10	213
08/17/09	KR9181	KRBI	<i>Anabaena sp.</i>	1,572,790	1	23,129
06/08/09	KR9063	KRBI	<i>Aphanizomenon flos-aquae</i>	12,353	26	196
06/22/09	KR9068	KRBI	<i>Aphanizomenon flos-aquae</i>	83,305	2	1,322
07/06/09	KR9099	KRBI	<i>Aphanizomenon flos-aquae</i>	10,005	20	159
08/03/09	KR9132	KRBI	<i>Aphanizomenon flos-aquae</i>	3,381,592	4	53,676
08/10/09	KR9137	KRBI	<i>Aphanizomenon flos-aquae</i>	179,165	4	2,844
07/06/09	KR9099	KRBI	<i>Microcystis aeruginosa</i>	4,065	21	508
07/20/09	KR9104	KRBI	<i>Microcystis aeruginosa</i>	406,316	1	50,790
08/03/09	KR9132	KRBI	<i>Microcystis aeruginosa</i>	37,431,991	1	4,678,999
08/10/09	KR9137	KRBI	<i>Microcystis aeruginosa</i>	129,268	7	16,158
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<sup>1</sup>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 <sup>1</sup>	Species	Biovolume, $\mu\text{m}^3/\text{mL}$	Rank <sup>2</sup>	Cells/mL
06/08/09	KR9060	CRCC	<i>Anabaena flos-aquae</i>	1,019,824	2	15,221
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06/22/09	KR9065	CRCC	<i>Anabaena flos-aquae</i>	61,364	4	916
06/08/09	KR9060	CRCC	<i>Aphanizomenon flos-aquae</i>	9,471	26	150
06/22/09	KR9065	CRCC	<i>Aphanizomenon flos-aquae</i>	1,262,193	1	20,035
07/06/09	KR9096	CRCC	<i>Aphanizomenon flos-aquae</i>	422,813	8	6,711
07/20/09	KR9100	CRCC	<i>Aphanizomenon flos-aquae</i>	799,116	11	12,684
08/03/09	KR9134	CRCC	<i>Aphanizomenon flos-aquae</i>	1,183,875	11	18,792
08/03/09	KR9134	CRCC	<i>Gloeotrichia echinulata</i>	76,670,000	8	1,127,500
07/06/09	KR9096	CRCC	<i>Microcystis aeruginosa</i>	25,950,397	1	3,243,800
07/20/09	KR9100	CRCC	<i>Microcystis aeruginosa</i>	50,589,145	1	6,323,643
08/03/09	KR9134	CRCC	<i>Microcystis aeruginosa</i>	64,893,889	2	8,111,736
07/20/09	KR9100	CRCC	<i>Oscillatoria sp.</i>	229,951	20	3,709

06/08/09	KR9059	CRMC	<i>Anabaena flos-aquae</i>	271,627,386	1	4,054,140
06/22/09	KR9064	CRMC	<i>Aphanizomenon flos-aquae</i>	826,007	1	13,111
07/06/09	KR9095	CRMC	<i>Aphanizomenon flos-aquae</i>	7,941	13	126
07/20/09	KR9101	CRMC	<i>Aphanizomenon flos-aquae</i>	191,548	8	3,040
07/06/09	KR9095	CRMC	<i>Microcystis aeruginosa</i>	1,471	26	184
07/20/09	KR9101	CRMC	<i>Microcystis aeruginosa</i>	26,147,865	1	3,268,483
08/03/09	KR9133	CRMC	<i>Microcystis aeruginosa</i>	65,031,611	2	8,128,951
06/08/09	KR9062	IRCC	<i>Anabaena flos-aquae</i>	83,936	2	1,253
06/22/09	KR9067	IRCC	<i>Anabaena flos-aquae</i>	1,303,884	1	19,461
07/06/09	KR9098	IRCC	<i>Anabaena sp.</i>	36,222	8	533
06/22/09	KR9067	IRCC	<i>Aphanizomenon flos-aquae</i>	406,734	2	6,456
08/03/09	KR9136	IRCC	<i>Aphanizomenon flos-aquae</i>	617,248	3	9,798
07/06/09	KR9098	IRCC	<i>Microcystis aeruginosa</i>	227,276	2	28,409
07/20/09	KR9103	IRCC	<i>Microcystis aeruginosa</i>	320,366	1	40,046
08/03/09	KR9136	IRCC	<i>Microcystis aeruginosa</i>	352,506	1	44,063
07/20/09	KR9102	IRJW	<i>Anabaena flos-aquae</i>	112,414	12	1,678
06/08/09	KR9061	IRJW	<i>Anabaena flos-aquae</i>	18,829,827	1	281,042
06/22/09	KR9066	IRJW	<i>Anabaena flos-aquae</i>	22,136	12	330
06/22/09	KR9066	IRJW	<i>Aphanizomenon flos-aquae</i>	272,567	3	4,326
07/06/09	KR9097	IRJW	<i>Aphanizomenon flos-aquae</i>	417,838	13	6,632
07/20/09	KR9102	IRJW	<i>Aphanizomenon flos-aquae</i>	42,281	13	671
07/06/09	KR9097	IRJW	<i>Microcystis aeruginosa</i>	8,312,549	1	1,039,069
07/20/09	KR9102	IRJW	<i>Microcystis aeruginosa</i>	6,550,238	1	818,780
08/03/09	KR9135	IRJW	<i>Microcystis aeruginosa</i>	46,612,848	1	5,826,606
07/20/09	KR9102	IRJW	<i>Oscillatoria sp.</i>	24,966	14	403
06/08/09	KR9063	KRBI	<i>Anabaena flos-aquae</i>	9,306	27	139
06/22/09	KR9068	KRBI	<i>Anabaena flos-aquae</i>	14,238	10	213
06/08/09	KR9063	KRBI	<i>Aphanizomenon flos-aquae</i>	12,353	26	196
06/22/09	KR9068	KRBI	<i>Aphanizomenon flos-aquae</i>	83,305	2	1,322
07/06/09	KR9099	KRBI	<i>Aphanizomenon flos-aquae</i>	10,005	20	159
08/03/09	KR9132	KRBI	<i>Aphanizomenon flos-aquae</i>	3,381,592	4	53,676
08/10/09	KR9137	KRBI	<i>Aphanizomenon flos-aquae</i>	179,165	4	2,844
07/06/09	KR9099	KRBI	<i>Microcystis aeruginosa</i>	4,065	21	508
07/20/09	KR9104	KRBI	<i>Microcystis aeruginosa</i>	406,316	1	50,790
08/03/09	KR9132	KRBI	<i>Microcystis aeruginosa</i>	37,431,991	1	4,678,999
08/10/09	KR9137	KRBI	<i>Microcystis aeruginosa</i>	129,268	7	16,158
08/17/09	KR9177	CRMC	<i>Microcystis aeruginosa</i>	22,253,821	1	2,781,728
08/17/09	KR9177	CRMC	<i>Aphanizomenon flos-aquae</i>	3,790,167	5	60,161
08/17/09	KR9178	CRCC	<i>Microcystis aeruginosa</i>	6,370,968	1	796,371
08/17/09	KR9178	CRCC	<i>Aphanizomenon flos-aquae</i>	15,452,684	2	245,281
08/17/09	KR9179	IRJW	<i>Microcystis aeruginosa</i>	6,402,431	1	800,304
08/17/09	KR9180	IRCC	<i>Anabaena sp.</i>	982,949	17	14,455
08/17/09	KR9180	IRCC	<i>Microcystis aeruginosa</i>	346,923	20	43,365
08/17/09	KR9180	IRCC	<i>Aphanizomenon flos-aquae</i>	127,494	23	2,024
08/17/09	KR9181	KRBI	<i>Anabaena sp.</i>	1,572,790	1	23,129
08/17/09	KR9181	KRBI	<i>Microcystis aeruginosa</i>	20,964	11	2,620

<sup>1</sup>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

<sup>2</sup>Rank = The rank of the species in the sample based on the count of algal units.



## Appendix 2

Laboratory Data Sheets for August 3 and August 10, 2009 Public Health Samples.

**Phytoplankton Sample Analysis**

**Sample:** Klamath Basin  
**Sample Site:** KR 9178  
**Sample Depth:**  
**Sample Date:** 17-Aug-09

**Total Density (#/mL):** 41,539  
**Total Biovolume (um<sup>3</sup>/mL):** 23,035,418  
**Trophic State Index:** 72.5

Species	Density #/mL	Density Percent	Biovolume um <sup>3</sup> /mL	Biovolume Percent	Group
1 Microcystis aeruginosa	24,132	58.1	6,370,968	27.7	bluegreen
2 Aphanizomenon flos-aquae	12,264	29.5	15,452,684	67.1	bluegreen
3 Chlamydomonas sp.	2,374	5.7	771,447	3.3	green
4 Nitzschia palea	1,187	2.9	213,632	0.9	diatom
5 Gomphonema angustatum	791	1.9	142,421	0.6	diatom
6 Nitzschia amphibia	396	1.0	37,979	0.2	diatom
7 Rhoicosphenia curvata	396	1.0	46,287	0.2	diatom

Microcystis aeruginosa cells/mL = 796,371  
Aphanizomenon flos-aquae cells/mL = 245,281  
Aphanizomenon flos-aquae heterocysts/mL = 2,057

Note: 4X count for toxic species.

Aquatic Analysts

Sample ID: ML76

**Phytoplankton Sample Analysis**

**Sample:** Klamath Basin  
**Sample Site:** KR 9177  
**Sample Depth:**  
**Sample Date:** 17-Aug-09

**Total Density (#/mL):** 92,135  
**Total Biovolume (um<sup>3</sup>/mL):** 72,119,191  
**Trophic State Index:** 80.7

Species	Density #/mL	Density Percent	Biovolume um <sup>3</sup> /mL	Biovolume Percent	Group
1 Microcystis aeruginosa	48,802	53.0	22,253,821	30.9	bluegreen
2 Nitzschia amphibia	10,097	11.0	969,313	1.3	diatom
3 Nitzschia palea	7,573	8.2	1,363,097	1.9	diatom
4 Gomphoneis herculeana	5,049	5.5	27,261,940	37.8	diatom
5 Aphanizomenon flos-aquae	4,628	5.0	3,790,167	5.3	bluegreen
6 Synedra ulna	4,207	4.6	11,720,951	16.3	diatom
7 Cocconeis placentula	2,524	2.7	1,161,157	1.6	diatom
8 Fragilaria vaucheriae	1,683	1.8	969,313	1.3	diatom
9 Fragilaria construens venter	841	0.9	161,552	0.2	diatom
10 Navicula cryptocephala veneta	841	0.9	79,935	0.1	diatom
11 Nitzschia paleacea	841	0.9	82,459	0.1	diatom
12 Gomphonema subclavatum	841	0.9	504,851	0.7	diatom
13 Chlamydomonas sp.	841	0.9	273,461	0.4	green
14 Fragilaria capucina mesolepta	841	0.9	858,246	1.2	diatom
15 Amphora ovalis	841	0.9	486,340	0.7	diatom
16 Nitzschia microcephala	841	0.9	84,142	0.1	diatom
17 Rhoicosphenia curvata	841	0.9	98,446	0.1	diatom

Microcystis aeruginosa cells/mL = 2,781,728

Aphanizomenon flos-aquae cells/mL = 60,161

Note: 4X count for toxic species.

**Aquatic Analysts**

**Sample ID:** ML75

**Phytoplankton Sample Analysis**

**Sample:** Klamath Basin  
**Sample Site:** KR 9179  
**Sample Depth:**  
**Sample Date:** 17-Aug-09

**Total Density (#/mL):** 92,853  
**Total Biovolume (um<sup>3</sup>/mL):** 10,817,545  
**Trophic State Index:** 67.0

Species	Density #/mL	Density Percent	Biovolume um <sup>3</sup> /mL	Biovolume Percent	Group
1 Microcystis aeruginosa	80,030	86.2	6,402,431	59.2	bluegreen
2 Cocconeis placentula	6,190	6.7	2,847,490	26.3	diatom
3 Fragilaria construens venter	1,769	1.9	356,555	3.3	diatom
4 Nitzschia palea	1,769	1.9	318,353	2.9	diatom
5 Chlamydomonas sp.	884	1.0	287,402	2.7	green
6 Fragilaria vaucheriae	442	0.5	127,341	1.2	diatom
7 Rhocosphenia curvata	442	0.5	51,732	0.5	diatom
8 Synedra rumpens	442	0.5	61,902	0.6	diatom
9 Fragilaria construens	442	0.5	99,043	0.9	diatom
10 Gomphonema subclavatum	442	0.5	265,294	2.5	diatom

Microcystis aeruginosa cells/mL = 800,304

Note: 4X count for toxic species.

Aquatic Analysts

Sample ID: ML77

**Phytoplankton Sample Analysis**

**Sample:** Klamath Basin  
**Sample Site:** KR 9181  
**Sample Depth:**  
**Sample Date:** 17-Aug-09

**Total Density (#/mL):** 8,592  
**Total Biovolume (um<sup>3</sup>/mL):** 6,811,424  
**Trophic State Index:** 63.7

Species	Density #/mL	Density Percent	Biovolume um <sup>3</sup> /mL	Biovolume Percent	Group
1 Anabaena sp.	1,779	20.7	1,572,790	23.1	bluegreen
2 Nitzschia palea	1,310	15.2	235,844	3.5	diatom
3 Gomphonema subclavatum	965	11.2	579,266	8.5	diatom
4 Amphora coffeiformes	759	8.8	72,063	1.1	diatom
5 Cocconeis placentula	690	8.0	317,217	4.7	diatom
6 Gomphoneis herculeana	414	4.8	2,234,312	32.8	diatom
7 Synedra ulna	414	4.8	823,385	12.1	diatom
8 Fragilaria construens	276	3.2	123,577	1.8	diatom
9 Rhoicosphenia curvata	276	3.2	32,273	0.5	diatom
10 Nitzschia frustulum	276	3.2	33,101	0.5	diatom
11 Microcystis aeruginosa	262	3.0	20,964	0.3	bluegreen
12 Amphora ovalis	138	1.6	79,718	1.2	diatom
13 Nitzschia amphibia	138	1.6	13,240	0.2	diatom
14 Chlamydomonas sp.	138	1.6	44,824	0.7	green
15 Diatoma vulgare	138	1.6	270,324	4.0	diatom
16 Cymbella minuta	69	0.8	25,515	0.4	diatom
17 Gomphonema ventricosum	69	0.8	58,616	0.9	diatom
18 Melosira varians	69	0.8	89,648	1.3	diatom
19 Nitzschia capitellata	69	0.8	24,826	0.4	diatom
20 Navicula cryptocephala veneta	69	0.8	6,551	0.1	diatom
21 Cryptomonas erosa	69	0.8	35,859	0.5	cryptophyte
22 Fragilaria construens venter	69	0.8	99,303	1.5	diatom
23 Nitzschia paleacea	69	0.8	6,758	0.1	diatom
24 Amphora perpusilla	69	0.8	11,447	0.2	diatom

Note: 4X count for toxic species.

Anabaena sp. cells/mL = 23,129  
 Anabaena sp. heterocysts/mL = 48  
 Microcystis aeruginosa cells/mL = 2,620

**Aquatic Analysts**

**Sample ID:** ML79

**Phytoplankton Sample Analysis**

**Sample:** Klamath Basin  
**Sample Site:** KR 9180  
**Sample Depth:**  
**Sample Date:** 17-Aug-09

**Total Density (#/mL):** 30,124  
**Total Biovolume (um<sup>3</sup>/mL):** 40,969,245  
**Trophic State Index:** 76.6

Species	Density #/mL	Density Percent	Biovolume um <sup>3</sup> /mL	Biovolume Percent	Group
1 Synedra ulna	10,119	33.6	24,163,192	59.0	diatom
2 Nitzschia amphibia	2,313	7.7	244,234	0.6	diatom
3 Gomphonema subclavatum	2,313	7.7	1,387,692	3.4	diatom
4 Cocconeis placentula	1,735	5.8	797,923	1.9	diatom
5 Nitzschia palea	1,735	5.8	312,231	0.8	diatom
6 Gomphonema augur	1,446	4.8	505,929	1.2	diatom
7 Fragilaria construens venter	1,156	3.8	610,585	1.5	diatom
8 Chlamydomonas sp.	867	2.9	281,875	0.7	green
9 Fragilaria construens	867	2.9	1,068,523	2.6	diatom
10 Gomphonema angustatum	867	2.9	202,950	0.5	diatom
11 Melosira granulata	867	2.9	1,764,971	4.3	diatom
12 Fragilaria capucina mesolepta	578	1.9	1,474,423	3.6	diatom
13 Synedra radians	578	1.9	208,154	0.5	diatom
14 Nitzschia capitellata	578	1.9	208,154	0.5	diatom
15 Nitzschia frustulum	578	1.9	138,769	0.3	diatom
16 Rhoicosphenia curvata	578	1.9	67,650	0.2	diatom
17 Anabaena sp.	578	1.9	982,949	2.4	bluegreen
18 Spirogyra sp.	578	1.9	3,469,231	8.5	green
19 Nitzschia paleacea	578	1.9	113,328	0.3	diatom
20 Microcystis aeruginosa	434	1.4	346,923	0.8	bluegreen
21 Fragilaria crotonensis	289	1.0	2,428,462	5.9	diatom
22 Asterionella formosa	289	1.0	63,603	0.2	diatom
23 Aphanizomenon flos-aquae	202	0.7	127,494	0.3	bluegreen

Note: 4X count for toxic species.

Anabaena sp. cells/mL = 14,455  
 Anabaena sp. heterocysts/mL = 781  
 Aphanizomenon flos-aquae cells/mL = 2,024  
 Microcystis aeruginosa cells/mL = 43,365

**Aquatic Analysts**

**Sample ID:** ML78

## 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

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