TECHNICAL MEMORANDUM

Tenmile Lakes Toxic Algae Monitoring, August 25, 2009

Prepared for: **Tenmile Lakes Basin Partnership**

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August 25th, 2009 toxic algal cell count results for Tenmile Lakes are as follows (see Figure 1 below for sample station location):

Station	Date	*Microcystis* (cells/ml)	*Gloeotrichia* (cells/ml)	Total *Microcystis*+ *Gloeotrichia* (cells/ml)	Total *Anabaena* (cells/ml)
S3	8/25/2009	0	0	0	1945
S8	8/25/2009	3915	0	3915	537
N11	8/25/2009	741	0	741	293
N16	8/25/2009	1611	0	1611	941

*Exceeds World Health Organization Alert Level 1 increased vigilance guideline level of 500 cells ml^{-1} for potentially toxigenic species in drinking water systems.
**Exceeds World Health Organization Alert Level 2 public health posting guideline level of 2000 cells ml^{-1} for potentially toxigenic species in drinking water systems

Samples form August 25th show that stations S3 and S8 again reversed (as they did between 7/27 and 8/10) with M*icrocystis aeruginosa* (MSAE) at station S3 declining to a non-detect, and station S8 increasing to 3915 cells/ml, exceeding the WHO Alert Level 2 guideline of 2000 cells/ml (at which time DHS and local health services typically issue a public alert for drinking water lakes and reservoirs) by approximately 2 times (Figure 2). In past years such levels have been associated with microcystin toxin levels exceeding the WHO 1 µg/L drinking water level in Tenmile Lakes, thus, home-owners should ensure that treatment systems are operating effectively. MSAE also increased at N11 and N16, although neither station exceeded Alert Level 2 (Figure 2). Total *Anabaena* declined overall, dropping below Alert Level 2 at all stations (Figure 2); *h*owever, as noted in previous Algal Memos, the predominant *Anabaena* species identified was *Anabaena planctonica* (Appendix I), a species less commonly associated with toxin production.

Blue-green algae (cyanobacteria) continued to comprise the majority of algal biomass at S3, S8, and N11; with the predominant species being A*phanizomenon flos-aquae and Anabaena planktonica* (Appendix I). Station N16 was comprised predominantly by the diatom *Fragilaria crotonensis* and secondarily by *Anabaena planktonica*. Various Chrysophytes, Cryptophytes, and Diatoms comprised the remainder of the biovolume at all stations. Although reported levels for non-dominant species (such as MSAE) indicate the general trend, they do not guarantee that levels of potentially toxigenic species at a particular location do not exceed guideline values. This spatial variability and the fact that cyanobacterial cells have been reported in home-owner drinking water treatment systems (see Kann 2007), make it prudent that all drinking water protection efforts should be in place. ***Levels of all potentially toxic cyanobacteria were well below recreational guidelines.***

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.

Stone, D., and W. Bress. 2007. Addressing Public Health Risks for Cyanobacteria in Recreational Freshwaters: The Oregon and Vermont Framework. Integrated Environmental Assesement and Managment; 3(1): 137 - 143 (2007). http://www.oregon.gov/DHS/ph/hab/docs/Stone_cyano_rec.pdf

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 2009 Tenmile Lakes Sample Site Locations

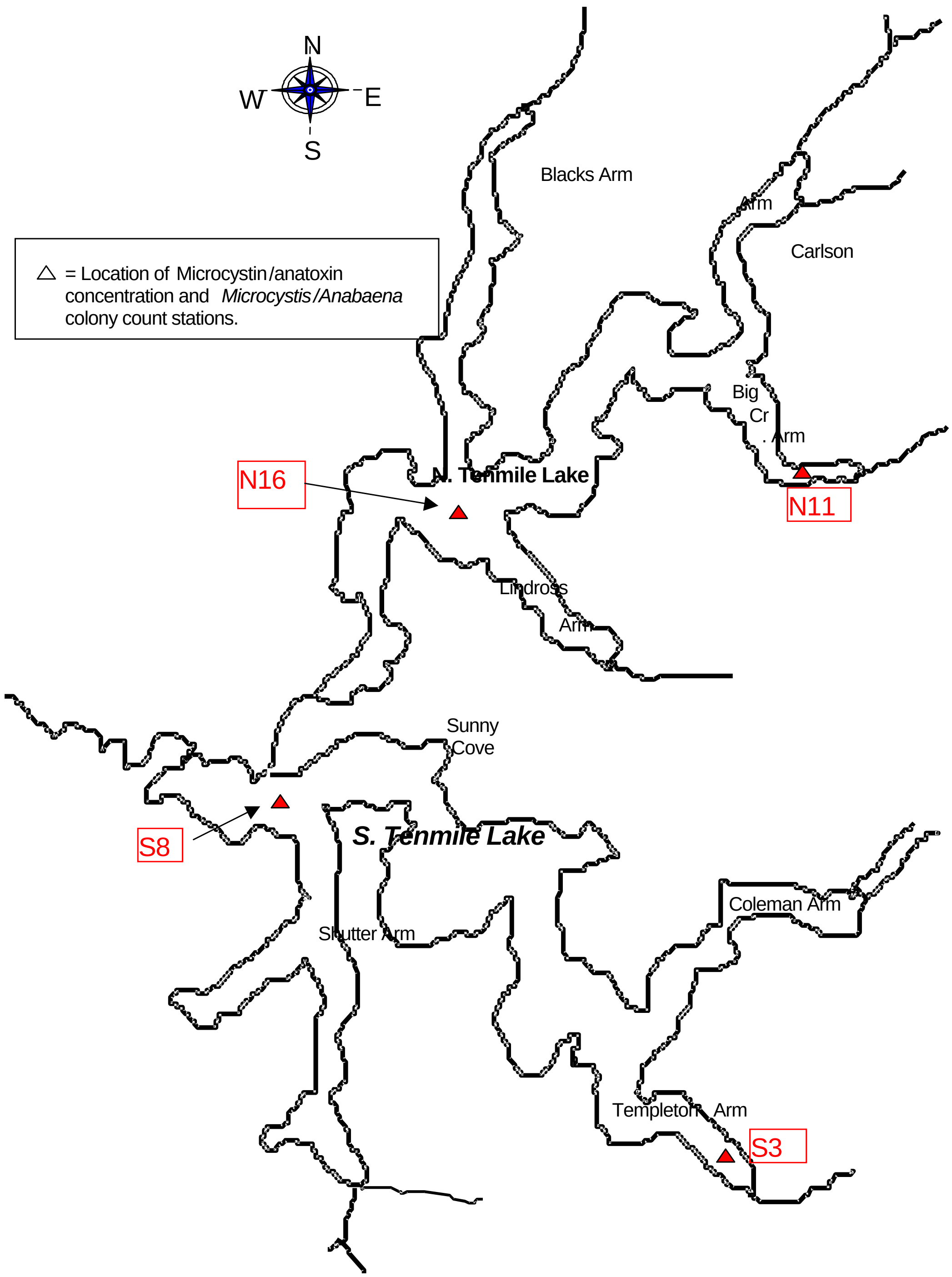

Figure1. Sample station location for potentially toxigenic cyanobacteria, Tenmile Lakes, 2009.

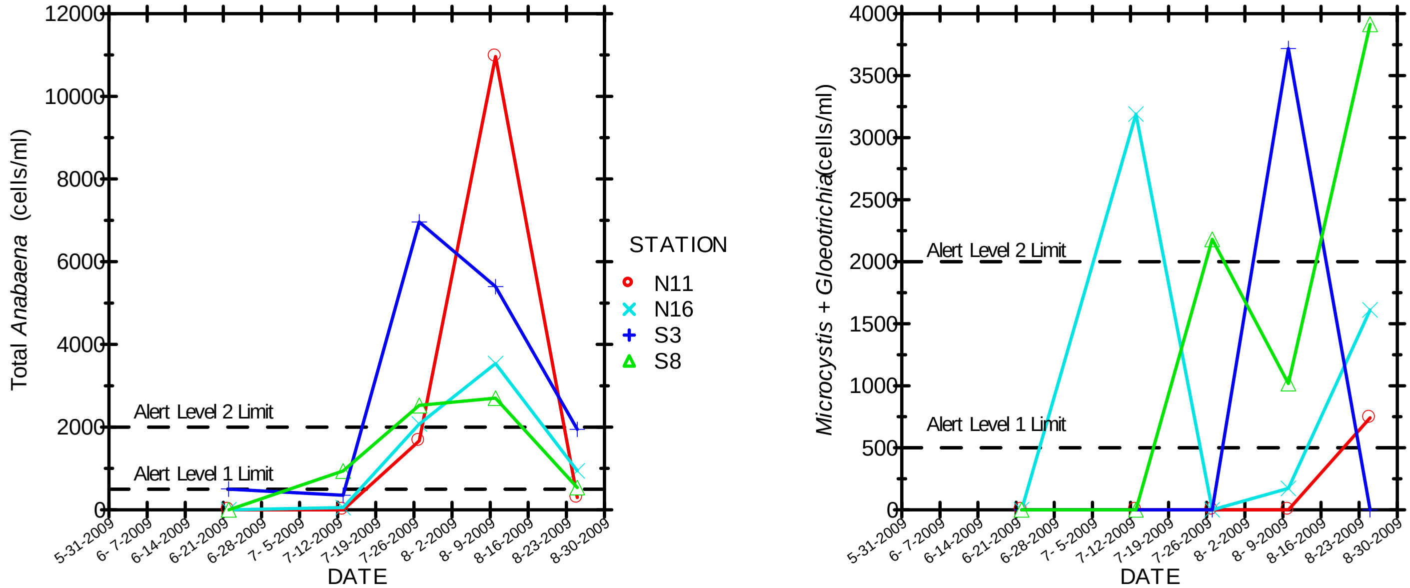

Figure 2. Trend of potentially toxic cyanobacteria in Tenmile Lakes, 2009.

Appendix I: Aquatic Analysts Phytoplankton Lab Sheets

Phytoplankton Sample Analysis

	Sample:	Tenmile Lake				
	Sample Site:	S3				
	Sample Depth:					
	Sample Date:	25-Aug-09				
	Total Density (#/mL):	687				
	Total Biovolume (um^3/mL):	1,333,443				
	Trophic State Index:	51.9				

	Species	**Density #/mL**	**Density Percent**	**Biovolume um^3/mL**	**Biovolume Percent**	**Group**
1	Aphanizomenon flos-aquae	531	77.3	669,132	50.2	bluegreen
2	Anabaena planctonica	76	11.1	349,253	26.2	bluegreen
3	Melosira ambigua	27	3.9	107,913	8.1	diatom
4	Melosira granulata	20	2.9	76,671	5.7	diatom
5	Cryptomonas erosa	17	2.4	8,630	0.6	cryptophyte
6	Dictyosphaerium ehrenbergianum	7	1.0	3,186	0.2	green
7	Melosira granulata angustissima	3	0.5	2,489	0.2	diatom
8	Ceratium hirundinella	3	0.5	32,527	2.4	dinoflagellate
9	Fragilaria crotonensis	3	0.5	83,641	6.3	diatom

Aphanizomenon flos-aquae cells/mL =	10,621
Aphanizomenon flos-aquae heterocysts/mL =	10
Anabaena planctonica cells/mL =	1,908
Anabaena planctonica heterocysts/mL =	37

Note: 200 count.

Aquatic Analysts **Sample ID:** MB60

Phytoplankton Sample Analysis

Sample:	Tenmile Lake
Sample Site:	S8
Sample Depth:	
Sample Date:	25-Aug-09
Total Density (#/mL):	216
Total Biovolume (um^3/mL):	410,765
Trophic State Index:	43.4

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Aphanizomenon flos-aquae	100	46.2	113,455	27.6	bluegreen
2	Mallomonas sp.	26	12.1	9,918	2.4	chrysophyte
3	Anabaena planctonica	23	10.6	91,942	22.4	bluegreen
4	Melosira ambigua	16	7.5	52,843	12.9	diatom
5	Melosira granulata	15	7.0	36,844	9.0	diatom
6	Microcystis aeruginosa	11	5.0	31,319	7.6	bluegreen
7	Dictyosphaerium ehrenbergianum	5	2.5	3,099	0.8	green
8	Melosira granulata angustissima	5	2.5	7,340	1.8	diatom
9	Fragilaria crotonensis	4	2.0	47,501	11.6	diatom
10	Cryptomonas erosa	2	1.0	1,131	0.3	cryptophyte
11	Sphaerocystis schroeteri	2	1.0	761	0.2	green
12	Anabaena circinalis	1	0.5	1,544	0.4	bluegreen
13	Melosira varians	1	0.5	2,121	0.5	diatom
14	Asterionella formosa	1	0.5	239	0.1	diatom
15	Schroderia sp.	1	0.5	49	0.0	green
16	Ceratium hirundinella	1	0.5	10,657	2.6	dinoflagellate

Aphanizomenon flos-aquae cells/mL =	1,801
Aphanizomenon flos-aquae heterocysts/mL =	5
Microcystis aeruginosa cells/mL =	3,915
Anabaena planctonica cells/mL =	502
Anabaena planctonica heterocysts/mL =	12
Anabaena circinalis cells/mL =	22
Anabaena circinalis heterocysts/mL =	1

Note: 200 count.

Aquatic Analysts **Sample ID:** MB61

Phytoplankton Sample Analysis

Sample: Tenmile Lake
Sample Site: N11
Sample Depth:
Sample Date: 25-Aug-09

Total Density (#/mL): 77
Total Biovolume (um^3/mL): 133,924
Trophic State Index: 35.4

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Aphanizomenon flos-aquae	39.4	51.2	52,101	38.9	bluegreen
2	Cryptomonas erosa	12.0	15.7	6,264	4.7	cryptophyte
3	Anabaena planctonica	10.2	13.3	52,227	39.0	bluegreen
4	Trachelomonas volvocina	3.7	4.8	6,987	5.2	euglenoid
5	Scenedesmus quadricauda	3.2	4.2	780	0.6	green
6	Chlamydomonas sp.	2.3	3.0	753	0.6	green
7	Melosira granulata	2.3	3.0	7,645	5.7	diatom
8	Microcystis aeruginosa	1.9	2.4	5,930	4.4	bluegreen
9	Gomphonema subclavatum	0.5	0.6	278	0.2	diatom
10	Trachelomonas pulchella	0.5	0.6	927	0.7	euglenoid
11	Rhodomonas minuta	0.5	0.6	9	0.0	cryptophyte
12	Achnanthes minutissima	0.5	0.6	23	0.0	diatom

Aphanizomenon flos-aquae cells/mL = 827
Aphanizomenon flos-aquae heterocysts/mL = 6

Anabaena planctonica cells/mL = 285
Anabaena planctonica heterocysts/mL = 8

Microcystis aeruginosa cells/mL = 741

Note: 200 count.

Aquatic Analysts **Sample ID:** MB62

Phytoplankton Sample Analysis

Sample: Tenmile Lake
Sample Site: N16
Sample Depth:
Sample Date: 25-Aug-09

Total Density (#/mL): 307
Total Biovolume (um^3/mL): 1,442,676
Trophic State Index: 52.5

	Species	Density #/mL	Density Percent	Biovolume um^3/mL	Biovolume Percent	Group
1	Aphanizomenon flos-aquae	170	55.2	213,909	14.8	bluegreen
2	Fragilaria crotonensis	48	15.7	933,085	64.7	diatom
3	Anabaena planctonica	40	12.9	166,319	11.5	bluegreen
4	Melosira ambigua	15	4.8	74,995	5.2	diatom
5	Melosira granulata	7	2.4	24,148	1.7	diatom
6	Melosira granulata angustissima	6	1.9	8,049	0.6	diatom
7	Microcystis aeruginosa	4	1.4	12,891	0.9	bluegreen
8	Cryptomonas erosa	4	1.4	2,283	0.2	cryptophyte
9	Glenodinium sp.	3	1.0	2,049	0.1	dinoflagellate
10	Ulothrix sp.	3	1.0	1,873	0.1	green
11	Staurastrum sp.	3	1.0	1,054	0.1	green
12	Sphaerocystis schroeteri	3	1.0	1,229	0.1	green
13	Staurastrum gracile	1	0.5	790	0.1	green

Aphanizomenon flos-aquae cells/mL = 3,395
Aphanizomenon flos-aquae heterocysts/mL = 22

Anabaena planctonica cells/mL = 909
Anabaena planctonica heterocysts/mL = 32

Microcystis aeruginosa cells/mL = 1,611

Note: 200 count.

Aquatic Analysts **Sample ID:** MB63

Oregon Health Division
Drinking water treatment guidance
August 31, 2001

DHS Contact Information:

Harmful Algae Program Coordinator: Laura Boswell at (971) 673 – 0438
If she is not available call the main line for the Office of Environmental Public Health at: (971) 673 – 0440 or
Toll Free: (877) 290 – 6767 and press 0. Ask for Laura Boswell

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