Lake Erie Harmful Algal Bloom Monitoring and Response Strategy for Recreational Waters

Pennsylvania Department of Environmental Protection
Office of the Great Lakes
Pennsylvania Department of Conservation and Natural Resources
Presque Isle State Park
Erie County Department of Health

Photo courtesy of Anna McCartney, Pennsylvania Sea Grant

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1. INTRODUCTION

1.1 Background

1.1.1 Cyanobacteria

Cyanobacteria, commonly known as blue-green algae, can produce a variety of toxins that can cause illness and death in humans and animals. These cyanotoxins include liver toxins, nerve toxins, and skin toxins. Some of the more common cyanotoxins found in Pennsylvania waters include microcystins, cylindrospermopsin, saxitoxin and anatoxin-a. Cyanotoxins can be found within cells or in the water. Toxin production is strain specific, and many of these organisms can produce one or several different types of toxins. These toxins are colorless and persist in the water. Toxins may be degraded by bacterial action and sunlight over time.

In addition to toxin production, cyanobacteria can cause other problems in recreational waters. Large cyanobacteria blooms can cause decreased dissolved oxygen concentrations resulting in fish kills. Many cyanobacteria also produce taste and odor compounds that affect the taste of drinking water derived from surface waters and fish. The foul smell produced by some cyanobacteria is a nuisance to those living around or recreating on the water.

1.1.2 Cyanobacterial Blooms

Cyanobacterial blooms vary in species composition and toxin production over time and within a water body. The distributions of cyanobacteria populations are affected by weather and lake conditions, hydrology and morphology. They may be distributed evenly throughout a lake, or may be irregularly distributed because of currents and/or prevailing winds. Hydrologic changes from heavy rains, or the discharge from a stream resulting in "localized" currents, can significantly affect cyanobacteria population distributions. Areas like shallow bays, coves, sites directly affected by nutrient-rich inflows, or structures that affect flow (e.g., dikes, piers, or intake towers) can significantly affect population growth rates and cyanobacteria distribution.

Cyanobacteria may maintain a position at a particular depth, or may be found throughout the photic zone (e.g. *Planktothrix,Cylindospermopsis*). Cyanobacteria may migrate vertically to different locations in the photic zone throughout the day. Surface accumulations (scum) may develop when cyanobacteria float to the surface during calm, sunny weather and may dissipate

within hours as conditions change. Entire cyanobacteria populations may accumulate at 1 or 2 cm below the water surface. Surface accumulations of cyanobacteria may concentrate further when blown by wind to leeward areas like bays, inlets, or near-shore areas (with the direction of the wind). Dense accumulations may extend from the surface to depths more than 1 m.

Not all cyanobacteria blooms result in cyanotoxin production. The specific mechanism and conditions necessary for toxin production are not yet fully understood. When a cyanobacteria bloom produces toxin levels that have potential to harm humans or animals, the episode is referred to as a harmful algal bloom, or HAB.

1.1.3 Rationale for Strategy Development

HABs are not rare or unique; they are prolific and predictable in the western basin of Lake Erie and other inland lakes. Ohio government officials became aware of HAB development in Ohio's lakes in 2007 when the Ohio EPA participated in the Nation Lakes Survey. This survey included sampling for the cyanotoxin, microcystin, and showed that more than 36% of the randomly selected 19 Ohio lakes sampled had detectable levels of microcystin, which was higher than the national average. Although not commonly seen in the central basin of Lake Erie, in 2013 a HAB was documented in Presque Isle Bay. A sample collected from Presque Isle Bay during the episode exceeded 50 ppb microcystin. Significant cyanobacteria blooms, but not confirmed HABs, have also been observed on inland lakes in northwestern Pennsylvania, including: Edinboro Lake in 2008, Tionesta Lake in 2012, and the Allegheny Reservoir in 2012 and 2013.

HABs near and around Presque Isle State Park with its 11 public beaches and multiple public access areas to Lake Erie, and elsewhere throughout Lake Erie, pose a risk to recreational water users and their pets. With the onset of the 2013 HAB in Presque Isle Bay a task force was formed to explore efforts being done to monitor HABs and what level of restriction and/or public advisory should be taken in the event of a HAB to minimize exposure risks and potential health effects. These questions were of immediate concern for Presque Isle State Park officials to ensure the safety of its approximately 4 million users per year. HABs are also a concern for other Lake Erie and Presque Isle Bay waters users, among others, public water suppliers, public and private beachgoers, boaters and watercraft users, sportsmen, marina operators, employees working in water environments, and individuals and their pets who come into contact with the water.

1.2 Purpose, Focus and Coordination

1.2.1 Purpose

The task force was not aware of a Pennsylvania response strategy for HABs and identified a need for Lake Erie waters. The task force researched literature and reviewed HAB response strategies for other Great Lakes. From this information the task force determined its strategy must include:

- studying environmental conditions that promote HAB episodes for predictive purposes;

- monitoring to determine HAB formation and the presence of toxins in surface waters;
- trigger levels for public advisory and restrictive use; and
- public outreach and awareness on how to recognize HABs and the hazards.

The purpose of Lake Erie Harmful Algal Bloom Monitoring and Response Strategy is to provide a unified approach to identifying and addressing HABs in Lake Erie waters to protect people from cyanotoxins. The strategy is designed to monitor environmental conditions to predict HAB formation, sample for toxin levels in public recreational waters, use sample results to make advisory decisions, and inform the public and water resource managers on how to recognize a HAB and the associated hazards.

1.2.2 Focus

The focus of the Lake Erie Harmful Algal Bloom Monitoring and Response Strategy is on public recreational waters and water access locations on and around Presque Isle State Park. These park facilities are state managed and ensuring the health and safety of the park users is a top priority. These same principles and practices; however, can also be applied to other public beaches or state managed facilities, and privately managed facilities in or around Presque Isle Bay, Lake Erie and other inland lakes.

Although private ponds and waters sources used for livestock watering are not a focus of this strategy, HABs can pose a risk to agricultural operations. Agricultural operators should also be aware of the dangers of HABs and how to manage their operation to mitigate threats to livestock.

1.2.3 Coordination

A coordinated effort is necessary to monitor environmental conditions that support HAB formation, confirm a HAB episode, advise the public of the hazards associated with HABs and respond to HAB related illness. The primary agencies with the responsibility to carry out these actions include the Pennsylvania Department of Environmental Protection, the Pennsylvania Department of Conservation and Natural Resources and the Erie County Department of Health. The work; however, cannot be completed without the help of other agencies and community partners.

1.3 Agency Responsibilities

The following are the responsibilities of each of the three agencies involved in this Strategy:

Department of Conservation and Natural Resources-Presque Isle State Park

- Monitor state park waters for HAB development
- Receive HAB related complaints and direct to the appropriate parties
- Sample when blooms are sighted at state park beaches and Priority I locations on the bayside
- Post appropriate advisories
- Provide informational materials to park users about HABs

Erie County Department of Health

- Recommend advisory thresholds
- Advise the public about the health hazards of HAB
- Provide information to the public about HAB safety

Pennsylvania Department of Environmental Protection-Office of the Great Lakes

- Collect and review HAB reports and determine appropriate follow-up
- Collect algae and cyanotoxin samples from Presque Isle Bay and Lake Erie waters
- Assist in determining the presence of a HAB by microscopic review and cyanotoxin testing
- Monitor satellite imagery provided by NOAA to track HAB development
- Train others in sample collection and make referrals for additional assistance
- Provide informational materials and outreach to the public about HABs

1.4 Other Agencies and Community Partners

The following are possible assisting roles of other agencies and community partners:

Regional Science Consortium

- Collect cyanotoxin samples from Presque Isle Bay and Presque Isle State Park beaches
- Determine the presence of a cyanobacteria bloom by microscopic review
- Analyze samples to determine levels of cyanotoxins
- Research environmental conditions that promote HAB development for predictive purposes
- Provide scientific support to DCNR and DEP in the case of a suspected/confirmed HAB

Pennsylvania Sea Grant

- Maintain a database of all Lake Erie HAB data
- Maintain a web-based map of confirmed HABs in Presque Isle Bay and Lake Erie
- Provide informational materials and outreach to the public about HABs
- Facilitate various educational workshops

Citizen Volunteer Monitoring Coordinator

- Act as the go between for the volunteers and the PA DEP
- Conduct sampling of Presque Isle Bay and Lake Erie
- Determine the presence of a cyanobacteria bloom by microscopic review
- Relay monitoring information and the presence of a cyanobacteria bloom to PADEP
- Notify private beach and marina managers about HAB issues and safety
- Train private beach and marina managers on HAB identification and advisory protocols
- Coordinates Volunteer HAB Monitoring

Citizen Volunteer Monitoring

- Conduct sampling of Presque Isle Bay and Lake Erie
- Notify private beach and marina managers about HAB issues and safety

 Train private beach and marina managers on HAB identification and advisory protocols

Pennsylvania Fish and Boat Commission
 Provide information to employees and the public about HAB issues and safety
 Collect information on HAB conditions during routine creel surveys
 Report suspected HABs to PADEP
 Provide outreach to the public about HABS
 Post advisories at state managed waters on Fish & Boat access areas

Pennsylvania Game Commission
 Provide information to employees and the public about HAB safety
 Collect information on HAB conditions during routine waterfowl surveys and license checks
 Report suspected HABs to PADEP
 Provide outreach to the public about HABS
 Post advisories at state managed waters on Game commission access areas

PA Department of Agriculture
 Provide information to employees and the public about HAB safety
 Collect information on HAB conditions during routine agricultural visits
 Review animal illness reports and determine if they are related to cyanotoxins
 Provide outreach to the public about HABS

Erie County Conservation District
 Provide information to employees and the public about HAB safety
 Collect information on HAB conditions during routine agricultural visits
 Provide outreach to the public about HABS

Penn State Cooperative Extension
 Provide information to employees and the public about HAB safety
 Collect information on HAB conditions during routine agricultural visits
 Provide outreach to the public about HABS

NOAA
 Research environmental conditions that promote HAB development for predictive purposes
 Provide scientific support to agencies

1.5 Review, Reporting and Revision

At the conclusion of each HAB monitoring season the monitoring and response efforts will be evaluated by the participating agencies and community partners. The evaluation will include, at a minimum: sample collection locations and results, water resource areas of potential concern, confirmed HABs, advisory postings, public response to advisories, and reports of human or pet

illness. The results of the evaluation will be compiled into an After Action Report, which will be used as a basis for any modifications to the Lake Erie Harmful Algal Bloom Monitoring Strategy for Recreational Waters. The After Action Report will also be made available for public review.

2. Cyanotoxin Toxicity Thresholds

2.1 Introduction

This section is intended to provide guidelines for water resource managers responding to HABs. Included in this section are recommended cyanotoxin thresholds protective of human health in recreational waters and trigger levels that may be used for issuing HAB advisories.

There are no national or Pennsylvania water contact or water use standards for human exposure to HABs or related toxins. The World Health Organization (WHO) has published adult thresholds for microcystins of 20 ppb for recreational use and 1 ppb for drinking water use. Some U.S. states have adopted the WHO thresholds, or a modification, to create guidelines for public advisories and action levels.

2.1.1 Human health impacts from exposure to cyanobacteria toxins

Cyanotoxins have the ability to produce some of the most potent toxins known to humankind. These toxins can affect liver and brain function. Many of the cyanobacteria produce toxins that can cause skin irritation. Due to the potency of these toxins and no known antidote, it is recommended that public health and other regulatory agencies take a conservative approach with human exposure to these toxins when setting recreational water thresholds.

Many of the health symptoms associated with exposure to cyanotoxins can mimic other illnesses and diseases and therefore may not be readily recognized by the medical community or the public. Some of these symptoms include nausea, skin rashes, gastro-intestinal distress, disorientation, numbness and fatigue. Increasing the level of awareness through education within the medical community, general public and government agencies is strongly recommended in order to determine the public health impact of these cyanotoxins.

2.1.2 Fish Consumption and Cyanotoxins

The PADEP has not sampled fish tissue for cyanotoxin analysis, and such analysis is not part of DEP's routine fish consumption sampling program. Ohio EPA has sampled for microcystin in Grand Lake Saint Marys, and Lake Erie during the 2011 to determine if fish were affected by cyanotoxins. All samples taken within the Ohio boundaries of Lake Erie in October 2011, testing yellow perch and walleye, showed no detections. Grand Lake Saint Marys samples were also taken in November 2010, June 2011 and August 2011, and only the June sample set showed a detection level, only in black crappie. PADEP does not plan to conduct fish tissue analysis for cyanotoxins as part of this strategy at this time.

2.2 Cyanotoxin Thresholds for Recreational Waters

Numerous risk assessment frameworks, exposure assumptions, and toxicity values from state, national, and primary literature sources were considered in the development of the State of Ohio Harmful Algal Bloom Response Strategy for cyanotoxin thresholds (Table 1). The thresholds adopted by the State of Ohio are considered by its agencies as protective of human exposures based on information available in 2011, and are adopted as part of the Lake Erie Harmful Algal Bloom Monitoring and Response Strategy for Recreational Waters. The state of the science of HABs and their related toxins is evolving, and these guidelines may require updating, revising, and/or may become obsolete with the issuance of new toxicity information or national algal bloom guidance or policy. The thresholds given here may or may not be protective of animals such as dogs or livestock.

Table 1. Recreational Cyanotoxin Advisory Thresholds

Threshold (µg/L)	Microcystin	Anatoxin-a	Cylindrospermopsin	Saxitoxin*
Recreational Public Health Advisory	6	80	5	0.8
Recreational No Contact Advisory	20	300	20	3

3. HARMFUL ALGAL BLOOM ADVISORIES

3.1 Priority Water Resource Areas

Priority water resources identified for HAB monitoring and response activities are prioritized based on the likelihood of public and/or pet contact and/or ingestion. A water resource manager identifies the priority level of a specific location based on local use, season, or special events. Priority levels may change.

Priority I – High risk of public and/or pet contact– public beaches, canoe/kayak launches, popular wading areas, designated waterfowl hunting sites, pet training and exercise areas, drinking water intakes, etc.

Priority II – Intermediate risk of public and/or pet contact– public marinas, docks, open water likely to be used for recreational activities with direct water contact

Priority III – Areas of public waters that represent minimized contact/ingestion risk - public fishing access locations and shoreline walkways with public water access

3.2 Algae Bloom Identification and Reporting

The initial observation of a potential HAB involves identifying the presence of color and/or scum in surface waters. Frequent, close monitoring of the bloom's location(s) should be continued, especially in priority water resource areas. Generally, the water will be discolored if the algae count is 4,000 cells/ml or more. The color can vary from brown, green, blue green, white, black, purple or red.

Presque Isle State Park Waters- A report of a potential HAB on Presque Isle State Park should be directed to park staff or the park office for confirmation and advisory posting. If park staff are unavailable, or the park office is closed, citizens can make a report by notifying the PADEP Customer Service Representative at 814.332.6839, or by emailing the HAB Visual Assessment Data Sheet (Appendix B) to PADEP's online complaint report system at www.dep@state.pa/.

Presque Isle Bay and Lake Erie Waters- A report of a potential HAB in Presque Isle Bay and Lake Erie waters, outside of Presque Isle State Park, can be made by notifying the PADEP Customer Service Representative at the contact information listed above. Bloom observers can submit digital photographs with the HAB Visual Assessment Data Sheet (Appendix B) for HAB evaluation. Close-up (within 24 inches) and landscape photographs showing the extent and location of the bloom are needed to evaluate the bloom. If no photographs are available, or if a determination cannot be made, a qualified agency staff member may visit the site to corroborate the initial report.

Reports of human and pet illnesses believed to be related to HABs will be investigated by the Erie County Department of Health.

3.3 Public Advisories

Advisories are necessary to inform the public on how to recognize a HAB and the potential health risks associated with exposure to water containing cyanotoxins. Different advisories and action levels should be implemented based on the public use of the water resource and the available evidence. The three public advisories used in this strategy include: General Advisory, Recreational Public Health Advisory, and Avoid Contact Advisory.

3.3.1 General Advisory

General Advisory signage should be posted in noticeable locations near Priority I, II, and III areas. General Advisories are educational and signage will inform water resource users on how to identify HABs, the associated risks, safety precautions, reporting information, and where to get more information. General Advisory signage postings are the responsibility of the managing agency. A sample of the General Advisory signs used for Presque Isle State Park are located in Appendix D.

3.3.2 Recreational Public Health Advisory

A Recreational Public Health Advisory should be issued at Priority II and III areas when there is a visible blue-green algae bloom, or when cyanotoxin levels are equal to or exceed the Recreational Public Health Advisory thresholds, noted above. The Recreational Public Health Advisory thresholds should be used whether or not a HAB is still visible. The Recreational Public Health Advisory sign will warn citizens of the hazards associated with HABs. Recreational Public Health Advisory signage postings are the responsibility of the managing agency. A sample of the Recreational Public Health Advisory sign used by the Presque Isle State Park is located in Appendix E. Figure 2, below, illustrates the monitoring and response strategy for Priority II areas.

Once a Recreational Public Health Advisory is issued, sampling for cyanotoxins will continue and the advisory will remain until after the bloom has been gone for one week, or sampling confirms that cyanotoxin concentrations are below threshold levels and the bloom is gone.

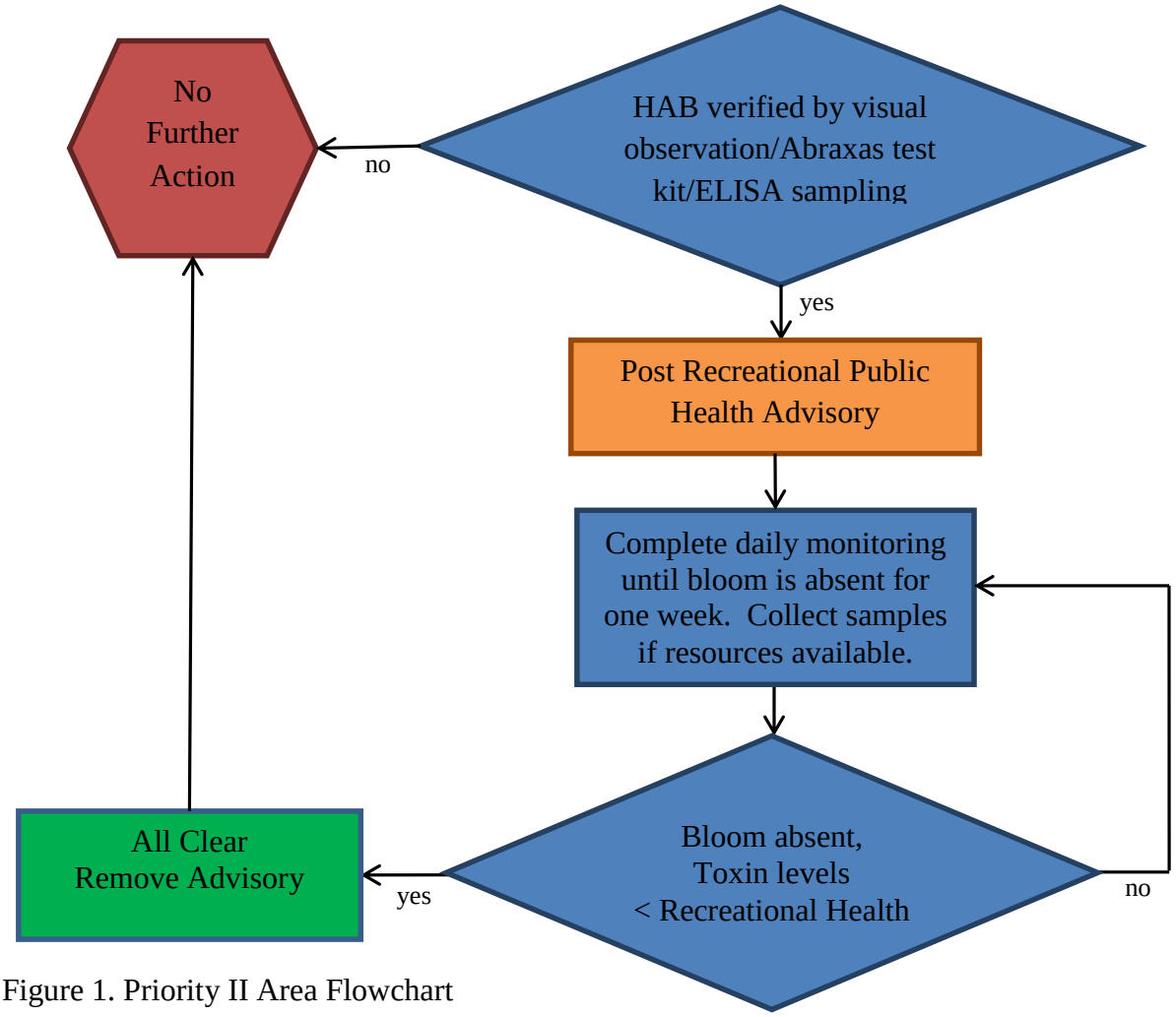


Figure 1. Priority II Area Flowchart

3.3.3 Avoid Contact Advisory

An Avoid Contact Advisory should be issued at Priority I locations when there is a visible blue-green algae bloom, or when cyanotoxin levels are equal to or exceed the Recreational Public Health Advisory threshold noted in Table 1. The Recreational Public Health Advisory thresholds should be used whether or not a HAB is still visible. An Avoid Contact Advisory sign will be posted to warn citizens that high levels of algal toxins have been detected and to avoid contact with the water. Avoid Contact Advisory signage postings are the responsibility of the managing agency.

Once an Avoid Contact Advisory is issued for a Priority I area, sampling for cyanotoxins should continue until the visible bloom is gone, then upon its dissipation to document accurate cyanotoxin levels. The advisory may be removed after the bloom has been absent for one week and toxin levels are below the Recreational Public Health Advisory threshold. If levels are still at or above the Recreational Public Health Advisory Threshold, continue cyanotoxin sampling. Sample until levels are found to be below the threshold. The advisory may be removed when cyanotoxin levels are below the Recreational Public Health Advisory threshold and there is no visible bloom.

A sample of the Avoid Contact Advisory sign used for Presque Isle State Park is located in Appendix F. Figure 1, below, illustrates the monitoring and response strategy for Priority I areas.

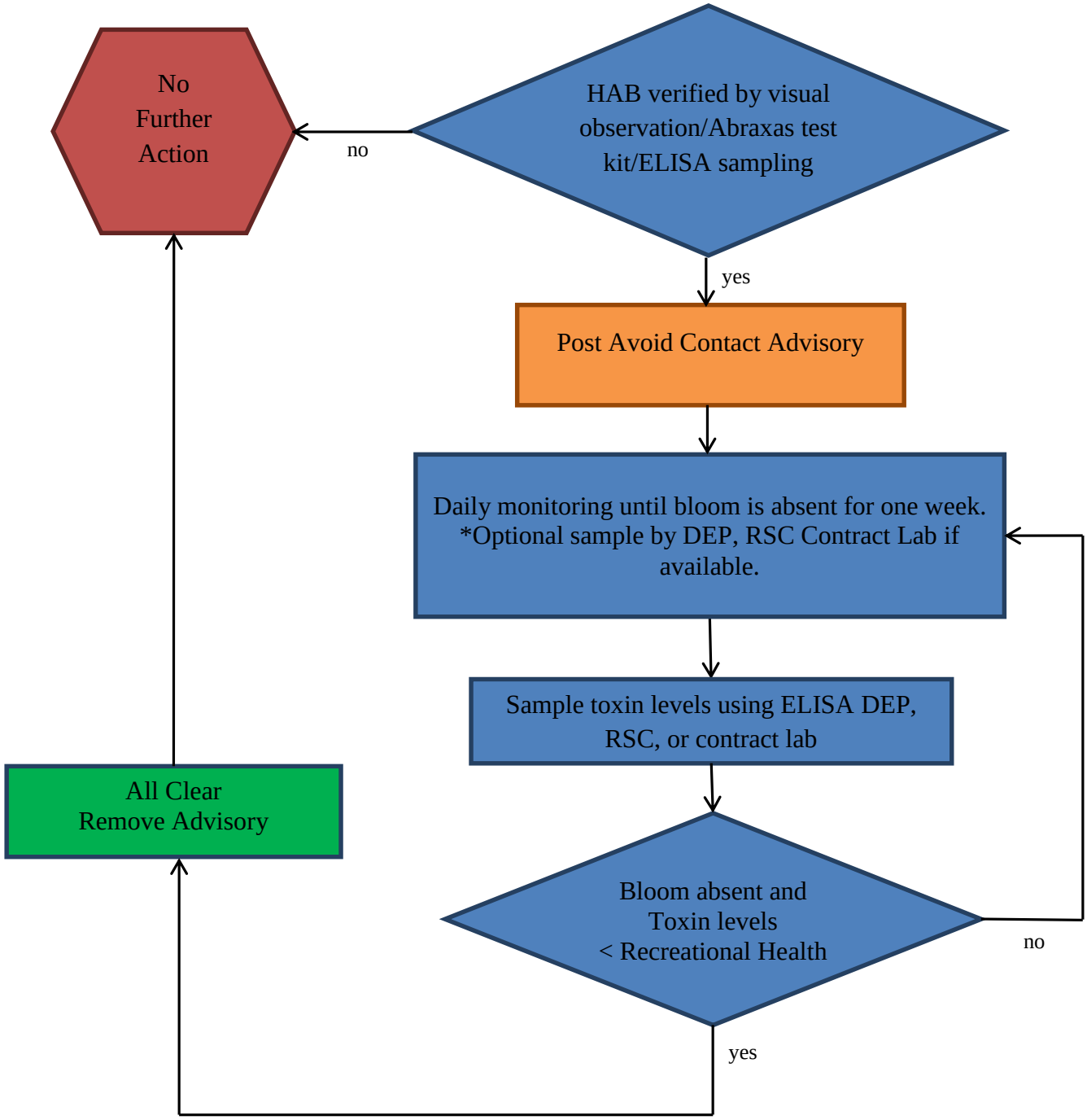


Figure 2. Priority I Area Flowchart

3.3.4 HAB Verification Sampling and "All Clear"

HAB verification may involve cyanobacterial screening, including: qualitative identification of genera and/or species present; cell quantification (cell counts); and rapid assessment field tests for cyanotoxins. In certain cases, particularly in Priority I areas, toxin analysis will be used to confirm a HAB, and to verify "All Clear" indicating that conditions are safe for public contact. HAB verification and "All Clear" sampling can be made by PADEP, DCNR, and the RSC.

The procedural requirements for collecting, preserving, transporting and analyzing phytoplankton and/or cyanotoxin samples (standard operating procedures or SOPs) are described in Section 5.

3.5 Advisories for Other Public and Privately Managed Waters

The primary agencies do not have the responsibility to monitor cyanobacteria/cyanotoxins and post advisories at other state managed waters and privately owned/operated beaches and lake access points. The task force; however, recognizes the potential risk to the public from potential HAB exposure at other water resources. Facility managers and staff should be able to recognize and report a blue-green algae bloom. Anytime a blue-green algae bloom exists there is potential of a HAB. When observed, facility mangers should post advisories as described in Paragraphs 3.3.1 through 3.3.4, above.

Response to a potential HAB at other public and privately managed waters in Presque Isle Bay and Lake Erie requires a cooperative effort. PADEP will provide assistance to verify a cyanobacteria bloom and the potential for HAB episode when available. The efforts of a Citizen Volunteer Monitor Program is the key to monitoring other state managed waters and privately owned/operated beaches and lake access points. Trained volunteers can provide information to water resource managers, conduct routine monitoring and testing, and share information regarding algal blooms. PADEP can use this information to evaluate algal blooms and appropriately respond to a potential HAB episode.

4. MONITORING FOR ALGAL BLOOMS AND HAB PREDICTION

PADEP in partnering with RSC will conduct routine monitoring of the waters of Presque Isle Bay and beach areas on Presque Isle Park. Citizen Science Volunteers will also assist with the monitoring. Monitoring will focus on nutrients, general water chemistry, cyanobacteria cell counts, and cyanotoxin levels. Satellite imagery may also be used to assist in identifying the location of HABs in Presque Isle Bay and Lake Erie waters.

5. HAB SAMPLING IN RECREATIONAL WATERS

This sampling protocol is designed to be responsive to HAB reports in recreational waters so that public health may be protected. It is applicable to collections by anyone who wishes to characterize phytoplankton and cyanotoxins in freshwater lakes and reservoirs waters.

5.1 Safety Precautions

Safety must come first when sampling HAB toxins. Shoulder-length gloves should be worn when sampling HABs. Goggles should be worn to prevent spray from getting into the eyes. Chest waders should also be worn if collecting a cyanotoxin sample when wading off the shore to protect skin from contact with toxins. A personal floatation device should also be worn. Avoid inhaling spray from boats, wind, or irrigation water from areas with harmful algal blooms. Wear a mask to prevent inhalation of spray. Do not ingest or allow the water to come in contact with the skin. Always wash hands with clean, fresh water after sampling and do not touch hands to mouth or other exposed areas of the body before washing. All equipment, gloves, and waders should be rinsed with de-ionized water (not lake water) after collections.

5.2 Sampling Methodology Goal

The goal of sample collection in response to a potential HAB report is to verify a HAB episode. Sample collection procedures are focused on obtaining a full representation of area being sampled. Higher cyanotoxin concentrations are expected near shore, especially on the downwind (away from where the wind is coming from) side of a lake. Highest cyanotoxin concentrations are usually expected with scums (below the dead material at the surface), and within dense cyanobacteria blooms. Most cyanobacteria that produce cyanotoxins hold them within their cells and release the toxins upon cell death. Higher cyanotoxin concentrations may be detected after a rapid bloom die-off, such as when algaecide is added to a dense bloom of cyanobacteria producing cyanotoxins.

5.3 Sample Location(s)

Consider wind direction and where the blooms may be blown such as the downwind side of a lake, or transported by currents. Review any satellite data, if available, to see where the heaviest concentration of cyanobacteria is located. Look for areas of bloom growth and decay throughout the photic zone.

5.4 Sample Frequency

Sampling will occur on a case-by-case basis depending on Priority Level and water conditions. Routine sampling will occur during the peak recreational season between Memorial Day and Labor Day. Weekly sampling, or more frequently, should be conducted for suspected or

confirmed HABs. Continued monitoring may occur beyond the peak recreational season based on environmental conditions and relative health risk, in consultation with PA DEP, ECDH, PA DCNR, PA Sea Grant, and Regional Science Consortium.

5.5 Preparations

Cyanotoxin samples need to be analyzed within 36 hours of collection, and must be kept cold and in the dark. Phytoplankton samples should be kept on wet ice or ice packs, but not frozen.

IMPORTANT – Samples to be shipped to PADEP lab should be sent Monday – Thursday to ensure for ample processing time. Be sure to contact the DEP sample courier with any questions before shipping.

5.6 Label Information

Label the collection containers with a waterproof marker or attach a label to the outside of the container and mark with a waterproof marker. Include the following information:
Site, Name, Date, Time, Preservative (if applicable)

5.7 Sample Collection

5.7.1 Phytoplankton Sample Collection

The purpose of collecting phytoplankton samples is to identify organisms to determine if the bloom consists of cyanobacteria. If the bloom is cyanobacteria, then the type of cyanobacteria will determine which cyanotoxins should be analyzed. If the location of the bloom is evident (i.e. at the surface or just below the surface), collect a grab sample from the densest part of a bloom. The grab sample should be collected in a 500ml Nalgene bottle or other PADEP-approved container. If the bloom is not at a distinct location, but diffuse throughout the water column, use a composite sampler (Appendix A) that includes a collection for a range of depth. When collecting a scum, collect a grab sample from the scum-water surface interface. If you suspect the presence of benthic cyanobacteria, collect a sample near (at 1 foot above) the bottom where you believe the benthic cyanobacteria is located.

Ideally, samples should be preserved at the time of collection with Lugol's iodine solution at a ratio of 1:100, although Lugol's can be added to a sample anytime within eight hours. To achieve a 1:100 ratio add about 1 ml of Lugol's solution per 100 ml of sample (final Lugol's solution in a sample should be 1%.). Final preserved sample color should be similar to that of weak tea. Deliver samples to the PADEP at TREC for shipment to the PADEP main laboratory in Harrisburg. Samples should be kept on wet ice and in the dark during transport. **Do not freeze the phytoplankton sample - doing so will make identification difficult.**

5.7.1.1 Cyanotoxin Sample Collection –Overview

The initial cyanotoxin analysis will be conducted using an Abraxis Algal Toxin (Microcystins) Test Strip Kit to provide quick on site results for microcystin levels. Additionally samples will be collected for analysis by the Regional Science Consortium for a more comprehensive ELISA analysis. These will be collected from a suspected HAB using a composite sampler (Appendix A) at nine locations within the designated recreational area and composited. The nine locations will be determined by evenly dividing the recreational area into three transects that begin at the beach and extend into the water. Samples will be collected from three locations (ankle, knee and hip deep) along each transect. Note: use a rod ahead of where you are walking to gauge depth. Do not stir up the sediment. If the depth drops off quickly past hip depth, then collect ankle-depth and knee depth samples. Do not go past hip depth. Wade slowly (as not to stir bottom substrate) to the sampling locations. Avoid collecting suspended sediment that may be kicked up while accessing the sampling point. Ankle-deep water samples will be collected approximately 15 cm below the surface. Knee- and hip-deep water samples will be collected approximately 30 cm below the surface. If dense cyanobacterial accumulations are present outside of the transect locations (which includes a scum or heavy biomass in the photic zone), an additional sample will be collected from the densest accumulation by filling a separate clean 500ml Nalgene sampling bottle or other PA DEP approved container half way (250 ml). Submit this sample in addition to the composited samples with a separate Sample Submission Form and clearly marked as scum (adapted from USGS, 2008).

5.7.1.2 Cyanotoxin Sample Collection Instructions

1) Use a clean 500ml Nalgene sampling bottle or other PA DEP-approved container to collect from each sampling point along all three transects at a Priority I location. Carry the clean bucket with you (or you can place a float around the bucket). Fill the 500ml Nalgene sampling bottle or other PA DEP-approved container from the ankle-depth location on the first transect and completely dispense the collection into the bucket. Carefully wade out to the knee-depth location with the bucket and collect another 500 mL sample using the same Nalgene sampling container or other PA DEP-approved container. Completely dispense the sample into the bucket. Then wade out to hip depth and collect another 500mL sample and completely dispense the collection into the bucket.

2) Go to the second transect. Using the same 500ml Nalgene sampling bottle or other PA DEP-approved container, collect the three samples along the second transect in the same way the samples were collected along the first transect and dispense them into the bucket with the first transect collections. Once the second transect collections are dispensed into the bucket, go to the third transect and collect the three samples along the third transect in the same way collections were made on the first two transects and dispense into the bucket.

3) Use a clean stirring rod to mix the composite samples from all three transects in the bucket. Continue to stir the composite sample while you dispense a sub-sample of the composite sample into the same 500ml Nalgene sampling bottle or other PA DEP-

approved container you used to collect all the samples at that beach. This is the sample you will submit to the laboratory.

4) In addition, if a scum is found at any area where the public is expected to recreate outside the transect lines, collect a surface grab sample which includes the scum at the scum-water interface and clearly noted on the container label. Note the percentage of recreational area covered by the scum on your Sample Submission Form. This sample is **not** mixed into the composite sample but submitted to the laboratory in addition to the composite sample.

5) Immediately transfer each capped sample to a dark cooler on wet ice or ice packs when collected. The sample must be kept in the dark and cool to preserve any toxin that may be present.

If there are multiple Priority I locations on a single lake with cyanobacteria blooms, all beaches should be sampled in the same manner as stated above, differentiating each sample location by an alternate location name. When you move to a new beach location to set up new transects, rinse the collection bucket and stirring rod three times with lake water at each location. Rinse away from the transect sampling points so as not to cross contaminate or mix the water where samples will be collected. Use a new, clean 500ml Nalgene sampling bottle or other PA DEP-approved container for each different beach sampled.

5.7.1.3 Volunteer Response Monitoring

Following a confirmed HAB, citizen volunteers will monitor the existence and the extent of the bloom on a daily basis for Priority I and II locations. Priority III locations will be monitored with visual assessments as time allows, no float test will be conducted for these locations. Monitoring will include a visual assessment along with a Float Test (Appendix C). Information will be documented on the visual assessment data sheet (Appendix B).

5.7.2 Open Water (Inland Lakes)

Open water sampling is not prescribed by this Strategy, but if it is deemed necessary, this section describes the methodology for collecting samples.

Establish a **central sampling point** in the approximate center of a HAB on the open lake and record the latitude and longitude. Each time an open-water HAB sample is collected, there will probably be a different central sampling location and those coordinates should be recorded each time. Collect phytoplankton and toxin samples.

Choose one of the following methods that will best capture the extent of the HAB.

5.7.2.1 Radial Transect Method (for irregular-shaped, or elongated HABs)

Project three transects through the central sampling point ensuring there are six equal arcs

radiating from the central sampling point. Extend each of the six radial arms to the shore. Each of the six radial arms, divide each into two equal length segments with two equally spaced sampling points (not counting the central sampling point.)

5.7.2.1.1 Phytoplankton Samples

Using a vertical-composite sampler, collect a phytoplankton sample from the densest bloom area and dispense the sample into a 500ml Nalgene sampling bottle or other PA DEP-approved container or a clean bucket. Take a 500ml Nalgene sampling bottle or other PA DEP-approved container or sub-sample for analysis. Collect additional separate samples of blooms that have a different appearance if applicable and note the latitude and longitude of each collection. Note if a scum is included in the collection. Preserve with Lugol's iodine (1 ml Lugol's solution to 100 ml sample). Do not freeze sample.

5.7.2.1.2 Cyanotoxin Samples

Collect a grab toxin sample in a rinsed 500ml Nalgene sampling bottle or other PA DEP-approved container at each collection point. Rinse by filling the 500ml Nalgene sampling bottle or other PA DEP-approved container with native water on the opposite side of the boat from where the collection will be made. Collect 1 quart sample from the photic zone where there is the highest concentration of cyanobacteria at each sampling location. If there is a surface scum, collect a surface sample (scum-water interface) at that location. If it is unclear where the highest concentration of phytoplankton is located in the water column, then collect a grab sample from approximately 15 cm below the surface. Combine a sample collected from the central sampling point to the 12 sample collections along each of the six radial arms in a clean churn splitter or clean bucket. Mix the composite sample in the churn splitter or in the bucket with a clean stirring rod and continue to mix while decanting a sub-sample into the 500ml Nalgene sampling bottle or other PA DEP-approved container. If saxitoxin analysis is ordered, collect a sample form the churn splitter or clean bucket in a 40 ml glass vial pre-dosed with preservative from DEP. **Important - The composite sample should be placed on wet ice or ice packs in a cooler as soon as possible.**

5.7.2.2 Perpendicular Transect Method (For regular-shaped, or round HABs)

Establish two transects that cross at right angles through the central sampling point. Extend each transect end to the shore. Along each of the four radial arms, divide each into three equal length segments with three equally spaced sampling points (not counting the central sampling point.)

5.7.2.2.1 Phytoplankton Samples

Using a vertical-composite sampler, collect a phytoplankton sample from the densest bloom area and dispense the sample in a clean bucket. Collect a subsample in a clean 500ml Nalgene

sampling bottle or other PA DEP-approved container. Collect additional separate samples of blooms that have a different appearance if applicable and note the latitude and longitude of each collection. Note if a scum is included in the collection. Preserve with Lugol's iodine (1 ml Lugol's solution to 100 ml sample).

5.7.2.2.2 Cyanotoxin Samples

Collect a cyanotoxin grab sample in a rinsed 500ml Nalgene sampling bottle or other PA DEP-approved container at each collection point. Rinse by filling the 500ml Nalgene sampling bottle or other PA DEP-approved container with native water on the opposite side of the boat from where the collection will be made. Collect a 500ml sample from the photic zone where there is the highest concentration of cyanobacteria at each sampling location. If there is a surface scum, collect a surface sample (scum-water interface) at that location. If it is unclear where the highest concentration of phytoplankton is located in the water column, then collect a grab sample from approximately 15 cm below the surface. Combine a sample collected from the central sampling point to the 12 samples collected from the transect arms in a clean churn splitter or clean bucket. Mix the composite sample in the churn splitter or in the bucket with a clean stirring rod and continue to mix while decanting a sub-sample into the rinsed 500ml Nalgene sampling bottle or other PA DEP-approved container.

If saxitoxin analysis is ordered, collect a sample form the churn splitter or clean bucket in a 40 ml glass vial pre-dosed with preservative from DES.
Important - The composite sample should be placed on wet ice or ice packs in a cooler as soon as possible.

5.8 Cyanotoxin Preservation Instructions

Upon collection, samples should be immediately put in a cooler in the dark and on wet ice. If a sample will not arrive for processing at the laboratory within 24 - 36 hours, the sample must be frozen in a standard freezer until it is processed.

5.9 Phytoplankton Preservation Instructions

Ideally samples should be preserved at the time of collection with Lugol's iodine solution at a ratio of 1:100, although Lugol's iodine can be added to a sample anytime within eight hours. Addition of Lugol's iodine will allow for extended preservation.

5.10 Equipment Decontamination Between Sampling Locations

When sampling for phytoplankton or algal toxins at different contact recreational areas, use clean

sampling containers and rinse the collection bucket and stirring rod three times with lake water at each location. Rinse away from the transect sampling points so as not to cross contaminate or mix the water where samples will be collected.

5.11 Toxin Processing Instructions

Total toxin (free toxins and endotoxins) shall be determined for recreational water sample analysis. Samples will be processed to ensure all algal cells are lysed, which should be verified through microscopic observation. Utilizing an ultrasonicator is a good way to lyse algal cells, however care must be employed to prevent any loss of the toxin while sonicating. This will mean careful selection of the processing parameters for the type of sonicator used, and possibly sonicating the sample in a cold water bath.

5.12 QA/QC

PA DEP will use quality assurance/quality control procedures that meet quality objectives for HAB sampling.

5.13 Paperwork

Fill out a Chain of Custody Report and Sample Submission Forms (one for each sample) (see attached templates in Appendix B). Put the paperwork in double ziplock-type bags and seal each bag well. Place the paperwork on the samples in the cooler.

5.14 Shipping

Contact the appropriate laboratory prior to collecting samples. Include any paperwork required by the receiving laboratory. This will usually include a Chain of Custody Report and a Sample Submission Form (see Appendix E.) Make sure that the data are reported back to the sample submitter and to the HAB Coordinator so that data can be entered into the HAB database. Enclose each sample container in a separate sealed plastic bag. Place on ice in a sealed plastic bag and place in the shipping container. Note that ice packs should be used if shipping Fed-Ex and wet ice sealed in plastic bags or ice packs for UPS shipments. Prepare the package for shipment.

6. GLOSSARY

Algal toxin: A toxin produced by cyanobacteria. Also called cyanotoxin.
Anatoxin-a: A nerve toxin produced by a number of cyanobacteria.
Beach: Area along the shore that is a designated swimming area and is managed for public use.
Biovolume: Biovolume can be estimated by associating the phytoplankton with similar geometric forms and determining the volume of these by measuring the linear dimensions required for its calculation under the microscope (Vadrucci et al. 2007).
Blue-green algae: Photosynthesizing bacteria, also called cyanobacteria (see definition below).
Contact recreational area: Water area where swimming, wading, diving, jet skiing, water skiing, tubing, wakeboarding, windsurfing, kite boarding or any other in-water activity may occur that is likely to result in immersion or ingestion of water.
Cyanobacteria: Also called blue-green algae. These photosynthesizing bacteria may produce toxins that can cause sickness and possibly death in exposed populations of humans and animals. Cyanobacteria can be present as unicellular, colonial, or filamentous organisms. Some have the ability to fix nitrogen and/or regulate their buoyancy.
Cyanotoxin (algal toxin): Toxin produced by cyanobacteria. These toxins include liver toxins, nerve toxins and skin toxins.
Cylindrospermopsin: A nerve toxin produced by a number of cyanobacteria.
ELISA (Enzyme Linked Immunoassay): A rapid assessment method commonly used to detect microcystins, cylindrospermopsin and saxitoxin.
Grab Sample: A sample of river, stream, or lake water collected for the purpose of analyzing its constituent water chemistry and/or biological community
HAB (Harmful Algal Bloom): A visually identified concentration of cyanobacteria that discolors the water, or a cell count greater than 4,000 cells/ml of cyanobacteria genera (Shambaugh and Brines, 2003) Accumulations of cyanobacteria cells may be present at the water surface, at a defined depth, or throughout the water column.
Microcystin: A common type of cyanotoxin that is toxic to the liver. There are more than 80 congeners (forms) of this toxin. Microcystin-LR is the most toxic congener.
PA DEP: Pennsylvania Department of Environmental Protection
ECDH: Erie County Department of Health
PA DCNR: Pennsylvania Department of Conservation of Natural Resources
PISP: Presque Isle State Park
Photic zone: The uppermost layer in a body of water into which light penetrates in sufficient amounts to influence living organisms, especially by permitting photosynthesis.
Public Lake: A lake managed by a political subdivision of the State of Pennsylvania.
Saxitoxin: A nerve toxin produced by a number of cyanobacteria.
Scum: A cyanobacteria bloom that has a dense surface accumulation of cyanobacteria cells.

REFERENCES

Ohio Environmental Protection Agency. April 2012. State of Ohio Harmful Algal Bloom Response Strategy For Recreational Waters.

Oregon Health Authority. October 2012. Oregon Harmful Algae Bloom Surveillancee (HABS) Program: Sampling Guidelines for Cyanobacterial Harmful Blooms in Recreational Waters.

Vermont Department of Health. 2012. Cyanobacteria (Blue-green Algae): Guidance for Vermont Communities.

Virginia Department of Health. 2013. Recreational Water Guidance for Microcystin and Mcrocystis Blooms: Provisional Guidance.

World Health Organization. 2001. Guidelines for Safe Recreational Water Environments. http://www.who.int/water_sanitation_health/bathing/srwe1/en/

APPENDIX A – SAMPLING AND SAFETY MATERIALS

Materials for basic grab sample phytoplankton and toxin collections at beaches:

 Plastic shoulder-length gloves (to protect skin from toxin irritation)

 Goggles, and mask for over nose and mouth

 Chest waders – if collecting samples by wading off the shore

 Personal flotation device (PFD)

 For phytoplankton collections: Two 500ml Nalgene bottles or other PA DEP-approved containers/beach to sample (one for phytoplankton and one for additional scum sample if needed)

For toxin collections: Two 500ml Nalgene bottles or other PA DEP DEP-approved containers/beach to sample (one for transect collection which is used for the final composite collection and one for a scum sample (if any) outside the transects)

 40 ml vials from DES pre-dosed with preservative for saxitoxin collection (if ordered by HAB Coordinator)

 Secchi disk (if available)

 Lugol's iodine

 Clean bucket (at least 12 quart capacity) and clean non-porous stirring rod (metal or plastic, not wood)

 Centimeter measure for selecting sampling depth at sampling locations

 Walking stick to check depth ahead of sampling when wading

 Yardstick or weighted measuring tape

 Digital camera to record appearance of bloom (submit to HAB Coordinator)

 GPS or a map to mark the location of collection (email scanned map to HAB coordinator)

 Cooler with wet ice or ice packs

 Waterproof permanent marker

 Large trash bags and twist ties (to contain ice in cooler)

 Chain of Custody Report and Sample Submission Forms (See Appendix D)

 FedEx or UPS shipping labels

 Multi-probe sampler (if available)

*** Collection containers and preservative will be determined by PA DEP.**

For composite phytoplankton collections, add the following:

 Vertical whole water composite sampler (2 m integrated tube sampler)

o Build the units as a two-piece for easier transport, although they may be built as a one-piece as well. The sampler is constructed from 1 1/4 inch Schedule 40 PVC pipe and fittings. The graduations on the sampler are in tenth meter increments which can be marked with colored tape. The material list is:

1. one 1 1/4 inch neoprene stopper
2. one PVC coupler (slip to slip type)
3. 1 meter of 1 1/4 inch PVC pipe
4. one 1 1/4 inch valve (optional; can also be accomplished with a stopper if necessary)

(Modeled after Minnesota DNR. Not commercially available)

 Churn splitter OR clean bucket (at least 16 quart capacity) and clean non-porous stirring rod (metal or plastic, not wood)

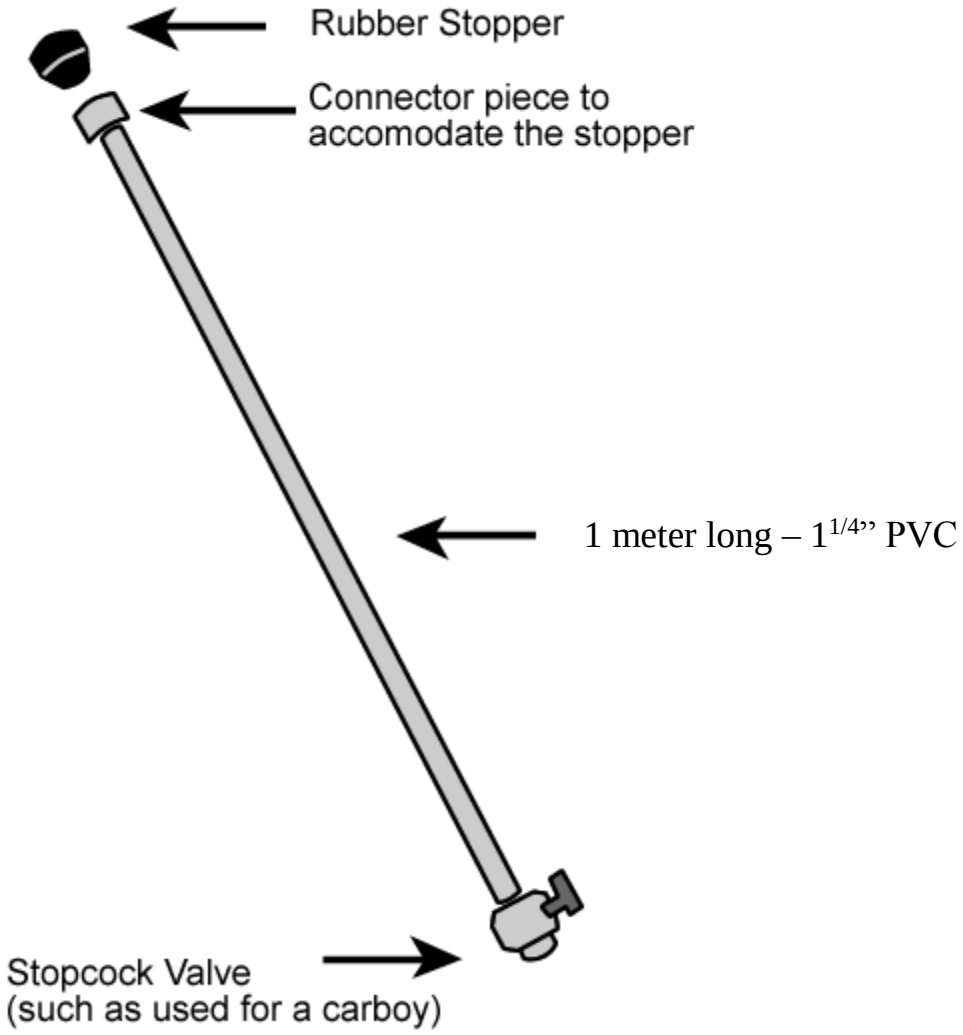
 Multi-probe sonde/water quality instrument (if available)

 At least two 500ml Nalgene bottles or other PA DEP-approved container for phytoplankton collection(s)

 At least two 500ml Nalgene bottles or other PA DEP-approved container for toxin collections

 Lake map or chart to measure off transects

 Boat


Rubber Stopper
Connector piece to accomodate the stopper
1 meter long – 1 1/4'' PVC
Stopcock Valve
(such as used for a carboy)

Appendix B: HAB Visual Assessment Data Sheet

Date of Assessment:_____
Name of Waterbody: _____
Location (as specific as possible, town, beach name or other easily identifiable landmarks nearby):
_____
Coordinates: _____ _____
Report Completed by: _____
Existing Advisory Level: _____Priority Level (I, II, or III): _____
Weather Conditions (sunny, rainy, approximate air temperature):
_____
Water Temperature: _____
Wave Conditions: _____
Water Clarity (circle all that apply): Clear Cloudy Hazy Opaque Don't know
Water Color: _____
Visible Scum: _____
If Buoyancy Test is completed, thickness of a scum (mm/time):_____/_____
Water usage at this location (check all that apply):

☐Swimming or other full body contact activities ☐Canoe/Kayak launch

☐Wading area ☐Boating ☐Pet swimming/drinking area

☐Fishing ☐Water Fowl Hunting ☐Water Supply

☐Not likely to come in contact with people or pets

Were pictures included (close-up and landscape): _____
Estimated size of bloom:_____
Were Samples Collected (if yes, type and number of samples): _____

Date HAB confirmed (How): ☐Visual ☐ABRAXIS Test Kit_____ ☐ELISA_____

Priority Level Description: Priority water resources identified for HAB monitoring and response activities are prioritized based on the likelihood of public and/or pet contact and/or ingestion. A water resource manager identifies the priority level of a specific location based on local use, season, or special events. Priority levels may change.

Priority I – High risk of public and/or pet contact– public beaches, canoe/kayak launches, popular wading areas, designated waterfowl hunting sites, pet training and exercise areas, drinking water intakes, etc.

Priority II – Intermediate risk of public and/or pet contact– public marinas, docks, open water likely to be used for recreational activities with direct water contact

Priority III – Areas of public waters that represent minimized contact/ingestion risk - public fishing access locations and shoreline walkways with public water access

Appendix C: Ways to identify a cyanobacteria/blue-green algae accumulation

STEP 1 Examine the material visually:

NOT cyanobacteria if:

- you can see leaf-like structures or roots
- the material is long and stringy, or can be lifted out of the water on a stick
- if it is firmly attached to plants, rock or the bottom (e.g. you can't lift it out)

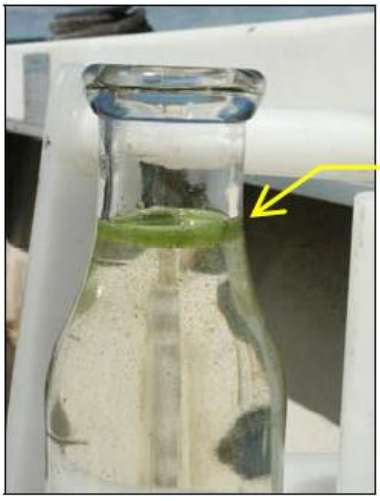
MAY be potentially hazardous cyanobacteria if :

- the material consists of small particles that are pinhead size or smaller
- the material is collecting in a layer at the surface or along the shoreline
- the water is murky and colored a brownish green, milky green or blue

STEP 2 Do the "float" test:

Many cyanobacteria can regulate their buoyancy and will float to the top of the water when it is calm. Most other algae don't have this ability. Most debris and plant material will sink or be identifiable as debris. Microscopic animals will swim randomly and often with a jerky motion.

You can check to see if cyanobacteria are present by filling a clear 2L soda bottle or a bucket with water. The water should be collected away from any debris or large plant material floating along the shoreline. Allow the bucket or bottle to stand in a quiet sunny place, out of the wind. If present, cyanobacteria will often begin to move toward the surface. Wait 15 – 30 minutes and observe the upper portion of the container. Cyanobacteria, which may be a mix of several different kinds, will tend to accumulate in the upper portion while debris and plant material will be at the bottom. There may be smaller material in the middle, which will remain suspended for some time. When filling the container from a dense accumulation, minimize skin contact with the material by wearing gloves or a plastic bag over your hands.



A thin layer of cyanobacteria at the top is usually not a problem. Cyanobacteria are found in most water bodies at concentrations that are not of concern. If you have ruled out non- cyanobacteria using the steps above, and there is a thick layer that is more than an inch deep at the top of the container, it may be prudent to have the sample examined microscopically.

Be aware that the concentration of cyanobacteria at a location can change daily, even hourly, as the weather conditions change. If you do the float test routinely, you will begin to become familiar with how the water and cyanobacteria look under different conditions. Also, cyanobacteria may not always move to the surface in 30 minutes. If there is a bloom in progress, with a large amount of cyanobacteria in the water, at least a portion should move toward the surface. With experience, you will become familiar with how your lake looks and when conditions warrant a closer examination.

Appendix D: General Advisory Signs

IF IN DOUBT, STAY OUT!

Have fun on and in the water, but know that blue-green algae blooms are a global problem in lakes, rivers and other water bodies. Their toxins may be too. Knowing how to identify harmful algae blooms (HABs) and being alert can keep you, your family and your pets safe!

Avoid contact with water that:

- **Looks like spilled paint**
- **Has surface scum, mats or films**
- **Is discolored or has colored streaks**
- **Has green globs floating below the surface**

And ALWAYS AVOID…

swallowing water from lakes or other water bodies!

To report a suspicious algae bloom contact the PADEP at 814-332-6839

For more information, visit www.paseagrant.org

Sea Grant Pennsylvania

BE AWARE

Harmful Algal Blooms (HABs) ...

What is a Harmful Algal Bloom?
HABs are so named because many of these blooms may produce poisons (or toxins) that can cause illness, irritation or even death. While HABs are commonly referred to as "blue-green algae," they are not true algae. They are actually cyanobacteria.

HABs have been observed worldwide including Lake Erie and other Pennsylvania waters and can occur almost anywhere: lakes, ponds, stormwater retention basins, rivers, streams, or reservoirs.

How dangerous are HABs?
Humans, pets, livestock and wildlife that come into contact with, or ingest HAB toxins can experience sickness, paralysis or even death.

Know the signs of HAB poisoning:
Humans: rashes, blisters and hives, and eye and nose irritations. If swallowed, diarrhea, vomiting, abdominal pain, numbness of lips, tingling in fingers and toes, dizziness, headache.

Pets/livestock/wildlife: staggering, difficulty breathing, convulsions, salivation, weakness, and vomiting.

How will I know if there is a HAB?
Confirmation of HABs can only be made under a microscope. HABs generally occur from late summer into early fall when water temperatures are warmest and an abundance of sunlight and nutrients are available.

Check for posted HAB advisories or ask the park manager about any recent HABs because colorless toxins can still be in the water after visible blooms have faded.

Always look for HABs before going in the water.
HABs have different colors and looks. Some colors are green, blue-green, brown, black, white, purple, red and black. They can look like film, crust or puff balls at the surface, grass clippings, or dots in the water. Some HABs look like spilled paint, pea soup, foam, wool, or streaks.

What should I do if I see a HAB?
Stay out of water that may have a HAB.
Don't let children or pets play in HAB debris on shore.
After swimming/wading in water, even with no visible HABs, rinse off with fresh water as soon as possible.
NEVER swallow untreated surface water. It may contain algal toxins or other bacteria, parasites, or viruses that could cause illness if consumed.
Do not let pets lick or eat HAB material from their fur.
Don't drink/cook with suspected water. In-home treatments like boiling, chlorine bleach or water filtration units offer no protection from HAB toxins!
See a doctor if you or your children might be ill from HAB toxins. Contact your veterinarian for sick pets.

What about fishing and other activities?
Consider minimal consumption of fish fillets from water bodies with HAB events. Research indicates toxin levels are highest in internal organs but can be found in fillets. At a minimum, remove the skin and wash fillets thoroughly before cooking, being sure not to use HAB affected water.

Other activities near the water such as camping, biking
picnicking, and hiking are safe. If you are picnicking, and have had contact with suspected water or shore debris, be sure to wash your hands before handling food.

Where can I report a bloom or find more information?
Report a bloom to: The Pennsylvania Department of Environmental Protection (PADEP) at 814-332-6839
For more information, visit *www.paseagrant.org*

Sea Grant Pennsylvania

Appendix E: Recreational Public Health Advisory

TOXIC ALGAE ALERT

A suspected harmful algal bloom has made this location potentially dangerous for humans and animals

AVOID ALL CONTACT WITH THIS WATER and SURFACE SCUM

For more information contact the Pennsylvania Department of Environmental Protection (PADEP) at 814-332-6839
OR
Visit www.paseagrant.org

Appendix F: Avoid Contact Advisory Sign