Proactive Management of Harmful Algae Blooms

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Harmful Algae Blooms (HABs)

What is a HAB?

- Severe cyanobacteria (bluegreen algae) bloom.
- Potential to produce very high concentrations of cyanotoxins.
- High concentrations of cyanotoxins can impact the health of humans, pets, and livestock.
- Responsible for closure of beach, shellfish/aquaculture operations heath advisories, and even shut-down of potable water supplies.

The “Bad Guys”

- Microcystis
- Planktothrix
- Anabaena
- Aphanizomenon
- Lyngbya
- Gloeotrichia

Unique Properties of Cyanobacteria

- Prokaryotes…not eukaryotes (such as algae)…lack membrane encased organelles or mitochondria.
- Can photosynthesize. Thus, share properties of both bacteria and algae.
- Produce cyanotoxins as well as taste and odor compounds.

Unique Properties of Cyanobacteria

- Many can fix and assimilate atmospheric nitrogen.
- Biologically adept at assimilating organic phosphorus.
- Many have gas vacuoles…can regulate their position in water column.
- Many can effectively photosynthesize even in low light.

Unique Properties of Cyanobacteria

- Some produce *akinetes*, vegetative cells resistant to freezing and desiccation that remain in sediment until proper conditions exist for successful germination.
- Some can survive under extreme conditions (e.g. hot springs at 70°C) .
- Selectively rejected as food source by filter feeders and zooplankton.

What About Cyanotoxins?

- Cyanotoxins provide competitive advantage.
- Released into environment by both living and dead cyanobacteria.
- Large amounts released when cells physically damaged…e.g., following an algae treatment.
- Extremely stable and decompose slowly.

Reasons why reliance solely on conventional algaecides not a good management strategy

Not As Simple As It Sounds

- Blooms may happen any time of year and even in low nutrient (mesotrophic) waterbodies.
- Confusion with non-HAB phytoplankton bloom.
- Not all cyanobacteria cause HABs.
- Not all cyanobacteria produce cyanotoxins.
- Cyanotoxin producers may not always produce cyanotoxins even during bloom conditions.

Do I Have a HAB Problem Or Am I About to Have a Problem?

Only definitive way to know is to collect data!

- Phytoplankton assemblage and density
- Chlorophyll a, phycoerythrin and phycocyanin
- In-situ (DO, temperature, pH, Secchi)
- Nutrients (Phosphorus and Nitrogen)
- Geosmin and MIB
- Cyanotoxins

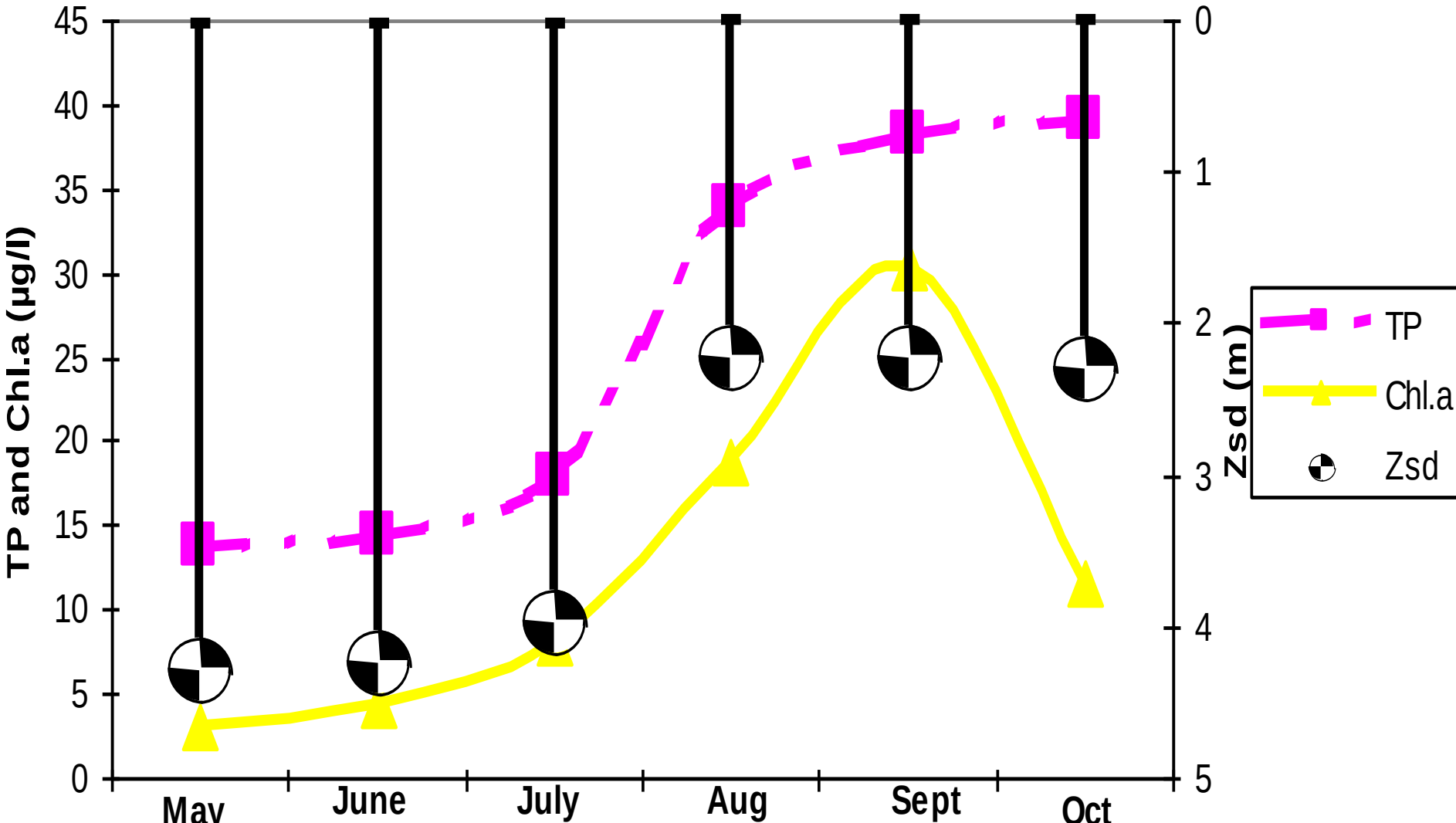
PARE ™ - A Strategy For Dealing with HABs

- **Predict** – Forecast bloom using long-term database, keystone parameters, and/or remote sensing techniques.
- **Analyze** – Measure/quantify bloom's severity:
  - Chlorophyll a,
  - Cyanobacteria ID and cell counts
  - Measure concentration of Microcystin
- **React** – Implement measures to prevent, control or terminate bloom.
- **Educate** – Share info and educate community.

The Phosphorus Connection

- The amount of available phosphorus is typically the primary driver of lake productivity.
- HABs and nuisance algae blooms strongly linked to amount of available phosphorus.
- Can vary seasonally and can originate from internal and external sources.
- Quantification of phosphorus loading "corner stone" of a successful HAB management program.

Phosphorus Drives Productivity



P Loading

Loading Source	Load (Kg/Yr)	% of Total
Stormwater (Watershed-Based)	81.3	20.6%
Atmospheric	89	22.6%
Septic	65	16.5%
Internal regeneration – Oxic load	103.9	26.4%
Internal regeneration – Anoxic load	54.7	13.9%
Total	**393.9**	**100%**


Don’t Just Treat The Symptom….
Correct the Cause


WE HAVE MET THE ENEMY AND HE IS US.
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Phosphorus & Nitrogen Loading

- Stormwater runoff from impervious/pervious areas
- Fertilizers
- Septic systems
- Internal regeneration
  - Decay weeds, algae and biota
  - Release from anoxic sediments
  - Bioturbation/Boating

Successful HAB Management Requires Controlling Nutrients

- External Strategies
  - Source Controls
    - Septic management
    - Fertilizer management and control
    - Shoreline buffers
    - Waterfowl control
  - Stormwater Management / Delivery Control
- Internal Strategies
  - Aeration
  - Nutrient Inactivation

Put Your Lake on a Diet

Stormwater Management

- Reduce
- Infiltrate
- Collect
- Retain

Turn Down The Volume!!!

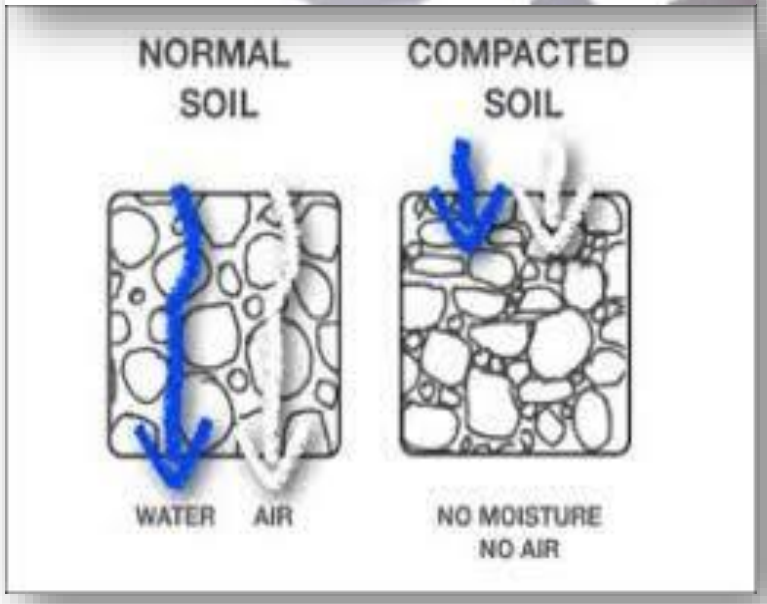
- Reduce volume of runoff generated from a site.
- Generating less runoff reduces the amount stormwater nutrient load entering lake.

Pro-Active Source Control

Maintain Soil Health

Healthy soils have good porosity…

- Green doesn't mean good.
- The greater the porosity the less runoff…
- Less runoff … less pollutant loading.



Rainwater Harvesting

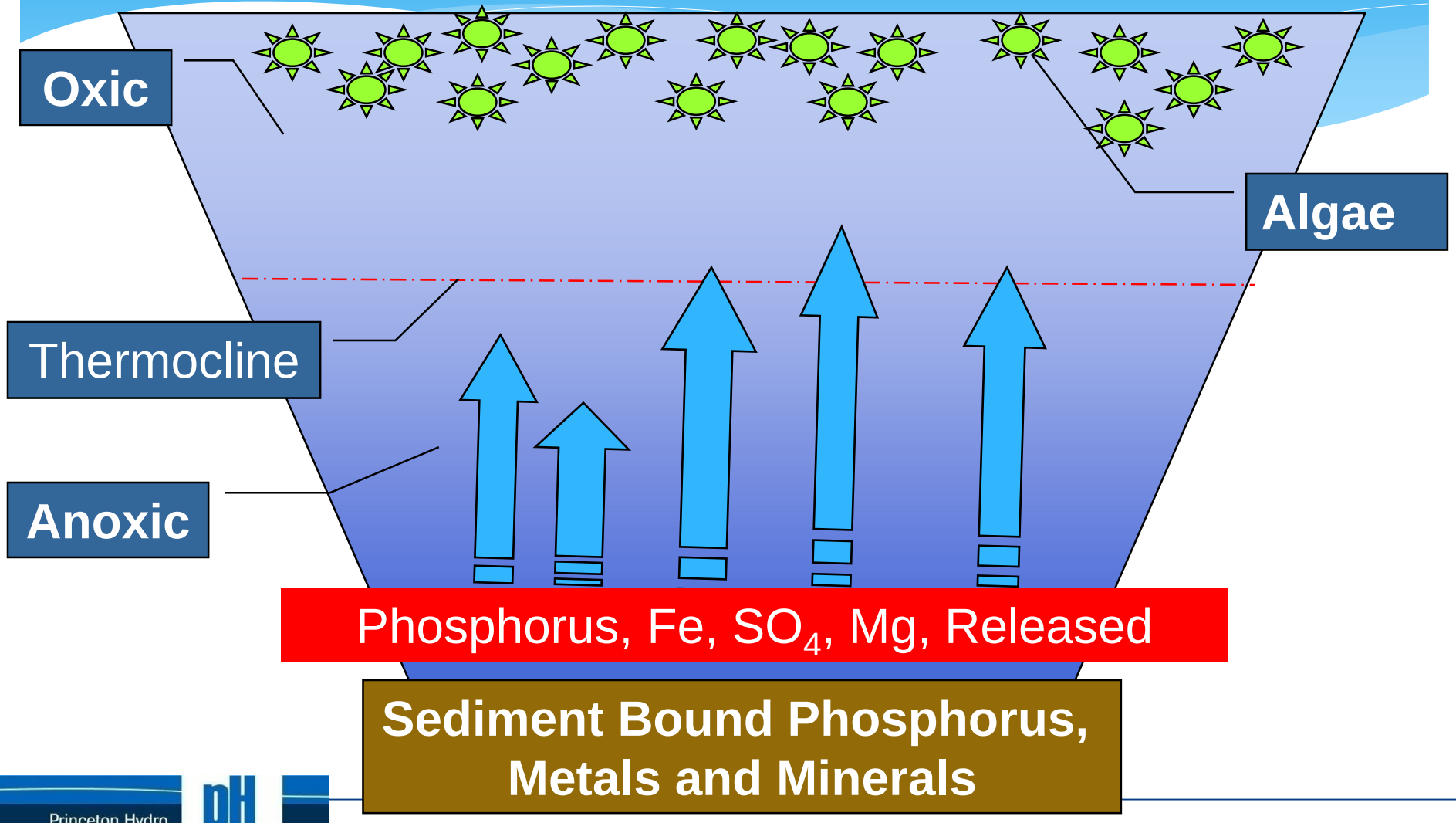
Lakeside Buffers

Rain Gardens and Bioretention Systems

Internal Source Management

- Control internal sources of nutrient (Phosphorus)
- Aeration / Destratification
- Nutrient sequestration/ Inactivation
  - Alum, PhosLock. PACl, Iron
- Biomanipulation
- Bioturbation Control

Temperature, DO, Nutrients & Minerals



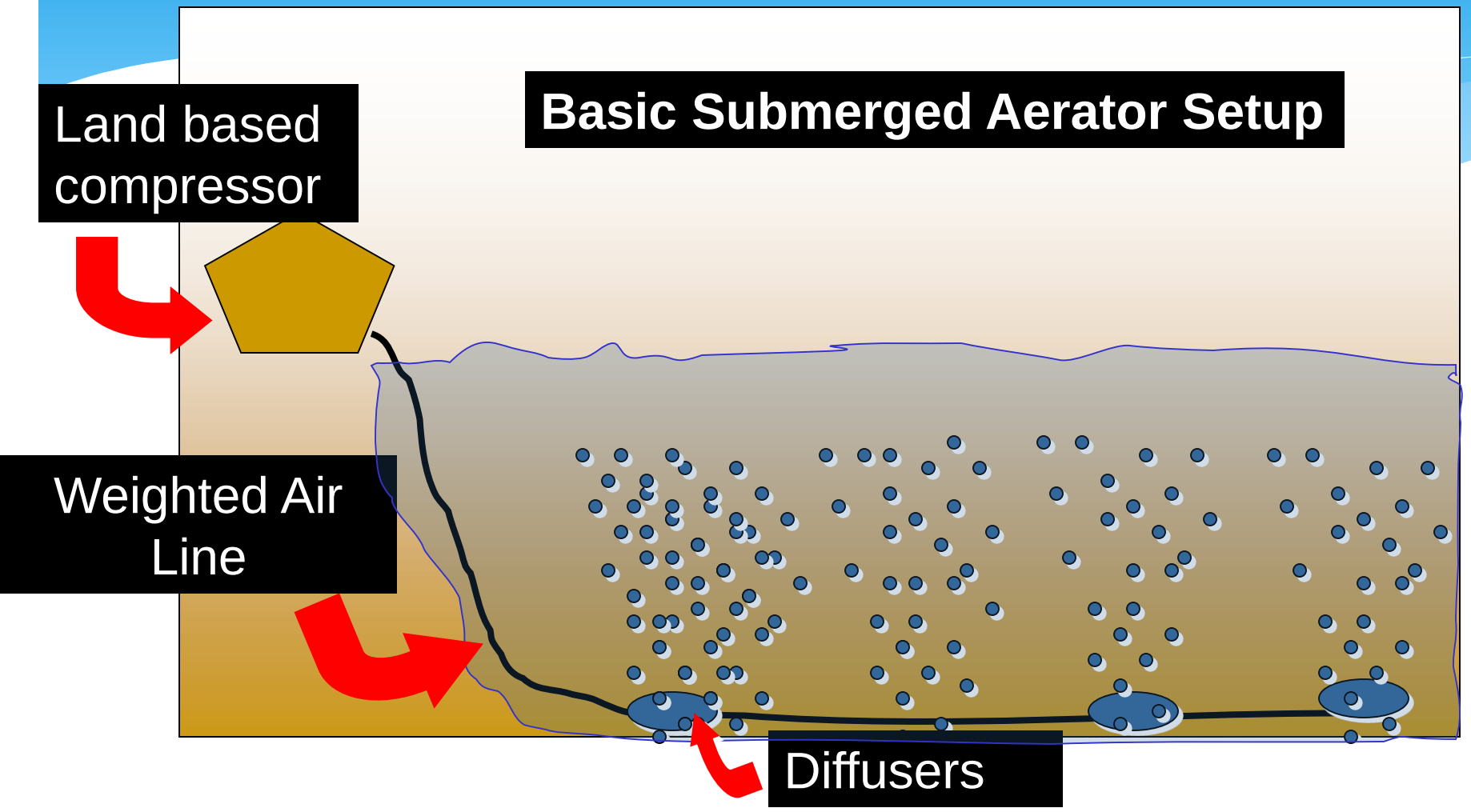
Aeration's HAB Control Benefits

- Prevent stratification and anoxia – limits internal nutrient and metals recycling.
- Actively drive cyanobacteria cells into deeper water.
- Decrease development of dense surface scums.

Aeration

- Two basic options
- Maintain Lake in Stratified State
  - Hypolimnetic aeration (for deep lakes)
- Destratify and Keep In Mixed State
  - Maintain a vertical circulation of water to prevent the onset of stratification and deep-water anoxia

Destratification Aeration Systems



Nutrient Sequestration or Inactivation

- Nutrient inactivators bind specifically with phosphorus making it unavailable for algal or cyanobacteria assimilation
- This limits growth rates and contributes toward a reduction in the magnitude and frequency of blooms
- Less “food” = less algae/cyanobacteria

Phosphorus Sequestering Products

- Alum (aluminum sulfate, sodium aluminate)
- Polyaluminum chloride (PACl)
- PhosLock (Lanthunum)
- Iron
- Calcium
- Certain polymers

Alum

- Aluminum sulfate (alum) binds **available phosphorus** in water column under both oxic or anoxic conditions.
- Alum creates colloidal aggregates of aluminum hydroxide.
- Phosphates (PO_4) bond with the aluminum hydroxide, making it unavailable for bio-uptake by algae or cyanobacteria.
- Long history of use in lake and reservoir mgmt.

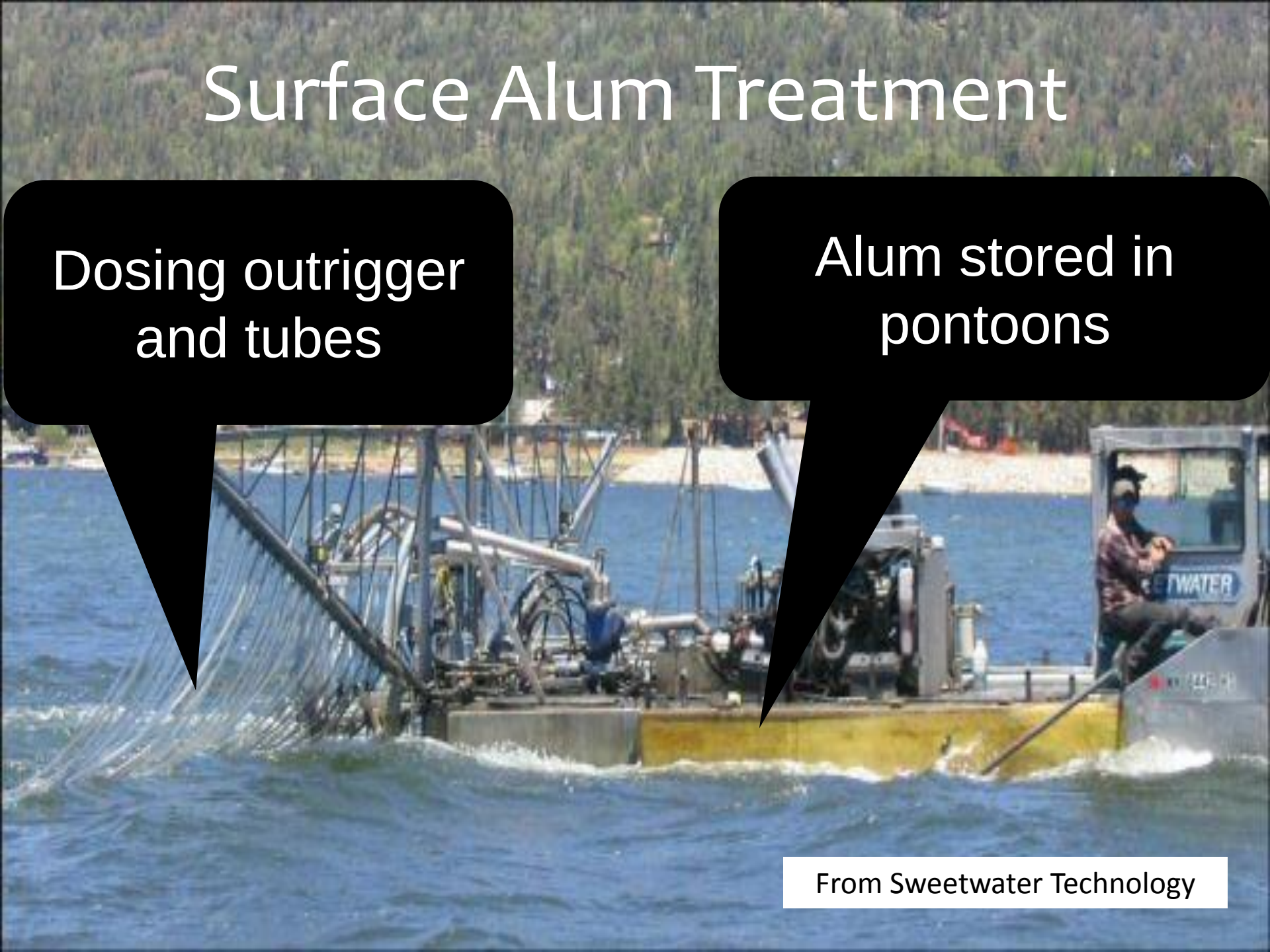
Issues Of Concern

- Baseline water quality - hardness, alkalinity, pH, temperature, dissolved oxygen
- Phosphorus sources – internal versus external
- Flushing rate (both annually and seasonally)
- Biological Impacts
- Permitting
- Longevity
- Cost

Bench Testing

- Amount of product needed to effectively bind available P.
- Environmentally safe dose.
- Cost-effectiveness.
- Longevity.

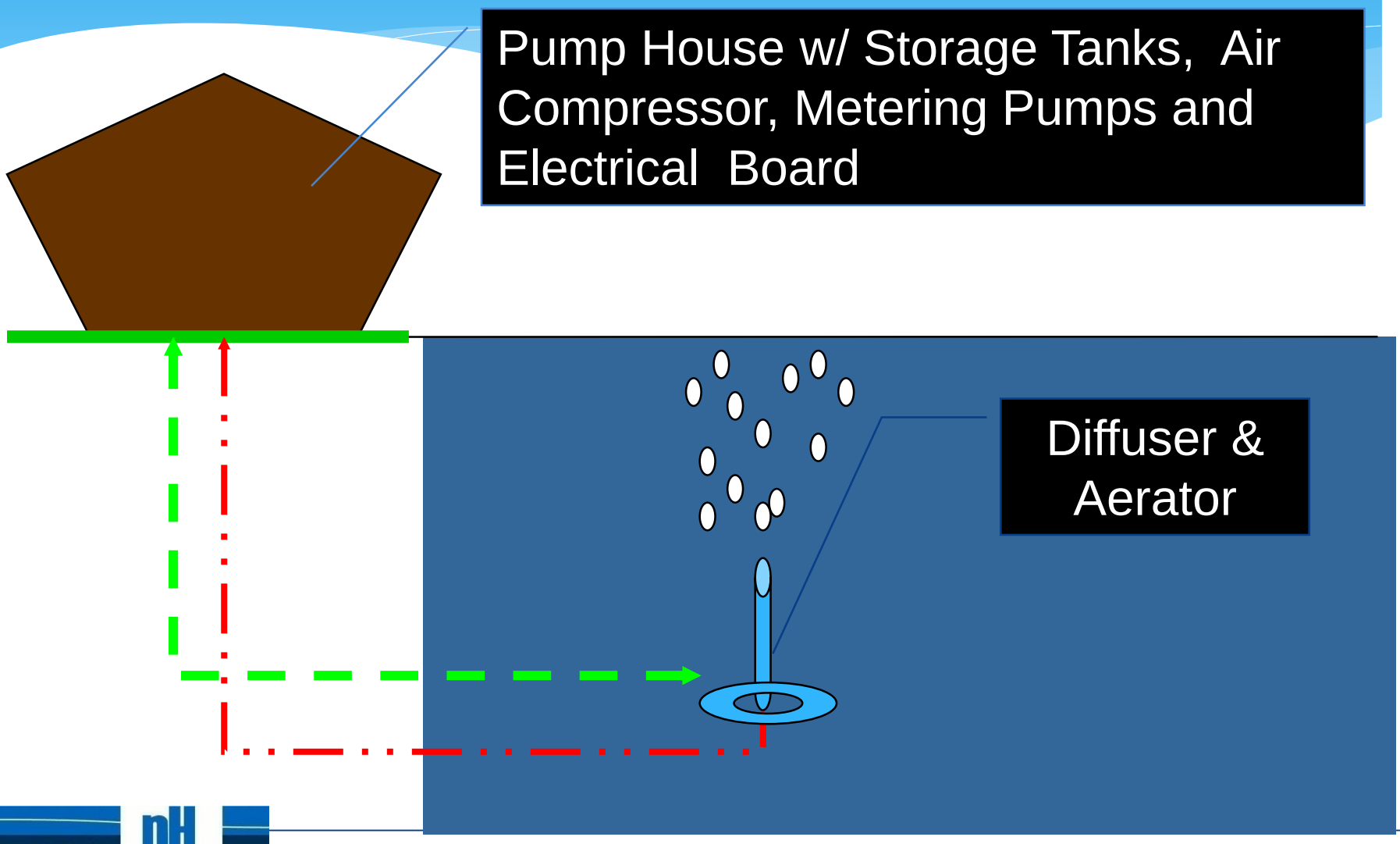
Surface Alum Treatment



Dispersion of Slurry

From North American Lake Management Society

In-Lake Metered Dosing



Metered Dosing… Conceptual Approach

- Alum introduced in computed, controlled rate.
- Dose based on daily modeled internal and/or external TP load.
- Aeration system used to mix the alum into the water column and promote phosphorus binding.

Other In-Lake Nutrient Controls

- Biomanipulation
  - Zooplankton
  - Phytoplankton
  - Fishery
- Floating Wetland Islands
- Weed and algae harvesting

Algaecides

- Standard approach to "dealing" with HAB or nuisance algae bloom.
- Not proactive...reactive...
- Basically two options
  - Copper based
  - Hydrogen Peroxide/Percarbonte based

May Actually Trigger Worse Conditions and Spiraling Repetitive Blooms

Although a tool to control algae blooms and HABs; reliance on $CuSO_4$ alone can actually worsen conditions and prolong bloom:

- Quick, large release of cyanotoxins from decaying cyanobacteria.
- Large release of organic phosphorus.
- Possible precipitous DO drop

In Summary….HABs

- Increasing frequency and severity of HABs.
- Not all algae blooms are HABs.
- Why do they occur?…not fully understood.
- Key to preventing HABs is nutrient management and environmental manipulation.
- Copper sulfate may be a tool…but it is not the solution and can actually worsen conditions and intensify microcystin impacts.

In Summary… PARE

- PARE ™ provides a means of forecasting, assessing and managing HABs.
- Data helps predict onset of bloom and how to best manage factors responsible for blooms.
- With correct data can pre-empt blooms or its lessen severity and duration.
- Roadmap to proactive approach that focuses on nutrient management.

Importance of Education and Outreach

- NYSFOLA
- NALMS.org
- NYSDEC -
  - https://www.dec.ny.gov/chemical/77118.html
  - Harmful Algal Bloom brochure
  - Harmful Algal Bloom Program Guide
- USEPA -
  - http://www2.epa.gov/nutrientpollution/harmful-algal-blooms

Take Advantage of Resources Available Thru FOLA and NALMS

HABs

Thank You….

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