Aquatic Ecosystem Sciences LLC

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Tech Memo

To:	Mike Mader/Jason – TLBP	From:	Jake Kann
Fax:	(503) 731-4077 541-759-3711	Pages:	12
Phone:		Date:	08-28-07
Re:	*Tenmile Sampling*	CC:	Ken Kauffman – OHD

To all concerned,

Aug 22nd, 2007 toxic algal cell count results for Tenmile Lakes are as follows:

Station[1]	Date	*Microcystis* (cells/ml)	*Gloeotrichia* (cells/ml)	Total *Microcystis+ Gloeotrichia*[2]	Total *Anabaena* (cells/ml)
S3	8/22/2007	223	0	223	1179
S8	8/22/2007	113	0	113	4995
N11	8/22/2007	318	0	318	298.3
N16	8/22/2007	464	0	464	2865

[1]See Figure 1 for station location
[2]The combined density of MSAE and GTEC is computed because GTEC is a potential microcystin producer (Carey et al. 2007).

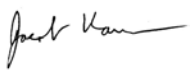
Samples from August 22nd show that cell density of potentially toxigenic cyanobacteria species remained low for *Microcystis aeruginosa* (MSAE), with none of the stations exceeding the WHO Alert Level 1 guideline (500 cells ml^{-1} or increased vigilance level for drinking water systems). Levels of total *Anabaena* (*A. flos-aquae [ABFA]*+ *A. planctonica [ABPL]*) remained similar to the previous sample period at both N16 and S8, exceeding the Alert Level 2 guideline of 2000 cells/ml (at which time DHS and local health services typically provide notification to remind homeowners to follow water treatment guidelines—see Appendix II) (Figure 2). However, as stated in the previous Tech Memo, the predominant species was *Anabaena planctonica* (Appendix I; max 4995 cells/ml at S8), a species less commonly associated with toxin production. Total *Anabaena* decreased at S3, falling below the Alert Level 2 threshold (Figure 2).

Biovolume at all four Tenmile stations continued to be comprised mainly of the cyanobacterium *Anabaena planctonica,* which represented 60.0, 90.4, 37.1, and 79.2 percent of the biovolume at S3, S8, N11, N16. Another cyanobacterium *(Aphanizomenon flos-aquae)* not known to produce cyanotoxins in Oregon comprised 36.2% of the biovolume at S3 (Appendix I). Various Chrysophytes, Cryptophytes, and Diatoms comprised the remainder of the biovolume at all stations.

Given the continued presence of potentially toxigenic cyanobacteria in Tenmile Lakes that exceeded Alert Level 2, and the fact that cyanobacterial cells have been reported in home-owner drinking water treatment systems (see Kann 2007), all drinking water protection efforts should be in place. Levels of all potentially toxic cyanobacteria were well below recreational guidelines.

Please call if you have any questions.

Sincerely,



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Due to the patchy nature of blue-green algal blooms it is possible for higher Microcystis aeruginosa and Anabaena flos-aquae densities (and therefore higher microcystin toxin and anatoxin concentrations to be present in areas not sampled in this survey, particularly along shorelines or during calm conditions of little to no wind. Given the lakes' demonstrated history of toxic blooms, and the fact that all areas of the lake cannot be tested at all times, those utilizing the lake for drinking water should <u>always</u> follow Oregon Health Division recommendations for purification (attached). In addition, recreational users should <u>always</u> avoid contact with water whenever noticeable surface concentrations of algae are evident or when the lake has an obvious green to blue-green appearance. Moreover, because pets or other domestic animals are the most likely to ingest contaminated water, these animals should not be allowed access to the lakeshore whenever either noticeable surface concentrations of algae or an obvious green to blue-green appearance is evident.

References for Alert Levels

Carey, C.C., and J.F. Haney, and K.L. Cottingham. 2007. First report of microcystin-LR in the cyanobacterium *Gloeotrichia echinulata.* Environmental toxicology 22:337-339.

Kann, J. 2007. Tenmile Lakes Toxic Algal Sampling Program: 2006 Data Summary Report. Tenmile Lakes Basin Partnership, Lakeside OR 97520

Falconer et al. 1999. Safe levels and safe practices. Pages 155-177 *in*: I. Chorus and J. Bartram, editors*. Toxic Cyanobacteria in water: a guide to their public health consequences*. World Health Organization Report. E & FN Spon, London and New York.

Yoo, S.R., W.W. Carmichael, R.C. Hoehn, and S.E. Hrudy. 1995. Cyanobacterial (blue-green algal) toxins: a resource guide. AWWA Research Foundation and American Water Works Association. Denver, CO. 229 p. (ISBN 0-89867-824-2)

Year 2007 Tenmile Lakes Sample Site Locations

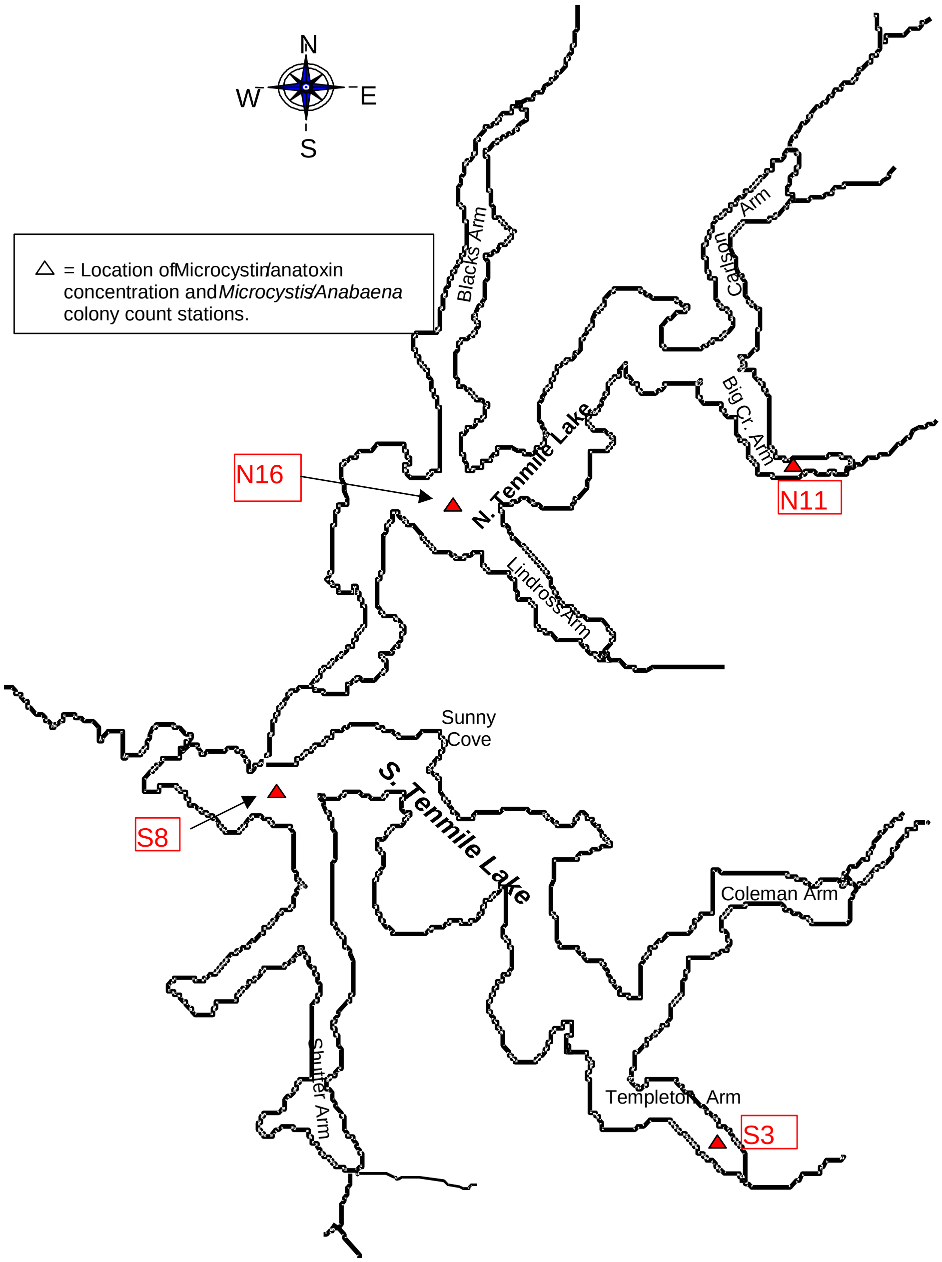

Figure 1. Sample station location for toxic cyanobacteria sampling in Tenmile Lakes, 2007.

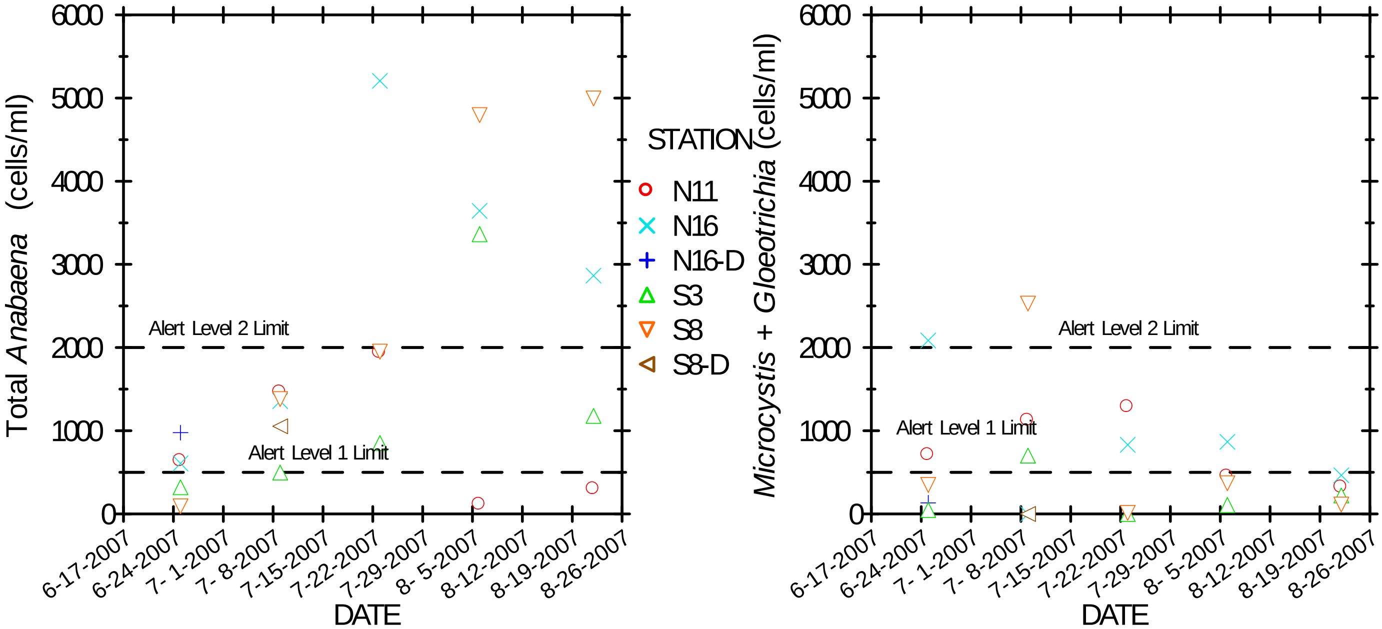

Figure 2. Trend of potentially toxic cyanobacteria in Tenmile Lakes, 2007.

Appendix I – Aquatic Analysts Laboratory Reports

Phytoplankton Sample Analysis

Sample:	Tenmile Lake
Sample Station:	S3
Sample Depth:	
Sample Date:	22-Aug-07
Total Density (#/mL):	145
Total Biovolume (um^3/mL):	357,577
Trophic State Index:	42.4

	Species	**Density #/mL**	**Density Percent**	**Biovolume um^3/mL**	**Biovolume Percent**	**Group**
1	Aphanizomenon flos-aquae	98	67.4	129,362	36.2	bluegreen
2	Anabaena planctonica	40	27.9	214,724	60.0	bluegreen
3	Melosira granulata	3	1.9	11,127	3.1	diatom
4	Microcystis aeruginosa	2	1.4	1,780	0.5	bluegreen
5	Chlamydomonas sp.	1	0.5	219	0.1	green
6	Unidentified flagellate	1	0.5	13	0.0	
7	Cryptomonas erosa	1	0.5	351	0.1	cryptophyte

Anabaena planctonica cells/mL =	1,173
Anabaena planctonica heterocysts/mL =	6
Aphanizomenon flos-aquae cells/mL =	2,053
Aphanizomenon flos-aquae heterocysts/mL =	5
Microcystis aeruginosa cells/mL =	223

Aquatic Analysts **Sample ID:** KR70

Phytoplankton Sample Analysis

Sample: Tenmile Lake
Sample Station: S8
Sample Depth:
Sample Date: 22-Aug-07

Total Density (#/mL): 247
Total Biovolume (um^3/mL): 996,990
Trophic State Index: 49.8

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Anabaena planctonica	170	68.8	901,694	90.4	bluegreen
2	Aphanizomenon flos-aquae	71	28.9	89,915	9.0	bluegreen
3	Microcystis aeruginosa	1	0.5	906	0.1	bluegreen
4	Rhodomonas minuta	1	0.5	23	0.0	cryptophyte
5	Chlamydomonas sp.	1	0.5	368	0.0	green
6	Melosira granulata angustissima	1	0.5	1,416	0.1	diatom
7	Melosira ambigua	1	0.5	2,669	0.3	diatom

Anabaena planctonica cells/mL = 4,927
Anabaena planctonica heterocysts/mL = 68

Aphanizomenon flos-aquae cells/mL = 1,427
Aphanizomenon flos-aquae heterocysts/mL = 3

Microcystis aeruginosa cells/mL = 113

Aquatic Analysts **Sample ID:** KR71

Phytoplankton Sample Analysis

Sample: Tenmile Lake
Sample Station: N16
Sample Depth:
Sample Date: 22-Aug-07

Total Density (#/mL): 166
Total Biovolume (um^3/mL): 654,790
Trophic State Index: 46.8

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Anabaena planctonica	101	60.9	518,898	79.2	bluegreen
2	Aphanizomenon flos-aquae	48	28.8	69,235	10.6	bluegreen
3	Microcystis aeruginosa	5	3.0	3,714	0.6	bluegreen
4	Melosira ambigua	4	2.1	2,100	0.3	diatom
5	Fragilaria crotonensis	4	2.1	56,910	8.7	diatom
6	Anabaena circinalis	1	0.9	1,013	0.2	bluegreen
7	Gloeocystis ampla	1	0.4	730	0.1	green
8	Asterionella formosa	1	0.4	784	0.1	diatom
9	Cryptomonas erosa	1	0.4	371	0.1	cryptophyte
10	Melosira granulata angustissima	1	0.4	178	0.0	diatom
11	Gomphonema subclavatum	1	0.4	856	0.1	diatom

Anabaena planctonica cells/mL =	2,836
Anabaena planctonica heterocysts/mL =	15
Aphanizomenon flos-aquae cells/mL =	1,099
Aphanizomenon flos-aquae heterocysts/mL =	2
Microcystis aeruginosa cells/mL =	464
Anabaena circinalis cells/mL =	14

Aquatic Analysts **Sample ID:** KR73

Phytoplankton Sample Analysis

Sample: Tenmile Lake
Sample Station: N11
Sample Depth:
Sample Date: 22-Aug-07

Total Density (#/mL): 59
Total Biovolume (um³/mL): 139,850
Trophic State Index: 35.7

	Species	Density #/mL	Density Percent	Biovolume um³/mL	Biovolume Percent	Group
1	Anabaena planctonica	10.1	17.2	51,918	37.1	bluegreen
2	Gomphonema subclavatum	6.9	11.8	5,002	3.6	diatom
3	Achnanthes minutissima	5.5	9.4	358	0.3	diatom
4	Fragilaria capucina mesolepta	4.9	8.4	33,884	24.2	diatom
5	Cocconeis placentula	4.1	6.9	1,864	1.3	diatom
6	Epithemia turgida	3.5	5.9	16,241	11.6	diatom
7	Microcystis aeruginosa	2.9	4.9	2,548	1.8	bluegreen
8	Gomphonema angustatum	2.9	4.9	521	0.4	diatom
9	Unident. green alga	2.3	3.9	1,390	1.0	green
10	Cryptomonas erosa	2.0	3.4	1,054	0.8	cryptophyte
11	Fragilaria vaucheria	1.7	3.0	13,006	9.3	diatom
12	Aphanizomenon flos-aquae	1.2	2.0	1,824	1.3	bluegreen
13	Cosmarium sp.	0.9	1.5	182	0.1	green
14	Glenodinium sp.	0.9	1.5	608	0.4	dinoflagellate
15	Ankistrodesmus falcatus	0.9	1.5	65	0.0	green
16	Gomphonema acuminatum	0.9	1.5	1,511	1.1	diatom
17	Chlamydomonas sp.	0.9	1.5	565	0.4	green
18	Synedra ulna	0.9	1.5	2,247	1.6	diatom
19	Sphaerocystis schroeteri	0.9	1.5	1,368	1.0	green
20	Cymbella minuta	0.6	1.0	214	0.2	diatom
21	Gomphonema clevei	0.6	1.0	52	0.0	diatom
22	Gomphonema olivaceum	0.3	0.5	65	0.0	diatom
23	Ulothrix sp.	0.3	0.5	926	0.7	green
24	Gomphonema tenellum	0.3	0.5	61	0.0	diatom
25	Navicula cryptocephala veneta	0.3	0.5	28	0.0	diatom
26	Pediastrum boryanum	0.3	0.5	14	0.0	green
27	Synedra delicatissima	0.3	0.5	191	0.1	diatom
28	Anabaena flos-aquae	0.3	0.5	776	0.6	bluegreen
29	Fragilaria construens venter	0.3	0.5	14	0.0	diatom
30	Botryococcus braunii	0.3	0.5	834	0.6	green
31	Scenedesmus denticulatus	0.3	0.5	52	0.0	green
32	Gomphonema truncatum	0.3	0.5	394	0.3	diatom
33	Scenedesmus quadricauda	0.3	0.5	75	0.1	green

Anabaena planctonica cells/mL = 284
Anabaena planctonica heterocysts/mL = 2

Aphanizomenon flos-aquae cells/mL = 29

Microcystis aeruginosa cells/mL = 318

Anabaena flos-aquae cells/mL = 12
Anabaena flos-aquae heterocysts/mL = 0.3

Aquatic Analysts **Sample ID:** KR72

APPENDIX II

Oregon Health Division
Drinking water treatment guidance
August 31, 2001

Contact Person: Ken Kauffman
503-731-4015
kenneth.w.kauffman@state.or.us

1. Treatment systems should consist of sand filtration followed by chlorination, followed by activated charcoal filtration. It is essential that sand filtration be done before disinfection to remove as many algal cells as possible without killing or rupturing them.

2. Chlorination systems should be capable of maintaining at least 1 ppm of chlorine residual for at least 20 minutes contact time before the water enters the activated charcoal system.

3. The final step in the process should be effective activated charcoal treatment to remove toxin remaining after the sand filtration and disinfection processes.

4. All treatment equipment used should meet NSF standard 53, and should be adequately sized to treat the maximum amount of water that you use. Treatment equipment needs regular monitoring and servicing to assure that it functions properly.

5. Ideally all water entering your home should be treated as recommended. It is possible to treat only water used in the kitchen, but this increases chances that animals or pets would inadvertently drink untreated water.

As more monitoring is done and toxin levels are measured this advisory may be altered. The advisory is to remain in effect until specifically changed or lifted by county and state health officials.

FACT SHEET

TOXIC *MICROCYSTIS* BLOOMS IN TENMILE LAKES

(information modified from Oregon Health Division Document: Hazards from *Microcystis aeruginosa* in Fresh Water – http://www.ohd.hr.state.or.us/esc/docs/mafact.htm)

➢ What is a toxic bloom of *Microcystis aeruginosa*?

Microcystis aeruginosa is a species of blue-green algae that grows naturally in many surface waters. In most bodies of fresh water and most weather conditions it does not pose a hazard to wildlife or human beings. However, under certain conditions (such as when the water is warm with abundant nutrients) *Microcystis aeruginosa* can grow more rapidly than normal. The result can be excessive numbers of large colonies that form floating masses on the water surface or that are dispersed within the water column. These occurrences are called "algal blooms". *Microcystis aeruginosa* can produce natural toxins (called microcystins) that are very potent, and these toxins are higher in concentration during bloom conditions. The microcystin toxins are produced and contained inside the *Microcystis* cells, and are released to the water when the cells die and disintegrate. Also, since the cells are very small, they can be ingested along with the water. Toxin levels in a water body tend to be higher near shorelines and at the surface of the water where animal and human contact is most likely.

➢ What are the primary toxic effects of these blooms?

The primary toxic effect of microcystins is on the liver. At very high doses, death of liver cells and destruction of blood vessels in the liver can result in serious injury and possibly death. Though less is known about the long-term effects of microcystin toxins, animal studies have shown these toxins can cause chronic liver damage and may promote the formation of liver tumors. These effects are more likely to occur if exposure is frequent over a long period of time.

The levels of toxin necessary to produce immediate or acute illness in humans and animals are much higher than levels that may cause chronic liver injury. Drinking water standards are usually based on chronic effects. Currently, there is no drinking water standard in the U.S. for microcystins. Canada, Australia, and Great Britain have developed a guideline level of 1 microgram toxin per liter of water, or 1 part per billion (1 ppb). During algal blooms, toxin levels can greatly exceed 1 ppb.

➢ How is it determined when the water becomes safe once a bloom is reported?

Changes in weather or in other conditions in a water body influence the growth of blue-green algae. Generally, cooler weather, rainfall, and reduced sunshine will lead to reductions in algal growth and toxin levels. Algal blooms generally peak and die off rapidly and toxin levels in the water decline over days or weeks. Only blue-green algae experts can distinguish visually between different kinds of algal growth, and are able to determine when blooms have disappeared. Testing of the water is the only way to be certain that toxin levels are no longer dangerous.

➢ When does the Oregon Health Division Issue Warnings?

Drinking Water -- When measured or estimated toxin levels reach 1 ug/l the Department of Human Services, Office of Public Health Systems issues public advisories or warnings. These will include warnings regarding the use of water for drinking or food preparation unless the water has been treated following specific guidelines for destroying and removing toxins. Animals should be kept away from water during periods when microcystin toxin levels exceed 1 ug/l, because drinking the water can cause serious or even fatal illness.

Contact Recreation -- If levels are high enough to pose hazards for swimming, water-skiing or other direct skin contact activities, the advisories will warn against water contact. Generally skin hazards occur where the water has a green or blue-green color or where there are visible clumps or mats of algae present in the water. When measured toxin levels reach 5 ug/L or cell counts reach 15,000 cells/ml, contact recreation is considered unsafe.

➢ Can testing ensure that all areas of the lake are safe?

No, due to the patchy nature of blue-green algal blooms it is possible for higher *Microcystis* densities (and therefore higher microcystin toxin concentrations) to be present in areas not sampled in a given survey, particularly along shorelines or during calm conditions of little to no wind. **Therefore, when a lake has a demonstrated history of algal toxicity or the presence of known toxin producing algal species, those utilizing the lake for drinking water should always follow Oregon Health Division recommendations for purification. In addition, recreational users should always avoid contact with water whenever noticeable surface concentrations of algae are evident or when the lake has an obvious green to blue-green appearance.**

➢ Are domestic animals at risk during blooms?

Yes, pets or other domestic animals are the most likely to ingest contaminated water, these animals should not be allowed access to the lakeshore whenever either noticeable surface concentrations of algae or an obvious green to blue-green appearance is evident.

➢ Is it safe to eat fish and other aquatic life?

Clams, mussels, snails and other shellfish should not be eaten during microcystin advisory periods, but it is believed that fish can be safely eaten if they are cleaned and all internal organs discarded. Internal organs of such fish may be toxic even to animals.

➢ How much does testing cost?

Samples must be shipped to qualified laboratories for analysis. A microscopic determination to quantify the number of Microcystis colonies and cells costs $90 per sample. A specialized test to analyze for the microcystin toxin concentration costs $100 per sample (overnight shipping costs not included), and for anatoxins the cost is $250/sample .

- NOTE: A fact sheet about microcystin toxin and its effects may be found on the Web at www.dhs.state.or.us/publichealth/esc/docs/mafact.cfm