U.S. Army Corps of Engineers
Tulsa District

Blue-green Algae Response Procedures
12 June 2012

U.S. Army Corps of Engineers
Southwestern Division
Tulsa District

Executive Summary

1. Blue-green algae (cyanobacteria) are a natural component of aquatic ecosystems and are generally present in low densities.
2. Under certain conditions blue-green algae (BGA) populations can rapidly grow in number. This is called a ‘bloom’. Blooms can occur quickly, without warning and are very difficult to predict.
3. SWT is following the guidelines published by the World Health Organization (WHO) in 2003 which lists safe BGA levels for recreational waters. These guidelines are widely accepted as the testing guidelines for determining acceptable levels in recreational waters such as the reservoirs managed by SWT.
4. The WHO report indicates that exposure to BGA in cell densities greater than 100,000 cells per millimeter (cells/ml) have been shown to result in adverse human health effects including: hay-fever-like symptoms, skin rashes, vomiting and diarrhea and respiratory distress. Additionally, freshwater blue-green algae are capable of producing multiple cyanotoxins capable of causing specific and severe dysfunction to the liver and/or central nervous system.
5. In Oklahoma, SWT is working cooperatively with the Oklahoma Tourism and Recreation Department (OTRD) to provide BGA education materials to the public. SWT will continue to post BGA related data to the public on the SWT web page and social media outlets. SWT will provide data related to SWT managed reservoirs to the OTRD for public notification of BGA levels at www.TravelOK.com/checkmyoklake. As of June 2012, the State of Oklahoma does not have a BGA response plan in place.
6. In Kansas, SWT is working cooperatively with the Kansas Department of Health and Environment to provide BGA education materials to the public. SWT will continue to provide BGA response support to KDHE.
7. Animal and livestock exposure to blue-green algae blooms may result in severe health effects and possibly death.
8. When a suspected bloom is reported, internal and external communication plans will be executed as described in this document and sampling will take place.

9. When BGA cell densities are >100,000 cells/ml or cyanotoxins exceed established thresholds, BGA Advisory signs can be posted, at the discretion of the Lake Manager, at SWT managed points of entry to inform the public of any risks posed by the presence of BGA.
10. Advisory signs, if posted, will be removed when BGA densities are below 100,000 cells/ml and cyanotoxins are below established actionable thresholds.

1. Introduction

The purpose of this document is to provide guidance to Tulsa District personnel for the purposes of communicating to the public the potential health risks associated with primary body contact recreation in surface waters during a blue-green algae bloom at reservoirs managed by the Tulsa District (SWT). This plan also provides guidance on the logistics of sampling and communication when responding to blue-green algae bloom events. The primary objectives of this plan include:

a. Assessment of health hazards caused by blue-green algae and their toxins.
b. Identification of affected areas (e.g., recreational areas, swim beaches).
c. Public education and information.

The policy outlined within this document shall be superseded by harmful algae bloom response plans enacted by the individual States within the Area of Responsibility (AOR) of the Tulsa District.

2. General Information

Blue-green algae (cyanobacteria) are a natural component of all aquatic ecosystems and are generally present at low densities. Within the United States, blue-green algae blooms have been identified in 36 states including the states of Kansas, Oklahoma, and Texas and blue-green algae blooms continue to increase in frequency and intensity globally.

Exposure to blue-green algae in cell densities greater than 100,000 cells per milliliter (cells/mL) have been shown to result in adverse human health effects including: hay-fever-like symptoms, skin rashes, vomiting and diarrhea and respiratory distress. Additionally, freshwater blue-green algae are capable of producing cyanotoxins capable of causing specific and severe dysfunction to the liver and/or central nervous system. A physician reference from the National Center for Environmental Health is located in Appendix A.

Animal and livestock exposure to blue-green algae blooms have been shown to result in the poisoning of cattle, sheep, dogs, horses and pigs. Adverse health effects observed following animal and livestock exposure to blue-green algae blooms include: excess drooling, foaming at the mouth, malaise, loss of appetite, blood in urine or dark urine, and abdominal

tenderness. A veterinarian reference from the National Center for Environmental Health is located in Appendix B.

3. Funding of Monitoring Activities

Funding sources for monitoring activities shall be Project specific. It shall be the responsibility of each Project Office to identify funding from annual appropriations related to equipment, supplies, analysis, and shipping. It is the intent to include a District-wide analytical contract with each project contributing funds proportionate to the number of samples each project will anticipate collecting each fiscal year. PE-E will assist the Project Offices locate sources for equipment, supplies, and expendable items through appropriate sources (e.g., DOD E-Mall, GSA.

4. Harmful Algae Bloom Response and Coordination Process

Responding to blue-green algae blooms at Tulsa District reservoirs will require coordination and communication among several local and state entities and agencies as well as multiple Divisions within the Tulsa District (Operations Division, Natural Resources and Recreation (OD-NR), Operations Division, Field Offices (OD), Planning and Environmental Division (PE) and the Public Affairs Office (PAO)).

Within the Tulsa District, Environmental Specialists and/or Project Environmental Coordinators shall be responsible for the evaluation and investigation of reports from the general public at Lake Projects within each Environmental Specialists AOR with support from Planning and Environmental Division, Environmental Analysis and Compliance Branch (PE-E). Results of the Environmental Specialists and/or Project Environmental Coordinators investigation shall be coordinated through PE-E.

Coordination with local and state entities, agencies and stakeholders will be initiated by the Tulsa District at all levels. The Project Offices will coordinate with local stakeholders with the support of PE-E and OD-NR. PE-E, PE-P (Water Supply) and OD-NR will coordinate with local, state and regional stakeholders with the support of OD Field Offices. State agencies the Tulsa District will coordinate with include:

Kansas:
Kansas Department of Health and Environment (KDHE). The Tulsa District will partner with KDHE when responding to blue-green algae blooms within the Arkansas River watershed in Kansas. In

accordance with the KDHE Blue-Green Algae Agency Response Plan (Appendix C), KDHE will be the lead response agency in Kansas. The Tulsa District will provide support and assistance to KDHE when responding to reports of blue-green algae blooms at reservoirs managed by the Tulsa District.

Oklahoma:
Oklahoma Tourism and Recreation Department (OTRD) and Oklahoma Department of Environmental Quality (DEQ). The Tulsa District will partner with OTRD when responding to blue-green algae blooms within State of Oklahoma for the purposes of education and risk communication related to primary and secondary body contact recreation at SWT managed reservoirs. The Tulsa District will partner with DEQ when responding to blue-green algae blooms within the State of Oklahoma at SWT managed reservoirs that also function as Public Water Supplies (PWS).

Texas:
Currently, the State of Texas does not have an approved state agency blue-green algae response plan. PE-E will coordinate with the following agencies when issuing advisories and warnings related to health risk associated with primary body contact in recreational waters:

Texas Commission on Environmental Quality (TCEQ)
Texas Department of State Health (TDSH)
Paris-Lamar County Health Department
Grayson County Health Department
Texas Parks and Wildlife Department (TPWD)
Red River Authority of Texas (RRAT)

Figure 1 illustrates the decision tree for responding to blue-green algae bloom reports and for posting health advisories and associated risks. Table 1 outlines the roles and responsibilities for monitoring and responding to a blue-green algae bloom.

5. Recreational Advisory Levels

Recreational advisory levels presented below are taken from the WHO (2003). Recreational advisory levels outlined for the State of Kansas (Appendix C) include: NO ADVISORY when cell densities are < 20,000 cells/ml; ADVISORY when cell densities are > 20,000 but < 100,000 cells/ml; WARNING when cell densities are > 100,000 cells/ml.

Recreational advisory levels outlined for the State of Oklahoma (Appendix D) include: NO ADVISORY when cell densities are < 100,000 cells/ml and microcystin is < 20 ug/l; ADVISORY when cell densities are > 100,000 cells/ml and microcystin is > 20 ug/l.

No recreational advisory levels have been established by the State of Texas.

TABLE 8.3. GUIDELINES FOR SAFE PRACTICE IN MANAGING RECREATIONAL WATERS[a]

Guidance level or situation	How guidance level derived	Health risks	Typical actions[b]
Relatively low probability of adverse health effects			
20000 cyanobacterial cells/ml *or* 10 µg chlorophyll-a/litre with dominance of cyanobacteria	• From human bathing epidemiological study	• Short-term adverse health outcomes, e.g., skin irritations, gastrointestinal illness	• Post on-site risk advisory signs • Inform relevant authorities
Moderate probability of adverse health effects			
100000 cyanobacterial cells/ml *or* 50 µg chlorophyll-a/litre with dominance of cyanobacteria	• From provisional drinking-water guideline value for microcystin-LR[c] and data concerning other cyanotoxins	• Potential for long-term illness with some cyanobacterial species • Short-term adverse health outcomes, e.g., skin irritations, gastrointestinal illness	• Watch for scums or conditions conducive to scums • Discourage swimming and further investigate hazard • Post on-site risk advisory signs • Inform relevant authorities
High probability of adverse health effects			
Cyanobacterial scum formation in areas where whole-body contact and/or risk of ingestion/aspiration occur	• Inference from oral animal lethal poisonings • Actual human illness case histories	• Potential for acute poisoning • Potential for long-term illness with some cyanobacterial species • Short-term adverse health outcomes, e.g., skin irritations, gastrointestinal illness	• Immediate action to control contact with scums; possible prohibition of swimming and other water contact activities • Public health follow-up investigation • Inform public and relevant authorities

[a] Derived from Chorus & Bartram, 1999.

[b] Actual action taken should be determined in light of extent of use and public health assessment of hazard.

[c] The provisional drinking-water guideline value for microcystin-LR is 1 µg/litre (WHO, 1998).

Within the Tulsa District AOR in Oklahoma and Texas, SWT will operate under the following protocols and within the intent of SB259 presented in Appendix D:

CONDITION 1: No BGA is present or reported.

RESPONSE FOR CONDITION 1: BGA educational materials and water safety signs posted. Posting on the SWT internet site indicating BGA cell counts and cyanotoxins are below action thresholds.

CONDITION 2: BGA cell counts are less than 100,000 cells/ml and cyanotoxin levels are below scientifically determined recreational health risk thresholds, 6 ug/l microcystin; 6 ug/l cylindrospermopsin; 0.8 ug/l saxatoxin.

RESPONSE FOR CONDITION 2: BGA educational materials and water safety signs posted. Posting on the SWT public internet site indicating BGA cell counts and toxins are below action thresholds.

CONDITION 3: BGA cell counts are equal to or greater than 100,000 cells/ml or toxin levels are greater than scientifically determined recreational health risk thresholds, 6 ug/l microcystin; 6 ug/l cylindrospermopsin; , 0.8 ug/l saxatoxin.

RESPONSE FOR CONDITION 3: BGA educational materials and water safety signs posted. At the discretion of the Lake Manager of the affected lake, BLUE-GREEN ALGAE AWARNESS LEVEL (Appendix E) signs will be posted at all entry points of the reservoir managed by SWT, or handouts could be provided to visitors that are entering through attended gates detailing additional information on BGA at specific locations at the lake. Posting on the SWT public internet site indicating BGA cell counts or cyanotoxins are above action thresholds.

CONDITION 4: BGA cell counts are equal to or greater than 100,000 cells/ml and cyanotoxin levels are greater than scientifically determined recreational health risk thresholds, 20 ug/l microcystin; 20 ug/l cylindrospermopsin; 3 ug/l saxatoxin.

RESPONSE FOR CONDITION 4: BGA educational materials and water safety signs posted. The Lake Manager of the affected lake shall post BLUE-GREEN ALGAE AWARNESS LEVEL (Appendix E) signs at all entry points of the reservoir managed by SWT and handouts will be provided to visitors that are entering through attended gates detailing additional information of BGA at specific locations at the lake. Posting on the SWT internet site indicating BGA cell counts and toxins are above action thresholds recognized as posing a significant health risk to those participating in primary body contact activities.

Additionally, Lake Managers will have the option to close designated swim beaches managed by SWT.

6. Rationale of protocols used to issue and lift recreational advisories and warnings

The most common types of blue-green algae known to bloom within the AOR of the Tulsa District include *Microcystis, Anabaena, Planktothrix, Cylindrospermopsis,* and *Aphanizomenon*. Some species and strains of these genera are capable of manufacturing various toxins, collectively referred to as cyanotoxins capable of causing severe dysfunction of the hepatic and central nervous systems. In addition to the cyanotoxins produced only by certain groups of blue-green algae, all blue-green algae produce an additional class of toxins, collectively referred to as dermatoxins, capable of causing skin irritation and contact dermatitis. Individual sensitivity to the dermatoxins can vary considerably and is related to both allergic reactions and direct responses to the toxins themselves.

Because a blue-green algae bloom can occur without warning and the intensity of the bloom can change rapidly, increasing or decreasing in severity within only a few hours to a few days, the World Health Organization guidelines for managing blue-green algae exposure in recreational waters is based upon direct evidence of acute, non-cumulative health effects associated with primary body contact in recreational surface waters with a blue-green algae bloom.

The epidemiological evidence indicates that activities including wading, swimming, canoeing, jet skiing and water skiing can significantly increase the risk of direct ingestion of blue-green algae present in surface waters as well as the aspiration or inhalation of water droplets that expose individuals internally through digestive system and the nasal and pharyngeal mucous membranes. At greatest risk for ingestion are children, as well as pets, who generally wade and play in shallow near-shore areas where blue-green algae tend to concentrate and form surface scums, if applicable (e.g., *Cylilndrospermopsis* does not form surface scums).

The WHO (2003) has concluded blue-green algae cell concentrations below 20,000 cells/mL represent a minor risk to public health through primary body contact. When blue-green algae cell concentrations are > 20,000 cells/mL but < 100,000 cells/mL, the risk to the public health is generally limited to

skin irritation, gastrointestinal illness or other allergenic effects and not from cyanotoxin toxicity.

In the State of Kansas AOR for the Tulsa District, blue-green algae cell densities > 20,000 cells/mL but < 100,000 cells/ml will be designated as a blue-green algae ADVISORY (e.g., primary body contact discouraged). The ADVISORY level signage is provided in Appendix C. When blue-green algae cell concentrations are > 100,000 cells/mL the WHO (2003) has concluded there is the potential for a greater risk of adverse health impacts due to cyanotoxin toxicity. The toxicity from an individual bloom can vary significantly and there is no way to determine, through observation alone, whether a blue-green algae bloom has a high level of cyanotoxin toxicity. Blooms where blue-green algae concentrations are > 100,000 cells/mL, to include scums, have a greater probability of producing highly toxic levels of cyanontoxins and will be designated as a blue-green algae WARNING (e.g., primary body contact prohibited). The WARNING level signage is provided in Appendix C.

In the State of Oklahoma AOR for the Tulsa District, blue-green algae cell densities > 100,000 cells/ml will be designated as a blue-green algae ADVISORY.

The Tulsa District will issue and lift advisories and warnings based on blue-green algae cell densities in accordance with the WHO (2003) guidelines for safe practice in managing recreational waters (Table 1) and within the intent of the multiple state response plans and/or state laws. Cell densities will need to be laboratory-confirmed as being above the WHO threshold values (Table 1) in order to issue an ADVISORY and/or WARNING. Cell densities will need to be laboratory-confirmed as being below the WHO threshold values (Table 1) in order to lift an ADVISORY and/or WARNING.

When blue-green algae are present, the Tulsa District will make data and information available to the public through the SWT web page and the SWT social media (e.g., Facebook).

7. Procedures for the selection of sampling locations and the collection of samples

Sampling locations should be common public points of access. These locations include swimming beaches, courtesy docks, boat ramps, and other frequently used public access areas. Additional sampling locations may be selected from areas only accessible by boat where large numbers of people gather to

recreate in the water as well as at the water's edge (e.g., islands, coves with large expanses of beach).

When evaluating a report from the public and/or Project personnel, the Project Environmental Coordinator and/or Area Environmental Specialist should use a calibrated oxygen probe and collect dissolved oxygen and water temperature readings at 0.1 m, 0.5 m, 1.0 m, and 2.0 m (0.3 ft, 1.6 ft, 3.2 ft, and 6.5 ft). Dissolved oxygen readings should be recorded in percent saturation (% sat) and in mg/L, as described in Figure 1. Field observations should include:

a. GPS location and written description of area being investigated
b. Dissolved oxygen (DO) readings
c. Presence/absence of surface scum
d. Notes on the coloration of the water (e.g., pea green, turbid, clear)
e. Photographs of the area being investigated
f. Phytoplankton samples (if DO supersaturation requirements are met)

Oxygen supersaturation is a useful surrogate parameter because it is indicative of high concentrations of algae producing oxygen through photosynthesis. Samples will be collected in accordance with the World Health Organization protocols on the monitoring of blue-green algae in recreational waters and the Standard Operating Procedures for Field Sampling: Lakes (USACE 2000). At a minimum, samples will be collected for the identification and enumeration of blue-green algae. Optional samples could be included for the analysis of:

g. Levels of microcystin toxin
h. Chlorophyll *a*
i. Phycocyanin
j. Dissolved Oxygen
k. pH
l. Water temperature
m. Total Kjeldahl Nitrogen and Total Phosphorus

Samples collected for the identification and enumeration of blue-green algae shall follow PE-E SOP 3.9: Collection of Samples for Algal Enumeration and Identification.

SOP 3.9: Collection of Samples for Algal Enumeration and Identification
Revision date: 24 November 1999

1. Label 250 ml opaque HDPE sample bottle for sample collection
2. Collect sample at a depth of 0.5 m by immersing bottle to elbow depth. Completely fill bottle.
3. Pour out just enough water to add approximately 1.8 ml of Lugol's Solution as preservative. Add Lugol's Solution and tightly cap bottle. Invert bottle a number of times to thoroughly mix sample and preservative.
4. Store samples in a secure area prior to enumeration and identification. Protect sample from temperature extremes (particularly high heat).

If samples are to be collected as described above, the sampler should use a shoulder length rubber/vinyl glove and avoid dermal contact with the water. The sampler can opt to collect samples at a depth of 0.5 meters using a Van Dorn or Kemmerer sampler in accordance with PE-E SOP 3.2: Collection of Lake Water Grab Samples at Depth (USACE 2000) and cover their hands with latex examination gloves. The Standard Operating Procedures for Field Sampling: Lakes (SOP) is provided in Appendix F. Any samples collected for optional analyses shall be collected in accordance with the Districts SOP's.

All necessary instrumentation, equipment, and sampling supplies necessary to perform site evaluations and collect samples should be maintained by the Area Environmental Specialists and Project Environmental Coordinators. PE-E will maintain and provide acidified Lugol's solution. PE-E will provide training and support to the Area Environmental Specialists and Project Environmental Coordinators related to the maintenance and calibration of oxygen meters and/or data sondes. Equipment and supplies to be maintained by Environmental Specialists and/or Project Environmental Coordinators includes:

a. Field Geographic Positioning System (GPS)
b. Field dissolved oxygen/temperature meter
c. Elbow length rubber/vinyl gloves
d. Latex examination gloves
e. Van Dorn Style sampler (optional)
f. 250ml opaque (amber) HDPE bottles
g. Acidified Lugol's solution (provided by PE-E, notify when replacement supplies are required)

Phytoplankton samples will be provided to a District approved analytical laboratory for the identification and enumeration, in cells/ml, of blue-green algae. Analytical results of all samples submitted will be provided to both PE-E and the

submitting Project electronically. PE-E will be responsible for the interpretation of analytical results and will provide recommendations based upon the WHO guidelines for safe practice in managing recreational waters (Section IV above), to the submitting Project Manager.

8. Public Notification and Communication

The Tulsa District Communications Plan: Blue-green algae advisories and warnings in Tulsa District Lakes is provided in Appendix G.

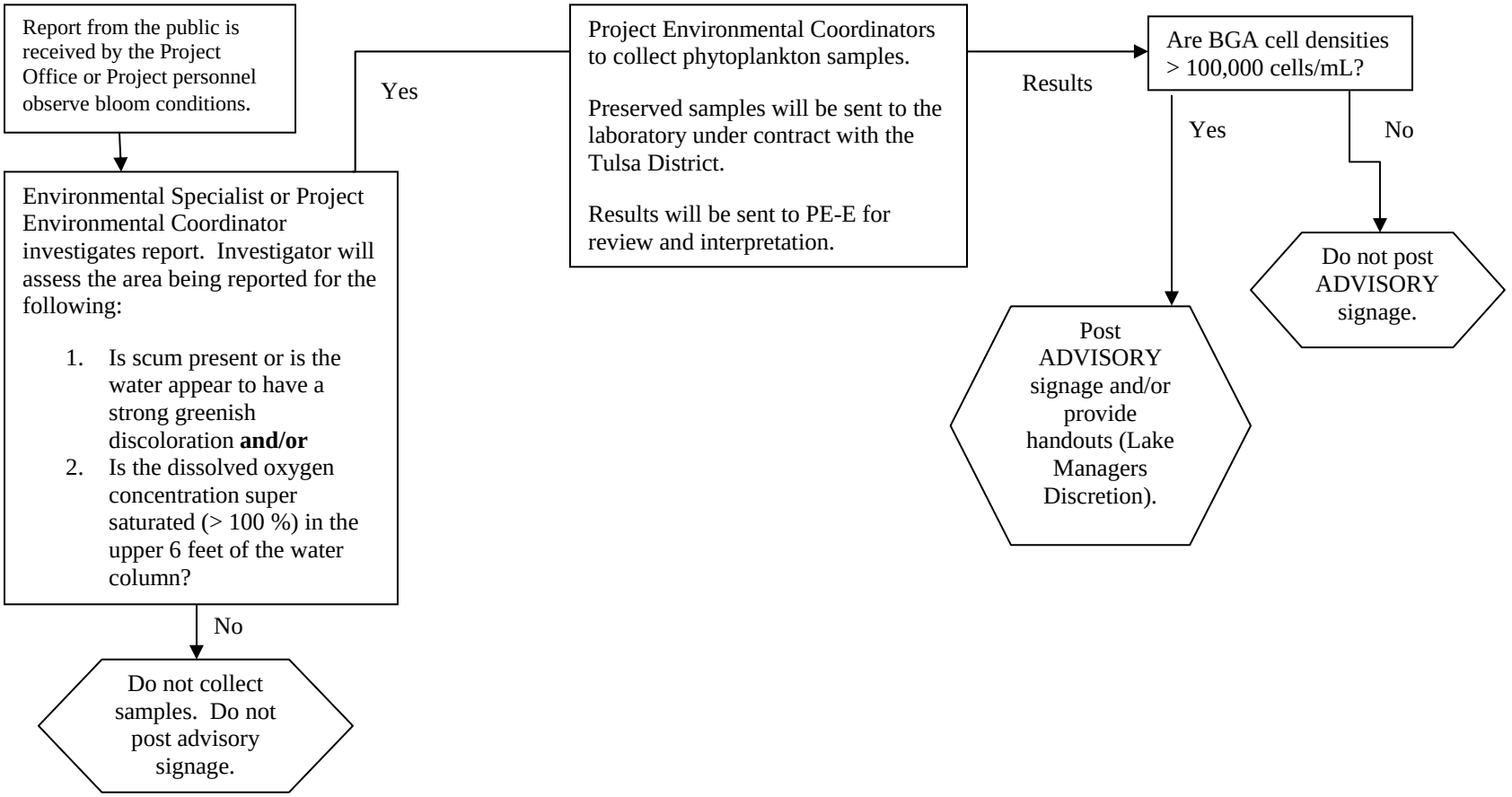


Figure 1. Decision tree for assessing BGA blooms within Oklahoma ARO for SWT.

Table 1. Roles and responsibilities for monitoring and responding to a blue-green algae bloom at reservoirs managed by the Tulsa District in the states of Kansas, Oklahoma and Texas with regard to primary and secondary body contact recreation only.

	Kansas		Oklahoma	
Activity	**Lead Role**	**Assisting Role**	**Lead Role**	**Assisting Role**
Monitor	KDHE monitors water bodies through on-site observations or evidence of blue-green algae blooms.	Tulsa District provides assistance with on-site observations.	Tulsa District monitors water bodies through on-site observations of blue-green algae blooms.	OTRD provides assistance with on-site observations.
Collect Water Samples	KDHE collects water samples using KDHE approved methods.	Tulsa District provides assistance with sampling USACE managed reservoirs.	Project Environmental Coordinators collect water samples using scientifically acceptable sample methodology	OTRD provide assistance with identifying sampling methodology and sample collection.
Analyze Samples	KDHE to perform the required analyses.		Tulsa District to perform the required analyses.	OTRD could provide assistance with additional capacity they may have to assist USACE.
Issue or lift advisories	KDHE evaluates analytical results and data quality and determines if an advisory should be issued or lifted.	Tulsa District consults with KDHE as appropriate before issuing or lifting advisories by KDHE.	Tulsa District evaluates analytical results and data quality and determines if any advisory should be issued or lifted.	Tulsa District consults with OTRD, as appropriate, before issuing or lifting advisories.
Communicate advisory information	KDHE informs the general public through advisories issued to the media and via its website.	Tulsa District provides assistance with informing the general public through posting advisories and via it website and Facebook.	OTRD informs the general public through advisories at www.TravelOK.com/checkmyoklake.	Tulsa District provides assistance with informing the general public through media statements, and via its website and/or Facebook..

Note: Texas agencies notified as necessary within Grayson and Lamar Counties, Texas.

9. References

Chorus, I. and J. Bartram. 1999. Toxic Cyanobacteria in Water: A guide to their public Health consequences, monitoring and management. Published by E & FN spon on behalf of the World Health Organization. http://www.who.int/water_sanitation_health/resourcesquality/toxcyanbegin.pdf

ER 1110-2-8154, Water Quality and Environmental Management for Corps Civil Works Projects. http://140.194.76.129/publications/eng-regs/er1110-2-8154/entire.pdf

Kansas Department of Health and Environment (KDHE). 2010. Blue-green algae in Kansas: KDHE Agency Response Plan. Kansas Department of Health and Environment.

U. S. Army Corps of Engineers (USACE). 2000. Standard Operating Procedures for Field Sampling: Lakes. U. S. Army Corps of Engineers, Tulsa, Oklahoma.

World Health Organization (WHO). 2003. Guidelines for Safe Recreational Water Environments, Volume 1: Coastal and Fresh Waters. World Heath Organization. http://www.who.int/water_sanitation_health/bathing/srwe1/en/

Appendix A

Physician Reference

Blue-green Algae Blooms

When in doubt, it's best to stay out!

Grand Lake Saint Mary's , Summer 2010

What are blue-green algae?
Cyanobacteria, sometimes called blue-green algae, are microscopic organisms that live in all types of water.

What is a blue-green algae bloom?
•Blue-green algae grow quickly, or bloom, when the water is warm, slow-moving, and full of nutrients.

What are some characteristics of blue-green algae blooms?
•Algae usually bloom during the summer and fall. However, they can bloom anytime during the year.
•When a bloom occurs, scum might form on the water's surface.
•Blooms can be many different colors, from green or blue to red or brown.
•As the bloom dies off, you might smell an odor that is similar to rotting plants.

What is a toxic bloom?
Sometimes, blue-green algae produce toxins.
•The toxins can be present in the algae or in the water.

Other important things to know:
•Swallowing water that has algae or algal toxins in it can cause serious illness.
•Dogs might have more severe symptoms than persons, including collapse and sudden death after swallowing the contaminated water while swimming or after licking algae from their fur.
•There are no known antidotes to these toxins. Medical care is supportive.

You cannot tell if a bloom is toxic by looking at it.

To report a blue-green algae bloom or related health event:

Call your local or state health department

For more information:
http//www.cdc.gov/hab/links.htm
or
Call the National Center for Environmental Health Harmful Algal Blooms Program (HABISS) Centers for Disease Control and Prevention:
866-556-0544

What we know about exposure to blue-green algae and cyanotoxins and possible health effects

Information about human health effects from exposure to blue-green algae and toxins is primarily derived from a few epidemiology studies of recreational exposures; studies with laboratory animals; reports of extreme human exposure events, such as the use of toxin-contaminated dialysis water; and from animal (e.g., cattle and pet dog) exposures. References are available at: http//www.cdc.gov/hab/links.htm

Potential exposure route	Information source for possible symptoms and signs	Possible symptoms and signs
Swallowing water contaminated with blue-green algae (cyanobacteria) or toxins	Data from laboratory animal studies, extreme human exposure events, and animal exposures	**Hepatotoxins and nephrotoxins** Nausea, vomiting, diarrhea Bad taste in mouth Acute hepatitis, jaundice Blood in urine or dark urine Malaise, lethargic Headache, fever Loss of appetite **Neurotoxins** Progression of muscle twitches For saxitoxin: high doses may lead to progressive muscle paralysis
Skin contact with water that is contaminated with blue-green algae or toxins	Data from human studies	Allergic dermatitis (including rash, itching and blisters) Conjunctivitis
Inhaling aerosols contaminated with blue-green algae or toxins	Anecdotal evidence from human exposures and data from human studies	Upper respiratory irritation (wheezing, coughing, chest tightness, shortness of breath)

Appendix B

Veterinarian Reference

Blue-green Algae Blooms. *When in doubt, it's best to stay out!*

What are blue-green algae?

- Cyanobacteria, sometimes called blue-green algae, are microscopic organisms that live in all types of water.

What is a blue-green algae bloom?

- Blue-green algae grow quickly, or bloom, when the water is warm, slow-moving, and full of nutrients.

What are some characteristics of blue-green algae blooms?

- Algae usually bloom during the summer and fall. However, they can bloom any time during the year.
- When a bloom occurs, scum might form on the water's surface.
- Blooms can be many different colors, from green or blue to red or brown.
- As the bloom dies off, you might smell an odor that is similar to rotting plants.

What is a toxic bloom?

- Sometimes, blue-green algae produce toxins, such as microcystins.
- The toxins can be present in the algae or in the water.

Other important things to know:

- Swallowing water that has algae or algal toxins in it can cause serious illness.
- Dogs might have more severe symptoms than persons, including collapse and sudden death after swallowing the contaminated water while swimming or after licking algae from their fur.
- There are no known antidotes to these toxins. Medical care is supportive.

You cannot tell if a bloom is toxic by looking at it.

To report a blue-green algae bloom or related health event:

- Call your local or state health department

For more information:

- http//www.cdc.gov/hab/links.htm or
- Call the National Center for Environmental Health Harmful Algal Blooms Program (HABISS) Centers for Disease Control and Prevention: 866-556-0544

CS223677-B

National Center for Environmental Health
Division of Environmental Hazards and Health Effects

Exposure and Clinical Information

Information about the health effects from exposure to blue-green algae and toxins is derived from reports of animal poisonings.*

POTENTIAL EXPOSURE ROUTE	LIKELY SYMPTOMS AND SIGNS	TIME TO SYMPTOM ONSET**	DIFFERENTIAL DIAGNOSIS	POSSIBLE LABORATORY OR OTHER FINDINGS
Swallowing water that is contaminated with blue-green algae (cyanobacteria) or toxins or licking it off fur or hair	**Hepatotoxins and nephrotoxins** • Excess drooling, vomiting, diarrhea, • foaming at mouth • Jaundice, hepatomegaly • Blood in urine or dark urine • Malaise • Stumbling • Loss of appetite • Photosensitization in recovering animals • Abdominal tenderness	Minutes to hours	Acetaminophen or NSAID overdose, rodenticide ingestion, aflatoxicosis and other hepatotoxin poisonings	• Elevated bile acids, ALP, AST, GGT • Hyperkalemia • Hypoglycemia • Prolo nged clotting tine • proteinuria • Presence of toxin in clinical specimens from stomach contents taken from animals that became ill
	Neurotoxins • Progression of muscle twitches • For saxitoxin, high doses may lead to respiratory paralysis and death if artificial ventilation is not provided.	Minutes to hours	Pesticide poisoning, myasthenia gravis, other toxin poisoning	Presence of toxin in clinical specimens from stomach contents taken from animals that became ill
Skin contact with water contaminated with blue-green algae or toxin(s)	**Dermal toxins** • Rash, hives, allergic reaction	Minutes to hours	Other dermal allergens	Blue-green staining of fur or hair

NOTES:

1. Monogastric animals appear less sensitive than ruminants or birds; however, the dose-response curve is very steep in dogs—up to 90% of a lethal dose may elicit no clinical signs.
2. There are no known antidotes to these toxins. Medical care is supportive. Activated charcoal may be useful within the first hour, and atropine has efficacy with saxitoxin exposure.

*References are available at: http//www.cdc.gov/hab/links.htm

Appendix C

Curtis State Office Building
1000 SW Jackson St., Suite 540
Topeka, KS 66612-1367

Kansas

Phone: 785-296-0461
Fax: 785-368-6388
www.kdheks.gov

Robert Moser, MD, Secretary

Department of Health & Environment

Sam Brownback, Governor

April 13, 2012

KDHE INTERNAL DIRECTIVE 1101.0

Subject: Policy: Guidelines for Addressing Harmful Algal Blooms in Kansas Recreational Waters

1. PURPOSE.

Protecting the environment as well as public health, safety and welfare is the mission of KDHE. Harmful Algal Blooms (HAB) present unique difficulties in health risk assessment determination. This policy considers health and environmental risks as well as the economic impact on resources within our agency. The basis for this policy is the epidemiologic study of HAB data collected by KDHE in Kansas and the analysis of established scientific and medical research including studies conducted by the World Health Organization (WHO).

2. DISCUSSION.

Cyanobacteria, also known as blue-green algae, can produce toxins in recreational waters and have been implicated in human and animal illness in Kansas. The threat to health is related to the prevalence of cyanotoxins and cyanobacteria cell concentrations in recreational water and corresponding contact with or accidental ingestion of the cyanobacterial cells or cyanotoxins. During a HAB those most susceptible when exposed are small children. Actual acute exposures have demonstrated that there is a higher incidence of illness among children that suggest risk calculations based on data from adults or animal studies may not be sufficient to protect children. The most common complaints after recreational exposure to cyanobacteria and associated toxins include vomiting, diarrhea, skin rashes, eye irritation and respiratory symptoms. As the concentration of cyanobacterial cells increases the probability of adverse health effects also increases.

3. PROCEDURES.

KDHE performs sampling of recreational bodies of water for cyanobacteria once alerted to a potential bloom. KDHE has the capability to test for microcystin toxin and to quantify and identify the type of cyanobacteria present. When a HAB has been properly identified in a Kansas public lake, KDHE will issue either a Public Health Advisory or Public Health Warning, dependent on the level of risk associated with the HAB as determined through water sampling and testing. The issuing of a Public Health Advisory or Public Health Warning is based on the concentration of microcystin toxin or cyanobacteria cell counts.

4. ACTION.

The primary distinctions between a Public Health Advisory and A Public Health Warning are:

a. the level of risk that needs to be communicated to the public; and

b. recommended actions to the governing authority of the affected body of water to discourage exposure.

Implementation of appropriate measures to restrict exposure will be the responsibility of the governing authority of the affected body of water. If the governing authority chooses to close the body of water, KDHE can provide example alert, warning or closure signs.

A Public Health Advisory will be issued when the microcystin toxin concentration is detectable at a concentration of 4 µg/L to less than 20 µg/L or cyanobacteria cell counts are 20,000 to less than 100,000 cells/mL. A Public Health Advisory includes posting of signs at beaches, marinas, boat ramps, and other points of entry to the body of water. The Public Health Advisory will indicate that harmful algae are present and that the body of water may be unsafe for people and animals, the symptoms of cyanobacterial poisoning, what to do in case of contact with the water and who to call in case of illness potentially associated with exposure. The Public Health Advisory will discourage people from having full body contact with water (e.g., no swimming, skiing, etc.) and allowing their pets to drink or swim in the water; however boating and fishing are permitted. If fish are caught during a Public Health Advisory, the fish should be properly cleaned and have internal organs removed before eating. If water from the lake is used for irrigation, people should avoid the spray, thoroughly wash fruits or vegetables in clean water and not allow livestock to drink irrigation water. In addition, a Health Alert Network message will be sent to all local health departments, physicians, veterinarians and hospitals to provide them an advance copy of a media release, which will be issued to the public, containing all lakes under a Public Health Advisory or Public Health Warning and ask them to report adverse health events associated with cyanobacterial toxin poisoning. Also, the public water suppliers with intakes in the water body affected will be notified.

A Public Health Warning will be issued when microcystin toxin concentrations are greater than or equal to 20 µg/L or cyanobacterial counts are greater than or equal to 100,000 cells/mL. A Public Health Warning may also be issued if there is verified documentation of visible cyanobacterial scum present. A Public Health Warning will indicate that harmful algae are present and that the body of water is unsafe for people and animals. A Public Health Warning includes all of the actions of a Public Health Advisory with the addition of all contact with water should be restricted, including prohibitions on swimming, water skiing, and other activities that would involve direct contact with the affected water. Also, the public water suppliers with intakes in the water body affected will be notified as well.

A body of water with a Public Health Advisory will be tested by KDHE on a determined basis and in a consistent manner. The Public Health Advisory will remain in effect until cyanobacteria concentrations are less than 20,000 cells/mL at all sampling sites and microcystin toxin concentrations are less than 4 µg/L detectable at all sampling sites.

A body of water with a Public Health Warning will be tested by KDHE on a determined basis and in a consistent manner. The Public Health Warning will remain in effect until the cyanobacterial concentrations are less than 100,000 cells/mL and concentrations of microcystin toxins are less than 20 µg/L, at which time it will be either reduced to a Public Health Advisory (if testing results exceed the Public Health Advisory thresholds) or under no status (if testing results are below the Public Health Advisory thresholds).

KDHE HAB RESPONSE MATRIX

Condition	*Alert Level*	*Recommended Action(s)*
• *Microcystin toxin concentration <4µg/L and* • *Cyanobacterial concentration <20,000 cells/mL*	✓ *None*	✓ *None*
• *Microcystin toxin concentration ≥4 to <20 µg/L or* • *Cyanobacterial concentration ≥20,000 to <100,000 cells/mL*	✓ *Public Health Advisory*	✓ *Post Public Health Advisory signage* ✓ *Discourage direct contact with the affected body of water* ✓ *Notify appropriate local health departments, healthcare providers, and veterinarians* ✓ *Notify public water suppliers with intakes in the water body affected* ✓ *Issue media release*
• *Microcystin toxin concentration ≥ 20µg/L or* • *Cyanobacterial concentration ≥ 100,000 cells/mL*	✓ *Public Health Warning*	✓ *Post Public Health Warning signage* ✓ *Prohibit direct contact with the affected body of water* ✓ *Notify appropriate local health departments, healthcare providers, and veterinarians* ✓ *Notify public water suppliers with intakes in the water body affected* ✓ *Issue media release*

Robert Moser

4/17/2012

Robert Moser, M.D.
Secretary/State Health Officer
KDHE

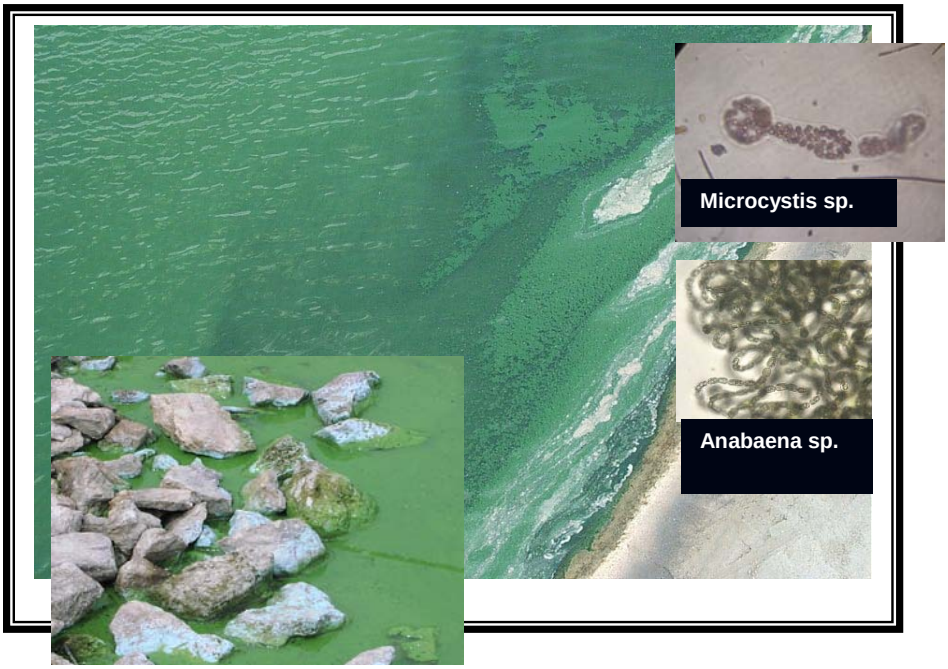
Date

Final Version

Kansas
Department of Health and Environment

Harmful Algae Blooms

KDHE Agency Response Plan



4/2012

KDHE Blue-Green Algae Response Plan

DATE: March, 2012

SUBJECT: Blue-green Algae Response

1. BASIS. The purpose of this plan is to provide guidance for Kansas Department of Health and Environment's (KDHE) response to reduce the risk of exposure to humans, pets and livestock from blue-green algal toxins.

Blue-green algae (also known as cyanobacteria) toxins in freshwaters have been implicated in human and animal illness in at least 36 states in the United States[1]. Blue-green algae are naturally present in most Kansas surface water resources. When certain conditions are present, such as high nutrient and abundant light levels, these organisms can reproduce rapidly. This dense growth of algae is called a bloom, sometimes leading to a harmful algal bloom (HAB). These conditions tend to occur in the warmer summer months after spring rainfalls wash accumulated high nutrient loads from animal waste, agricultural fertilizers and sewage effluent into surface waters. Dry conditions improve water clarity, allowing light to penetrate deeper into waters, fueling primary productivity where nutrients are plentiful. Dry conditions also increase the impact of wastewater effluent on streams. Organisms most frequently responsible for these HAB outbreaks include cyanobacteria and, rarely in freshwater, dinoflagellates.

HABs are potentially toxic and may pose a direct threat to human and animal health. Recreational exposure to cyanobacteria toxin can result in adverse human health effects such as: hay fever-like symptoms, skin rashes, vomiting, diarrhea and respiratory distress.[2] Freshwater blue-green algae under bloom conditions are capable of producing potent toxins that cause specific and severe hepatic or neurological dysfunction. These toxins have also been identified as the cause of several animal deaths. Exposure to these toxins most commonly occurs when persons or animals ingest or inhale contaminated water[3].

2. GENERAL. This plan outlines the interaction, responsibilities and activities of KDHE and coordination with other stakeholders to ensure that the HAB investigation is conducted in a rapid and effective manner and founded on the following principles[5]:

A. Potential HAB events will be treated as harmful until proven otherwise.

B. Response to HABs will be limited to "Public Waters" only. Owners/managers of waters not accessible to the public and not a public drinking water supply lake who request assistance with HABs will be directed to the Kansas State

Veterinary Diagnostic Laboratory in Manhattan, Kansas. The Veterinary Diagnostic Laboratory will be able to identify the presence or absence of cyanobacteria in a water sample.

i. In Kansas, for the purpose of the KDHE Blue Green Algae (BGA) response plan, "Public waters" and "Private water bodies" are defined as:

a. ***Public waters****: Those waters that are referred to as reservoirs, community lakes, state fishing lakes and/or are waters managed or owned by federal, state, county or municipal authorities and all privately owned lakes that serve as public drinking water supplies or that are open to the general public for primary or secondary contact recreation. Primary contact recreation includes those activities where the body is immersed to the extent that some inadvertent ingestion of water is probable. This use shall include activities such as: boating, mussel harvesting, swimming, skin diving, waterskiing and windsurfing. Secondary contact recreation includes any activity in which the ingestion of surface waters is not probable. These uses shall include activities such as wading, fishing, trapping and hunting.*

b. ***Private water bodies***: A*ny freshwater reservoir or pond that is both located on and completely bordered by land under common private ownership (or not accessible to the general public).*

C. Response should be as rapid as practicable considering the resources available.

D. Response to HAB events and any and all advice provided will be consistent across all bureaus and responding agencies.

E. KDHE will be the primary responder unless multi-agency response is requested.

F. The response will at least include the analysis and identification of concentrations of cyanobacteria and microcystin toxins and the determination of when the issuing of public health advisories is necessary for both public and private recreational water resources and for when public drinking water issues are a concern.

G. Training for all responding agencies for HAB events will be initiated by KDHE to ensure the effective coordination and consistency of response between agencies.

H. The KDHE Blue-Green Algae Response Plan is a dynamic document that is to be reviewed and maintained annually by KDHE.

3. PUBLIC HEALTH PROTECTION LEVELS: KDHE may issue two levels of public health protection notifications, a "Harmful Algae Bloom (HAB) Advisory" or "Harmful Algae Bloom (HAB) Warning". These notification levels are determined by the concentration of harmful toxin level(s) **or** the concentration of cyanobacteria cell counts. When appropriate, KDHE will recommend the following actions for:

A. Harmful Algae Bloom (HAB) **Advisory** notifies the public that a hazardous condition could exist and encourages limiting exposures. It has been analytically determined that the microcystin toxin concentration is greater than 4 µg/L but less than 20 µg/L or cyanobacterial cell counts are greater than 20,000 but less than 100,000 cells/mL[4].

i. The appropriate HAB Caution signage (See Attachment 1) should be posted at all primary public access locations such as beaches, marinas, boat ramps, and other main points of entry to the body of the water. Information should include:

a. that blue-green algae are present and that the body of water **may** be unsafe for people and animals;

b. contact information for the posting authority;

c. the date of the posting;

d. the symptoms of cyanobacterial poisoning;

e. what to do in case of contact with the water, and

f. whom to call in case of illness potentially associated with exposure.

The advisory should also:

a. discourage people from having contact with the water, especially full body contact (e.g., no swimming, skiing, etc.);

b. discourage allowing pets to drink or swim in the water. If pets do come in contact with the water, then they should be rinsed off with clean water immediately – not allowing them to lick the algae (and toxins) off their fur. Do not allow pets to consume dried algae on shorelines as algal toxins will remain toxic even in dry form;

c. permit boating and fishing, although boaters should be aware of inhalation of spray;

d. indicate that if fish are caught, the fish should be properly cleaned and rinsed with clean water, all internal organs removed, consuming only the filets;

e. indicate that if water from the lake is used for irrigation, that people should avoid contact with the spray; due to the potential illness. Avoid fruits and vegetables that have come in contact with contaminated water until they have been washed with clean water. Do not allow livestock to drink irrigation water. If water is used to irrigate pastures, livestock owners should be aware that continued application of heavily affected waters can lead to significant toxin build up on foliage. Although rare, this residue can affect livestock, and

f. indicate that areas of the lake may contain significantly higher HAB concentrations due to wind effects, increasing the health threats.

ii. A Health Alert Network message is to be sent to local health departments, physicians, veterinarians and hospitals in the immediate and surrounding counties to inform them of the bloom and ask them to report any adverse health events associated with cyanobacterial toxin poisoning.

iii. A Public Health press release (See Attachment 5) will also be issued either by KDHE or in conjunction with water impoundment managers/owners or other stakeholders to inform the public of the HAB.

B. Harmful Algae Bloom (HAB) **Warning** notifies the public that conditions are unsafe for human exposures and recommends action over and above those listed in the "HAB Advisory" be taken restricting or prohibiting public exposure. It has been analytically determined that the microcystin toxin concentration is greater than or equal to 20 µg/L, cyanobacterial cell counts are greater than or equal to 100,000 cells/mL, or there is verification of significant cyanobacterial surface scum present[4].

i. The appropriate HAB Warning signage (See Attachment 2) should be posted at all primary public access locations such as beaches, marinas, boat ramps, and other main points of entry to the body of the water. Information should include:

a. that blue-green algae are present and that the body of water **is** unsafe for people and animals;

b. contact information for the posting authority;

c. the symptoms of cyanobacterial poisoning;

d. what to do in case of contact with the water, and

e. who to call incase of illness potentially associated with exposure.

The warning should also:

a. prohibit swimming, water skiing, boating or other activities that would involve direct contact with the affected water;

b. warn that all contact with water should be avoided;

c. warn owners not to allow pets to drink or swim in the water. If pets do come in contact with the water, then they should be rinsed off with clean water immediately, not allowing them to lick the algae (and toxins) off their fur and pets should not be allowed to consume dried algae on shorelines as algal toxins will remain toxic even in dry form;

d. warn that if fish are caught, the fish should be properly cleaned and rinsed with clean water, all internal organs removed, consuming only the filets;

e. warn that if water from the lake is used for irrigation, that people should avoid contact with the spray due to the potential of illness. Avoid fruits and vegetables that have come in contact with contaminated water until they have been washed with clean water. Do not allow livestock to drink from contaminated irrigation water. If water is used to irrigate pastures, livestock owners should be aware that continued application of contaminated waters can lead to significant toxin build up on foliage. Although rare, this residue can affect livestock, and

f. warn that areas of the lake may contain significantly higher HAB concentrations due to wind affects, increasing the health threats.

ii. A Health Alert Network message is to be sent to local health departments, physicians, veterinarians and hospitals in the immediate and surrounding counties to inform them of the bloom and ask them to report adverse health events associated with cyanobacterial toxin poisoning.

iii. A Public Health press release will also be issued either by KDHE or in conjunction with water impoundment managers/owners or other stakeholders to inform the public of the HAB.

C. Mixed Status notifies the public that a combination of conditions exists in the affected impoundment and that the public should observe the advisories posted for each specific area. Such allowance for mixed status is based on the size of the lake: only if over 10,000 acres with a shoreline sinuosity index greater than 4. These impoundments are considered large enough in size with shorelines structured in a manner that could seclude blooms enough to allow for some areas to have limited public use. Only three separate lakes in Kansas fulfill these designations: Milford, Perry and Tuttle Creek Lakes.

4. KDHE RESPONSIBILITY:

Bureau of Environmental Health (BEH) – shall be responsible for:

A. serving as the clearing house for incoming BGA response requests and public health messaging for the agency;

B. developing and maintaining a BGA website that is associated with and available through the BEH web page. On this website, all information provided by the Bureau of Environmental Field Services (BEFS), Bureau of Epidemiology and Public Health Informatics (BEPHI) and the Bureau of Water (BOW) shall be made available to the public. Such information shall include, but is not limited to general blue-green algae information, maps, photos of HABs, analytical results, public health notices, and warning signs for the general public;

C. collecting and validating, in collaboration with BEFS, incoming requests for the investigation of blue-green algae blooms; and forwarding the requests to BEFS to initiate sampling activities. BEH will also collect incoming reports of illness

related to BGA from the public and forward the information to BEPHI. BEH will provide general public health protection information to the public to include;

D. contacting the KDHE Public Information Officer (PIO) for the preparation and release of official KDHE Public Health Advisories / News Releases;

E. contacting as needed, seats of government in affected jurisdictions;

F. coordinating with the Secretary's office, memos of recommendation of lake closures for Kansas Department of Wildlife, Parks and Tourism (KDWP&T), when needed;

G. tracking the reports over time for each affected body of water (database) for future trend and geospatial analysis, and

H. reviewing the Blue-Green Algae Data Management System.

Bureau of Environmental Field Services (BEFS) – shall be responsible for:

A. when needed, to collect and validate, in collaboration with BEH, incoming requests for the investigation of blue-green algae blooms; forwarding the requests to BEFS to initiate sampling activities. BEFS will also collect, when needed; incoming reports of illness related to BGA from the public and forward the information to BEPHI. BEFS will forward all requests for general public health protection information to BEPHI;

B. identification of sample type, location(s) and number of samples to be collected;

C. providing or coordinating field staff for water sample collection;

D. collection of water samples or recruiting non-KDHE staff to collect water samples;

E. collection and chain-of-custody for transport to the Kansas Health and Environmental Laboratories (KHEL) if sample collection is conducted by other non-KDHE entities;

F. providing technical expertise relative to initial and follow-up water samples;

G. analyzing water samples to determine the type and cell count of BGA and level of related microcystin toxins and entering the results into the BGA database;

H. coordinating other analytical needs with KHEL;

I. providing technical assistance for water quality questions and interpretation of laboratory result analyses as needed;

J. assisting the PIO or responding to requests for information when received that require technical or scientific responses from agency stakeholders;

K. educating non-KDHE staff concerning sampling, sample submission and chain-of-custody requirements;

L. retaining scientific data relative to the water sampling and share such data with BEH for cataloging in the BGA database;

M. coordinating with BOW to provide technical assistance to public drinking water suppliers when BGA affected lakes are their main source for drinking water.

N. coordinating with BOW in working with lake owners, if requested, to identify possible WRAPS (Watershed Restoration and Protection Strategy) projects for environmental remediation, and

O. reviewing the Blue-Green Algae Data Management System

Bureau of Epidemiology and Public Health Informatics (BEPHI) – shall be responsible for:

A. creating a Human Illness Reporting Form and an Animal Illness Reporting Form to collect information from health care providers and the public on HAB-related illness or death. The forms are made available on the BGA public website;

B. providing epidemiological investigation of human and animal illness related to harmful algal blooms;

C. analyze data and provide reports of epidemiological investigations of human and animal illness and death;

D. providing technical advice on the public health aspects of harmful algal blooms and coordination the KDHE public health response, and

E. coordinating a Health Alert Network message to be sent to local health departments, physicians, veterinarians and hospitals in the immediate and surrounding counties to inform them of the bloom and ask them to report adverse health events associated with cyanobacterial toxin poisoning.

Bureau of Environmental Health (BEH), Bureau of Surveillance and Epidemiology and Public Health Informatics (BEPHI) & Bureau of Environmental Field Services (BEFS) – shall be collectively response for:

A. reviewing the results of BGA analysis of water samples and determining the correct response as outlined by agency policy and issuing the proper notifications to the initial requesting entity and other responsible stakeholders.

i. The appropriate Bureau for notifying the stakeholders shall be determined during the initial response, depending on what impoundment is being considered and the entities involved, and shall continue until the conclusion of the response.

a. The KDHE's Topeka office shall be responsible for all communications regarding large reservoirs, public waters owned by other state and/or federal agencies, public waters with more than one stakeholder, or if it is used for public drinking water. These agencies include:

1) *Kansas Department of Wildlife, Parks and Tourism (KDWP&T)*

2) *U.S. Army Corps of Engineers (USACE)*

3) *U.S. Department of Interior, Bureau of Reclamation (BOR)*

4) *Kansas Department of Agriculture-Division of Animal Health (KDAH) - sending* information on all public health Advisories/Warnings via Health Alert Network messaging to KDAH. KDAH will be a point of contact for the public and veterinarians regarding health effects of cyanobacteria on pets and animals. Their number is 785-296-2326.

b. BEFS district offices shall be responsible for all communications regarding smaller county, city and privately owned/publicly used public waters.

B. Communications will include consistent messaging and public health advisory information to users of state managed waters through various means including but not limited to signage, public notice and publications.

KDHE Office of Communications (OC) – shall be responsible for:

A. preparing and releasing the official KDHE Public Health Advisories/News Releases;

B. advising BEH and BEFS when media requests for information are received that requires technical or scientific responses from agency stakeholders, and

C. coordinating any public forum events that may be required from time to time, (i.e. press conferences, public meetings) during which KDHE representatives may be required to address issues related to BGA.

Bureau of Water (BOW) – shall be responsible for:

A. advising Public Water Supply (PWS) Utilities of any public waters that are used as public drinking water supplies, both direct lake intakes and downstream intakes, and will work with affected public water suppliers during BGA blooms;

B. providing technical expertise related to water quality and watershed management and providing technical assistance for water quality questions and analysis as needed over time, and

C. coordinating with BEFS to assist lake owners, if requested, to identify possible projects.

6. BLUE-GREEN ALGAE RESPONSE PROCEDURES: (See Attachment 6)

A. A report is received concerning a BGA bloom in public waters and an investigation is requested. BEH will be the primary bureau to collect and validate the location information and forward the request to BEFS. BEFS will be secondary if BEH is unavailable. If a BEFS district office receives the request, it

will collect the location information and forward the information to BEH or complete the Algal Bloom Reporting Form for the complainant. The form is available on the BGA website.

B. BEH or BEFS will enter the investigation request information into the KDHE BGA Data Management Database for tracking.

C. BEFS will coordinate the investigation and collect samples if warranted. Samples will be transported to the BEFS/Technical Services Section (TSS) and/or the KHEL for analysis.

D. BEFS will notify BOW of all complaint locations so that they can determine whether the water body is a drinking water supply source to Public Water Supply (PWS) utilities. If so, then BOW will notify the affected PWS immediately to discuss the status of the source and technically assist when needed. BOW will continue to update the affected PWS weekly until the HAB has subsided

E. TSS will analyze the samples collected and enter the data into the Kansas Water Database which will then migrate into the BGA Data Management System.

F. The analytical results will be reviewed and if necessary, a public health recommendation will be issued consistent with KDHE's blue-green algae policy. (See Attachments 5).

G. BEH will then notify the Secretary's Office/OC of the status of the public water impoundment.

H. BEH, BEFS and BEPHI will coordinate to determine who will contact which agencies, municipalities, lake owner/managers, other external stakeholders and if applicable, the complainant, to provide them with the analysis results and the KDHE public health recommendations.

I. BEH will coordinate any meetings between bureaus and between KDHE and other state and federal agencies.

J. BEH will coordinate with BEPHI memos of recommendation for KDWP&T through the Secretary's office, if needed.

K. The Office of Communications will prepare formal agency press releases and coordinate as needed with other stakeholder's Office of Communications.

L. BEPHI will communicate with public health departments and animal health agencies as needed to deliver public health Advisory or Warning information.

M. BEFS will update BGA Management Database;

N. Based upon the HAB status, BEFS will coordinate proper follow-up testing consistent with the KDHE policy on blue-green algae.

O. BEFS and BEH will update BGA Management Database contact list as needed.

P. BEH will prepare information for updating of the BGA website.

Q. BEPHI will conduct investigations of human and animal illness or deaths related to harmful algal blooms.

R. BEPHI will analyze data and provide reports of epidemiological investigations and human and animal illness and death.

7. SAMPLE COLLECTION/SAMPLING LOCATIONS: Samples will be collected in accordance with the World Health Organization[4] protocols on the monitoring of cyanobacteria in recreational waters and at locations that are identified as most frequently used points of public access. Such locations include swimming beaches, boat docks, boat ramps and other frequently used areas designated for public access.

If public waters are water sources for a Public Water Supply (PWS) utility that has been determined to have a significant HAB, then:

A. samples will be collected as close to the intake as possible if the source water is drawn directly from a lake or reservoir, or

B. outfall monitoring will be initiated if the source is a river or stream, source water is collected downstream from the impacted lake/reservoir and the outflow from that lake/reservoir comprises a significant proportion of stream flow arriving at the intake of that PWS utility as determined by mass balance curves.

i. River monitoring may also be initiated at locations above the PWS intakes to confirm the presence or absence of significant concentrations of microcystin toxins.

Additional samples may be required to determine background levels, potential contaminant sources or to determine if other public waters that are used by livestock are impacted.

8. SAMPLE ANALYSIS: Analysis for blue-green algae samples will consist of the:

A. Required analysis of:

i. blue-green algal cell counts, and

ii. levels of microcystin toxins.

B. Optional analysis of:

i. percent blue-green cells;

ii. estimated chlorophyll-a;

iii. dissolved oxygen;

iv. pH;

v. temperature, and

vi. nutrients, specifically nitrate, nitrite, Kjeldahl nitrogen, total phosphorous and ammonia.

Additional analyses may be required and will be based on individual investigation circumstances.

9. Initial Sampling: Complaints received through the reporting process and that have been validated as suspect HABs shall be subject to:

A. When the number of complaints **does not exceed** KDHE's capacity resources (to include sample collection and laboratory analysis) then a response shall be initiated as promptly as possible.

B. When the number of complaints **exceeds** KDHE's capacity resources (to include sample collection and laboratory analysis) then the decision of what locations will receive priority response will be based on the following categories:

Lakes That:	Priority	Response
Support: Public Beach Public Water Supply Boating Full Body Contact Activities Confirm: Human Illness	**Priority 1**	Samples will be collected within the week if the HAB form was received on Monday or Tuesday. If the form was received after Tuesday, sampling will be conducted on the following Monday.
Public lakes that are publicly accessible but have no swimming beach and do not allow water skiing.	**Priority 2**	Considering that resources are available, samples will be collected within the week if the HAB form was received by Tuesday. If the form was received after Tuesday, sampling will be conducted on the following Monday.
Other public lakes that are largely inaccessible to the general public.	**Priority 3**	Will respond if capacity resources are available. Otherwise, complainant will be advised to contact their local extension office or the KS State Veterinary Diagnostic Laboratory at: KSVDL c/o Dr. Deon van der Merwe 1800 Denison Ave. Manhattan, KS 66502 785-532-4333 dmerwe@vet.ksu.deu

*** K.A.R. 28-16-28b -** Kansas Water Quality Standards **…***Public water bodies* - any surface water or surface water segment that supports or, in the absence of artificial sources of pollution, would support one or more of the designated uses of surface water defined in K.A.R. 28-16-28d(b) or K.S.A. 82a-2001(c), and amendments thereto, and that meets the criteria for classification given in K.A.R. 28-16-28d(a).

****K.S.A. 65-171d - (d) …** If a freshwater reservoir or farm pond is privately owned and where complete ownership of land bordering the reservoir or pond is under common private ownership, such freshwater reservoir or farm pond shall be exempt from water quality standards except as it relates to water discharge or seepage from the reservoir or pond to waters of the state, either surface or groundwater, or as it relates to the public health of persons using the reservoir or pond or waters there from.

C. Any situations that occur at surface waters not defined above will be considered on a case-by-case.

D. When the complaint is received for privately owned lakes (single owner shorelines), the complainant will be advised to contact their local extension office or the KS State Veterinary Diagnostic Laboratory at:

KSVDL
c/o Dr. Deon van der Merwe
1800 Denison Ave.
Manhattan, KS 66502
785-532-4333
dmerwe@vet.ksu.deu

10. Re-Sampling Frequency: During confirmed BGA blooms the re-sampling frequency for affected surface waters is directly associated with the initial sampling analytical results, the water's potential for public visitation* and three other potential factors. (See Diagrams 1 & 2 below). A "score" is calculated, establishing the water's re-sampling frequency.

* The "potential for public visitation" at water impoundments was determined by using the following formula. An explanation of each of the multiplicands within this formula can be found in Attachment 7.

Lake Visitation Potential = Population within 30 Miles x Lake Size Factor x Lake Density Factor x Public Access Factor x Contact Recreation Factor

All water impoundments listed in the Kansas Surface Water Register have been ranked using this formula and can be found in Attachment 8.

Diagram 1. Calculating the Initial Score

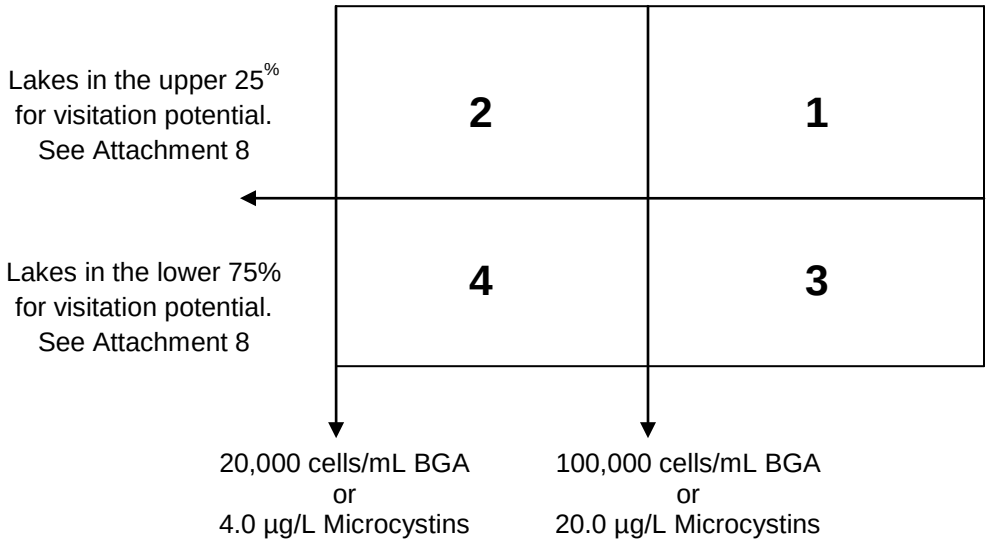
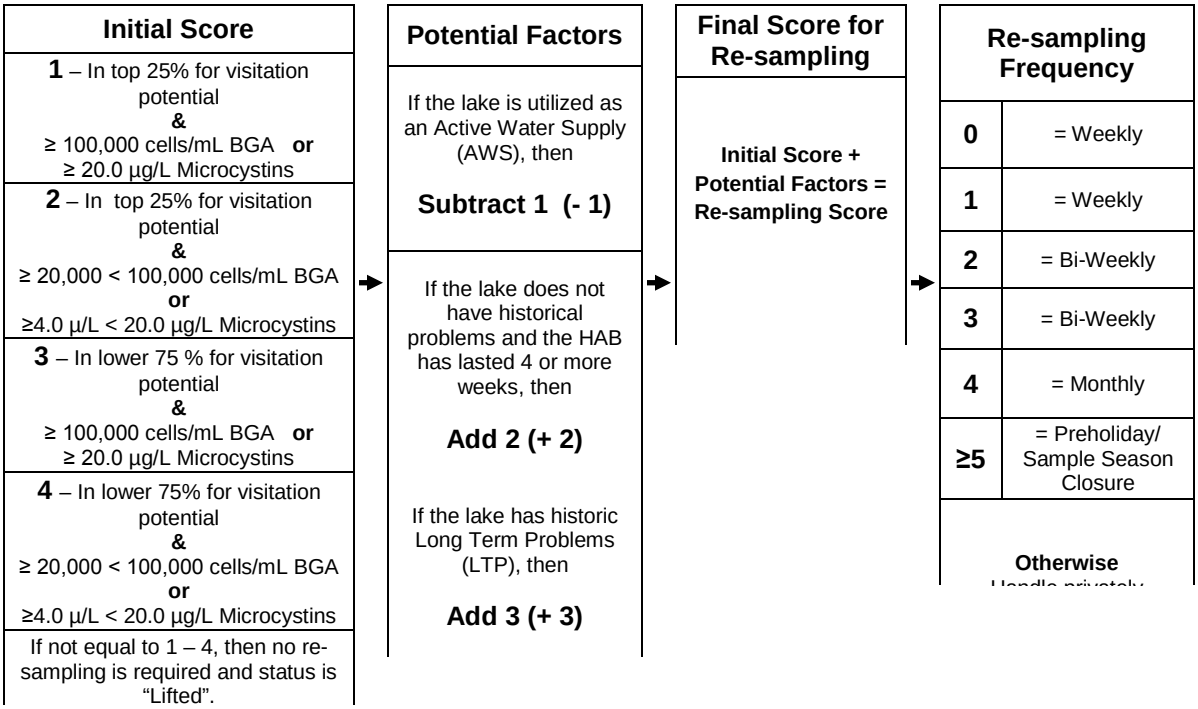


Diagram 2. Processing the Re-sampling Frequency



11. Sampling Season: The HAB sampling season will adopt a sampling duration concurrent with the Water Quality Standards – Primary Contact Recreation, from April 1 to October 31. New and continued investigations will no longer be conducted after the October 31st date unless planktothrix is suspected. Planktothrix is a blue - green alga that prefers winter temperatures. If planktothrix is suspected, then confirmatory sampling throughout the following five months will be periodically conducted. A final sample will be collected at all surface waters that are still under a HAB Advisory in October to document the final analytical results for the season.

12. Criteria for Lifting or Cancelation of HAB Advisories and Warnings: A body of water with a HAB Advisory will be tested by BEFS or other stakeholders based on the re-sampling frequency discussed above. The Advisory will remain in effect until cyanobacteria concentrations are less than 20,000 cells/mL at all sample sites and microcystin toxin concentrations are less than 4 µg/L at all sample sites.

A body of water with a HAB Warning will be tested by BEFS or other stakeholders based on the re-sampling frequency discussed above. The HAB Warning will remain in effect until the cyanobacterial concentrations are less than 100,000 cells/mL at all sample sites for at least one week and concentrations of microcystin toxins are less than 20 µg/L for two consecutive weeks at all sample sites. Bodies of water that fall below these levels and within these time periods may still not completely come off of a public health protection notification, but may be reduced to an "Advisory" level. The Public Health Advisory requirements will then need to be observed.

For further questions regarding sampling of lakes and cyanobacteria, contact KDHE's Bureau of Environmental Field Services at **785-296-6603**.

For further questions regarding health effects of cyanobacteria on people, contact KDHE's Bureau of Epidemiology and Public Health Informatics at **1-877-427-7317**.

For further questions regarding health effects of cyanobacteria on pets and animals, contact the Kansas Animal Health Department at **785-296-2326**.

Works Cited

1. **Graham JL, Loftin KA, and Kamman N**. Monitoring recreations freshwaters. *Lakeline*, Summer, 2009

2**. Falconer I, Bartram J, Chorus I, Kuiper-Goodman T, Utkilen H, Burch M and Codd GA**. Chapter 5. SAFE LEVELS AND SAFE PRACTICES. [BOOK AUTH.] Chorus I and Bartram J. (eds*.). Toxic Cyanobacteria in Water: A guide to their public health consequences, monitoring and management.* Geneva: World Health Organization, 2003.

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4. World Health Organization. Chapter 12: Monitoring and assessment. *Guidelines for safe recreational waters: Volume 1 – Coastal and fresh waters*. Geneva: World Health Organization, 2003.

5. Queensland HAB Steering Committee. *Queensland Harmful Algal Bloom Response Plan*, Version 1, December 2002.

Attachment 1:

"Caution" Sign Example

CAUTION

ADVISORY — Harmful Algae Present

People, animals may get sick

Swimming, Wading, Skiing, Jet Skiing Are Discouraged

No Pets or Livestock

- **Don't let people/pets eat dried algae or drink untreated lake water** No permita que las personas o mascotas consuman algas secas o beber el agua del lago sin tratamiento
- **Clean fish well and discard guts** Limpie bien el pescado y deseche las tripas
- **If people/pets contact lake water: wash with clean, potable water as soon as possible** Si las personas/mascotas llegan en contacto con agua del lago, lavar con agua potable limpia tan pronto como sea posible
- **Avoid areas of visible algae accumulation** Evite las áreas de acumulación de algas visibles

In case of harmful algae contact, call doctor/veterinarian if people/animals have nausea, vomiting, diarrhea, rash, irritated eyes, seizures, breathing problems or other unexplained illness

Report new algae blooms to Kansas Department of Health and Environment: www.kdheks.gov/algae-illness or call 785-296-5606	Report possible algae-bloom illness Call Local Health Department in Kansas:

For more information: Scan this code or visit kdheks.gov/algae-illness

Kansas Dept. of Health and Environment 1000 SW Jackson, Topeka, Kansas 66612, 785-296-1500 www.kdheks.gov

Attachment 2

”Warning” Sign Example

Attachment 3

”Danger - Lake Closed” Sign Example

Attachment 4

”Danger - Beach Closed” Sign Example

Attachment 5

Public Health Press Release Example

For Immediate Release:
June 30, 2011

KDHE contact: Miranda Myrick, 785-296-5795
Mmyrick@kdheks.gov
Jonathan Larance, 785-291-3684
Jlarance@kdheks.gov

Public Health Information Concerning Blue-Green Algae in Kansas Waters

The Kansas Department of Health and Environment (KDHE) continue to monitor waters for blue-green algae. Below is a list of advisories and warnings.

Advisory: Harmful algae have been detected at **Marion Reservoir** and **Old Herington City Lake** in Marion County. An advisory allows for boating and fishing at the lake. All other contact with water is discouraged for people and pets.

Warning: Elevated toxic blue-green algae concentrations have been detected **Marion County Lake**. Current concentrations of algae in these waters exceeded the KDHE recommended level of 100,000 cells/ml for recreational water use.

Other Kansas public waters currently under warning:

Memorial Park Lake, Great Bend, Barton County

Meade State Lake, Meade County

Logan City Lake, Logan, Norton County

KDHE recommends the following precautions be taken:

- Do not drink the lake water
- Avoid swimming, wading or other activities with full body contact of lake water
- Clean fish well, consume only the fillet portion, and discard all other body parts
- Keep pets from having contact with or drinking the water

KDHE will continue to monitor the situations and rescind this warning as soon as conditions warrant. If the public has any questions or concerns, KDHE can be contacted during normal business hours at 866-865-3233.

Further information on algae and algae blooms can be found at:
www.kdheks.gov/algae-illness/index.htm

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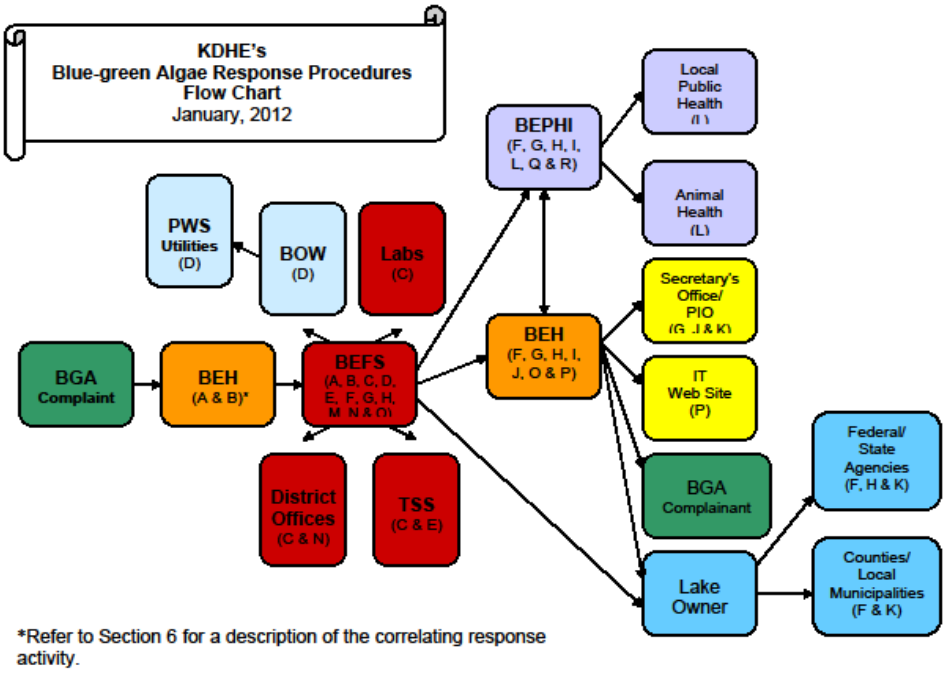
As the state's environmental protection and public health agency, KDHE promotes responsible choices to protect the health and environment for all Kansans.

Through education, direct services and the assessment of data and trends, coupled with policy development and enforcement, KDHE will improve health and quality of life. We prevent illness, injuries and foster a safe and sustainable environment for the people of Kansas.

Attachment 6

Flow Chart on Response Procedures



*Refer to Section 6 for a description of the correlating response activity.

Attachment 7

Lake Visitation Potential Multiplicand Explanation

In determining a lake's visitation potential, the following equation was used:

Population 30 x Lake Size Factor x Lake Density Factor x Public Access Factor x Contact Recreation Factor = Lake Visitation Potential

The following table is an explanation of the multiplicands in the above equation.

Population 30 Population within 30 mile radius

Lake Size Factor Based on lake size in acres, divided into classes and then assigned size factors:

Size Class	Size Factor
<1 acre =	**.001**
1 – 5 acres =	**.01**
5 – 50 acres =	**0.1**
50 – 500 acres =	**0.5**
500 – 1000 acres =	**1.0**
> 1000 acres =	**2.0**

Lake Density Factor Based on number of lakes within 30 mile diameter and then assigned density factors:

Number of Lakes	Density Factor
1 to 3 lakes =	**1.0**
4 to 6 lakes =	**0.8**
7 to 16 lakes =	**0.6**
> 16 lakes =	**0.4**

Public Access Factor

Private Lake	Open to Public
1.0	**0.1**

Contact Recreation (CR) Factor

Definition	Primary Contact Attainability	Recreation Factor
CR A - Swimming beach/boating/skiing facilities provided.	Attainable	**1.0**
CR B - Swimming/boating facilities not provided but water depth greater than 18 inches.	Attainable	**0.5**
CR a - Water body less than 18 inches in depth. Full immersion not likely.	Not Attainable	**0.1**

Once the visitation potential was calculated for all the lakes on the Kansas Surface Water Register, they were then ranked from the highest lake visitation potential to the lowest. A HAB Kansas Lake Ranking for Visitation Potential list was developed and divided into 25/75 percentile. The HAB Kansas Lake Ranking for Visitation Potential list can be found in Attachment 8.

Attachment 8.

HAB Kansas Lake Ranking for Visitation Potential

Lake Name	Pop_30	Acres	Size Class	Size Factor	Lake_30	Lakes_ Factor	Private	CR	Contact Factor	Final Score
Top 25% highlighted										
Atchison Co. SFL	89512	61.0	50-500	0.50	2	1.0	1.00	B	1.0	44756
Augusta City Lake	509828	175.7	50-500	0.50	2	1.0	1.00	A	1.0	254914
Augusta Santa Fe Lake	535020	259.6	50-500	0.50	2	1.0	1.00	A	1.0	267510
Banner Creek Lake	145753	487.1	50-500	0.50	4	0.8	1.00	A	1.0	58301
Big Hill Lake	84056	1094.3	>1000	2.00	2	1.0	1.00	A	1.0	168112
Bone Creek Lake	60750	502.6	500-1000	1.00	3	1.0	1.00	B	1.0	60750
Bourbon Co. SFL	61420	92.0	50-500	0.50	2	1.0	1.00	B	1.0	30710
Butler Co. SFL	99034	106.7	50-500	0.50	1	1.0	1.00	B	1.0	49517
Carey Park Lake	152484	77.6	50-500	0.50	2	1.0	1.00	A	1.0	76242
Cedar Bluff Lake	32321	4271.9	>1000	2.00	1	1.0	1.00	A	1.0	64642
Cedar Creek Lake	65034	308.5	50-500	0.50	3	1.0	1.00	A	1.0	32517
Cedar Lake	781930	62.2	50-500	0.50	11	0.6	1.00	B	1.0	234579
Chanute Santa Fe Lake	66349	73.4	50-500	0.50	1	1.0	1.00	B	1.0	33175
Cheney Lake	368923	9664.1	>1000	2.00	1	1.0	1.00	A	1.0	737846
Clinton Lake	381928	7389.9	>1000	2.00	4	0.8	1.00	A	1.0	611085
Council Grove City Lake	71922	387.7	50-500	0.50	2	1.0	1.00	A	1.0	35961
Council Grove Lake	77452	2730.7	>1000	2.00	2	1.0	1.00	A	1.0	154904
Douglas Co. SFL	602250	175.8	50-500	0.50	5	0.8	1.00	B	1.0	240900
Edgerton City Lake	717271	7.1	5-50	0.10	6	0.8	1.00	B	1.0	57382
El Dorado Lake	173182	7697.9	>1000	2.00	1	1.0	1.00	A	1.0	346364
Elk City Lake	63744	3414.6	>1000	2.00	2	1.0	1.00	A	1.0	127488
Emery Park Lake	546896	6.6	5-50	0.10	10	0.6	1.00	A	1.0	32814
Empire Lake	55092	416.4	50-500	0.50	1	1.0	1.00	B	1.0	27546
Fall River Lake	25456	2190.9	>1000	2.00	2	1.0	1.00	A	1.0	50912
Gardner City Lake	792878	105.5	50-500	0.50	10	0.6	1.00	A	1.0	237863
Geary Co. SFL	117663	95.6	50-500	0.50	2	1.0	1.00	B	1.0	58832
Hargis Lake	389436	60.2	50-500	0.50	3	1.0	1.00	B	1.0	194718
Harvey Co. East Lake	449243	180.8	50-500	0.50	3	1.0	1.00	A	1.0	224622
Harvey Co. West Park Lake	327562	12.4	5-50	0.10	1	1.0	1.00	A	1.0	32756
Herington City Lake	65571	168.7	50-500	0.50	3	1.0	1.00	A	1.0	32786

Lake Name	Pop_30	Acres	Size Class	Size Factor	Lake_30	Lakes_ Factor	Private	CR	Contact Factor	Final Score
Top 25% highlighted										
Herington Reservoir	61796	522.5	500-1000	1.00	3	1.0	1.00	A	1.0	61796
Hillsdale Lake	647463	4295.0	>1000	2.00	5	0.8	1.00	A	1.0	1035941
Inman Lake	137270	133.4	50-500	0.50	2	1.0	1.00	B	0.5	34318
John Redmond Lake	61949	8158.4	>1000	2.00	3	1.0	1.00	A	1.0	123898
Kanopolis Lake	91811	2933.5	>1000	2.00	1	1.0	1.00	A	1.0	183622
Kirwin Lake	15952	1535.1	>1000	2.00	1	1.0	1.00	A	1.0	31904
La Cygne Lake	49815	2371.2	>1000	2.00	2	1.0	1.00	B	1.0	99630
Lake Afton	506353	249.9	50-500	0.50	2	1.0	1.00	A	1.0	253177
Lake Shawnee	315903	378.2	50-500	0.50	12	0.6	1.00	A	1.0	94771
Leavenworth Co. SFL	811776	150.7	50-500	0.50	2	1.0	1.00	B	1.0	405888
Lebo City Lake	65139	63.2	50-500	0.50	3	1.0	1.00	A	1.0	32570
Lone Star Lake	368604	175.6	50-500	0.50	4	0.8	1.00	A	1.0	147442
Louisburg Old Lake	481872	22.0	5-50	0.10	3	1.0	1.00	A	1.0	48187
Louisburg SFL	262726	269.0	50-500	0.50	3	1.0	1.00	B	1.0	131363
Lyon Co. SFL	68250	128.5	50-500	0.50	1	1.0	1.00	B	1.0	34125
Madison City Lake	54446	94.6	50-500	0.50	1	1.0	1.00	A	1.0	27223
Marion Co. Lake	54200	123.4	50-500	0.50	2	1.0	1.00	A	1.0	27100
Marion Lake	63460	6195.8	>1000	2.00	3	1.0	1.00	A	1.0	126920
Melvern Lake	85020	6221.7	>1000	2.00	5	0.8	1.00	A	1.0	136032
Miami Co. SFL	106927	110.1	50-500	0.50	3	1.0	1.00	B	1.0	53464
Milford Lake	121813	15182.0	>1000	2.00	1	1.0	1.00	A	1.0	243626
Miola Lake	445952	182.7	50-500	0.50	5	0.8	1.00	A	1.0	178381
Montgomery Co. SFL	67401	85.4	50-500	0.50	3	1.0	1.00	B	1.0	33701
Neosho Co. SFL	92321	56.6	50-500	0.50	2	1.0	1.00	B	1.0	46161
New Olathe Lake	798253	141.8	50-500	0.50	12	0.6	1.00	A	1.0	239476
Osage City Reservoir	159618	50.3	50-500	0.50	3	1.0	1.00	B	1.0	79809
Osage Co. SFL	312092	131.1	50-500	0.50	6	0.8	1.00	B	1.0	124837
Oskaloosa Lake	411385	12.5	5-50	0.10	4	0.8	1.00	A	1.0	32911
Ottawa Co. SFL	74729	95.3	50-500	0.50	1	1.0	1.00	B	1.0	37365
Parsons Lake	84602	803.1	500-1000	1.00	4	0.8	1.00	A	1.0	67682
Perry Lake	357757	10587.6	>1000	2.00	3	1.0	1.00	A	1.0	715514
Pomona Lake	292313	3720.9	>1000	2.00	5	0.8	1.00	A	1.0	467701
Pottawatomie Co. SFL #2	115674	70.2	50-500	0.50	3	1.0	1.00	B	1.0	57837

Lake Name	Pop_30	Acres	Size Class	Size Factor	Lake_30	Lakes_ Factor	Private	CR	Contact Factor	Final Score
Top 25% highlighted										
Prairie Lake	96519	61.3	50-500	0.50	4	0.8	1.00	A	1.0	38608
Shawnee Co. SFL	222703	121.5	50-500	0.50	1	1.0	1.00	B	1.0	111352
Shawnee Mission Lake	797476	115.5	50-500	0.50	13	0.6	1.00	A	1.0	239243
Strowbridge Reservoir	313569	241.1	50-500	0.50	5	0.8	1.00	B	1.0	125428
Toronto Lake	39413	2476.0	>1000	2.00	3	1.0	1.00	A	1.0	78826
Tuttle Creek Lake	120588	11987.0	>1000	2.00	2	1.0	1.00	A	1.0	241176
Wabaunsee Co. Lake	143131	207.2	50-500	0.50	2	1.0	1.00	A	1.0	71566
Waconda Lake	18075	10050.0	>1000	2.00	1	1.0	1.00	A	1.0	36150
Watson Park Lake	555774	21.1	5-50	0.10	11	0.6	1.00	B	1.0	33346
Wellington Lake	149226	384.8	50-500	0.50	3	1.0	1.00	A	1.0	74613
Wellington New City Lake	120188	206.3	50-500	0.50	3	1.0	1.00	A	1.0	60094
Wilson Lake	19430	7760.8	>1000	2.00	1	1.0	1.00	A	1.0	38860
Winfield City Lake	162563	1041.3	>1000	2.00	2	1.0	1.00	A	1.0	325126
Wolf Creek Lake	63817	4983.9	>1000	2.00	3	1.0	1.00	B	1.0	127634
Wyandotte Co. Lake	744936	323.0	50-500	0.50	6	0.8	1.00	A	1.0	297974
Alma City Lake	152934	24.5	5-50	0.10	2	1.0	1.00	B	1.0	15293
Altamont City Main Lake (#1)	73347	21.3	5-50	0.10	4	0.8	1.00	B	1.0	5868
Altamont City West Lake (#3)	73347	11.0	5-50	0.10	4	0.8	1.00	B	1.0	5868
Antelope Lake	10724	1.6	1-5	0.01	2	1.0	1.00	B	1.0	107
Anthony City Lake	16874	113.2	50-500	0.50	1	1.0	1.00	A	1.0	8437
Antioch Park Lake	712904	2.4	1-5	0.01	8	0.6	1.00	A	1.0	4277
Atchison Co. Park Lake	58120	70.7	50-500	0.50	3	1.0	1.00	B	0.5	14530
Atwood Township Lake	9400	39.6	5-50	0.10	1	1.0	1.00	B	0.5	470
Barber Co. SFL	19820	44.1	5-50	0.10	1	1.0	1.00	B	1.0	1982
Bartlett City Lake	71317	15.9	5-50	0.10	5	0.8	1.00	B	1.0	5705
Barton Lake	44053	13.6	5-50	0.10	3	1.0	1.00	A	0.1	441
Belleville City Lake	17370	18.3	5-50	0.10	1	1.0	1.00	B	1.0	1737
Beymer Lake	53364	4.9	1-5	0.01	1	1.0	1.00	A	1.0	534
Big Creek Oxbow	40730	3.0	1-5	0.01	1	1.0	1.00	B	0.5	204
Big Eleven Lake	680789	3.4	1-5	0.01	5	0.8	1.00	B	0.5	2723

Lake Name	Pop_30	Acres	Size Class	Size Factor	Lake_30	Lakes_ Factor	Private	CR	Contact Factor	Final Score
Top 25% highlighted										
Blue Mound City Lake	55737	21.3	5-50	0.10	3	1.0	1.00	B	0.5	2787
Boy Scout Lake	37943	4.2	1-5	0.01	3	1.0	1.00	A	1.0	379
Bronson City Lake	60865	13.7	5-50	0.10	3	1.0	1.00	B	0.5	3043
Brown Co. SFL	41704	69.1	50-500	0.50	2	1.0	1.00	B	1.0	20852
Buffalo Park Lake	544397	11.9	5-50	0.10	8	0.6	1.00	B	0.5	16332
Caney City Lake	48681	64.7	50-500	0.50	1	1.0	1.00	B	0.5	12170
Carbondale West Lake	311608	7.1	5-50	0.10	6	0.8	1.00	B	0.5	12464
Cedar Creek Reservoir	52918	198.5	50-500	0.50	6	0.8	1.00	B	1.0	21167
Cedar Crest Lake	297115	2.6	1-5	0.01	11	0.6	1.00	B	0.5	891
Central Park Lake	306380	1.3	1-5	0.01	12	0.6	1.00	B	0.5	919
Centralia Lake	34278	232.9	50-500	0.50	1	1.0	1.00	A	1.0	17139
Chase Co. SFL	53635	104.1	50-500	0.50	1	1.0	1.00	A	1.0	26818
Chisholm Creek Park Lake	553034	2.7	1-5	0.01	9	0.6	1.00	B	1.0	3318
Cimarron Lake (Moss Lake Middle)	9837	1.1	1-5	0.01	3	1.0	1.00	B	0.5	49
Circle Lake	47404	21.7	5-50	0.10	3	1.0	1.00	B	0.5	2370
Clark Co. SFL	35045	292.5	50-500	0.50	1	1.0	1.00	B	1.0	17523
Colby City Lake	13208	1.6	1-5	0.01	1	1.0	1.00	B	0.5	66
Concannon SFL	46289	13.4	5-50	0.10	1	1.0	1.00	B	1.0	4629
Cowley Co. SFL	41133	77.1	50-500	0.50	1	1.0	1.00	B	1.0	20567
Critzer Lake	50000	212.0	50-500	0.50	4	0.8	1.00		1.0	20000
Crystal Lake	70301	13.8	5-50	0.10	4	0.8	1.00	B	1.0	5624
Dillon Park Lakes	133976	2.9	1-5	0.01	2	1.0	1.00	B	0.5	670
Dornwood Park Lake	314838	0.0	<1	0.00	12	0.6	1.00	B	0.5	94
Eagle Lake (BelAire Lake)	552268	4.6	1-5	0.01	9	0.6	1.00	B	0.5	1657
Edna City Lake	61240	11.8	5-50	0.10	4	0.8	1.00	A	1.0	4899
Elkhorn Lake	120243	4.4	1-5	0.01	4	0.8	1.00	B	0.5	481
Ellis City Lake	35480	8.6	5-50	0.10	1	1.0	1.00	B	1.0	3548
Elm Creek Lake	66006	78.5	50-500	0.50	8	0.6	1.00	A	1.0	19802
Eureka Lake	21111	251.3	50-500	0.50	2	1.0	1.00	A	1.0	10556
Finney Co. SFL/W.A.	20521	5.0	5-50	0.10	1	1.0	1.00	B	0.5	1026
Ford Co. Lake	40554	15.2	5-50	0.10	3	1.0	1.00	B	1.0	4055
Fort Scott City Lake	62490	333.4	50-500	0.50	6	0.8	1.00	A	1.0	24996

Lake Name	Pop_30	Acres	Size Class	Size Factor	Lake_30	Lakes_ Factor	Private	CR	Contact Factor	Final Score
Top 25% highlighted										
Fossil Lake	39866	42.2	5-50	0.10	1	1.0	1.00	B	0.5	1993
Francis Wachs W.A.	9717	7.7	5-50	0.10	1	1.0	1.00	A	0.1	97
Frisco Lake	846692	3.4	1-5	0.01	16	0.6	1.00	B	0.5	2540
Gage Park Lake	301669	2.8	1-5	0.01	11	0.6	1.00	B	0.5	905
Garnett North Lake	74584	44.1	5-50	0.10	4	0.8	1.00	A	1.0	5967
Goodman SFL	7777	23.5	5-50	0.10	1	1.0	1.00	B	1.0	778
Gridley City Lake	59484	33.7	5-50	0.10	1	1.0	1.00	A	1.0	5948
Gunn Park East Lake	52215	2.6	1-5	0.01	6	0.8	1.00	B	0.5	209
Gunn Park West Lake	52215	6.3	5-50	0.10	6	0.8	1.00	B	0.5	2089
Hain SFL	39804	27.5	5-50	0.10	2	1.0	1.00	B	1.0	3980
Hamilton Co. SFL	7000	43.8	5-50	0.10	1	1.0	1.00	B	1.0	700
Harrison Park Lake	525905	2.2	1-5	0.01	8	0.6	1.00	B	0.5	1578
Harvey Co. Camp Hawk Lake	516016	3.6	1-5	0.01	3	1.0	1.00	A	1.0	5160
Harveyville Lake	225876	17.1	5-50	0.10	1	1.0	0.01	A	0.5	113
Herington City Park Lake	61958	2.0	1-5	0.01	3	1.0	1.00	B	0.5	310
Heritage Park Lake	738651	38.9	5-50	0.10	11	0.6	1.00	A	0.5	22160
Hiawatha City Lake	45520	7.1	5-50	0.10	2	1.0	1.00	B	0.5	2276
Hillsboro City Lake	73989	0.6	<1	0.00	2	1.0	1.00	B	0.5	37
Hodgeman Co. SFL/W.A.	37843	251.2	50-500	0.50	3	1.0	1.00		0.0	0
Hole In The Rock	416361	0.1	<1	0.00	4	0.8	1.00	B	0.5	167
Horseshoe Lake	545822	11.0	5-50	0.10	11	0.6	0.01	B	0.5	164
Horsethief Cayon Lake	37943	450.0	50-500	0.50	1	1.0	1.00	A	1.0	18972
Jerry's Lake	65499	1.0	1-5	0.01	4	0.8	1.00	B	0.5	2502
Jetmore Lake	37582	30.9	5-50	0.10	3	1.0	1.00	A	1.0	3758
Jewell Co. SFL	18382	39.2	5-50	0.10	1	1.0	1.00	B	1.0	1838
Jones Park Lake	54297	1.2	1-5	0.01	2	1.0	1.00	B	0.5	271
Kid's Lake	545822	9.6	5-50	0.10	11	0.6	1.00	B	0.5	16375
Kingman Co. SFL	32787	125.0	50-500	0.50	1	1.0	1.00	B	1.0	16394
Kiowa Co. SFL	13954	20.1	5-50	0.10	1	1.0	1.00	B	1.0	1395
KWP Hatchery and Ponds	23156	80.5	50-500	0.50	3	1.0	1.00	B	0.5	5789
La Claire Lake	62827	6.4	5-50	0.10	2	1.0	1.00	B	1.0	6283

Lake Name	Pop_30	Acres	Size Class	Size Factor	Lake_30	Lakes_ Factor	Private	CR	Contact Factor	Final Score
Top 25% highlighted										
Lake Charles	40878	1.4	1-5	0.01	2	1.0	1.00	B	0.5	204
Lake Coldwater	8547	231.1	50-500	0.50	1	1.0	1.00	A	1.0	4274
Lake Crawford State Park #2	65383	120.2	50-500	0.50	4	0.8	1.00	A	1.0	26153
Lake Dabanawa	575103	77.8	50-500	0.50	4	0.8	0.01	A	1.0	2300
Lake Idlewild	24899	6.1	5-50	0.10	1	1.0	1.00	B	1.0	2490
Lake Jayhawk	390956	19.7	5-50	0.10	4	0.8	0.01	A	1.0	313
Lake Jewell	18382	57.0	50-500	0.50	1	1.0	1.00	A	1.0	9191
Lake Jivaro	321526	73.2	50-500	0.50	6	0.8	0.01	A	1.0	1286
Lake Kahola	50283	359.0	50-500	0.50	1	1.0	0.01	A	1.0	251
Lake Meade State Park	26648	66.2	50-500	0.50	1	1.0	1.00	A	1.0	13324
Lake Quivera	786119	159.5	50-500	0.50	10	0.6	0.01	A	1.0	2358
Lake Scott State Park	11895	108.6	50-500	0.50	1	1.0	1.00	A	1.0	5948
Lake Sherwood	286615	239.9	50-500	0.50	11	0.6	0.01	A	1.0	860
Lake Tanko (Cherryvale City Lake)	83475	15.4	5-50	0.10	2	1.0	1.00	B	1.0	8348
Lake Warnock (Atchison City Lake)	102602	33.0	5-50	0.10	2	1.0	1.00	A	1.0	10260
Lakeview Estates Lake	293903	16.9	5-50	0.10	11	0.6	0.01	B	0.5	88
Lakewood Park Lake	80197	10.9	5-50	0.10	2	1.0	1.00	B	1.0	8020
Lansing City Lake	756118	2.9	1-5	0.01	5	0.8	1.00	B	0.5	3024
Lebo City Park Lake	64185	2.3	1-5	0.01	3	1.0	1.00	B	0.5	321
Lemon Park Lake	22434	1.9	1-5	0.01	3	1.0	1.00	B	0.5	112
Leonard's Lake	45999	7.4	5-50	0.10	3	1.0	1.00	B	0.5	2300
Little Lake	53889	9.3	5-50	0.10	3	1.0	1.00	B	0.5	2694
Logan City Lake	16653	8.0	5-50	0.10	1	1.0	1.00	B	1.0	1665
Logan Co. SFL	5751	44.3	5-50	0.10	1	1.0	1.00	B	1.0	575
Lovewell Lake	11987	2626.8	>1000	2.00	1	1.0	1.00	A	1.0	23974
Lyndon City Lake	127546	56.2	50-500	0.50	4	0.8	0.01	B	0.5	255
Mahaffie Farmstead Lake	784664	1.3	1-5	0.01	12	0.6	1.00	B	0.5	2354
Mallard Lake (Moss Lake E.)	11365	0.5	<1	0.00	3	1.0	1.00	B	0.5	6

Lake Name	Pop_30	Acres	Size Class	Size Factor	Lake_30	Lakes_ Factor	Private	CR	Contact Factor	Final Score
Top 25% highlighted										
Mary's Lake	724098	4.2	1-5	0.01	4	0.8	1.00	B	0.5	2896
McPherson Co. SFL	110756	39.9	5-50	0.10	1	1.0	1.00	B	1.0	11076
Memorial Park Lake	43200	12.7	5-50	0.10	3	1.0	1.00	B	0.5	2160
Merrit Lake	463067	5.5	5-50	0.10	4	0.8	1.00	B	0.5	18523
Mined Land Lake 01	71174	3.1	1-5	0.01	10	0.6	1.00	B	1.0	427
Mined Land Lake 02	71384	1.6	1-5	0.01	10	0.6	1.00	a	0.1	43
Mined Land Lake 03	70818	0.5	<1	0.00	10	0.6	1.00	B	0.5	21
Mined Land Lake 04	70818	10.2	5-50	0.10	10	0.6	1.00	B	1.0	4249
Mined Land Lake 05	89393	6.3	5-50	0.10	12	0.6	1.00	B	1.0	5364
Mined Land Lake 06	89393	6.8	5-50	0.10	12	0.6	1.00	B	1.0	5364
Mined Land Lake 07	84357	12.5	5-50	0.10	17	0.4	1.00	B	1.0	3374
Mined Land Lake 08	82348	11.3	5-50	0.10	18	0.4	1.00	B	1.0	3294
Mined Land Lake 09	80138	8.4	5-50	0.10	24	0.4	1.00	B	0.5	1603
Mined Land Lake 10	82093	1.0	1-5	0.01	25	0.4	1.00	B	0.5	164
Mined Land Lake 11	83477	5.8	5-50	0.10	30	0.4	1.00	B	1.0	3339
Mined Land Lake 12	82093	16.0	5-50	0.10	28	0.4	1.00	B	1.0	3284
Mined Land Lake 13	82093	4.6	1-5	0.01	26	0.4	1.00	B	0.5	164
Mined Land Lake 14	82093	7.9	5-50	0.10	26	0.4	1.00	B	0.5	1642
Mined Land Lake 15	82093	13.6	5-50	0.10	24	0.4	1.00	B	0.5	1642
Mined Land Lake 17	86726	17.3	5-50	0.10	36	0.4	1.00	B	1.0	3469
Mined Land Lake 18	86333	13.7	5-50	0.10	36	0.4	1.00	B	1.0	3453
Mined Land Lake 19	85712	15.0	5-50	0.10	35	0.4	1.00	B	1.0	3428
Mined Land Lake 20	89283	16.9	5-50	0.10	32	0.4	1.00	B	1.0	3571
Mined Land Lake 21	88129	15.1	5-50	0.10	34	0.4	1.00	B	1.0	3525
Mined Land Lake 22	86889	22.2	5-50	0.10	31	0.4	1.00	B	1.0	3476
Mined Land Lake 23	88129	31.6	5-50	0.10	34	0.4	1.00	B	1.0	3525

Lake Name	Pop_30	Acres	Size Class	Size Factor	Lake_30	Lakes_ Factor	Private	CR	Contact Factor	Final Score
Top 25% highlighted										
Mined Land Lake 24	88910	35.0	5-50	0.10	28	0.4	1.00	B	1.0	3556
Mined Land Lake 25	88296	9.9	5-50	0.10	26	0.4	1.00	B	1.0	3532
Mined Land Lake 26	84491	9.5	5-50	0.10	24	0.4	1.00	B	1.0	3380
Mined Land Lake 27	89166	32.7	5-50	0.10	28	0.4	1.00	B	1.0	3567
Mined Land Lake 28	88910	0.5	<1	0.00	28	0.4	1.00	a	1.0	36
Mined Land Lake 29	88910	12.2	5-50	0.10	29	0.4	1.00	B	1.0	3556
Mined Land Lake 30	90064	30.6	5-50	0.10	28	0.4	1.00	B	1.0	3603
Mined Land Lake 31	86889	61.5	50-500	0.50	31	0.4	1.00	B	1.0	17378
Mined Land Lake 32	86889	14.2	5-50	0.10	34	0.4	1.00	B	1.0	3476
Mined Land Lake 33	90064	42.9	5-50	0.10	28	0.4	1.00	B	1.0	3603
Mined Land Lake 34	90064	32.7	5-50	0.10	28	0.4	1.00	B	1.0	3603
Mined Land Lake 35	88910	27.9	5-50	0.10	29	0.4	1.00	B	1.0	3556
Mined Land Lake 36	90812	20.8	5-50	0.10	28	0.4	1.00	B	1.0	3632
Mined Land Lake 37	86333	3.9	1-5	0.01	36	0.4	1.00	B	1.0	345
Mined Land Lake 38	86333	6.1	5-50	0.10	36	0.4	1.00	B	1.0	3453
Mined Land Lake 39	89283	14.3	5-50	0.10	34	0.4	1.00	B	1.0	3571
Mined Land Lake 40	88129	16.9	5-50	0.10	34	0.4	1.00	B	1.0	3525
Mined Land Lake 41	87495	41.8	5-50	0.10	36	0.4	1.00	B	1.0	3500
Mined Land Lake 42	86333	11.9	5-50	0.10	36	0.4	1.00	B	1.0	3453
Mined Land Lake 43	86333	9.9	5-50	0.10	36	0.4	1.00	B	1.0	3453
Mined Land Lake 44	86333	77.2	50-500	0.50	36	0.4	1.00	B	1.0	17267
Mined Land Lake 45	86333	47.5	5-50	0.10	35	0.4	1.00	B	1.0	3453
Mingenback Lake	140443	3.2	1-5	0.01	2	1.0	1.00	B	0.5	702
Mission Lake	52543	136.5	50-500	0.50	3	1.0	1.00	A	1.0	26272
Moline City #1 (Santa Fe Lake)	17924	12.9	5-50	0.10	4	0.8	1.00	A	1.0	1434
Moline City Lake #2	15945	25.0	5-50	0.10	3	1.0	1.00	B	1.0	1595

Lake Name	Pop_30	Acres	Size Class	Size Factor	Lake_30	Lakes_ Factor	Private	CR	Contact Factor	Final Score
Top 25% highlighted										
Moline Reservoir	21124	160.9	50-500	0.50	4	0.8	1.00	A	1.0	8450
Moss Lake	545822	13.6	5-50	0.10	11	0.6	1.00	B	0.5	16375
Mound City Lake	49818	122.9	50-500	0.50	4	0.8	1.00	B	1.0	19927
Murray Gill Lake	32540	401.6	50-500	0.50	3	1.0	1.00	A	1.0	16270
Myer's Lake	319862	13.1	5-50	0.10	10	0.6	1.00	B	0.5	9596
Nebo SFL	160582	30.0	5-50	0.10	4	0.8	1.00	B	1.0	12847
Neosho Falls City Lake	47404	1.7	1-5	0.01	3	1.0	1.00	B	0.5	237
New Strawn Park Lake	70143	3.0	1-5	0.01	3	1.0	1.00	B	0.5	351
New Yates Center Lake	49996	168.0	50-500	0.50	5	0.8	1.00	B	1.0	19998
Newton City Park Lake	470621	34.2	5-50	0.10	3	1.0	1.00	B	0.5	23531
North Park Lake	795260	2.3	1-5	0.01	5	0.8	1.00	B	0.5	3181
Norton Lake (Sebelius Lake)	11357	782.4	500-1000	1.00	1	1.0	1.00	A	1.0	11357
Ogden City Lake	125126	13.7	5-50	0.10	2	1.0	1.00	A	1.0	12513
Olathe Waterworks Lakes	779776	9.8	5-50	0.10	12	0.6	1.00	B	0.5	23393
Olpe City Lake	51343	75.3	50-500	0.50	1	1.0	1.00	A	1.0	25672
Osawatomie City Lake	242417	24.5	5-50	0.10	3	1.0	1.00	B	0.5	12121
Otis Creek Lake (Eureka)	31373	240.1	50-500	0.50	2	1.0	1.00	B	0.5	7843
Overbrook Lake	321788	6.0	5-50	0.10	7	0.6	1.00	B	1.0	19307
Paola City Lake	501558	23.9	5-50	0.10	4	0.8	1.00	B	0.5	20062
Parker City Lake	68429	7.5	5-50	0.10	1	1.0	1.00	B	1.0	6843
Peter Pan Lake	55838	2.8	1-5	0.01	2	1.0	1.00	B	0.5	279
Pierson Park Lake	722265	11.4	5-50	0.10	9	0.6	1.00	B	0.5	21668
Pittsburg College Lake	70254	2.1	1-5	0.01	12	0.6	1.00	B	0.5	211
Plainville Township Lake	34838	23.5	5-50	0.10	1	1.0	1.00	B	1.0	3484
Playter's Lake	74794	3.8	1-5	0.01	12	0.6	1.00	B	0.5	224
Pleasanton City Lake #1	47058	24.4	5-50	0.1	5	0.8	1.00	B	1.0	3765

Lake Name	Pop_30	Acres	Size Class	Size Factor	Lake_30	Lakes_ Factor	Private	CR	Contact Factor	Final Score
Top 25% highlighted										
Pleasanton City Lake #2	47058	15.3	5-50	0.1	5	0.8	1.00	B	1.0	3765
Pleasanton Reservoir	45226	100.1	50-500	0.5	4	0.8	1.00	A	1.0	18090
Point of Rocks Lake (Moss Lake West)	4369	1.0	1-5	0.01	3	1.0	1.00	B	0.5	22
Polk Daniels Lake (Elk Co. SFL)	24510	64.8	50-500	0.50	3	1.0	1.00	B	1.0	12255
Pony Creek Lake	25509	103.6	50-500	0.50	3	1.0	1.00	B	1.0	12755
Pottawatomie Co SFL #1	93146	17.3	5-50	0.10	1	1.0	1.00	B	1.0	9315
Potter's Lake	667491	1.2	1-5	0.01	3	1.0	1.00	B	0.5	3337
Pratt Co. Lake	23156	46.4	5-50	0.10	3	1.0	1.00	B	1.0	2316
Prescott City Lake	27862	16.6	5-50	0.10	4	0.8	1.00	B	1.0	2229
Quarry Lake	45414	16.9	5-50	0.10	4	0.8	1.00	B	0.5	1817
Richmond City Lake	76745	12.7	5-50	0.10	3	1.0	1.00	B	1.0	7675
Riggs Park Lake	523717	1.2	1-5	0.01	3	1.0	1.00	B	0.5	2619
Rimrock Park Lake	124316	2.5	1-5	0.01	3	1.0	1.00	B	0.5	622
Rock Creek Lake	57709	52.8	50-500	0.50	6	0.8	1.00	B	1.0	23084
Rocky Ford W.A.	120579	7.7	5-50	0.10	3	1.0	1.00	B	0.5	6029
Rooks Co. SFL	14433	28.4	5-50	0.10	2	1.0	1.00	B	1.0	1443
Rose's Lake	788410	2.3	1-5	0.01	13	0.6	1.00	B	0.5	2365
Sabetha City Lake	26388	105.9	50-500	0.50	3	1.0	1.00	B	0.5	6597
Sabetha Watershed Lake (Niehues)	31775	0.3	<1	0.00	3	1.0	1.00	B	0.5	16
Saline Co. SFL	81073	21.9	5-50	0.10	2	1.0	1.00	B	1.0	8107
Scranton City Lake	306324	10.3	5-50	0.10	6	0.8	0.01	B	0.5	123
Sedan City North Lake	29588	40.2	5-50	0.10	3	1.0	1.00	B	1.0	2959
Sedan City South Lake	29588	64.2	50-500	0.50	3	1.0	1.00	A	1.0	14794
Severy City Lake	21892	11.6	5-50	0.10	2	1.0	1.00	B	1.0	2189
Sheridan Co. SFL	8681	43.4	5-50	0.10	2	1.0	1.00	B	1.0	868
Smith Lake	463048	3.4	1-5	0.01	4	0.8	1.00	B	0.5	1852
Smoky Hill Garden Lake	8509	12.7	5-50	0.10	2	1.0	1.00	B	0.5	425
South Lake Park	705078	6.0	5-50	0.10	11	0.6	1.00	B	0.5	21152
Spring Creek Park Lake	519850	11.3	5-50	0.10	4	0.8	1.00	B	0.5	20794
Spring Hill City Lake	768642	33.3	5-50	0.10	10	0.6	1.00	B	0.5	23059

Lake Name	Pop_30	Acres	Size Class	Size Factor	Lake_30	Lakes_ Factor	Private	CR	Contact Factor	Final Score
Top 25% highlighted										
St. Jacobs Well (Big Basin W.A.)	8562	15.0	5-50	0.10	1	1.0	1.00	B	0.5	428
Sterling City Lake	85980	8.3	5-50	0.10	1	1.0	1.00	B	0.5	4299
Stohl Park Lake	763134	1.6	1-5	0.01	12	0.6	1.00	B	0.5	2289
Stone Lake	45526	37.4	5-50	0.10	3	1.0	1.00	B	1.0	4553
Sunflower Park Lake	829896	1.4	1-5	0.01	3	1.0	1.00	B	0.5	4149
Thayer New City Lake	71381	16.8	5-50	0.10	3	1.0	1.00	B	1.0	7138
Thayer Old City Lake	70838	23.5	5-50	0.10	3	1.0	1.00	A	1.0	7084
Timber Lake	68236	20.6	5-50	0.10	1	1.0	1.00	B	0.5	3412
Topeka Public Golf Course Lake	285001	3.3	1-5	0.01	10	0.6	1.00	B	0.5	855
Troy Fair Lake	37607	5.1	5-50	0.10	1	1.0	1.00	B	0.5	1880
Vic's Lake	545822	11.4	5-50	0.10	11	0.6	1.00	B	0.5	16375
Wamego City Lake	109648	0.8	<1	0.00	2	1.0	1.00	B	0.5	55
Warren Park Lake	304134	0.2	<1	0.00	12	0.6	1.00	B	0.5	91
Washburn Rural Environmental Lab Lake	300128	3.7	1-5	0.01	11	0.6	1.00	B	0.5	900
Washington Co. SFL	18735	77.8	50-500	0.50	1	1.0	1.00	B	1.0	9368
Webster Lake	13063	1337.9	>1000	2.00	2	1.0	1.00	A	1.0	26126
Wilson Co. SFL	50955	109.4	50-500	0.50	2	1.0	1.00	B	1.0	25478
Windmill Lake	547874	17.4	5-50	0.10	11	0.6	1.00	B	0.5	16436
Winfield Park Lagoon	123647	6.1	5-50	0.10	2	1.0	1.00	B	0.5	6182
Woodson Co. SFL	51694	112.5	50-500	0.50	5	0.8	1.00	B	1.0	20678
Xenia Lake	50005	65.5	50-500	0.50	3	1.0	1.00	B	0.5	12501
Yates Center Reservoir	49547	112.8	50-500	0.50	3	1.0	1.00	A	1.0	24774

Appendix D

ENROLLED SENATE
BILL NO. 259

By: Brecheen and Coates of the Senate

and

Cox, Roberts (Dustin), Roan and Hardin of the House

An Act relating to lakes; directing the Oklahoma Tourism and Recreation Department to develop and maintain certain website and provide certain written information; providing specifications of website and written information; directing certain entities to post specified signs at specified locations; directing the Oklahoma Tourism and Recreation Department to develop certain language; directing the State Department of Health to provide certain education; specifying parameters for issuing and lifting certain advisories; permitting certain testing results to be provided by specified entities; directing recognition of certain research; authorizing the publication of certain findings; defining certain terms; specifying certain applicability; providing for codification; and declaring an emergency.

SUBJECT: Recreational lakes and reservoirs

BE IT ENACTED BY THE PEOPLE OF THE STATE OF OKLAHOMA:

SECTION 1. NEW LAW A new section of law to be codified in the Oklahoma Statutes as Section 2301 of Title 74, unless there is created a duplication in numbering, reads as follows:

A. The Oklahoma Tourism and Recreation Department shall develop and maintain a website and provide written information for the public available on location that allows the public to check the water quality, as it adversely affects human and mammalian animal health, of recreational bodies of water in this state which are managed by state or federal agencies or entities. The website and written information shall be made available to the public on or before December 31, 2012, and shall provide internet links and other points of contacts for relevant state agencies.

B. Any state or municipal agency with authority to manage a recreational lake or reservoir in this state shall post signs at major access points for the body of water stating that information on water quality is available on the website or in the written information specified in subsection A of this section. The Oklahoma Tourism and Recreation Department shall develop and provide the language for the signs required by this subsection.

C. The State Department of Health shall provide to physicians, hospital personnel, and local health departments educational material and information on the effects and symptoms of exposure to blue-green algae.

D. 1. Any state or municipal agency with authority to manage a recreational lake or reservoir in this state, to regulate water quality or regulate public health shall:

a. issue advisories for blue-green algae for recreational lakes or reservoirs only when both the blue-green algae cell count and toxicity testing results exceed the World Health Organization guidelines for moderate probability of adverse health effects of one hundred thousand (100,000) cells per milliliter for cell count and twenty (20) micrograms per liter for microcystin toxin levels. The blue-green algae testing shall be conducted at predetermined locations which are published along with the testing results, and

b. lift advisories for blue-green algae for recreational lakes or reservoirs if the blue-green algae cell count and toxicity testing results are below guidelines as set forth in subparagraph a of this paragraph for two

consecutive tests taken at weekly intervals within thirty (30) calendar days of each other.

2. The blue-green algae cell count and toxicity testing results as described in this subsection may be provided by a public or private entity.

E. Any state or municipal agency with authority to manage a recreational body of water in this state, to regulate water quality or regulate public health and which may issue blue-green algae lake advisories shall recognize publicly and privately funded research if the research is scientifically verifiable and it will ensure that the public is more informed about water quality and safety. The Oklahoma Tourism and Recreation Department may publish the findings of the research on the website or in written information specified in subsection A of this section.

F. For purposes of this section:

1. "State or municipal agency" means any agency, board, commission, department, authority, office, subdivision or instrumentality of the state or a municipality located in the state; and

2. "Recreational lake or reservoir" means a lake or reservoir on which the public is allowed to fish, boat or swim.

G. Nothing in this section shall be construed to amend, modify, or repeal any state or federal requirements related to water testing.

SECTION 2. It being immediately necessary for the preservation of the public peace, health and safety, an emergency is hereby declared to exist, by reason whereof this act shall take effect and be in full force from and after its passage and approval.

Passed the Senate the 17th day of May, 2012.

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Presiding Officer of the Senate

Passed the House of Representatives the 21st day of May, 2012.

_____
Presiding Officer of the House
of Representatives

Appendix E

Blue-green Algae Awareness Level

Elevated Risk of Adverse Health Effects

BLUE-GREEN ALGAE BLOOMS ARE PRESENT

For Your Safety, The U.S. Army Corps of Engineers, Tulsa District Recommends the Following:

- **Children and pets are more likely to get sick because of blue-green algae.**
- **Use caution when swimming, water skiing and coming into contact with water.**
- **DO NOT drink untreated lake water.**
- **Keep pets/livestock off of the beach and out of the water.**
- **Avoid areas with visible algae accumulation.**

Symptoms from exposure may include nausea, vomiting, diarrhea, skin rash, eye irritation, respiratory problems or other unexplained illness.

For more information go to:

www.TravelOK.com/checkmyoklake
or
www.swt.usace.army.mil

To Report Illness Due to Exposure, Please Contact Your Doctor or the Oklahoma Poison Control Hotline at: 1-800-222-

Appendix F

STANDARD OPERATING PROCEDURES FOR FIELD SAMPLING: LAKES

Tulsa District
U.S. Army Corps of Engineers
Planning, Environmental, and Regulatory Division

FINAL DRAFT
FEBRUARY 2000

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Section 1: Introduction, Objectives, and Document Organization

The purpose of this compilation of standard operating procedures (SOPs) for field sampling is to provide a written guide for appropriate and consistent sampling methods for field data collection on Tulsa District Corps of Engineers lakes. When appropriately applied, these SOPs should provide consistency in methods for collection of field measurements and samples of various environmental media to be submitted for laboratory analyses. The intended result is documentation and consistency of sampling methods and a high level of confidence and reliability in the quality of data generated from field sampling activities.

This compilation of SOPs is intended to be a dynamic document amenable to periodic update and revision as needed. Accordingly, reference numbers and revision dates are provided for each individual SOP under appropriate section headings. Consecutive document page numbers have been intentionally omitted to permit update as needed.

It is imperative that all personnel involved in field sampling efforts on Tulsa District Corps of Engineers lakes are familiar with content and application of sampling methods described in these SOPs. Careful review and understanding of these SOPs are therefore a mandatory prerequisite to participation in field sampling activities supported by the Tulsa District.

Questions, comments, or suggestions for SOP improvement should be directed to John Carroll (918.669.7659) or Steve Nolen (918.669.4395).

End

Section 2: Pre-trip Planning

Organized planning prior to field sampling dates is necessary for efficient use of sampling personnel and resources. Pre-trip planning should include organization and maintenance of all sampling equipment and instruments, coordination among field sampling personnel and laboratory analysts, and pre-sampling briefings with field samplers. This section contains a checklist of field equipment sufficient for sampling under all SOPs provided in this document as well as guidelines for pre-sampling coordination with analytical labs.

End

SOP 2.1: Equipment Checklist
Revision date: 22 November 1999

Every item to be initialed as loaded (or marked N/A - not applicable) prior to each trip.

Vehicle

- ___ Keys
- ___ Fuel credit card
- ___ PikePass
- ___ Air pressure gage
- ___ Spare tire (w/air) and jack
- ___ Ice scraper / deicer

Boat

- ___ Boat keys
- ___ Full fuel tank(s)
- ___ Boat gas credit card
- ___ Oil
- ___ Tool kit
- ___ Life vests for all passengers
- ___ Charged battery(ies)
- ___ Oars / paddles
- ___ Anchor and line
- ___ Depth finder
- ___ Transom plug
- ___ Check trailer lights function
- ___ Check transom saver
- ___ Check trailer tire condition and pressure
- ___ Check / lube trailer wheel bearings
- ___ Check trailer hitch / safety chains / trailer brakes
- ___ Fenders
- ___ Throw line and/or ring
- ___ Lake map with marked sampling sites (and GPS coordinates)
- ___ Engine kill switch check
- ___ Properly charged fire extinguisher
- ___ First aid kit
- ___ Signal device (air horn, etc.)
- ___ 5-gallon bucket for bailing or general use

General / Personal

- ___ Sunscreen
- ___ Cellular phone and/or radio (w/phone number of lab and project office)
- ___ Raingear
- ___ Hat / sunglasses
- ___ Drinking water
- ___ Camera and film

Equipment checklist cont. (p.2 of 3)

Field Instruments (as needed)

___ Hydrolab (or equivalent multiparameter instrument)
___ Charged battery (w/spare) for above instrument
___ Maintenance kit and calibration standards for above instrument
___ GPS unit (hand-held or boat-mounted)
___ Light meter w/sensor and extra set of 6 D-cell batteries
___ Field nephelometer w/calibration standards, 4 spare AA batteries, tissues
___ Secchi disk
___ Field laptop w/charged battery
___ Dataloggers for all instruments (as appropriate)
___ Copies of instruction manuals for all instruments (in waterproof container)

Data Recording and Sample Labeling

___ Field notebook
___ Data sheets in waterproof field clipboard
___ Chain-of-custody forms
___ Pencils and permanent markers (Sharpies or equivalent)
___ Labeling tape
___ Extra sample container labels
___ Clear, wide adhesive tape (for taping over bottle labels if necessary)
___ SOP Manual

Water Sample Collection (Reference Section 3)

___ Van Dorn and/or Kemmerer sampler w/line and messenger (plus spare)
___ Sample containers as appropriate for analytical parameters (see SOP 3.4)
___ Extra sample containers (above those required) for all parameter groups
___ Coolers sufficient for samples and ice
___ Ice sufficient for all samples
___ Acids and other preservatives as appropriate (see SOP 3.6)
___ Filtration apparatus and accessories as appropriate (see SOP 3.10)
___ Appropriately filled bottles for blank samples (see SOP 3.3)

Sediment Sample Collection (if applicable) (Reference Section 4)

___ Core sampling device if appropriate (see Section 4)
___ Liners of appropriate materials for core sampler (see SOP 4.1)
___ Core sample extruder
___ Measuring device (e.g. ruler, tape) for core depths (see SOP 4.1)
___ Eckman dredge if appropriate
___ Line and messengers (plus spare) for all above samplers
___ Stainless steel bowl / spoons for replicate sample compositing (see SOP 4.3)
___ Detergent, brushes, isopropyl alcohol for equipment cleaning (see Section 4)
___ Waste container for equipment cleaning waste liquids
___ Sample containers as appropriate for analytical parameters (see SOP 4.4)

Equipment checklist cont. (page 3 of 3)

Sediment Sample Collection (continued)

___ Extra sample containers (above those required) for all parameter groups
___ Coolers and ice sufficient for all sediment samples
___ Type I water for equipment blank sample collection (see SOP 4.5)
___ Appropriate sample containers/preservatives for equipment blank samples
___ Type I water

Zooplankton Sample Collection (see SOP 3.8)

___ Plankton net w/net bucket and depth-marked line
___ Lugol's preservative (or 5% buffered formalin) and syringe
___ Rinse bottle w/ DI water
___ 250 ml polyethylene container for each site (plus extras)

Algal Sample Collection (see SOP 3.9)

___ 250 ml polyethylene container for each site (plus extras)
___ Lugol's preservative and syringe

Chlorophyll Sample Collection and Filtration (see SOP 3.7)

___ 1-liter opaque containers (1 per sample plus extras)
___ Vacuum pump (AC or hand powered)
___ Filter assembly
___ Filters (Gelman G/F 0.45um porosity, 47mm diameter)
___ 250 ml graduated cylinder
___ Forceps
___ Wash bottle w/ DI water (plus extra water)
___ Scintillation vials or alternate containers for sample filters
___ Aluminum foil

Personal Protection and Safety

___ Eye protection and gloves (if handling acids)

End of Checklist

SOP 2.2: Coordination with Analytical Lab
Revision date: 23 November 1999

Efficient coordination with the analytical laboratory(ies) handling sample analyses is essential to generation of quality data. Lack of proper communication with the analytical lab can result in missed sample holding times, confusion over desired analytical parameters, and increased cost of analyses. The following guidelines should be followed:

1. Prior to sampling date:
   a. Ensure that all contracting mechanisms are in place for sample analyses.
   b. Clearly communicate with the lab regarding desired analyses, quantitation limits, required sample volumes and preservatives, and other specifics related to analyses.
   c. Agree on tentative sampling dates well in advance of sampling to allow lab to schedule for samples.
   d. Establish point-of-contact (and alternate) at lab.

2. Day before sampling date:
   a. Call lab to confirm that sampling will be conducted and approximate time that samples will be delivered.
   b. Resolve any last-minute details regarding sample analyses.

3. On sampling date:
   a. Make sure that you have phone number of lab point-of-contact with you in field.
   b. If sampling is cancelled for any reason (e.g. weather), immediately inform lab that samples will not be arriving and coordinate an alternate sampling date.
   c. Upon delivery of samples, stay at lab until all sample numbers, parameters, etc. have been resolved and lab signs chain-of-custody form (take copy with you).
   d. Leave your name and phone number and request that you be immediately called if any discrepancies in sample numbers, parameters, etc. are discovered.

4. Days following sampling date:
   a. Immediately resolve any problems encountered during previous sampling event.
   b. Upon receipt of results, ensure that samples analyzed agree with those recorded in field notes.
   c. Transfer data to appropriate personnel for database entry or store in organized, secure location.

End

Section 3: Water Sample Collection

An important part of water quality sampling on Corps of Engineers lakes is proper collection of water samples to be analyzed for a wide variety of parameters by an analytical laboratory. Analytical data quality and reliability starts with proper sample collection techniques, appropriate containers and sample preservatives (if required), clear and consistent sample labeling, and reliable delivery of samples to the laboratory. Specific SOPs for these aspects of water sample collection are provided in this section.

End

SOP 3.1: Collection of Lake Surface Water Grab Samples (0.5 m depth)
Revision date: 23 November 1999

1. Locate appropriate sampling site using GPS, permanent buoys, or other means. Anchor boat if necessary. If anchoring in shallow water, make sure sampling is not conducted in water influenced by sediment disturbance. Sampling should also be conducted upwind of engine exhaust and out of wake area caused by engine. If sediment sampling is to be conducted at site, always collect water samples before sediments. If water samples are also to be collected at depth (SOP 3.2), collect surface samples first.

2. Use appropriate sample container for parameters of interest (see SOP 3.4). Label container appropriately (see SOP 3.5) prior to filling.

3. Uncap container and place cap upside down on deck or other secure, clean area. Submerge container to approximately 0.5 m depth (elbow depth) and fill container half full. Cap container, shake to rinse, and pour out contents.

4. Uncap container and place cap upside down on deck or other secure, clean area. Submerge container to 0.5 m depth and fill completely leaving no room for air while trying to avoid excessive aeration ("bubbling") of sample. Cap container tightly and place in secure container (usually cooler w/ice).

5. If acids are to be used as preservatives and wind and wave conditions are calm, acids can be added prior to capping. If wind and waves are such that acids cannot be handled safely on deck, preserve samples immediately upon returning to shore. Note presence of sample preservatives on bottle label at time of addition (see SOP 3.5).

6. Note sample ID in field notes for each sample collected at the site.

End

SOP 3.2: Collection of Lake Water Grab Samples at Depth
Revision date: 01 February 2000

1. Locate appropriate sampling site using GPS, permanent buoys, or other means. Always anchor boat for collection of subsurface samples (to ensure vertical deployment of sampling device). Let out sufficient anchor rope to ensure that subsurface samples are not collected in areas influenced by sediment disturbance by anchor. If surface water samples are also to be collected at site, collect surface samples first.

2. Use appropriate sample container for parameters of interest (see SOP 3.4). Label container appropriately (see SOP 3.5) prior to filling.

3. Use Van Dorn (preferably vertical style) or Kemmerer sampler fitted with laboratory tubing on outlet port to obtain sample at desired depth. Lower sampler to desired depth noted by calibrated line, close sampler using weighted messenger, and bring sampler to the surface.

4. Uncap sample container and place cap upside down on deck or other secure, clean area. Fill container half full from sampler, cap container, shake to rinse, and pour out contents.

5. Uncap sample container and place cap upside down on deck or other secure, clean area. Fill container by placing tubing at bottom of container and slowly filling while avoiding excessive aeration . Fill container completely leaving no room for air. Cap container tightly and place in secure container (usually cooler w/ice).

6. If acids are to be used as preservatives and wind and wave conditions are calm, acids can be added prior to capping. If wind and waves are such that acids cannot be handled safely on deck, preserve samples immediately upon returning to shore. Note presence of sample preservatives on bottle label at time of addition (see SOP 3.5).

7. Note sample ID in field notes for each sample collected at the site.

End

SOP 3.3: Collection of Replicate and Blank Water Samples
Revision date: 23 November 1999

Replicate and blank water samples are collected for quality assurance / quality control (QA/QC) purposes for some studies on Tulsa District lakes. Replicate samples are two (duplicate) or three (triplicate) water samples collected from the same location and depth and using identical sampling protocols. One serves as the primary field sample. Duplicate samples are often analyzed by the primary laboratory as a measure of analytical precision. In addition, a third sample (triplicate) is sometimes analyzed by an independent lab as a measure of analytical accuracy for selected parameters. As a rule of thumb, replicate samples are collected on a 10-percent of field sample frequency on each sampling date. An important aspect of replicate sample collection is that all replicates be collected from a single, homogeneous source for valid comparison of results.

Blank samples are samples of analyte-free water (frequently Type I[1]) which accompany field samples through sampling and analytical processes as a check for field and/or laboratory contamination for selected parameters.

1. Replicate water samples:
   a. Collect number of replicate water samples (if any) as called for in project-specific sampling plan.
   b. Replicate samples should be collected as described in SOPs 3.1 and 3.2 with exceptions as noted here. All water samples (including surface) should be collected with a lake water-rinsed Van Dorn or Kemmerer-type sampler. Prior to filling replicate sample bottles, the sampler should be repeatedly inverted to thoroughly homogenize the sample. Replicate sample bottles should then be filled sequentially with approximately one-fourth container volume and this sequence repeated until all containers are full. Replicate samples should always be filled from the same "grab" obtained by the sampling device.
   c. Replicate samples should be labeled with an ID number that is clearly recorded in field notes as a replicate but is not apparent as such to laboratory analysts.

2. Blank water samples:
   a. Fill sample container appropriate for desired parameters with Type I[1] water prior to sampling trip. Add preservatives as appropriate. Blank sample should be labeled with an ID number that is clearly recorded in notes as a blank but is not apparent as such to laboratory analysts.
   b. Carry blank samples throughout sampling event and submit with field samples.

[1] As defined in Standard Methods for the Examination of Water and Wastewater, 19th Ed.

End

SOP 3.4: Sample Containers and Volumes
Revision date: 23 November 1999

Proper sample containers should be used for analytes of interest as improper container materials can invalidate sample results. This SOP provides information on preferred sample container materials for analytes commonly measured at Tulsa District impoundments. While alternate container materials may be appropriate, those listed are acceptable and have proven most convenient. This SOP also provides general guidance on sample volumes required for common parameters. However, required sample volumes vary considerably depending upon analytical lab preference and all volumes should be verified with labs performing specific analyses prior to any sample collection.

It is the general policy of the Tulsa District to use certified, pre-cleaned, disposable sample containers for most lake sampling. Containers are to be used only once and disposed after use. This eliminates uncertainties associated with container cleaning.

Parameter	Container material	Volume (ml)
Total phosphorus	HDPE[1]	50
Ortho-phosphorus	HDPE	50
Nitrate-N	HDPE	100
Nitrite-N	HDPE	50
Ammonia-N	HDPE	400
Kjeldahl and Organic-N	HDPE	500
Total alkalinity	HDPE	100
Total hardness	HDPE	100
Chloride	HDPE	50
Sulfate	HDPE	100
Total dissolved solids	HDPE	100
Settleable solids	AG[2]	1000
Total suspended solids	HDPE	100
Turbidity	HDPE	100
Metals	HDPE	200[3]
Chlorophyll *a*	OHDPE[4]	1000
Total organic carbon	AG	40
Chlorinated pesticides	AG	1000
Chlorinated herbicides	AG	1000
Organophosphorus pesticides	AG	1000
Semivolatile organics	AG	1000
Total petroleum hydrocarbons	AG	1000

[1]HDPE = high density polyethylene
[2]AG = amber glass
[3]Double volume if requesting both total and dissolved metals
[4]OHDPE = opaque high density polyethylene

End

SOP 3.5: Sample labeling
Revision date: 23 February 2000

1. Use labels supplied with sample bottles, if available. If not available, alternate labels or quality labeling tape should be used. Labels should be applied to bottles prior to the sampling trip, but label information should not be filled in until immediately before sample collection. Alternately, pre-filled out labels may be used. However, if sampling must be delayed or modified, pre-filled out labels should be completely replaced with those with correct information. This prevents confusing changes in written label information.

2. Label information should be neatly filled in with permanent marker (Sharpie or equivalent) prior to sample collection. Fine tip markers generally work best and result in easily-read information. Writing should be neat. If any information is changed or marked out on label, this change should be initialed by sampler.

3. Prior to sample collection, clear packaging tape wide enough to completely cover label should be wrapped completely around label and sample container. This prevents label from coming off (particularly in melting ice), prevents label information from being blurred or rubbed out by other sample containers, and provides security to label information. If preservatives are to be added on shore, this step can wait until preservative information has been added to label.

4. Label information should include the following at a minimum:
   a. Date in the form mm/dd/yyyy;
   b. Military time;
   c. Unique sample site ID number that remains constant throughout the study;
   d. Depth at which sample was collected (in meters);
   e. Requested analytes;
   f. Preservatives (if any); If none, fill in "none" in space for preservatives.
   g. Sampler's initials.

5. Sample ID numbers should be determined by reference to sampling plans for the specific project. However, it is often useful to combine critical information into a unique sample ID number . (e.g. "TEX5-11051999-D12" would indicate a sample collected at Texoma Lake site 5 on 5 November 1999 at a depth of 12 meters). Sample ID numbers should be clearly recorded in field notes for future reference.

6. A single "sample" often includes multiple containers that are to be analyzed for a variety of analytes. In this case, all sample labels should include identical information (with exception of requested analytes and preservatives). Number of containers comprising the sample should be recorded in field notes. These multiple containers are collectively considered as one sample.

End

SOP 3.6: Water Sample Preservation and Holding Times
Revision date: 29 November 1999

Proper sample preservation is essential to generation of quality data from samples submitted for laboratory analyses. Sample preservation minimizes changes in sample characteristics resulting from physical, chemical, or biological alteration of the sample between collection and analysis. Appropriate preservatives for parameters commonly measured in samples from Tulsa District lakes are presented here for reference. However, specific labs may have sample preservation preferences that must be resolved on a case-by-case basis prior to any sample collection.

Sample preservatives should be noted on sample label only after addition is complete. This will ensure preservatives are added as appropriate. Commercially-prepared, individually sealed ampules should be used for all acid preservatives. This minimizes problems with potential contamination of acids in repeatedly used containers and transfer pipettes. This approach also minimizes safety risks associated with spilled acids.

It is the policy of the Tulsa District to transfer water samples to the analytical lab immediately upon collection. This will minimize problems with holding time requirements. However, holding times for commonly-measured parameters are presented here for general information.

End of text
See next page for table

Parameter	Preservative(s)	Holding time (days)
Total phosphorus	pH<2 H_2SO_4, Ice 4°C	28
Diss. ortho-phosphorus	Filter, Ice 4°C	2
Nitrate-N	Ice 4°C[1]	2[1]
Nitrite-N	Ice 4°C[1]	2[1]
Ammonia-N	pH<2 H_2SO_4, Ice 4°C	28
Kjeldahl-N	pH<2 H_2SO_4, Ice 4°C	28
Total alkalinity	Ice 4°C	14
Total hardness	pH<2 HNO_3, Ice 4°C	180
Chloride	none	28
Sulfate	Ice 4°C	28
Total dissolved solids	Ice 4°C	7
Settleable solids	Ice 4°C	2
Total suspended solids	Ice 4°C	7
Turbidity	Ice 4°C	2
Chlorophyll *a*	Ice 4°C, dark[2]	21[2]
Total organic carbon	pH<2 HCl or H_2SO_4, Ice 4°C, Dark	28
Chlorinated pesticides	Ice 4°C	7 / 40[3]
Chlorinated herbicides	Ice 4°C	7 / 40[3]
OrganoP pesticides	Ice 4°C	7 / 40[3]
Semivolatile organics	Ice 4°C	7 / 40[3]
Tot. Pet. Hydrocarbons	pH<2 HCl, Ice 4°C	ASAP
Total metals	pH<2 HNO_3	180[4]
Dissolved metals	filter, pH<2 HNO_3	180[4]

[1] If Nitrate-Nitrite to be analyzed, preserve with H_2SO_4 to pH <2, ice to 4°C. Holding time is 28 days. If acidified, nitrate and nitrite species cannot be separately determined.

[2] Filter samples immediately and freeze filter. Analyze within 21 days if lake water pH was >7.0. If lake water pH was <7.0, analyze immediately.

[3] 7 days to perform extraction / 40 days to analyze after extraction

[4] Holding time for mercury analysis is 28 days.

End

SOP 3.7: Chlorophyll *a* Sample Collection and Processing
Revision date: 24 November 1999

1. Collect water sample at a depth of 0.5 m using procedure described in SOP 3.1. Required sample volume will depend upon productivity of waters, but generally a 1 liter sample is more than sufficient for Tulsa District lakes. Sample should be placed in opaque container and immediately placed on ice.

2. Samples should be filtered in the field if possible. If not, sample should be filtered immediately (same day as collection) upon return to a suitable area. Filtration will require all equipment listed under "Chlorophyll Sample Collection and Filtration" in equipment checklist (SOP 2.1). Filtration should be conducted in as dark an area as practical according to the following procedure:

   a. Using forceps, place a 47mm-diameter G/F filter in filter assembly and clamp apparatus securely. Attach AC-powered or hand vacuum pump to assembly.
   b. Wet the filter with DI water and turn on pump.
   c. Thoroughly shake sample bottle and measure out 200 ml in graduated cylinder which has been rinsed with a small amount of sample water. Pour 200 ml sample into filter assembly. Thoroughly rinse graduated cylinder with DI water and pour into filter assembly.
   d. Filter sample maintaining vacuum pressure less than 40 psi.
   e. Repeat steps c and d until filter clogs or a volume of 1000 ml has been filtered, whichever comes first. Note volume filtered in notes and on container to hold filter. (Note: If fluorometry is to be used in determination of chlorophyll, a 200 ml filtered sample is usually sufficient. If spectrophotometric method is to be used, a larger sample volume may need to be filtered. Check with lab for method. In addition, inorganic turbidity in sample will largely determine volume of sample that can be effectively filtered).
   f. When filtration is complete, rinse down sides of filter well with DI water and filter this water.
   g. Disassemble filtration apparatus, use forceps to carefully fold filter in half and then in half again without touching material on filter. Place folded filter in tightly-capped scintillation vial or centrifuge tube. Copy sample label information on this container, wrap container in foil, and immediately place in freezer for storage.
   h. Repeat entire procedure for all samples.
   i. Samples should be analyzed within 3 weeks of sample collection.

End

SOP 3.8: Collection of Zooplankton Samples
Revision date: 24 November 1999

1. Assemble required equipment listed under "Zooplankton Sample Collection" in equipment checklist (SOP 2.1). The plankton net should be of 80-micron mesh and equipped with a Wisconsin net bucket and depth-marked line.

2. Collect depth-integrated sample using a vertical net tow as follows:
   a. Invert net over lake surface and wash from outside using squirt bottle w/ DI water;
   b. Insert stopper in tow net bucket opening;
   c. Lower net to depth of 10 m (or 1 m from bottom if depth is <10 m). (Note: desired depth of samples are sometimes based on multiples of Secchi depth. Check with project-specific sampling plan for desired depth). Note depth of tow in field notes and on sample container.
   d. Hold net stationary for at least 30 seconds to allow disturbed zooplankton to settle.
   e. Rapidly pull net to surface until net opening clears lake surface. Thoroughly rinse sides of net by dunking net 5 times in lake taking care not to submerge net opening.
   f. With net bucket opening over sample collection bottle (250 ml opaque HDPE), remove bucket stopper and allow sample to drain into collection bottle.
   g. Thoroughly rinse inside of the net bucket into the collection bottle using squirt bottle filled with DI water.
   h. If sample is to be analyzed within one year, preserve sample with Lugol's solution (add about 0.7 ml or get to color of "weak tea"). Invert sample to mix.
   i. If permanent preservation is desired, preserve sample with 5% buffered formalin solution. Invert sample to mix water and preservative.
   j. Calculate volume of water filtered using: $V=\pi r^2 d$ where: V = volume filtered (m^3); $\pi = 3.14$; r = radius of net orifice (m); and d = tow depth (m). Record this volume in field notes and on sample bottle label.

Preparation of Lugol's solution:

Dissolve 20 g of potassium iodide (KI) and 10 g of iodine crystals in a mixture of 200 ml distilled water and 20 ml glacial acetic acid.

End

SOP 3.9: Collection of Samples for Algal Enumeration and Identification
Revision date: 24 November 1999

1. Label 250 ml opaque HDPE sample bottle for sample collection.

2. Collect sample at a depth of 0.5 m by immersing bottle to elbow depth. Completely fill bottle.

3. Pour out just enough water to add approximately 1.8 ml of Lugol's solution as preservative. Add Lugol's solution and tightly cap bottle. Invert bottle a number of times to thoroughly mix sample and preservative.

4. Store samples in secure area prior to enumeration and identification. Protect sample from temperature extremes (particularly high heat).

See SOP 3.8 for Lugol's solution formulation.

End

SOP 3.10 Filtration of Water Samples for Dissolved Analyte Analyses
Revision date: 29 November 1999

Analysis for dissolved constituents requires pre-analysis filtration of water samples. This filtration should be conducted as soon as possible after sample collection. Samples should be filtered in the field, if possible. If not, sample should be filtered immediately (same day as collection) upon return to a suitable area. If it can be done in a timely manner (same day), filtration may be done by analytical laboratory. Filtration should always be performed prior to addition of any preservatives (e.g. acids).

An important consideration in sample filtration is avoidance of sample contamination with analytes of interest as a result of the filtration process. The following procedures should be followed:

1. Prior to filtration of each sample, appropriately wash all glassware to be used in the filtration step:
   a. Thoroughly wash with phosphate-free laboratory-grade detergent;
   b. Thoroughly rinse with hot tap water to remove visible soap;
   c. Triple rinse with Type I[1] water;
   d. Rinse all interior surfaces with 0.2 N nitric acid (or alternate dilute acid for N-containing analytes);
   e. Triple rinse with Type I water.

2. Assemble filtration apparatus with 0.45-um-pore-diameter polycarbonate or cellulose acetate filter. Filters should be stored in 0.5 N nitric acid (or alternate acid for N-containing analytes) and rinsed with Type I water prior to use.

3. Shake sample container and pour sample into filtration apparatus. For metals analyses, filter approximately 250 ml. For analysis of dissolved ortho-P, approximately 100 ml should be filtered.

4. Filter sample using either AC-powered or hand-operated vaccuum pump at approximately 40 psi. If filter clogs prior to attainment of sufficient sample volume, change filter and continue process.

5. Following filtration, transfer filtrate to appropriate sample container (SOP 3.4) and add appropriate preservative (SOP 3.6) if required. Discard filter and wash filtration apparatus (Step 1) prior to next sample.

6. Use above procedure to filter a similar volume of Type I water and submit as blank sample. Submit one blank sample for each sampling day.

[1] As defined in Standard Methods for the Examination of Water and Wastewater, 19th Ed.

End

SOP 3.11: Trip Blank Sample Collection
Revision date: 04 January 2000

A trip blank consists of a sample of reagent water that is prepared in the analytical laboratory, shipped with sample containers, carried through all sampling procedures, and returned to the laboratory having never been opened. The purpose of the trip blank sample is to evaluate the potential for cross-contamination of field samples owing to sample containers, laboratory analyses, sample handling, or sample shipping. Trip blanks are often used when volatile organics are analytes of interest. The need for collection of trip blank samples will be defined in project-specific sampling plans.

The following procedure will be used for preparation of trip blanks:

1. Prior to sampling event, fill sample container(s) identical to those to be used for field samples with Type I[1] water in the laboratory. Make sure that sample volume is adequate for desired analysis (see SOP 3.4). Preserve sample if necessary (see SOP 3.6) using preservatives that will be used in the field.

2. Label sample such that it is not readily apparent to analytical laboratory that sample is a trip blank.

3. Transport this sample along with sample containers for field sampling event. The sample(s) should accompany sample containers during all sampling activities but should remain unopened. Transport on ice if required (see SOP 3.6).

4. After sampling is completed, transport trip blank sample(s) with field samples and return to analytical lab.

[1]As defined in Standard Methods for the Examination of Water and Wastewater, 19th Ed.

End

Section 4: Sediment Sample Collection

Proper collection of sediment samples is an important part of water quality investigations on Tulsa District, Corps of Engineers lakes. Sediments often serve as both "sink" and "source" for a variety of chemical constituents that influence water quality in reservoirs. Sediment "patchiness", requirements for different depths of samples, and a variety of sampling methods all complicate sediment sample collection techniques. Specific SOPs dealing with certain aspects of lake sediment sample collection are presented in this section.

End

SOP 4.1: Collection of Sediment Samples Using Sediment Coring Device
Revision date: 29 November 1999

Collection of sediment samples using some form of coring device is often the preferable means of sample collection on Tulsa District lakes. Sediment coring has the advantages of minimizing the loss of fine-grained sediments as well as permitting reasonably-accurate definition of sediment sample depths. If desired, core sectioning can be employed to study analyte distribution with sediment depth. Proper sampling protocol includes appropriate cleaning of the sampling device and proper sample collection techniques. A variety of coring devices exist and may be used in sediment sample collection. Owing to this variety, devices should be used in accordance with manufacturer's instructions. Sediment sampling should always be conducted at a site **following** collection of all water samples and field measurements. General instructions are as follows:

1. If coring device employs removable liners, nosepieces, and/or sediment retainers (e.g. "egg shell" core catchers), select appropriate liner and other parts material for analyte of interest. If samples are to be analyzed for organics, use stainless steel. If metals or other inorganics are the analyte of interest, use non-metal material (e.g. plastic).

2. Properly clean all parts of the sampling device that have a potential to contact the sediment sample. Thorough cleaning should be conducted before initial sampling and between all samples as follows:
    a. Using a stiff brush and lake water, remove all visible sediments and debris from sampler parts;
    b. Using a separate brush, scrub all parts with non-phosphate detergent;
    c. Rinse three (3) times with ASTM Type I water;
    d. Rinse once with isopropyl alcohol (retain in waste container) followed by three (3) rinses with Type I water (this step is optional depending upon analytes of interest).

3. Deploy assembled sediment coring device. If sampling is in shallow water, a hand corer may be used. If sampling in deeper water, a gravity corer may be used (with or without stabilizing fin). If applicable, use messenger to close sampling device valve.

4. Retrieve sampler and disassemble. Extrude sediment core with core sample removal tool. Measure appropriate sample depth (from water interface end) and transfer sample to pre-labeled (SOP 3.5) appropriate sample container (see SOP 4.4). Consult project-specific workplan for desired sediment depth.

5. Immediately place sample on ice and clean sampler prior to collection of next sample.

End

SOP 4.2: Collection of Sediment Samples using Eckman or Ponar Grab Sampler
Revision date: 29 November 1999

Sediment samples can be collected using an Eckman, Ponar, or other grab sampler of similar design. This type of sampler is also commonly-employed in collection of benthic macroinvertebrates samples from lakes. As with other sediment sampling techniques, samples should always be collected at a site after all water samples and field data have been collected. Techniques applicable to sampling for chemical constituents are described here.

1. Ensure that sampler has been properly cleaned prior to collection of each sample. The cleaning procedure described in SOP 4.1 should be followed.

2. Deploy sampler in sediments and release messenger (if applicable) to trip sampler. Retrieve sampler with as minimal amount of disturbance (loss of sample) as possible.

3. Transfer sediment sample to appropriate (SOP 4.4), pre-labeled (SOP 3.5) sample container using pre-cleaned spoon of appropriate material (stainless steel for organics, plastic for metals and other inorganics). Obtain sample from the desired sediment depth interval (consult project-specific sampling plan).

4. Immediately place sample on ice and clean sampler (using procedure described in SOP 4.1) prior to collecting next sample.

End

SOP 4.3 Collection of Replicate Sediment Samples
Revision date: 29 November 1999

Replicate sediment samples are collected for quality assurance / quality control (QA/QC) purposes for some studies on Tulsa District lakes. Replicate samples are two (duplicate) or three (triplicate) sediment samples collected from the same location and depth using identical protocols. One serves as the primary field sample. Duplicate samples are often analyzed by the primary laboratory as a measure of analytical precision. In addition, a third sample (triplicate) is sometimes analyzed by an independent laboratory as a measure of analytical accuracy for selected parameters. As a rule of thumb, replicate samples are collected on a 10-percent of field sample frequency on each sampling date.

A particular challenge with collection of replicate sediment samples is typical heterogeneity of sediments and difficulties associated with obtaining a homogenous mix required for good replicate sampling. Procedures are as follows:

1. Collect sediment sample using methods described in SOPs 4.1 or 4.2. Collect sufficient sample mass for number of replicates desired.

2. Transfer sediments to mixing bowl of appropriate material. Use stainless steel for organics and alternate material (e.g. glass or polyethylene) for metals and other inorganics. All materials should be pre-cleaned according to cleaning procedures described in SOP 4.1. Sample should be transferred with spoon of appropriate material that has likewise been cleaned according to this protocol.

3. Thoroughly mix sediments to obtain as homogenous a mixture as possible. Once thorougly mixed, transfer sediment subsamples to pre-labeled, appropriate containers for submission as replicate samples. (Note: Samples to be analyzed for volatile organic compounds should not be mixed according to this protocol. See project-specific sampling plan for instructions on replicate sampling for volatile compounds).

   Alternatively, if a small number of replicates of small sample mass are collected, samples can be mixed in an appropriate, pre-cleaned sample container of sufficient volume to contain sediment composite. This eliminates the need for and uncertainty associated with cleaning a mixing bowl. Following sample separation into sample jars, this mixing jar should be clearly labeled as contaminated, not used for other replicate samples, and discarded following the sampling event.

4. Replicate samples should be labeled with an ID number that is clearly recorded in field notes as a replicate but is not apparent as such to laboratory analysts.

5. Immediately place all samples on ice.

End

SOP 4.4: Sample Containers and Required Sample Mass
Revision date: 29 November 1999

Proper sediment sample containers should be used for analytes of interest as improper container materials can invalidate sample results. This SOP provides information on preferred sample container materials for sediment analytes commonly measured at Tulsa District impoundments. While alternate container materials may be appropriate, those listed are acceptable and have proven most convenient. This SOP also provides general guidance on sample mass required for common parameters. However, required sample mass may vary considerably depending upon analytical lab preference and should be verified with labs performing specific analyses prior to any sample collection.

It is the general policy of the Tulsa District to use certified, pre-cleaned, disposable sample containers for most lake sediment sampling. Containers are to be used only once and disposed after use. This eliminates uncertainties associated with container cleaning.

Parameter	Container material	Mass(g)
Total phosphorus	HDPE[1]	100
Total nitrogen	HDPE	100
Chloride	HDPE	100
Sulfate	HDPE	100
Sulfide	HDPE	100
Metals	HDPE	200
Total organic carbon	AG[2]	10
Chlorinated pesticides	AG	30
Chlorinated herbicides	AG	50
Organophosphorus pesticides	AG	50
Semivolatile organics	AG	30
Total petroleum hydrocarbons	AG	10

[1]HDPE = high density polyethylene
[2]AG = amber glass

End

SOP 4.5: Equipment Blank Sample Collection
Revision date: 29 November 1999

An equipment blank sample is a water sample collected by pouring Type I water[1] over appropriately cleaned sediment sampling equipment. The sample is used to measure efficiency of cleaning procedures and as a check against associated cross-contamination of sediment samples among sampling sites. As a rule of thumb for most projects, an equipment blank is collected once per sampling day. Samples are collected as follows:

1. Clean sediment sampling equipment according to protocol contained in SOP 4.1.

2. Pour Type I water over cleaned surfaces of sampling equipment and collect sufficient sample volume in sample container appropriate for analytes of interest (SOP 3.4). If use of a funnel is necessary for transfer of sample, funnel should be of appropriate material and also cleaned according to protocol in SOP 4.1.

3. Properly preserve sample (SOP 3.6) and submit for analysis with field samples.

4. Samples should be labeled with an ID number that is clearly recorded in field notes as an equipment blank.

[1] As defined in Standard Methods for the Examination of Water and Wastewater, 19th Ed.

End

Section 5: Field Instruments

An integral part of sampling on Tulsa District lakes is the use of a variety of instruments for *in-situ* measurement of field parameters. Collection of reliable data with these instruments requires proper maintenance, calibration, and an understanding of efficient operation of the instrument. SOPs for proper use of instruments commonly used on Tulsa District lakes are provided in this section. In addition to these SOPs, manufacturer's manuals for these instruments should be transported with the instrument to the field (in waterproof container) and consulted for operational details not described in these SOPs.

End

SOP 5.1a Calibration of Multiparameter Water Quality Instruments
Revision date: 24 February 2000

Several different brands and configurations of multiparameter water quality instruments are used by the Tulsa District for measurement of field parameters in lakes and streams. Commonly measured water quality parameters using these instruments include water temperature, pH, dissolved oxygen (DO), conductivity, and turbidity. These instruments commonly employ a sonde unit equipped with multiple probes for different parameters, a length of cable connecting the sonde and an output device, and some sort of data output device (display unit, data logger, or laptop computer).

It cannot be overemphasized that collection of reliable, quality data using these instruments is largely dependent upon proper instrument maintenance and accurate calibration. Careful calibration of the instrument prior to each sampling event, documentation of calibration activities, and periodic calibration checks are therefore critical to obtaining reliable field data with these instruments.

Owing to the different brands and possible configurations of multiparameter instruments used by the Tulsa District, it is not possible to list specific calibration steps for each possible combination of components. Rather, the user is referred to the manufacturer's user's manual for details on calibration steps for the specific components to be used. These manuals provide very good detail on calibration steps, maintenance, and other matters pertaining to instrument use. Prior to calibration, the user should ensure that the proper manual for the specific sonde and data output device are available for reference. Manufacturer's calibration procedures should be followed in detail. In addition to adherence to specific calibration procedures, the following guidelines and highlights are provided:

1. Multiparameter instruments should not be used by field sampling personnel until they have been briefed (including calibration demonstration) on instrument use by District personnel familiar with these instruments.

2. Instrument calibration should be performed immediately prior to (generally the day before) each sampling event. Date and time of calibration should be electronically logged by the instrument (if possible) or recorded in project notes. In addition, calibration should be checked at the end of the sampling event and this information likewise recorded. Calibration should be checked during the sampling event if there is reason to believe instrument readings are questionable. There is a place on the field data sheet (SOP 6.1) for recording instrument calibration information.

3. Only reliable, commercially-prepared calibration standards shall be used in instrument calibration. Following use, standards shall always be discarded and never poured back into bottles for re-use. Any documentation (certification numbers, etc) accompanying standards shall be recorded in calibration notes.

4. When dissolved oxygen calibration requires input of barometric pressure, make sure that proper values (e.g. "station pressure" as opposed to values corrected for sea level) and units (e.g. mm of Hg as opposed to inches) are used.

5. When setting up and calibrating instrument for conductivity, units of uS/cm should be used. These are the standard conductivity units to be recorded for District lakes.

6. Depth calibration should always be conducted at the sampling location (lake). The water surface elevation is used as "zero" for depth calibration. This elevation will most likely vary from that at the District office lab or other location removed from the lake.

7. On most instruments, several probes require periodic maintenance (most notably, probes for pH and dissolved oxygen). Maintenance should be in accordance with manufacturer's recommendations.

End

SOP 5.1b Use of Multiparameter Water Quality Instrument for Lake Profiling
Revision date: 24 February 2000

Multiparameter water quality instruments are commonly used in District lakes for measuring depth profiles of a number of water quality parameters. The following procedures should be followed:

1. Ensure that instrument is properly calibrated before each sampling event (SOP 5.1a). Instrument identification information (e.g. model and serial numbers) should be recorded on the field data sheet (SOP 6.1). As a general rule, the same instrument should be used throughout a given study.

2. If depth profiles (not just surface readings) are to be measured, anchor boat and ensure that boat is stationary before beginning profile.

3. As a general rule, depth profiles are measured beginning at a depth of 0.5 m. Readings are then recorded at 1 m depth and progressive readings recorded downward through the water column at 1 m depth increments. The sonde should be slowly lowered through the water column while monitoring depth readings on the instrument. Readings should continue to be recorded until the sonde unit contacts the lake sediments. The last reading to be recorded should be the one prior to sonde contact with the bottom. Readings should not be recorded following sonde contact with lake sediments as sediment disturbance may result in atypical measurements. If the instrument is equipped with a stirring or circulation device for accurate DO measurement, make sure the device is enabled while recording data.

4. Most instruments used by the District have data logging capability. Electronic storage of data has the advantage of minimizing errors associated with manual data recording and entry. Automatic logging of data according to manufacturer's recommendations is therefore preferable to manual data recording. However, as a back-up against loss of electronic data, manual data recording may be also be desirable. The Tulsa District field data sheet (SOP 6.1) has spaces designated for notation of both manual data entry as well as entry of electronic file names.

5. While travelling between sampling sites, sonde units should be stored in a bucket of water or fitted with a cup containing water. This prevents drying out of certain probes.

End

SOP 5.2 Determining Secchi Disk Visibility
Revision date: 29 November 1999

1. The Secchi disk used by the Tulsa District is a 20 cm-diameter weighted disk with the surface painted with opposing black and white quarters. It is attached to a calibrated line which is marked in 10-cm (0.1 meter) increments (black marks) with each meter marked in red.

2. If practical, Secchi disk readings should be taken by the same observer for a given study. At a minimum, Secchi disk readings should be measured by the same observer on any given sampling trip.

3. Secchi disk visibility is measured as follows:
    a. Remove sunglasses and stand to take reading;
    b. With back to the sun, lower disk into water on shaded side of boat until disk disappears. Note this depth in meters, interpolating between 10-cm marks.
    c. Lower disk a little further, then slowly raise it until it reappears. Note this depth in meters, interpolating between 10-cm marks.
    d. The average of these two readings is recorded as Secchi depth visibility (in meters) on field data sheet. (Example format: 1.45 m). Record initials of observer next to the number.

End

SOP 5.3: Field Turbidimeter
Revision date: 30 November 1999

While turbidity in a water sample can be measured in the laboratory, it is sometimes useful to measure turbidity on Tulsa District lakes in the field using a portable, field turbidimeter. Use of this instrument has the advantages of allowing a higher number of turbidity readings without the need for collection and transportation of a large number of water samples. Problems with short laboratory holding times for turbidity (2 days) can also be avoided by field readings.

The following instructions are applicable to use of the Orbeco-Hellige Model 966 Portable Turbidimeter currently in use by the Tulsa District. They are only applicable to this specific instrument. Results are recorded in nephelometric turbidity units (NTUs). Procedure is as follows:

1. Ensure that turbidimeter has fresh batteries (carry an extra set of 4 AA). Low batteries are indicated by "BAT" in the upper left side of display.

2. Confirm calibration prior to reading each sample:
    a. Set meter on 0-200.0 NTU range using switch on upper left of panel.
    b. Wipe outside of zero standard (vial containing black liquid) clean and holding it by its cap, lower it completely into TUBE well, cover with black well cap (labeled as such), and press test button. Meter should read "0.00". If not, adjust zero (described in Step 4 below).
    c. After zero calibration is confirmed (or adjusted), check calibration using 40.0 NTU secondary standard. (Note: Secondary standard is labeled and prepared in a sealed tube using commercial 40.0 NTU primary standard. Standard is stable for approximately one year – replace after this period). Align mark on secondary standard vial with arrow and dot at bottom of TUBE well, cover with black well cap, and push TEST button. Meter should read "40.0". If not, adjust to 40.0 using CAL. knob (described in Step 4 below).

3. Read sample:
    a. Following calibration check described in Step 2 above, fill clean, undamaged (not scratched) vial half way with sample, swirl to mix, and discard water. Next, fill vial to neck avoiding introduction of bubbles and cap tightly.
    b. Holding tube by cap, thoroughly wipe fingerprints and other matter from outside of tube with paper towel or tissue. Thorough cleaning is important. Also make sure tube is wiped free of condensation. Gently swirl to mix (do not shake) and push down completely in TUBE hole. Place black Tube Cover over cap of the tube.
    c. Press the TEST button down for 5-10 seconds until reading is stable and note test result on data sheet. Release TEST button, discard sample, and place red dust cover plug in TUBE hole until meter is used next.

4. Adjusting zero and calibration (if necessary – see Step 1):
    a. Zero is adjusted using ZERO knob on lower left of instrument. The knob consists of an outer lock ring which must be depressed to allow adjustment of the inner, central knob. The central knob is rotated clockwise to increase reading or counterclockwise to decrease reading. Releasing pressure on outer ring locks the setting of the central control knob. Adjust meter to read "0.00" while reading zero standard.
    b. Using 40.0 NTU standard, adjust meter to read 40.0 NTU using CAL. knobs on lower right of instrument. These knobs work identically to ZERO knobs described above.

Note on Standards: Commercially-prepared standards are to be used. In preparing secondary standards for field use, never pour used standard back into the primary standard bottle. Standards are stable for about a year and should be replaced after this time period.

End

SOP 5.4a: Set-up and Configuration of Underwater Radiation Sensor
Revision date: 2 December 1999

This SOP describes physical set-up and configuration of a unit made by Li-Cor, Inc. (Box 4425, Lincoln, Nebraska, 68504, phone 402-467-3576, fax 402-467-2819). This sensitive but versatile device is used to quantify photosynthetically active radiation (PAR) in surface waters of lakes and ponds. This particular unit consists of a spherical quantum sensor (LI-193SA) which looks like a light bulb; a metal lowering frame; a ten-meter data cable, and a datalogger (LI-1000).

1. Prior to use:
   a. Inspect the sensor. It should be protected from scratches, abrasions and harsh chemicals. If it needs to be cleaned, use only water and mild detergents such as dishwashing soap. If it has been stained by hard water deposits, use a vinegar and water solution. NEVER use alcohol, organic solvents, abrasives, or strong detergents. These can easily alter the accuracy of the sensor. When packing the sensor for the field, take special care to prevent abrasion or scratching during long car rides or rough boat trips.
   b. Check line to be used to lower sensor frame. The line should be ten meters long and be calibrated in half meter increments from 0.5 to 9.0 meters with the zero point at the center of the spherical sensor, not the top of the lowering frame. Use a strip of lab tape or other marker to indicate on the lowering frame the 10 cm depth as measured from the middle of the spherical sensor. This 10 cm depth will be the uniform depth to take all "surface" readings with the sensor. This places the sensor just below the water surface.
   c. Pack a spare set of batteries to power the data logger. You will need 6 D cell batteries. They should be high quality alkaline batteries. When there is approximately 10% of battery life left, the word "Lo" is displayed by the datalogger to indicate battery voltage is low.

2. Confirm datalogger configuration and cable connection. The data logger has two channels. Both are programmed identically for our single spherical sensor (serial number – SPQA 1984). Channel one is on the left and channel two on the right. Carefully connect the data cable to either of the channels. Turn the meter on using <FCT – ON> key.
   a. Check the configurations hit <CFG>, the display should read "mode is INST";
   b. Hit <ENTER>, the display should read "ch1 is LIGHT";
   c. Hit <ENTER>, the display should read "range=A";
   d. Hit <ENTER>, the display should read "multi= -261.7";
   e. Hit <ENTER>, the display should read "label=UM";
   f. Hit <ENTER>, the display should read "ave=60";
   g. Hit <ENTER>, the display should read "ch2 is LIGHT";
   h. Hit <ENTER>, the display should read "range=A";
   i. Hit <ENTER>, the display should read "multi= -261.7"

j. Hit <ENTER>, the display should read "label=UM";
k. Hit <ENTER>, the display should read "ave=60"

3. By hitting a sequence of <ENTER> key strokes, you should find Ch3 through M should all be OFF. It will then return you to channel 1.

4. The above will set up the unit as follows:
   a. LIGHT = it will process the data signal as voltage from a light sensor;
   b. Range=A is used to set the range of the measurement for electronics. We use autorange (A) to cover the widest input signal range with the best resolution;
   c. Multi = -261.7 is the factory determined calibration multiplier of this specific radiation sensor when used in water. The calibration multipliers for both air and water are attached to the lowering frame with the sensor;
   d. Label=UM is to remind us that the display units are in umol s^{-1} m^{-2};
   e. Ave=60. This is a signal averaging function which has been set here to display the average light level for the last 60 seconds. Therefore, once the sensor has been lowered to a desired depth it will not begin displaying the average PAR for this depth until 60 seconds have elapsed. This long averaging period is used to increase resolution.

5. Use the <CHAN> key to select the channel you have attached to the sensor. Let's assume channel 1, the datalogger will read "1A#####.##UM". The "1A" in this display indicates channel 1, set on autorange. In high light levels the autorange function omits decimal places. As values get smaller and the ranges shift, it will begin displaying decimal point notation.

6. Confirm the signal response of the sensor by slightly shading the sensor and confirming a drop in detected light intensity. If the meter fails to respond, check your channel selection and the cable connections.

If the configuration is not set as above or the meter fails to respond, consult the Li-Cor instruction manual or the abbreviated instruction set on the back of the datalogger.

End

SOP 5.4b: Use of the Underwater Radiation Sensor
Revision date: 2 December 1999

1. Light readings are best taken at midday on calm, clear sunny days on the sunny side of the boat. Other times and conditions are fine but they generally take more time to get usable readings.

2. Anchor the boat. If the site is unfamiliar, check the water column you will be sampling to check for vegetation or obstructions that could interfere with the sensor or its cable. Determine the depth of water under the boat. NEVER use the sensor and data cable as a sounding or depth-finding device.

3. Secure the calibrated lowering line to the boat at the nine meter mark. Only use the line to raise and lower the sensor on its frame – never use the data cable for this purpose. In addition, avoid any sharp kinks or bends in the data cable.

4. Attach the data cable to the datalogger and reconfirm the calibrations and reaction of the sensor as described earlier in SOP 5.4a.

5. On the **sunny side of the boat**, lower the sensor and frame to 10 cm as marked on the lowering frame. After 60 seconds, assuming the meter readings are stable, record this light level as the surface reading and the time of reading.

6. Lower the sensor to 7 meters or one meter above the bottom, whichever is less. After 60 seconds, assuming the meter readings are stable, record this light level as the 7m (or shallower) reading. Bring the sensor up in one-meter increments and continue to take readings as before. The last three readings should be at one meter, 0.5 meter, and at the surface (10 cm). Record the time of last reading.

7. If clouds interfere in the middle of the profile, note the depths influenced on the data sheet. Then, after taking the second surface reading immediately lower the sensor to the first depth influenced by clouds and record a second light reading for this depth. Again, record the time.

8. Secure and store the sensor and datalogger. The case of the datalogger is weather resistant. However, the sensor and datalogger should not be exposed to direct sunlight for long periods of time. In particular, the datalogger case cannot vent the heat built up during prolonged exposure to sun.

9. Take a Secchi disk reading.

End

SOP 5.4c: Optional Use of a Second Spherical Quantum Sensor (LI-193SA)
Revision date: 2 December 1999

As an optional step to SOP 5.4b, a second sensor may be used as a surface reference during the profile described above. The distinct advantage of this setup is that clouds will not cause as much interference.

In this setup, both sensors are connected to the datalogger – each on its own channel. The second sensor will have a different factory calibration. This new calibration can be entered through the "configure" routine <CFG> described in SOP 5.4a. Look at the new sensor and find the factory calibration numbers attached. Find the number for water. (For our present sensor, serial number SPQA 1984, this number is –276.71). While in the <CFG> you will be prompted with "multi= -276.71". Using the numeric keypad on the datalogger simply enter the water multiplier noted on the new sensor. Do not omit the negative sign. Now the datalogger is set up with each sensor configured for only one channel. This must be carefully noted each time the setup is used.

1. Follow the same setup as described in SOP 5.4a and 5.4b.

2. On the **sunny side of the boat**, lower both sensors to 10 cm (or surface readings). After 60 seconds, assuming the meter readings are stable, record both light levels as the surface reading and the time of the reading.

3. Next lower one of the sensors to 0.5 m while the second remains at the surface (10 cm). After 60 seconds, assuming meter readings are stable, record both depths and light levels. Again record the time.

4. Continue as in #3 above, with one sensor remaining at 10 cm while the second is lowered to 1, 2, 3, 4, 5, 6, and 7 meters or one meter above the bottom, whichever is less.

5. If cloud cover changes, note it on the data sheet but there is no need to take additional, repeated measurements.

6. Secure and store the sensor and datalogger as descibed in SOP 5.4b.

7. Take a Secchi disk depth measurement.

End

SOP 5.5: Use of Hand-held GPS Receiver
Revision date: 6 December 1999

Location information for lake water quality sampling sites is frequently obtained by use of a global positioning system (GPS) receiver. This device permits initial storage of locational information for sampling sites and aids in navigation to these sites for subsequent sampling events.

This SOP provides limited information for use of the Trimble SCOUT^{M+} hand-held receiver, manufactured by Trimble Navigation Limited, 645 North Mary Avenue, Sunnyvale, CA 94088-3642, 1-800-827-8000. Instructions are limited solely to this instrument. The SOP provides the minimum information necessary for basic use of the instrument to store sampling site location information and use the receiver to navigate back to stored sites. For more advanced instructions beyond these basic uses, consult the user's guide supplied with the instrument. The user's guide should always accompany the receiver to the field. A quick reference card describing basic functions and keys is also packed in the instrument case and can be consulted for key functions.

1. Power on instrument by pressing bottom button (one with vertical bar). When in use, the receiver should be positioned such that the antenna (under the Trimble sextant logo) is parallel to the horizon with an unobstructed view of the sky.

2. Check battery condition by pressing and holding same button again and reading remaining battery time (hours) at bottom right corner of screen (do not hold for more than 4 seconds, or unit will shut off). Four AA batteries should be carried as spares. A "batteries low" message will appear if batteries need replacement. If receiver is left without batteries for more than 30 minutes, all memory may be lost. Therefore, if batteries are removed, replace them immediately.

3. Allow unit to obtain "fix" on a minimum of 4 satellites. Initially, this may take up to 15 to 20 minutes (but may be less). Number of satellites obtained scrolls across the top of the screen and is shown by small icons on bottom left corner of screen. Until a proper fix is obtained, the display alternates with: "-Old Position-". Make sure that fix on minimum of 4 satellites is obtained before further use of receiver. When fix is obtained, unit will be in GPS mode and constantly display current location information.

4. Typically, we will use Universal Transverse Mercator (UTM) coordinates which should be noted by "UTM" on left end of second line of display (we also use NAD83 as a mapping datum). The units should be preset to these conditions. If not, consult

user's guide for instructions for resetting to these values. An example GPS-mode screen for the unit should look like this:

5 satellites
UTM 15 242338
S 4003267
190m

The top line indicates that 5 satellites are being used. The bottom line is elevation (meters) which we normally will not need to record for lake work (we have more accurate record of surface elevation). The middle two lines are coordinate data which should be recorded, in this case, as: Zone 15 242338E 4003267N.

5. To store location information for a sampling site ("waypoint") for future reference:
   a. When at site, press upper left button (dot surrounded by circle). Unit will read: "Stored in Memory" beneath which will be a number. This waypoint will be stored as "FIX#####" where # is the number assigned above.
   b. To give this waypoint a more meaningful name (e.g. Birch4), do the following:
      1. press right arrow once to get "memory" screens, next press diamond (middle) button, then use up or down arrow to get "rename waypoint";
      2. press upper right button (enter);
      3. use right arrow button to place cursor directly under the "*" (press 14 times). Then press up arrow key to erase old name. Now press right arrow key once more to get back at start of name;
      4. enter new name using up and down arrow keys to toggle through alphabet, numbers, etc for each position. Use right and left arrow keys to move to next position. When name is as desired, press upper right key (enter). New name is saved as waypoint and unit returns to location data. Now press left arrow button once to return to GPS screen (current position).

6. To use unit to navigate to a stored waypoint (i.e. sampling site), do the following:
   a. Press right arrow twice to get to navigation screens;
   b. Press diamond (middle) button once;
   c. Press up arrow until "set goal" is displayed, then press upper right button;
   d. Use up / down arrow keys to scroll to desired site, then press upper right button;
   e. Press diamond (middle) button to return to navigation screens;
   f. Follow information on navigation screens to navigate to site.

7. To turn off unit, press bottom key, hold it down, and press down arrow key.

End

SOP 5.6: Use of Boat-mounted GPS / Sonar Unit
Revision date: 7 December 1999

Location information for lake water quality sampling sites is frequently obtained by use of a global positioning system (GPS) receiver. This device permits initial storage of locational information for sampling sites and aids in navigation to these sites for subsequent sampling events. When available, a boat-mounted GPS unit can be used in the place of a hand-held unit. This SOP describes basic use of such an instrument.

The SOP provides limited information for use of the GLOBALMAP 2000™ Sonar and GPS unit manufactured by Lowrance Electronics, Inc., 12000 E. Skelly Dr., Tulsa, OK 74128, 1-800-324-1356. Instructions are limited solely to this instrument which is currently in use by the Tulsa District. The SOP provides the minimum information necessary for basic use of the instrument to store sampling site location information, use the receiver to navigate back to stored sites, and use the unit as a basic water depth indicator. For more advanced instructions beyond these basic uses, consult the user's guide (which should be taken to field) supplied with the instrument.

1. Ensure that the unit is properly installed in the boat according to the manufacturer's instructions (see instruction booklet). Installation should include the Maplink™ cartridge reader, a cartridge adapter, and the appropriate SmartMap™ cartridge for the lake of interest.

2. Power the unit by pressing "on" key at lower right hand corner of display screen. Pressing this button again will turn on key and display lights. The unit will display a map of the lake with your current position shown as a circle with a cross on the screen. As you travel, the circle showing your present position moves on the lake map and a line trace shows the path you've taken. Also present are location coordinates (LAT / LONG) at bottom of screen as well as bearing, speed, and time information to the right of the map screen. **Important note: Any flashing information displayed on the unit is invalid (due to lost position data, malfunction, etc.). Do not use this information or navigate with unit until problem is resolved.**

3. To display sonar water depth information:
    a. Press MAP key twice. A "split-screen" map and sonar display will appear. On the sonar screen, depth (m) is shown in top left corner. Press MAP key again to return unit back to original mapping display. (Note: See p. 57 of user's manual to change depth units to meters if readings are in feet)
    b. To display full-screen sonar information only, press the SONAR key. The unit is in the automatic mode and sonar data will scroll from right to left. Range and sensitivity levels will automatically change as required. See user's manual for sonar display options. Pressing MAP key will return display to map and location information.

4. To save sampling site location (create a "waypoint") using QUICKSAVE:
    a. Present position can be saved as a waypoint simply by pressing the WAYPT QUICKSAVE key (next to bottom key on left of unit).
    b. This option does not allow you to select the waypoint number. A more useful option is described in (5) below.

5. To save sampling site location and enter additional information for waypoint:
    a. Press WAYPT/ROUTE key – a new screen will appear
    b. Press the key next to "Waypoints" label – a new screen showing saved waypoints will appear
    c. Use the down arrow key (below numeric keypad) to highlight first "empty" waypoint number
    d. Press the key next to "Save Present" label – a new screen will appear with a question mark flashing in the "Name" field
    e. Use instructions on this screen to enter a meaningful name (e.g. "Kaw6") – when name is as desired, press ENT key
    f. If you wish to use a symbol for the waypoint, press down arrow key to the "Symbol" location. Follow instructions on screen to assign symbol.
    g. Once everything on screen is correct, press the ENT key. Unit returns to mapping screen. If waypoint is in map location, a box (or symbol) appears on screen with the waypoint's number beneath it.

6. To set navigation alarm to indicate arrival at waypoint (if not already set):
    a. Press MENU key, then press key next to "Navigation Alarms" label
    b. Check to see if "On" is checked next to "Arrival Alarm" label. If not, press key next to this label to check "On" box
    c. Check distance in "Arrival Radius" label. If not 0.01 mi, press button next to this label and enter 0 0 1 using numeric keypad. Press ENT key.
    d. Press CLR key to exit screen.

7. To navigate to a waypoint:
    a. Press WAYPT / ROUTE key. Then, press the key next to "Waypoints" label
    b. Highlight the desired waypoint using up or down arrow keys
    c. Press key next to "Go to Waypt" label
    d. Unit will return to mapping screen. Your position is indicated by a "S" with a box around it. A dotted line extends from this box to the recalled waypoint. This line is the shortest path to the waypoint. Steer the boat along this line or use other displayed navigational data to arrive at waypoint.
    e. Slow boat when approaching waypoint. Alarm will sound at preset arrival distance (0.01 miles) from waypoint.

End

Section 6: Field Notes, Data Recording, and Sample Documentation

An integral part of data collection on Tulsa District lakes is accurate, consistent, and legible recording of field data and specific information regarding sample collection. In addition, a traceable history of sample custody through sampling, transport, and analysis activities is essential for collection of quality, defensible data. In general, sampling activity documentation and data recording should be conducted in such a way that someone not familiar with the sampling event can clearly reconstruct what was done, how it was accomplished, and what resulting field data are using only data sheets, field notes, and written sample documentation. This section contains SOPs specific to recording of field data, field notes, and chain-of-custody procedures.

SOP 6.1: Field Data Sheets
Revision date: 03 January 2000

Field data including sampling site information, weather observations, data for field measurements, and information regarding samples collected on Tulsa District lakes will be collected in a consistent manner using a standardized form. Procedure is as follows:

1. A standardized form will be used for recording data. This form is attached to this SOP. It should be noted that this form is two-sided (information on front and back) to alleviate potential problems with segregation of multiple pages for a site. The form attached to this SOP is printed on two pages for ease of copying the entire SOP document, but the form to be used in the field should be two-sided. For protection from elements, forms should be carried in the field in a weatherproof binder (e.g. enclosed data clipboard).

2. All forms should be completed using waterproof ink only. Pencil is not acceptable.

3. All spaces for information will be filled in with appropriate data. Where data are not available or not being collected, place "N/A" (not applicable) in the corresponding space.

4. "Primary Station Code" refers to STORET station code (if established). Numbers next to some of the parameters are STORET parameter codes.

5. If a field instrument is calibrated (or calibration checked) at a site, record this information in the appropriate space on the form.

6. If a mistake is made in data entry, a single line should be drawn through the error and this correction initialed by the recording individual. The correct value can then be recorded.

7. Immediately upon return to the District office, a photocopy of the form should be made and placed in a separate location from the original. The original should never be discarded, regardless of condition.

End

PRIMARY STATION CODE: _____

FIELD MEASUREMENTS OF WATER QUALITY PARAMETERS
U.S. ARMY CORPS OF ENGINEERS
TULSA DISTRICT

PROJECT: _____ DATE: ___/___/2000 TIME: _____
STATION: _____
WATER DEPTH: ____m GPS COORDINATES: _____ GPS UNIT: _____
INSTRUMENT TYPE: _____ INSTRUMENT ID: _____
CLOUD COVER (circle): Clear Partly Cloudy Overcast Rain Fog
SECCHI (78) ____m TURBIDITY (NTU) (82078) 0.5m _____ ___.__ m _____
TDS (mg/l): 0.5m_____ ___.__m _____ ___.__m _____ COLLECTED BY: _____

DEPTH (m f)	TEMP (10) (c f)	DO (299) (mg/l)	pH (400) (su)	COND (94) (uS/cm)
.5				
1				
2				
3				
4				
5				
6				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
5				
26				
27				

PROFILE DATA STORED ELECTRONICALLY? _____ FILENAME: _____

WATER SAMPLES COLLECTED:

ID	DEPTH(m)	PARAMETERS

SEDIMENT SAMPLES COLLECTED:

ID	DEPTH(cm)	PARAMETERS

ZOOPLANKTON SAMPLE? _____ NO. OF TOWS: _____ TOW DEPTH: _____

LIGHT READINGS:

INSTRUMENT ID: _____

DEPTH (m)	***umol $s^{-1}m^{-2}$***
0.1	
7.0	
6.0	
5.0	
4.0	
3.0	
2.0	
1.0	
0.5	
0.1	

STRUMENT CALIBRATION DATA:

SOP 6.2: Field Logbook
Revision date: 03 January 2000

Most field data for lake water quality sampling events can be recorded on field data sheets (see SOP 6.1). However, it may sometimes be necessary to record additional sampling information in the field. In this case, a field logbook dedicated to the project should be used. This SOP describes use of the field logbook for sampling on Tulsa District Lakes.

1. The logbook should consist of a bound book with pages of waterproof paper. For major projects, a specific logbook should be dedicated solely to the project and multiple books for the same project should be avoided. The book should be labeled on the face and spine as to the associated sampling project.

2. If pages are not pre-numbered, the individual recording observations should number pages sequentially as information is entered. If multiple books are required (i.e. the initial book becomes full of information), books should be labeled as "Book __ of __".

3. All entries to the logbook should be made with waterproof ink. Pencil is not acceptable.

4. If a mistake is made in data entry, a single line should be drawn through the error and initialed by the recording individual. The correct information can then be entered.

5. Immediately upon return to the District office, a photocopy of all pages pertaining to the most recent sampling event should be made and placed in a separate location from the logbook. The logbook should be maintained by the employee in charge of the project. Upon project completion, the logbook should be placed in the project file in the District office water quality file cabinet.

End

SOP 6.3: Chain-of-Custody Procedures
Revision date: 03 January 2000

Chain-of-custody (COC) procedures as described in this SOP will be followed for all samples collected on District lakes by Tulsa District employees. These procedures permit documentation of sample possession from collection to analysis.

1. Standardized chain-of-custody forms will be used for all samples. This form is attached to this SOP.

2. All COC forms should be completed using blue or black waterproof ink only. Pencil is not acceptable.

3. All spaces will be filled in with appropriate information. If a space calls for information that is not applicable, place "N/A" in the space rather than leave it blank. If sample numbers are not sufficient to fill up all sample lines on a form, vertical lines should be drawn in all spaces below information for the last sample such that no more samples can be entered.

4. Note multiple pages in the appropriate location at top right corner of form.

5. Upon transfer of samples to another party (e.g. analytical lab), both parties should sign in appropriate location at bottom of form. This should be repeated for each transfer of sample custody. The original copy of the form should remain with the samples, but individual relinquishing the sample should obtain a photocopy of form signed by receiving party. The original COC form should be a part of the data results package received from the analytical laboratory.

6. Check to make sure that all sample information on COC is consistent with field notes and field data sheets.

7. If a mistake is made on the form, a single line should be drawn through the error and this correction initialed by the recording individual. The correct information can then be entered. Regardless of condition, the original COC form should never be discarded.

8. Field samplers are personally responsible for care and custody of all samples until they are transferred to another party (e.g. laboratory). Custody should be maintained by keeping samples in the sampler's possession, keeping samples in view of the sampler after collection, or storage of samples in a secure, locked area to prevent tampering.

9. "Remarks" section should be used to record information on sample preservatives or other sample-specific information (e.g. sample filtration).

End

US Army Corps of Engineers®
Tulsa District

CLIENT CONTACT	PHONE NUMBER
P.O. NUMBER	PROJECT NAME

SAMPLE CHAIN OF CUSTODY RECORD

PLANNING ENVIRONMENTAL AND REGULATORY DIVISION
CESWT-PE-E
TULSA, OKLAHOMA
OFFICE: 918.669.7659/4395 FAX: 918.669.7546

SAMPLER (SIGNATURE)

SAMPLE ID	DATE	TIME	COMP	GRAB	LOCATION	MATRIX	# OF BTLS	ANALYTICAL PARAMETERS	REMARKS

RELINQUISHED BY: (SIGNATURE)	DATE	TIME	RECEIVED BY: (SIGNATURE)

RELINQUISHED BY: (SIGNATURE)	DATE	TIME	RECEIVED BY: (SIGNATURE)

RELINQUISHED BY: (SIGNATURE)	DATE	TIME	RECEIVED BY: (SIGNATURE)

RELINQUISHED BY: (SIGNATURE)	DATE	TIME	RECEIVED BY: (SIGNATURE)

Section 7: Field Safety

Safety is an important element of sampling on Tulsa District lakes. Collection of water samples from a sampling boat involves a number of activities with potential for personal injury. Application of good safety practices will minimize accidents and ensure protection and well-being of all sampling personnel.

This SOP section is not intended as a comprehensive safety manual for all field activities. Project-specific safety plans (if applicable) and the Tulsa District safety office should be consulted for overall safety specifics. Rather, these SOPs highlight a few key areas specific to lake sampling where good safety practices can avoid injury or endangerment to sampling personnel. As always, good common sense is the first prerequisite to safe sampling practices.

End

SOP 7.3: Weather Considerations
Revision date: 04 January 2000

Many of the potential hazards associated with water quality sampling on lakes involve adverse weather conditions. Sampling personnel should therefore be mindful of current weather conditions, weather forecasts, and lake-specific impacts of current or predicted meteorological conditions (e.g. susceptibility of a particular lake to wind and wave action).

It cannot be stressed enough that no amount of data collection is worth endangering the health and safety of sampling personnel owing to weather-related dangers. A general rule of thumb should always be that if weather conditions are such that sampling personnel question the safety of sampling, the event should be put off until weather conditions improve. Rescheduling should be coordinated with all involved personnel. The following are a few key highlights regarding weather-related considerations associated with lake sampling:

1. Excessive wind speeds often result in unsafe wave conditions on Tulsa District lakes. High winds and resulting wave action result in unstable working conditions and increase the chances of injury during boat operation and/or sampling. As each lake is affected differently by wind speed and direction, samplers should use their own cautious judgement as to safety concerns resulting from wind impacts. Excessive wave action may be cause for delayed sampling.

2. Severe danger in lake sampling is associated with lightning. Lightning over open water is a condition that should be taken very seriously and sampling should be immediately canceled during such conditions. When lightning is observed or threatens during a sampling event, sampling personnel will immediately get off the water and delay sampling until such dangers are clearly no longer present.

3. Rainfall poses particular hazards for lake sampling. Sampling should therefore be generally avoided during these periods. In addition, high inflow events on Tulsa District lakes often result in excessive floating debris which increases the potential for boating-related accidents.

4. Sampling will be avoided during icy conditions. Ice-related hazards are many and will be avoided by cancellation of sampling during such times.

5. Water quality sampling in the Tulsa District is often conducted under conditions of extreme heat and humidity. Samplers should always drink plenty of cool liquids, use adequate suncreen, and be mindful of physical symptoms of heat-related problems. Personnel exhibiting signs of heat-related illness should immediately cease sampling and be removed from the heat.

End

Appendix G

TULSA DISTRICT (SWT) COMMUNICATIONS PLAN
Blue-green algae warnings and advisories in Tulsa District Lakes

PURPOSE: This plan will be used to assist SWT in carrying out an effective communication strategy regarding blue-green algae blooms at Tulsa District lakes in Oklahoma and Texas. SWT will utilize the KDHE communication strategy for Kansas lakes and will assist KDHE communicate information to the public.

SITUATION: High levels of blue-green algae were discovered in several Corps-managed lakes in Oklahoma in 2011. These lakes were Fort Gibson, Tenkiller, Eufaula, Keystone, Skiatook, Waurika, and Lake Texoma. Because of the potential risks to public safety, the Tulsa District issued advisories and warnings discouraging or prohibiting water contact at these reservoirs. At some lakes, certain areas and swim beaches were closed completely. Although blue-green algae is present in all lakes and high levels have been discovered in the past in Tulsa District lakes, there has not been an outbreak in as many lakes at the same time as in 2011, likely due to the unusually hot, dry summer. The impacts to recreation and businesses at these lakes caused a high level of public and media interest. Based on historical data, this is likely an event that will occur again.

COMMUNICATIONS OBJECTIVES:

1. Communicate the BGA policy and execution plan with appropriate internal audiences to make them informed, effective force multipliers. (Command Information)

2. Coordinate with appropriate congressional offices and local elected officials. (Congressional Liaison, Mike Abate)

3. Communicate with business owners around affected lake. (Stakeholder Relationship Manager, Lori Hunninghake)

4. Communicate any advisories or warnings with the general public through the mass media, website, phone system, and social media. (Public Information)

5. Communicate consistently and concisely across communication platforms.

ISSUES:

1. Loss of revenue and substantial impact to businesses.

2. Impact to recreation.

3. Corps of Engineers testing methods: cell densities vs. toxin levels.

POTENTIAL STAKEHOLDERS:

1. Congressional delegation and elected officials

2. Business owners around the lakes

3. Federal and state agencies

4. Concerned members of the public

NOTIFICATIONS:

1. Congressional (e-mail or phone)

2. Business owners

3. Federal and state agencies

4. Public notification

5. News Release to local media outlets

COMMUNICATION ROLLOUT:

Planning and Environmental Division (PE) and Operations Division (OD-NR) are the team leaders for communications of the blue-green algae issue. PE will ensure that the actions detailed below take place. Spokespersons will include Planning, Operations (OD-NR), and PAO employees as well as all OD personnel who communicate with the public. All potential spokespersons will familiarize themselves with the policy, key messages, talking points, and Q&As.

Once plan is approved/finalized

What?	How?	Who?	When?
Prepare OD field office staffs	Ops meetings	Lake Managers	T-
Educate General Workforce	Team Page	PAO	T-
Educate business owners	Fact sheets	PAO/Lake Managers	T-

Once advisory/warning issued

Notify Congressional offices (Federal and state)	Phone/e-mail	Congressional Liaison (Mike Abate)	Target
Notify federal and state agencies	Phone/ e-mail	Stakeholder relationship manager (Lori Hunninghake)	T
Inform Business Owners	Phone/e-mail	Lake Managers	T
Inform General Public	Automated phone message	Lake Managers	T
Inform General Public	News Release & Social Media	PAO	T
Inform General Public	Presentations to Community Groups	Lake managers	T+

TACTICS

1. Once policy is approved and finalized

    A. Inform potential spokespersons and OD field staffs

    B. Create awareness of policy internally through teampage and Pacesetter articles.

    C. Create fact sheets about policy and distribute to local businesses around lakes.

    D. Lake managers and staff should brief stakeholder of policy through presentations to community groups, phone calls to local leaders, etc.

    E. News release regarding policy sent to media outlets and posted to social media sites.

F. Create blue-green algae webpage on external website with fact sheets about policy.***Once web migration occurs***

2. Once an advisory/warning is issued.

A. Congressional offices should be notified for any advisory or warnings or updates/end to the advisories and warnings, by congressional liaison.

B. Businesses should be notified by lake staff.

C. The automated phone system will be updated with an option for blue-green algae report at the local lake if applicable. A phone number similar to the lake conditions number shall be created and updated with an automated message with any BGA advisories and warnings.

D. A news release will be sent to local media and posted on social media sites for the initial notification, for any updates and at the end of the advisories and warnings.

E. The blue-green algae page on the district website will be updated with the locations and data from all test sites including an interpretation of the data.

F. District and lake office staff will coordinate through the District Public Affairs Office, response to any speaker requests regarding blue-green algae.

G. All messaging and external communications documents both print, broadcast or web will be written and/or approved by public affairs prior to distribution.

KEY MESSAGES:

1. We want to provide the safest possible recreation opportunities to the public.

2. Blue-green algae are present in all lakes, but during certain conditions can become concentrated at levels which can cause adverse health effects to people and pets.

3. Some but not all blue-green algae blooms produce nerve and liver toxins, which are extremely dangerous, but most produce skin toxins which may cause rash, nausea, diarrhea, vomiting, upper respiratory symptoms, and other flu-like symptoms.

4. Children, pets, and individuals susceptible to illness or rash are most likely to be affected by blue-green algae.

5. Our goal is to provide as much information as possible so that individuals can make the best possible decision for themselves and their families.

6. Reservoirs with advisories or warnings are NOT closed. Boating and swimming are still permitted and businesses are still open. Visitors are encouraged to enjoy the lake, but be aware of the potential risk associated with primary body contact with the water.

TALKING POINTS:

1. This is not a new occurrence in the Tulsa District. There have been reported algal blooms in several Tulsa District reservoirs in the past including R.S. Kerr Reservoir and Lake Texoma in Oklahoma and Marion Reservoir in Kansas. In 2011, it was an unusual summer because of the amount of reservoirs affected and the severity of those blooms.

2. Recent research has helped scientists to better understand the health risks associated with blue-green algae. Prior to this research not much was known. In 2003, the World Health Organization established the guidelines for safe levels of BGA in recreational waters. These guidelines are widely accepted as the testing guidelines for determining acceptable levels in recreational waters such as the reservoirs managed by the Tulsa District.

3. The WHO guidelines are based on cell counts. While there are tests available that examine the amount of toxins produced, there aren’t any widely accepted guidelines that establish safe levels of toxins for recreational waters. In addition, tests can measure liver and nerve toxins but tests that measure levels of skin toxins, which most BGA produce, are limited.

4. We will post all data from all sample locations on our website after a blue-green algae bloom has been confirmed. We intend to provide as much information as available so that visitors can make an informed decision about recreating at a reservoir affected by BGA.

QUESTIONS AND ANSWERS:

Q1. What are blue-green algae and why should I be concerned?
A1: Blue-green algae are a type of bacteria present in all lakes, but during certain conditions can become concentrated at levels which can cause adverse health effects to people and pets. Some but not all blue-green algae blooms produce nerve and liver toxins, which are extremely dangerous, but most produce skin toxins which can cause rash, nausea, diarrhea, vomiting, upper respiratory symptoms, and other flu-like symptoms. Individuals recreating at reservoirs with elevated BGA levels should take precautions to minimize their exposure to high levels of BGA and be aware of the levels present so they can make informed decisions.

Q2: What does an advisory mean? What does a warning mean?
A2: Based on the World Health Organization's BGA guidelines for recreational waters, once cell counts exceed 20,000 cells per milliliter of water, the entire lake is placed under a blue-green algae awareness level advisory. Under an advisory there is an elevated risk of adverse health effects from blue-green algae. Once cell counts exceed 100,000 cells per milliliter of water, that specific area is placed under a blue-green algae awareness level warning. Under an advisory there is a high possibility of adverse health effects from BGA in that particular area.

Under both advisories and warning awareness levels, the Corps of Engineers advises that children and pets are more likely to get sick because of blue-green algae. We recommend using caution when swimming, water skiing and coming into contact with the water and keep pets and livestock off the beach and out of the water. We also advise to avoid areas with visible algae accumulation and do not drink untreated lake water.

Q3: Why is the Corps of Engineers testing for blue-green algae now but haven't in the past?
A3: Blue-green algae have been around for millions of years, but scientific research on the effects of BGA is relatively new. In fact, the World Health Organization's guidelines were only created in 2003. We have tested for BGA in several reservoirs in our district in past years, however, the extreme heat and dry conditions seen in summ23 2011 combined with nutrients coming

into the lake from stream run-off caused algal blooms in several reservoirs simultaneously. During this time, the public became more vigilant of blue-green algae which led to more reported blooms and further testing.

Q4: How does the Corps of Engineers determine which lakes to test?
A4: Typically, we rely on reports from members of the public or lake staff. Once we receive a report of a possible blue-green algae bloom, project staff collect samples for analysis. Once results are received, a determination is made based on the World Health Organization's guidelines as to whether an advisory or warning is needed.

Q5: The World Health Organization's guidelines are based on cell counts not toxin levels. Aren't the toxins what should matter?
A5: Though there are tests for liver and nerve toxin production, currently tests for skin toxins, which all types of BGA are considered to produce, are limited. These skin toxins can cause rash, upper respiratory illness, gastrointestinal illness and other flu-like symptoms. These can especially impact people with existing health issues, children, and pets.

The Corps of Engineers strives to provide the safest possible recreational opportunities and it is our due diligence to let the public know of ANY potential effects of BGA. We will continue to rely on cell counts and WHO guidelines in the absence of approved BGA response plans by the State of Oklahoma and the State of Texas.

Q6: The Grayson County Health Department says the water is fine. Why should I listen to the Corps of Engineers?
A6: In the absence of approved response plans by the state of Oklahoma and the State of Texas to inform the public of potential risks associated with recreating in lakes affected by harmful algal blooms, the Tulsa District has relied upon the guidelines established in 2003 by the World Health Organization.

We use the World Health Organization's guidelines, which are based on cell counts per milliliter of water. These guidelines were created for recreational waters, which include Texoma and other Corps' lakes in the Tulsa District.

Grayson County tests for liver and nerve toxin production, however, currently tests for skin toxins, which all types of BGA are considered to produce, are limited. these skin toxins can cause rash, upper respiratory illness, gastrointestinal illness

and other flu-like symptoms. These can especially impact people with pre-existing health issues, children and pets.

The Corps of Engineers strives to provide the safest possible recreational opportunities and it is our due diligence to let the public know of ANY potential effects of BGA so that they can make the best decision for themselves and their family.

Q7: Is the Corps of Engineers intentionally trying to destroy businesses?
A7: Public safety is a top priority for the Corps of Engineers. While we understand that advisories and warnings may have negative impacts to businesses, it is our due diligence to let the public know of ANY potential risks from BGA so that members of the public can make the best decisions for themselves and their family.

Q8: Why do the warnings say that water contact is prohibited? Will I get fined if I go into a warning area?
A8: The Corps of Engineers has never actively enforced a water contact prohibition, which was never the intent of the wording. We have changed the warning language from water contact is prohibited to elevated possibility of adverse health effects. We have also changed the wording of an advisory from water contact is discouraged to low possibility of adverse health effects. These adjustments are intended to effectively clarify the intent of the notices. These notices are designed to inform the public of the risks of BGA and allow them to make informed decisions about recreating at lakes with blue-green algae blooms.

Q9: What does it take for blue-green algae to go away?
A9: There are many factors that influence the blue-green algae levels. Hot, dry conditions are just one factor. Other factors include lower lake levels, lack of inflow, and nutrients in the water from stream runoff. One or more of these factors can impact the levels of blue-green algae present at any time.

Q10: How often does the Corps test?
A10: Once a blue-green algae bloom is confirmed, we test on a 30-day cycle.

A11: Where can I find updated information?
A11: We distribute information on our website, www.swt.usace.army.mil, our facebook account, www.facebook.com/usacetulsa, and through the local news media as well as our project offices at each lake.