

TECHNICAL MEMORANDUM

Results of Cyanobacteria and Microcystin Monitoring in the Vicinity of the Klamath Hydroelectric Project

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Introduction

This technical memorandum summarizes the results for the 2022 public health monitoring for cyanobacteria species and an associated toxin, microcystin, from Upper Klamath Lake and within PacifiCorp's Klamath Hydroelectric Project (Project) from Keno Reservoir to the Klamath River downstream Iron Gate Dam. Microcystin results from 2022 baseline monitoring program are also included in the result summaries below. This monitoring is particularly focused on *Microcystis aeruginosa* (MSAE) which is known to produce microcystin. 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.

Results from the baseline and public health sampling are used in coordination with the appropriate public health authority to determine if public health advisories are warranted^{1,2}. In addition to PacifiCorp's website (<https://www.pacifiCorp.com/energy/hydro/klamath-river.html>), these memos are also posted on the Klamath Basin Monitoring Program's (KBMP) website (www.kbmp.net) and inform the Blue Green Algae tracker on the KBMP website.

The data in Appendix 1 and Appendix 2 summarize results from all of the 2022 public health sampling events to date and microcystin results from the 2022 baseline sampling events, respectively.

Methods

PacifiCorp and the Oregon Department of Environmental Quality (ODEQ) are conducting public health sampling at ten sites (Table 1). Samples are collected and sent for laboratory analysis of potentially toxigenic cyanobacteria, notably MSAE and microcystin, from:

- Three shoreline sites in Upper Klamath Lake, Oregon
- One shoreline site in Keno Reservoir, Oregon

¹ The California State Water Resources Control Board (SWRCB) provides guidelines for posting advisories in recreation water (California SWRCB 2016) for Project waters in California. SWRCB recommends posting advisories in recreation waters at three levels based on laboratory testing for microcystin. The posting levels are Caution, Warning, and Danger at microcystin concentrations of 0.8, 6, and 20 µg/L respectively. Toxin producing cells at concentrations of over 4,000 cells/mL or blooms, scums, or mats would result in posting at the Caution level.

² Postings of Project waters in Oregon are coordinated with the Oregon Health Authority (OHA). The health advisory guideline for recreational use in Oregon waters is microcystin concentrations of 8 µg/L (OHA 2019).

- One shoreline site in J.C. Boyle Reservoir, Oregon
- Four shoreline sites in coves in Copco and Iron Gate reservoirs (i.e., two cove sites in each reservoir), California
- One Klamath River site downstream of Iron Gate Dam near the hatchery bridge, California

Table 1. Sites of cyanobacteria and microcystin public health monitoring in Upper Klamath Lake, Keno Reservoir, J.C Boyle Reservoir, Copco Reservoir, Iron Gate Reservoir, and the Klamath River during 2022.			
Location	Approximate River Mile	Sampling Entity	Site ID
Upper Klamath Lake at Eagle Ridge County Park	N/A	ODEQ	UKEP
Upper Klamath Lake at Howard's Bay Park	N/A	ODEQ	UKHP
Upper Klamath Lake at Moore Park	N/A	ODEQ	UKMP
Keno Reservoir at Keno Park	234.0	ODEQ	KEKP
J.C. Boyle Reservoir at Topsy Campground	225.0	ODEQ	BRTC
Copco Reservoir at Mallard Cove	201.5	PacifiCorp	CRMC
Copco Reservoir at Copco Cove	200.0	PacifiCorp	CRCC
Iron Gate Reservoir at Camp Creek	192.8	PacifiCorp	IRCC
Iron Gate Reservoir at John Williams Campground	192.4	PacifiCorp	IRJW
Klamath River below Iron Gate dam near Hatchery Bridge	189.7	PacifiCorp	KRBI

Samples are planned to be taken once in May, November, and December and twice per month in June, July, August, September, and October.

In addition to public health sampling, monthly and bi-monthly baseline sampling for microcystin is conducted by PacifiCorp from May through October at 12 locations extending from Link River Dam to the Klamath River downstream of Iron Gate Dam (Table 2).

Public health samples are taken as grab samples offshore according to the standard operating procedure (SOP) developed by the Klamath Blue Green Algae Working Group (www.kbmp.net/collaboration/klamath-hydroelectric-settlement-agreement-monitoring).

Samples for determination of microcystin toxin are placed in a cooler on ice and shipped to the U.S. Environmental Protection Agency (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 with a detection limit of 0.10 µg/L and a quantification limit of 0.15 µg/L. 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.

Table 2. Sites of microcystin baseline monitoring from Link River Dam to the Klamath River downstream of Iron Gate reservoir during 2022.

Site Description	Approximate River Mile	Depth (m)	Sampling Entity	Site ID
Link River Dam	254.4	0.5	PacifiCorp	KR25411
Keno Reservoir at Miller Island	246.0	0.5	PacifiCorp	KR24600
Klamath River below Keno Dam near a USGS Gage	231.8	0.5	PacifiCorp	KR23340
Klamath River below JC Boyle Reservoir	224.6	0.5	PacifiCorp	KR22460
Klamath River at USGS Gage	219.5	0.5	PacifiCorp	KR21950
Klamath River above Shovel Creek	206.4	0.5	PacifiCorp	KR20642
Copco Reservoir at Buoy Line (surface)	198.7	0.5	PacifiCorp	KR19874
Copco Reservoir at Buoy Line (integrated)	198.7	0-8	PacifiCorp	KR19874
Klamath River below Copco 2 Reservoir	196.5	0.5	PacifiCorp	KR19645
Iron Gate Reservoir at Log Boom (surface)	190.2	0.5	PacifiCorp	KR19019
Iron Gate Reservoir at Log Boom (integrated)	190.2	0-8	PacifiCorp	KR19019
Klamath River below Hatchery Bridge	189.7	0.5	PacifiCorp	KR18973

Results

All public health samples (Table 3) and baseline microcystin samples (Tables 4 and 5) were collected as planned.

Table 3. Summary of available public health laboratory microcystin results from sampling July and August 2022.

Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth (m)	Microcystin (µg/L)
7/5/2022	11:33	UKEP	N/A	ODEQ	UKEP22004	SG	1.6
7/5/2022	11:59	UKHP	N/A	ODEQ	UKHP22004	SG	0.27
7/5/2022	12:19	UKMP	N/A	ODEQ	UKMP22004	SG	0.11 ^{C1, J}
7/5/2022	10:34	KEKP	234	ODEQ	KEKP22004	SG	0.14 ^{C1, J}
7/5/2022	10:14	BRTC	225	ODEQ	BRTC22004	SG	ND
7/12/2022	15:50	CRMC	201.5	PacifiCorp	KR22815	SG	0.22
7/12/2022	12:15	CRCC	200.0	PacifiCorp	KR22816	SG	360
7/12/2022	13:25	IRCC	192.8	PacifiCorp	KR22817	SG	0.15
7/12/2022	13:40	IRJW	192.4	PacifiCorp	KR22818	SG	0.12 ^{C1, J}
7/12/2022	14:05	KRBI	189.7	PacifiCorp	KR22819	SG	ND
7/20/2022	11:05	UKEP	N/A	ODEQ	UKEP22005	SG	0.44
7/20/2022	11:21	UKHP	N/A	ODEQ	UKHP22005	SG	87
7/20/2022	11:35	UKMP	N/A	ODEQ	UKMP22005	SG	0.13 ^{C1, J}
7/20/2022	10:20	KEKP	234	ODEQ	KEKP22005	SG	0.65
7/20/2022	10:00	BRTC	225	ODEQ	BRTC22005	SG	0.16
7/26/2022	11:15	CRMC	201.5	PacifiCorp	KR22820	SG	1.9
7/26/2022	9:40	CRCC	200.0	PacifiCorp	KR22821	SG	42
7/26/2022	9:05	IRCC	192.8	PacifiCorp	KR22822	SG	1.1 ^{C1, J}
7/26/2022	8:50	IRJW	192.4	PacifiCorp	KR22823	SG	0.20
7/26/2022	12:05	KRBI	189.7	PacifiCorp	KR22824	SG	0.13 ^{C1, J}
8/3/2022	11:11	UKEP	N/A	ODEQ	UKEP22006	SG	0.43

Table 3. Summary of available public health laboratory microcystin results from sampling July and August 2022.

Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth (m)	Microcystin (µg/L)
8/3/2022	11:32	UKHP	N/A	ODEQ	UKHP22006	SG	0.69
8/3/2022	11:52	UKMP	N/A	ODEQ	UKMP22006	SG	0.34
8/3/2022	10:25	KEKP	234	ODEQ	KEKP22006	SG	0.13 ^{C1, J}
8/3/2022	10:10	BRTC	225	ODEQ	BRTC22006	SG	0.13 ^{C1, J}

"C1" indicates the reported concentration for this analyte is below the quantitation limit.
"J" indicates the reported result for this analyte should be considered an estimated value.
"ND" value indicates a result less than the laboratory analytical detection limit (0.1 µg/L)

Table 4. Summary of July 2022 baseline laboratory microcystin results for samples collected in Oregon.

Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth (m)	Microcystin (µg/L)
7/11/2022	18:30	KR21950	219.5	PacifiCorp	KR22092	0.5	0.12 ^{C1, J}
7/11/2022	17:50	KR22460	224.6	PacifiCorp	KR22091	0.5	0.12 ^{C1, J}
7/11/2022	17:05	KR23340	233.4	PacifiCorp	KR22093	0.5	0.21
7/11/2022	16:15	KR24600	246	PacifiCorp	KR22094	0.5	0.16
7/11/2022	14:35	KR25411	254.4	PacifiCorp	KR22090	0.5	0.20
7/11/2022	14:50	KR25411	254.4	PacifiCorp	KR22097	0.5	0.14 ^{C1, J}
7/25/2022	14:35	KR25411	254.4	PacifiCorp	KR22099	0.5	0.20
7/25/2022	14:50	KR25411	254.4	PacifiCorp	KR22103	0.5	0.23

"C1" indicates the reported concentration for this analyte is below the quantitation limit.
"J" indicates the reported result for this analyte should be considered an estimated value.

Table 5. Summary of July 2022 baseline laboratory microcystin results for samples collected in California.

Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth (m)	Microcystin (µg/L)
7/12/2022	14:10	KR18973	189.7	PacifiCorp	KR22076	0.5	ND
7/12/2022	14:20	KR18973	189.7	PacifiCorp	KR22089	0.5	ND
7/12/2022	8:15	KR19019	190.1	PacifiCorp	KR22077	0.5	0.24
7/12/2022	8:35	KR19019	190.1	PacifiCorp	KR22078	0-8	0.16
7/12/2022	12:55	KR19645	196.4	PacifiCorp	KR22081	0.5	0.88
7/12/2022	10:50	KR19874	198.7	PacifiCorp	KR22082	0.5	46
7/12/2022	11:15	KR19874	198.7	PacifiCorp	KR22083	0-8	0.88
7/12/2022	16:20	KR20642	206.4	PacifiCorp	KR22086	0.5	0.12 ^{C1, J}

"ND" value indicates a result less than the laboratory analytical detection limit (0.1 µg/L)
"C1" indicates the reported concentration for this analyte is below the quantitation limit.
"J" indicates the reported result for this analyte should be considered an estimated value.

References

California SWRCB 2016. Draft Statewide Voluntary Guidance on CyanoHABs in Recreational Waters. Available online at:
http://www.mywaterquality.ca.gov/monitoring_council/cyanohab_network/docs/triggers.pdf

Oregon Health Authority. 2019. Oregon Harmful Algal Bloom Surveillance (HABS) Program – Recreational Use Public Health Advisory Guidelines, Cyanobacterial Blooms in Freshwater Bodies. 27 pp. Available online at:
<https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/RECREATION/HARMFULALGAE/BLOOMS/Documents/Advisory-Guidelines-Harmful-Cyanobacterial-Blooms-Recreational-Waters.pdf>

Appendix 1: Cyanobacteria Species and Microcystin Data for 2022 Public Health Samples

Table A1. Summary of available public health laboratory microcystin results from 2022 sampling.							
Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth (m)	Microcystin (µg/L)
5/23/2022	11:33	UKEP	N/A	ODEQ	UKEP22001	SG	0.93 ^{A2, J}
5/23/2022	12:23	UKHP	N/A	ODEQ	UKHP22001	SG	0.10 ^{A2, C1, J}
5/23/2022	12:43	UKMP	N/A	ODEQ	UKMP22001	SG	ND ^{A2, J}
5/23/2022	10:41	KEKP	234	ODEQ	KEKP22001	SG	ND ^{A2, J}
5/23/2022	10:21	BRTC	225	ODEQ	BRTC22001	SG	ND ^{A2, J}
5/24/2022	7:25	CRMC	201.5	PacifiCorp	KR22800	SG	ND
5/24/2022	8:00	CRCC	200.0	PacifiCorp	KR22801	SG	ND
5/24/2022	8:25	IRCC	192.8	PacifiCorp	KR22802	SG	ND
5/24/2022	8:35	IRJW	192.4	PacifiCorp	KR22803	SG	ND
5/24/2022	8:50	KRBI	189.7	PacifiCorp	KR22804	SG	ND
6/6/2022	11:08	UKEP	N/A	ODEQ	UKEP22002	SG	2.2
6/6/2022	11:35	UKHP	N/A	ODEQ	UKHP22002	SG	0.90
6/6/2022	12:08	UKMP	N/A	ODEQ	UKMP22002	SG	0.52
6/6/2022	10:12	KEKP	234	ODEQ	KEKP22002	SG	ND
6/6/2022	9:53	BRTC	225	ODEQ	BRTC22002	SG	0.93
6/7/2022	8:15	CRMC	201.5	PacifiCorp	KR22805	SG	ND
6/7/2022	13:30	CRCC	200.0	PacifiCorp	KR22806	SG	1.4
6/7/2022	14:30	IRCC	192.8	PacifiCorp	KR22807	SG	0.14 ^{C1, J}
6/7/2022	14:45	IRJW	192.4	PacifiCorp	KR22808	SG	ND
6/7/2022	15:05	KRBI	189.7	PacifiCorp	KR22809	SG	ND
6/21/2022	11:25	UKEP	N/A	ODEQ	UKEP22003	SG	61
6/21/2022	11:46	UKHP	N/A	ODEQ	UKHP22003	SG	ND
6/21/2022	12:04	UKMP	N/A	ODEQ	UKMP22003	SG	ND
6/21/2022	10:35	KEKP	234	ODEQ	KEKP22003	SG	0.20
6/21/2022	10:16	BRTC	225	ODEQ	BRTC22003	SG	ND
6/21/2022	9:15	CRMC	201.5	PacifiCorp	KR22810	SG	ND
6/21/2022	10:30	CRCC	200.0	PacifiCorp	KR22811	SG	ND
6/21/2022	11:05	IRCC	192.8	PacifiCorp	KR22812	SG	ND
6/21/2022	11:20	IRJW	192.4	PacifiCorp	KR22813	SG	0.12 ^{C1, J}
6/21/2022	11:35	KRBI	189.7	PacifiCorp	KR22814	SG	ND
7/5/2022	11:33	UKEP	N/A	ODEQ	UKEP22004	SG	1.6
7/5/2022	11:59	UKHP	N/A	ODEQ	UKHP22004	SG	0.27
7/5/2022	12:19	UKMP	N/A	ODEQ	UKMP22004	SG	0.11 ^{C1, J}
7/5/2022	10:34	KEKP	234	ODEQ	KEKP22004	SG	0.14 ^{C1, J}
7/5/2022	10:14	BRTC	225	ODEQ	BRTC22004	SG	ND
7/12/2022	15:50	CRMC	201.5	PacifiCorp	KR22815	SG	0.22
7/12/2022	12:15	CRCC	200.0	PacifiCorp	KR22816	SG	360
7/12/2022	13:25	IRCC	192.8	PacifiCorp	KR22817	SG	0.15
7/12/2022	13:40	IRJW	192.4	PacifiCorp	KR22818	SG	0.12 ^{C1, J}
7/12/2022	14:05	KRBI	189.7	PacifiCorp	KR22819	SG	ND
7/20/2022	11:05	UKEP	N/A	ODEQ	UKEP22005	SG	0.44
7/20/2022	11:21	UKHP	N/A	ODEQ	UKHP22005	SG	87
7/20/2022	11:35	UKMP	N/A	ODEQ	UKMP22005	SG	0.13 ^{C1, J}
7/20/2022	10:20	KEKP	234	ODEQ	KEKP22005	SG	0.65
7/20/2022	10:00	BRTC	225	ODEQ	BRTC22005	SG	0.16

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Table A1 cont.							
Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth (m)	Microcystin (µg/L)
7/26/2022	11:15	CRMC	201.5	PacifiCorp	KR22820	SG	1.9
7/26/2022	9:40	CRCC	200.0	PacifiCorp	KR22821	SG	42
7/26/2022	9:05	IRCC	192.8	PacifiCorp	KR22822	SG	1.1 ^{C1, J}
7/26/2022	8:50	IRJW	192.4	PacifiCorp	KR22823	SG	0.20
7/26/2022	12:05	KRBI	189.7	PacifiCorp	KR22824	SG	0.13 ^{C1, J}
8/3/2022	11:11	UKEP	N/A	ODEQ	UKEP22006	SG	0.43
8/3/2022	11:32	UKHP	N/A	ODEQ	UKHP22006	SG	0.69
8/3/2022	11:52	UKMP	N/A	ODEQ	UKMP22006	SG	0.34
8/3/2022	10:25	KEKP	234	ODEQ	KEKP22006	SG	0.13 ^{C1, J}
8/3/2022	10:10	BRTC	225	ODEQ	BRTC22006	SG	0.13 ^{C1, J}

"ND" value indicates a result less than the laboratory analytical detection limit (0.1 µg/L)

"A2" indicates the sample was received above the recommended temperature range.

"C1" indicates the reported concentration for this analyte is below the quantitation limit.

"J" indicates the reported result for this analyte should be considered an estimated value.

Appendix 2: Microcystin Data for 2022 Baseline Samples

Table A2-1. Summary of 2022 baseline laboratory microcystin results for samples collected in Oregon.

Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth (m)	Microcystin (µg/L)
5/9/2022	18:35	KR21950	219.5	PacifiCorp	KR22038	0.5	ND
5/9/2022	17:30	KR22460	224.6	PacifiCorp	KR22037	0.5	ND
5/9/2022	16:15	KR23340	233.4	PacifiCorp	KR22039	0.5	ND
5/9/2022	15:20	KR24600	246	PacifiCorp	KR22040	0.5	ND
6/6/2022	18:30	KR21950	219.5	PacifiCorp	KR22064	0.5	ND
6/6/2022	17:50	KR22460	224.6	PacifiCorp	KR22063	0.5	ND
6/6/2022	17:15	KR23340	233.4	PacifiCorp	KR22065	0.5	ND
6/6/2022	14:35	KR24600	246	PacifiCorp	KR22066	0.5	ND
7/11/2022	18:30	KR21950	219.5	PacifiCorp	KR22092	0.5	0.12 ^{C1, J}
7/11/2022	17:50	KR22460	224.6	PacifiCorp	KR22091	0.5	0.12 ^{C1, J}
7/11/2022	17:05	KR23340	233.4	PacifiCorp	KR22093	0.5	0.21
7/11/2022	16:15	KR24600	246	PacifiCorp	KR22094	0.5	0.16
7/11/2022	14:35	KR25411	254.4	PacifiCorp	KR22090	0.5	0.20
7/11/2022	14:50	KR25411	254.4	PacifiCorp	KR22097	0.5	0.14 ^{C1, J}
7/25/2022	14:35	KR25411	254.4	PacifiCorp	KR22099	0.5	0.20
7/25/2022	14:50	KR25411	254.4	PacifiCorp	KR22103	0.5	0.23

"ND" value indicates a result less than the laboratory analytical detection limit (0.1 µg/L)

"C1" indicates the reported concentration for this analyte is below the quantitation limit.

"J" indicates the reported result for this analyte should be considered an estimated value.

Table A2-2. Summary of 2022 baseline laboratory microcystin results for samples collected in California.

Date	Time	Site ID	RM	Sampling Entity	Sample ID	Depth (m)	Microcystin (µg/L)
5/10/2022	10:35	KR19019	190.1	PacifiCorp	KR22023	0.5	ND
5/10/2022	10:45	KR19019	190.1	PacifiCorp	KR22024	0-8	ND
5/10/2022	15:00	KR19645	196.4	PacifiCorp	KR22027	0.5	ND
5/10/2022	13:05	KR19874	198.7	PacifiCorp	KR22028	0.5	ND
5/10/2022	13:25	KR19874	198.7	PacifiCorp	KR22029	0-8	ND
5/10/2022	8:50	KR20642	206.4	PacifiCorp	KR22032	0.5	ND
6/7/2022	9:40	KR19019	190.1	PacifiCorp	KR22049	0.5	ND
6/7/2022	9:50	KR19019	190.1	PacifiCorp	KR22050	0-8	ND
6/7/2022	14:05	KR19645	196.4	PacifiCorp	KR22053	0.5	ND
6/7/2022	12:15	KR19874	198.7	PacifiCorp	KR22054	0.5	ND
6/7/2022	12:35	KR19874	198.7	PacifiCorp	KR22055	0-8	ND
6/7/2022	7:40	KR20642	206.4	PacifiCorp	KR22058	0.5	ND
7/12/2022	14:10	KR18973	189.7	PacifiCorp	KR22076	0.5	ND
7/12/2022	14:20	KR18973	189.7	PacifiCorp	KR22089	0.5	ND
7/12/2022	8:15	KR19019	190.1	PacifiCorp	KR22077	0.5	0.24
7/12/2022	8:35	KR19019	190.1	PacifiCorp	KR22078	0-8	0.16
7/12/2022	12:55	KR19645	196.4	PacifiCorp	KR22081	0.5	0.88
7/12/2022	10:50	KR19874	198.7	PacifiCorp	KR22082	0.5	46
7/12/2022	11:15	KR19874	198.7	PacifiCorp	KR22083	0-8	0.88
7/12/2022	16:20	KR20642	206.4	PacifiCorp	KR22086	0.5	0.12 ^{C1, J}

"ND" value indicates a result less than the laboratory analytical detection limit (0.1 µg/L)

"C1" indicates the reported concentration for this analyte is below the quantitation limit.

"J" indicates the reported result for this analyte should be considered an estimated value.