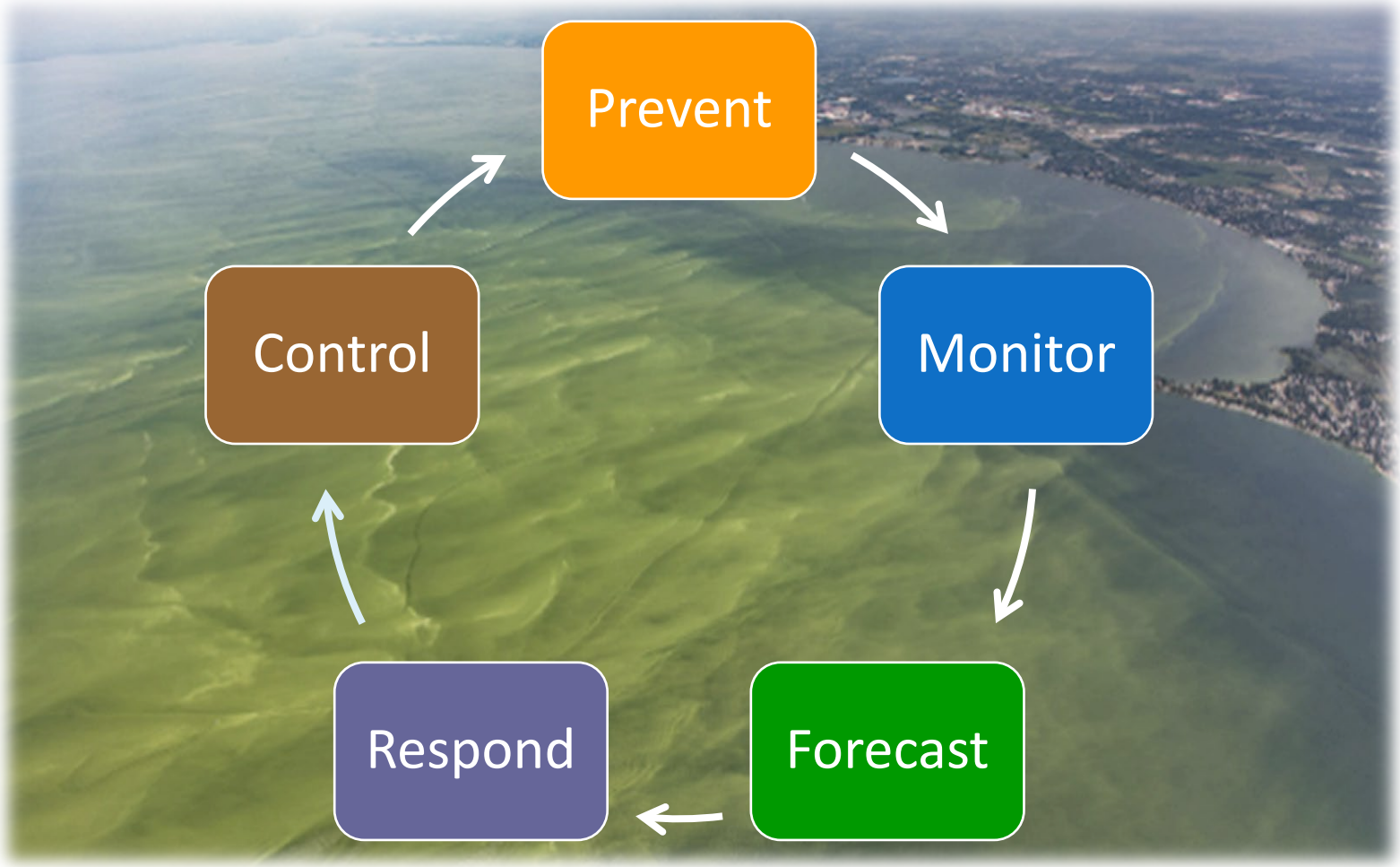
SDWA Program Tools to Address HAB-Related Risks to Drinking Water

CyanoSymposium 2023
Tom Waters, PE
EPA Office of Water
Office of Ground Water and Drinking Water

Overview

- EPA resources to support state, tribal, and water system management of HABs and related cyanotoxins for SDWA purposes



Prevention – health advisories, regulations

Objective: Prevent HABs in source water from impacting finished drinking water and minimize public health impacts

- Federal Health Advisories published in 2015 for total microcystins, cylindrospermopsin in finished drinking water
  - Total Microcystins: 0.3 µg/L for vulnerable people; 1.6 µg/L for all persons.
  - Cylindrospermopsin: 0.7 µg/L for vulnerable people; 3 µg/L for all persons
- UCMR4 monitoring (2018-2020) for 10 cyanotoxins (total MC, MC-LA, MC-LF, MC-LR, MC-LY, MC-RR, MC-YR, nodularin, anatoxin-a, cylindrospermopsin)
- States such as Oregon and Ohio have enacted monitoring and response regulations

Prevention – EPA publications and tools

- ***Cyanotoxin Management Plan Template and Example Plans***
- ***Cyanotoxin Management Tools for Public Water Systems***
- ***Recommendations for Public Water Systems to Manage Cyanotoxins in Drinking Water***

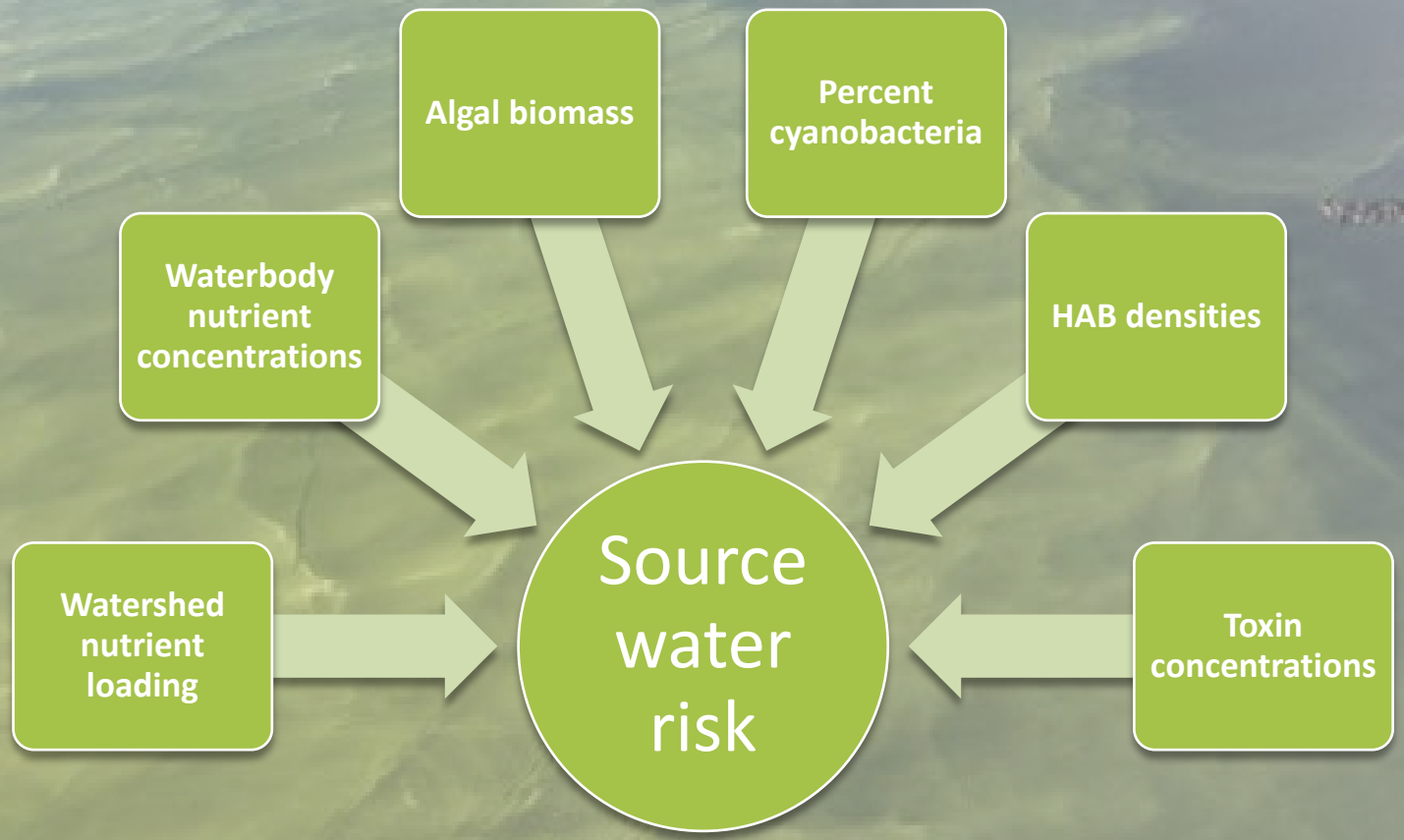
Prevention – WTP evaluation

- Water treatment plant evaluation: Harmful Algal Bloom Comprehensive Performance Evaluation Protocol
  - Support primacy agency and PWS managers, staff and operators
  - Evaluate WTPs for optimized cyanotoxin removal performance during a potential HAB in source water
  - Evaluate results and identify a prioritized list of factors that could limit WTP performance during a HAB
  - Help direct resources to process control optimization, as well as potential administrative, financial, managerial, design and O&M limitations
  - Understand limitations and address them prior to a HAB impacting source water

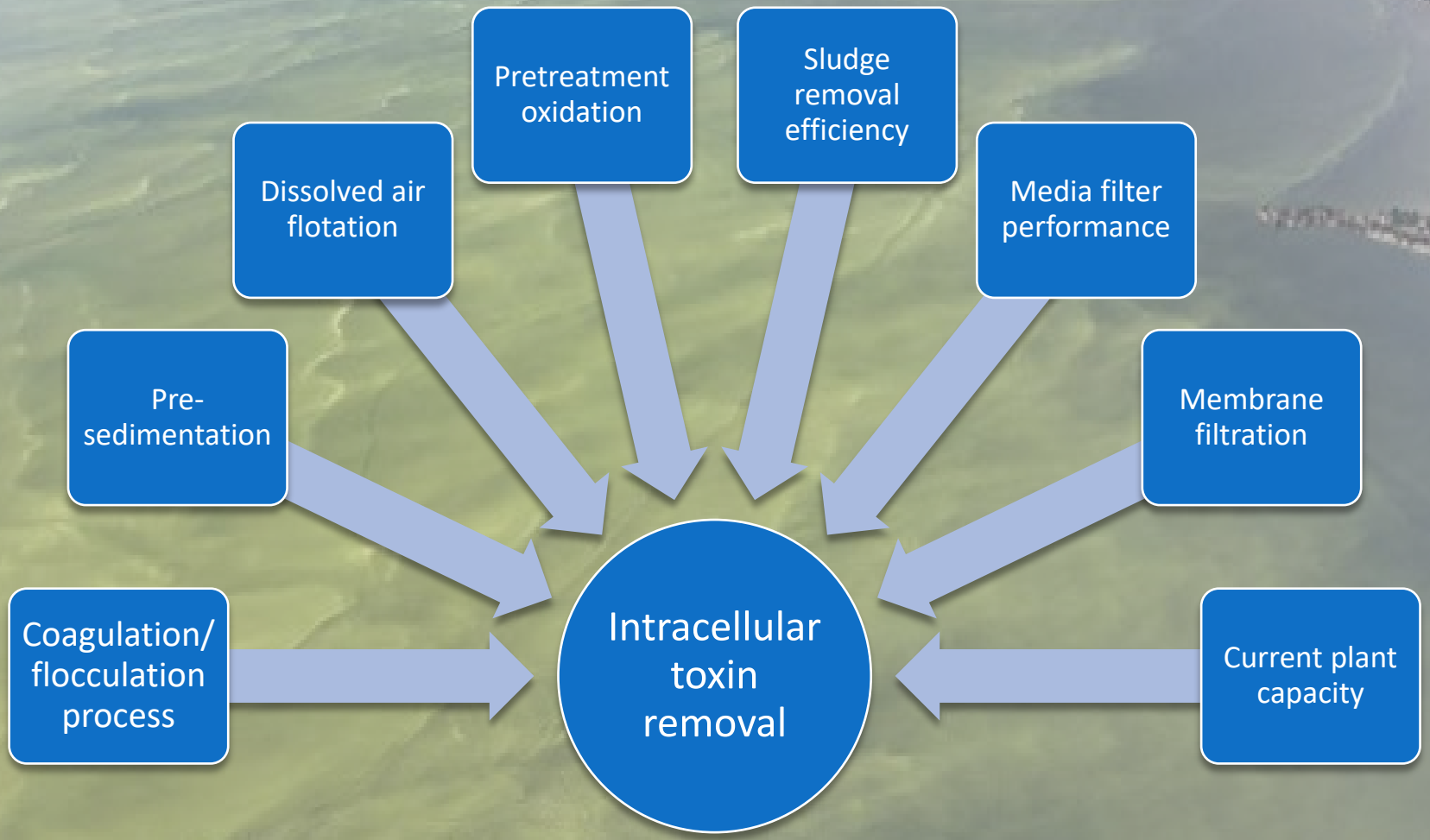
Prevention – vulnerability analysis

- Conducted water system vulnerability analysis project in Wyoming
  - Study objective: understand WY drinking water system vulnerability to cyanotoxin breakthrough
    - Water system information and performance data → EPA Region 8 (directly implements DW program in WY)
    - Source water vulnerability to HABs – collaborated with Wyoming DEQ (recreational HAB data)
  - Result: spreadsheet-based risk analysis and prioritization of WY water system vulnerability to HABs (EPA Region 8 has DW primacy in WY)
- Expanding WY work for national scale (OW & ORD partnership)

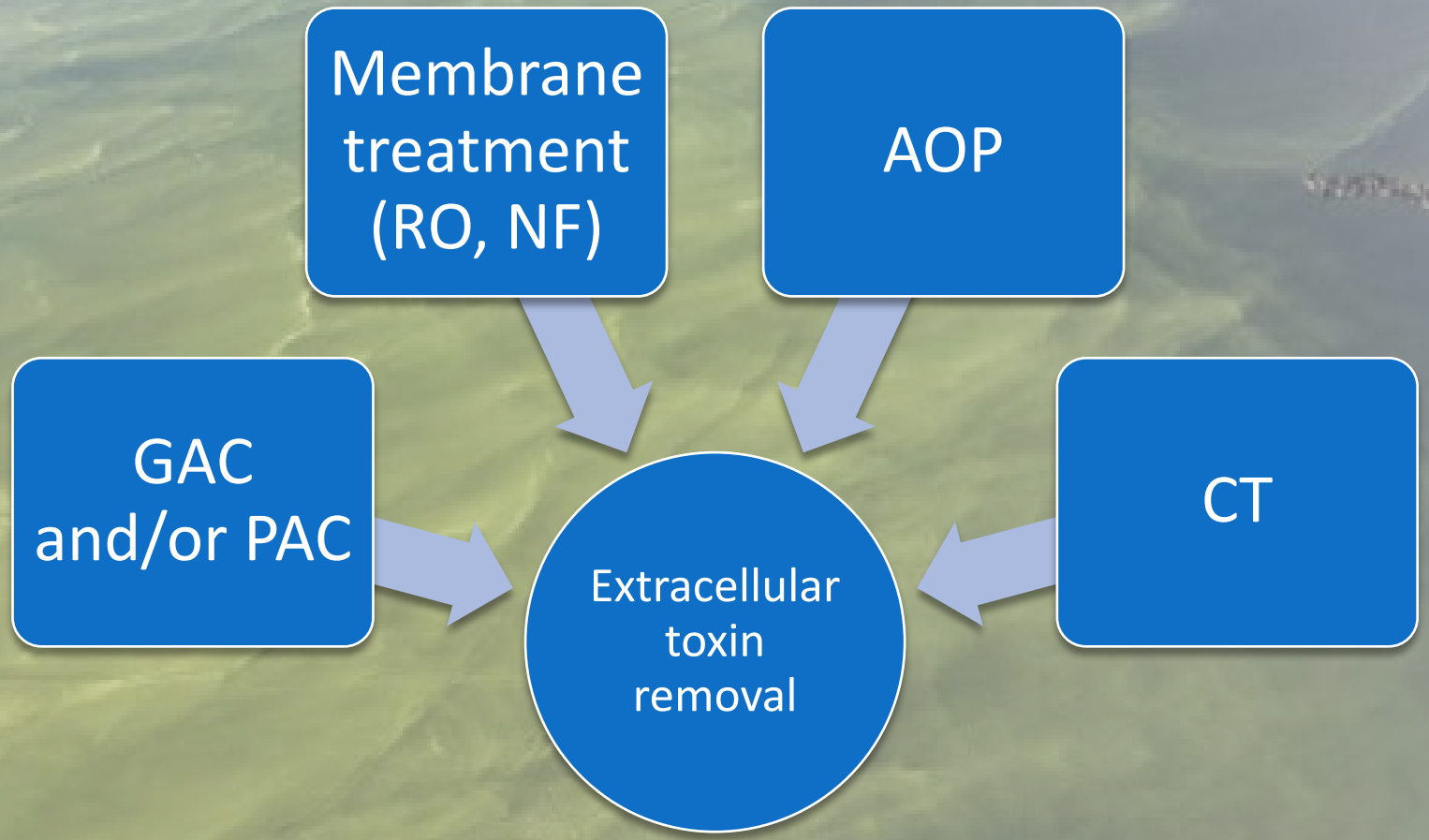
Prevention – WTP source vulnerability



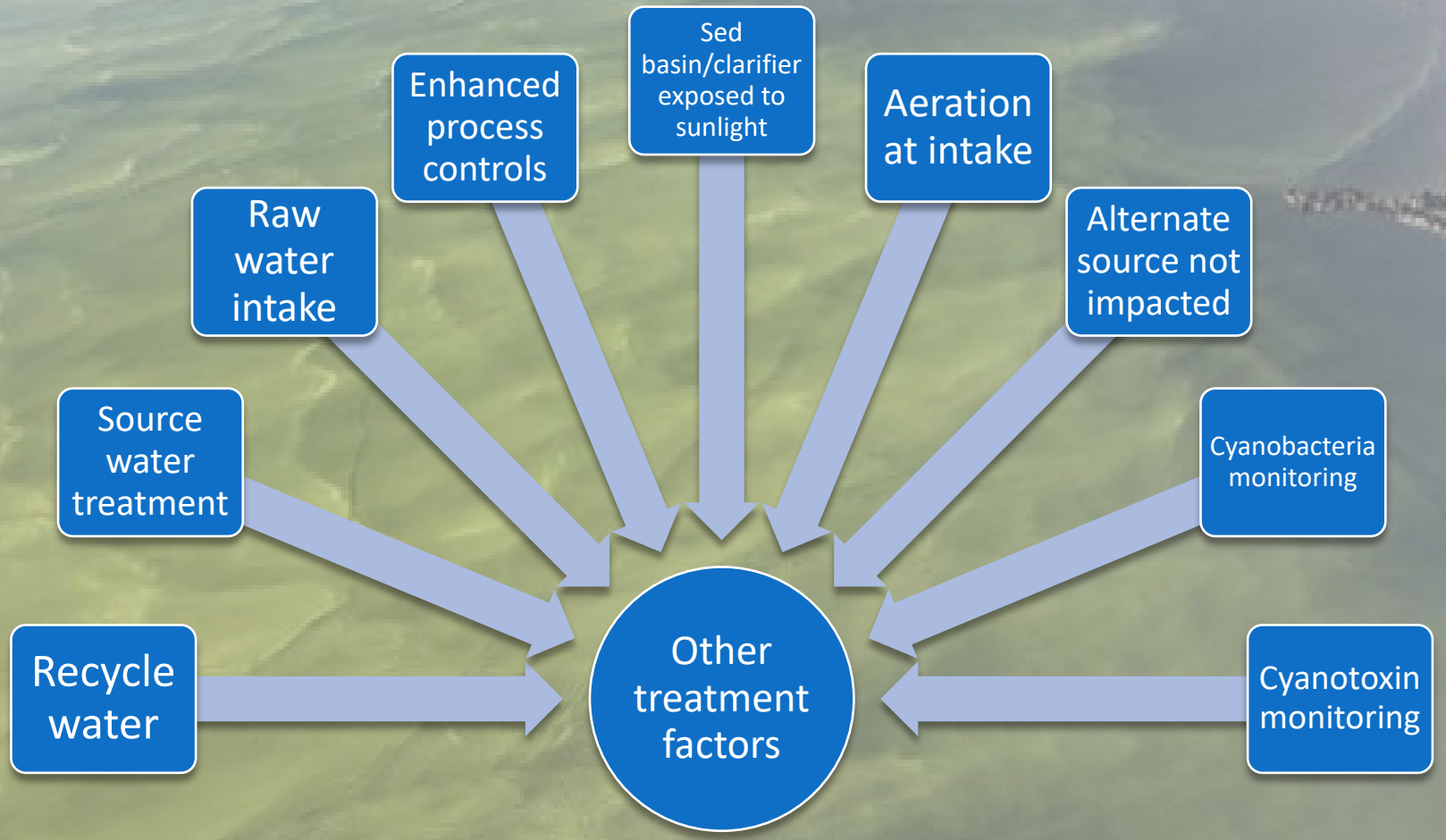
Prevention – WTP vulnerability to intracellular cyanotoxin breakthrough



Prevention – WTP vulnerability to extracellular cyanotoxin breakthrough



Prevention – WTP vulnerability – additional risk factors



Monitoring

- Objective: monitor source water and treatment processes regularly to establish a baseline and to understand when treatment adjustments may be needed to optimize during a source water HAB
  - See Dr. Paul's slides 8-18 – same CWA monitoring and forecasting concepts can be applied for monitoring drinking source water

Monitoring – summary of known approaches

Visual observation

- Bottle test
- Stick test

Cyanobacteria biomass indicators

- Turbidity, particle counts
- Pigments: chlorophyll-a, phycocyanin
- DOC
- UV254
- Color

Other indicators

- pH, temperature
- Taste & odor
- Secchi depth
- Decreased filter run times
- Increased chemical usage/needs
- Difficulty maintaining secondary disinfectant residual or meeting turbidity goals

Satellite imagery/analysis

Cyanobacteria cell identification, counting

Molecular methods

- qPCR

Analytical methods

- ELISA
  - Strip/tube tests
  - Immunoassay
  - Automated CAAS
- LC-MS/MS

Monitoring – methods

- EPA Method 546: Determination of **Total Microcystins and Nodularins** in Drinking Water and Ambient Water by Adda Enzyme-Linked Immunosorbent Assay (**Adda-ELISA**)
- EPA Method 544 : Determination of Microcystins and Nodularin in Drinking Water by Solid Phase Extraction and Liquid Chromatagraphy/Tandem Mass Spectrometry (**LC/MS/MS**): LA, LF, LR, LY, RR, YR, NOD
- EPA Method 545: Determination of **Cylindrospermopsin and Anatoxin-a** in Drinking Water by Liquid Chromatography Electrospray Ionization Tandem Mass Spectrometry (**LC/ESI-MS/MS**)

Monitoring / Forecasting – qPCR

Water Research 170 (2020) 115262

Contents lists available at ScienceDirect

Water Research

journal homepage: www.elsevier.com/locate/watres

Use of qPCR and RT-qPCR for monitoring variations of microcystin producers and as an early warning system to predict toxin production in an Ohio inland lake

Jingrang Lu [a, *], Ian Struewing [b], Larry Wymer [a], Daniel R. Tettenhorst [a], Jody Shoemaker [a], Joel Allen [a]

[a] *Office of Research and Development, United States Environmental Protection Agency, Cincinnati, OH, 45268, USA*
[b] *Pegasus Technical Services Inc, Cincinnati, OH, 45268, USA*

Forecasting

- See slide 18 of Dr. Paul's talk (previously)
- Using satellite imagery (CyAN) for drinking water applications:
  - SDWIS, UCMR4 data sources

Water Research 201 (2021) 117377

Contents lists available at ScienceDirect

Water Research

journal homepage: www.elsevier.com/lc

Assessing cyanobacterial frequency and abundance a
drinking water intakes across the United States

Megan M. Coffer [a,b,*], Blake A. Schaeffer [c], Katherine Foreman [d], Al
Keith A. Loftin [e], Richard P. Stumpf [f], P. Jeremy Werdell [g], Erin Urc
John A. Darling [c]

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[c] U.S. Environmental Protection Agency, Office of Research and Development, Durham, NC, USA
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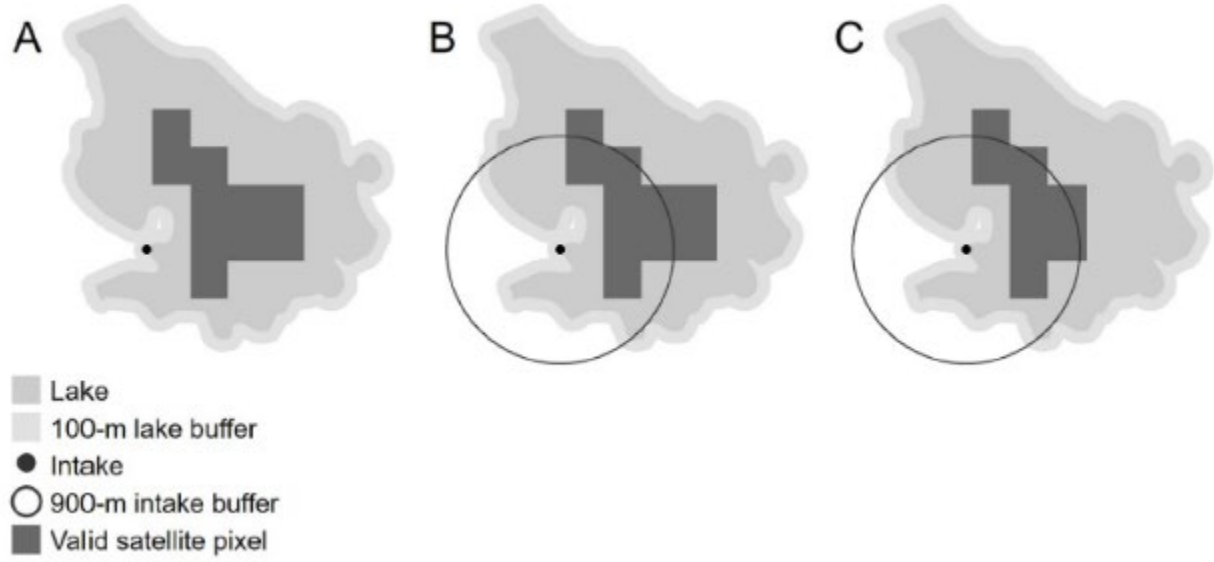
[f] National Oceanic and Atmospheric Administration, National Centers for Coastal Ocean Science, Silver Spring, MD,
[g] Ocean Ecology Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD, USA
[h] Science Systems and Applications, Inc., Ocean Ecology Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD, USA



Forecast support

Harmful Algae 84 (2019) 75–83

Contents lists available at ScienceDirect

Harmful Algae

journal homepage: www.elsevier.com/locate/hal

Combining national and state data improves predictions of microcystin concentration

Lester L. Yuan*, Amina I. Pollard

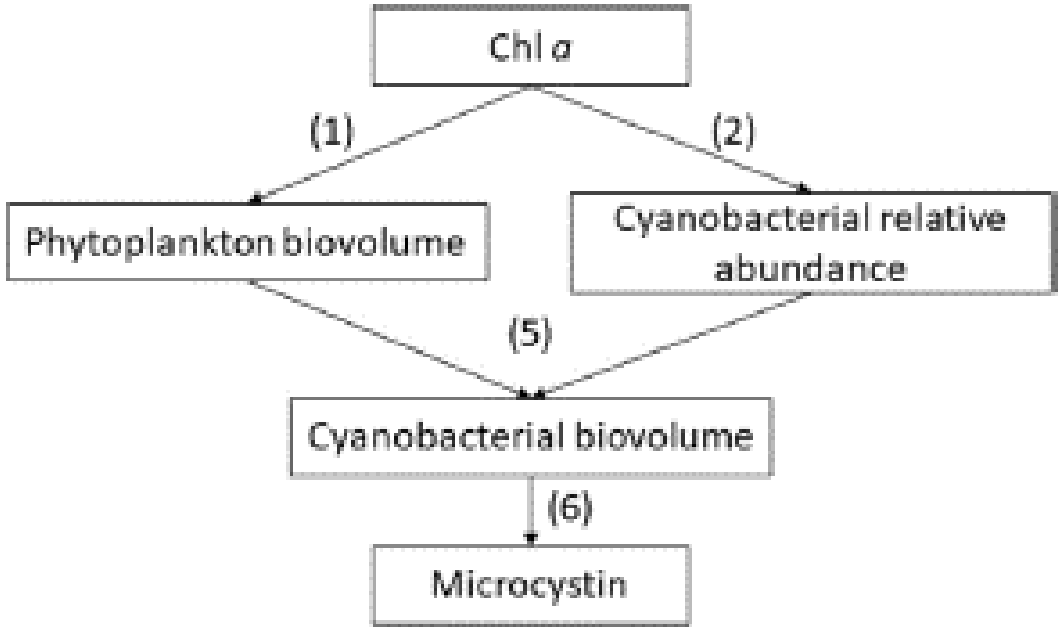
Office of Water, U.S. Environmental Protection Agency, Washington DC, 20460, USA

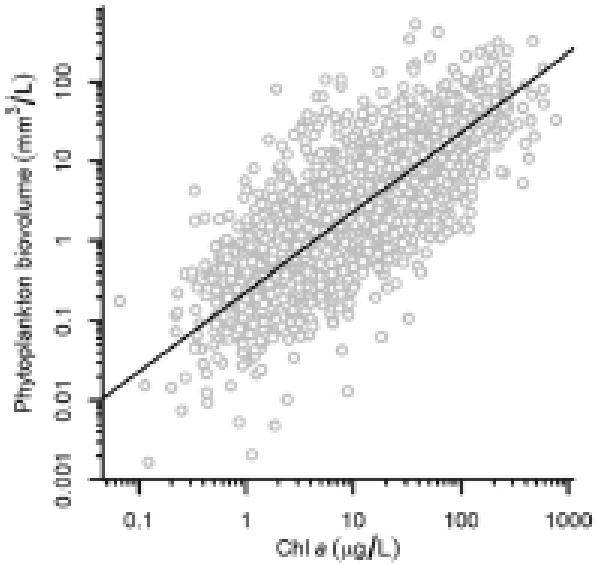
ARTICLE INFO

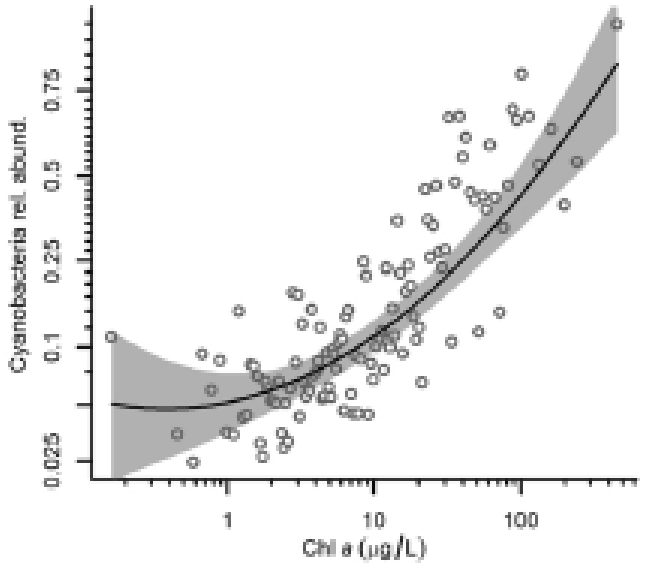
Keywords:
Cyanotoxin
Microcystin
Chlorophyll
Cyanobacteria
Bayesian network

ABSTRACT

Data collected from lakes at national (regional) scales and state (lo
regarding relationships between environmental factors and biological
of data can potentially yield more precise and accurate understandin
can include many measures, cover large spatial areas, and span broad
characteristics, analyses of these data can yield accurate estimates o
acteristics. However, the number of samples in a national data set tha
specific to waterbodies within a smaller region, like a single state, is l
provide intensive sampling of lakes within a smaller area, but these da
may only include a subset of relevant measurements. Here, a Baye
presents the causal linkages between observations of chlorophyll *a* con
microcystin concentration. This network model was fit to national d
observations of chlorophyll *a* and microcystin collected from lakes in l
national network model improved the accuracy of predictions of mic
to a model based only on Iowa data.




Phytoplankton biovolume (mm³/L)
0.001
0.01
0.1
1
10
100
0.1
1
10
100
1000
Chl a (µg/L)


Cyanobacteria rel. abund.
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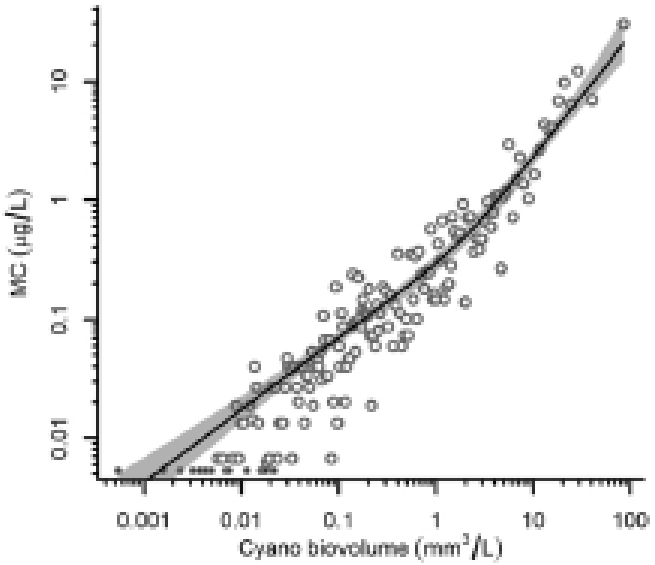
0.25
0.5
0.75
1
10
100
Chl a (µg/L)


MC (µg/L)
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0.001
0.01
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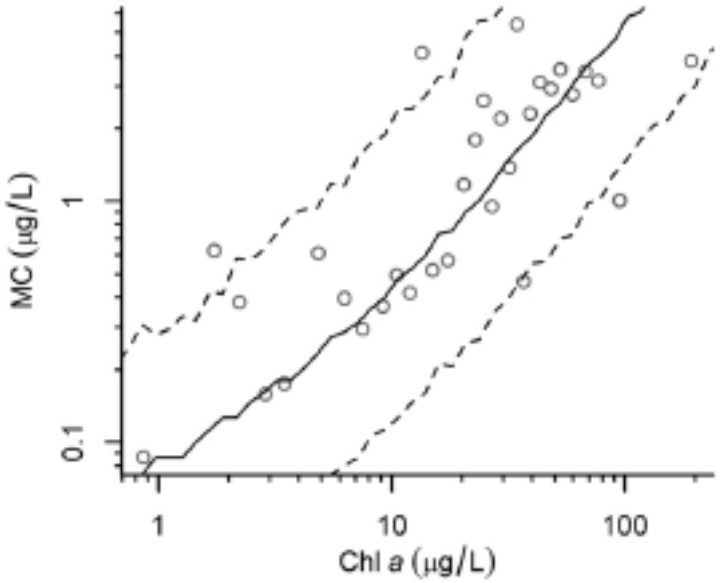
Cyano biovolume (mm³/L)


MC (µg/L)
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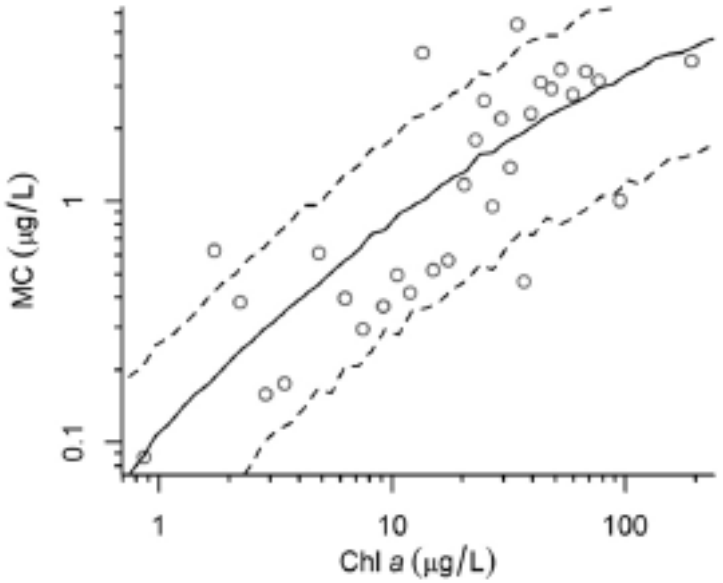
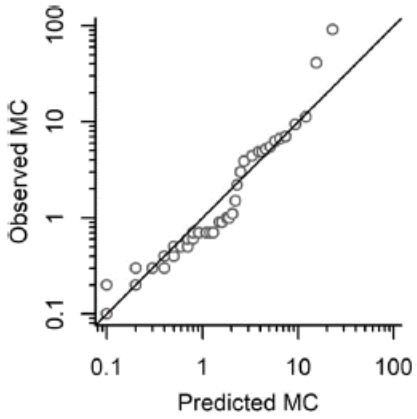
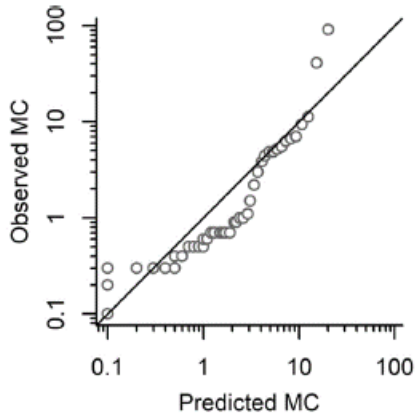
Chl a (µg/L)


MC (µg/L)
0.1
1
1
10
100
Chl a (µg/L)


Observed MC
0.1
1
10
100
0.1
1
10
100
Predicted MC


Observed MC
0.1
1
10
100
0.1
1
10
100
Predicted MC

Forecast support

F1000Research F1000Research 2016, 5:151 Last updated: 25 DEC 2016

Check for updates

RESEARCH ARTICLE

REVISED Associations between chlorophyll *a* and various microcystin health advisory concentrations [version 2; referees: 1 approved, 2 approved with reservations]

Jeffrey W. Hollister, Betty J. Kreakie

Office of Research and Development, National Health and Environmental Effects Research Laboratory, Atlantic Ecology Division, US Environmental Protection Agency, Narragansett, RI, USA

v2 **First published:** 09 Feb 2016, **5**:151 (doi: 10.12688/f1000research.7955.1)
Latest published: 13 Jun 2016, **5**:151 (doi: 10.12688/f1000research.7955.2)

Abstract

Cyanobacteria harmful algal blooms (cHABs) are associated with a wide range of adverse health effects that stem mostly from the presence of cyanotoxins. To help protect against these impacts, several health advisory levels have been set for some toxins. In particular, one of the more common toxins, microcystin, has several advisory levels set for drinking water and recreational use. However, compared to other water quality measures, field measurements of microcystin are not commonly available due to cost and advanced understanding required to interpret results. Addressing these issues will take time and resources. Thus, there is utility in finding indicators of microcystin that are already widely available, can be estimated quickly and *in situ*, and used as a first defense against high levels of microcystin. Chlorophyll *a* is commonly measured, can be estimated *in situ*, and has been shown to be positively associated with microcystin. In this paper, we use this association to provide estimates of chlorophyll *a* concentrations that are indicative of a higher probability of exceeding select health advisory concentrations for microcystin. Using the 2007 National Lakes Assessment and a conditional probability approach, we identify chlorophyll *a* concentrations that are more likely than not to be associated with an exceedance of a microcystin health advisory level. We look at the recent US EPA health advisories for drinking water as well as the World Health Organization levels for drinking water and recreational use and identify a range of chlorophyll *a* thresholds. A 50% chance of exceeding one of the specific advisory microcystin concentrations of 0.3, 1, 1.6, and 2 µg/L is associated with chlorophyll *a* concentration thresholds of 23, 68, 84, and 104 µg/L, respectively. When managing for these various microcystin levels, exceeding these reported chlorophyll *a* concentrations should be a trigger for further testing and possible management action.

Open Peer Review

Referee Status: ? ? ✓

	Invited Referees 1	2	3
REVISED version 2 published 13 Jun 2016			✓
version 1 published 09 Feb 2016	? report	? report	✓ report

1 **Alan E. Wilson**, Auburn University USA

2 **Jason W. Marion**, Eastern Kentucky University USA

3 **Zofia E Taranu**, Université de Montréal Canada

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Comments (0)

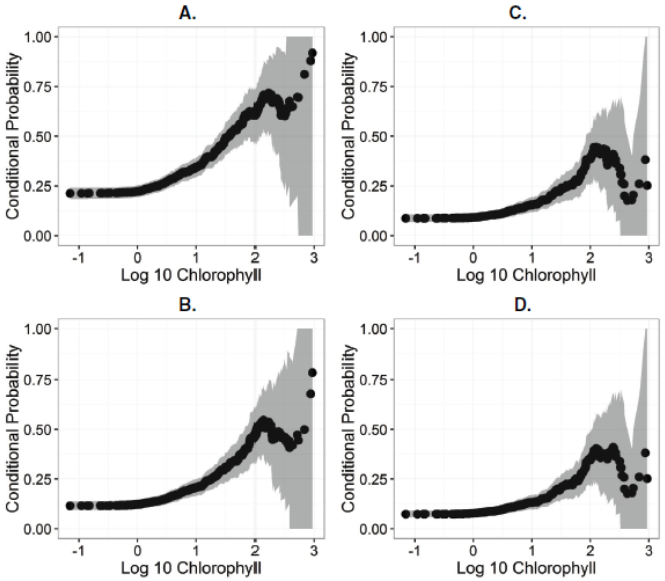


Figure 1. Conditional probability plots showing association between the probability of exceeding various microcystin-LR (MLR) health advisory Levels. A.) Plot for USEPA Child (0.3 µg/L). **B**.) Plot for WHO Drinking (1 µg/L). **C**.) Plot for USEPA Adult (1.6 µg/L). **D**.) Plot for WHO Recreational (2 µg/L).

Table 2. Chlorophyll *a* concentrations that are associated with a 50% probability of exceeding a microcystin health advisory concentration.

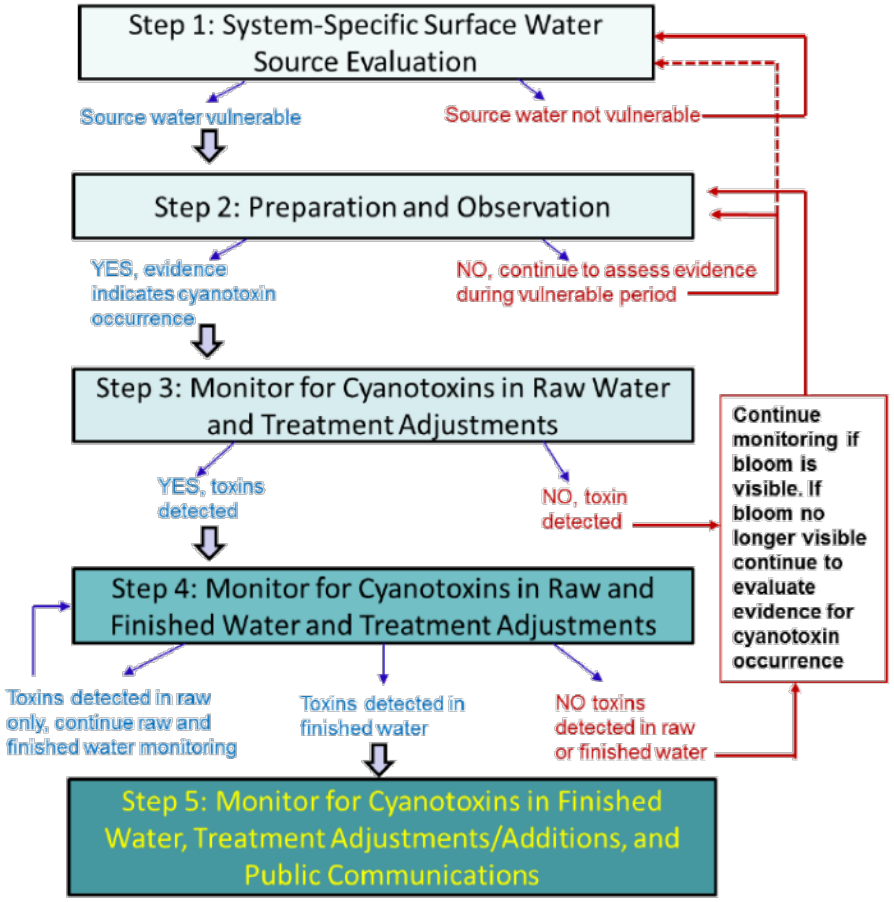
Cond. Probability	USEPA Child (0.3 µg/L)	WHO Drink (1 µg/L)	USEPA Adult (1.6 µg/L)	WHO Recreational (2 µg/L)
0.1	0.07	0.07	0.07	1
0.2	0.07	4	12	17
0.3	3	17	32	45
0.4	11	37	68	77
0.5	23	68	84	104
0.6	39	97	115	185
0.7	66	126	871	871
0.8	116	271	871	871
0.9	170	516	871	871

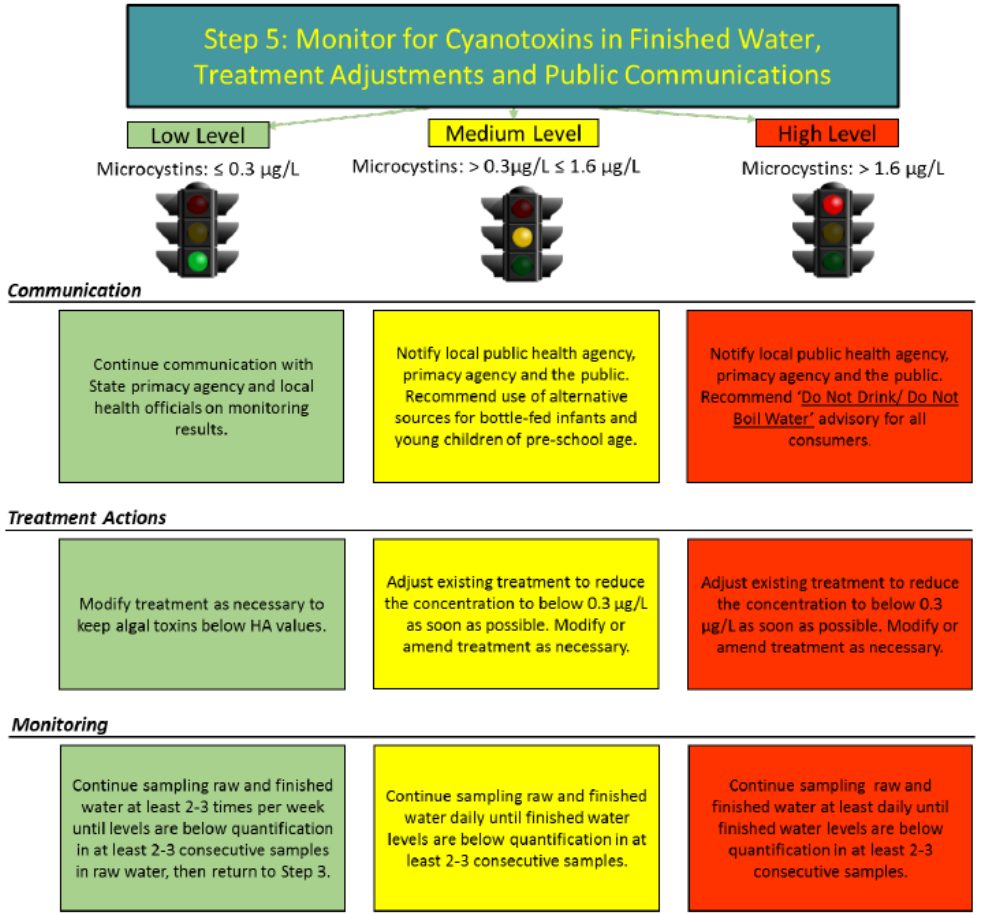
Response – EPA online publications/tools

- ***Cyanotoxin Management Plan Template and Example Plans***
- ***Cyanotoxin Management Tools for Public Water Systems***
- ***Recommendations for Public Water Systems to Manage Cyanotoxins in Drinking Water***

Response

- **U.S. EPA *Recommendations for Public Water Systems to Manage Cyanotoxins in Drinking Water***





Response – public communication tools

- **U.S. EPA *Drinking Water Cyanotoxin Risk Communication Toolbox***
- **U.S. EPA *Water Contamination Response Resources***

Response – state outreach

- Drinking water HAB workshops conducted as part of AWOP in R10 (Oregon, remote) and R6 (Des Moines, IA)
- Operator and technical assistance provider training for Idaho DEQ

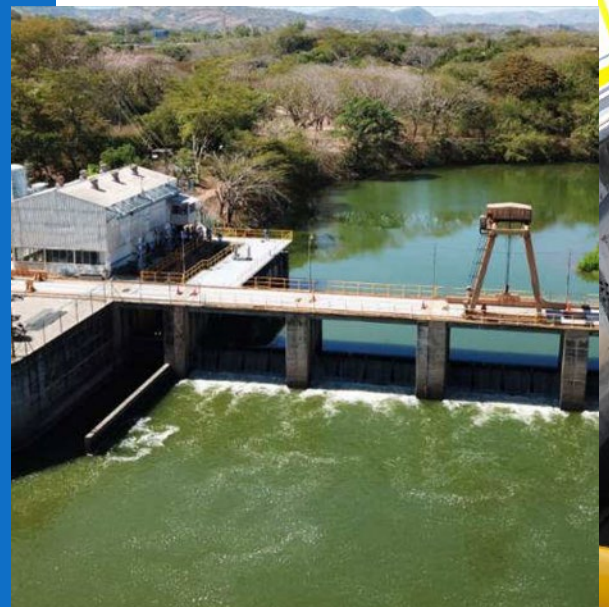
Response – technical assistance

GOBIERNO DE EL SALVADOR

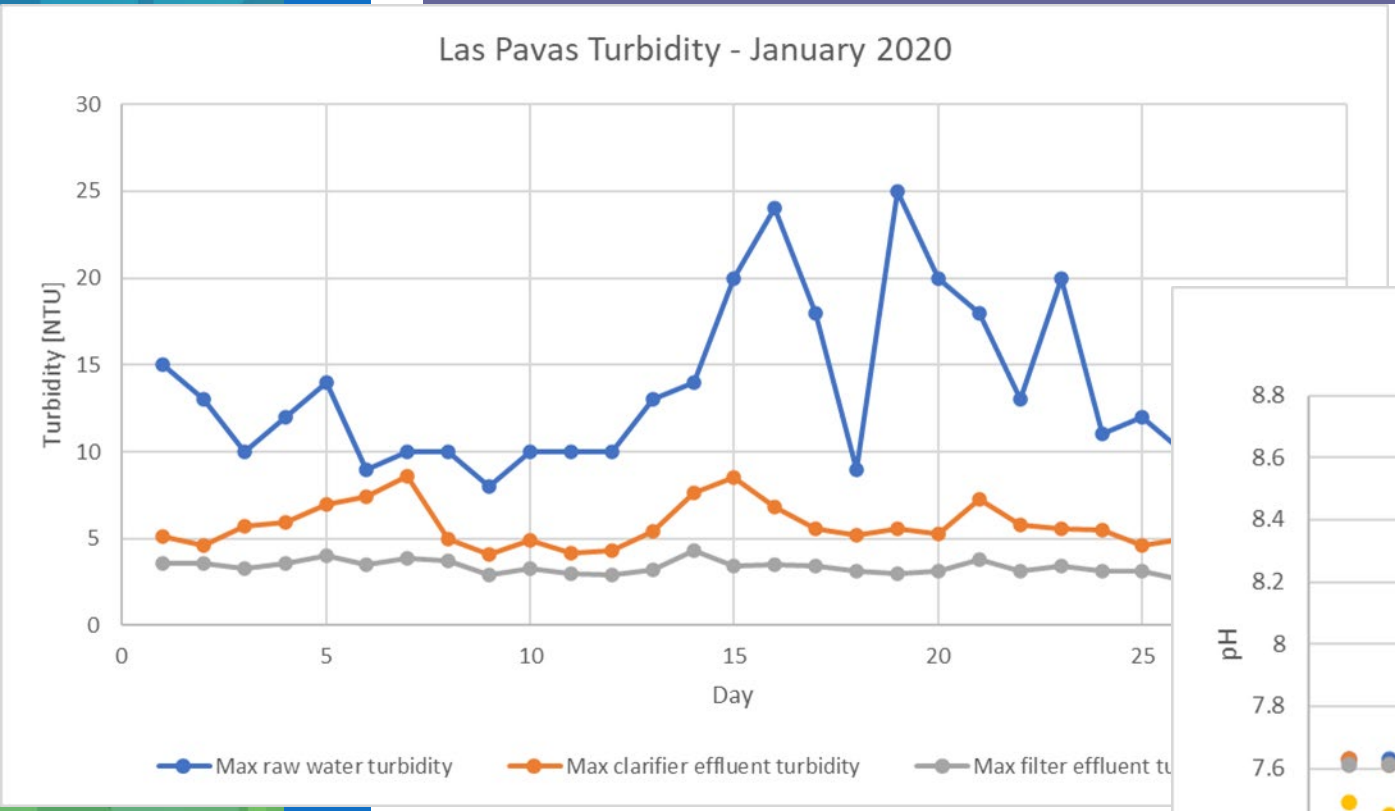
ANDA
El Agua es desarrollo

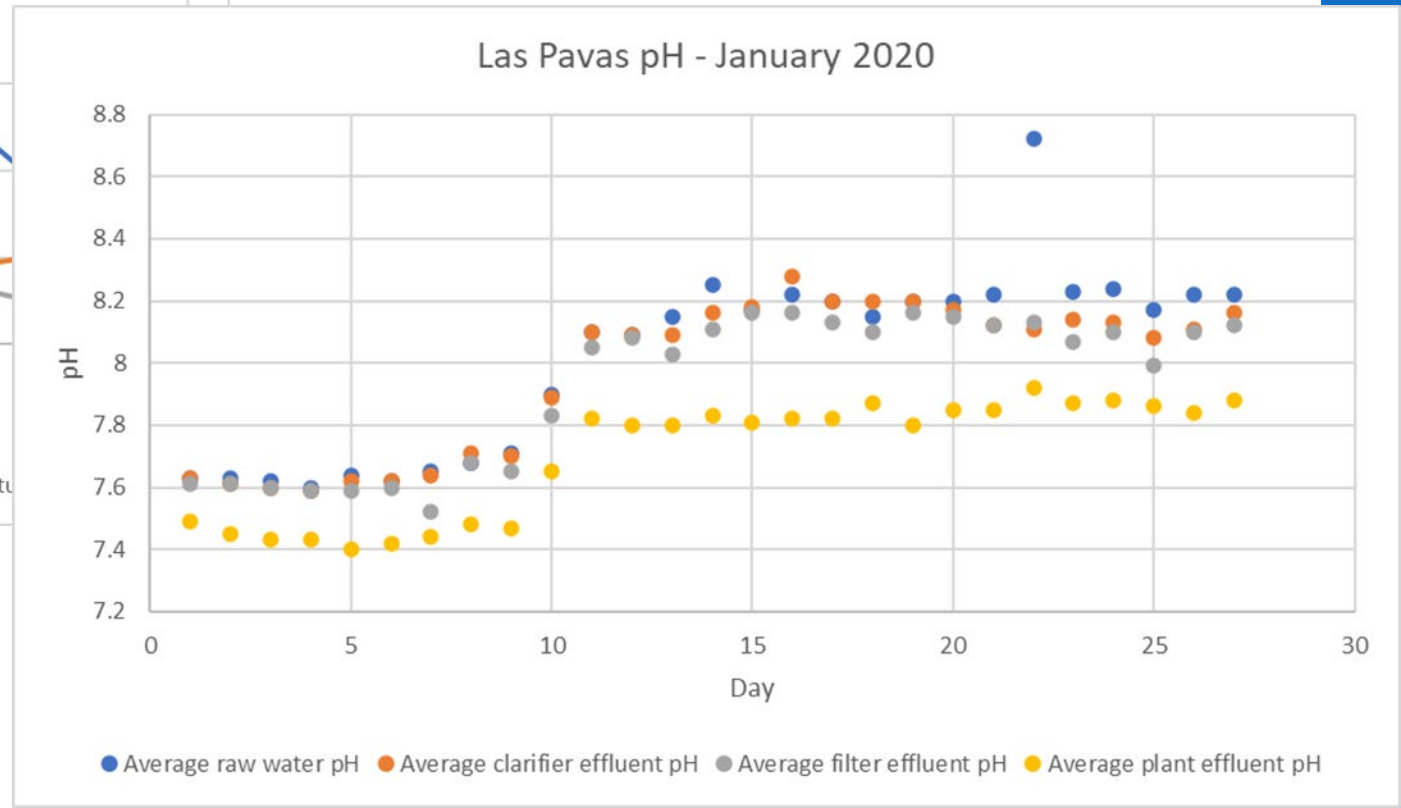
USAID
FROM THE AMERICAN PEOPLE

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY



Response – technical assistance





Luis Rodriguez Retweeted

Embajada EEUU en ES @USE... · 20h

Seguimos ayudando a #ElSalvador a buscar soluciones integrales para garantizar la calidad del agua. Tom Waters, de @EPA, estuvo en la planta potabilizadora Las Pavas de @ANDASV para conocer la situación y dar asesoría técnica según las mejores prácticas de EE.UU. #SocioConfiable

Embajada EEUU en ES @USE... · 20h

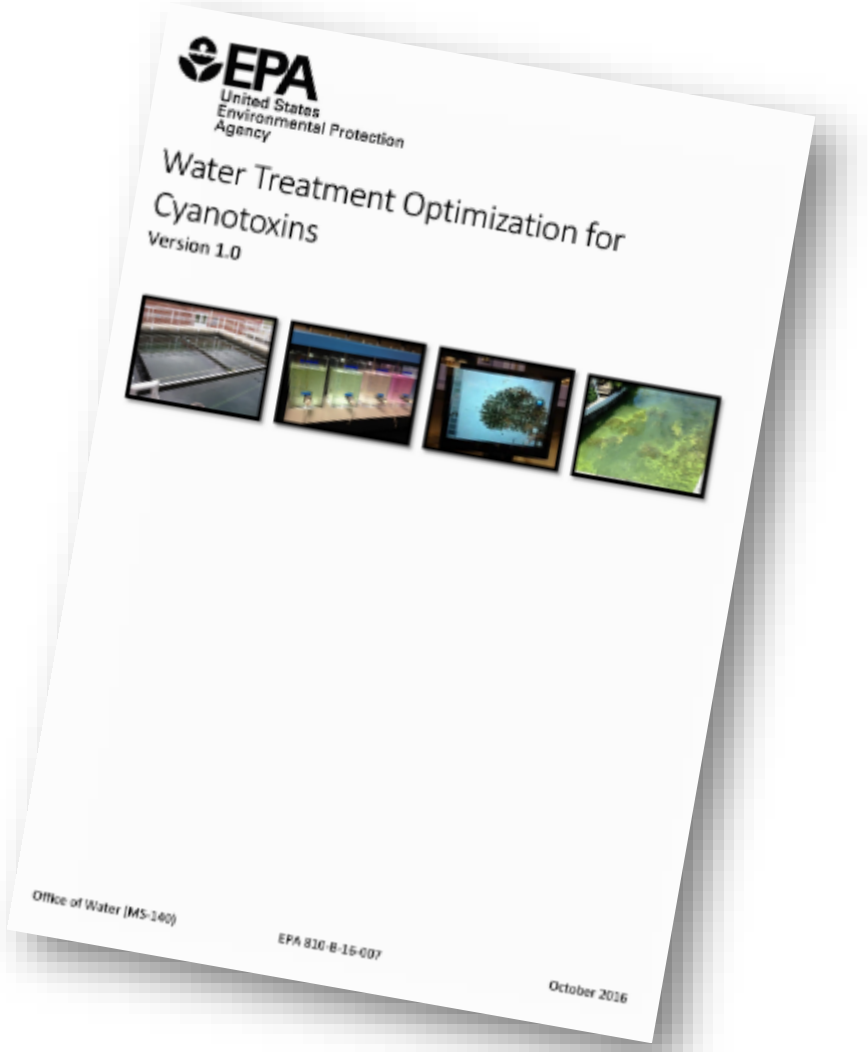
Después de la ayuda inmediata en la reciente crisis, Tom Waters, experto de la Agencia de Protección Ambiental de EEUU (@EPA), está en El Salvador. El experto se reunió con @FredckBenitez de @ANDASV y @LRodriguez_SV, comisionado presidencial de proyectos estratégicos del país.

Luis Rodriguez
@LRodriguez_SV

Gracias al apoyo de nuestro principal aliado estratégico Estados Unidos y la gestión de @USEmbassySV, el #PlanNacionalDeAgua tendrá los resultados que esperamos y nuestra población tendra acceso al servicio de agua del que por mucho tiempo estuvieron limitados. @EPA

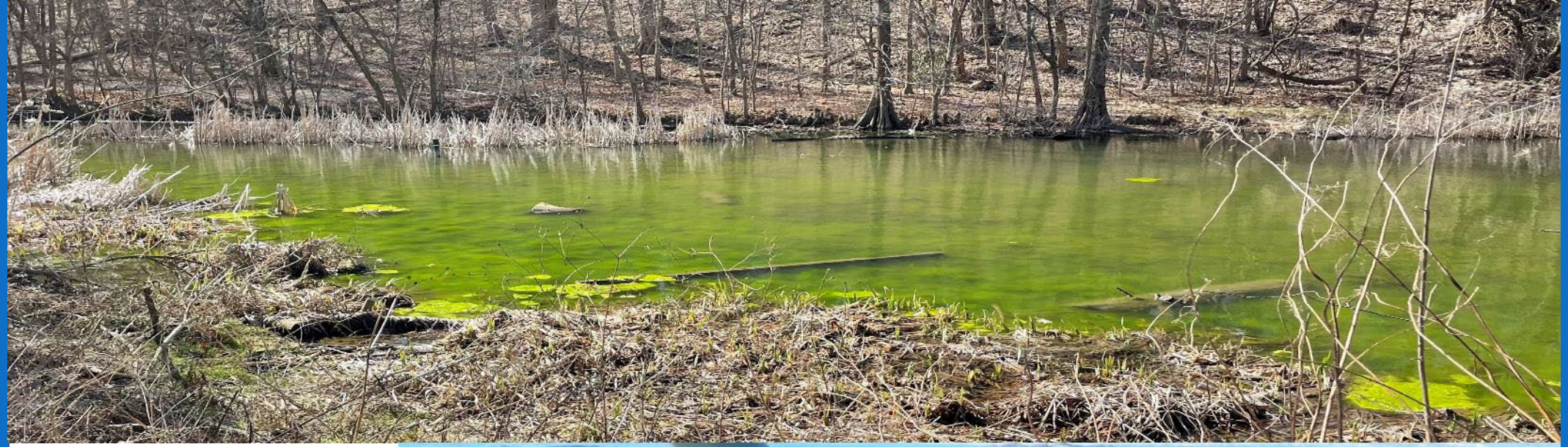
Control – online documents

- Water Treatment Optimization for Cyanotoxins
  - Supports PWS in developing monitoring and treatment optimization approaches
  - Proactive approaches for sampling/monitoring to help PWS anticipate treatment needs and remove cyanotoxins from DW.



Control - AWOP

- Area-Wide Optimization Program
  - Provides tools and approaches to meet water quality optimization goals
  - Increased, sustainable public health protection
  - Compliance assistance through optimization
  - Teaches problem-solving skills to improve operations without costly capital improvements



Thanks!

Contact info:
Tom Waters, PE
waters.tom@epa.gov
513-569-7611

Photo courtesy of Idaho DEQ