

## TECHNICAL MEMORANDUM

Results of Cyanobacteria and Microcystin Monitoring in the Vicinity of the Klamath Hydroelectric Project: October 23<sup>rd</sup>, October 29<sup>th</sup>, and November 4<sup>th</sup>

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**Date:** November 12<sup>th</sup>, 2013



## Introduction

This technical memorandum summarizes the results for the public health monitoring conducted during 2013 for cyanobacteria species and the associated toxin, microcystin, in Copco and Iron Gate reservoirs within PacifiCorp's Klamath Hydroelectric Project (Project) and at 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 and that is known to produce microcystin. This monitoring also estimates the presence of other potentially-toxic cyanobacteria, including *Anabaena* spp., *Planktothrix* (*Oscillatoria*) spp. and others. This monitoring is being conducted pursuant to Interim Measure 15, Water Quality Monitoring Activities, contained in the Klamath Hydroelectric Settlement Agreement (KHSA) executed between the United States Department of Interior, the states of California and Oregon, PacifiCorp, and other parties.

The data summarized in this memorandum also include results the previous 2013 public health sampling events (see Appendix 1).

## Methods

PacifiCorp is conducting phytoplankton sampling at 5 sites (Table 1) for laboratory analysis of potentially toxic cyanobacteria, notably MSAE, and microcystin at:

- Four shoreline sites in coves in Copco and Iron Gate reservoirs (i.e., two cove sites in each reservoir).
- One Klamath River site below Iron Gate Dam near the hatchery bridge.

Samples are planned to be taken at shoreline locations in the reservoirs once in May; and twice per month in June, July, August, September, October, and November. Samples to be collected from the river site below Iron Gate Dam are scheduled to be collected according to the discretion of the sampling entity (PacifiCorp) based on river conditions.

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 (<http://www.kbmp.net/collaboration/klamath-hydroelectric-settlement-agreement-monitoring>). Additional samples, collected at open water sites in Copco and Iron Gate reservoirs, 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.

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Samples for potentially toxic phytoplankton are preserved in Lugol's solution and sent to Aquatic Analysts in Friday Harbor, Washington for analysis. The laboratory analysis of phytoplankton speciation and abundance is performed on prepared microscope slides of filtered samples using phase contrast microscopy. Species are counted as algal units of cell, filament, or colony depending on the natural growth form of the species. Algal forms are identified to species or otherwise to the lowest practicable taxonomic level. 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 0.18 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 measurable microcystin variants.

<b>Location</b>	<b>Approximate River Mile</b>	<b>Site ID</b>
Copco Reservoir at Mallard Cove	201.5	CRMC
Copco Reservoir at Copco Cove	200.0	CRCC
Iron Gate Reservoir at Camp Creek	192.8	IRCC
Iron Gate Reservoir at John Williams campground	192.4	IRJW
Klamath River below Iron Gate dam near hatchery bridge	189.7	KRBI

## Results

Laboratory data sheets for the October 23<sup>rd</sup>, October 29<sup>th</sup>, and November 4<sup>th</sup> are provided in Appendix 2. A summary of these result sheets is contained within Table 2. The cell counts in Copco reservoir remain above California public health posting guidelines<sup>1</sup>. However, public health sampling results in Iron Gate reservoir met the criteria for removing health advisories. Copco and Iron Gate reservoirs were posted with public health advisories on June 18 and June 27, respectively. The health advisory was removed from the Klamath River site (KBRI) in late October.

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<sup>1</sup> The California State Water Resources Control Board provides guidelines for posting advisories in recreation water (SWRCB 2010). SWRCB recommends 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.

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**Table 2.** Summary of public health monitoring for October 23<sup>rd</sup>, October 29<sup>th</sup>, and November 4<sup>th</sup> 2013.

Date	Time	Location	RM	Sample ID	Depth	MSAE <sup>(1)</sup>	AFA <sup>(2)</sup>	ANA <sup>(3)</sup>	Other <sup>(6), (7), (8), (9), or (10)</sup>	Microcystin (µg/L)
10/23/2013	15:20	CRMC	201.5	KR13915	SG	14,432,000	551,812	0	0	18,000
10/23/2013	17:00	CRCC	200.0	KR13916	SG	8,493	0	0	0	6.0
10/23/2013	17:30	IRCC	192.8	KR13917	SG	0	0	0	0	1.2
10/23/2013	17:45	IRJW	192.4	KR13918	SG	0	0	0	0	1.1
10/23/2013	18:00	KRBI	189.7	KR13919	SG	0	0	0	0	0.15
10/29/2013	18:20	CRMC	201.5	KR13922	SG	26,458,667	2,201,732	0	0	5,200
10/29/2013	16:30	CRCC	200.0	KR13923	SG	20,377,000	6,970,000	0	0	440
10/29/2013	15:45	IRCC	192.8	KR13924	SG	177	0	0	0	0.17
10/29/2013	15:30	IRJW	192.4	KR13925	SG	0	0	0	0	0.17
10/29/2013	14:40	KRBI	189.7	KR13926	SG	0	0	0	0	0.20
11/04/2013	11:30	CRMC	201.5	KR13928	SG	0	0	0	0	0.29
11/04/2013	13:20	CRCC	200.0	KR13929	SG	14,099,444	3,674,815	0	0	12
11/04/2013	12:50	IRCC	192.8	KR13930	SG	0	0	0	0	0.36
11/04/2013	12:35	IRJW	192.4	KR13931	SG	0	0	0	0	0.17
11/04/2013	12:15	KRBI	189.7	KR13932	SG	0	0	0	0	ND

<sup>1</sup>MSAE = *Microcystis aeruginosa* (cells/mL)

<sup>2</sup>AFA = *Aphanizomenon flos-aquae* (cells/mL)

<sup>3</sup>ANA = *Anabaena flos-aquae* (cells/mL)

Other = either <sup>5</sup>*Planktothrix (Oscillatoria) sp.* or <sup>6</sup>*Gloeotrichia echinulata* or <sup>7</sup>*Anabaena sp.* or <sup>8</sup>*Lyngbya sp.* (cells/mL) or

<sup>9</sup>*Anabaena circinalis* (cells/mL) or <sup>10</sup>*Anabaena planctonica* (cells/mL)

“0” value indicates non-detect by analytical laboratory

“\*” value indicates results were not available upon the date this memo was submitted and will be included in subsequent memos as availability allows

## References

SWRCB. 2010. Cyanobacteria in California Recreational Water Bodies: Providing Voluntary Guidance about Harmful Algal Blooms, Their Monitoring, and Public Notification. July 2010. 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).

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## Appendix 1 Cumulative Cyanobacteria Species data for 2013 Public Health Samples

**Table 3.** Summary of public health monitoring: 2013

Date	Time	Location	RM	Sample ID	Depth	MSAE <sup>(1)</sup>	AFA <sup>(2)</sup>	ANA <sup>(3)</sup>	Other <sup>(6), (7), (8), (9), or (10)</sup>	Microcystin (µg/L)
5/20/2013	9:40	CRMC	201.5	KR13800	SG	0	0	0	0	ND
5/20/2013	11:15	CRCC	200.0	KR13801	SG	0	0	90	0	ND
5/20/2013	10:45	IRCC	192.8	KR13802	SG	0	0	0	0	ND
5/20/2013	10:30	IRJW	192.4	KR13803	SG	0	0	0	0	ND
5/20/2013	11:20	CRCC <sub>dup</sub>	201.5	KR13804	SG	0	0	0	0	ND
6/06/2013	14:15	CRMC	201.5	KR13805	SG	9,429	0	379,340	0	10
6/06/2013	16:00	CRCC	200.0	KR13806	SG	12,403	0	88,088	0	2.4
6/06/2013	15:30	IRCC	192.8	KR13807	SG	839	0	5,264	0	0.22
6/06/2013	15:15	IRJW	192.4	KR13808	SG	29	0	615	0	0
6/06/2013	15:20	IRJW <sub>dup</sub>	201.5	KR13809	SG	18	0	483	0	0.15
6/20/2013	16:30	CRMC	201.5	KR13811	SG	802,969	4,205	475,179	0	240
6/20/2013	15:45	CRCC	200.0	KR13812	SG	13,903	303	454	0	2.1
6/20/2013	13:05	IRCC	192.8	KR13813	SG	3,679	0	300,667	0	2.6
6/20/2013	12:45	IRJW	192.4	KR13814	SG	61,419	2,967	665,967	14,539	24
6/20/2013	15:45	CRCC <sub>dup</sub>	201.5	KR13815	SG	3,794	0	3,502	0	2.0
7/11/2013	14:35	KRBI	189.7	KR13821	SG	16,443	0	0	0	9.9
7/16/2013	12:20	KRBI	189.7	KR13828	SG	10,585	537	0	0	1.2
7/29/2013	11:15	KRBI	189.7	KR13835	SG	8,093	916	0	72 <sup>(6)</sup>	6.4
7/29/2013	12:40	KRBI	189.7	KR13841	SG	11,615	4,832	0	0	6.6
8/05/2013	14:15	KRBI	189.7	KR13848	SG	15,967	33,451	0	128 <sup>(7)</sup> / 448 <sup>(9)</sup>	4.0
8/13/2013	11:50	KRBI	189.7	KR13855	SG	2,549	20,501	0	784 <sup>(9)</sup>	1.8
8/21/2013	15:00	KRBI	189.7	KR13862	SG	11,227	29,145	141	768 <sup>(7)</sup> / 1,024 <sup>(9)</sup>	3.5
8/26/2013	13:25	KRBI	189.7	KR13869	SG	16,356	22,730	0	1,684 <sup>(7)</sup> / 1,789 <sup>(9)</sup>	5.6
9/02/2013	11:50	KRBI	189.7	KR13876	SG	19,086	25,933	0	1,199 <sup>(9)</sup> / 2,583 <sup>(7)</sup>	6.9
9/10/2013	11:40	KRBI	189.7	KR13883	SG	45,741	12,108	0	1,948 <sup>(7)</sup>	14
9/19/2013	15:00	KRBI	189.7	KR13886	SG	36,080	884	0	295 <sup>(7)</sup>	6.5
9/25/2013	17:00	KRBI	189.7	KR13891	SG	44,155	209	0	472 <sup>(7)</sup>	0.36
9/30/2013	11:40	KRBI	189.7	KR13892	SG	2,190	0	0	0	0.56
10/09/2013	12:50	KRBI	189.7	KR13905	SG	820	0	0	0	1.0
10/14/2013	16:25	KRBI	189.7	KR13913	SG	510	0	0	0	0.21
10/23/2013	15:20	CRMC	201.5	KR13915	SG	14,432,000	551,812	0	0	18,000
10/23/2013	17:00	CRCC	200.0	KR13916	SG	8,493	0	0	0	6.0
10/23/2013	17:30	IRCC	192.8	KR13917	SG	0	0	0	0	1.2
10/23/2013	17:45	IRJW	192.4	KR13918	SG	0	0	0	0	1.1
10/23/2013	18:00	KRBI	189.7	KR13919	SG	0	0	0	0	0.15
10/29/2013	18:20	CRMC	201.5	KR13922	SG	26,458,667	2,201,732	0	0	5,200
10/29/2013	16:30	CRCC	200.0	KR13923	SG	20,377,000	6,970,000	0	0	440
10/29/2013	15:45	IRCC	192.8	KR13924	SG	177	0	0	0	0.17

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10/29/2013	15:30	IRJW	192.4	KR13925	SG	0	0	0	0	0.17
10/29/2013	14:40	KRBI	189.7	KR13926	SG	0	0	0	0	0.20
11/04/2013	11:30	CRMC	201.5	KR13928	SG	0	0	0	0	0.29
11/04/2013	13:20	CRCC	200.0	KR13929	SG	14,099,444	3,674,815	0	0	12
11/04/2013	12:50	IRCC	192.8	KR13930	SG	0	0	0	0	0.36
11/04/2013	12:35	IRJW	192.4	KR13931	SG	0	0	0	0	0.17
11/04/2013	12:15	KRBI	189.7	KR13932	SG	0	0	0	0	ND

<sup>1</sup>MSAE = *Microcystis aeruginosa* (cells/mL)

<sup>2</sup>AFA = *Aphanizomenon flos-aquae* (cells/mL)

<sup>3</sup>ANA = *Anabaena flos-aquae* (cells/mL)

Other = either <sup>5</sup>*Planktothrix (Oscillatoria) sp.* or <sup>6</sup>*Gloeotrichia echinulata* or <sup>7</sup>*Anabaena sp.* or

<sup>8</sup>*Lyngbya sp.* (cells/mL) or <sup>9</sup>*Anabaena circinalis* (cells/mL) or <sup>10</sup>*Anabaena planctonica*

“0” value indicates non-detect by analytical laboratory

“\*” value indicates results were not available upon the date this memo was submitted and will be included in subsequent memos as availability allows

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## Appendix 2

### Laboratory Data Sheets October 29<sup>rd</sup>, October 29<sup>th</sup>, and November 4<sup>th</sup> 2013 Public Health Sampling

Phytoplankton Sample Analysis					
Sample:		Klamath Basin			
Sample Site:		KR 13915			
Sample Depth:					
Sample Date:		23-Oct-13			
Total Density (#/mL):		1,248,651			
Total Biovolume (um <sup>3</sup> /mL):		150,220,141			
Trophic State Index:		86.0			
Species	Density #/mL	Density Percent	Biovolume um <sup>3</sup> /mL	Biovolume Percent	Group
1 Microcystis aeruginosa	1,202,667	96.3	115,456,000	76.9	bluegreen
2 Aphanizomenon flos-aquae	45,984	3.7	34,764,141	23.1	bluegreen
Microcystis aeruginosa cells/mL =		14,432,000			
Aphanizomenon flos-aquae cells/mL =		551,812			
Note: Toxic Algae Only					
Aquatic Analysts			Sample ID: RX03		

Phytoplankton Sample Analysis					
Sample:		Klamath Basin			
Sample Site:		KR 13916			
Sample Depth:					
Sample Date:		23-Oct-13			
Total Density (#/mL):		772			
Total Biovolume (um <sup>3</sup> /mL):		67,946			
Trophic State Index:		30.5			
Species	Density #/mL	Density Percent	Biovolume um <sup>3</sup> /mL	Biovolume Percent	Group
1 Microcystis aeruginosa	772	100.0	67,946	100.0	bluegreen
Microcystis aeruginosa cells/mL =		8,493			
Note: Toxic Algae Only					
Aquatic Analysts			Sample ID: RX04		

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Phytoplankton Sample Analysis					
Sample:		Klamath Basin			
Sample Site:		KR 13917			
Sample Depth:					
Sample Date:		23-Oct-13			
Total Density (#/mL):		<3			
Total Biovolume (um <sup>3</sup> /mL):					
Trophic State Index:					
Species	Density #/mL	Density Percent	Biovolume um <sup>3</sup> /mL	Biovolume Percent	Group
-----					
1 No Toxic Algae Present	<3				
Note: Toxic Algae Only					
Aquatic Analysts			Sample ID: RX05		

Phytoplankton Sample Analysis					
Sample:		Klamath Basin			
Sample Site:		KR 13918			
Sample Depth:					
Sample Date:		23-Oct-13			
Total Density (#/mL):		<3			
Total Biovolume (um <sup>3</sup> /mL):					
Trophic State Index:					
Species	Density #/mL	Density Percent	Biovolume um <sup>3</sup> /mL	Biovolume Percent	Group
-----					
1 No Toxic Algae Present	<3				
Note: Toxic Algae Only					
Aquatic Analysts			Sample ID: RX06		

Phytoplankton Sample Analysis					
Sample:		Klamath Basin			
Sample Site:		KR 13919			
Sample Depth:					
Sample Date:		23-Oct-13			
Total Density (#/mL):		<4			
Total Biovolume (um <sup>3</sup> /mL):					
Trophic State Index:					
Species	Density #/mL	Density Percent	Biovolume um <sup>3</sup> /mL	Biovolume Percent	Group
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1 No Toxic Algae Present	<4				
Note: Toxic Algae Only					
Aquatic Analysts			Sample ID: RX07		

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Phytoplankton Sample Analysis					
Sample:		Klamath Basin			
Sample Site:		KR 13922			
Sample Depth:					
Sample Date:		29-Oct-13			
Total Density (#/mL):		1,312,753			
Total Biovolume (um <sup>3</sup> /mL):		1,684,509,858			
Trophic State Index:		103.4			
Species	Density #/mL	Density Percent	Biovolume um <sup>3</sup> /mL	Biovolume Percent	Group
1 Aphanizomenon flos-aquae	1,202,667	91.6	1,666,896,000	99.0	bluegreen
2 Microcystis aeruginosa	110,087	8.4	17,613,858	1.0	bluegreen
Aphanizomenon flos-aquae cells/mL =		26,458,667			
Microcystis aeruginosa cells/mL =		2,201,732			
Note: Toxic Algae Only					
Aquatic Analysts			Sample ID: RX09		

Phytoplankton Sample Analysis					
Sample:		Klamath Basin			
Sample Site:		KR 13923			
Sample Depth:					
Sample Date:		29-Oct-13			
Total Density (#/mL):		1,380,333			
Total Biovolume (um <sup>3</sup> /mL):		1,339,511,000			
Trophic State Index:		101.8			
Species	Density #/mL	Density Percent	Biovolume um <sup>3</sup> /mL	Biovolume Percent	Group
1 Aphanizomenon flos-aquae	970,333	70.3	1,283,751,000	95.8	bluegreen
2 Microcystis aeruginosa	410,000	29.7	55,760,000	4.2	bluegreen
Aphanizomenon flos-aquae cells/mL =		20,377,000			
Microcystis aeruginosa cells/mL =		6,970,000			
Note: Toxic Algae Only					
Aquatic Analysts			Sample ID: RX10		



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Phytoplankton Sample Analysis					
Sample:		Klamath Basin			
Sample Site:		KR 13924			
Sample Depth:					
Sample Date:		29-Oct-13			
Total Density (#/mL):		2			
Total Biovolume (um <sup>3</sup> /mL):		1,415			
Trophic State Index:		6.4			
Species	Density #/mL	Density Percent	Biovolume um <sup>3</sup> /mL	Biovolume Percent	Group
1 Microcystis aeruginosa	2	100.0	1,415	100.0	bluegreen
Microcystis aeruginosa cells/mL =		177			
Note: Toxic Algae Only					
Aquatic Analysts			Sample ID: RX11		

Phytoplankton Sample Analysis					
Sample:		Klamath Basin			
Sample Site:		KR 13925			
Sample Depth:					
Sample Date:		29-Oct-13			
Total Density (#/mL):		<2			
Total Biovolume (um <sup>3</sup> /mL):					
Trophic State Index:					
Species	Density #/mL	Density Percent	Biovolume um <sup>3</sup> /mL	Biovolume Percent	Group
1 No Toxic Algae Present	<2				
Note: Toxic Algae Only					
Aquatic Analysts			Sample ID: RX12		

Phytoplankton Sample Analysis					
Sample:		Klamath Basin			
Sample Site:		KR 13926			
Sample Depth:					
Sample Date:		29-Oct-13			
Total Density (#/mL):		<2			
Total Biovolume (um <sup>3</sup> /mL):					
Trophic State Index:					
Species	Density #/mL	Density Percent	Biovolume um <sup>3</sup> /mL	Biovolume Percent	Group
1 No Toxic Algae Present	<2				
Note: Toxic Algae Only					
Aquatic Analysts			Sample ID: RX13		

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Phytoplankton Sample Analysis					
Sample:		Klamath Basin			
Sample Site:		KR 13928			
Sample Depth:					
Sample Date:		4-Nov-13			
Total Density (#/mL):		<3			
Total Biovolume (um <sup>3</sup> /mL):					
Trophic State Index:					
Species	Density #/mL	Density Percent	Biovolume um <sup>3</sup> /mL	Biovolume Percent	Group
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1 No Toxic Algae Present	<3				
Note: Toxic Algae Only					
Aquatic Analysts			Sample ID: RX25		

Phytoplankton Sample Analysis					
Sample:		Klamath Basin			
Sample Site:		KR 13929			
Sample Depth:					
Sample Date:		4-Nov-13			
Total Density (#/mL):		1,107,000			
Total Biovolume (um <sup>3</sup> /mL):		344,308,889			
Trophic State Index:		92.0			
Species	Density #/mL	Density Percent	Biovolume um <sup>3</sup> /mL	Biovolume Percent	Group
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1 Microcystis aeruginosa	939,963	84.9	112,795,556	32.8	bluegreen
2 Aphanizomenon flos-aquae	167,037	15.1	231,513,333	67.2	bluegreen
Microcystis aeruginosa cells/mL =		14,099,444			
Aphanizomenon flos-aquae cells/mL =		3,674,815			
Note: Toxic Algae Only					
Aquatic Analysts			Sample ID: RX26		

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Phytoplankton Sample Analysis					
Sample:		Klamath Basin			
Sample Site:		KR 13930			
Sample Depth:					
Sample Date:		4-Nov-13			
Total Density (#/mL):		<17			
Total Biovolume (um <sup>3</sup> /mL):					
Trophic State Index:					
Species	Density #/mL	Density Percent	Biovolume um <sup>3</sup> /mL	Biovolume Percent	Group
1 No Toxic Algae Present	<17				
Note: Toxic Algae Only					
Note: Extreme amount of debris in sample (empty diatom frustules).					
Aquatic Analysts			Sample ID: RX27		

Phytoplankton Sample Analysis					
Sample:		Klamath Basin			
Sample Site:		KR 13931			
Sample Depth:					
Sample Date:		4-Nov-13			
Total Density (#/mL):		<2			
Total Biovolume (um <sup>3</sup> /mL):					
Trophic State Index:					
Species	Density #/mL	Density Percent	Biovolume um <sup>3</sup> /mL	Biovolume Percent	Group
1 No Toxic Algae Present	<2				
Note: Toxic Algae Only					
Aquatic Analysts			Sample ID: RX28		

Phytoplankton Sample Analysis					
Sample:		Klamath Basin			
Sample Site:		KR 13932			
Sample Depth:					
Sample Date:		4-Nov-13			
Total Density (#/mL):		<2			
Total Biovolume (um <sup>3</sup> /mL):					
Trophic State Index:					
Species	Density #/mL	Density Percent	Biovolume um <sup>3</sup> /mL	Biovolume Percent	Group
1 No Toxic Algae Present	<2				
Note: Toxic Algae Only					
Aquatic Analysts			Sample ID: RX29		