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:	09-18-07
Re:	*Tenmile Sampling*	CC:	Ken Kauffman – OHD

To all concerned,

September 12^{th}, 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	9/12/2007	1,877	0	1,877	3,162
S8	9/12/2007	131	0	131	8,687
N11	9/12/2007	6,605	0	6,605	304
N16	9/12/2007	69	0	69	2,818

[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 12^{th} show that cell density of potentially toxigenic cyanobacteria species increased at several stations for both *Microcystis aeruginosa* (MSAE) and total *Anabaena* (*A. flos-aquae [ABFA]*+ *A. planctonica [ABPL]*) (Table1; Figure 2). MSAE density increased at both of the stations located in the arms (S3 and N11; Figure 1), with S3 exceeding the WHO Alert Level 1 guideline (500 cells ml^{-1} or increased vigilance level for drinking water systems), and N11 at 6,605 cells/ml exceeding 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). 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.

Levels of total *Anabaena* remained similar to the previous sample period at both N11 and N16; with N16 continuing to exceed the Alert Level 2 guideline (Figure 2). However, increases in total *Anabaena* occurred at both south-Lake stations, with S8 sharply increasing to 8,687 cells per ml (exceeding the Alert Level 2 guideline by 4.3 times). However, as stated in previous Tech Memos, the predominant species was *Anabaena planctonica* (Appendix I), a species less commonly associated with toxin production.

Biovolume at stations S3, S8, and N16 continued to be comprised mainly of the cyanobacterium *Anabaen*a *planctonica,* which represented 59.4, 86.5, and 81.3 percent of the total biovolume (Appendix I). North-Lake station N11 was comprised approximately equally by MSAE (23.2%) and ABPL (23.7%). Another cyanobacterium *(Aphanizomenon flos-aquae)* not known to produce cyanotoxins in Oregon comprised 32.8% 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 and slightly increasing trend (red line; Figure 2) of potentially toxigenic cyanobacteria in Tenmile Lakes that exceeded Alert Level 2 (particularly the maximum MSAE value of 6,605 cells/ml at N11), 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 <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

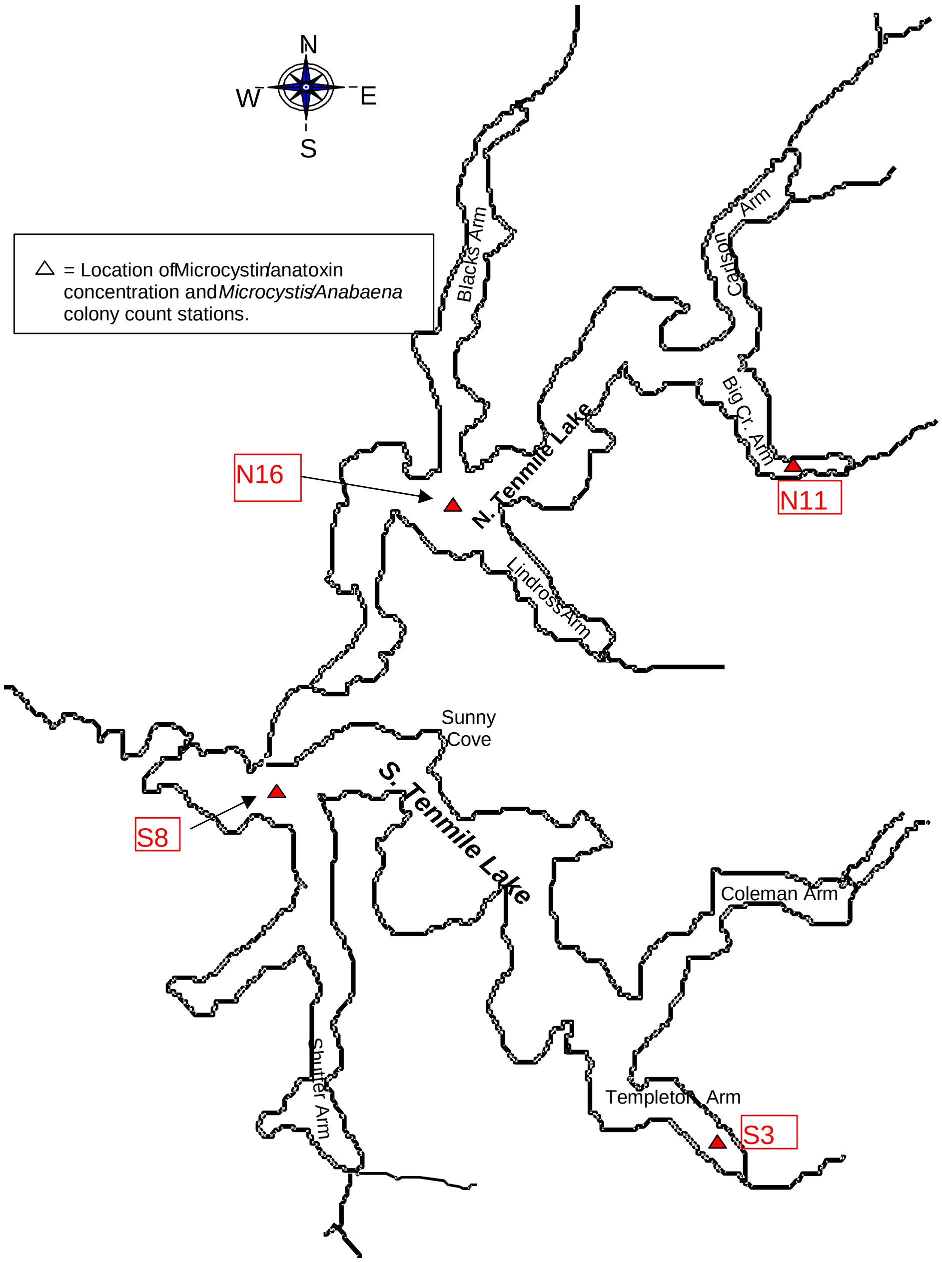

Figure 1. Sample station location for toxic cyanobacteria sampling in Tenmile Lakes, 2007.

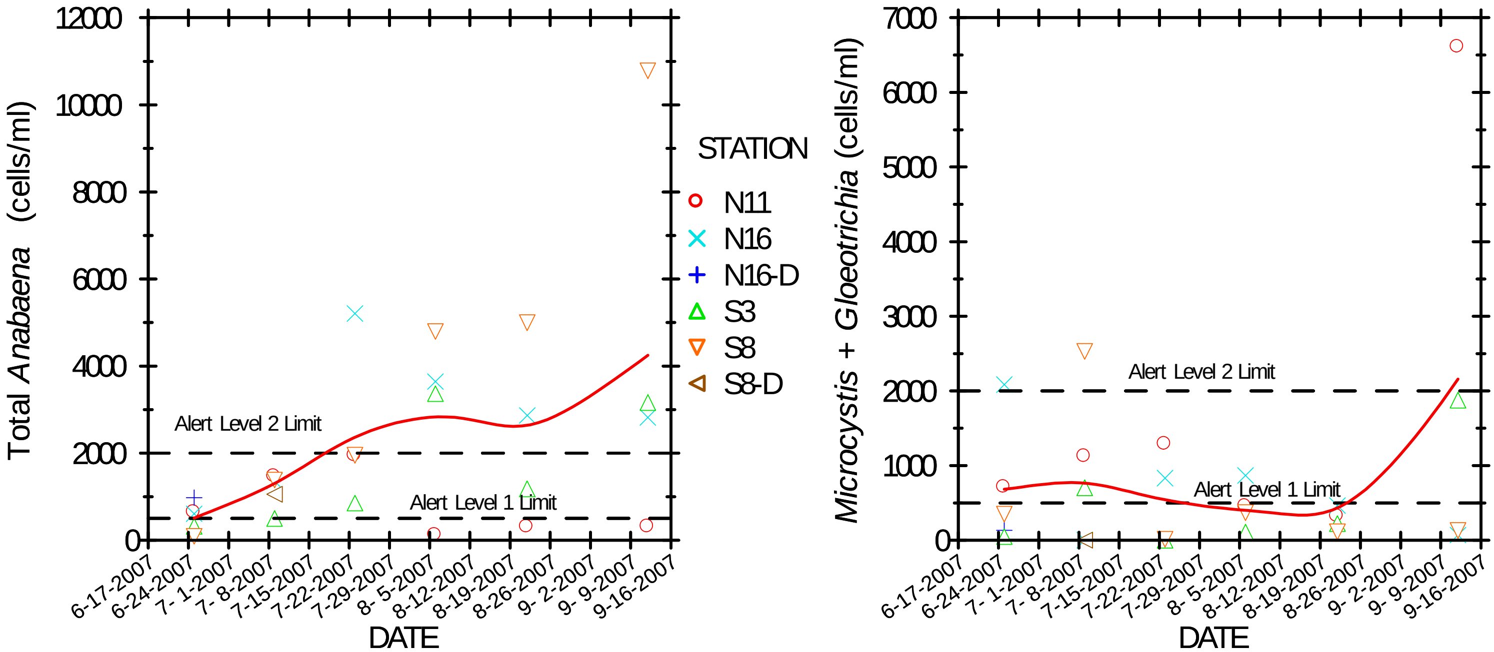

Figure 2. Trend of potentially toxic cyanobacteria in Tenmile Lakes (red line is distance weighted least square trend line), 2007.

Appendix I – Aquatic Analysts Laboratory Reports

Phytoplankton Sample Analysis

	Sample:	Tenmile Lake					
	Sample Station:	S3					
	Sample Depth:						
	Sample Date:	12-Sep-07					
	Total Density (#/mL):	326					
	Total Biovolume (um^3/mL):	966,792					
	Trophic State Index:	49.6					
		Density	**Density**	**Biovolume**	**Biovolume**		
	Species	**#/mL**	**Percent**	**um^3/mL**	**Percent**		**Group**
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1	Aphanizomenon flos-aquae	194	59.5	317,117	32.8		bluegreen
2	Anabaena planctonica	101	31.1	574,108	59.4		bluegreen
3	Melosira granulata	15	4.5	39,527	4.1		diatom
4	Microcystis aeruginosa	6	1.8	15,019	1.6		bluegreen
5	Melosira ambigua	4	1.4	18,919	2.0		diatom
6	Cocconeis placentula	1	0.5	675	0.1		diatom
7	Chlamydomonas sp.	1	0.5	477	0.0		green
8	Cyclotella meneghiniana	1	0.5	557	0.1		diatom
9	Nitzschia dissipata	1	0.5	395	0.0		diatom
	Anabaena planctonica cells/mL =	3,137					
	Anabaena planctonica heterocysts/mL =	25					
	Aphanizomenon flos-aquae cells/mL =	5,034					
	Aphanizomenon flos-aquae heterocysts/mL =	97					
	Microcystis aeruginosa cells/mL =	1,877					
	Aquatic Analysts			**Sample ID:**	KR74		

Phytoplankton Sample Analysis

Sample:	Tenmile Lake
Sample Station:	S8
Sample Depth:	
Sample Date:	12-Sep-07
Total Density (#/mL):	376
Total Biovolume (um^3/mL):	1,798,186
Trophic State Index:	54.1

	Species	**Density #/mL**	**Density Percent**	**Biovolume um^3/mL**	**Biovolume Percent**	**Group**
1	Anabaena planctonica	230	61.1	1,556,093	86.5	bluegreen
2	Aphanizomenon flos-aquae	103	27.5	130,306	7.2	bluegreen
3	Melosira granulata	20	5.2	61,755	3.4	diatom
4	Melosira ambigua	13	3.5	44,089	2.5	diatom
5	Melosira granulata angustissima	5	1.3	4,063	0.2	diatom
6	Chlamydomonas sp.	2	0.4	534	0.0	green
7	Microcystis aeruginosa	2	0.4	1,051	0.1	bluegreen
8	Scenedesmus denticulatus	2	0.4	295	0.0	green

Aphanizomenon flos-aquae cells/mL =	2,068
Aphanizomenon flos-aquae heterocysts/mL =	26
Anabaena planctonica cells/mL =	8,503
Anabaena planctonica heterocysts/mL =	184
Microcystis aeruginosa cells/mL =	131

Aquatic Analysts **Sample ID:** KR75

Phytoplankton Sample Analysis

Sample: Tenmile Lake
Sample Station: N11
Sample Depth:
Sample Date: 12-Sep-07

Total Density (#/mL): 149
Total Biovolume (um^3/mL): 227,299
Trophic State Index: 39.2

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Achnanthes minutissima	29	19.8	1,769	0.8	diatom
2	Gomphonema angustatum	18	11.9	3,821	1.7	diatom
3	Cocconeis placentula	12	7.9	5,426	2.4	diatom
4	Fragilaria capucina mesolepta	12	7.9	19,550	8.6	diatom
5	Microcystis aeruginosa	10	6.9	52,840	23.2	bluegreen
6	Melosira ambigua	9	5.9	19,799	8.7	diatom
7	Eunotia pectinalis	7	4.5	5,255	2.3	diatom
8	Anabaena planctonica	6	4.0	53,961	23.7	bluegreen
9	Gomphonema subclavatum	6	4.0	6,015	2.6	diatom
10	Cryptomonas erosa	4	3.0	2,300	1.0	cryptophyte
11	Scenedesmus quadricauda	4	3.0	1,150	0.5	green
12	Chlamydomonas sp.	4	2.5	1,198	0.5	green
13	Unidentified flagellate	4	2.5	74	0.0	
14	Aphanizomenon flos-aquae	3	2.0	2,786	1.2	bluegreen
15	Epithemia turgida	2	1.5	9,399	4.1	diatom
16	Cymbella minuta	2	1.5	818	0.4	diatom
17	Scenedesmus acuminatus	2	1.5	796	0.4	green
18	Cymbella tumida	2	1.5	5,529	2.4	diatom
19	Oocystis pusilla	1	1.0	318	0.1	green
20	Fragilaria crotonensis	1	1.0	17,338	7.6	diatom
21	Botryococcus braunii	1	1.0	8,492	3.7	green
22	Synedra radians	1	0.5	265	0.1	diatom
23	Tabellaria fenestrata	1	0.5	1,769	0.8	diatom
24	Gomphonema gracile	1	0.5	181	0.1	diatom
25	Ulothrix sp.	1	0.5	1,179	0.5	green
26	Synedra ulna	1	0.5	1,467	0.6	diatom
27	Fragilaria vaucheria	1	0.5	212	0.1	diatom
28	Asterionella formosa	1	0.5	1,297	0.6	diatom
29	Cosmarium sp.	1	0.5	155	0.1	green
30	Cymbella affinis	1	0.5	1,327	0.6	diatom
31	Staurastrum dejectum	1	0.5	295	0.1	green
32	Glenodinium sp.	1	0.5	516	0.2	dinoflagellate

Anabaena planctonica cells/mL = 295
Anabaena planctonica heterocysts/mL = 9

Aphanizomenon flos-aquae cells/mL = 44

Microcystis aeruginosa cells/mL = 6,605

Aquatic Analysts **Sample ID:** KR76

September 18, 2007

Phytoplankton Sample Analysis

Sample:	Tenmile Lake
Sample Station:	N16
Sample Depth:	
Sample Date:	12-Sep-07
Total Density (#/mL):	166
Total Biovolume (um^3/mL):	630,809
Trophic State Index:	46.5

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Anabaena planctonica	97	58.1	512,988	81.3	bluegreen
2	Aphanizomenon flos-aquae	25	14.7	30,932	4.9	bluegreen
3	Melosira granulata	12	7.4	35,105	5.6	diatom
4	Melosira ambigua	11	6.5	22,774	3.6	diatom
5	Melosira granulata angustissima	7	4.1	7,422	1.2	diatom
6	Microcystis aeruginosa	4	2.3	552	0.1	bluegreen
7	Rhodomonas minuta	3	1.8	61	0.0	cryptophyte
8	Ulothrix sp.	2	1.4	3,130	0.5	green
9	Asterionella formosa	2	0.9	1,013	0.2	diatom
10	Fragilaria crotonensis	2	0.9	12,888	2.0	diatom
11	Unidentified flagellate	1	0.5	15	0.0	
12	Dinobryon sertularia	1	0.5	91	0.0	dinoflagellate
13	Sphaerocystis schroeteri	1	0.5	3,437	0.5	green
14	Cryptomonas erosa	1	0.5	399	0.1	cryptophyte

Anabaena planctonica cells/mL =	2,803
Anabaena planctonica heterocysts/mL =	15
Aphanizomenon flos-aquae cells/mL =	491
Microcystis aeruginosa cells/mL =	69

Aquatic Analysts **Sample ID:** KR77

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