

## 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 2015 public health monitoring for cyanobacteria species and an associated toxin, microcystin, in Copco and Iron Gate reservoirs within PacifiCorp's Klamath Hydroelectric Project (Project) and in the Klamath River below Iron Gate Dam. This monitoring is particularly focused on *Microcystis aeruginosa* (MSAE), which is known to produce microcystin. This monitoring also assesses the presence of other potentially-toxic cyanobacteria, including *Anabaena* sp., 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.

Results from the public health sampling are used to determine if public health advisories are warranted<sup>1</sup>. In addition to PacifiCorp's website ([www.pacificorp.com/es/hydro/hl/kr.html#](http://www.pacificorp.com/es/hydro/hl/kr.html#)), these memos are also posted on the Klamath Basin Monitoring Program's (KBMP) website ([www.kbmp.net](http://www.kbmp.net)) and inform the Blue Green Algae tracker on the KBMP website.

The data in Appendix 1 summarize results from all of the 2015 public health sampling events.

## Methods

PacifiCorp is conducting public health sampling at five 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.

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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 toxic BGA is 100,000 cells/ml or greater, or 4) if microcystin is 8 µg/L or greater.

**Table 1. Sites of cyanobacteria and microcystin public health monitoring in Copco and Iron Gate reservoirs and the Klamath River during 2015.**

| Location   | Approximate River Mile | Site ID |
|--|------------------------|---------|
| 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    |

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](http://www.kbmp.net/collaboration/klamath-hydroelectric-settlement-agreement-monitoring)). Samples collected for potentially toxic phytoplankton are preserved in Lugol's solution and sent to Aquatic Analysts in Friday Harbor, Washington for analysis. The samples are labeled rushed for timely analysis and only potentially toxic cyanobacteria are identified and enumerated. However, once the reservoirs are posted with health advisories signs, the reservoir samples are collected but not rushed until it visually appears that the algae bloom conditions have waned. 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.

## Results

On July 1, 2015, Copco reservoir was posted with health advisories based on the public health sampling results from samples collected at Copco Cove (CRCC) on June 22, 2015, and in accordance with California posting guidelines (SWRCB 2010; see Appendix 1). Samples collected from Iron Gate reservoir on July 21, 2015 at the Camp Creek (IRCC) public health monitoring location had microcystis cell counts of 45,100 cells/mL, which exceed the posting guidelines. Public health samples from both reservoirs will continue to be collected but these samples will not be rushed for analysis since both reservoirs are now posted. Results will be available in the end of the year summary database.

The Oregon Health Authority issued a health advisory for Upper Klamath Lake and Agency Lake on July 28, 2015 and the advisory was extended to Lake Ewauna and Keno Reservoir on July 29, 2015. A health advisory was issued for JC Boyle Reservoir and the Klamath River downstream to the Oregon/California state line by the Oregon Health Authority on August 5, 2015 based on a microcystin result of 470 µg/L on July 20, 2015 from a sample collected in JC Boyle Reservoir. More specific sampling data below JC Boyle Dam was not available at the time the health advisory was extended downstream by the Oregon Health Authority.

Baseline sampling conducted on August 4 and 5, 2015 included samples collected in of JC Boyle Reservoir and the Klamath River downstream. Because of the microcystis bloom going on in Upper Klamath Lake, Keno Reservoir, and JC Boyle Reservoir, PacifiCorp rushed the algae processing of these samples even though they were not technically part of the public health sampling effort. Results indicated

that the JC Boyle Reservoir and the upstream end of the bypass reach immediately downstream of the reservoir continued to exceed the posting guidelines (Table 2). The samples from Klamath River downstream of the JC Boyle Powerhouse and upstream of Copco Reservoir were below the posting guidelines, although with a cell count over 32,000 cells/mL the site at the USGS gage downstream of JC Boyle Powerhouse had cell counts very close to the 40,000 cells/mL posting threshold (Table 2). This information was sent to the Oregon Health Authority and Oregon Department of Environmental Quality on August 10, 2015.

| <b>Table 2. Summary of August 4 and 5, 2015 laboratory algal identification and enumeration.</b> |       |                    |       |           |       |                     |                    |                    |  |                    |
|--|-------|--------------------|-------|-----------|-------|---------------------|--------------------|--------------------|--|--------------------|
| 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), (10), (11), or (12)</sup> | Microcystin (µg/L) |
| 08/04/2015   | 8:10  | Above JC Boyle     | 228.2 | KR15212   | SG    | 66,783              | 0                  | 0                  | 0  | *                  |
| 08/04/2015   | 11:05 | JC Boyle Reservoir | 224.8 | KR15214   | SG    | 1,127,500           | 0                  | 0                  | 76,875 <sup>12</sup>                                     | *                  |
| 08/04/2015   | 11:30 | Below JC Boyle     | 224.6 | KR15211   | SG    | 229,707             | 0                  | 0                  | 1,515 <sup>12</sup>                                      | *                  |
| 08/04/2015   | 10:10 | USGS Gage          | 219.5 | KR15213   | SG    | 32,477              | 0                  | 0                  | 0  | *                  |
| 08/05/2015   | 14:35 | Above Shovel Creek | 206.4 | KR15219   | SG    | 16,729              | 0                  | 0                  | 138 <sup>12</sup>  | *                  |
| 08/05/2015   | 15:00 | CRMC               | 201.5 | KR15824   | SG    | *                   | *                  | *                  | *  | *                  |
| 08/05/2015   | 11:55 | CRCC               | 200.0 | KR15825   | SG    | *                   | *                  | *                  | *  | *                  |
| 08/05/2015   | 10:55 | IRCC               | 192.8 | KR15826   | SG    | *                   | *                  | *                  | *  | *                  |
| 08/05/2015   | 10:40 | IRJW               | 192.4 | KR15827   | SG    | *                   | *                  | *                  | *  | *                  |
| 08/05/2015   | 15:30 | KRBI               | 189.7 | KR15828   | SG    | 13,423              | 224                | 0                  | 0  | *                  |

<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 = Cells/mL of either <sup>5</sup>*Planktothrix (Oscillatoria) sp.*, <sup>6</sup>*Gloetrichia echinulata*, <sup>7</sup>*Anabaena sp.*, <sup>8</sup>*Lyngbya sp.*, <sup>9</sup>*Anabaena circinalis*, <sup>10</sup>*Anabaena planctonica*, <sup>11</sup>*Planktothrix (Oscillatoria) limosa*, or <sup>12</sup>*Pseudanabaena spp.*

“0” value indicates non-detect by analytical laboratory

\* Results were not available upon the date this memo was submitted and will be included in Appendix 1 of subsequent memos

## 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).

# Appendix 1

## Cyanobacteria Species data for 2015 Public Health Samples

**Table 3.** Summary of 2015 laboratory algal identification and enumeration

| 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), (10), (11), or (12)</sup> | Microcystin (µg/L)  |
|--------------------------|-------|--------------------|-------|-----------|-------|---------------------|--------------------|--------------------|--|---------------------|
| 5/18/2015                | 16:00 | CRMC               | 201.5 | KR15800   | SG    | 0                   | 0                  | 0                  | 0  | ND                  |
| 5/18/2015                | 17:00 | CRCC               | 200.0 | KR15801   | SG    | 0                   | 0                  | 0                  | 0  | ND                  |
| 5/18/2015                | 17:40 | IRCC               | 192.8 | KR15802   | SG    | 0                   | 0                  | 0                  | 0  | ND                  |
| 5/18/2015                | 18:05 | IRJW               | 192.4 | KR15803   | SG    | 0                   | 0                  | 0                  | 0  | ND                  |
| 06/08/2015               | 9:00  | CRMC               | 201.5 | KR15804   | SG    | 0                   | 139                | 104                | 0  | .20                 |
| 06/08/2015               | 10:20 | CRCC               | 200.0 | KR15805   | SG    | 0                   | 0                  | 967                | 0  | ND                  |
| 06/08/2015               | 11:00 | IRCC               | 192.8 | KR15806   | SG    | 0                   | 0                  | 841                | 0  | ND                  |
| 06/08/2015               | 11:10 | IRJW               | 192.4 | KR15807   | SG    | 0                   | 0                  | 324                | 1,060 <sup>7</sup>                                       | ND                  |
| 06/08/2015               | 18:30 | KRBI               | 189.7 | KR15808   | SG    | 0                   | 0                  | 163                | 0  | ND                  |
| 06/22/2015               | 10:30 | CRMC               | 201.5 | KR15809   | SG    | 0                   | 0                  | 0                  | 0  | *                   |
| 06/22/2015               | 12:05 | CRCC               | 200.0 | KR15810   | SG    | 2,373,318           | 0                  | 218,262            | 0  | 1,000 <sup>13</sup> |
| 06/22/2015               | 12:29 | IRCC               | 192.8 | KR15811   | SG    | 0                   | 0                  | 18,401             | 0  | ND <sup>13</sup>    |
| 06/22/2015               | 12:40 | IRJW               | 192.4 | KR15812   | SG    | 0                   | 0                  | 678                | 0  | ND <sup>13</sup>    |
| 06/22/2015               | 16:30 | KRBI               | 189.7 | KR15813   | SG    | 0                   | 18                 | 335                | 0  | ND <sup>13</sup>    |
| 07/08/2015               | 14:40 | CRMC               | 201.5 | KR15814   | SG    | *                   | *                  | *                  | *  | 12,000              |
| 07/08/2015               | 12:30 | CRCC               | 200.0 | KR15815   | SG    | *                   | *                  | *                  | *  | 3,300 <sup>14</sup> |
| 07/08/2015               | 11:40 | IRCC               | 192.8 | KR15816   | SG    | 5,315               | 4,905              | 121                | 0  | 0.66                |
| 07/08/2015               | 11:20 | IRJW               | 192.4 | KR15817   | SG    | 841                 | 2,322              | 0                  | 0  | 0.26                |
| 07/08/2015               | 10:35 | KRBI               | 189.7 | KR15818   | SG    | 0                   | 249                | 33                 | 0  | 0.31                |
| 07/21/2015               | 11:25 | CRMC               | 201.5 | KR15819   | SG    | *                   | *                  | *                  | *  | 830                 |
| 07/21/2015               | 13:10 | CRCC               | 200.0 | KR15820   | SG    | *                   | *                  | *                  | *  | 16,000              |
| 07/21/2015               | 13:30 | IRCC               | 192.8 | KR15821   | SG    | 45,100              | 4,997              | 0                  | 324 <sup>6</sup><br>973 <sup>7</sup>                     | 11                  |
| 07/21/2015               | 13:40 | IRJW               | 192.4 | KR15822   | SG    | 13,877              | 10,616             | 0                  | 0  | 3.6                 |
| 07/21/2015               | 14:05 | KRBI               | 189.7 | KR15823   | SG    | 12,916              | 0                  | 0                  | 0  | 5.6                 |
| 08/04/2015 <sup>15</sup> | 8:10  | Above JC Boyle     | 228.2 | KR15212   | SG    | 66,783              | 0                  | 0                  | 0  | *                   |
| 08/04/2015 <sup>15</sup> | 11:05 | JC Boyle Reservoir | 224.8 | KR15214   | SG    | 1,127,500           | 0                  | 0                  | 76,875 <sup>12</sup>                                     | *                   |
| 08/04/2015 <sup>15</sup> | 11:30 | Below JC Boyle     | 224.6 | KR15211   | SG    | 229,707             | 0                  | 0                  | 1,515 <sup>12</sup>                                      | *                   |
| 08/04/2015 <sup>15</sup> | 10:10 | USGS Gage          | 219.5 | KR15213   | SG    | 32,477              | 0                  | 0                  | 0  | *                   |
| 08/05/2015 <sup>15</sup> | 14:35 | Above Shovel Creek | 206.4 | KR15219   | SG    | 16,729              | 0                  | 0                  | 138 <sup>12</sup>  | *                   |
| 08/05/2015               | 15:00 | CRMC               | 201.5 | KR15824   | SG    | *                   | *                  | *                  | *  | *                   |
| 08/05/2015               | 11:55 | CRCC               | 200.0 | KR15825   | SG    | *                   | *                  | *                  | *  | *                   |
| 08/05/2015               | 10:55 | IRCC               | 192.8 | KR15826   | SG    | *                   | *                  | *                  | *  | *                   |
| 08/05/2015               | 10:40 | IRJW               | 192.4 | KR15827   | SG    | *                   | *                  | *                  | *  | *                   |
| 08/05/2015               | 15:30 | KRBI               | 189.7 | KR15828   | SG    | 13,423              | 224                | 0                  | 0  | *                   |

<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 = Cells/mL of either <sup>5</sup>*Planktothrix (Oscillatoria) sp.*, <sup>6</sup>*Gloeotrichia echinulata*, <sup>7</sup>*Anabaena sp.*, <sup>8</sup>*Lyngbya sp.*, <sup>9</sup>*Anabaena circinalis*, <sup>10</sup>*Anabaena planctonica*, <sup>11</sup>*Planktothrix (Oscillatoria) limosa*, or <sup>12</sup>*Pseudanabaena spp.*

<sup>13</sup> The sample was received above the recommended temperature range

<sup>14</sup> The reported concentration for this analyte is above the calibration range of the instrument and should be considered an estimated value

<sup>15</sup> Baseline samples, not part of routine public health sampling protocols. Data reported because of interest in *Microcystis aeruginosa* data at sites upstream of Copco Reservoir.

“0” value indicates non-detect by analytical laboratory

“NA” value indicates sample loss

“ND” value indicates result less than quantitation limit (0.18 µg/L) by analytical laboratory

\* Results were not available upon the date this memo was submitted and will be included in subsequent memos

## Appendix 2 – Laboratory Phytoplankton Results

## Phytoplankton Sample Analysis

**Sample:** Klamath Basin  
**Sample Site:** KR 15211  
**Sample Depth:**  
**Sample Date:** 4-Aug-15 1130

**Total Density (#/mL):** 20,909  
**Total Biovolume ( $\mu\text{m}^3/\text{mL}$ ):** 2,167,997  
**Trophic State Index:** 55.4

|   | <b>Species</b>         | <b>Density<br/>#/mL</b> | <b>Density<br/>Percent</b> | <b>Biovolume<br/><math>\mu\text{m}^3/\text{mL}</math></b> | <b>Biovolume<br/>Percent</b> |
|---|------------------------|-------------------------|----------------------------|---|------------------------------|
| - | -                      | -                       | -                          | -   | -                            |
| 1 | Microcystis aeruginosa | 19,142                  | 91.5                       | 1,837,657   | 84.8                         |
| 2 | Pseudanabaena sp.      | 252                     | 1.2                        | 98,446  | 4.5                          |

Microcystis aeruginosa cells/mL = 229,707

Pseudanabaena sp. cells/mL = 1,515

Note: Toxic algae only

### Phytoplankton Sample Analysis

**Sample:** Klamath Basin  
**Sample Site:** KR 15212  
**Sample Depth:**  
**Sample Date:** 4-Aug-15 810

**Total Density (#/mL):** 8,673  
**Total Biovolume ( $\mu\text{m}^3/\text{mL}$ ):** 1,003,995  
**Trophic State Index:** 49.9

| <b>Species</b>           | <b>Density<br/>#/mL</b> | <b>Density<br/>Percent</b> | <b>Biovolume<br/><math>\mu\text{m}^3/\text{mL}</math></b> | <b>Biovolume<br/>Percent</b> |
|--------------------------|-------------------------|----------------------------|---|------------------------------|
| 1 Microcystis aeruginosa | 6,678                   | 77.0                       | 534,262   | 53.2                         |

Microcystis aeruginosa cells/mL = 66,783

Note: Toxic Algae Only



## Phytoplankton Sample Analysis

**Sample:** Klamath Basin  
**Sample Site:** KR 15213  
**Sample Depth:**  
**Sample Date:** 4-Aug-15 1010

**Total Density (#/mL):** 4,381  
**Total Biovolume ( $\mu\text{m}^3/\text{mL}$ ):** 738,911  
**Trophic State Index:** 47.7

| <b>Species</b>           | <b>Density<br/>#/mL</b> | <b>Density<br/>Percent</b> | <b>Biovolume<br/><math>\mu\text{m}^3/\text{mL}</math></b> | <b>Biovolume<br/>Percent</b> |
|--------------------------|-------------------------|----------------------------|---|------------------------------|
| 1 Microcystis aeruginosa | 3,248                   | 74.1                       | 259,815   | 35.2                         |

Microcystis aeruginosa cells/mL = 32,477

Note: Toxic Algae Only

## Phytoplankton Sample Analysis

**Sample:** Klamath Basin  
**Sample Site:** KR 15214  
**Sample Depth:**  
**Sample Date:** 4-Aug-15 1105

**Total Density (#/mL):** 127,954  
**Total Biovolume (um<sup>3</sup>/mL):** 14,836,704  
**Trophic State Index:** 69.3

| <b>Species</b>           | <b>Density<br/>#/mL</b> | <b>Density<br/>Percent</b> | <b>Biovolume<br/>um<sup>3</sup>/mL</b> | <b>Biovolume<br/>Percent</b> |
|--------------------------|-------------------------|----------------------------|--|------------------------------|
| 1 Microcystis aeruginosa | 112,750                 | 88.1                       | 9,020,000                              | 60.8                         |
| 2 Pseudanabaena sp.      | 12,813                  | 10.0                       | 4,996,875                              | 33.7                         |

Microcystis aeruginosa cells/mL = 1,127,500

Pseudanabaena sp. cells/mL = 76,875

Note: Toxic Algae Only

### Phytoplankton Sample Analysis

Klamath  
**Sample:** Basin  
**Sample Site:** KR 15219  
**Sample Depth:**  
**Sample Date:** 5-Aug-15                      1435

**Total Density (#/mL):**                      3,071  
**Total Biovolume (um<sup>3</sup>/mL):**            490,424  
**Trophic State Index:**                      44.7

| Species                  | Density<br>#/mL | Density<br>Percent | Biovolume<br>um <sup>3</sup> /mL | Biovolume<br>Percent |
|--------------------------|-----------------|--------------------|----------------------------------|----------------------|
| 1 Microcystis aeruginosa | 1,673           | 54.5               | 133,833                          | 27.3                 |
| 2 Pseudanabaena sp.      | 23              | 0.7                | 8,938                            | 1.8                  |

Microcystis aeruginosa cells/mL =            16,729

Pseudanabaena sp. cells/mL =                138

Note: Toxic Algae Only

### Phytoplankton Sample Analysis

Klamath  
**Sample:** Basin  
**Sample Site:** KR 15828  
**Sample Depth:**  
**Sample Date:** 5-Aug-15 1530

**Total Density (#/mL):** 906  
**Total Biovolume (um<sup>3</sup>/mL):** 121,475  
**Trophic State Index:** 34.7

| Species                    | Density<br>#/mL | Density<br>Percent | Biovolume<br>um <sup>3</sup> /mL | Biovolume<br>Percent |
|----------------------------|-----------------|--------------------|----------------------------------|----------------------|
| 1 Microcystis aeruginosa   | 895             | 98.8               | 107,381                          | 88.4                 |
| 2 Aphanizomenon flos-aquae | 11              | 1.2                | 14,094                           | 11.6                 |

Microcystis aeruginosa cells/mL = 13,423

Aphanizomenon flos-aquae cells/mL = 224

Note: Toxic Algae Only