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Advancing Environmental Solutions

Strategies For Preventing And Managing Harmful Cyanobacteria Blooms

Fig. A-38. *Microcystis aeruginosa*.
Central Park Lake, KS.
Source: Elizabeth Fabri Smith, used with permission.

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Why Manage Cyanobacteria?

- Cyanobacteria are common and native
  - May become very abundant (blooms)
  - May produce harmful compounds (cyanotoxins)

Fig. A-36. *Microcystis aeruginosa*, FL. Source: Andy Chapman, used with permission.

Planktothrix spp. Fleeinghorse Lake, Alberta Canada. Source: Ron Zurawell, used with permission.

Planktothrix spp. Cedar Lake, MN. Source: Rachel Crabb, used with permission

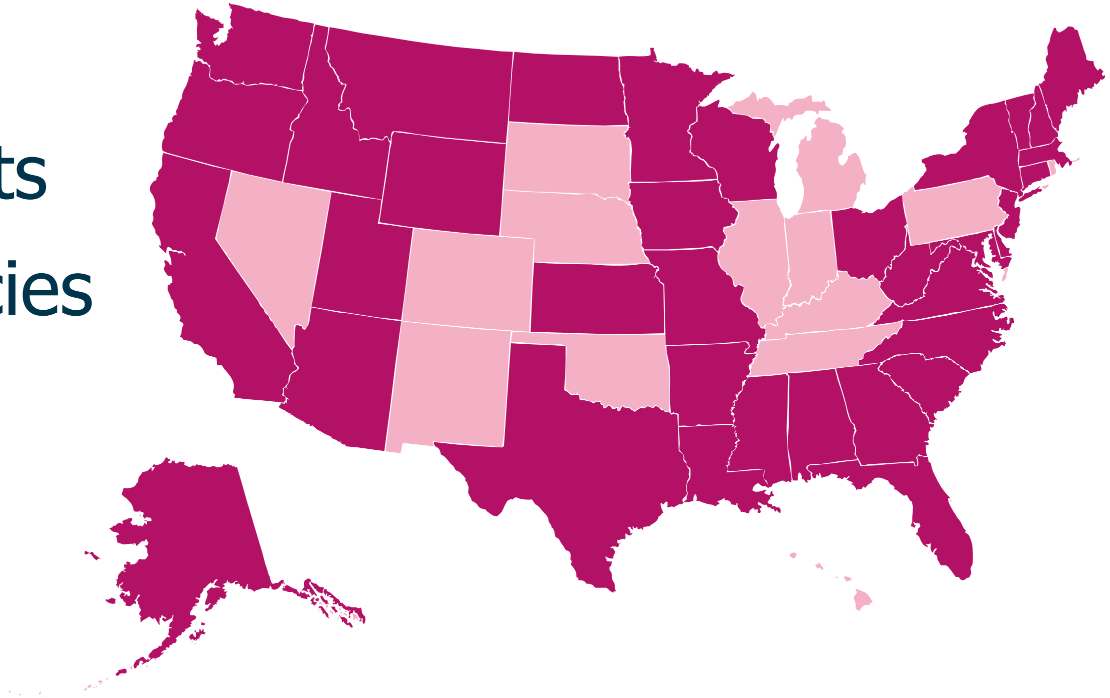
The Future Looks Bright for Cyanobacteria

- Future environmental conditions expected to be perfect for their needs
  - A warming climate
  - Increasing nutrient levels
- Important to take steps now to limit their growth

Photo Credit: Angela Shambaugh

HCB Guidance Builds on Our Team's Experience

- 284 team members representing:
  - Federal, State and Local governments
  - Natural Resources and Health Agencies
  - Scientists and Academics
  - Lake Associations



Today's Trainers

Gina LaLiberte

WI Dept. of Natural Resources

- Introduction to Cyanobacteria (Section 3)
- Risk Communication & Response (Section 5)

Robert Newby

NJ Dept. of Environmental Quality

- Management & Control (Section 6)

Ben Holcomb

UT Department of Environmental Quality

- Monitoring (Section 4)
- Nutrient Management (Section 7)

ITRC INTERSTATE TECHNOLOGY REGULATORY COUNCIL

Advancing Environmental Solutions

★ **Introduction to Cyanobacteria**

Monitoring for Cyanobacteria

Communication and Bloom Response Planning

Management and Control Strategies for HCBs

HCB Nutrient Reduction Strategies

This Training: HCB Introduction

- Introduction to cyanobacteria biology and ecology
- Terminology used in the Guidance Document
- Health concerns associated with HCBs
- Current HCB regulations and guidance

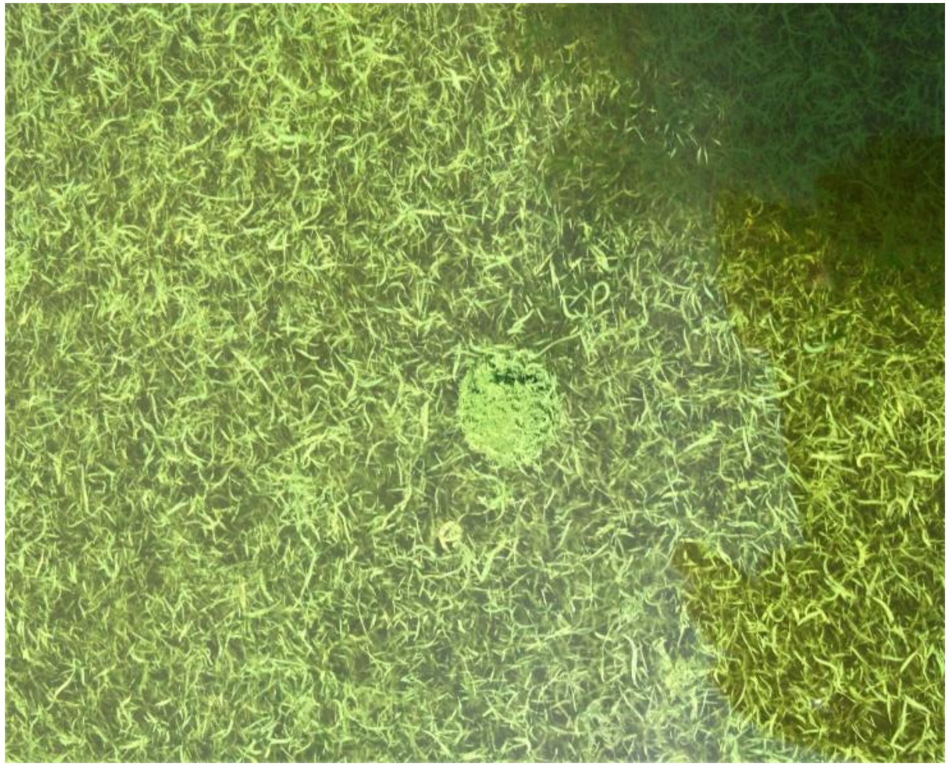


Figure A – 6: Jacob Kann. Used with permission.

Cyanobacteria Basics

- Naturally occurring and widely distributed across both aquatic and terrestrial environments
- Beneficial roles include
  - acting as food source for other organisms
  - producing oxygen via photosynthesis
  - some types also fix nitrogen
- Unique characteristics include
  - resting/dormant stages
  - buoyancy control

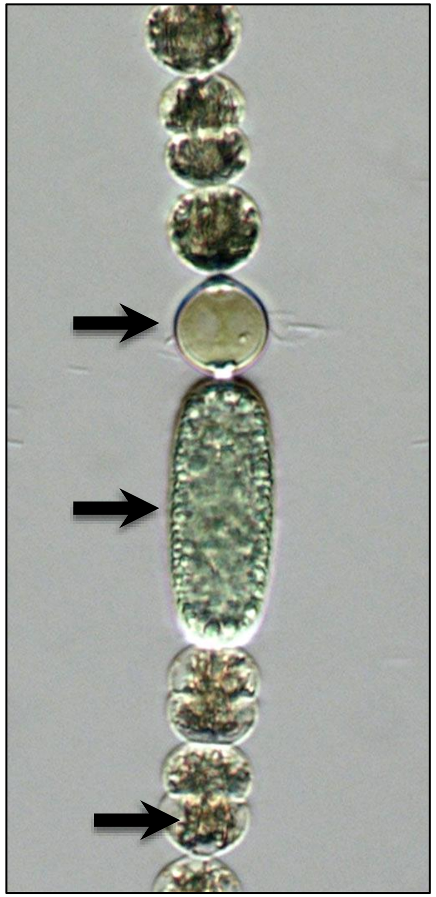


Figure Source: Gina LaLiberte. Used with permission.

What do they look like and how can I tell them apart?

- Check out the Visual Guide
  - Field photos and microscopic images
  - Cyanobacteria assemblages and taxa by:
    - form, such as colonial or filamentous
    - habitat, such as planktonic/water column vs. benthic/attached
  - Also includes non-cyanobacterial examples such as aquatic plants, filamentous algae, other toxic algae for comparison

Figure A – 43. Elizabeth Fabri Smith. Used with permission.

See Appendix A Visual Guide to Common Harmful Cyanobacteria

Cyanobacteria Terminology

- All cyanobacteria = "blue-green algae" but they are true bacteria that photosynthesize
- Not all harmful algae blooms (HABs) are harmful cyanobacteria blooms (HCB; cyanoHAB)
  - Other algae can form HABs or nuisance blooms in freshwater and marine habitats

Figure A – 44. Jacob Kann. Used with permission.

Figure A – 119. *Spirogyra* sp. Terri Peters. Used with permission.

Cyanobacteria Terminology

- Terms vary based on location and type of accumulation:
  - Blooms: visible accumulations of cyanobacteria in the water column

Figure A – 49. Anne St. Amand. Used with permission.

Figure A – 61. Rachel Crabb. Used with permission.

Cyanobacteria Terminology

- Terms vary based on location and type of accumulation:
  - Blooms: visible accumulations of cyanobacteria in the water column
  - Scums: accumulations of cyanobacteria on the surface of the water or along the shoreline

Figure A – 75. Anne St. Amand. Used with permission.

Figure A – 41. Elizabeth Fabri Smith. Used with permission.

Cyanobacteria Terminology

- Terms vary based on location and type of accumulation:
  - Blooms: visible accumulations of cyanobacteria in the water column
  - Scums: accumulations of cyanobacteria on the surface of the water or along the shoreline
  - Mats: accumulations of benthic cyanobacteria growing on substrates on the bottom of the water body, or floating free from the bottom

Figure A – 30. Ken Wagner. Used with permission.

What promotes HCB growth?

- Cyanobacteria can grow and accumulate into HCBs with favorable environmental conditions including
  - Increase in nutrients (phosphorus and nitrogen)
  - Increase in temperatures
  - Hydrological stability – stratification, slow flow, reduced turbulence

Figure A – 35. Anne St. Amand. Used with permission.

What promotes HCB growth?

- Climate change can enhance factors promoting HCB growth:
  - Warmer temperatures and longer growing seasons
  - Periods of drought
  - Nutrient loading from intensifying rain events

Figure A – 43. Elizabeth Fabri Smith. Used with permission.

What makes cyanobacterial blooms harmful?

- Cyanobacteria can produce cyanotoxins and other irritants that cause serious health effects in people and animals:
  - Liver (hepatotoxin)
  - Nervous system (neurotoxin)
  - Skin and mucous membranes (dermatoxin)
  - General irritation/allergic reaction
- Environmental effects:
  - Low dissolved oxygen, shading plants, etc.

Figure C- 1. Eric Roberts, 2019. Used with permission.

Cyanotoxin Production and Release

- Toxin production varies over time and space

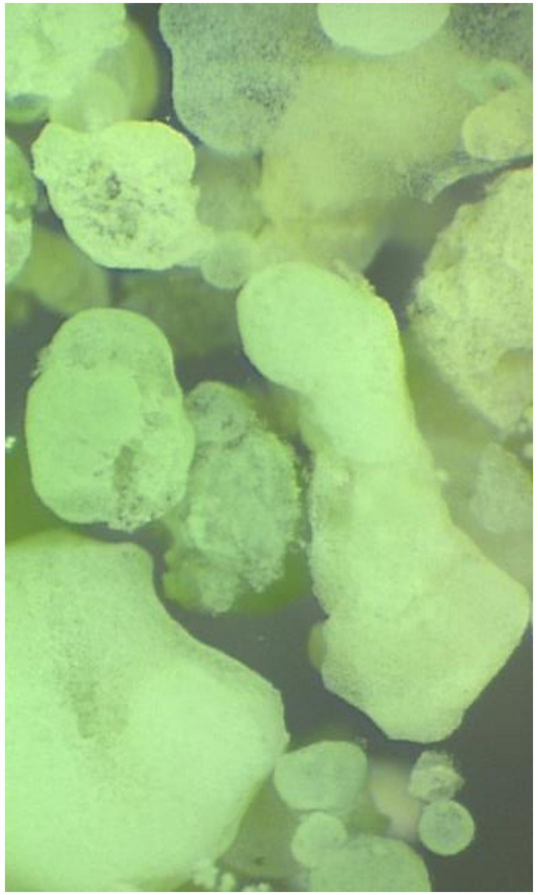


Figure Source: Gina LaLiberte. Used with permission.

Cyanotoxin Production and Release

- Toxin production varies over time and space
- Multiple toxin types may be produced by single species

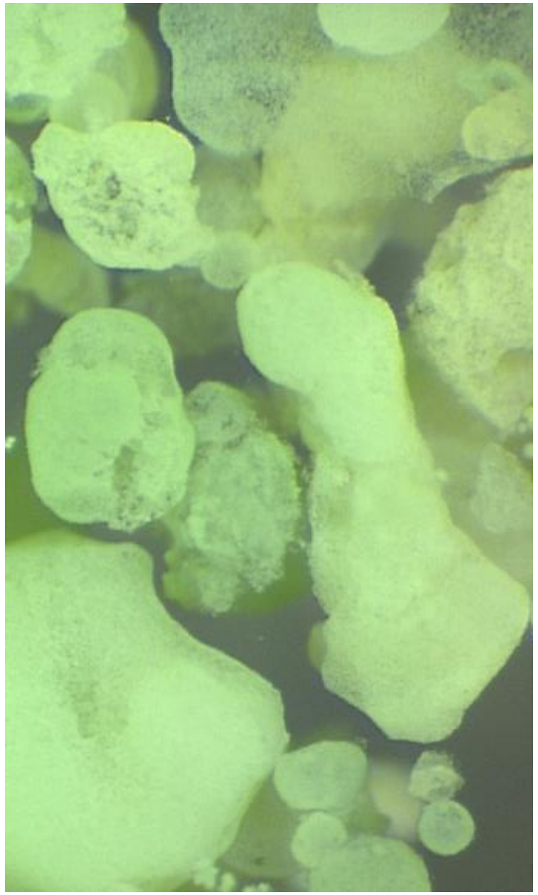


Figure Source: Gina LaLiberte. Used with permission.

Cyanotoxin Production and Release

- Toxin production varies over time and space
- Multiple toxin types may be produced by single species
- Toxins generally held within the cyanobacterial cell (intracellular) with the exception of cylindrospermopsin

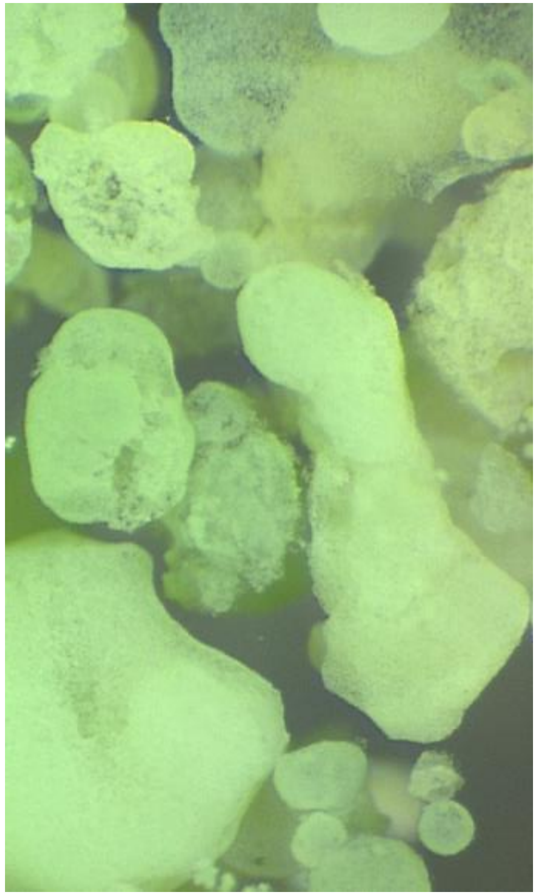


Figure Source: Gina LaLiberte. Used with permission.

Cyanotoxin Production and Release

- Toxin production varies over time and space
- Multiple toxin types may be produced by single species
- Toxins generally held within the cyanobacterial cell (intracellular) with the exception of cylindrospermopsin
- Toxins are released to water (become extracellular) as the cell dies/lyses
  - when the bloom naturally decays
  - when a chemical treatment is applied
  - when cells are ingested

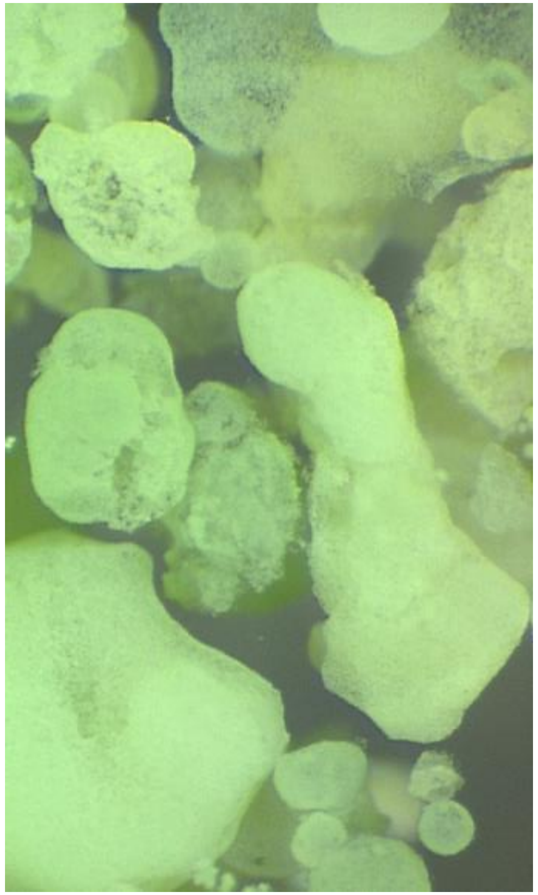


Figure Source: Gina LaLiberte. Used with permission.

How can humans and animals be exposed?

- Potential exposure to cyanobacteria and cyanotoxins can occur:
  - In or near a water body with HCB
    - accidentally swallowing affected water
    - breathing in aerosols in water spray or mist
    - direct water contact with skin
  - Ingestion of contaminated drinking water or food

Figure A – 36. Andrew Chapman. Used with permission.

How can humans and animals be exposed?

- Animals are especially at risk because of:
  - higher exposure while drinking and swimming in affected waters
  - ingestion from grooming cyanobacteria that has accumulated on their fur/feathers, or eating scum/mat material
- Children also have higher risk due to smaller body weight, more time in water, hand to mouth behavior

Figure A – 36. Andrew Chapman. Used with permission.

Current HCB Regulations and Guidance

- There are currently no federal standards for cyanobacteria or cyanotoxins
- Guidance has been released by the USEPA for two cyanotoxins (microcystin and cylindrospermopsin) in recreational and drinking water
- WHO developed recreational guidance for microcystin-LR, anatoxin-a, cylindrospermopsin, and saxitoxin
- Many states have developed their own regulatory or guidance values for HCBs and their cyanotoxins
- Guidelines for benthic cyanobacteria are lacking

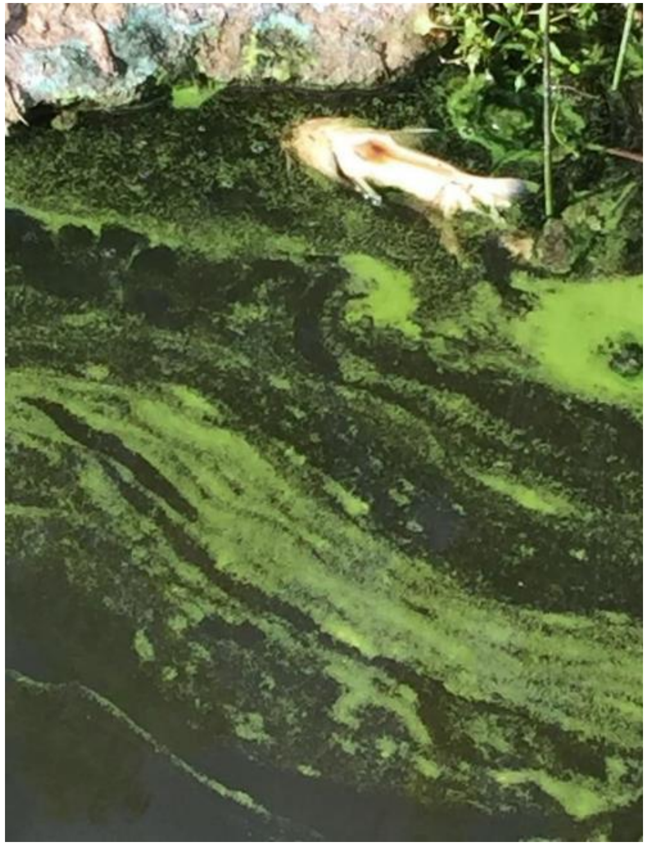


Figure A – 38. Elizabeth Fabri Smith. Used with permission.

Stay tuned to learn about:

- Guidance and selection tools for a HCB management plan
  - Monitoring for Cyanobacteria and Cyanotoxins
  - Communication and Response Planning
  - In-lake Management and Control
  - Nutrient Reduction

Figure A – 25. Midge Eliassen. Used with permission.

Advancing
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Introduction to Cyanobacteria

★ **Monitoring for Cyanobacteria**

Communication and Bloom Response Planning

Management and Control Strategies for HCBs

HCB Nutrient Reduction Strategies

See Section 4 of the HCB Guidance Document

HCB Monitoring

- Analytical methods for measuring cyanobacteria and cyanotoxin levels
- Field collection methods
- Demonstration of the interactive analytical method selection tool
- Elements of a cyanobacteria monitoring program

Fig. 4 – 9. Examples of several ways to collect grab samples for cyanobacteria. Source: NJ DEP, used with permission.

Today's training will provide the basic understanding to design and conduct a monitoring plan to meet your needs.

Monitoring Data Describe Conditions

- Counts and measures cyanobacteria or cyanotoxins
  - What kind
  - How much
  - When
  - Where
- May include other water quality parameters

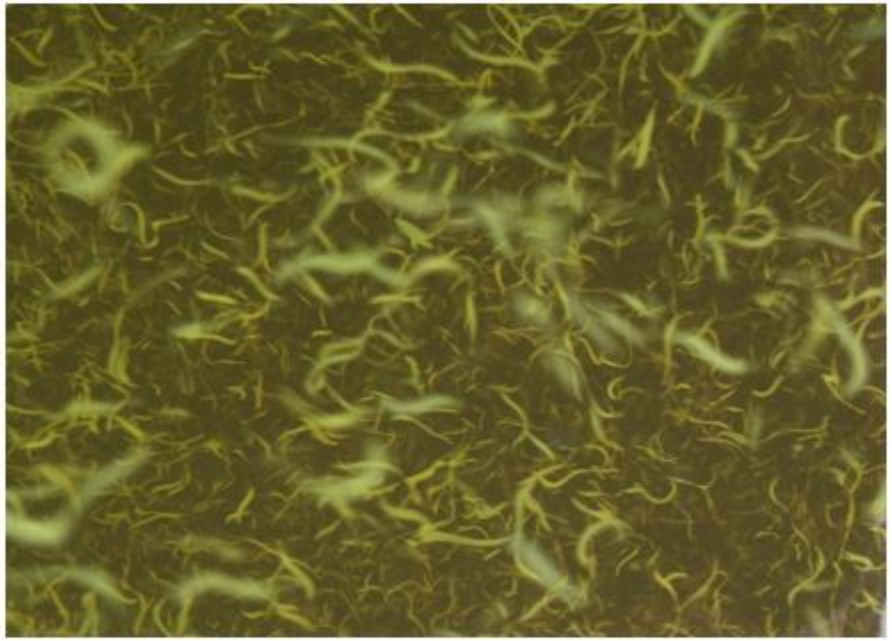


Fig. A – 7. *Aphanizomenon flos-aquae*, Klamath Lake OR.
Source: Jacob Kann, used with permission.

Monitoring Supports Response Plans

Response plans tell you:

- What to do when a bloom is reported
- The level of cyanobacteria/cyanotoxins leading to action

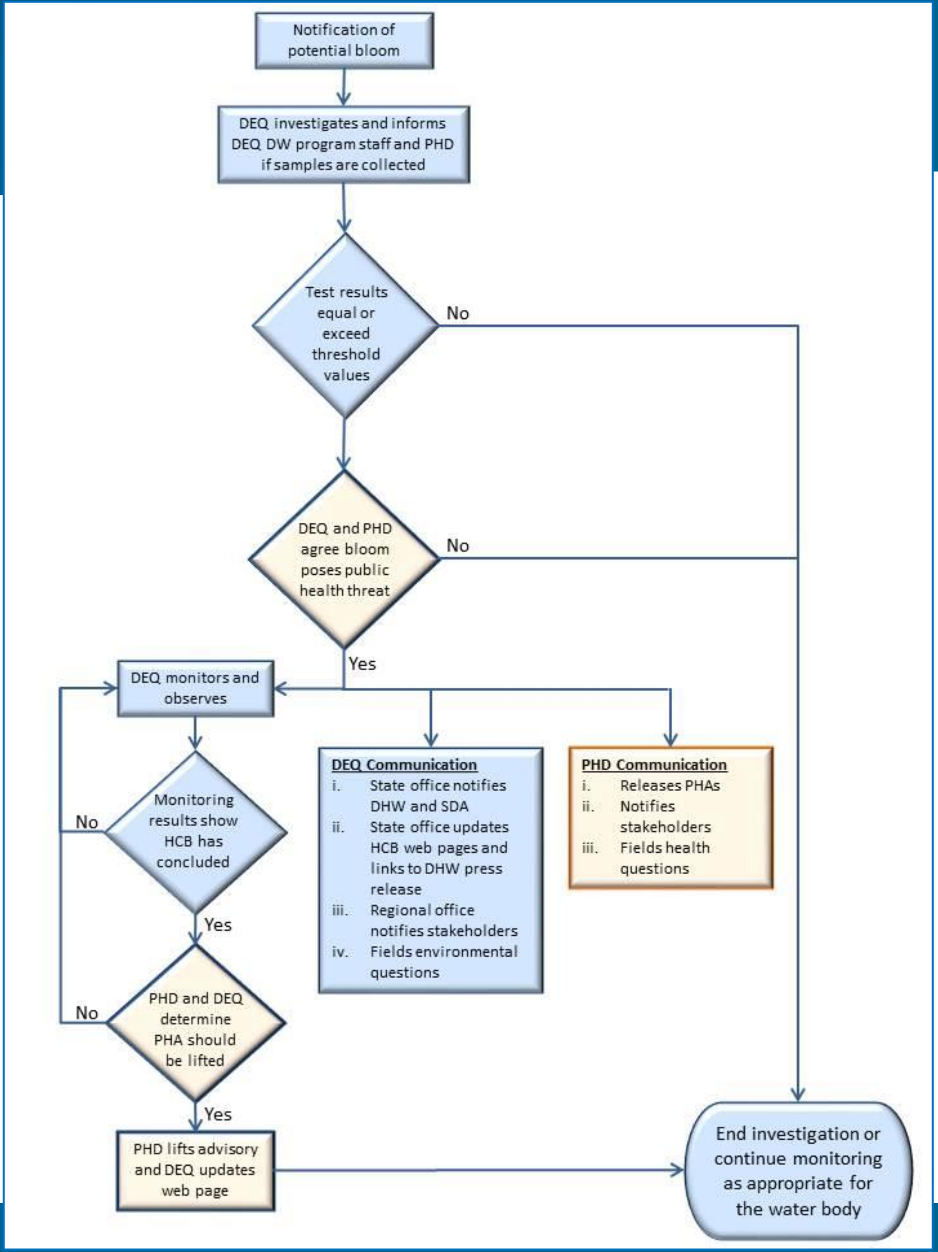


Figure 5-2. Idaho Department of Environmental Quality HCB response flow chart.
Source: Idaho DEQ, used with permission.

See Section 5 of the HCB Guidance Document

Monitoring May Support Management

- Management options include
  - In-lake HCB control
  - Watershed nutrient reductions
- Monitor BEFORE to characterize HCBs
- Monitor AFTER to evaluate success

Fig. C – 10. Applying P-binding compounds to a lake.
Source Keith Pilgrim, used with permission.

Monitoring Plans Focus On Your Needs

- Identify methods
  - Get the data for action/alert levels
- Set a budget and staff resources
- Create consistency
  - Save time and avoid confusion

Fig. A – 61. *Planktothrix* spp., Clear Lake, MN.
Source: Rachel Crabb, used with permission.

Sampling Or Monitoring?

- Sampling = Single point data in response to a report of HCBs
- Monitoring = Routine data to detect impending blooms and chart trends

Fig. A – 75. *Woronichinia naegeliana*, Kalamazoo County, MI.
Source: Ann St. Amand, used with permission.

Methods For Cyanobacteria

Visual assessment

Jar and stick test

Remote sensing

Microscopy

Pigments

Genetic identification

Simple -
minimal training & tools

Complex –
specific training and equipment

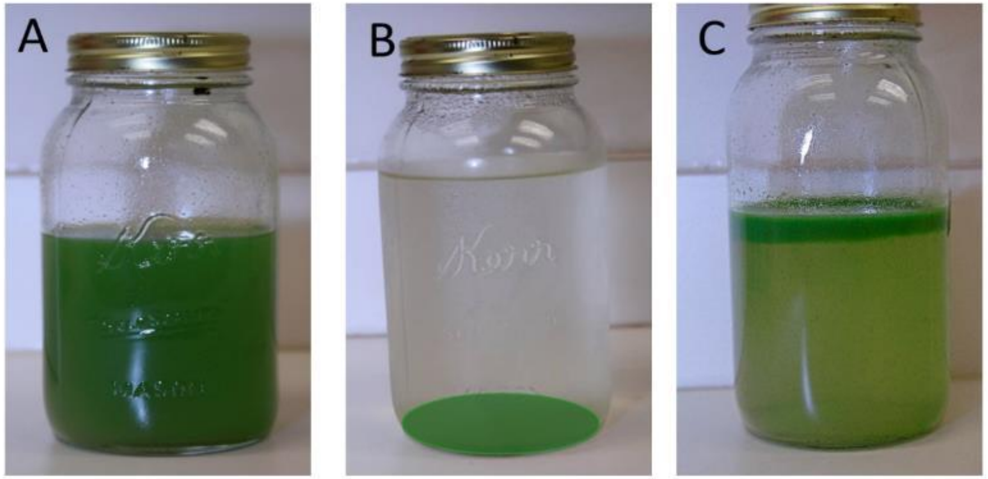


Fig. 4 – 4, using the jar test. Source: KS DHE, used with permission.

Evaluation Criteria For Cyanobacteria Methods

- Result
- Sampling type
- Turn around time
- Level of training
- Lab required
- Relative cost

- Cyanobacteria presence/absence
- Cyanobacteria identification
- Cyanobacteria density
- Cyanobacteria toxins

Make Sure You Understand The Criteria

- Turn around time = time needed to prepare sample, run analysis, receive raw data
  - Less than 1 day
  - 1 – 3 days

Fig. A-5, *Aphanizomenon flos-aquae*.
Source: Jacob Kann, used with permission.

Cyanobacteria Methods Don't Measure Cyanotoxins

- <u>Cyanobacteria toxins</u> refers to ability to detect presence of cyanotoxins
  - Suitable – can tell you if cyanotoxins are present
  - Not Suitable – cannot tell you if cyanotoxins are present

Visual assessment
Jar and stick test
Remote sensing

Microscopy
Genetic identification
Pigments

Methods For Cyanotoxins

Strip tests/dipsticks

Enzyme-linked Immunosorbent Assay (ELISA)

Protein Phosphatase Inhibition Assay (PPIA)

Chromatography (LC)

Mass Spectrometry (MS, LC/MS)

Cyanotoxin Gene Expression (PCR and qPCR)

Simple - minimal training & tools

Complex – Specific training & equipment

Fig. 4-12. Deployment of a SPATT sampler for cyanotoxins in Zion National Park.
Source: Robyn Henderek, used with permission.

Things To Remember About Cyanotoxin Testing

- No single method measures all possible cyanotoxins
- Guidance values may not be available
- Interference from environmental compounds or other contaminants can occur
- Careful preparation and extraction may be needed

Cyanotoxin results tell you **ONLY** about conditions at the time you filled your bottle!

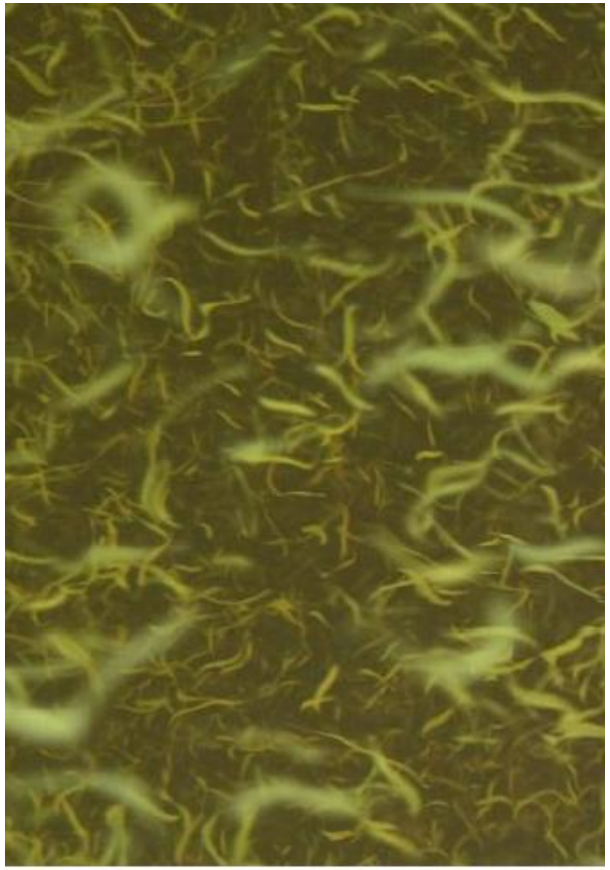
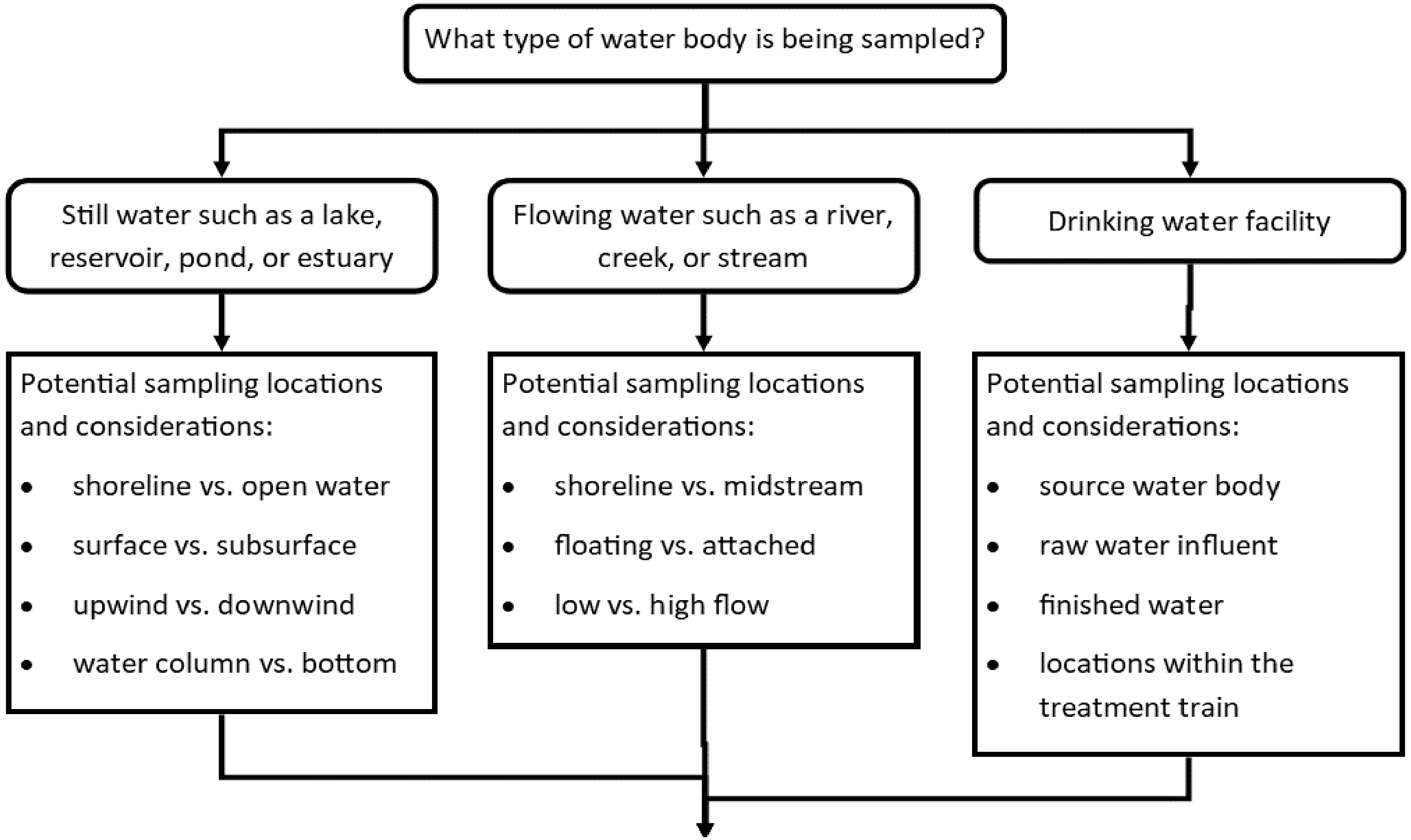


Fig. A-7, *Aphanizomenon flos-aquae.*
Source: Jacob Kann, used with permission.

Choosing Sample Collection Methods



Partial image of Fig. 4 – 8. Considerations in selecting HCB monitoring approaches.
Source: ITRC, used with permission.

See Section 4 of the HCB Guidance Document

Where Is the HCB Located?

- Planktonic methods
- Benthic methods
- Extracellular (dissolved) cyanotoxins

The guidance is currently focused on planktonic HCBs. Benthic HCBs will be added in 2022.

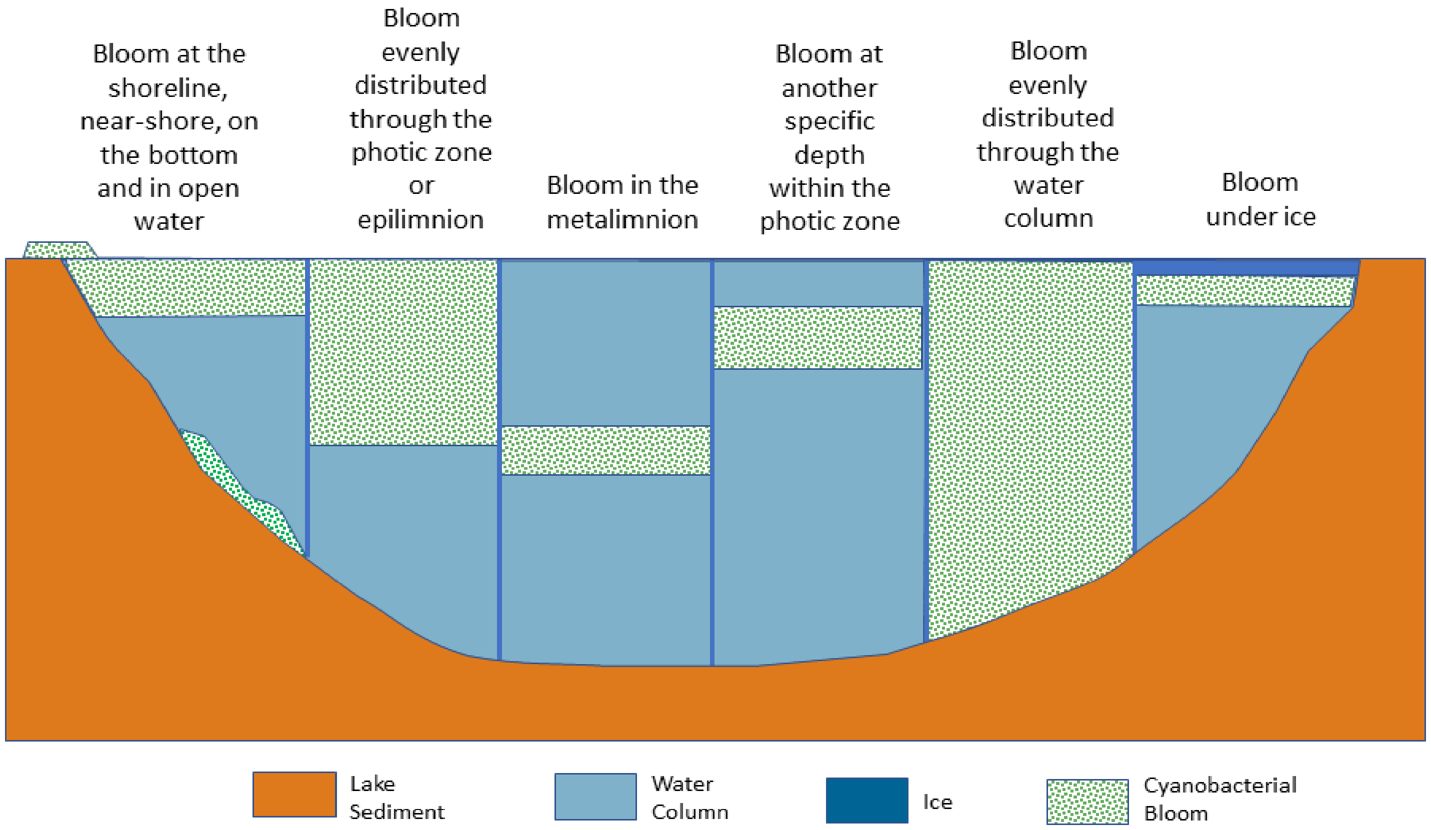


Fig. 4 – 1. Examples of cyanobacteria distribution in a lake or pond.
Source: modified from Graham et al. 2008, used with permission.

Building A Monitoring Plan

- Why?
- When?
- Where?
- How?
- Who?

Source: KDHE, used with permission.

Building A Monitoring Plan

- Consider the sustainability:
  - Staffing and analytical resources
  - Training needs
  - Quality control requirements
- Develop partnerships with other agencies/entities to improve sampling frequency/coverage.

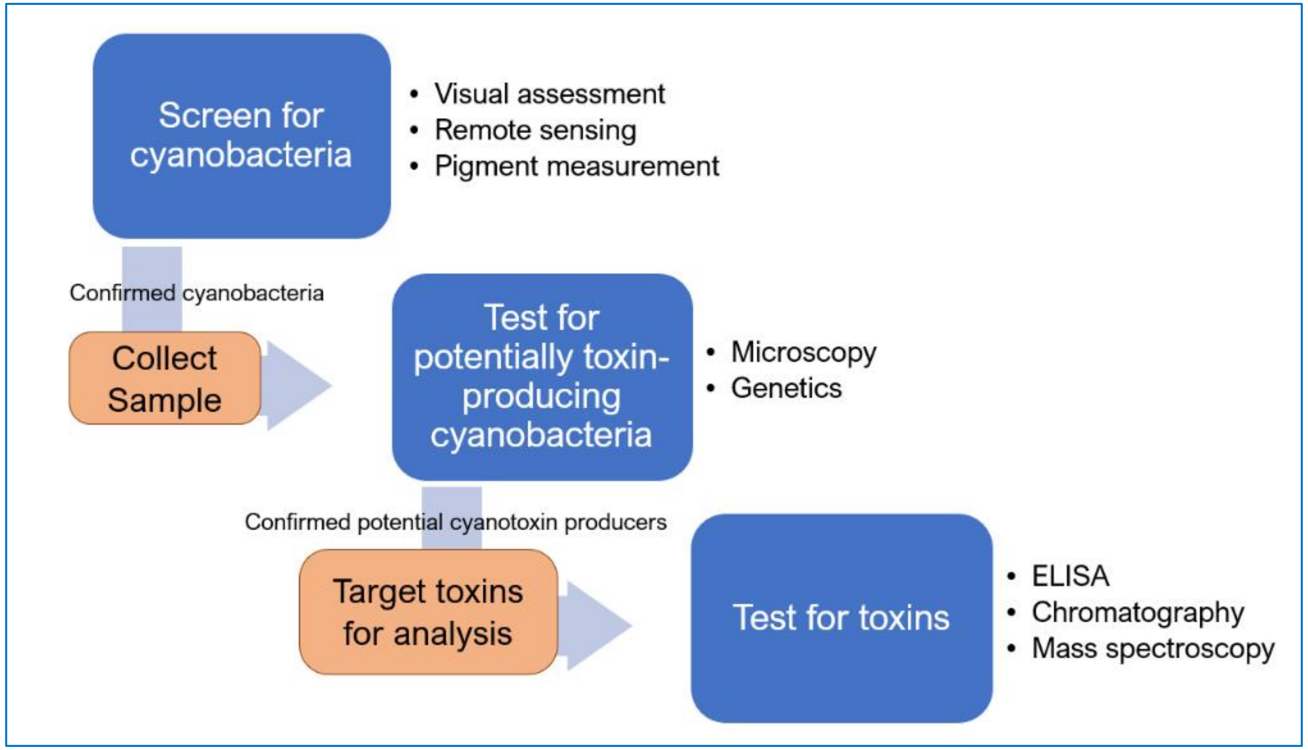


Fig. 4 – 3. Common sequence of monitoring steps used to evaluate risk from HCBs.
Source: ITRC, used with permission.

See Section 4.3 of the HCB Guidance Document

Building A Monitoring Plan

- Take into account additional monitoring considerations
  - Monitoring for environmental conditions
  - Evaluation of management and best management practice (BMP) success

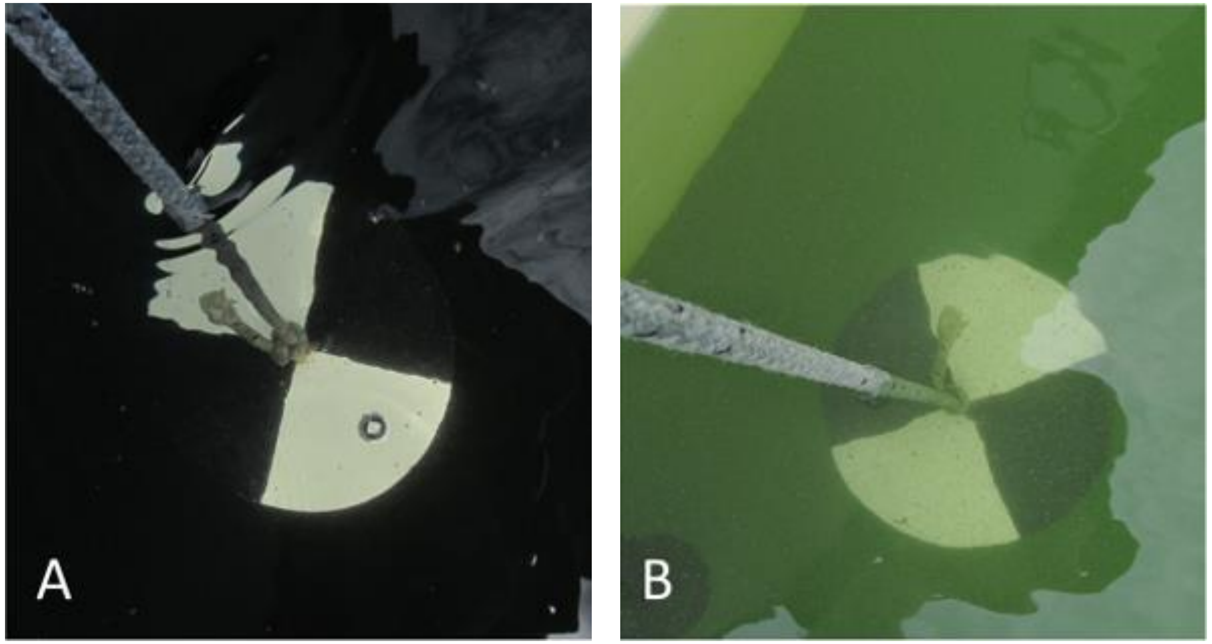
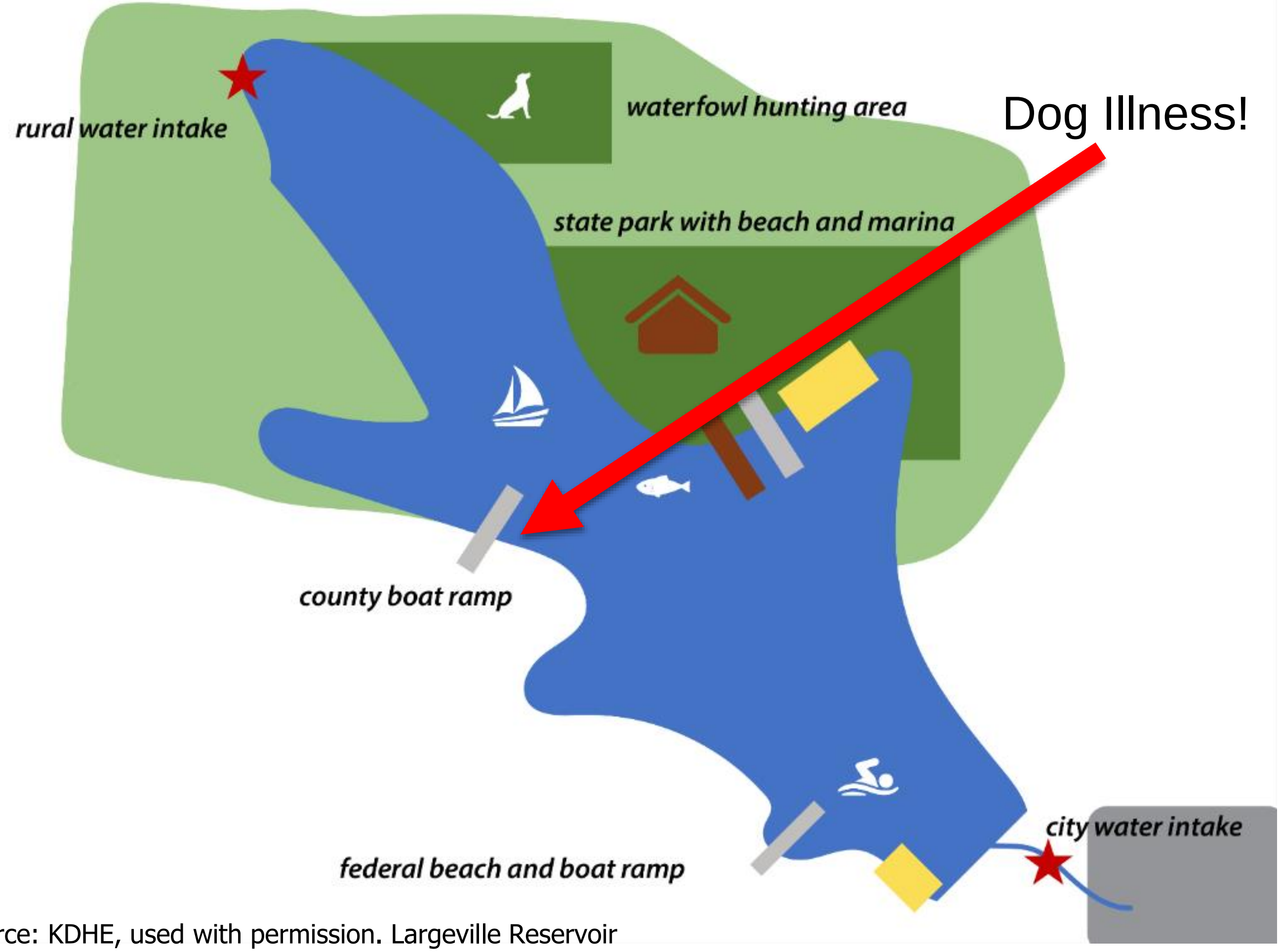


Fig. 4-13. Secchi discs are a common tool to measure water transparency.
Source: VT DEC, used with permission.

Using The Monitoring Tool To Design A Program

- In our hypothetical watershed
  - No previous HCB reports
- State confirmed HCB and presence of cyanotoxins



Source: KDHE, used with permission. Largeville Reservoir

Example Response Plan Goals

- Rapid communication about HCBs
- Early recognition of a potential HCB
- Information for
  - Drinking water (rural, city)
  - Recreation (boating, swimming, fishing)
  - Pets

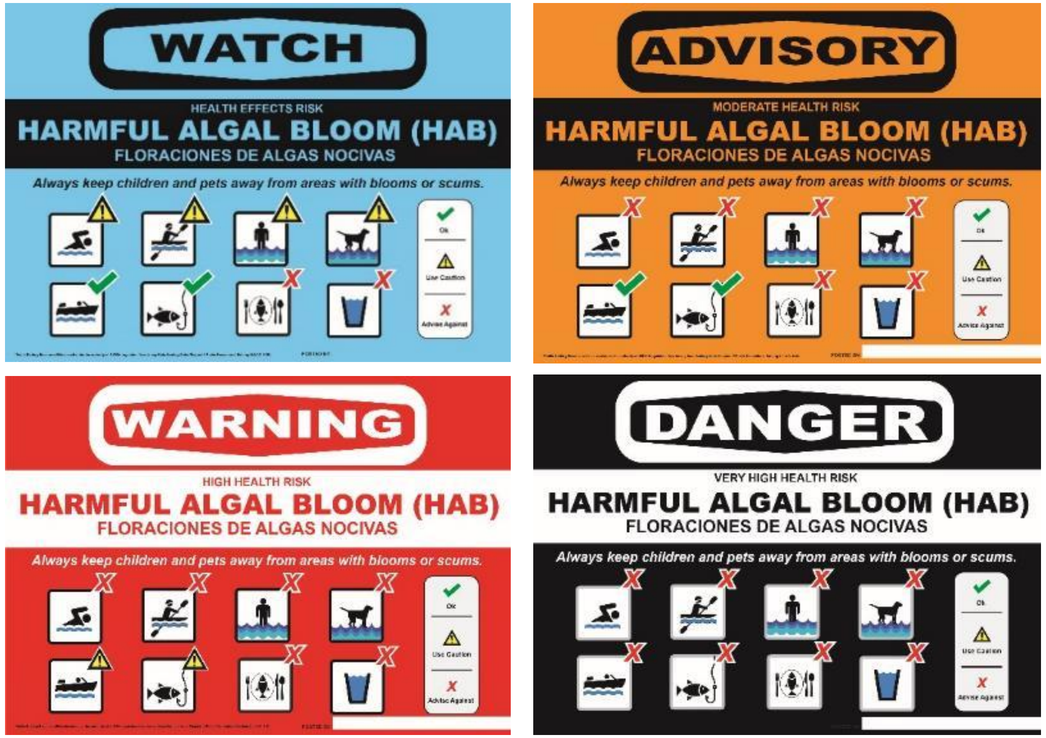


Fig. 5-3, NJ DEP HCB Advisory signage, 2020. Used with permission.

Using The Monitoring Selection Tool

Select your monitoring requirements:					
Target Analyte		Lab Required		Turnaround Time	
☑	Cyanobacteria	☐	Yes	☑	Less than 24 hours
☑	Cyanotoxin	☑	No	☐	1 to 3 days

- What are the fastest methods?

Method	Cyanobacteria			Cyanotoxin			Result Type	Sample Type	Relative Cost	Level of Training
	P/A	ID	DEN	P/A	CGN	TOT				

Using The Monitoring Selection Tool

Method	Cyanobacteria			Cyanotoxin			Result Type	Sample Type	Relative Cost	Level of Training
	P/A	ID	DEN	P/A	CGN	TOT				
Visual Assessments	●	●	●	●	●	●	Qualitative	Variable	$	Novice
Jar and Stick Tests	●	●	●	●	●	●	Qualitative	Point sampling	$	Novice
Pigments	●	●	●	●	●	●	Quantitative	Point sampling	$$	Intermediate
Remote Sensing	●	●	●	●	●	●	Quant./Qual.	Indirect	$	Intermediate / Expert

- Will they confirm HCBs? ID species? Measure cyanotoxins?

Using The Monitoring Selection Tool

Method	Cyanobacteria			Cyanotoxin			Result Type	Sample Type	Relative Cost	Level of Training
	P/A	ID	DEN	P/A	CGN	TOT				
Visual Assessments	🟢	🔴	🔴	🔴	🔴	🔴	Qualitative	Variable	$	Novice
Jar and Stick Tests	🟢	🔴	🔴	🔴	🔴	🔴	Qualitative	Point sampling	$	Novice
Pigments	🟢	🔴	🟢	🔴	🔴	🔴	Quantitative	Point sampling	$$	Intermediate
Remote Sensing	🟢	🔴	🟢	🔴	🔴	🔴	Quant./Qual.	Indirect	$	Intermediate / Expert
Microscopy	🟢	🟢	🟢	🔴	🔴	🔴	Quant./Qual.	Point sampling	$$	Intermediate / Expert
Genetic Methods for Identification	🟢	🟢	🟡	🔴	🔴	🔴	Quantitative	Point sampling	$$	Intermediate
Automatic Classification and Machine Learning	🟢	🟢	🟢	🔴	🔴	🔴	Quantitative	Point sampling	$$	Intermediate

- How much do they cost?
- Can anyone run them?

Key Things To Remember For Monitoring

- What are your goals?
  - Analytical results must support goals!
- Use the selection tool to evaluate options
- Build a monitoring plan that includes:
  - Who, what, when, where, and why
  - Meets your needs
    - Response plan
    - Management plan
  - Is sustainable in the long-term

Figure A – 71. Sampling *Raphidiopsis* spp. in OK.
Source: Ann St. Amand, used with permission.

Questions? Use the Q&A Pod

- More information needed? Email us at training@itrcweb.org

- There will be a second Q&A at the end of the training

Photo Credit: Gina LaLiberte

Advancing
Environmental
Solutions

Introduction to Cyanobacteria

Monitoring for Cyanobacteria

★ **Communication and Bloom Response Planning**

Management and Control Strategies for HCBs

HCB Nutrient Reduction Strategies

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INSTITUTE OF THE STATES
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See Section 5 of the HCB Guidance Document

HCB Risk Communication Training Objectives

- Basics of risk communication
- Immediate bloom response
- Long-term bloom response planning

Source: Utah Department of Environmental Quality. Used with permission.

What Is Risk Communication?

- Science-based approach for communicating effectively in high-stakes situations
- Leads to the public making informed decisions about threats to their health and safety
- Meets the needs of different audiences

Photo by Larry Crayton on Unsplash

Risk Communication: Best Practices

- Learn what the audience knows about the risk and listen to their concerns
- Convey information in a way the audience can understand
- Combine understanding and empathy into your explanations of risk
- Build trust and credibility

Photo by Mieke Campbell on Unsplash

Risk Communication: Best Practices

- Develop concise messages that focus on the most important information
  - Three short, key messages
  - Health risks
  - Advisories and activities that threaten human and animal health
- Coordinate and collaborate with other credible sources
- Meet the needs of the media

Message Map		
Key Message 1	Key Message 2	Key Message 3
Supporting Fact 1-1	Supporting Fact 2-1	Supporting Fact 3-1
Supporting Fact 1-2	Supporting Fact 2-2	Supporting Fact 3-2
Supporting Fact 1-3	Supporting Fact 2-3	Supporting Fact 3-3

Source: ITRC Risk Communication Toolkit. Used with permission.

See ITRC Risk Communication Toolkit, Appendix D

Risk Communication: Best Practices

- Develop communication plans before the risk becomes an issue
- Evaluate communication efforts and revise as needed

Source: ITRC Risk Communication Toolkit, Figure 4-1. Used with permission

See ITRC Risk Communication Toolkit, Section 4

Communication and Response Planning

Two types of planning:

- Immediate communication and monitoring response plan during a harmful cyanobacterial bloom (HCB)
- Long-term bloom response plan during the off-season

Source: Utah Department of Environmental Quality. Used with permission.

Immediate HCB Response Planning

- Reporting, notification, and coordination
- Bloom confirmation
- Drinking-water source identification and response
- Health advisories
- HCB-related illness reporting

Source: Utah Department of Environmental Quality. Used with permission.

Reporting, Notification, and Coordination

- Bloom reporting mechanism
- Notification of partner agencies
- Partner response coordination
- Public notification

Source: Utah Department of Environmental Quality. Used with permission.

Bloom Identification and Confirmation

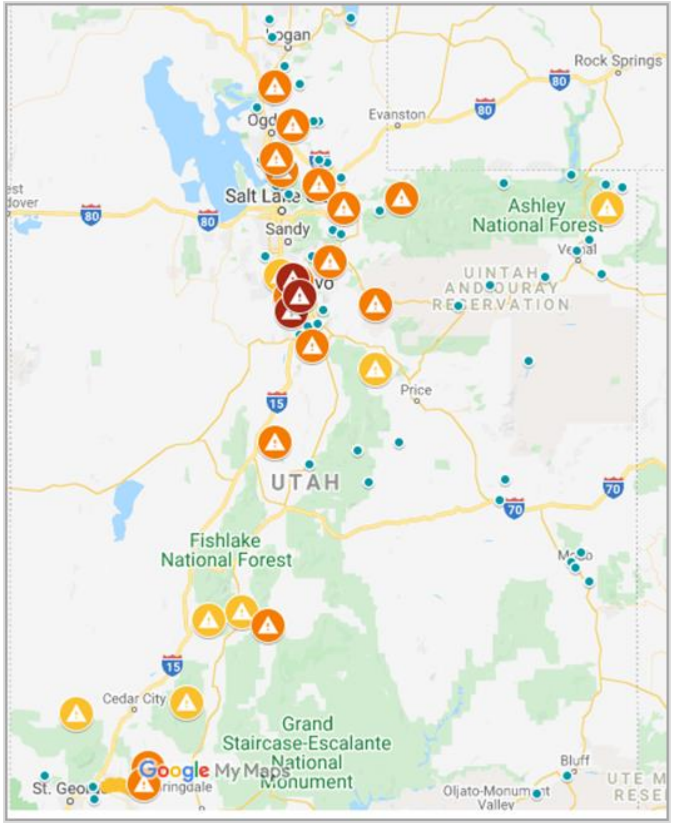
- Visual observations
- Remote sensing
- Field sampling
- Laboratory analysis

Visit the Monitoring section of the ITRC HCB Guidance document and the Interactive Monitoring Tool for more information.

Source: Utah Department of Environmental Quality. Used with permission.

Communication about Confirmed Blooms

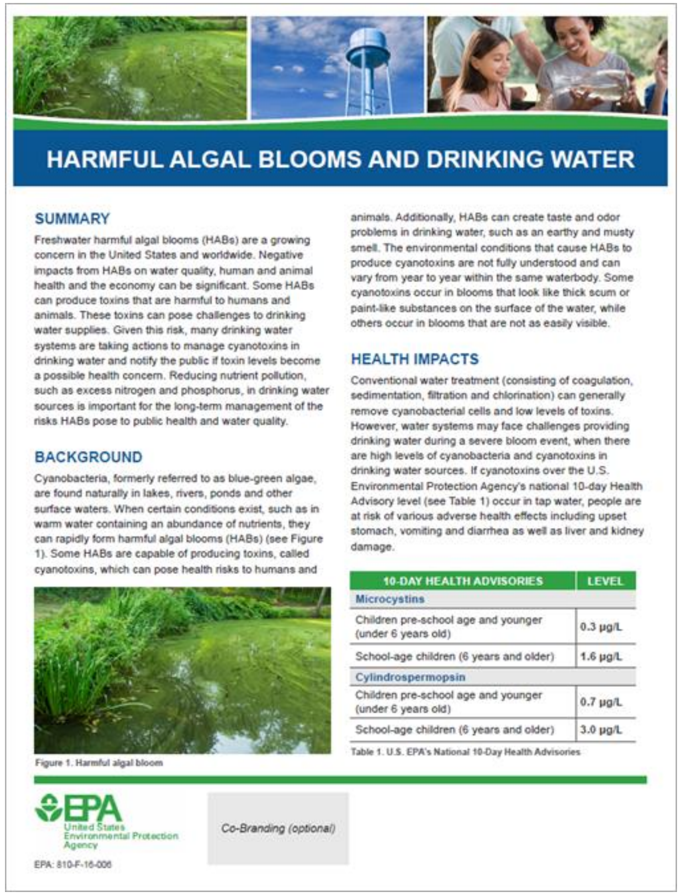
- What is known and unknown about an HCB and when updates will be available
- Locations for additional information
  - Dedicated website
  - Call-in lines
  - Social media channels
- Mechanism for reporting blooms or potential HCB-related illness



Source: Utah Department of Environmental Quality. Used with permission

Drinking Water Sources

- Coordination with public water systems
- Cyanotoxin management response plans for water systems
  - Sampling of source waters near plant intakes
  - Appropriate treatment considerations
  - Alternative water sources
  - Public notification



HARMFUL ALGAL BLOOMS AND DRINKING WATER

SUMMARY

Freshwater harmful algal blooms (HABs) are a growing concern in the United States and worldwide. Negative impacts from HABs on water quality, human and animal health and the economy can be significant. Some HABs can produce toxins that are harmful to humans and animals. These toxins can pose challenges to drinking water supplies. Given this risk, many drinking water systems are taking actions to manage cyanotoxins in drinking water and notify the public if toxin levels become a possible health concern. Reducing nutrient pollution, such as excess nitrogen and phosphorus, in drinking water sources is important for the long-term management of the risks HABs pose to public health and water quality.

BACKGROUND

Cyanobacteria, formerly referred to as blue-green algae, are found naturally in lakes, rivers, ponds and other surface waters. When certain conditions exist, such as in warm water containing an abundance of nutrients, they can rapidly form harmful algal blooms (HABs) (see Figure 1). Some HABs are capable of producing toxins, called cyanotoxins, which can pose health risks to humans and animals. Additionally, HABs can create taste and odor problems in drinking water, such as an earthy and musty smell. The environmental conditions that cause HABs to produce cyanotoxins are not fully understood and can vary from year to year within the same waterbody. Some cyanotoxins occur in blooms that look like thick scum or paint-like substances on the surface of the water, while others occur in blooms that are not as easily visible.

Figure 1. Harmful algal bloom

HEALTH IMPACTS

Conventional water treatment (consisting of coagulation, sedimentation, filtration and chlorination) can generally remove cyanobacterial cells and low levels of toxins. However, water systems may face challenges providing drinking water during a severe bloom event, when there are high levels of cyanobacteria and cyanotoxins in drinking water sources. If cyanotoxins over the U.S. Environmental Protection Agency's national 10-day Health Advisory level (see Table 1) occur in tap water, people are at risk of various adverse health effects including upset stomach, vomiting and diarrhea as well as liver and kidney damage.

10-DAY HEALTH ADVISORIES	LEVEL
Microcystins	
Children pre-school age and younger (under 6 years old)	0.3 µg/L
School-age children (6 years and older)	1.6 µg/L
Cylindrospermopsin	
Children pre-school age and younger (under 6 years old)	0.7 µg/L
School-age children (6 years and older)	3.0 µg/L

Table 1. U.S. EPA's National 10-Day Health Advisories

EPA United States Environmental Protection Agency

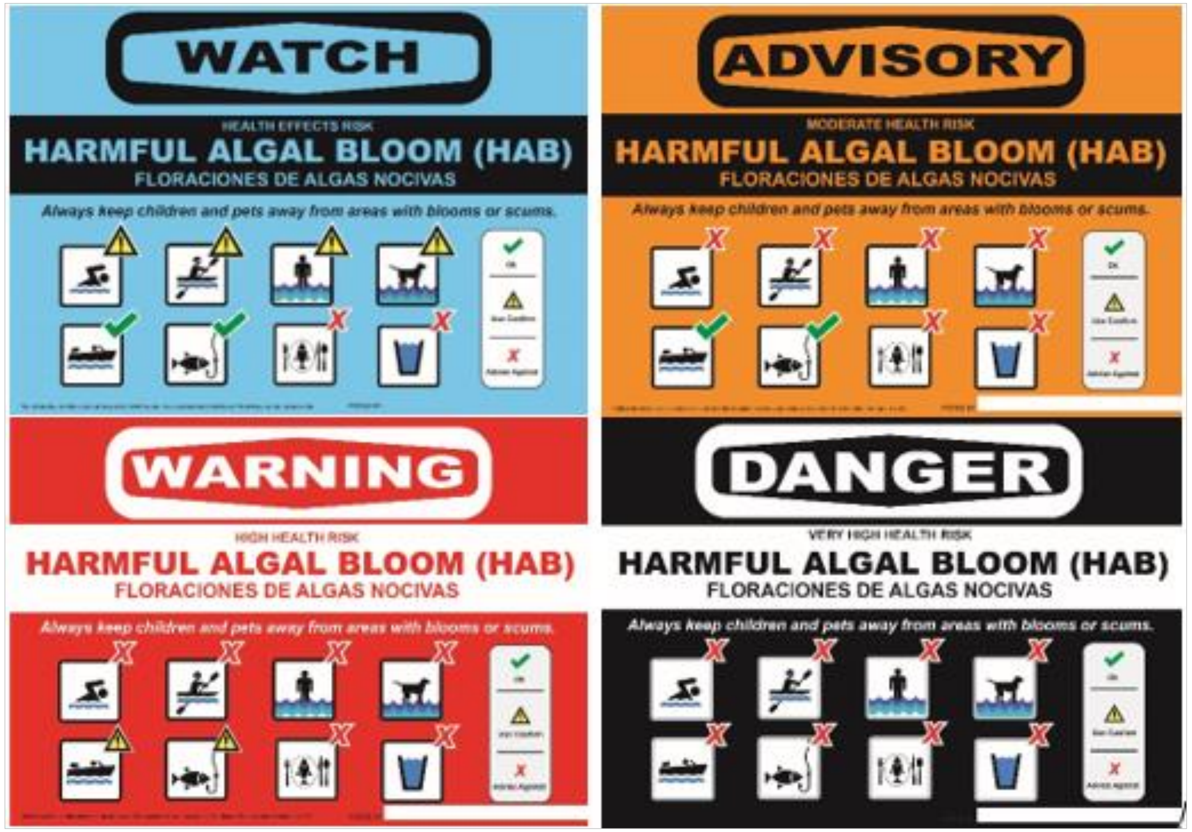
Co-Branding (optional)

EPA: 810-F-16-006

Source: EPA. Used with permission.

Signage

- Color-coding for different advisory levels and easy-to-understand icons
- Plain-language instructions
- Multi-lingual
- Specific information on the impacts to dogs
- Temporary signs vs. permanent signs for areas that often experience HCBs

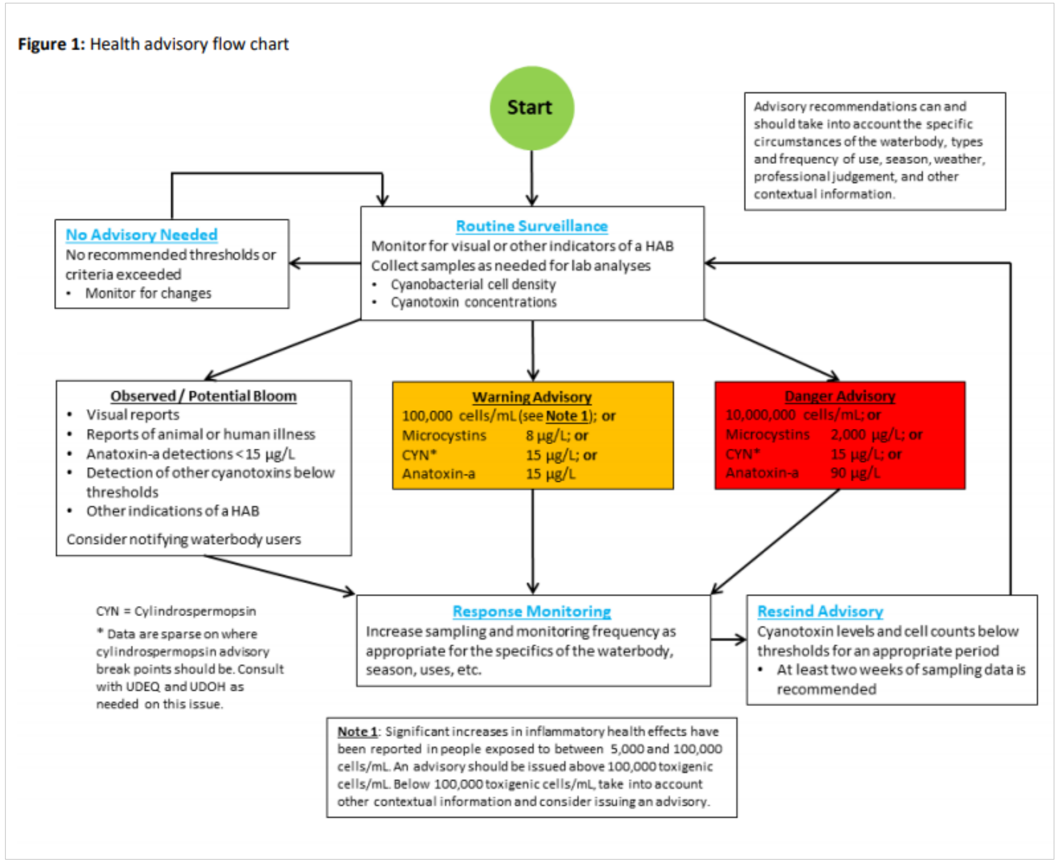


Source: New Jersey Department of Environmental Protection. Figure 5-3, ITRC HCB Guidance document. Used with permission.

See Section 5.1.5 of the HCB Guidance Document

Health Advisories

- Advisory Thresholds
  - Cyanobacteria visual abundance and/or cell count concentrations
  - Cyanotoxins
- Mechanism to issue advisory
- How and when to post advisories
  - Signs
  - Press release
  - Website
  - Social media



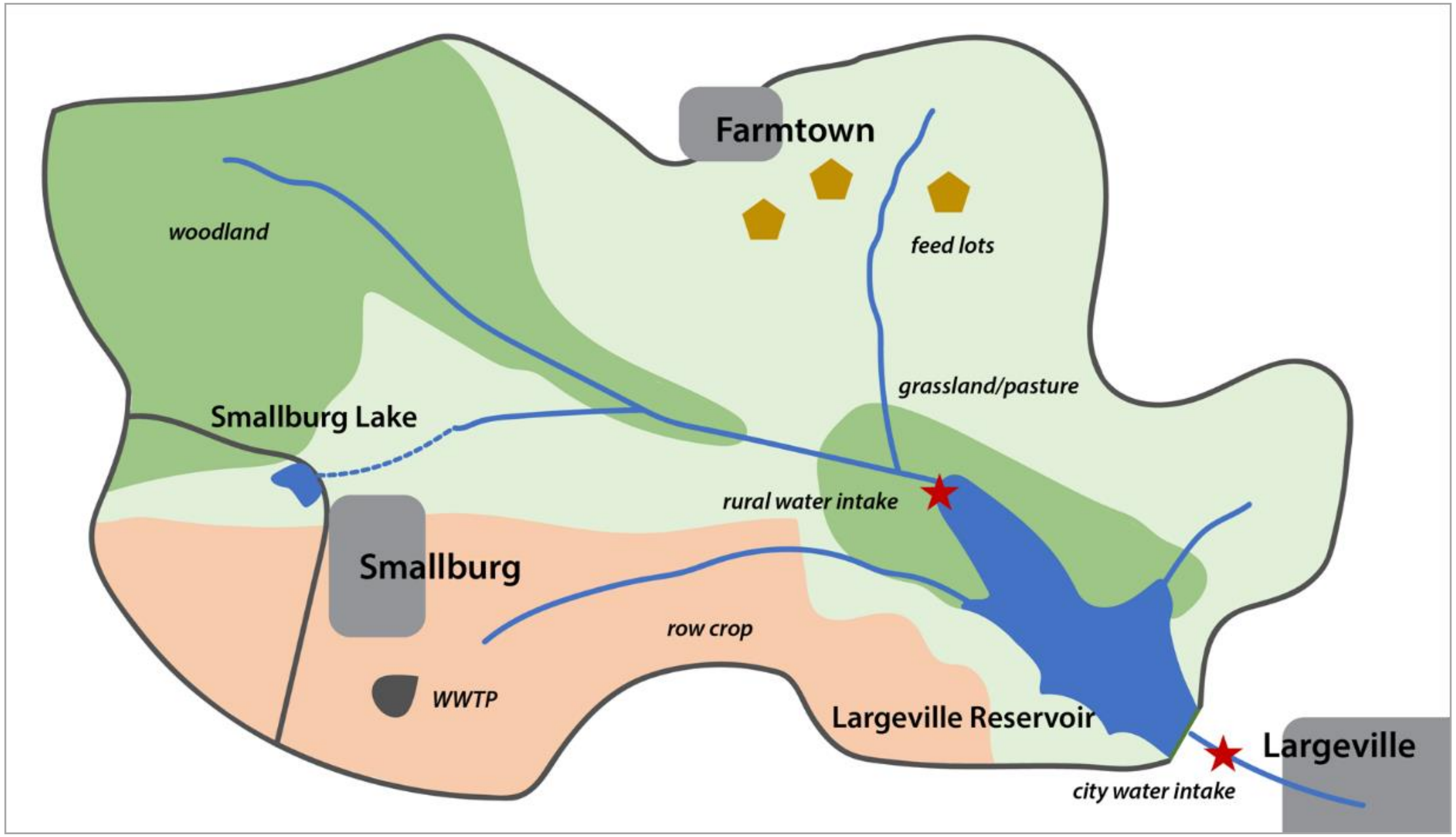
Source: Utah Department of Environmental Quality. Used with permission

HCB-related Illnesses

- Information about HCB-related illnesses and health risk
- Centralized reporting and data collection
- Coordination with local poison control center, local health departments, and CDC (OHHABS)
- Public notification of HCB-related illnesses (human and animal)

Photo by Jove Duero on Unsplash

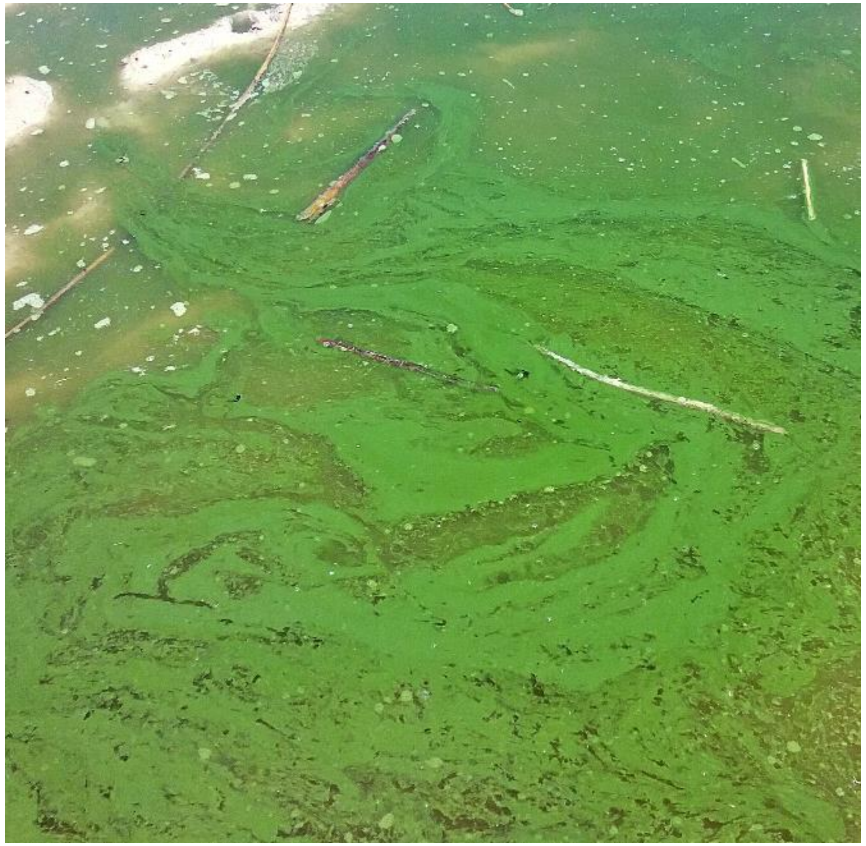
HCB Scenario: Largeville Reservoir Bloom



Source: Kansas Department of Health and Environment. Used with permission.

Step 1: Reporting, Notification, Coordination

- HCB Report-a-Bloom line receives a phone call about a suspected HCB
- Agency notifies partner organizations
- Agency issues alerts on social media



Source: Utah Department of Environmental Quality. Used with permission.

Step 2: Bloom Confirmation

- State Park staff collect samples
- State Park staff deliver samples to lab
- Lab analyzes samples for toxins
- Agency and partners notify the public and media of sampling results
- Agency organizes a town hall to answer questions

Source: Utah Department of Environmental Quality. Used with permission.

Step 3: Drinking Water Response

- Agency contacts drinking water plant
- The plant doesn't have a cyanotoxin response plan in place
- Agency samples intakes and outflows
- Drinking water plant uses alternate water source
- Drinking water plant notifies residents that the water is safe to drink

Photo by Bluewater Globe on Unsplash

Step 4: Health Advisories

- Cyanotoxin levels exceed thresholds
- Health Department issues health advisories
- Agency posts bilingual signs
- Agency issues press release
- Agency posts information on social media

Source: Utah Department of Environmental Quality. Used with permission.

Step 5: Illness Reporting

- Families fall ill and call poison control center
- The poison control center recommends that the families contact their physician
- The center collects their information and places it in its database

Photo by Dawid Sobolewsk on Unsplash

HCB Scenario: Message Mapping

Three Key Messages

1. (Your Agency) identified a harmful cyanobacteria bloom in Smallburg Lake and Largeville Reservoir.
2. The Health Department issued health advisories for toxins.
3. Do not swim in the water and obey posted notices.

Long-term Bloom Response Planning

- Routine and response sampling and monitoring
- Drinking water emergency response
- Communication and outreach
- Collaboration with partners
- Data management optimization
- Evaluation of reporting and communication of HCB-related illnesses
- Evaluation of response plan

Source: Utah Department of Environmental Quality. Used with permission.

Key Takeaways

- Risk communication provides members of the public with the information they want and need to make informed decisions.
- Immediate and long-term plans establish important processes and procedures to address HCBs before, during, and after a bloom event.
- Clear messaging and timely communication about HCBs build trust and credibility and protect public health.

Advancing Environmental Solutions

Introduction to Cyanobacteria

Monitoring for Cyanobacteria

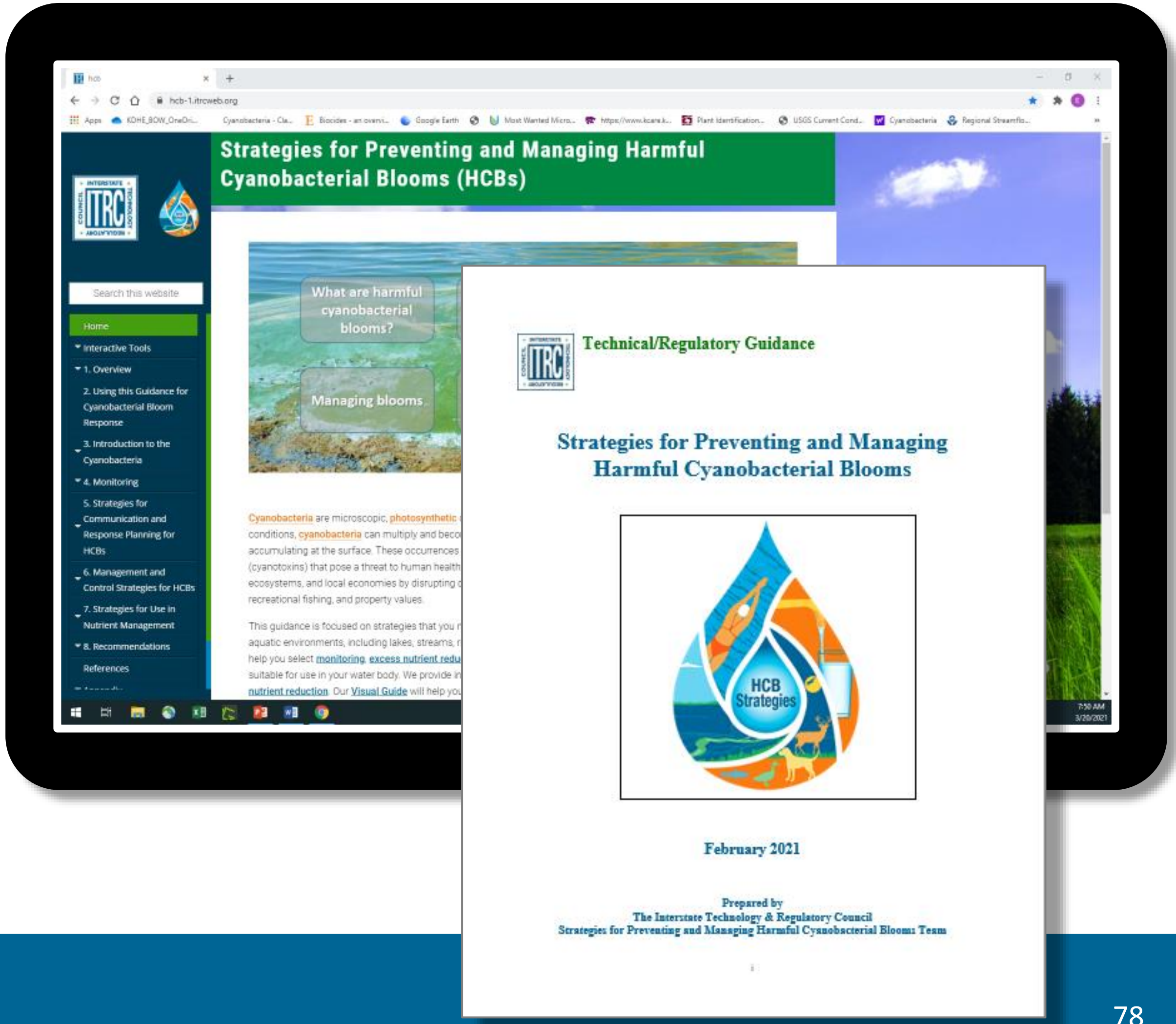
Communication and Bloom Response Planning

★ **Management and Control Strategies for HCBs**

HCB Nutrient Reduction Strategies

Management and Control Strategies

- "Help – we have a bloom! Now what?"
- Focus is on in-lake approaches
- Guidance to support sound decision making
- Browse online and download documents
  - Section 6 and Appendix C
- Explore options interactively:
  - Management Criteria Tool



Guidance Document – Section 6

- Section 6: Management and Control Strategies for HCBs
  - Broad overview of unifying themes and considerations
  - Table summarizing 24 researched strategies
  - *Strategies are linked…*

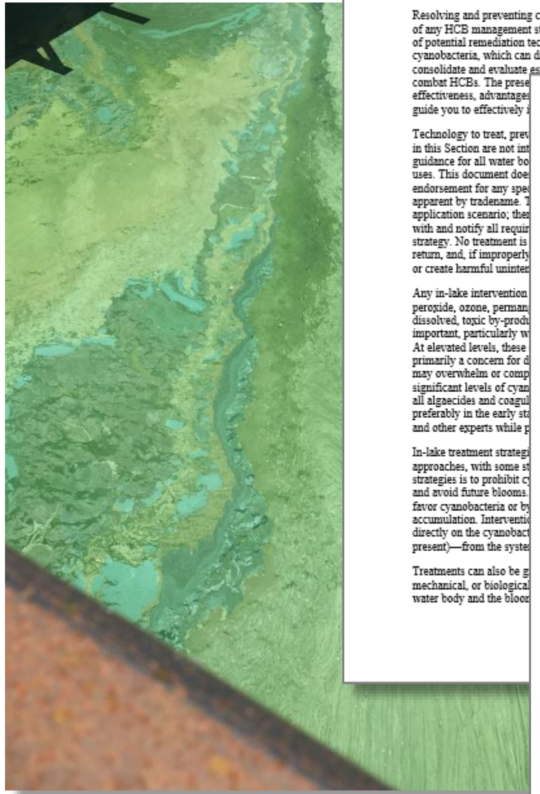
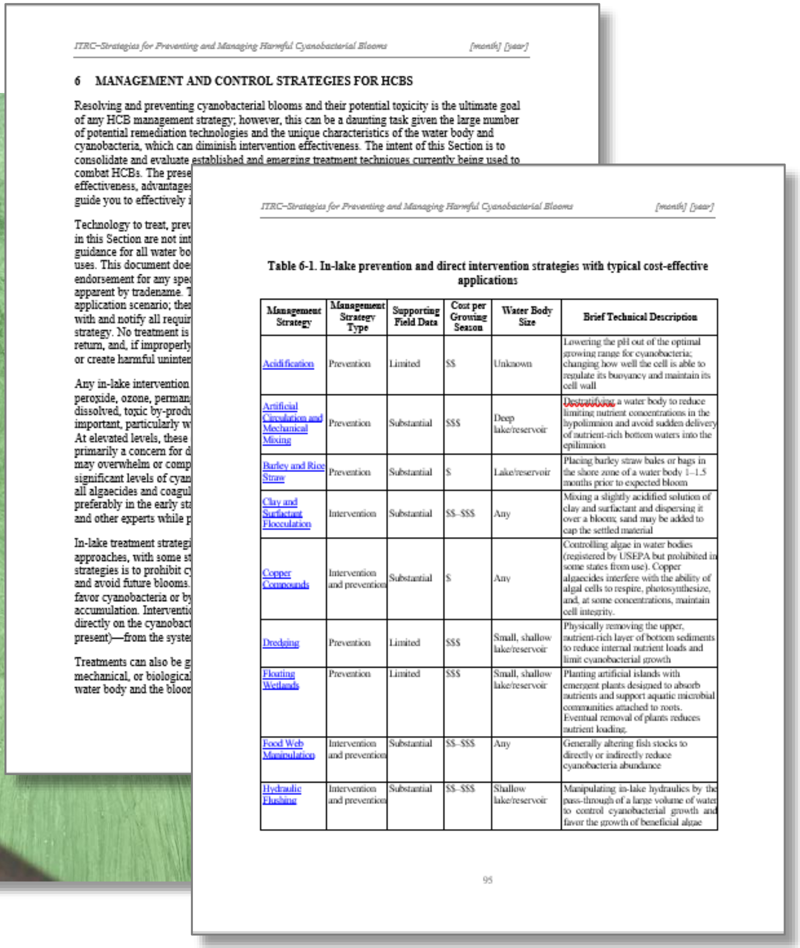


Photo by Elizabeth Smith; used with permission.



ITRC–Strategies for Preventing and Managing Harmful Cyanobacterial Blooms [month] [year]

6 MANAGEMENT AND CONTROL STRATEGIES FOR HCBS

Resolving and preventing cyanobacterial blooms and their potential toxicity is the ultimate goal of any HCB management strategy; however, this can be a daunting task given the large number of potential remediation technologies and the unique characteristics of the water body and cyanobacteria, which can diminish intervention effectiveness. The intent of this Section is to consolidate and evaluate established and emerging treatment techniques currently being used to combat HCBs. …

ITRC–Strategies for Preventing and Managing Harmful Cyanobacterial Blooms [month] [year]

Table 6-1. In-lake prevention and direct intervention strategies with typical cost-effective applications

Management Strategy	Management Strategy Type	Supporting Field Data	Cost per Growing Season	Water Body Size	Brief Technical Description
Acidification	Prevention	Limited	$$	Unknown	Lowering the pH out of the optimal growing range for cyanobacteria; changing how well the cell is able to regulate its buoyancy and maintain its cell wall
Artificial Circulation and Mechanical Mixing	Prevention	Substantial	$$$	Deep lake/reservoir	Destratifying a water body to reduce limiting nutrient concentrations in the hypolimnion and avoid sudden delivery of nutrient-rich bottom waters into the epilimnion
Barley and Rice Straw	Prevention	Substantial	$	Lake/reservoir	Placing barley straw bales or bags in the shore zone of a water body 1–1.5 months prior to expected bloom
Clay and Surfactant Flocculation	Intervention	Substantial	$$–$$$	Any	Mixing a slightly acidified solution of clay and surfactant and dispersing it over a bloom; sand may be added to cap the settled material
Copper Compounds	Intervention and prevention	Substantial	$	Any	Controlling algae in water bodies (registered by USEPA but prohibited in some states from use). Copper algaecides interfere with the ability of algal cells to respire, photosynthesize, and, at some concentrations, maintain cell integrity.
Dredging	Prevention	Limited	$$$	Small, shallow lake/reservoir	Physically removing the upper, nutrient-rich layer of bottom sediments to reduce internal nutrient loads and limit cyanobacterial growth
Floating Wetlands	Prevention	Limited	$$$	Small, shallow lake/reservoir	Planting artificial islands with emergent plants designed to absorb nutrients and support aquatic microbial communities attached to roots. Eventual removal of plants reduces nutrient loading.
Food Web Manipulation	Intervention and prevention	Substantial	$$–$$$	Any	Generally altering fish stocks to directly or indirectly reduce cyanobacteria abundance
Hydraulic Flushing	Intervention and prevention	Substantial	$$–$$$	Shallow lake/reservoir	Manipulating in-lake hydraulics by the pass-through of a large volume of water to control cyanobacterial growth and favor the growth of beneficial algae

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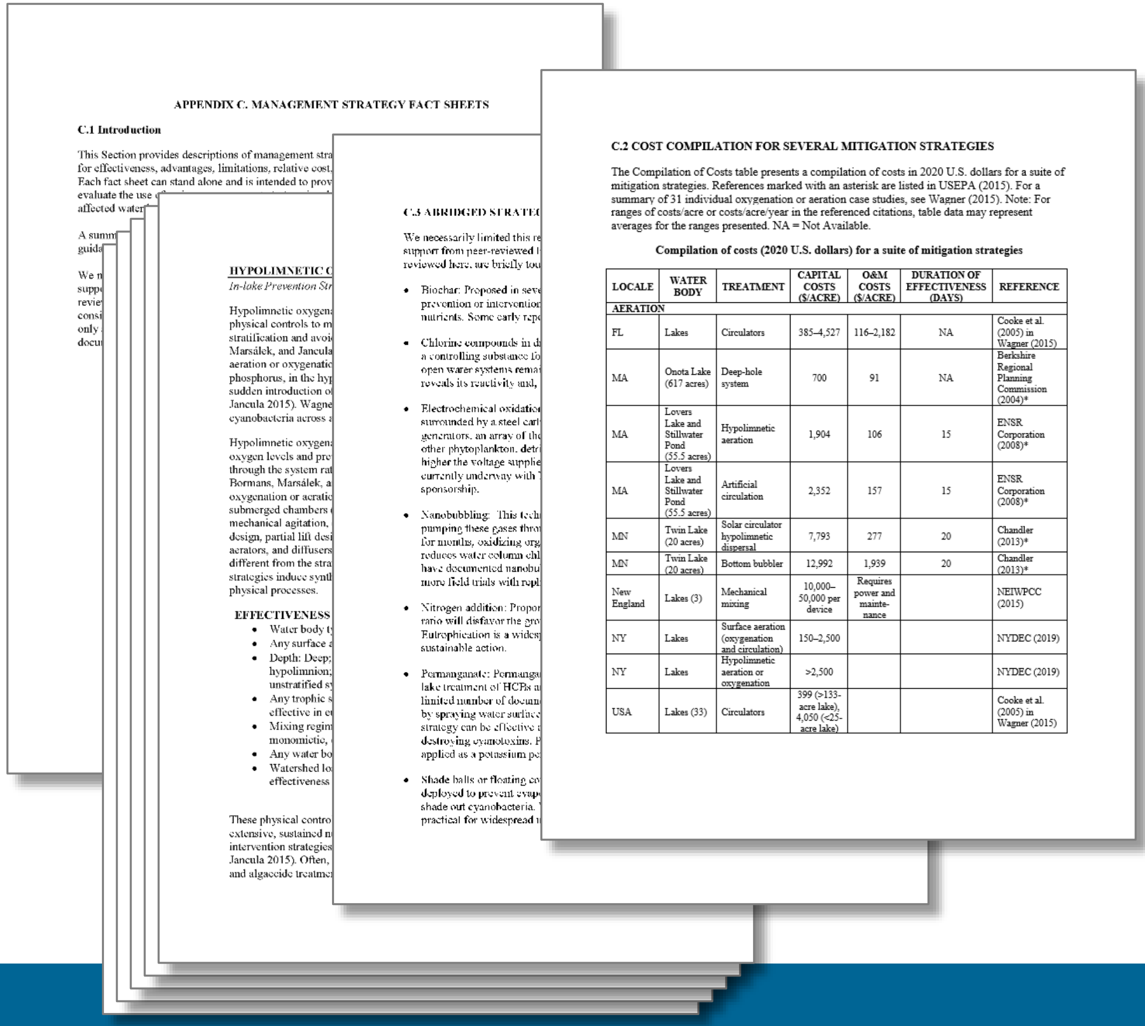
What's in Appendix C?

- Content:
  - 70+ pages of information
  - Stand alone Fact Sheets for 24 in-lake strategies
  - Brief overview of strategies not covered by Fact Sheets
  - Cost comparison table



APPENDIX C. MANAGEMENT STRATEGY FACT SHEETS

C.1 Introduction

C.2 COST COMPILATION FOR SEVERAL MITIGATION STRATEGIES

The Compilation of Costs table presents a compilation of costs in 2020 U.S. dollars for a suite of mitigation strategies. References marked with an asterisk are listed in USEPA (2015). For a summary of 31 individual oxygenation or aeration case studies, see Wagner (2015). Note: For ranges of costs/acre or costs/acre/year in the referenced citations, table data may represent averages for the ranges presented. NA = Not Available.

Compilation of costs (2020 U.S. dollars) for a suite of mitigation strategies

LOCALE	WATER BODY	TREATMENT	CAPITAL COSTS ($/ACRE)	O&M COSTS ($/ACRE)	DURATION OF EFFECTIVENESS (DAYS)	REFERENCE
AERATION						
FL	Lakes	Circulators	385–4,527	116–2,182	NA	Cooke et al. (2005) in Wagner (2015)
MA	Onota Lake (617 acres)	Deep-hole system	700	91	NA	Berkshire Regional Planning Commission (2004)*
MA	Lovers Lake and Stillwater Pond (55.5 acres)	Hypolimnetic aeration	1,904	106	15	ENSR Corporation (2008)*
MA	Lovers Lake and Stillwater Pond (55.5 acres)	Artificial circulation	2,352	157	15	ENSR Corporation (2008)*
MN	Twin Lake (20 acres)	Solar circulator hypolimnetic dispersal	7,793	277	20	Chandler (2013)*
MN	Twin Lake (20 acres)	Bottom bubbler	12,992	1,939	20	Chandler (2013)*
New England	Lakes (3)	Mechanical mixing	10,000–50,000 per device	Requires power and mainte-nance		NEIWPCC (2015)
NY	Lakes	Surface aeration (oxygenation and circulation)	150–2,500			NYDEC (2019)
NY	Lakes	Hypolimnetic aeration or oxygenation	>2,500			NYDEC (2019)
USA	Lakes (33)	Circulators	399 (>133-acre lake), 4,050 (<25-acre lake)			Cooke et al. (2005) in Wagner (2015)

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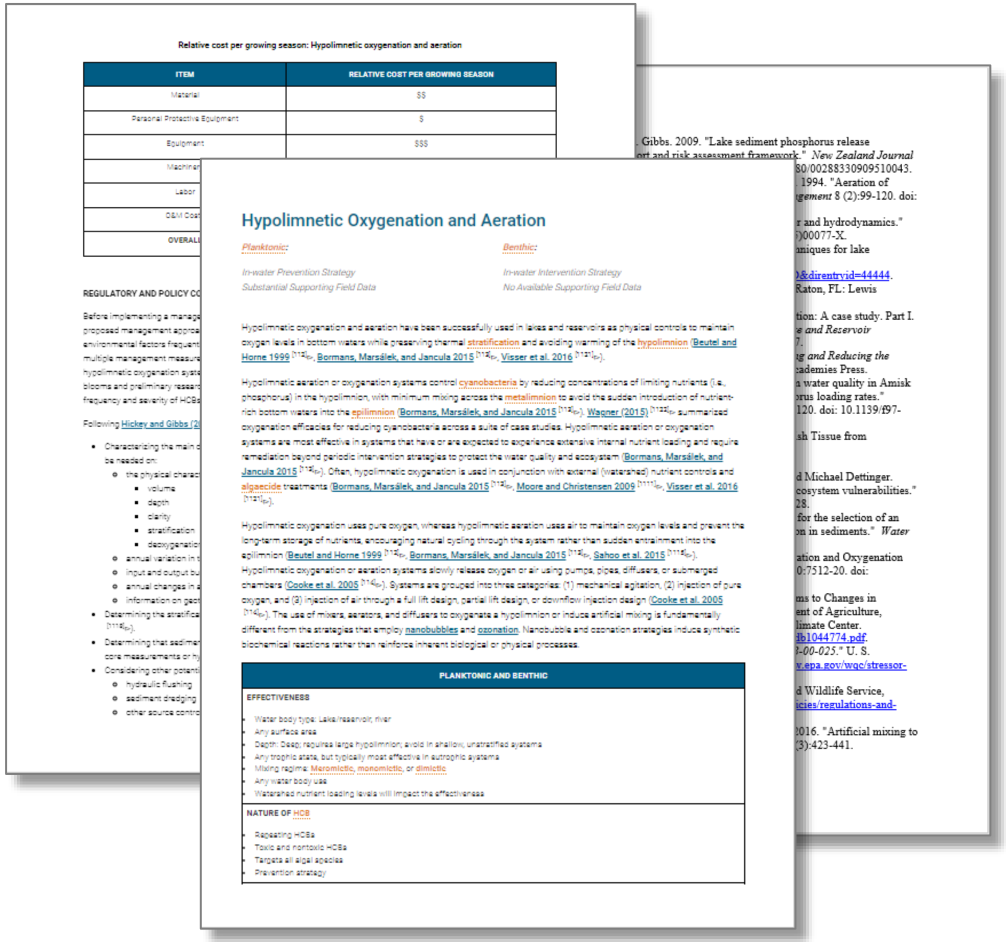
Strategies Presented in Fact Sheets

INCLUDED	EXCLUDED
Freshwater and estuarine systems	Marine systems
Surface water bodies	Engineered water systems
Support in scientific literature	Lacking independent scientific review
Widely applicable and available	Narrow range of use

Photo by Josh Ludahl on Unsplash; public domain.

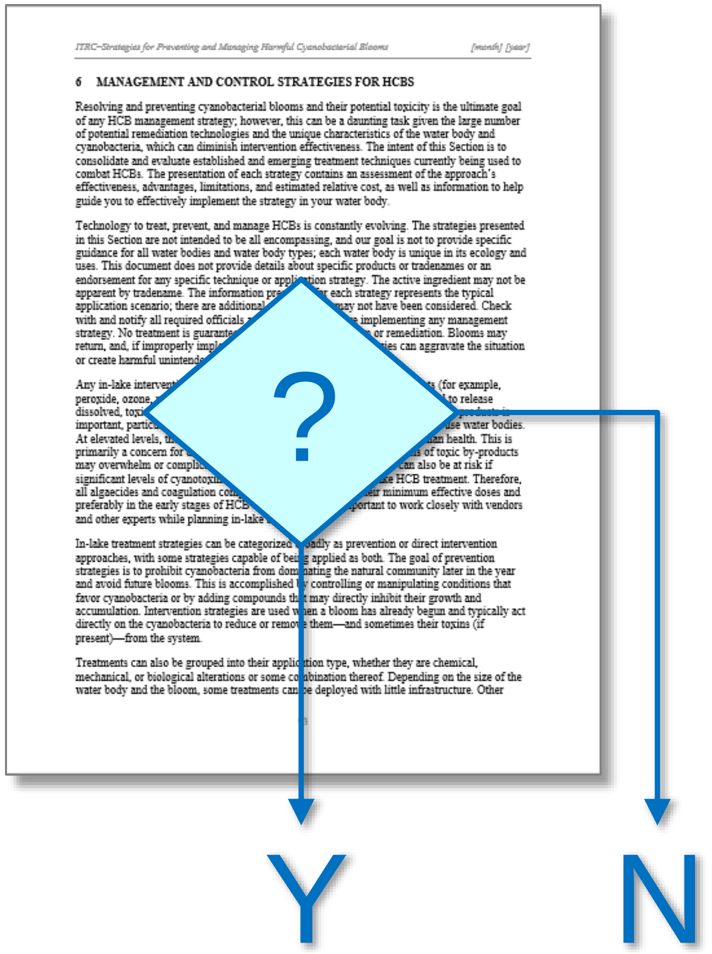
Fact Sheet Structure

- Bloom type (Planktonic/Benthic)
  - Strategy type (Intervention/Prevention)
  - Supporting data (Substantial/Limited/Emerging)
- Technical overview
- Advantages and limitations
- Cost analysis and case studies
- Regulatory and policy considerations
- Literature references



HCB Management and Control Strategies

- Resource aims provide an overview of methods, with references to scientific literature
- Resource is *not* intended to prescribe or promote one strategy over another
- Goal is to support informed decision making:
  - Place these approaches in larger context
  - Understand constraints, weigh costs and benefits, make sense of alternatives
  - Set realistic expectations for outcomes



Basic Management Strategy Factors

- Type of Approach:
  - Prevention / Intervention
- Water Body Type
  - Pond / Lake-Reservoir / River
- Type of HCB
  - Planktonic / Benthic

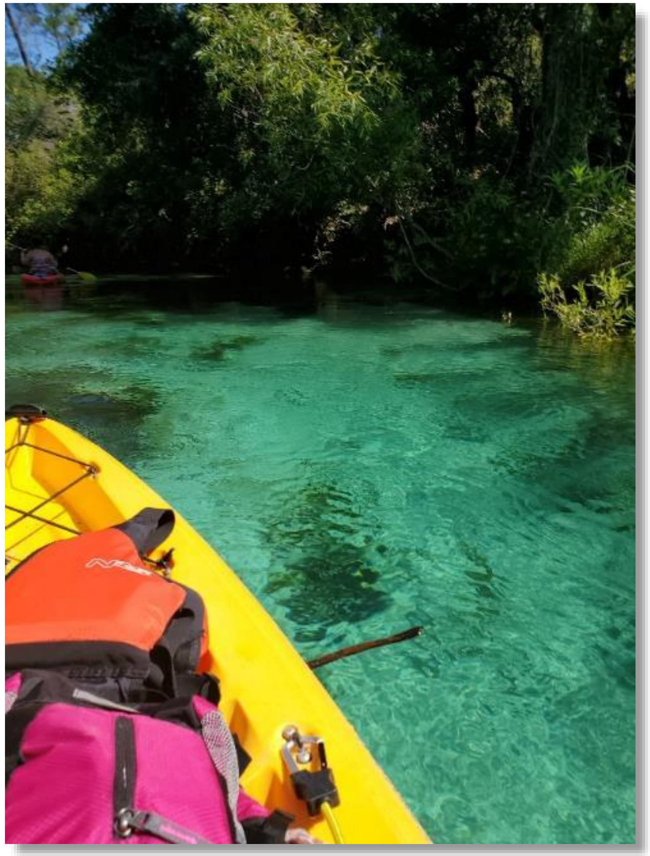


Photo by Autumn Kuney on Unsplash; public domain.

Other Relevant Factors to Consider: the Water Body

- Water Body Characteristics
  - Surface area and depth
  - Mixing regime, residence time
  - Natural turbidity and chemistry
  - Internal vs. external nutrient loading
  - Use related factors, e.g., drinking water, recreation, ecological considerations
  - Seasonal/weather influences or other factors

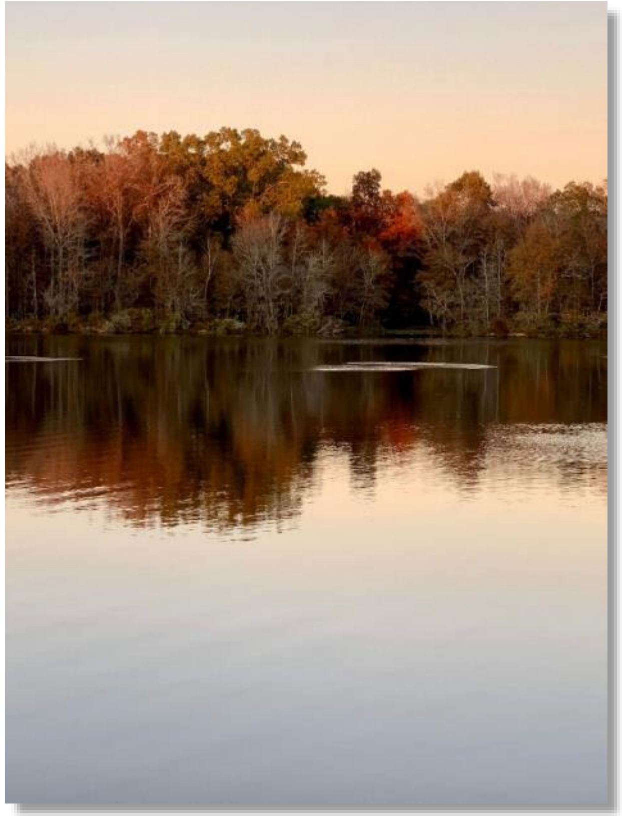


Photo by Tracy Selmon on Unsplash; public domain.

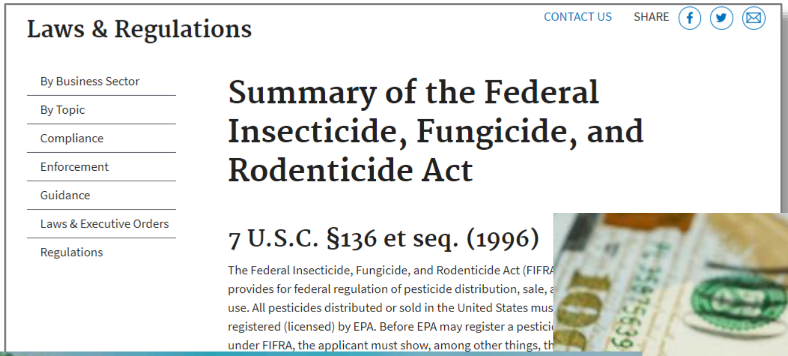
Other Relevant Factors: The Bloom

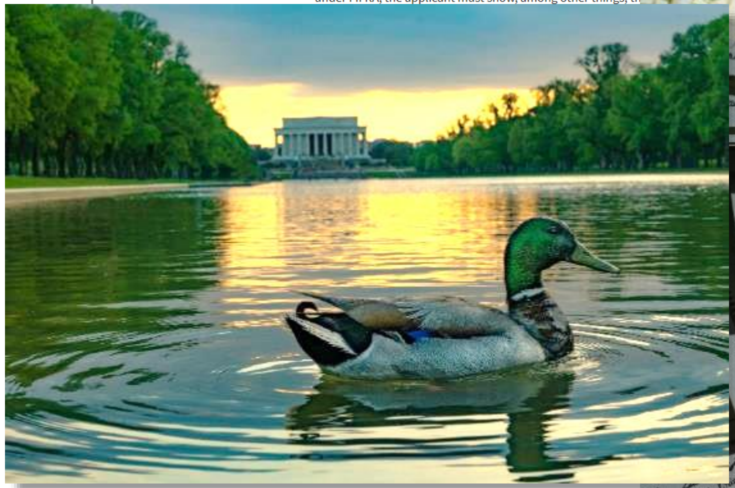
- Nature of the bloom
  - History and Frequency
  - Timing and Duration
  - Location and scale
  - Intensity
  - Taxonomic assemblage
  - Toxicity

Photo by Elizabeth Smith; used with permission.

Other Relevant Factors: Human Dimensions

- Human Dimensions
  - Priority of goals
  - Other management actions
  - Budget, up-front and annual
  - Infrastructure and staff
  - Regulatory constraints
  - Stakeholder perspectives
  - Risk tolerance

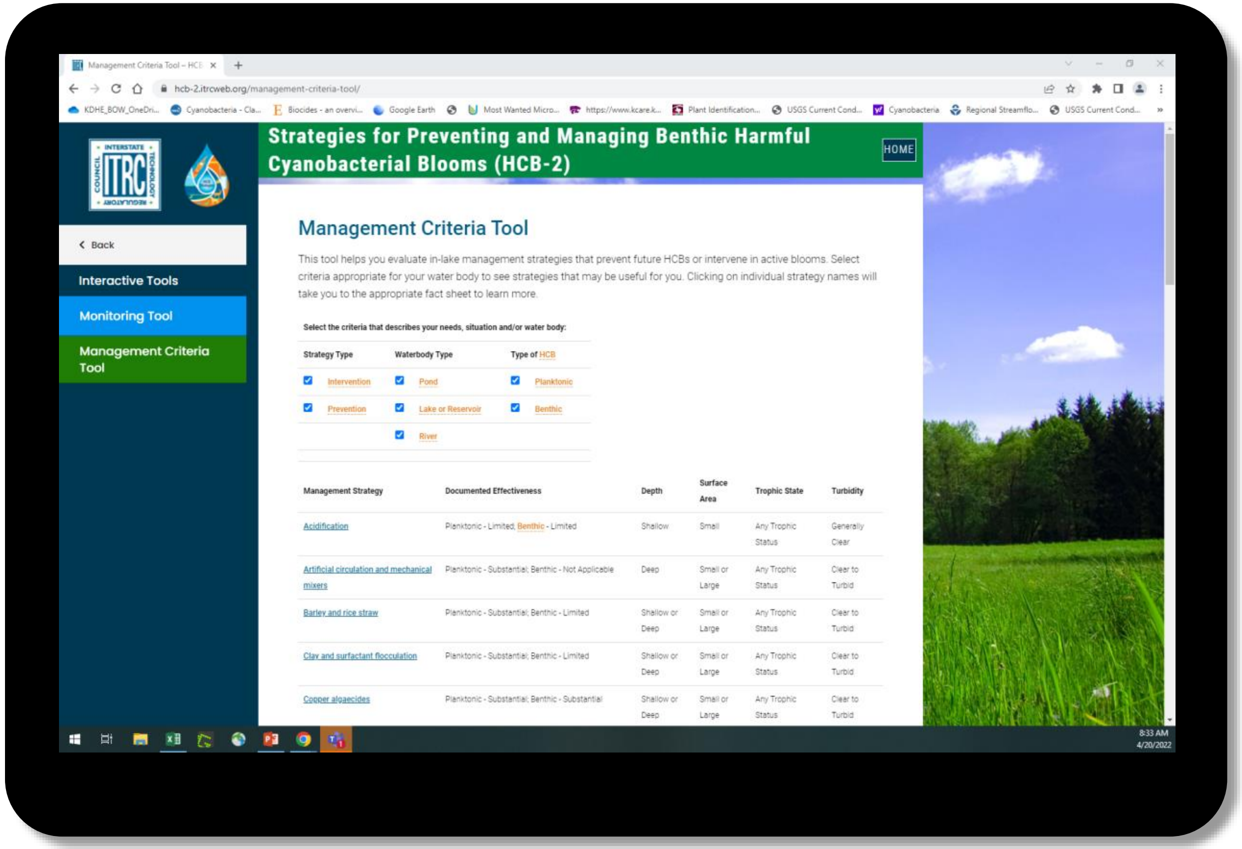




Photos by Tom Gainor (above) and Giorgio Trovato (at right) on Unsplash; public domain.

Management Criteria Tool – Interactive Selection

- Document Section 6 and Appendix C for hotlinked browsing or .pdf document download
- Interactive selection tool with filtering criteria
- Let's explore a scenario: Smallburg Lake



Smallburg Lake: Defining the Problem

- Shallow, 50 acre lake
- Unregulated outflow (long residence time)
- Nutrient loading from septic systems, waterfowl and likely row crop
- Loosely managed by county
- Access at county park and scout camp (north side) and private shoreline (south side)
- "Gets green" most summers, but no prior concerns
- Planktonic bloom
- Toxins found, recreational use halted

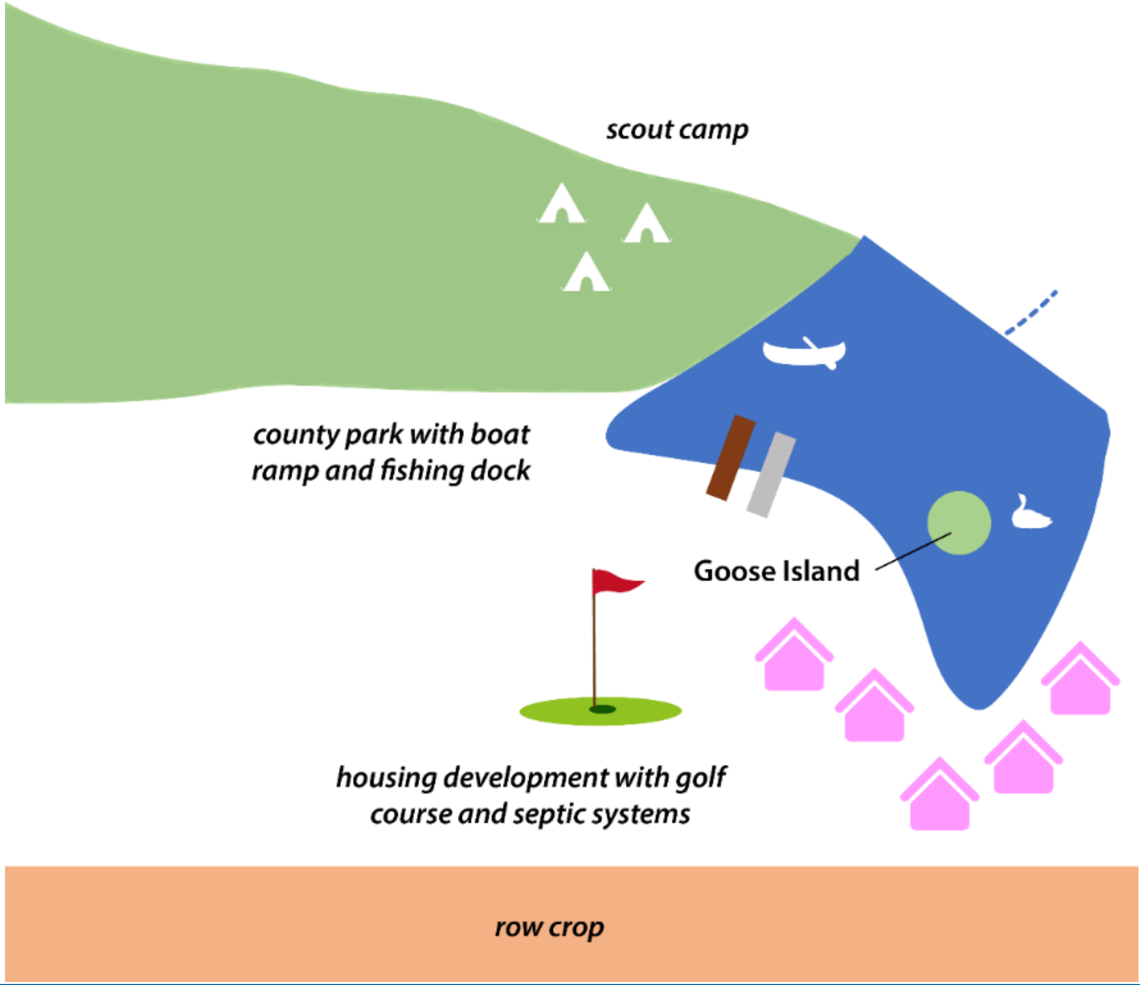


Illustration courtesy of KDHE

Smallburg Lake: Basic Characterization and Constraints

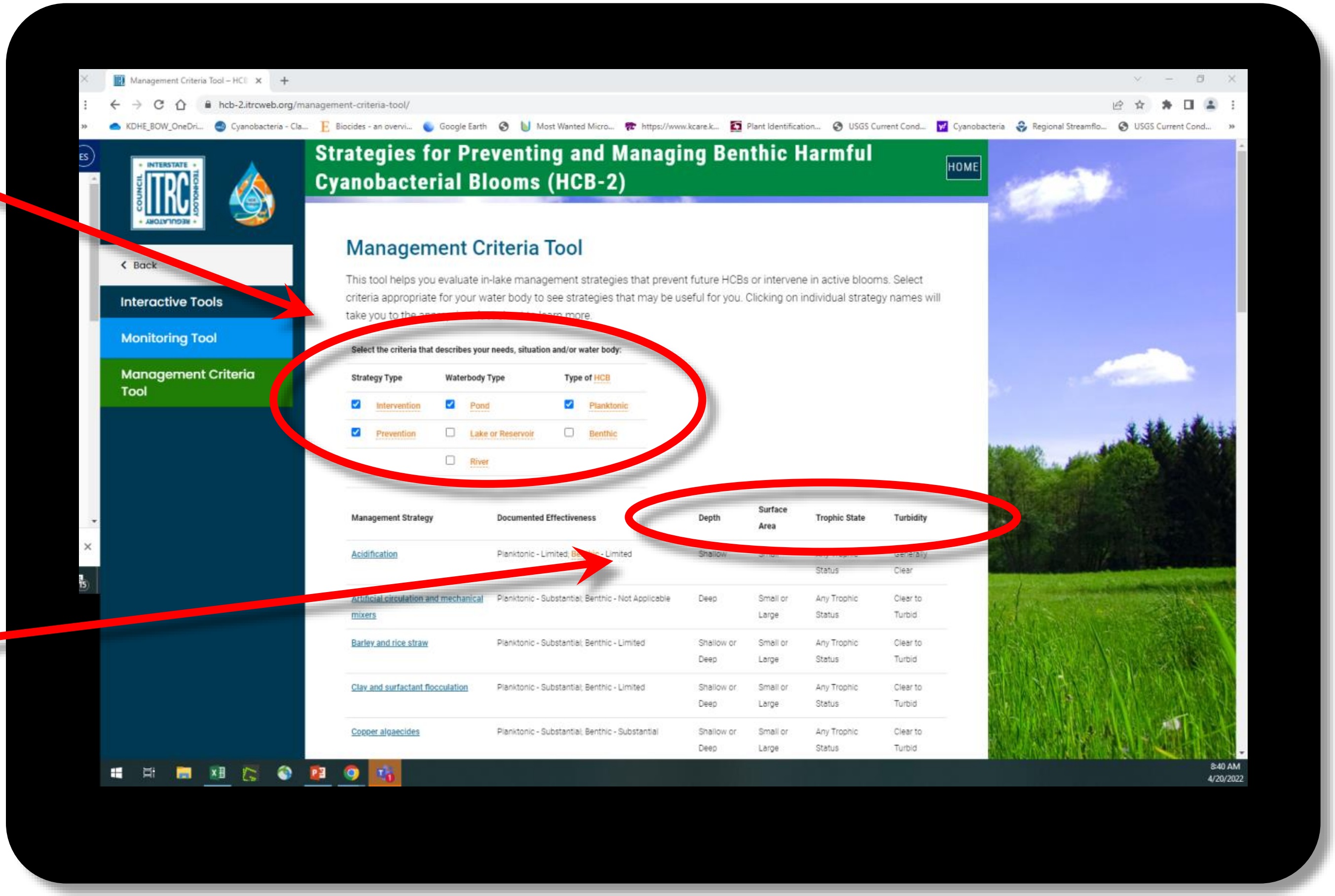
- Type of Approach:
  - **Prevention -and- Intervention**
- Type of HCB:
  - **Planktonic** / ~~Benthic~~
- Waterbody type:
  - ~~Pond~~ / **Lake-Reservoir** / ~~River~~
- Other information
  - Eutrophic, turbid, well mixed, long residence time, recreational use

Photo by Jordan Bauer on Unsplash; public domain.

Management Criteria Tool – Interactive Selection

Applying these very broad selection criteria eliminates just one option…

…but table criteria can be used to eliminate 5, yielding 18



Candidate Strategies for Smallburg Lake

PREVENTION

- Barley/rice straw
- Dredging
- Floating wetlands
- P-binding compounds
- Shading with dyes

PREVENTION and INTERVENTION

- Clay & surfactant flocculation
- Copper algaecides
- Food web manipulation
- Hydraulic flushing
- Microbial biomanipulation
- Nanobubbling
- Organic biocides
- Ozonation
- Ultrasound

INTERVENTION

- Monitored natural attenuation
- Nanoparticles
- Peroxide algaecides
- Skimming/ harvesting

Candidate Strategies for Smallburg Lake

PREVENTION

- Barley/rice straw
- ~~Dredging~~
- Floating wetlands
- ~~P-binding compounds~~
- ~~Shading with dyes~~

Prevention and Intervention

- ~~Clay & surfactant flocculation~~
- Copper algaecides
- ~~Food web manipulation~~
- ~~Hydraulic flushing~~
- ~~Microbial biomanipulation~~
- ~~Nanobubbling~~
- ~~Organic biocides~~
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INTERVENTION

- ~~Monitored natural attenuation~~
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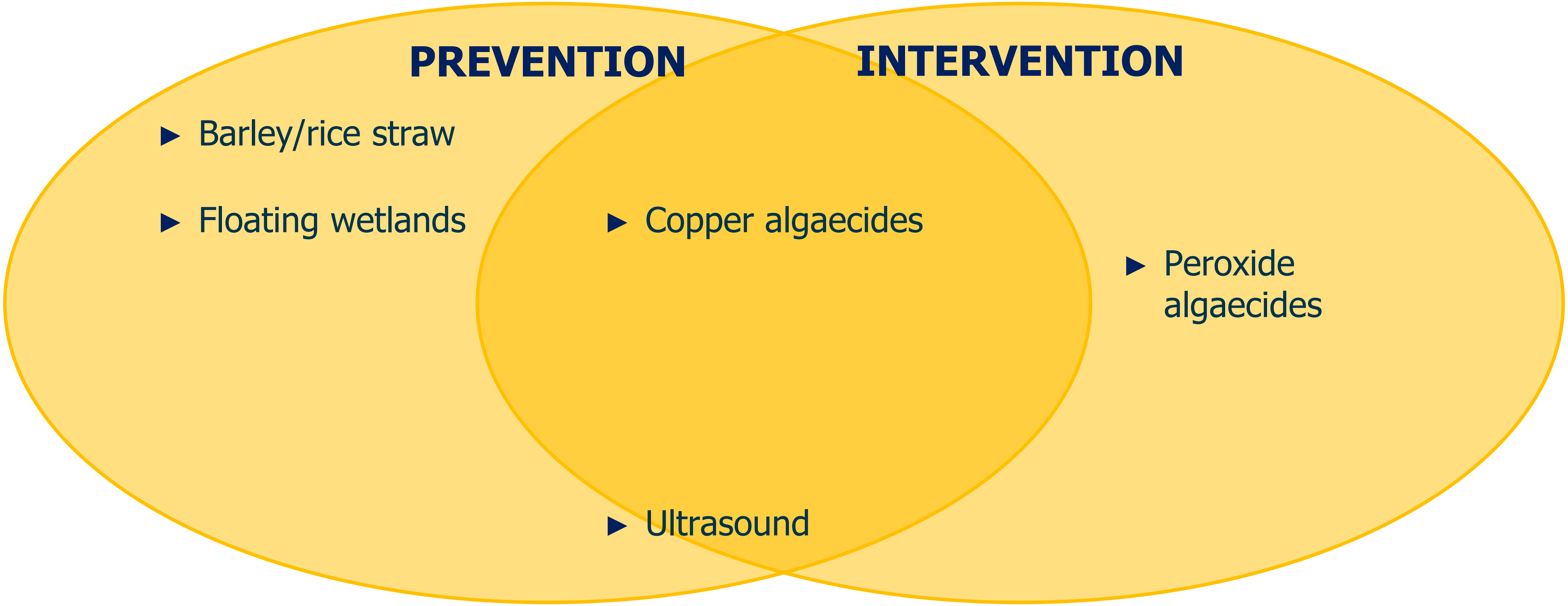
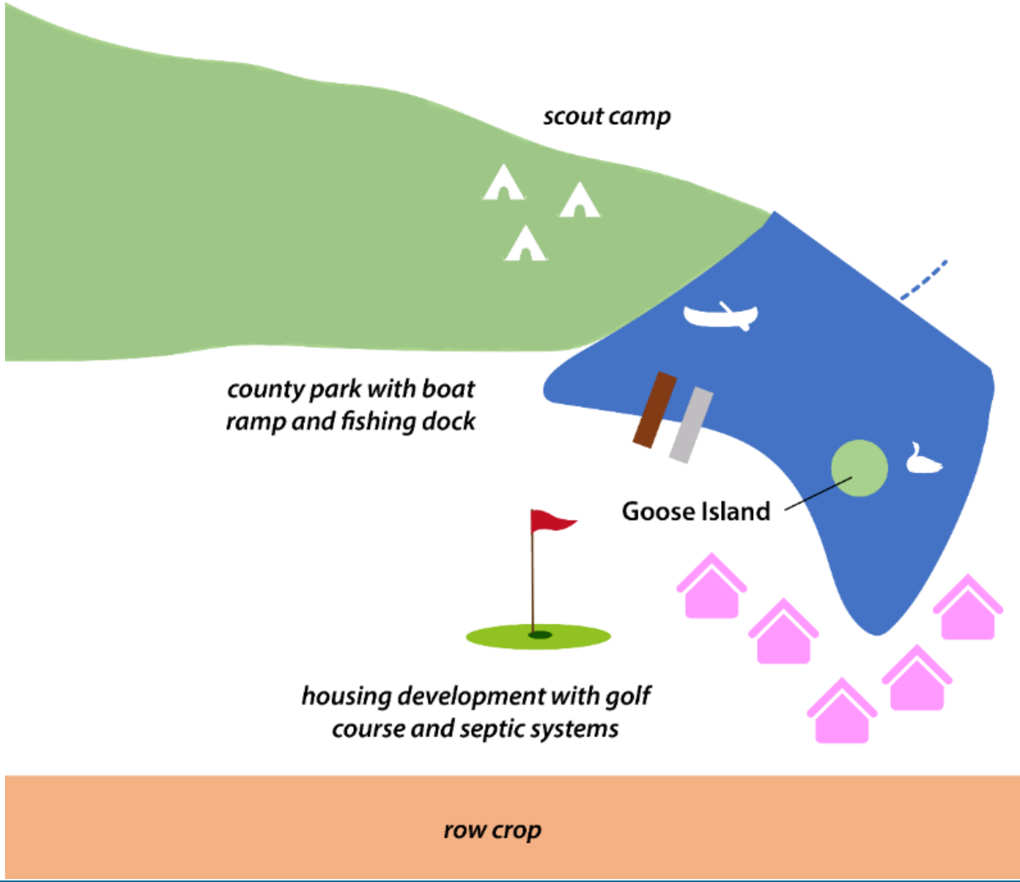
Candidate Strategies for Smallburg Lake



Smallburg Lake: Management Decisions in Context

- Intervention:
  - County will pay to treat the north shore bloom with algaecide: peroxide first, copper as a backup
- Prevention:
  - County and scouts will install barley straw bales next spring (and buy a microscope)
  - Homeowners' association will buy an ultrasound device and research floating wetlands
- Additional:
  - County will provide lakewide toxin monitoring with traditional media and social media updates
  - County will convene stakeholder/watershed group



Before Finalizing a Strategy for Implementation

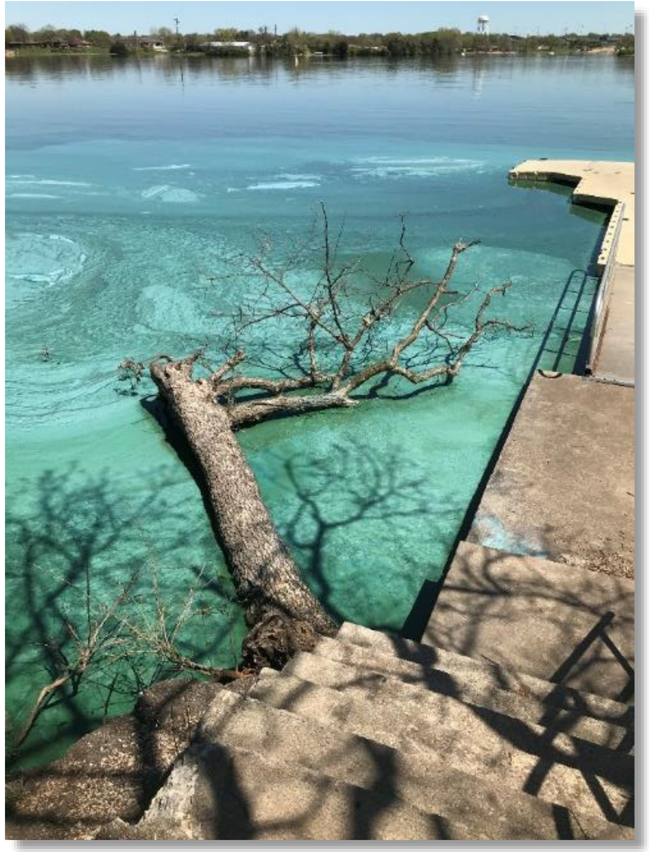


Photo by Tom Stiles; used with permission.

- Research permit requirements
- Check in with stakeholders
- Consider possible consequences (toxin release, DO impacts, residuals)
- Solicit estimates from multiple vendors
- Review budget impacts
- Consider logistics of strategy (timing, infrastructure, contract management)
- Communicate goals and plans

Efficacy Monitoring

- Integrate efficacy monitoring into the project
  - BACI model: Before/After/Control/Impact
  - Untreated controls may be hard to identify; consider small scale pilots or sub-sectioning
- Identify parameters relevant to your objectives
  - Consider monitoring cost as part of treatment
  - As a condition of a permit, regulatory agencies may require monitoring certain parameters for water quality standards

MONITORED NATURAL ATTENUATION

In-lake Intervention Strategy *Substantial Supporting Field Data*

HCBs go through natural growth and die-off cycles, often driven by seasons (Yamamoto and Nakahara 2009). Consider monitored natural attenuation (MNA) for the water body if your community is interested in more passive and less costly HCB management strategies. MNA may be feasible for an HCB if exposure risks can be controlled. Even if a more active approach is preferred, in certain cases MNA may be the only practical option—for example, if the affected water body is too remote or too large to be cost-effectively treated through an imposed engineered solution. Similarly, if the HCB occurs late in the growing season or after the recreational season is over, there may not be support or funding to invest the resources needed for active bloom treatment and management. On the other hand, if the water body is used as a drinking water source, MNA may not be an option (see Section 5).

Figure C-7. Signage instructing citizens not to drink pond water.

Source: Eric Roberts, 2019. Used with permission.

MNA is fundamentally a risk management strategy. This means that stakeholders will need to be comfortable temporarily living with a controlled level of risk. It also means that the risks will need to be regularly reassessed as the character and toxicity of the bloom changes through its life cycle—and as uses of and exposures to the water body evolve seasonally. Cyanotoxins also have variable persistence in natural systems, from days for anatoxin-a to over 200 years for microcystin in lake sediments (Stevens and Krieger 1991, Zastepa et al. 2017). Depending on stakeholder use of the affected water body, varying degrees of control measures may be needed to mitigate potential exposure pathways. For example, if the bloom-affected water is within a sparsely populated residential community or remote, isolated areas, posting warning signs along the shore may be adequate. However, in more densely populated communities, signage will

Adaptive Management

- Set realistic expectations
- Manage adaptively – remain flexible
  - Place alternative options in a decision tree
  - Use iterative approach
  - Learn from every attempt, whether successful or not
- Consider sustainability: fiscal, practical, and ecological
- Recruit allies
  - Communicate with stakeholders
  - Seek watershed solutions if appropriate
- For interventions: respond to a cue, not a schedule
- Keep monitoring; include academic partners if possible

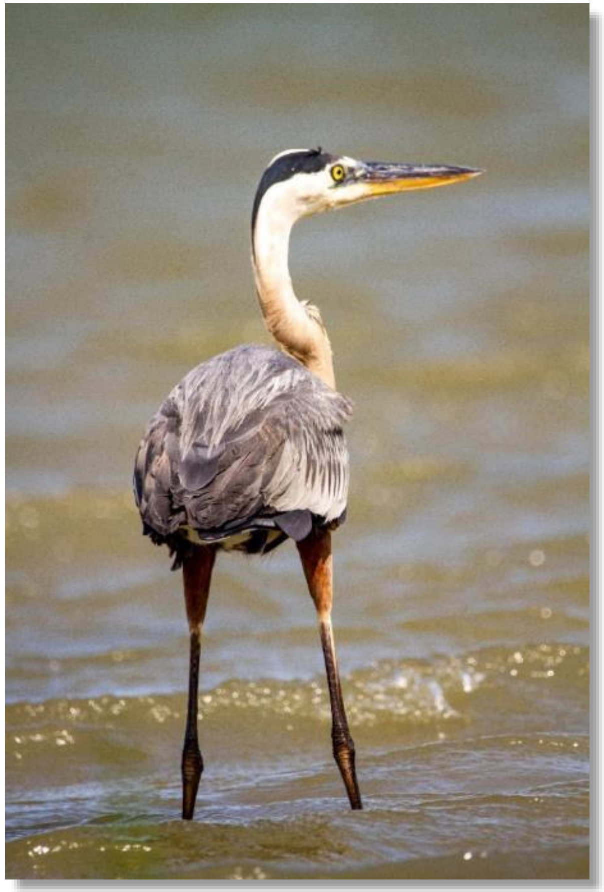


Photo by Joshua J. Cotten on Unsplash; public domain.

As New Strategies are Identified

- Complex, persistent problems inspire many "solvers"
  - Some are focused on the theory (forgetting cost)
  - Some are eager for quick results (forgetting the future)
  - Some are interested mostly in profit
- New options emerge constantly
- Think before you jump; ask questions:
  - Are peer reviewed (independent) field studies available? Does evidence match claims?
  - Does it fit our water body goals and constraints?
  - Up front and recurring costs?
  - Frequency and spatial scope of treatment?
  - Short- and long-term impacts to priority uses?
  - Is it reversible, or will it leave a lasting impact? Are there possible side effects?

Photo by Zdenek Machacek on Unsplash; public domain.

Key Takeaways

Photo by Mihaly Koles on Unsplash; public domain.

- Improve odds of success by knowing your water body
- Review options (old or new) systematically
- Set realistic goals – relative to uses and known constraints
- Does proposed strategy address an underlying cause or treat a symptom?
- Evaluate success with thoughtful monitoring
- Use ITRC document as a framework for planning
- Adopt lake management strategies as part of larger framework: monitoring, communication and response, watershed management

Advancing
Environmental
Solutions

Introduction to Cyanobacteria

Monitoring for Cyanobacteria

Communication and Bloom Response Planning

Management and Control Strategies for HCBs

★ **HCB Nutrient Reduction Strategies**

See Section 7 of the HCB Guidance Document

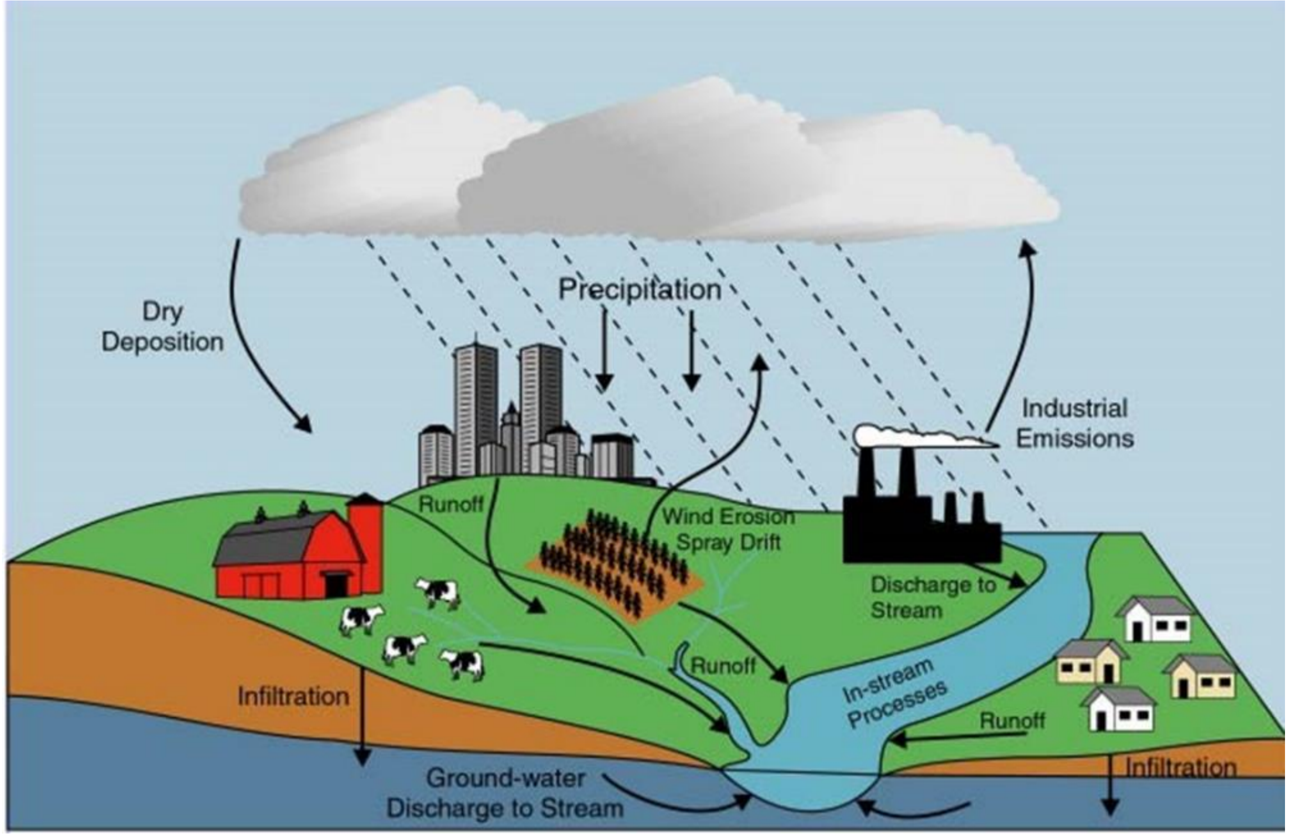
Training Overview

- Review of factors influencing HCBs
- Steps for success
- ITRC HCB Webportal & Tools
- Scenario Application

Photo Credit: Big East Lake from aerial drone by Nathan Guymon, 2020

Planktonic Cyanobacterial Blooms Overview

- Prominent factors important in planktonic cyanobacterial blooms:
  - Nutrients, such as
    - Phosphorus
    - Nitrogen
  - Physical conditions
    - Sunlight
    - Temperature
- Controlling nutrients are the most effective way to help reduce the magnitude, frequency, and extent of planktonic blooms longer term



Source: USGS Water Resources Investigations Report

Preventing Blooms: Nutrient Management

- Roles of Nitrogen/Phosphorus
- External vs Internal Loading

See Section 6

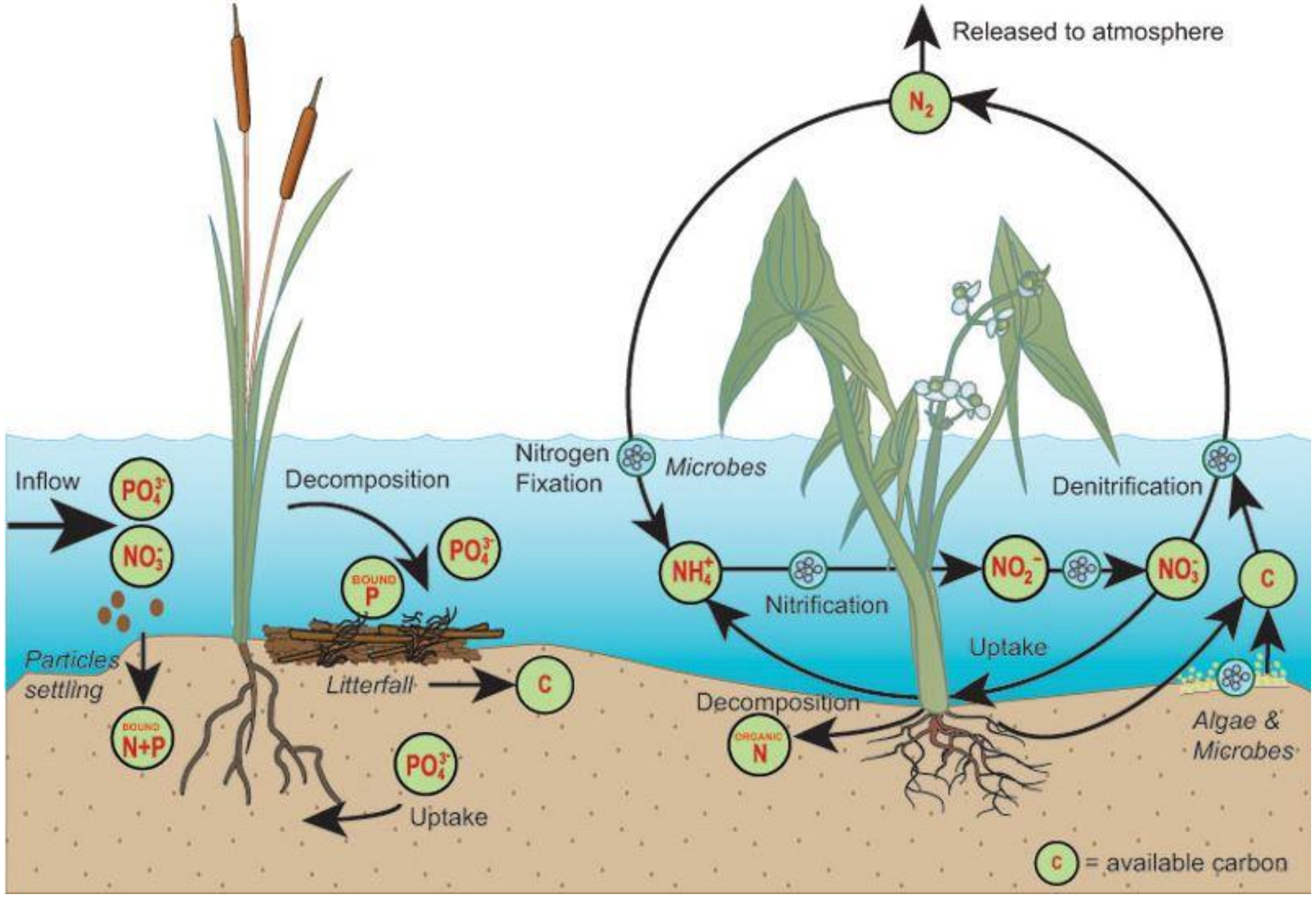


Photo Credit: A simplified illustration of the nitrogen and phosphorus cycles in a wetland (modified from Kadlec and Knight (1996), "Treatment Wetlands"; images from IAN, University of Maryland).

Steps for Water Body Managers

1. Check with regulatory agencies
2. Gather information about nutrient loading for the water body
3. Generate community awareness and support
4. Prioritize actions
5. Implement actions
6. Evaluate effectiveness

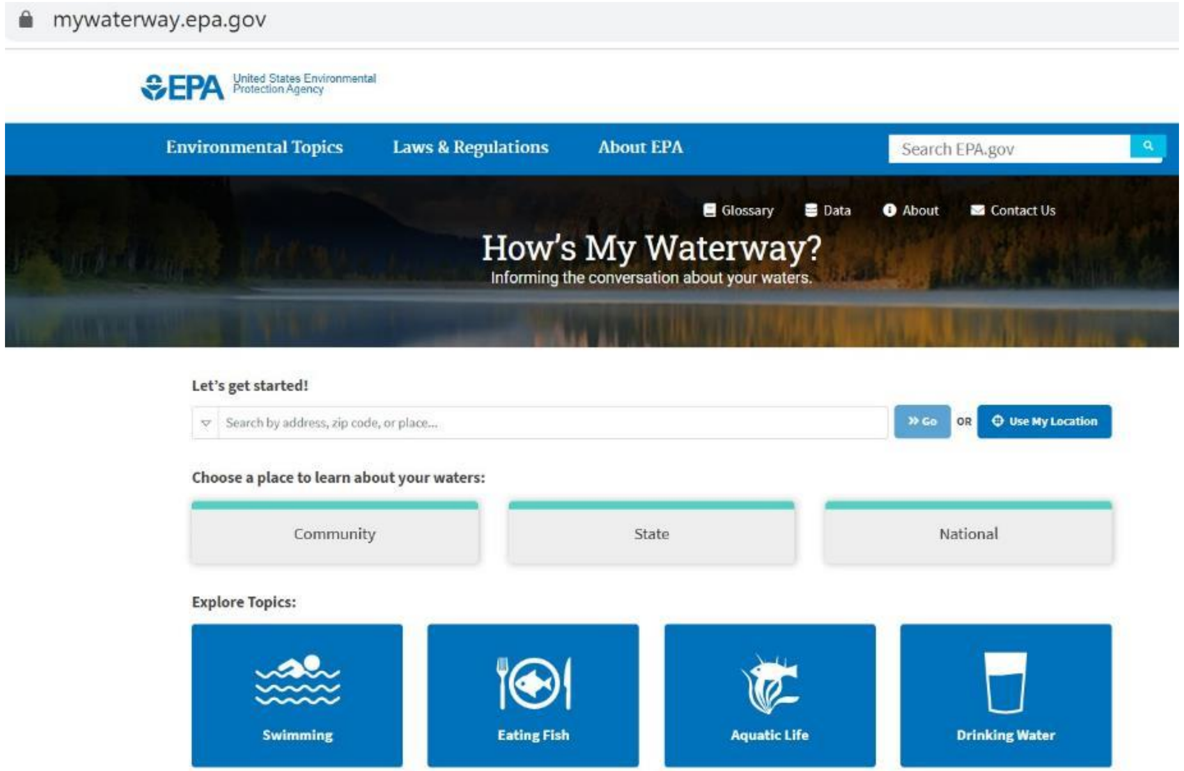
1. Consult with Regulatory Agencies

- Check with regulatory agencies regarding:
  - Are excessive nutrients identified as a pollutant of concern?
  - Have nutrient-related goals been determined?
  - Have any nutrient-related regulatory actions occurred?

Photo Credit: "_PDA3148" by U.S. Embassy Jerusalem is licensed under CC BY-SA 2.0

2. Gather Information

- Characterize the waterbody by:
  - Gathering data (satellite imagery, WQ results, survey surrounding areas and watershed landuse)
  - Determining loading using models
  - Consider using nutrient source tracking and recovery potential screening tools.



Screen capture: Mywaterway.epa.gov

3. Generate Community Support

Photo Credit: "Community engagement training in Bangladesh. Photo by Md Mahabubur Rahman, 2013." by WorldFish is licensed under CC BY-NC-ND 2.0

- Ensure that outreach is appropriate for the community
- Look for informed members who may be leaders
- Look for educational outreach opportunities

4. Identify and Prioritize Strategies

Photo Credit: "Prioritize" by Orange Steeler is licensed under CC BY 2.0

Consider:

- Which nutrient reduction strategies are most plausible?
- Which of these are a priority?
- Where should they be installed?

5. Implement Strategies

- Control sources of nutrients
- Prioritize for most effective reduction

Photo Credit: Bureau of Land Management, Flickr

6. Evaluation: Effectiveness Monitoring

- Is it working?

Most of these projects won't be an overnight success, but it's critical to develop a plan to demonstrate whether your project is achieving the intended outcome.

Photo Credit: Pixabay, public image

Regulatory Strategies: Section 7.2

Photo Credit: CDC, public image

- Clean Water Act: nutrient-related water quality goals
  - Nutrient criteria
  - Total Maximum Daily Loads (TMDLs)
- Community/local ordinances
- Permits

Point Sources: Section 7.5

- Municipal and Industrial discharges
- Stormwater
- Agriculture
  - CAFOs

Photo Credit: James M. Pease | National Institute of Health (left); USDA public image (Top)

Nonpoint Sources: Section 7.6

- Agriculture
- Stormwater
- Onsite (septic) wastewater management
- Forest management
- Roadway Management
- Hydrologic and habitat modification

Photo Credit: "ditch leaving Circle lake 090302" by MN Pollution Control Agency is licensed under CC BY-NC 2.0

WQ Trading: Section 7.7

- Water Quality Trading
- Mechanism to offset higher costs associated with reducing pollution sources to meet/exceed other potential sources.

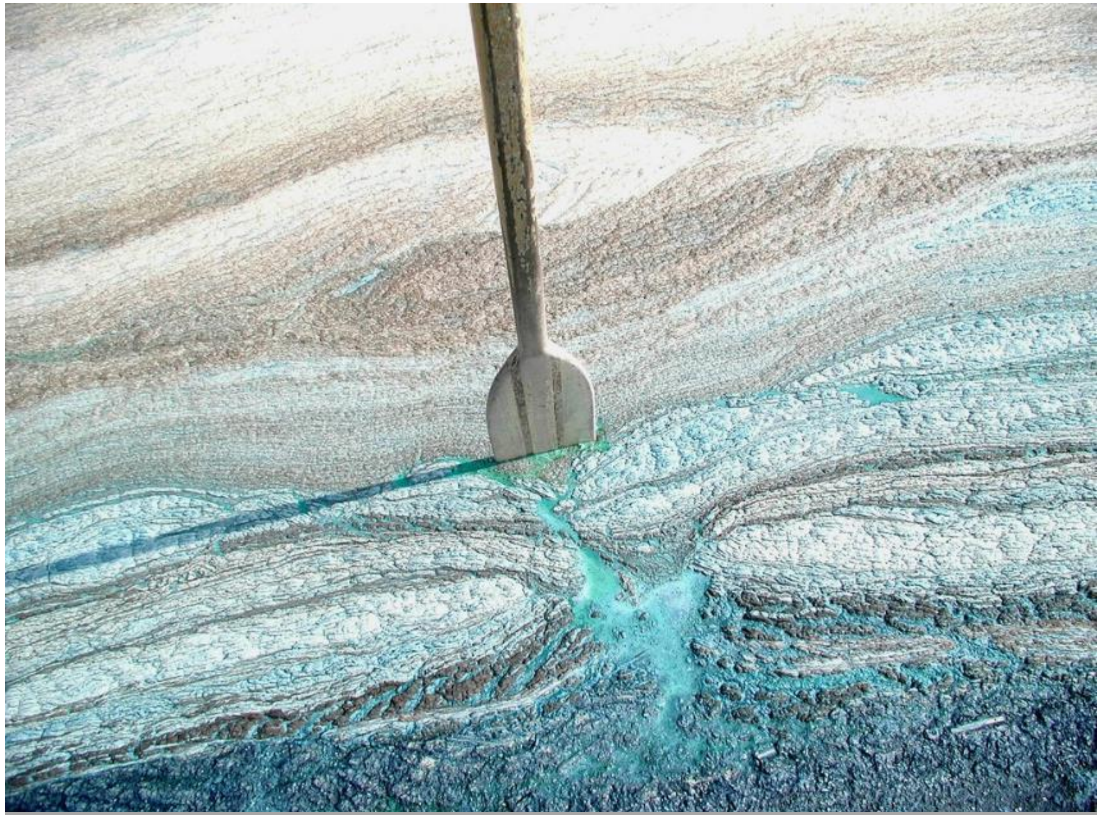


Photo Credit: "Carver County Turbidity and Excess Nutrient photo" by MN Pollution Control Agency is licensed under CC BY-NC 2.0

Strategy Selection Graphic

See Nutrient Reduction Tool, HCB Guidance Document

Table 7-1. Nutrient reduction strategy organization and selection based on source category and land use type or feature

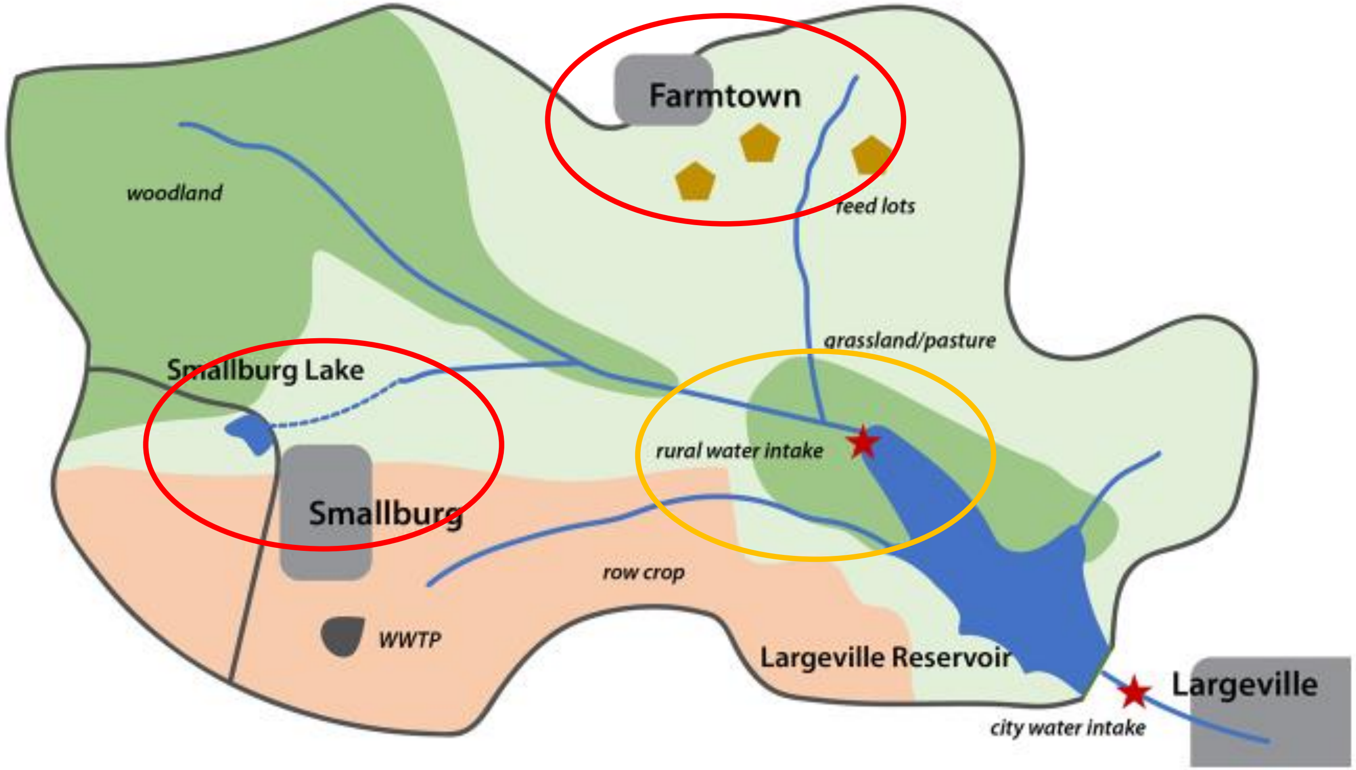
Source Category	Watershed Land Use Type					Description
	Lake/Stream	Agricultural	Forest	Urban	Suburban	
Point Sources						
Municipal and Industrial Wastewater	🔴	🔴	🔴	🟢	🟢	Wastewater discharged directly into Waters of the United States
Stormwater	🔴	🟡	🔴	🟢	🟢	Rainwater or melted snow that is delivered to the water at a specific site
CAFOs	🔴	🟢	🔴	🔴	🔴	Agricultural facilities where many animals are raised, generating large amounts of manure and wastewater
Non-point sources						
Agricultural Runoff	🔴	🟢	🔴	🔴	🔴	Runoff from agricultural land
Forestry Management Activities	🟡	🟡	🟢	🔴	🔴	Includes removal of streamside vegetation, road construction and use, timber harvesting, and mechanical preparation for the planting of trees
Hydromodification /Habitat Alteration	🟢	🟢	🟢	🟡	🟢	Activities such as channelization and channel modification, dams, riparian buffers, and other activities resulting in streambank and shoreline erosion
Septic Systems	🔴	🔴	🔴	🟢	🟢	Underground wastewater treatment structures, commonly used in rural areas without centralized sewer systems
Municipal and Rural Roads	🔴	🟡	🟢	🟢	🟢	Stormwater flowing off paved and unpaved roads
Other Nonpoint Nutrient Sources	🟡	🟡	🟡	🟡	🟡	Other less prominent nonpoint nutrient sources may exist within a watershed.
🔴 Unlikely Source	🟡 Potential Source					🟢 Likely Source

Scenario: Nutrient Reduction Strategies

- Largeville Reservoir is a semi-urban lake that includes point and non-point sources of nutrients in the watershed.
- High recreational use
- Source of drinking water

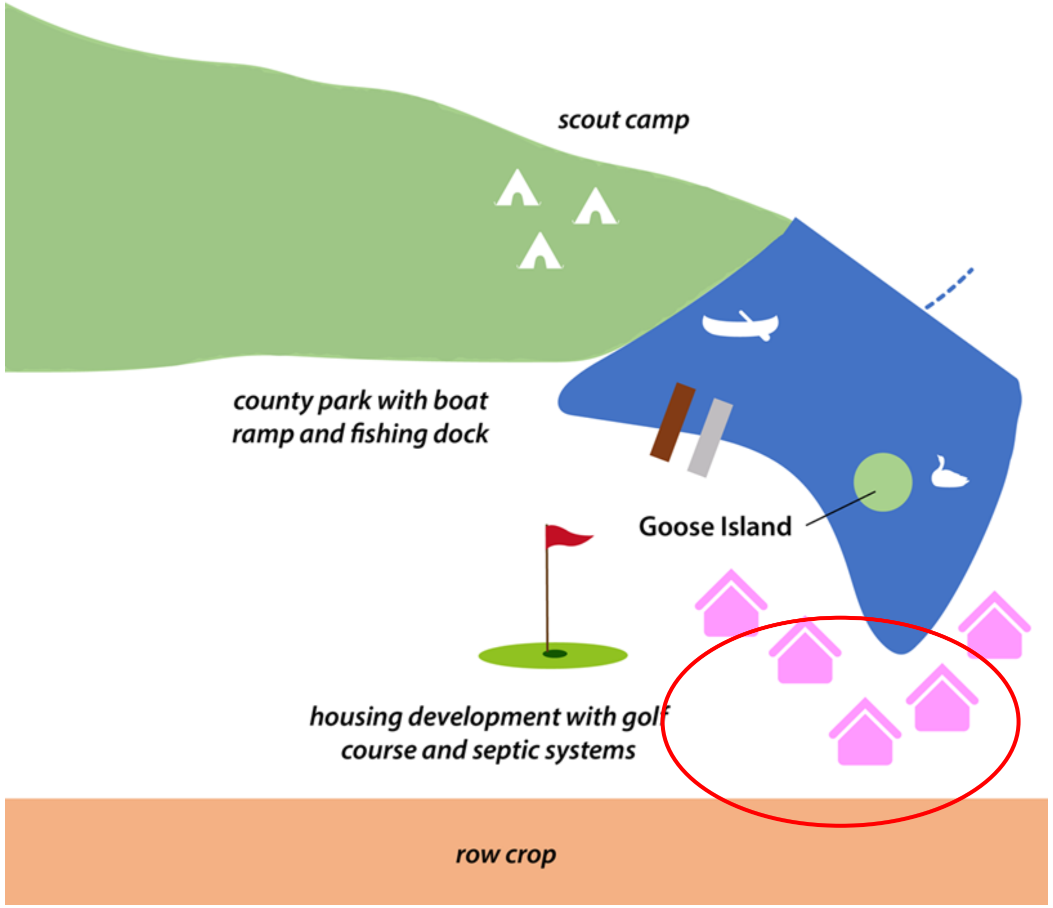
Source: KDHE, used with permission.

Scenario: Nutrient Reduction Strategies



Source: Kansas Department of Health and Environment. Used with permission.

Scenario: Nutrient Reduction Strategies



Source: Kansas Department of Health and Environment. Used with permission.

Strategy Selection Graphic

Scenario: Nutrient Reduction Strategies

Search this website

7.6.4 Septic Systems

More than one in five households in the United States depend upon individual, on-site septic systems or small community cluster systems to treat their wastewater (USEPA 2005a ▻). Septic systems treat wastewater in relatively small volumes (versus advanced centralized wastewater treatment plants) through both natural and technological processes, typically beginning with solids settling in a septic tank and ending with wastewater treatment in the soil via a drain field. Septic systems include a wide range of individual and cluster treatment system designs that process household and commercial sewage.

Septic systems that are properly planned, designed, sited, installed, operated, and maintained can provide excellent wastewater treatment at reduced infrastructure, energy, and operating cost. The proper use of septic systems reduces the risk of disease transmission and human exposure to pathogens and positively affects water resources by recharging and replenishing groundwater aquifers.

Although septic systems may contribute a relatively small portion of total nutrient loads within a catchment, they can still represent a significant source of in-stream nutrients fueling HCBs, especially during periods when flow is low. In addition, it is estimated that 10–20% of septic systems are not adequately treating waste (USEPA 2005a ▻). State water quality agencies identify septic systems as the second-greatest threat to groundwater quality (USEPA 1998 ▻). Septic system failure results in contamination of surface and groundwater with excess nutrients.

▾Read more

7.6.4.1 Nonstructural Strategies

Scenario: Nutrient Reduction Strategies

Search this website

Pros. BMPs, when used appropriately, can mitigate the nutrient enrichment of neighboring water bodies, which are the principal factors of eutrophication and HCBs. Importantly, BMPs can help reduce agricultural production costs through effective water and nutrient application rates and reduce erosion and soil loss—often more than offsetting implementation costs. Certain BMPs for agricultural producers can be funded through federal, state, or county cost-share programs.

Cons. BMP implementation costs are often an unanticipated capital expenditure for the agricultural producer. BMPs are often implemented on a field-by-field basis and change annually, making it difficult to track and measure success. Moreover, the implementation of BMPs may not reach the targeted loading reduction of nutrients for all cases, resulting in additional measures to meet watershed management goals.

Regulatory or policy considerations. Some states have developed policies that associate BMP implementation and maintenance with a presumption of compliance with water quality standards for the pollutants addressed by the BMPs to offset cost-prohibitive monitoring. Under certain circumstances, such as within watersheds that have developed basin management action plans for water quality improvements, the development and implementation of BMPs and performance monitoring, in some cases, have become mandatory.

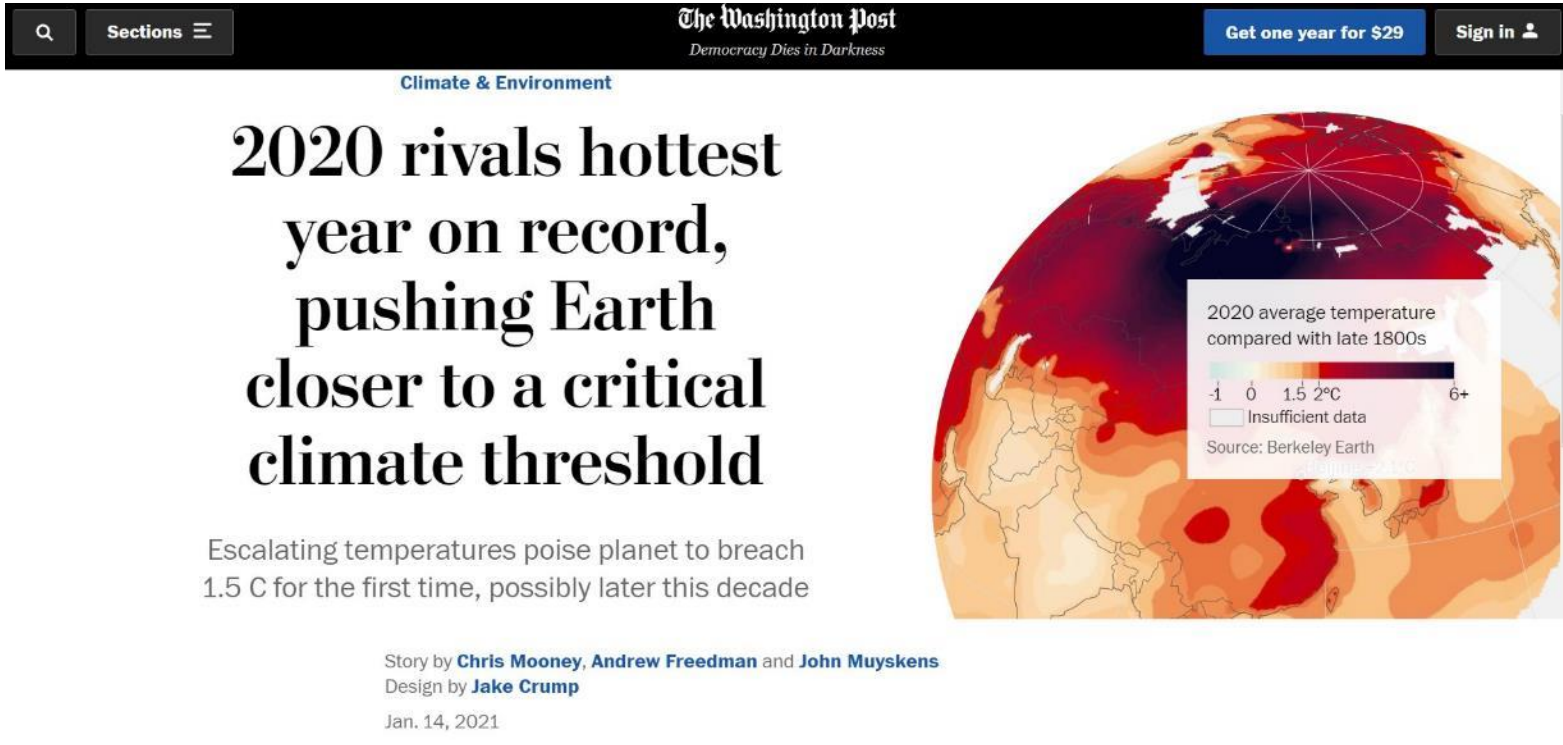
Application Examples. Many states provide grants to farms that are using the newest structural strategies to protect water quality and manage nutrients while producing food. Your state's agriculture agency newsletter is a good way to learn about local examples. These two additional resources may also be helpful.

- USEPA Watershed Academy Web's Agricultural Management Practices for Water Quality Protection
- The Florida Department of Agriculture and Consumer Services' BMP Success Stories

Disclaimer & Cautionary Tales

- The climate is changing faster than our ability to reduce nutrients in waterways.
- Lake Erie was a success story until it wasn't

Photo Credit: USGS, Lake Erie



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Story by Chris Mooney, Andrew Freedman and John Muyskens
Design by Jake Crump
Jan. 14, 2021

Credits: Mooney et al. 2021. 2020 Rivals Hottest Year on Record. Climate & Environment. January 14 2021 (screenshot).

Final Thoughts

- There are many success stories
- A long-term, full court press to reduce excess nutrients from prioritized, at-risk waterbodies is critical
- Reducing nutrients in waterways takes tremendous fortitude and perseverance– not a quick fix
- Document and share

Credits: NASA/JPL-Caltech

Questions? Please use Q&A Pod

- More information needed? Email us at training@itrcweb.org
- Links to additional resources: http://www.clu-in.org/conf/itrc/HCB-1
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