Aquatic Ecosystem Sciences LLC

Jacob Kann, Ph.D.
Aquatic Ecologist

295 East Main St., Suite 7
Ashland, OR 97520
Voice: 541-482-1575
Fax: 541-552-1024
Email: jacobkann@aol.com

Tech Memo

To:	Mike Mader/Jason – TLBP	From:	Jake Kann
Email:	**To:** tlbp@presys.com, kenneth.w.kauffman@state.or.us	Pages:	14
Phone:		Date:	10-02-07
Re:	*Tenmile Sampling*	CC:	Ken Kauffman – OHD

To all concerned,

September 25th, 2007 toxic algal cell count results for Tenmile Lakes are shown in Table 1:

Table 1. Cell density of potentially toxigenic cyanobacteria in Tenmile Lakes.

Station[1]	Date	*Microcystis* (cells/ml)	*Gloeotrichia* (cells/ml)	Total *Microcystis+ Gloeotrichia*[2]	Total *Anabaena* (cells/ml)
S3	9/25/2007	1632	0	1632	227
S8	9/25/2007	1115	0	1115	1274
N11	9/25/2007	2771	0	2771	227
N16	9/25/2007	277	0	277	4289.9

[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 collected on September 25th show that cell density of potentially toxigenic cyanobacteria species increased or remained similar at 3 stations (S3, S8, and N16) for *Microcystis aeruginosa* (MSAE), but decreased overall for total *Anabaena* (*A. flos-aquae [ABFA]*+ *A. planctonica [ABPL]*) (Table1; Figure 2). Although MSAE at N11 decreased since the 9/12 sampling trip, it remained above the WHO Alert Level 2 guideline of 2,000 cells ml^{-1} (at which time DHS and local health services typically provide notification to remind homeowners to follow water treatment guidelines—see Appendix II). MSAE at both S3 and S8 exceeded the WHO Alert Level 1 guideline (also known as the increased vigilance level for drinking water systems) of 500 cells ml^{-1}.

Although total *Anabaena* density at N16 increased slightly compared to the previous sample period, total *Anabaena* density decreased at S3, S8, and N11. MSAE at N16 was 4290 cells/ml and continued to exceed the Alert Level 2 guideline (Figure 2). However, as stated in previous Tech Memos, the predominant *Anabaena* species was *Anabaena planctonica* (Appendix I), a species less commonly associated with toxin production.

Aside from S3 where biovolume of *Aphanizomenon flos-aquae* (31.6%) and the diatom *Melosira ambigua* (29.3%) replaced *A. planctonica* as the dominant phytoplankton species, *A. planctonica* continued to comprise the majority of biovolume at other stations (43.6 to 81.4%; Appendix I). MSAE biovolume at N11 comprised 24% of the total biovolume. Various Chrysophytes, Cryptophytes, and Diatoms comprised the remainder of the biovolume at all stations.

9/12/07 Microcystin Toxin Results

Because the peak MSAE cell density of 6,605 cells/ml that occurred at N11 on 9/12 exceeded the Alert Level 2 guideline by over 3 times, and past research from Tenmile Lakes as well as other lake systems indicates that 5000 cells per ml of MSAE can commonly be associated with 1 µg/L of the hepatotoxin microcystin, a sample from this station was sent to GreenWater Labs for ELISA testing for the microcystin toxin (Appendix III). These results show that microcystin at Station N11 (Big Creek Arm of North-Tenmile) on September 25, 2007 was 5.4 µg/L. Although the associated cell count level (6,605 cells/ml) for the station exceeded the World Health Organization (WHO) Alert Level 2 guideline of 2000 cells/ml, and that information was forwarded to local and state health offices, the attached microcystin toxin result confirms the presence of toxin that was 5.4 times higher than the WHO guideline level of 1 µg/L for drinking water. As such, it is essential that homeowners utilizing lake water for potable uses redouble their treatment efforts and ensure their treatment systems follow current OHS guidelines. These results also confirm that the lower public health guideline levels (compared to those used for generalized recreational contact advisories) for lake and reservoir systems utilized for drinking water are necessary for warning public and private entities drawing water to treat for potable uses.

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. However, levels of all potentially toxic cyanobacteria were well below Oregon's recreational guidelines (100,000 cells per ml for *Anabaena* and 40,000 cells/ml for *Microcystis*).

Please call if you have any questions.

Sincerely,

Jacob Kann Ph.D.

Aquatic Ecologist

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 always follow Oregon Health Division recommendations for purification (attached). 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. 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

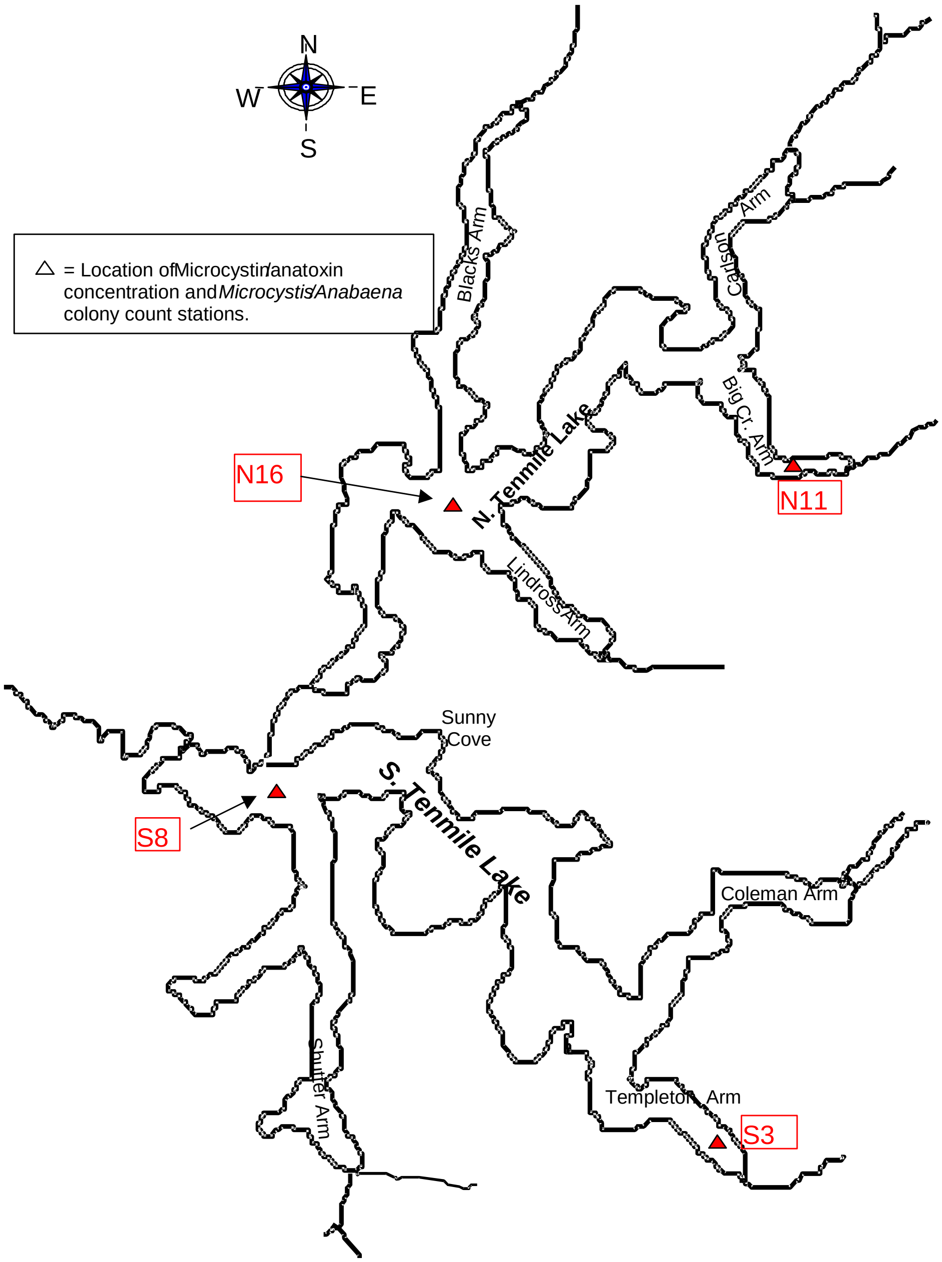

Figure 1. Sample station location for toxic cyanobacteria sampling in Tenmile Lakes, 2007.

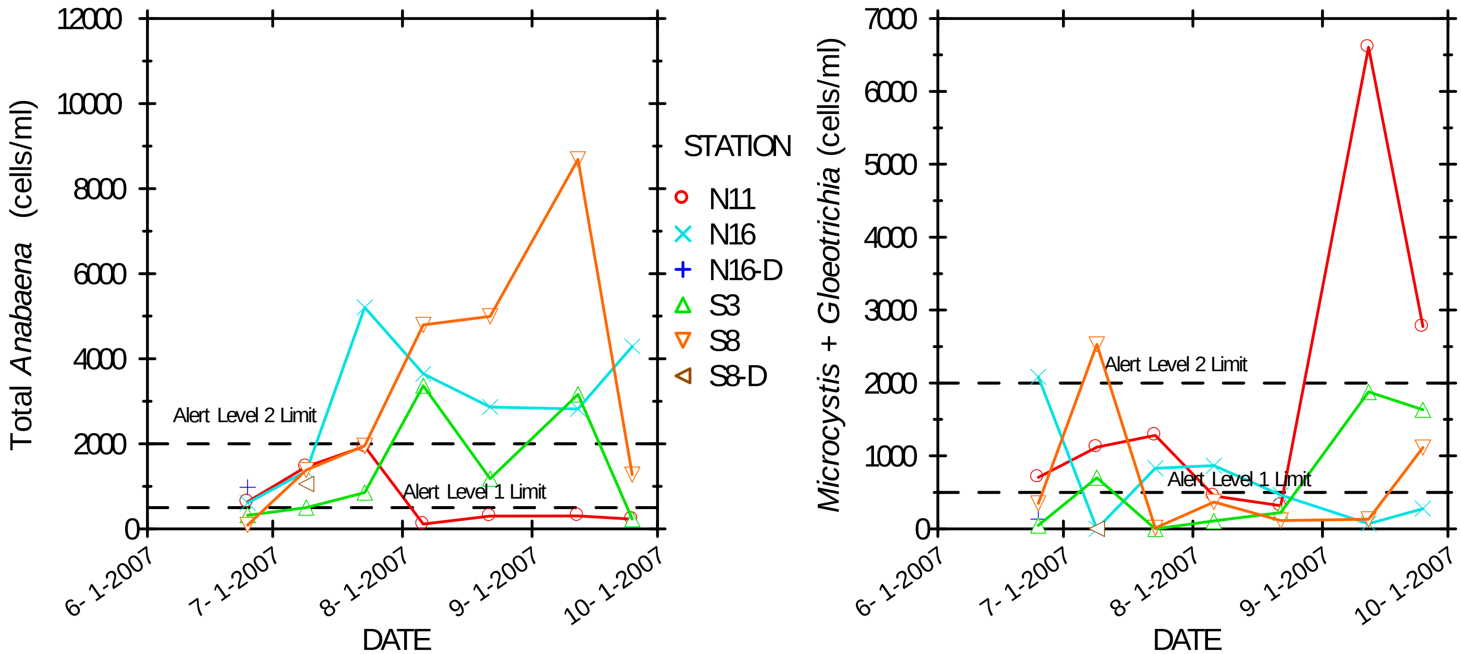

Figure 2. Trend of potentially toxic cyanobacteria in Tenmile Lakes, 2007.

Appendix I – Aquatic Analysts Laboratory Reports

Phytoplankton Sample Analysis

Sample:	Tenmile Lake
Sample Station:	S3
Sample Depth:	
Sample Date:	25-Sep-07
Total Density (#/mL):	133
Total Biovolume (um^3/mL):	241,484
Trophic State Index:	39.6

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Aphanizomenon flos-aquae	61	45.6	76,247	31.6	bluegreen
2	Melosira ambigua	18	13.7	70,825	29.3	diatom
3	Melosira granulata	15	11.3	32,924	13.6	diatom
4	Microcystis aeruginosa	14	10.8	13,055	5.4	bluegreen
5	Anabaena planctonica	8	6.4	40,247	16.7	bluegreen
6	Cryptomonas erosa	5	3.4	2,368	1.0	cryptophyte
7	Dictyosphaerium ehrenbergianum	2	1.5	937	0.4	green
8	Cyclotella stelligera	2	1.5	107	0.0	diatom
9	Rhodomonas minuta	1	1.0	26	0.0	cryptophyte
10	Cocconeis placentula	1	1.0	599	0.2	diatom
11	Chlamydomonas sp.	1	0.5	211	0.1	green
12	Mallomonas sp.	1	0.5	247	0.1	chrysophyte
13	Melosira granulata angustissima	1	0.5	1,952	0.8	diatom
14	Selenastrum minutum	1	0.5	13	0.0	green
15	Navicula tripunctata	1	0.5	729	0.3	diatom
16	Cymbella minuta	1	0.5	241	0.1	diatom
17	Sphaerocystis schroeteri	1	0.5	364	0.2	green
18	Gomphonema subclavatum	1	0.5	390	0.2	diatom

Aphanizomenon flos-aquae cells/mL =	1,210
Aphanizomenon flos-aquae heterocysts/mL =	27
Microcystis aeruginosa cells/mL =	1,632
Anabaena planctonica cells/mL =	220
Anabaena planctonica heterocysts/mL =	7

Aquatic Analysts — **Sample ID:** KR80

Phytoplankton Sample Analysis

Sample:	Tenmile Lake
Sample Station:	S8
Sample Depth:	
Sample Date:	25-Sep-07
Total Density (#/mL):	109
Total Biovolume (um^3/mL):	288,456
Trophic State Index:	40.9

	Species	**Density #/mL**	**Density Percent**	**Biovolume um^3/mL**	**Biovolume Percent**	**Group**
-----	--	--------------------	-------------	--------------------------------	------------------	--------------------------------------
1	Anabaena planctonica	56	51.9	226,996	78.7	bluegreen
2	Aphanizomenon flos-aquae	33	30.4	35,361	12.3	bluegreen
3	Melosira ambigua	6	5.1	13,822	4.8	diatom
4	Microcystis aeruginosa	5	4.2	8,924	3.1	bluegreen
5	Melosira granulata	3	2.3	1,397	0.5	diatom
6	Chlamydomonas sp.	2	1.4	495	0.2	green
7	Dictyosphaerium ehrenbergianum	1	0.9	488	0.2	green
8	Cryptomonas erosa	1	0.9	528	0.2	cryptophyte
9	Cyclotella stelligera	1	0.9	56	0.0	diatom
10	Cymbella minuta	1	0.5	188	0.1	diatom
11	Unidentified flagellate	1	0.5	10	0.0	
12	Navicula cryptocephala veneta	1	0.5	48	0.0	diatom
13	Nitzschia acicularis	1	0.5	142	0.0	diatom

Aphanizomenon flos-aquae cells/mL =	561
Aphanizomenon flos-aquae heterocysts/mL =	8
Anabaena planctonica cells/mL =	1,240
Anabaena planctonica heterocysts/mL =	34
Microcystis aeruginosa cells/mL =	1,115

Aquatic Analysts	**Sample ID:**	KR81

Phytoplankton Sample Analysis

Sample:	Tenmile Lake
Sample Station:	N11
Sample Depth:	
Sample Date:	25-Sep-07
Total Density (#/mL):	41
Total Biovolume (um^3/mL):	92,267
Trophic State Index:	32.7

	Species	**Density #/mL**	**Density Percent**	**Biovolume um^3/mL**	**Biovolume Percent**	**Group**
1	Anabaena planctonica	11.6	27.9	40,263	43.6	bluegreen
2	Microcystis aeruginosa	4.5	10.8	22,168	24.0	bluegreen
3	Aphanizomenon flos-aquae	4.1	9.8	3,840	4.2	bluegreen
4	Melosira ambigua	3.9	9.3	10,003	10.8	diatom
5	Rhodomonas minuta	3.9	9.3	77	0.1	cryptophyte
6	Dictyosphaerium ehrenbergianum	3.0	7.4	2,925	3.2	green
7	Melosira granulata	2.8	6.9	5,319	5.8	diatom
8	Ulothrix sp.	2.0	4.9	2,763	3.0	green
9	Achnanthes minutissima	0.8	2.0	41	0.0	diatom
10	Cryptomonas erosa	0.8	2.0	423	0.5	cryptophyte
11	Chlamydomonas sp.	0.8	2.0	264	0.3	green
12	Asterionella formosa	0.8	2.0	572	0.6	diatom
13	Ankistrodesmus falcatus	0.4	1.0	20	0.0	green
14	Melosira granulata angustissima	0.4	1.0	914	1.0	diatom
15	Eunotia pectinalis	0.4	1.0	293	0.3	diatom
16	Mougeotia sp.	0.2	0.5	360	0.4	green
17	Selenastrum minutum	0.2	0.5	4	0.0	green
18	Cocconeis placentula	0.2	0.5	93	0.1	diatom
19	Mallomonas sp.	0.2	0.5	77	0.1	chrysophyte
20	Botryococcus braunii	0.2	0.5	1,828	2.0	green
21	Nitzschia paleacea	0.2	0.5	20	0.0	diatom

Anabaena planctonica cells/mL =	220
Anabaena planctonica heterocysts/mL =	6
Anabaena planctonica akinetes/mL =	1
Aphanizomenon flos-aquae cells/mL =	61
Microcystis aeruginosa cells/mL =	2,771

Aquatic Analysts **Sample ID:** KR82

October 2, 2007

Phytoplankton Sample Analysis

Sample:	Tenmile Lake
Sample Station:	N16
Sample Depth:	
Sample Date:	25-Sep-07
Total Density (#/mL):	285
Total Biovolume (um^3/mL):	920,854
Trophic State Index:	49.3

	Species	**Density #/mL**	**Density Percent**	**Biovolume um^3/mL**	**Biovolume Percent**	**Group**
1	Anabaena planctonica	178.1	62.5	749,576	81.4	bluegreen
2	Aphanizomenon flos-aquae	59.4	20.8	78,537	8.5	bluegreen
3	Melosira ambigua	29.0	10.2	68,376	7.4	diatom
4	Melosira granulata	5.3	1.9	13,640	1.5	diatom
5	Anabaena flos-aquae	2.6	0.9	4,419	0.5	bluegreen
6	Microcystis aeruginosa	2.6	0.9	2,216	0.2	bluegreen
7	Dictyosphaerium ehrenbergianum	2.6	0.9	1,266	0.1	green
8	Cryptomonas erosa	1.3	0.5	686	0.1	cryptophyte
9	Ulothrix sp.	1.3	0.5	1,055	0.1	green
10	Mallomonas sp.	1.3	0.5	501	0.1	chrysophyte
11	Asterionella formosa	1.3	0.5	580	0.1	diatom

Anabaena planctonica cells/mL =	4,096
Anabaena planctonica heterocysts/mL =	124
Anabaena planctonica akinetes/mL =	1.3
Aphanizomenon flos-aquae cells/mL =	1,247
Aphanizomenon flos-aquae heterocysts/mL =	0.0
Anabaena flos-aquae cells/mL =	66
Anabaena flos-aquae heterocysts/mL =	2.6
Microcystis aeruginosa cells/mL =	277

Aquatic Analysts **Sample ID:** KR83

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

APPENDIX III

GreenWater laboratories — aquatic analysis ... research ... consulting

Microcystin Analysis Report

Project: City of Lakeside
(TLBP)

Sample Identification	Sample Collection Date
1. N. Ten Mile	09/12/07

Sample Prep – The sample was ultra-sonicated to lyse all cells and release toxins. Due to the concentration of the sample, a 2-fold dilution was required to bring the concentration of the sample in range of the standard curve for the MC ELISA.

Analytical Methodology – A microcystins enzyme linked immunosorbent assay (ELISA) was utilized for the quantitative and sensitive congener-independent detection of MCs. The current ELISA kit is sensitive down to a detection/quantification limit of 0.15 µg/L. Standard recovery was 104%.

Summary of Results

Sample	MC levels (µg/L)
1. N. Ten Mile	≈ 5.4

ND = not detected above the detection limit
Limit of Detection = 0.15 µg/L

* Microcystin data is contained in accompanying spreadsheet.

Cyano LAB

205 Zeagler Drive, Suite 302 • Palatka, FL 32177
info@greenwaterlab.com • www.greenwaterlab.com
386.328.0882 voice • 386.328.9646 fax
cyanomail@cyanolab.com • www.cyanolab.com