Data-Driven Source Water Management and Decision Support

Ashley Bair | July 12, 2022

OTCO Reservoir Management Workshop

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Outline

- Overview of HABs
- HAB Source Water Management Practices
- Water Column Profiling
- Treatment Optimization for Cyanotoxin Removal

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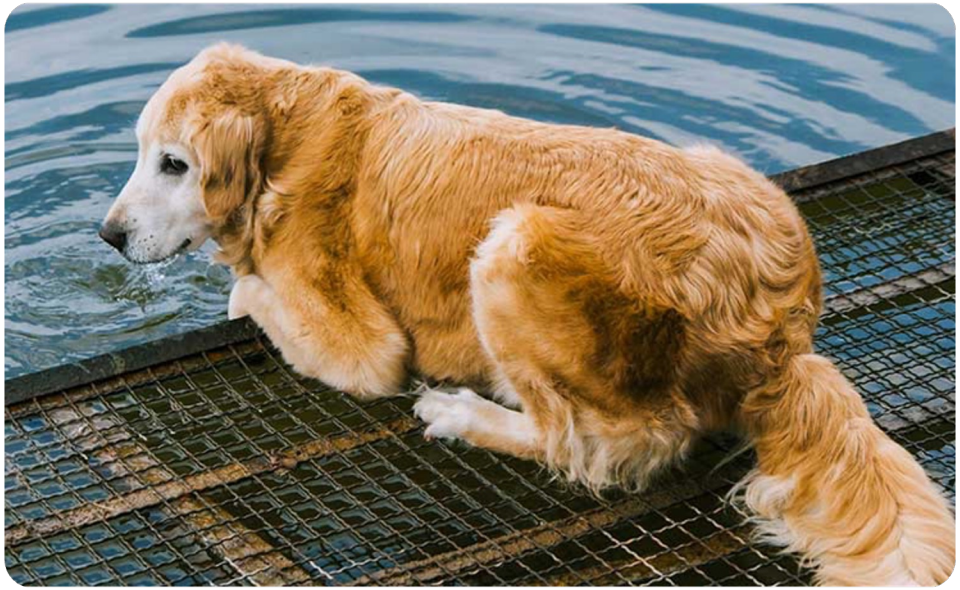
Quick Overview of **HABs**

What are **Harmful Algal Blooms** (HABs)

- HABs are overgrowths of algae (especially cyanobacteria) that can cause harm to people or animals
- Anoxic "dead zones"
  - Fish kills, bad smells
- Blue-green algae produces **dangerous** toxins (cyanotoxins)



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HAB **Concerns**

- Cyanotoxins (regulatory)
  - Microcystin
  - Cylindrospermopsin
  - Anatoxin-a
  - Saxitoxin
- Interfere with water plant performance (i.e. filtration)
- Taste and odor issues
- Increase TOCs and DBP precursors

What Causes **HABs**

- Slow moving water
- Warm water temperatures
- Sunlight
- Excessive nutrients, especially nitrogen and phosphorus

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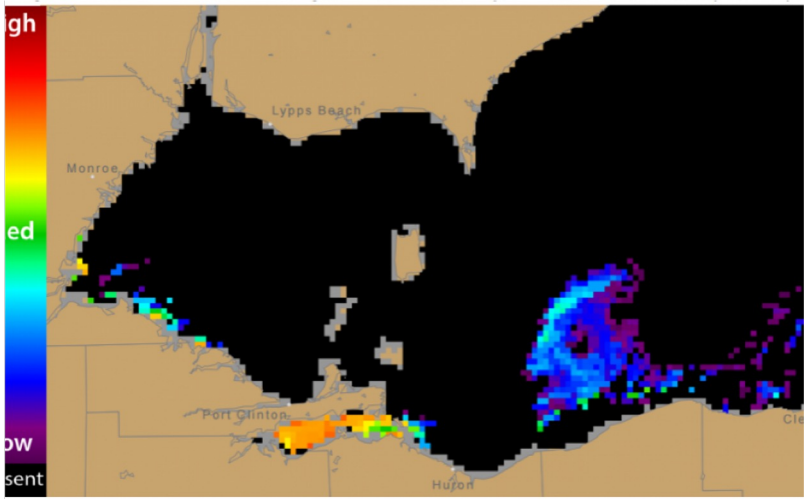
HAB Source Water **Management Practices**

Current HAB **Monitoring Strategies**

- Surface Observation
- Satellite
- Intake water quality
- Profiling water quality
- Cell identification / enumeration
- qPCR
- Toxin screening (ELISA, LCMS)



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Current HAB **Prevention and Mitigation**

- Mixing / Destratification
- Hypolimnetic Oxygenation / Aeration
- Ultrasonication
- Algaecide (e.g. Copper Sulfate, Peroxide)

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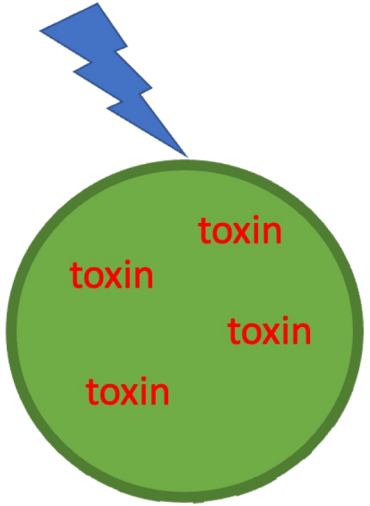
Algaecide **Use**

- Algaecides are most effective when Cyanobacteria cell counts are < 10,000 cells/mL
  - Early application reduces the potential for release of high concentrations of toxins
- If you wait until you have a **lot** of algae



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Monitoring Your Water Source… **It's Complicated**

- Reservoirs are three-dimensional, water intakes are one-dimensional
- Reservoirs are highly variable across horizontal and vertical dimensions and time
  - Temperature
  - Nutrients
  - Light intensity
  - Primary productivity
- Responding to information from a single point samples in like tasting a single sesame seed and then trying to judge the quality of the whole burger

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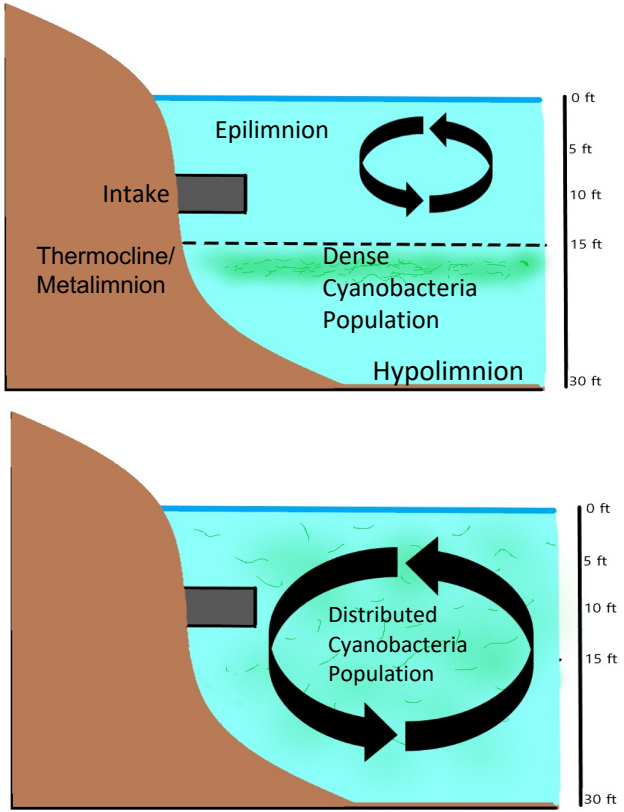
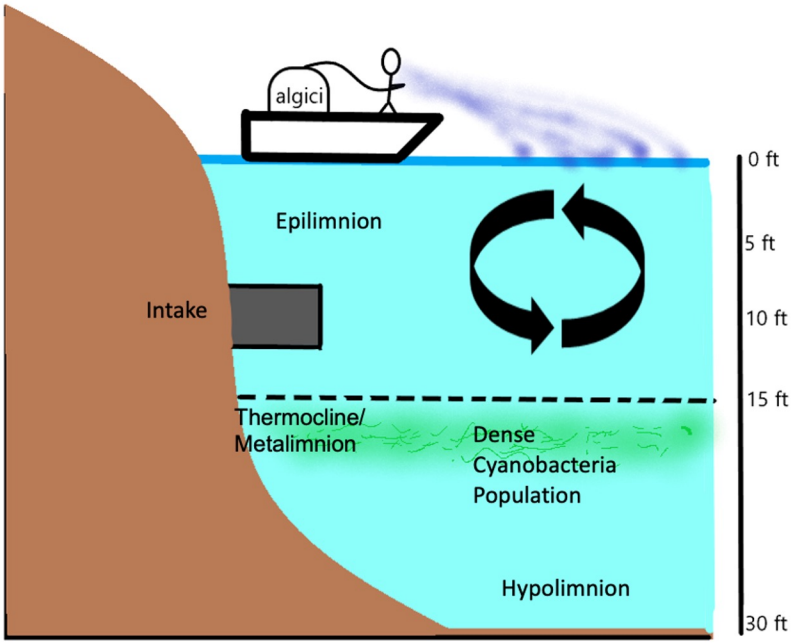
Cyanobacteria Blooms can lurk in **Stratified Layers**

- Cyanobacteria are know to satisfy and concentrate at varying depths (eg metalimnion)
  - This includes potentially toxic species such as Planktothrix
- Population may rise with the thermocline, subjecting to mixing and entrances into intake
- Loss of the thermocline forces mixing in lower depths, distributing cyanobacteria throughout water column



It's Easy to Apply Algaecide **Ineffectively**

- Epilimnion mixes well
- Little mixing between epilimnion and metalimnion
- Application of algaecide at the surface may not reach stratified cyanobacteria



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Data-Driven Reservoir Management with Water Column **Profiling**

Water Column Profiling - Tools

- Boat
- Sonde
  - Temperature
  - Phycocyanin RFU (cyanobacteria pigment)
  - Chlorophyll RFU (photoautotroph pigment)
  - Dissolved Oxygen
  - pH
  - Dissolved Organic Matter
- PPE – Sunglasses, sunscreen, lifejacket

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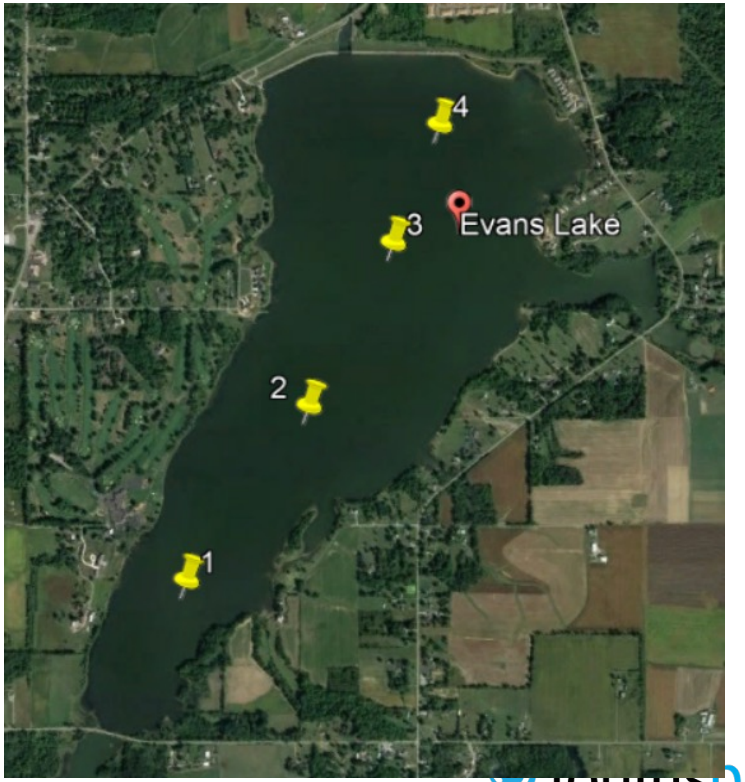
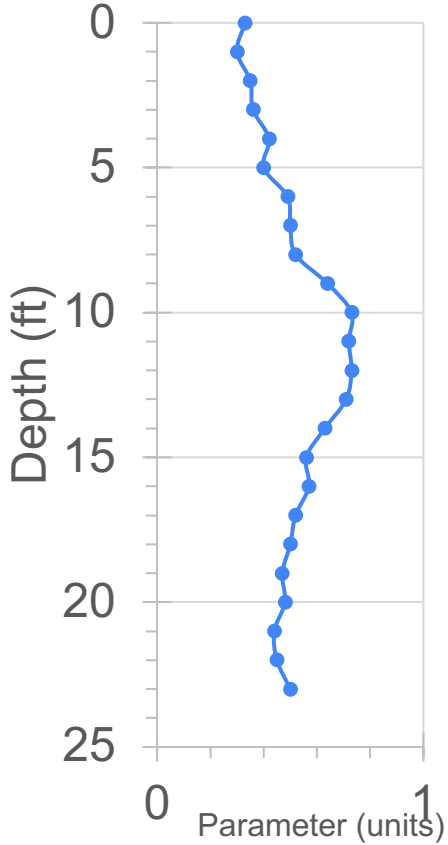
Water Column Profiling – Plan a Protocol

- Start date
- Frequency
- Sampling Sites
  - Ends and middle
  - Plant Intake area
  - Near Stream Inlets
  - Intake from River source
- Sampling Depths



Visualizing Water Column Data

- Scatter Chart
  - Y-axis: Depth (values in reverse order)
  - X-axis: Parameter
- Track the impact of any HAB management technology (Phycocyanin peaks)
- Track the performance of mixing or aeration (Dissolved Oxygen)
- Understand relative HAB risk throughout the reservoir



Depth (ft)	Sample 1
0	0.33
1	0.3
2	0.35
3	0.36
4	0.42
5	0.4
6	0.49
7	0.5
8	0.52
9	0.64
10	0.73
11	0.72
12	0.73
13	0.71
14	0.63
15	0.56
16	0.57
17	0.52
...	...

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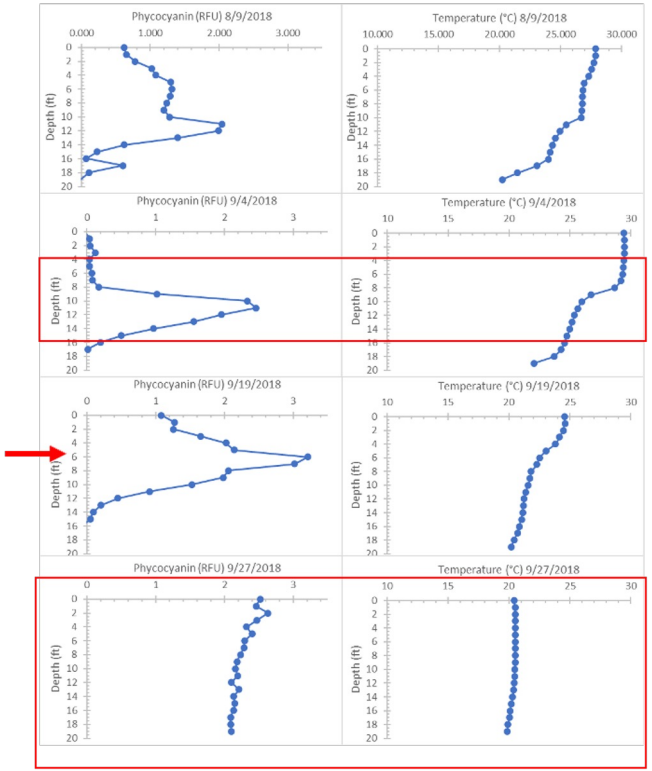
Water Column **Profiling Trends**

- Phycocyanin peaks observed in metalimnion
- Peaks sometimes cross intake depth
- Peaks disappear when thermocline disappears



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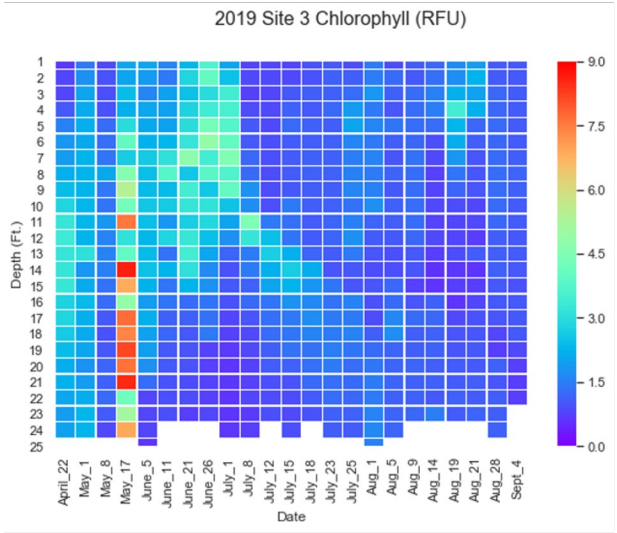
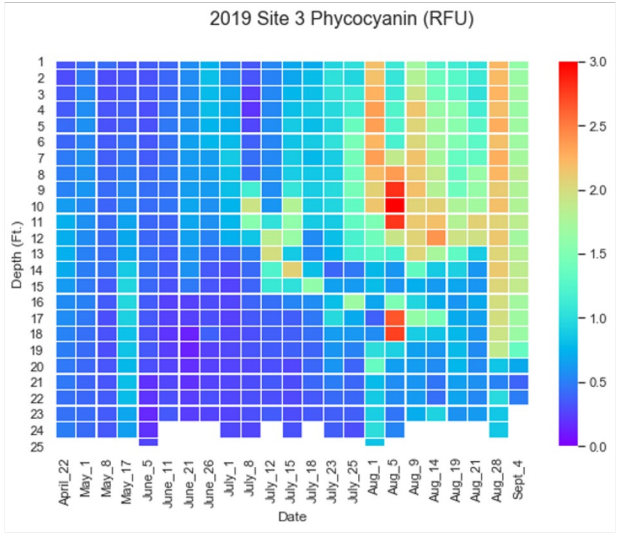
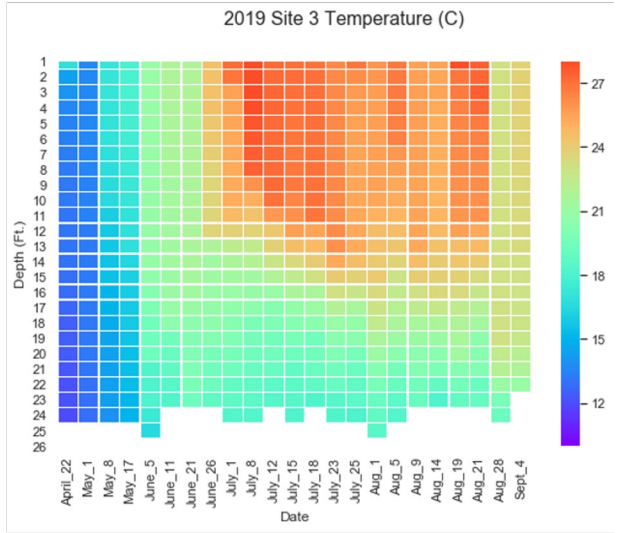
Parameters of **Interest**







- Chlorophyll - quantify primary productivity
- Phycocyanin - quantify cyanobacteria specific productivity
- Temperature - identify thermoclines and seasonal turnover

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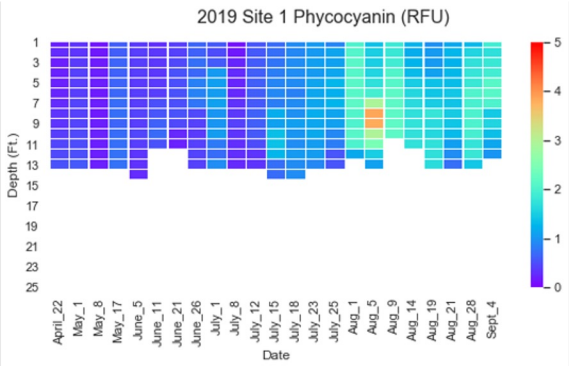
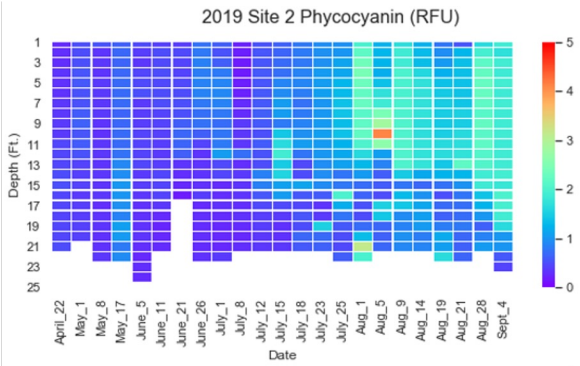
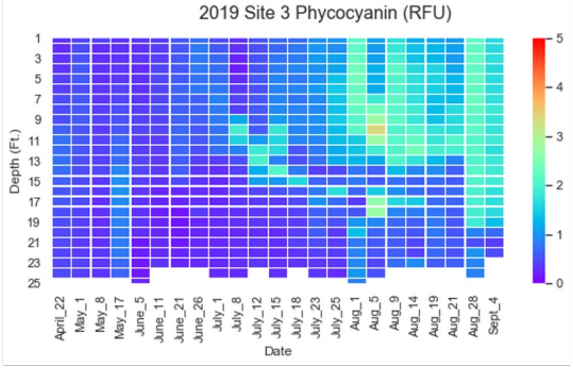
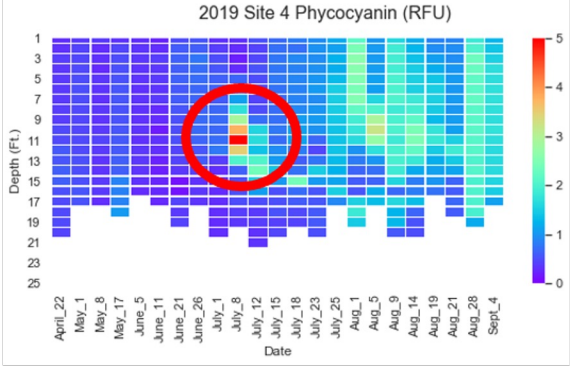
Comparison Between **Sites**









- Identify problems and areas early
- Identify stratification trends and limits

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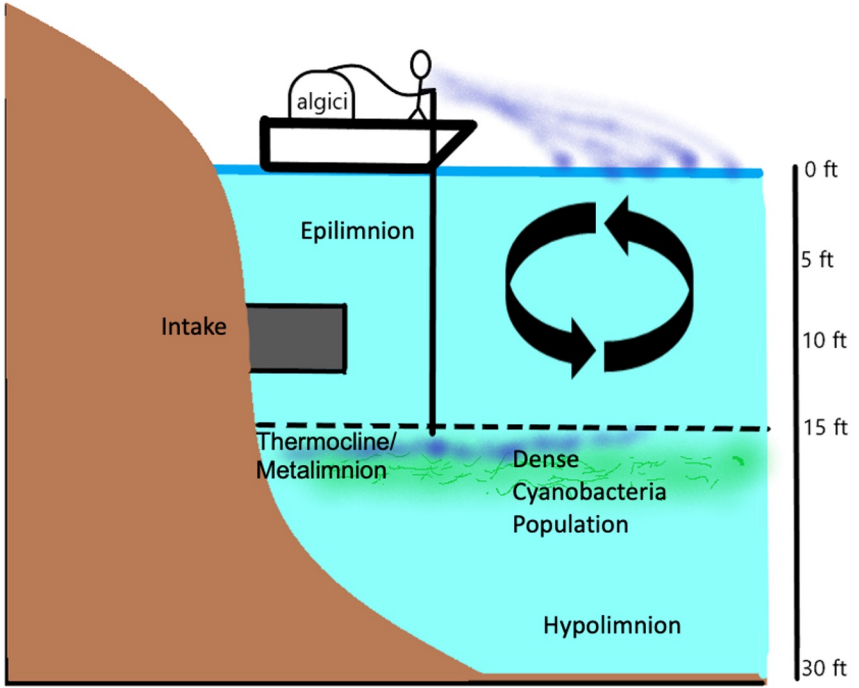
Targeted Application of **Algaecide**

- Profile before algaecide application
- “Aim” for phycocyanin peaks
- Requires “rig” to pump algaecide
- Limitations - Cannot apply as widely



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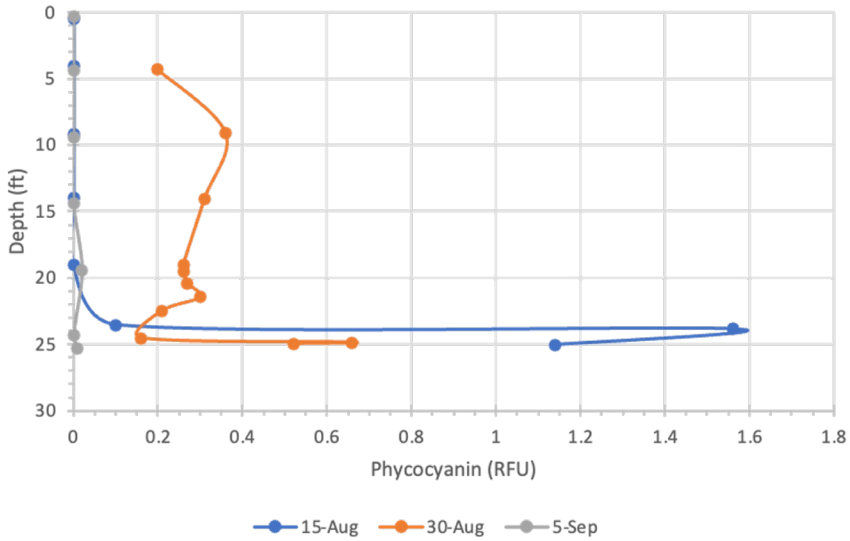
Delphos, **OH WTP**

- Fall 2018-Winter 2019 persistent bloom of Planktothrix rubescens caused high raw microcystin
- Late-Summer Profiling showed stratified cyanobacteria bloom near reservoir bottom (>100,000 cells/mL)
- Targeted application followed by whole lake application decreased phycocyanin to below detectable levels throughout most of the water column



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Delphos, **OH WTP**

2019

- Dosed 5-10 mg/L of PAC
- $96-190 / Day on PAC for several months
- $37 - 74 / MG water treated

2020

- Treated 450 MG reservoir
- Applied 1 barrel of algaecide each application
- ~$672 / Application
- $1.49 x 10^-6 / mg treated
- Confidently paused algaecide application for additional cost savings

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Data-Driven Treatment Optimization for **Cyanotoxin Removal**

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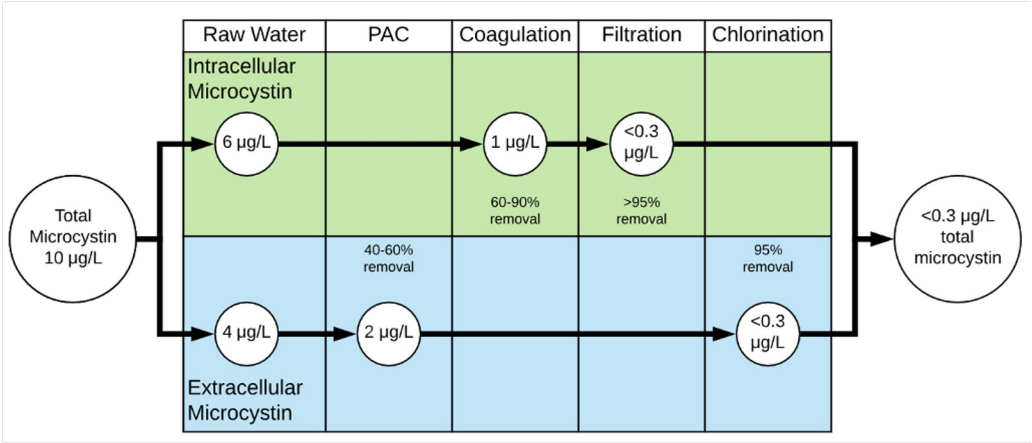
Toxin Treatment **Barriers**

- Chemicals or processes that remove toxins from water
- Intracellular and Extracellular Removals Using
  - Carbon (PAC and GAC)
  - Coagulations / Sedimentation and Filtration
  - Oxidation (Permanganate Chlorination, etc)



Question: Why not just use high concentrations of chlorination to oxidize microcystin?

Answer: You'll blow your DBPs!

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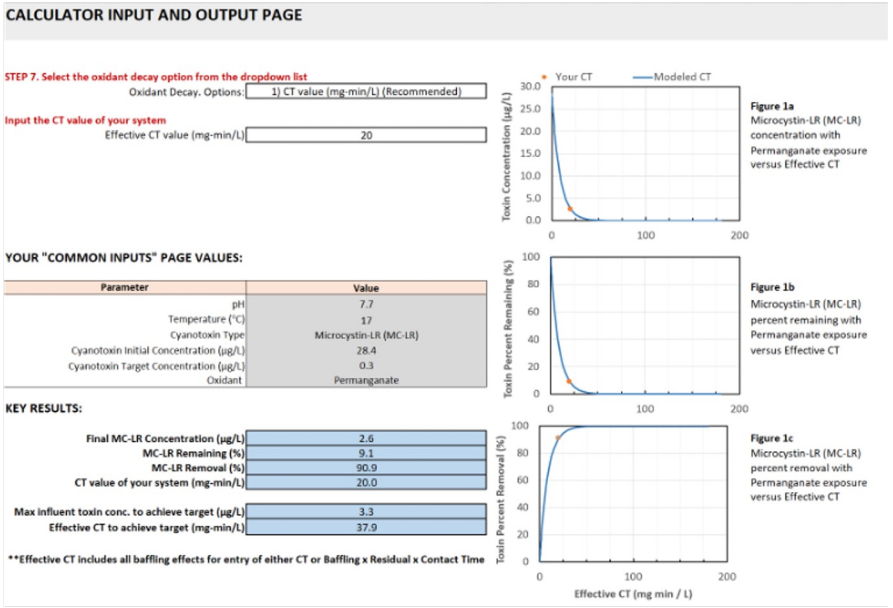
Tools to Manage & Quantify Your Cyanotoxin **Treatment Barriers**

- Manual Jar Test
  - Estimate carbon microcystin barrier
- Spreadsheets (AWWA / Hazen CyanoTox (for Chlorination, Permanganate)
- Treatment Simulation Software
  - Real-Time Data Acquisition
  - Real-Time Treatment Optimizations
  - Sequential Barriers



CALCULATOR INPUT AND OUTPUT PAGE

STEP 7. Select the oxidant decay option from the dropdown list

Oxidant Decay. Options: 1) CT value (mg-min/L) (Recommended)

Input the CT value of your system

Effective CT value (mg-min/L): 20

YOUR "COMMON INPUTS" PAGE VALUES:

Parameter	Value
pH	7.7
Temperature (°C)	17
Cyanotoxin Type	Microcystin-LR (MC-LR)
Cyanotoxin Initial Concentration (µg/L)	28.4
Cyanotoxin Target Concentration (µg/L)	0.3
Oxidant	Permanganate

KEY RESULTS:

Final MC-LR Concentration (µg/L)	2.6
MC-LR Remaining (%)	9.1
MC-LR Removal (%)	90.9
CT value of your system (mg-min/L)	20.0
Max influent toxin conc. to achieve target (µg/L)	3.3
Effective CT to achieve target (mg-min/L)	37.9

**Effective CT includes all baffling effects for entry of either CT or Baffling x Residual x Contact Time

Figure 1a Microcystin-LR (MC-LR) concentration with Permanganate exposure versus Effective CT

Figure 1b Microcystin-LR (MC-LR) percent remaining with Permanganate exposure versus Effective CT

Figure 1c Microcystin-LR (MC-LR) percent removal with Permanganate exposure versus Effective CT

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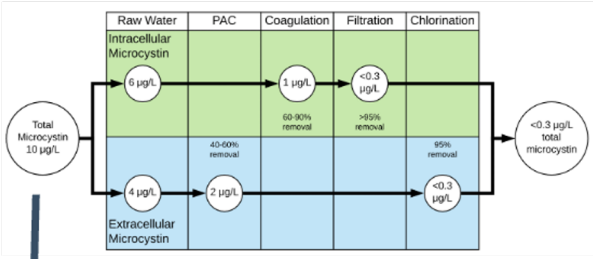
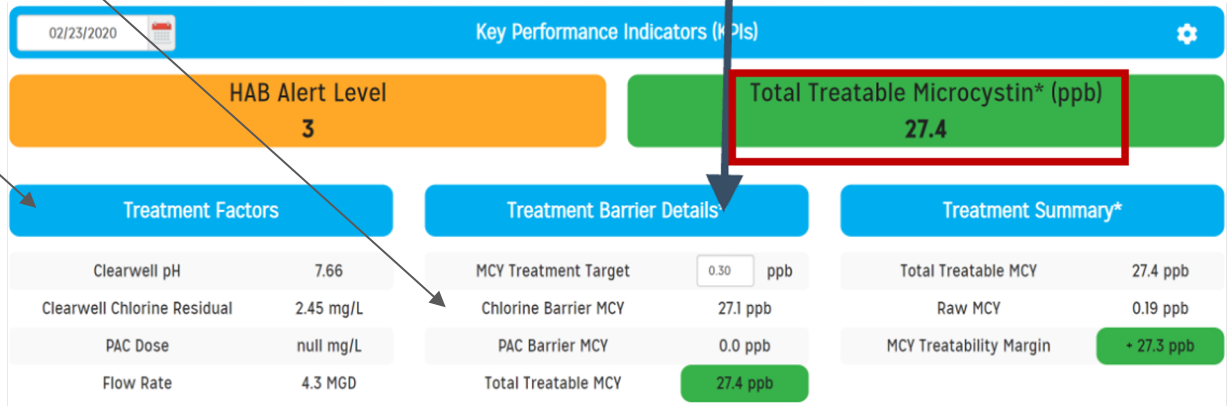
HAB Monitor™ **Treatment Details**

- **Sequence of treatment barriers** to achieve treatment target
- Incorporates current conditions (i.e. treatment factors)
- **Total Treatable** is current estimate of toxin barriers





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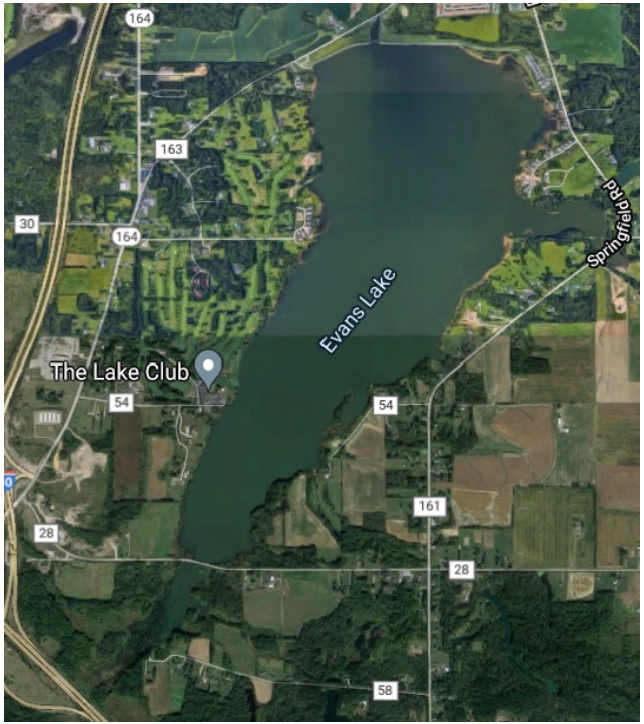
Struthers Source Water – Evans Lake

- Evans Lake
- Near Youngstown, OH
- Profiling since 2018
- 4 Sample Sites
- Average max depth 30ft (Site 3)
- Intake at 10 feet (Site 4)
- Surface Area 582 acres
- Max volume 12,574 ac-ft



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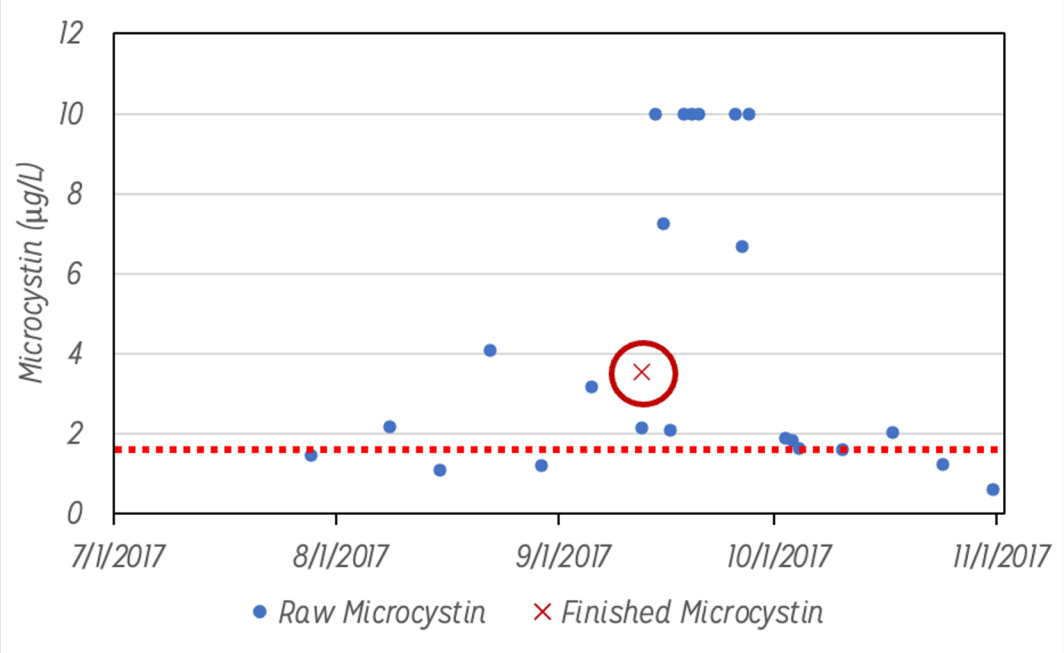
Struthers **HAB Event**

- What do you do when algal toxins get into your drinking water?
- Treatment!
  - But: What works? How much do you need? How much will it cost?



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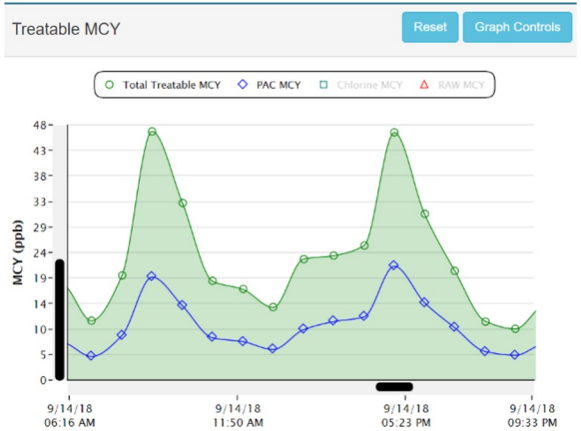
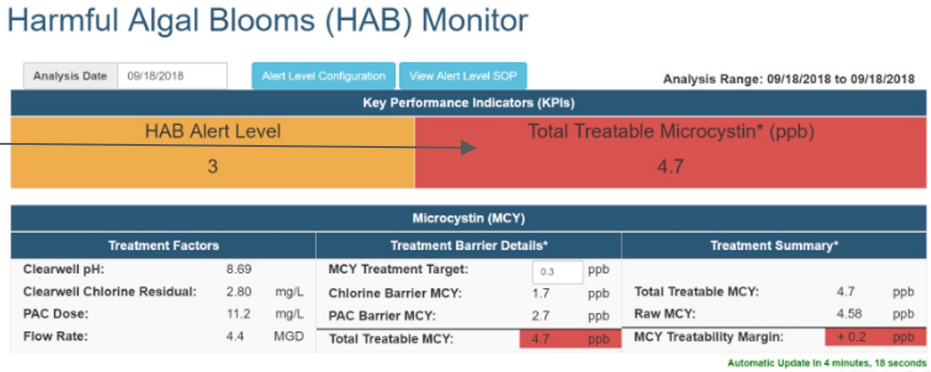
2018 Struthers **HAB Event**

Staff followed and Observed:

- Total treatable estimate for each toxin barrier
- Notification when total treatable was below 5 ppb





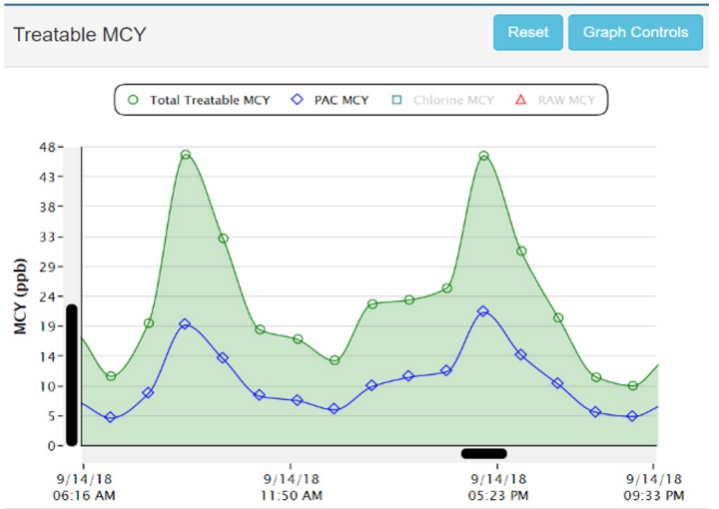
Lessons Learned

- Small water quality changes can have a large impact on treatment barriers
- Combining the tools, embedded safety factors, with real-time data, and a visual environment where measures are clearly presented, allow operators to handle complex challenges

American Water Works Association | Hazen | Saint Louis University

Hazen-Adams CyanoTOX (Ver. 2.0)

Hazen-Adams CyanoTOX (Version 2.0)
(Cyanotoxin Tool for Oxidation Kinetics)
Tool Developed by C. Adams, B. Stanford, E. Arevalo, A. Reinert, and E. Rosenfeldt



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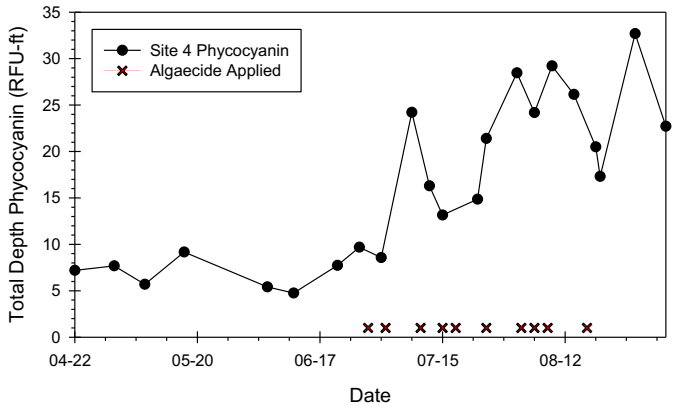
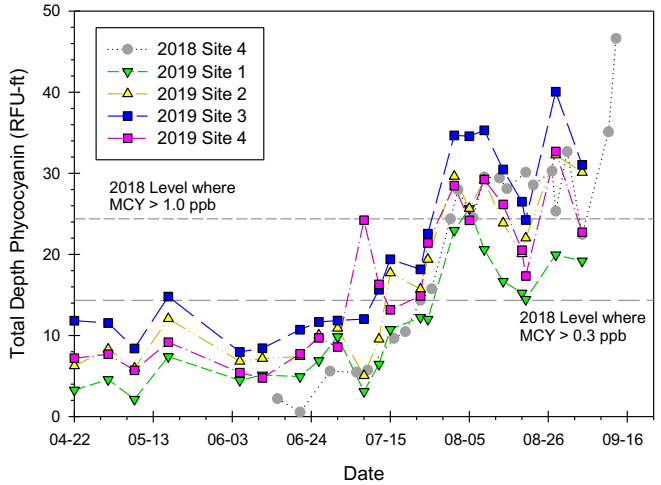
Struthers 2019

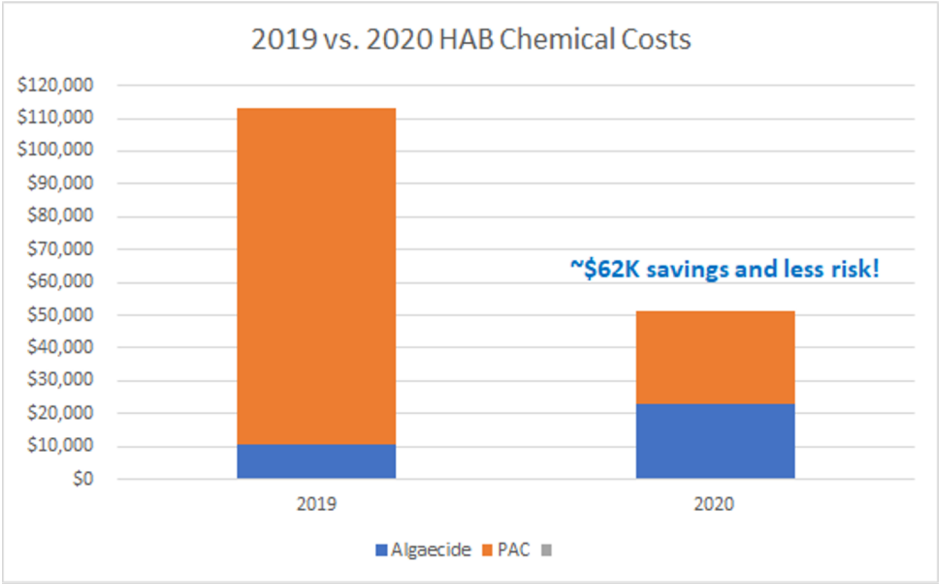
- 582 Acres, 4000 MG
- Struthers applied 40-75 gallons every 3-8 days
- Managed well when applying more frequently (3 days) and at all sites
- Application stopped when saxitoxin was detected and HAB grew uncontrolled
- Increased Dosage in 2020





Struthers Cost Savings **2019 vs 2020**

- Manage HABs with low-dose, targeted algaecide, use less PAC in treatment
- Maintained consistently low levels of microcystin and saxitoxin



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Summary

- HABs will be part of your future
- Algaecide treatment is good and can reduce the problem but:
  - You **must** develop a strong monitoring program
  - You **must** be able to apply the algaecide where it is needed
  - you must **not** think that algaecide will solve all your HAB problems
- Manage treatment barriers cost effectively with PAC jar tests and treatment barrier calculations (spreadsheet, software)
- Save money and provide great water!

Questions?

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Delphos WTP

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