

A Systems Approach to Freshwater Management: Waterbody Treatments

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US Environmental Protection Agency Webinar

May 14, 2014

Overview

- The Clean Water Act
 - Calls for Watershed and Waterbody Management

- A Systems Approach to Freshwater Management
 - Uses Most Cost-Effective Watershed & Waterbody Tools
 - Quicker, Less Expensive Water Quality Improvement

- Waterbody Management Technologies
 - Suppress Cyanobacteria
 - Remove or Inactivate Nutrients

- Will Jordan Lake, NC, become the 1st Large, Eutrophic Waterbody to attain Water Quality Standards?

The Clean Water Act

- Watershed Management Program - reduce nutrient input
 - * Point sources, **Implemented NPDES** - now 5-10% nutrient input
 - 1972-1986: \$49B Title II grants
 - 1987: Replaced Title II with Title VI CW State Revolving Fund
 - 1987-2012: \$36B to capitalize CWSRF loan program
 - Jurisdiction & locality spending is approximately \$63B annually
 - * Non-point sources, **Implemented BMPs** - now 90-95% input
 - 1987-2012: \$3.2B Section 319 grants, \$200M/yr since 1999
 - Almost all spent on BMP implementation
 - 1989-2012: \$650M CWSRF used for BMP implementation
 - Jurisdiction & locality spending is \$??B annually

The Clean Water Act

➤ Clean Lakes Program- treat impaired waterbodies

* Waterbody management - **Not Currently implemented**

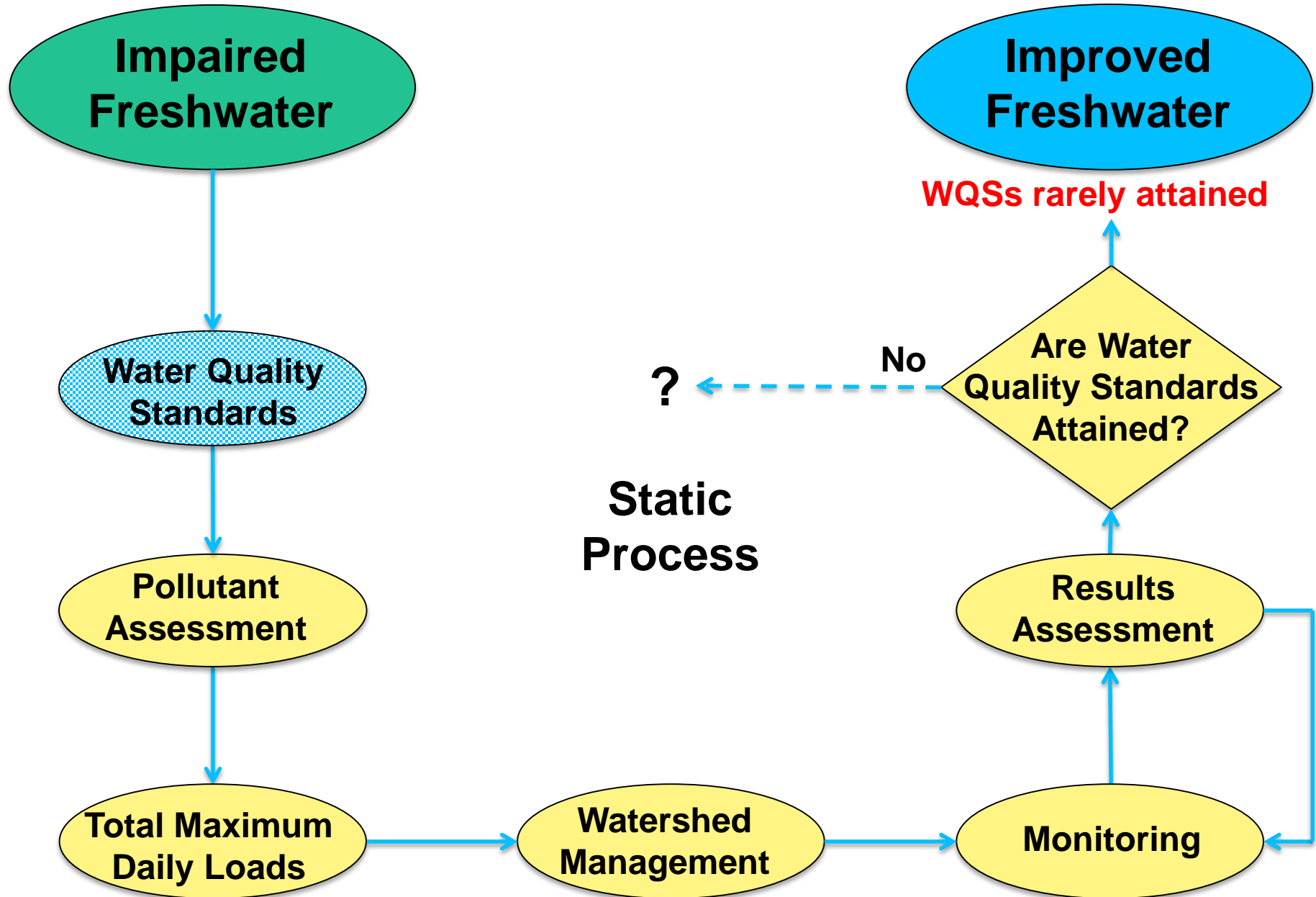
- 1972-1995: \$145M Section 314 grants, none since
- Reauthorized in 2000, but no appropriation requests
- 2000: Encourage use of 5% Section 319 grant funds for Waterbody Management
- 2002: Focused Section 319 funding on Nonpoint source BMP implementation

✧ Safe Drinking Water Act, some source water protection funding

✧ HABHRCA - The Harmful Algal Bloom and Hypoxia Research and Control Act

- Research grant funds for NOAA and coastal HABs, but not for EPA and all freshwater

Watershed Management Process



Watershed Management Results

- 44% of river & stream miles, & 64% of lake & reservoir acres are Impaired (CWA Section 303(d))
 - EPA estimate - 7.9% pre-2003 impaired now attain WQs
 - Most small & point source dominated
- Eutrophication - 1972: 10-20% US lakes & reservoirs
 - 2007: approximately 50%
- Cyanotoxin health risks - 2007: 27-41% moderate to high
- Rivers & streams with excessive phosphorus - 2004 = 47%, 2008-2009 = 66%, primarily agricultural sources
- EPA data, OW, 10 regions - No impaired reservoir $\geq 1,000$ ac & $\geq 90\%$ input from nonpoint sources ever attained WQs

Watershed Management Drawbacks

- Addresses only some new pollutant (HABs nutrients) inputs
 - Misses groundwater and atmospheric inputs
- Misses internal legacy loads that cycle from sediment to water column, stimulating HABs
- Agriculture is exempt from the CWA
- Nonpoint source BMPs difficult to implement over large areas, many are expensive, only marginally effective & lack cost-benefit analyses
- Does not address cyanobacteria's need for quiescent, stagnant water to predominate
- Gives the “sick patient” “preventive medicine” by not “therapy”

Watershed Management Alone is Not Preventing HABs

**Preventive
Medicine
Only**

**No Therapy
when Ill**

Watershed Management

- TMDLs, Nutrient Management Strategies



Nonpoint Sources

- BMPs

Point Sources

- NPDES



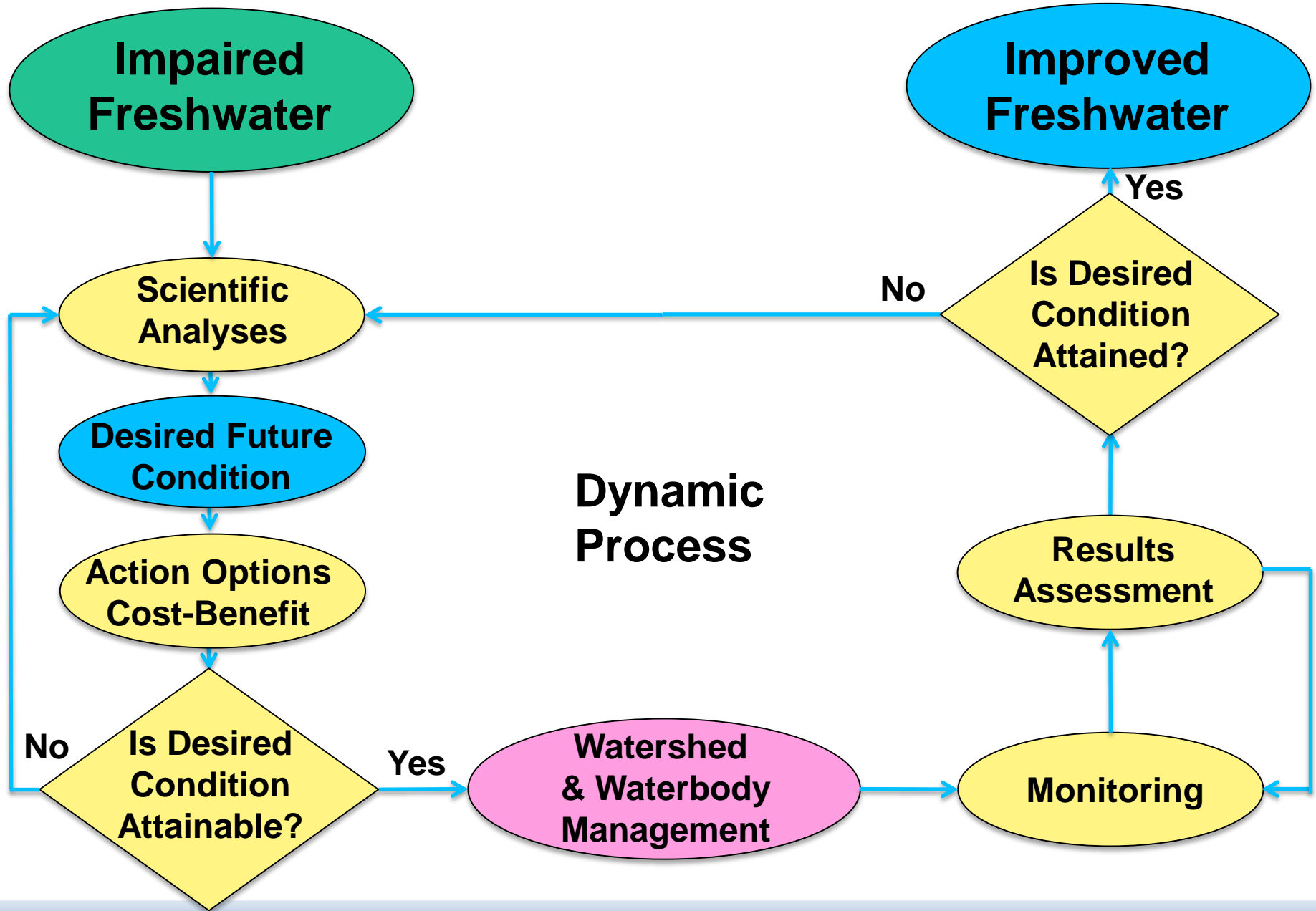
Residential Exposure

Potential Drinking Water Exposure

Relatively Ineffective Expensive

Effective Diminishing Returns

Systems Approach Process



A Systems Approach

Uses cost effective WSM & WBM approached to restore designated uses in the near term at reduced costs

➤ **Watershed Management - Preventive medicine**

➤ **Waterbody Management - Supportive therapy**

- Circulation
- Aeration
- Side-stream flow-ways
- Flocculants & oxidizers
- Floating artificial wetlands
- N & de-N bacteria
- Biological manipulations
- Hydrologic manipulations
 - Suppress HABs
 - Channel nutrients up trophic levels
 - Remove or deactivate nutrients
 - Degrade toxic substances
 - Deactivate pathogens

Systems Approach

Systems Approach = Waterbody + Watershed management

**Preventive
Medicine**

**Therapy
When Ill**

Watershed Management

- TMDLs, Nutrient Management Strategies

Waterbody Management

- Suppress HABs
- Remove pollutants

Point Sources

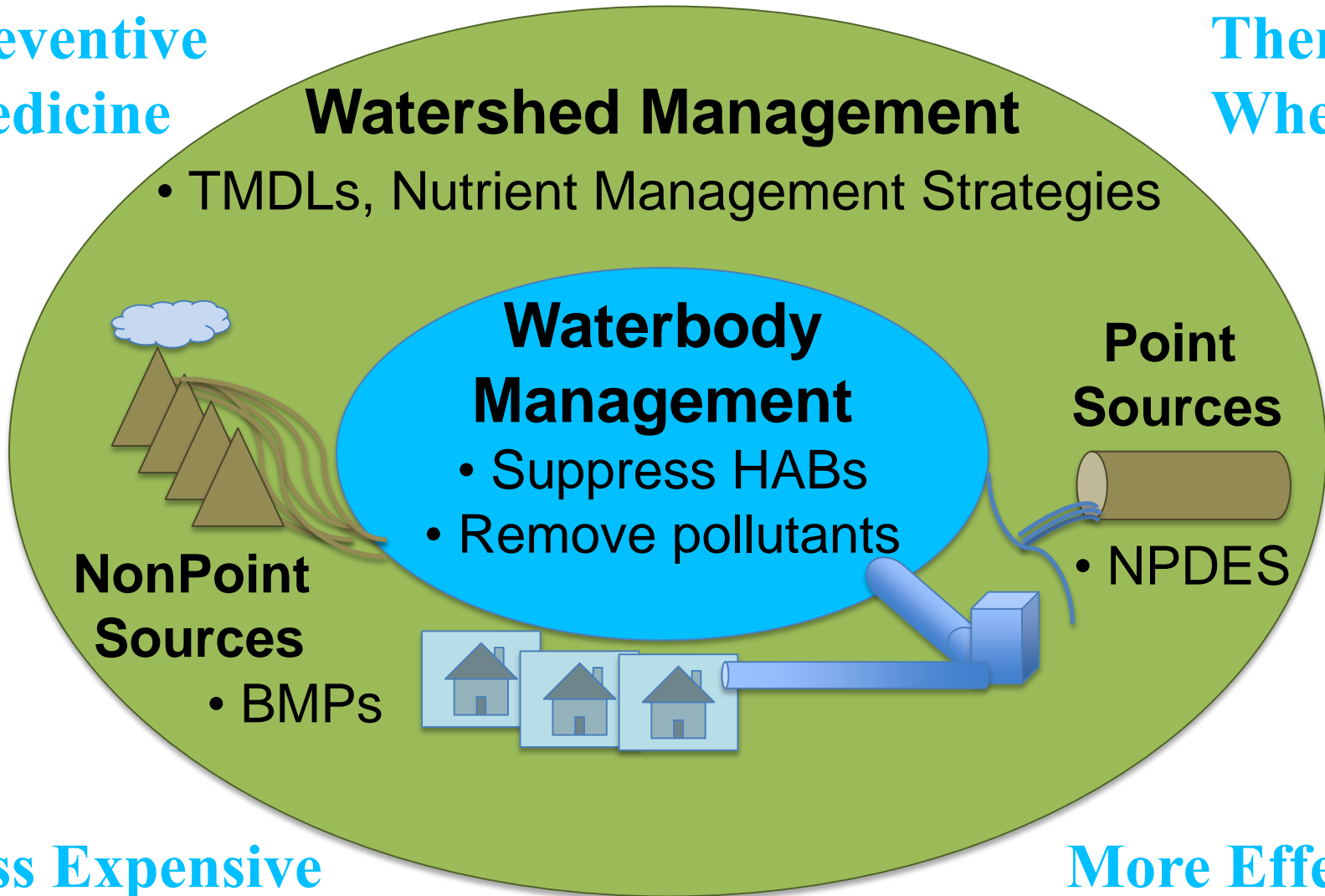
- NPDES

NonPoint Sources

- BMPs

Less Expensive

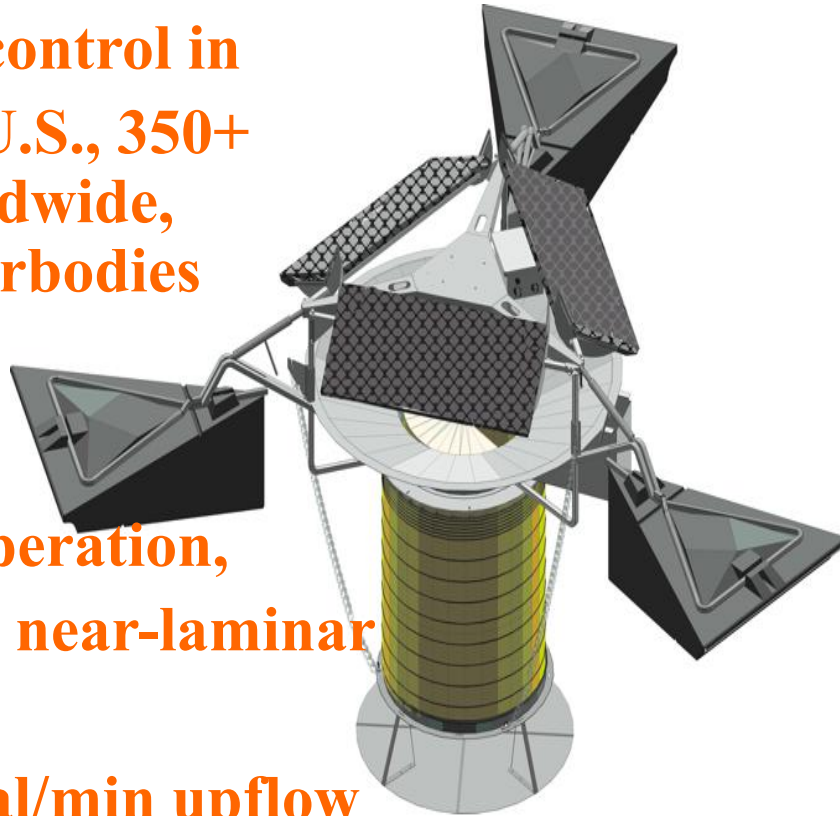
More Effective



Waterbody Management Technologies

Solar-powered, long-distance circulation

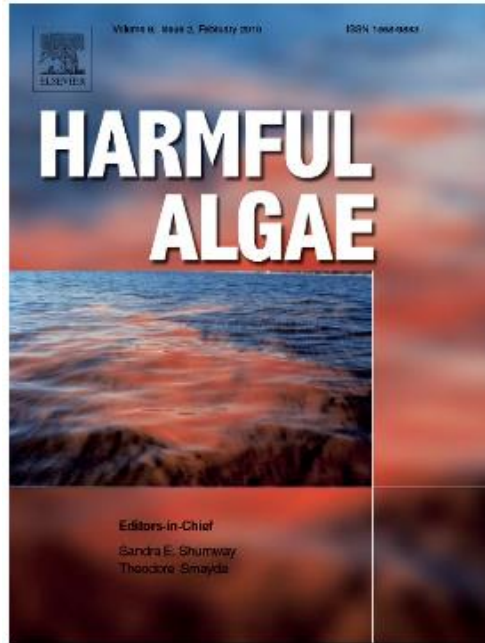
HAB control in
300+ U.S., 350+
worldwide,
waterbodies



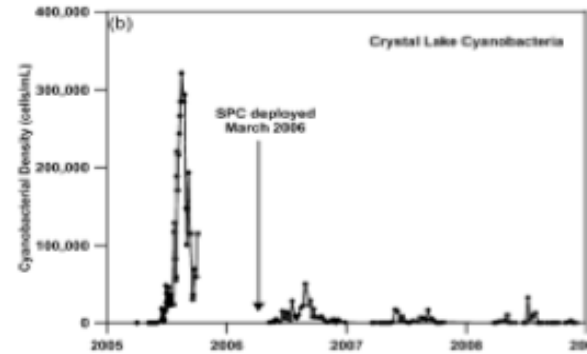
24/7 operation,
radial, near-laminar
inflow
10K gal/min upflow



Solar-Powered Long-Distance Circulation



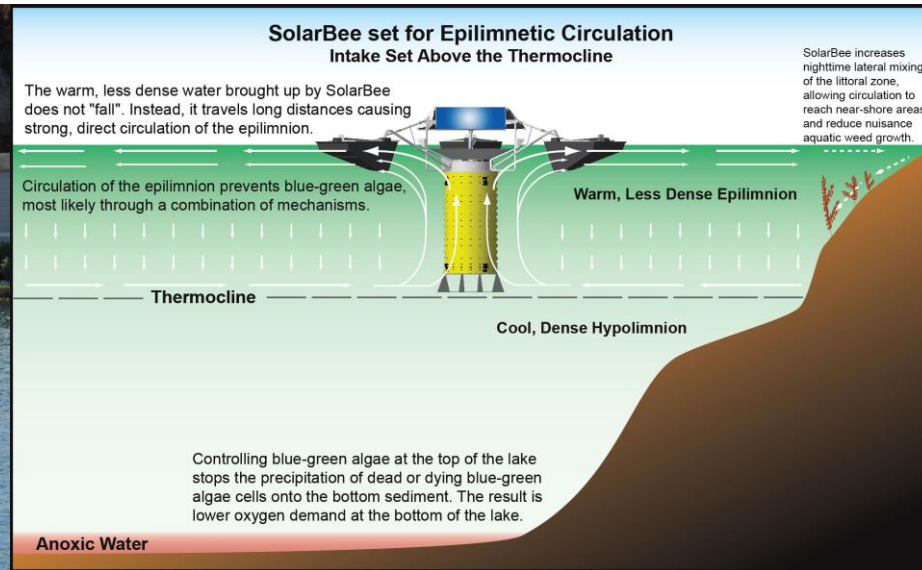
Hudnell *et al.*
(2010)
Freshwater
harmful algal
bloom (HAB)
suppression with
solar-powered
circulation
(SPC). Harmful
Algae, 9, 208-
217



**HAB
suppression in
3 source water
reservoirs**

**Increased densities of: Green algae
Diatoms
Zooplankton**

**35 acres/unit
treatment area**



Waterbody Management Technologies

HAB Suppression: Oxidizers, Peroxygen



Jeff Morgan

www.peroxygensolutions.com

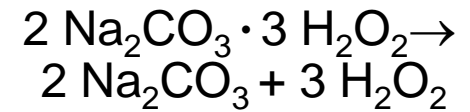
336-272-0127

- White, granular, free flowing, non-dusting
- Active ingredient: hydrogen peroxide (H₂O₂)
- Inert Ingredient: Soda ash
- Effective dosing rate dependent on:
 - Species
 - Stage of Algae Growth
 - Density of Algae
 - Light Intensity
 - Water Temperature
 - Water Quality
 - Metals Concentration
 - Turbidity
 - Organic Content

PAK[®]27 Algaecide

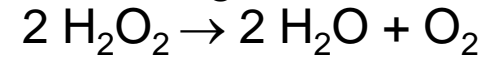
An Environmentally Safe Algaecide

EPA registered



Penetrates cyanobacteria membrane and kills cell

Degrades



HAB Suppression: Oxidizers, Peroxygen

California Department of Water Resources - Dyer Reservoir Study

During the spring of 2012, Dyer Reservoir developed a cyanobacterial bloom of *Aphanizomenon flos-aquae* and *Anabaena flos-aquae*. This bloom adversely affected the water utility by clogging the intake filters of the pumping station.

Cyanobacteria cells/mL

04/04/2012	0	
04/17/2012	42	
04/23/2012	156	
04/30/2012	370	
05/07/2012	4,166	
05/14/2012	2,953	
05/21/2012	11,400	
05/25/2012	28,975	PAK®27 Treatment @ 21 pounds / acre foot
05/25/2012	2,342	7 hours Post-Treatment
05/26/2012	2,298	
05/29/2012	10	
06/05/2012	0	
06/11/2012	0	
06/18/2012	31	

Waterbody Management Technologies

HAB Suppression: Ultrasound

SONIC SOLUTIONS^{LLC}

Kirk Whatley

www.sonicsolutionsllc.com

866-562-5423

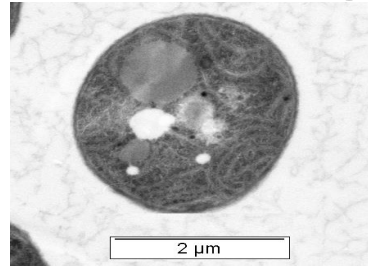
- **Submerge transducer**
 - 2 feet minimum depth
 - Above first thermocline
 - “Line of Sight” device



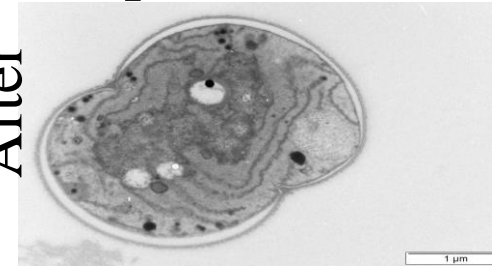
24volts DC
Grid or Solar
0.2 to 0.7 amps

Blue-Green Algae - Ruptures Gas vesicles

Before

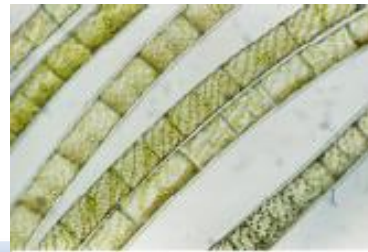


After

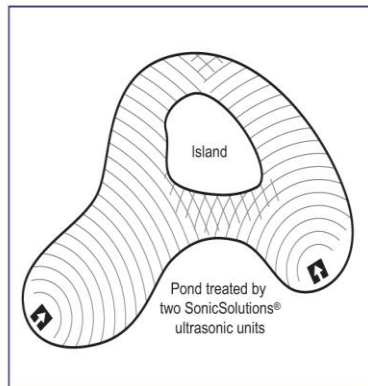
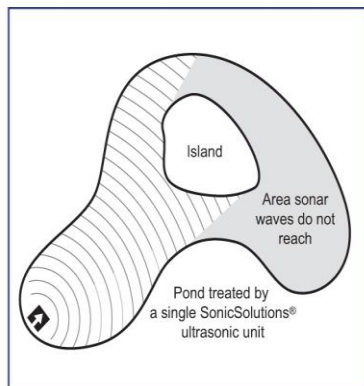
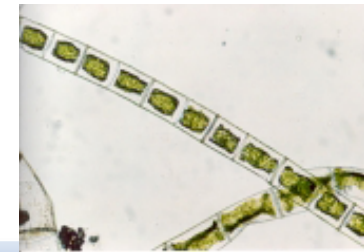


Green Algae - Vibration breaks bond between cell wall and inside of cell

Before



After



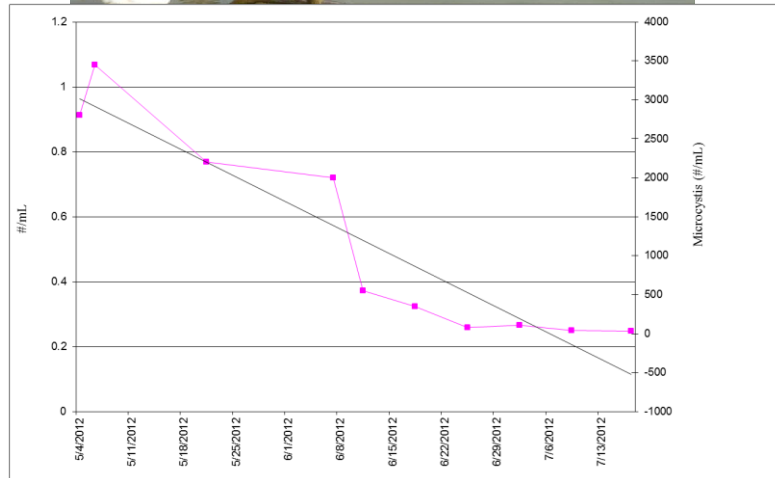
HAB Suppression: Ultrasound

➤ Evaluation of Sonic Solutions Ultrasound for Control of HABs

Paul V. Zimba,
Center for Coastal Studies,
Texas A&M University, Corpus Christi, TX



Microcystis/mL



3.5 months

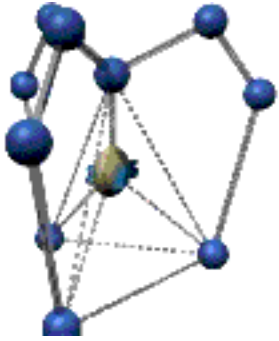
➤ Rockland County Club, Sparkill NY

- Chronic algae problems
- Helped to achieve Audubon Certification



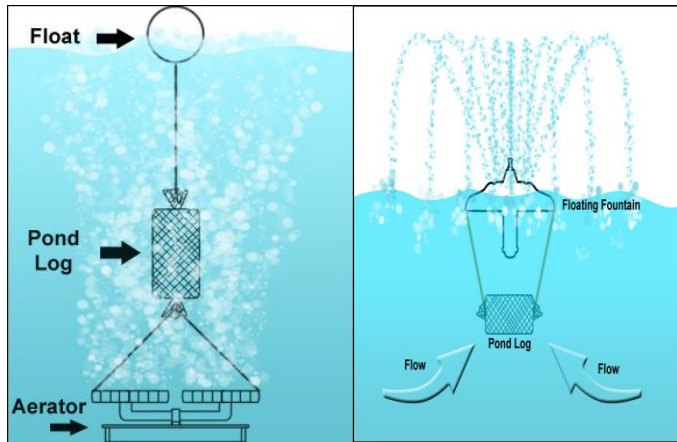
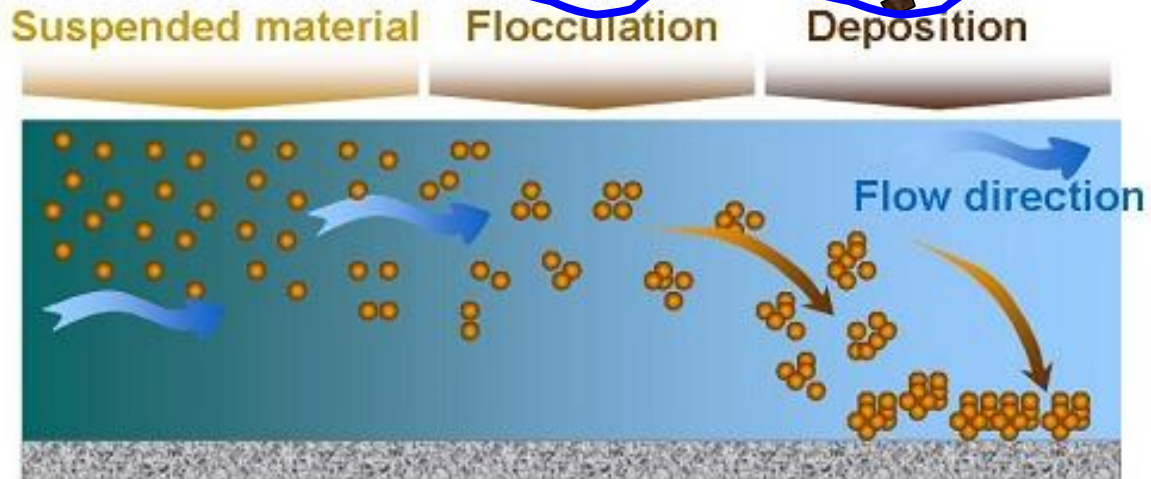
Waterbody Management Technologies

Nutrient Reduction: Flocculants, Anionic Polyacrylamide



>150,000 chained monomers/molecule

EPA registered



Applied Polymer Systems, Inc

Seva Iwinski

info@siltstop.com

386-428-8578

Nutrient Reduction: Flocculants, Anionic Polyacrylamide

Florida DEP phosphorus sequestration with circulation & floc logs in Lake Hilaman

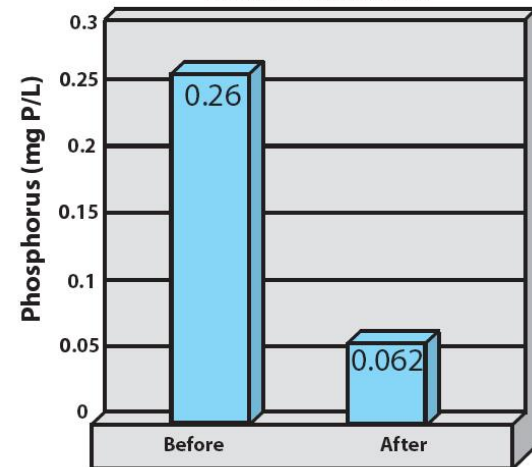
Reedy Creek Water District stormwater pond study.



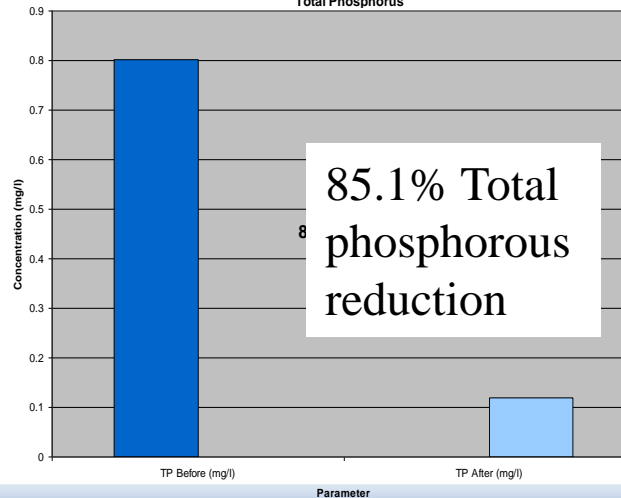
Stormwater Pond With SolarBee & Floc Logs

Stormwater Pond With SolarBee & Floc Logs

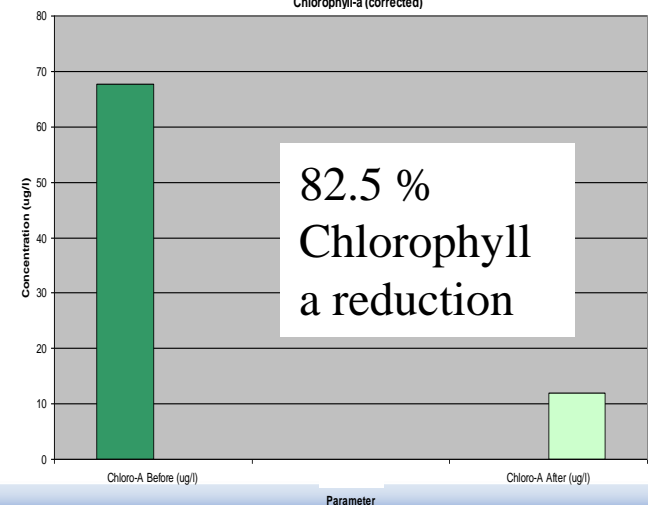
Nutrient Reduction



Total Phosphorus



Chlorophyll-a (corrected)



Waterbody Management Technologies

Nutrient Reduction: Floating Artificial Wetlands: Beemats



Steve Beeman

www.beemats.com

386-428-8578



Floating Lettuce Garden

- Mats 1/2" pva foam
- 2.5 plant holes/ft²



Waterbody Management Technologies

Nutrient Reduction: Bacteria, MicrobeLift

Bioaugmentation ➤ Multistage fermentation process: Aerobic, facultative, anaerobic, photosynthetic bacteria

Ecological
Laboratories, Inc.

Doug Dent

www.microbelift.com

215-208-0815

- Enhance organic matter, sludge digestion
- Enhance ammonia conversion to nitrate
- Enhance nitrate conversion to nitrogen gas
- Enhance H₂S conversion to sulfate
- Compete with algae for nutrients



Clean Room Pressurized
Fermentation area



Photosynthesis
growth process

- 29 Species
12 Genus
(including purple sulfur eating bacteria)
- Vegetative cultures adapt to variety of environments

Nutrient Reduction: Bacteria, MicrobeLift

Xiba River, China, Study

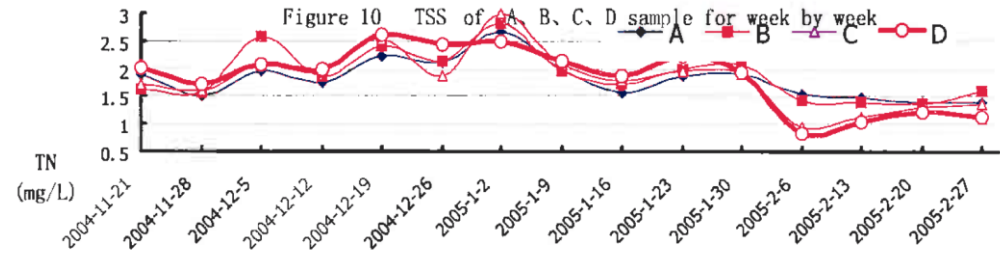
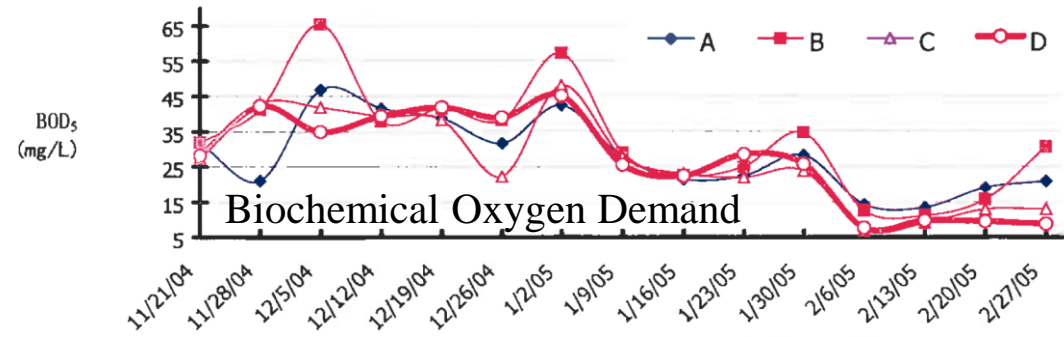
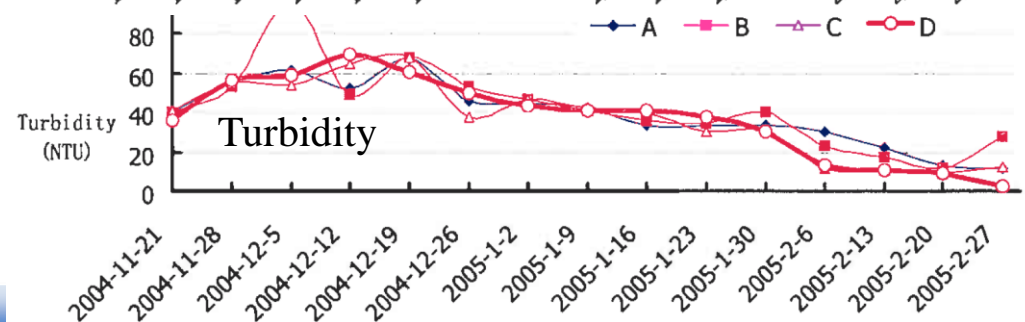
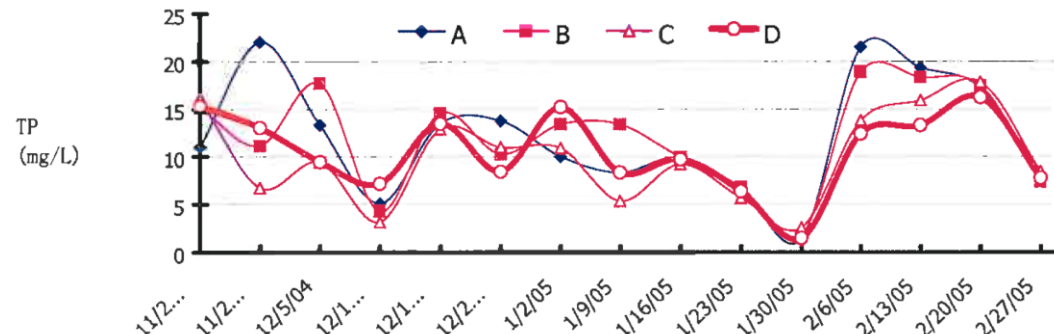
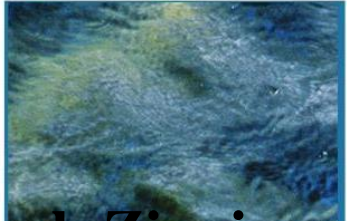


Figure 11 TN of A, B, C, D sample for week by week



Waterbody Management Technologies

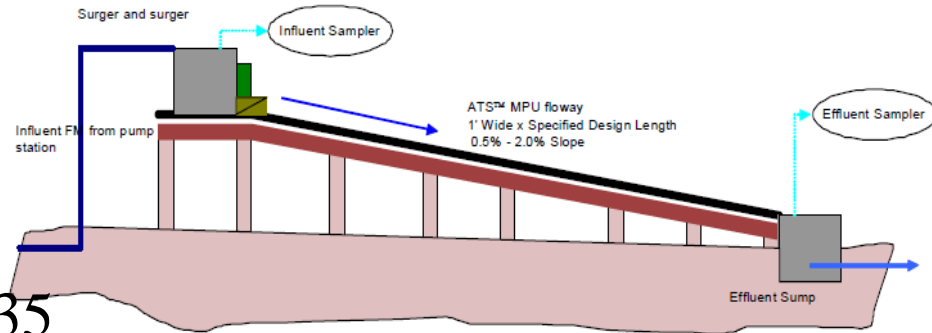
Nutrient Reduction: Flow-way, Algal Turf Scrubber



Mark Zivojnovich

<http://www.hydromentia.com/35>

2-804-5126



What is an Algal Turf Scrubber®?

A culture unit for native attached algae

The algae remove nitrogen and phosphorus and add dissolved oxygen to source water

The algae is regularly recovered and processed

Recovery of algal biomass maintains the culture units in an accelerated growth phase

Optimally, nutrients are continuously recovered and removed from the treatment unit



Nutrient Reduction: Flow-way, Algal Turf Scrubber

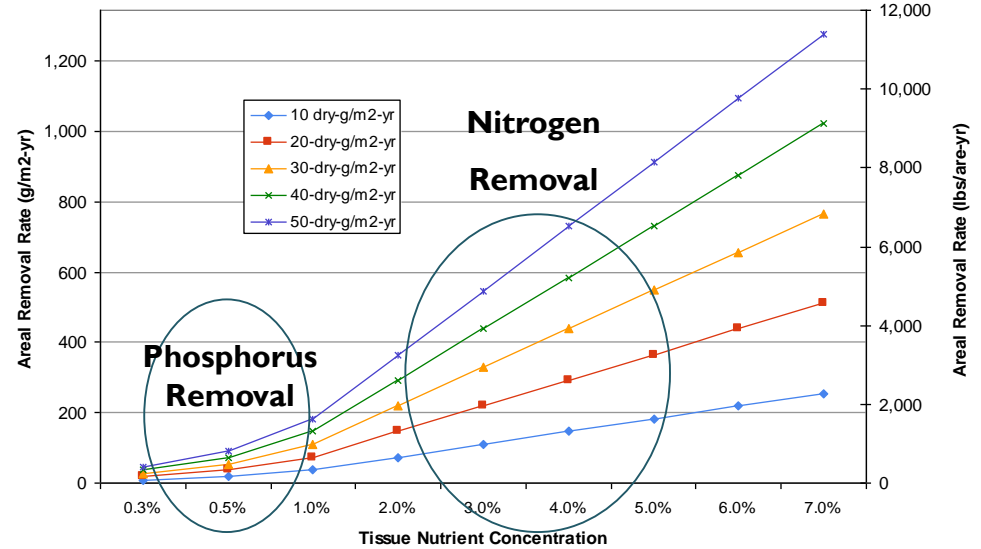
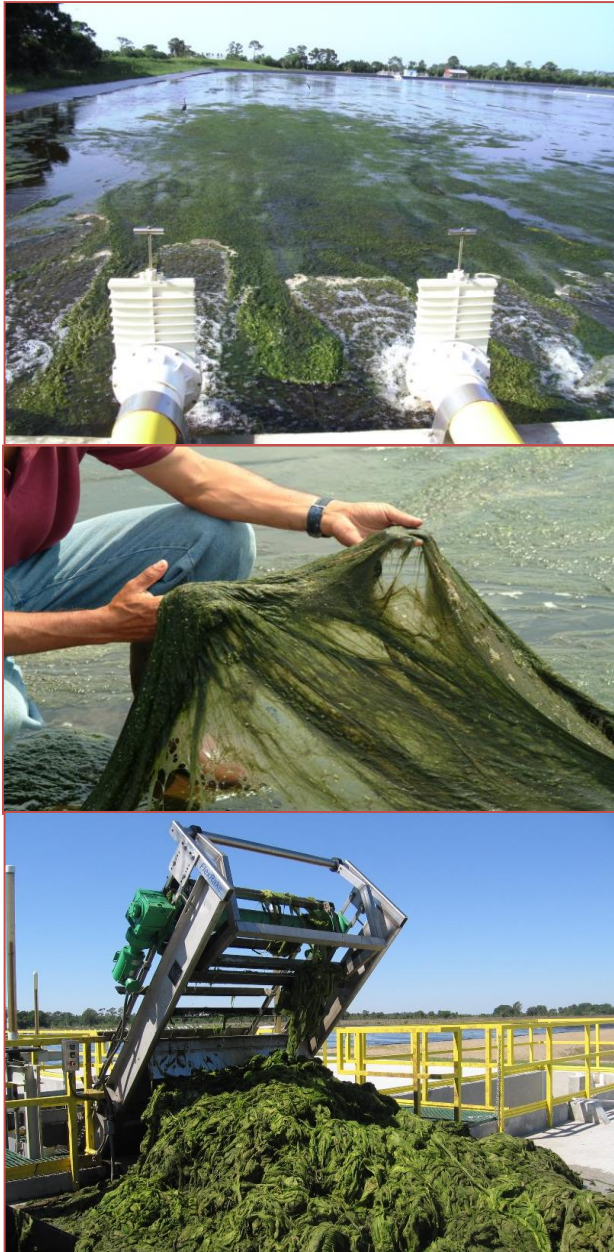
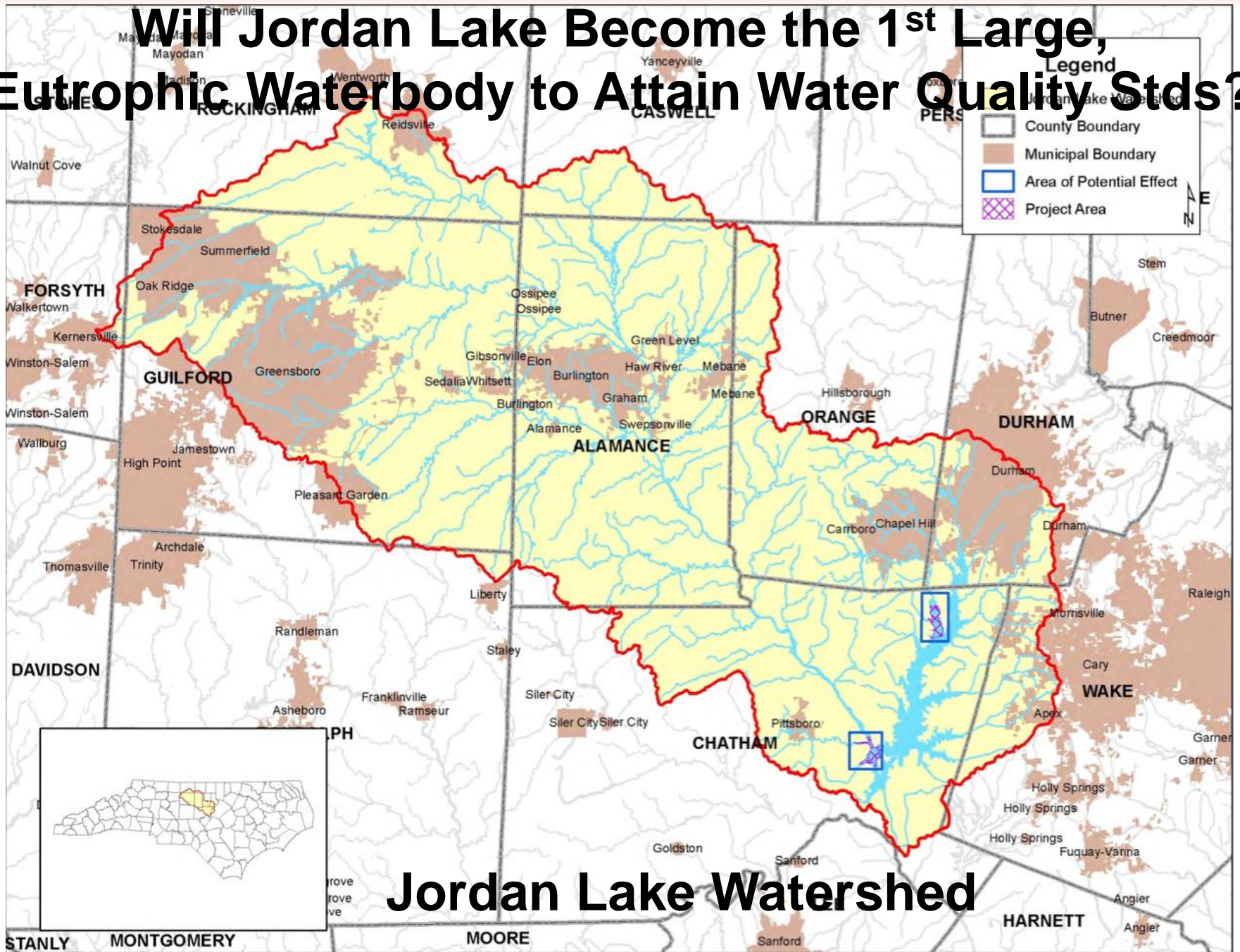


Figure 1. Nutrient Areal Removal Rates Based on Algal Productivity (dry-g/m²-yr) and Tissue Nutrient Concentrations.

Removal Rates Affected by:

- Nutrient concentrations in water
- Temperature
- Sunlight
- Available carbon (alkalinity)

Will Jordan Lake Become the 1st Large, Eutrophic Waterbody to Attain Water Quality Stds?



Jordan Lake Watershed

Jordan Lake

➤ History

- 13,940 ac reservoir completed in 1982 to provide flood control and designated uses – drinking source water, wildlife habitat, recreation
- Algal impairment predicted due to high nutrients & low flow rate

➤ Water Quality

- Harmful algal blooms (HABs) cause impairments: chlorophyll-a exceedances of state standard (40 $\mu\text{g/L}$), high pH, and turbidity

➤ NCDENR TMDL & Nutrient Strategy Rules

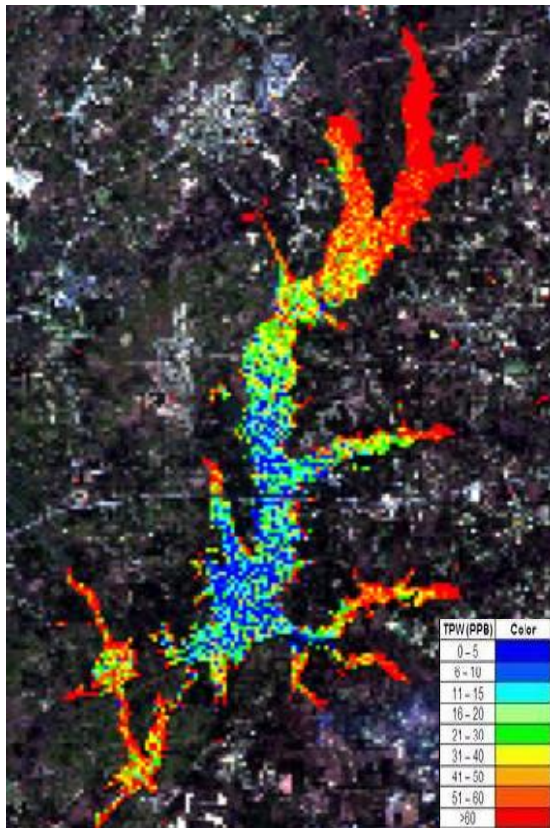
- 9 rules to reduce nutrient input (8 nonpoint-, 1 point-source)
 - Estimated cost of up to \$2 billion

➤ 2013 NC Legislation

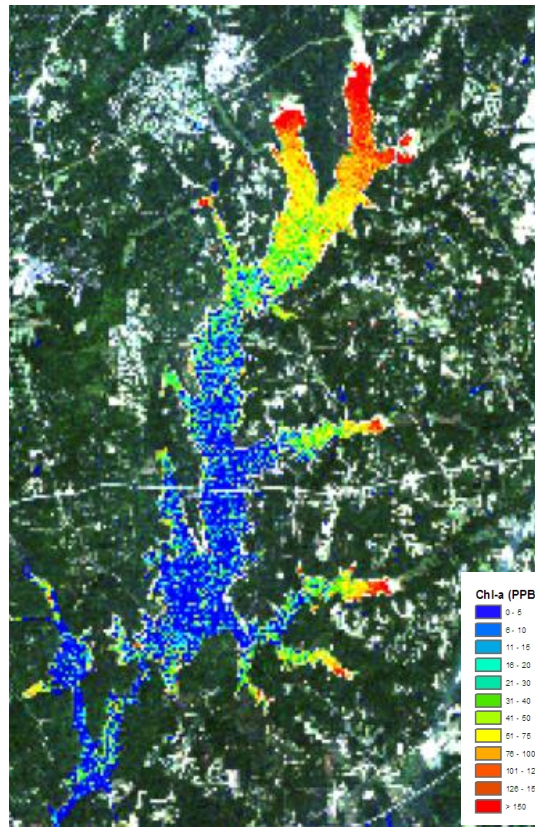
- Suspends 8 unimplemented rules for 3 years
- Budgets demonstration project in Jordan Lake to stop HABs
- Committee oversee systems approach plan development

Jordan Lake

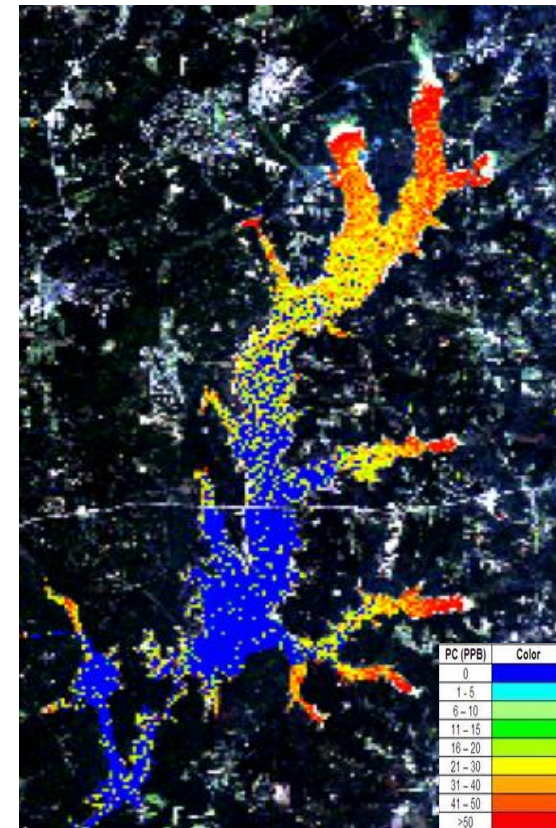
Phosphorus



Chlorophyll-a

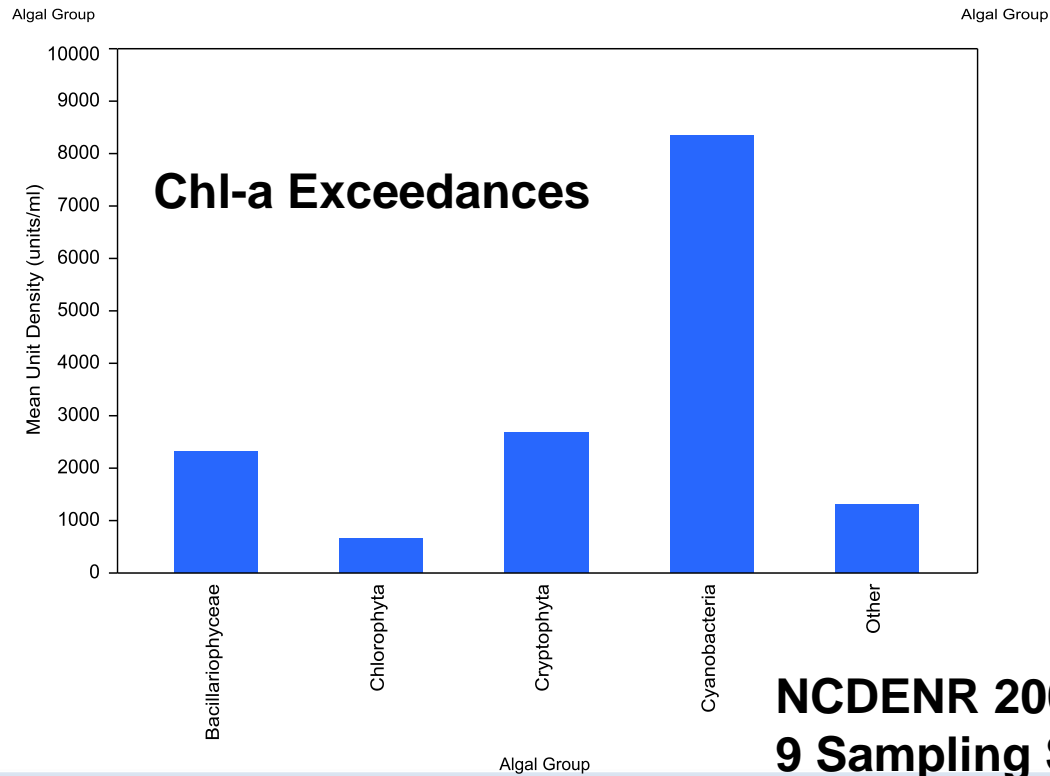
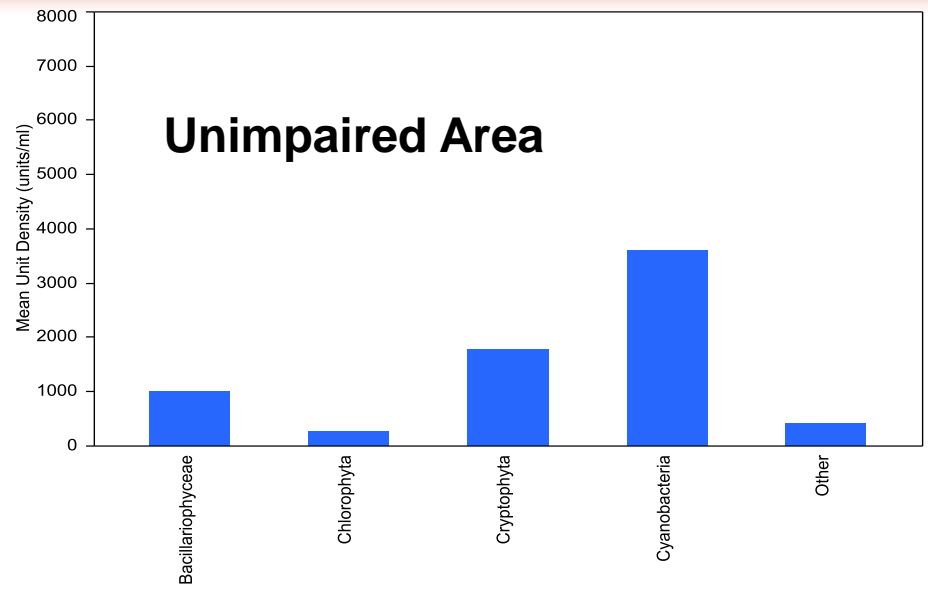
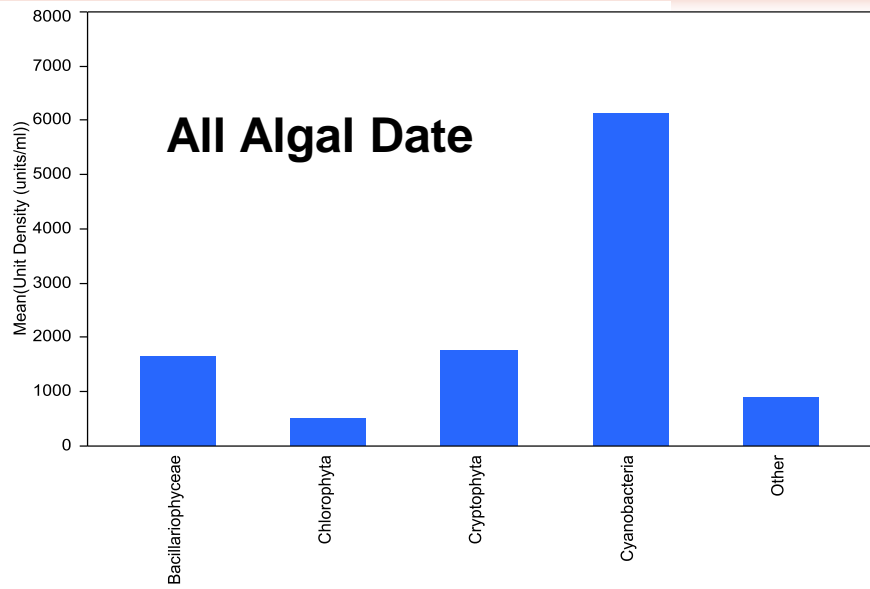


Phycocyanin



Cyanobacterial Harmful Algal Bloom



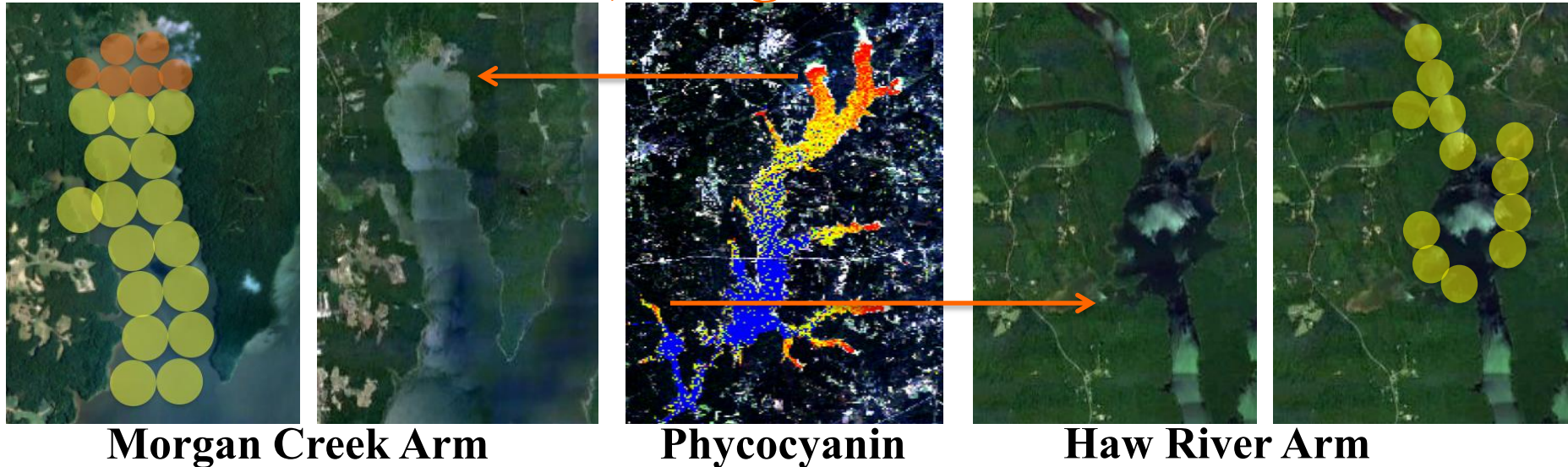


**Cyanobacterial
Predominance**

**NCDENR 2000-2013 Data, All
9 Sampling Stations**

Jordan Lake Demonstration Project

Solar-Powered, Long-Distance Circulation



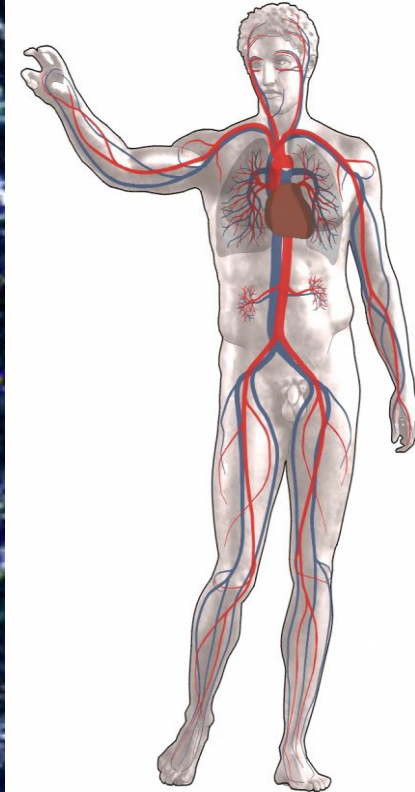
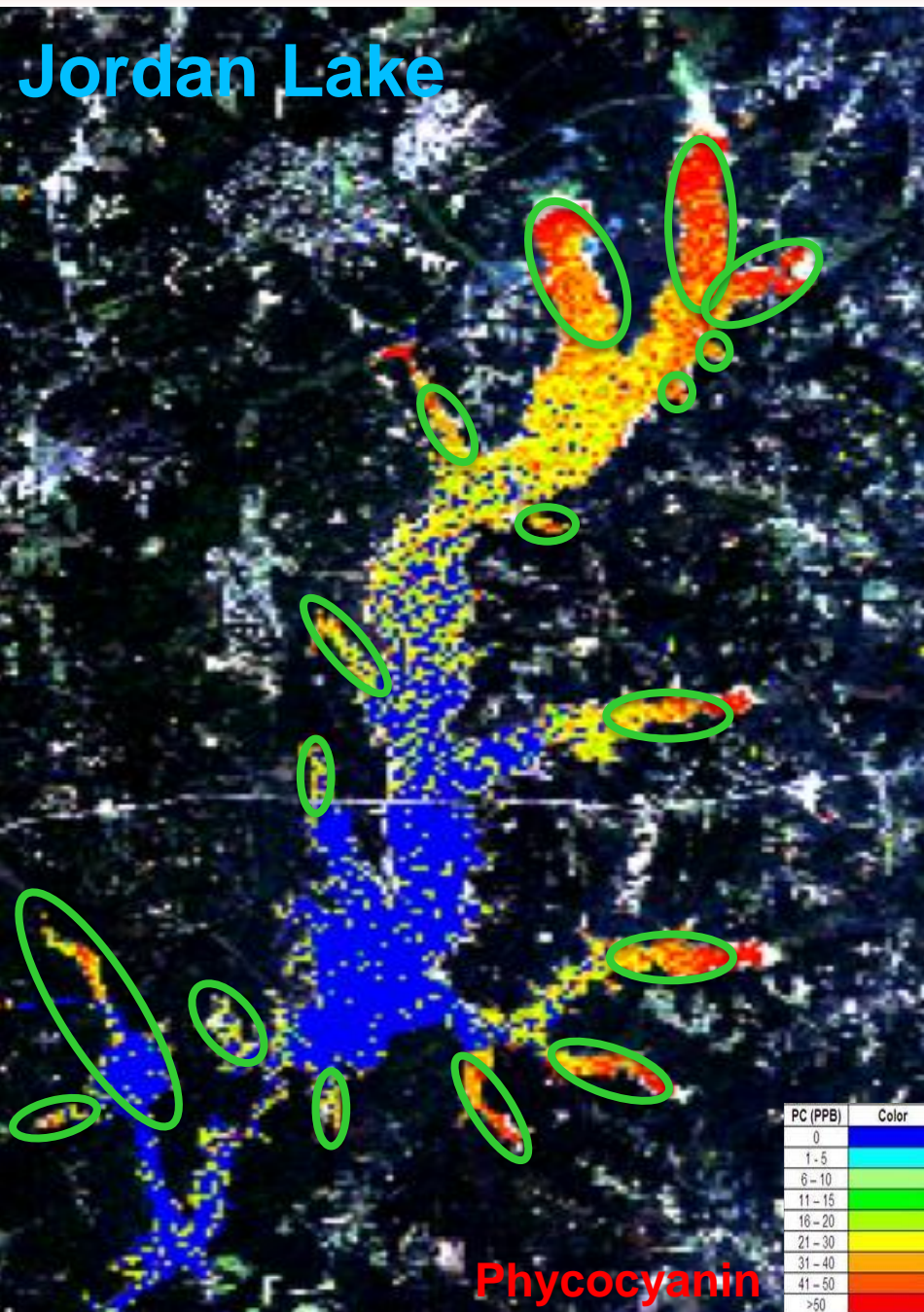
- 2 year rental, study design, data collection & analysis by DENR,
 - Goal - suppress cyanobacteria
 - Chlorophyll-a exceedances $\leq 10\%$ time May-September
- **Develop Comprehensive, Systems Approach Plan**
 - Watershed management upstream - Most cost-effective BMPs
 - Waterbody management in Jordan - Circulate & remove nutrients

Waterbody Treatments

- Whole Lake Protection with ~155 Circulation Units



Suppress
Cyanobacteria
& Channel
Nutrients Up
Trophic
Levels



Waterbody Treatments

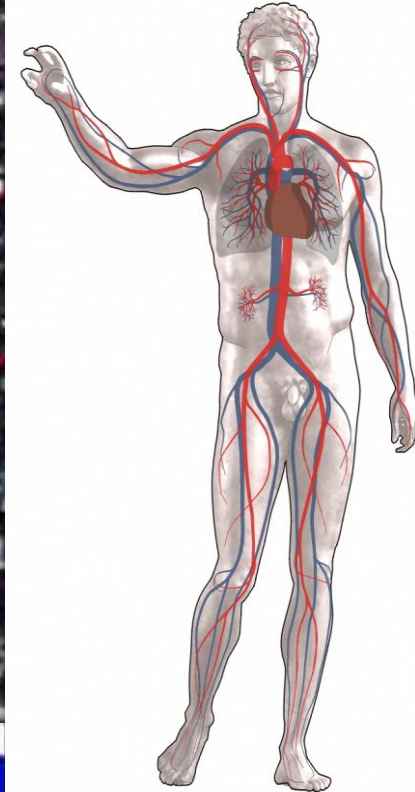
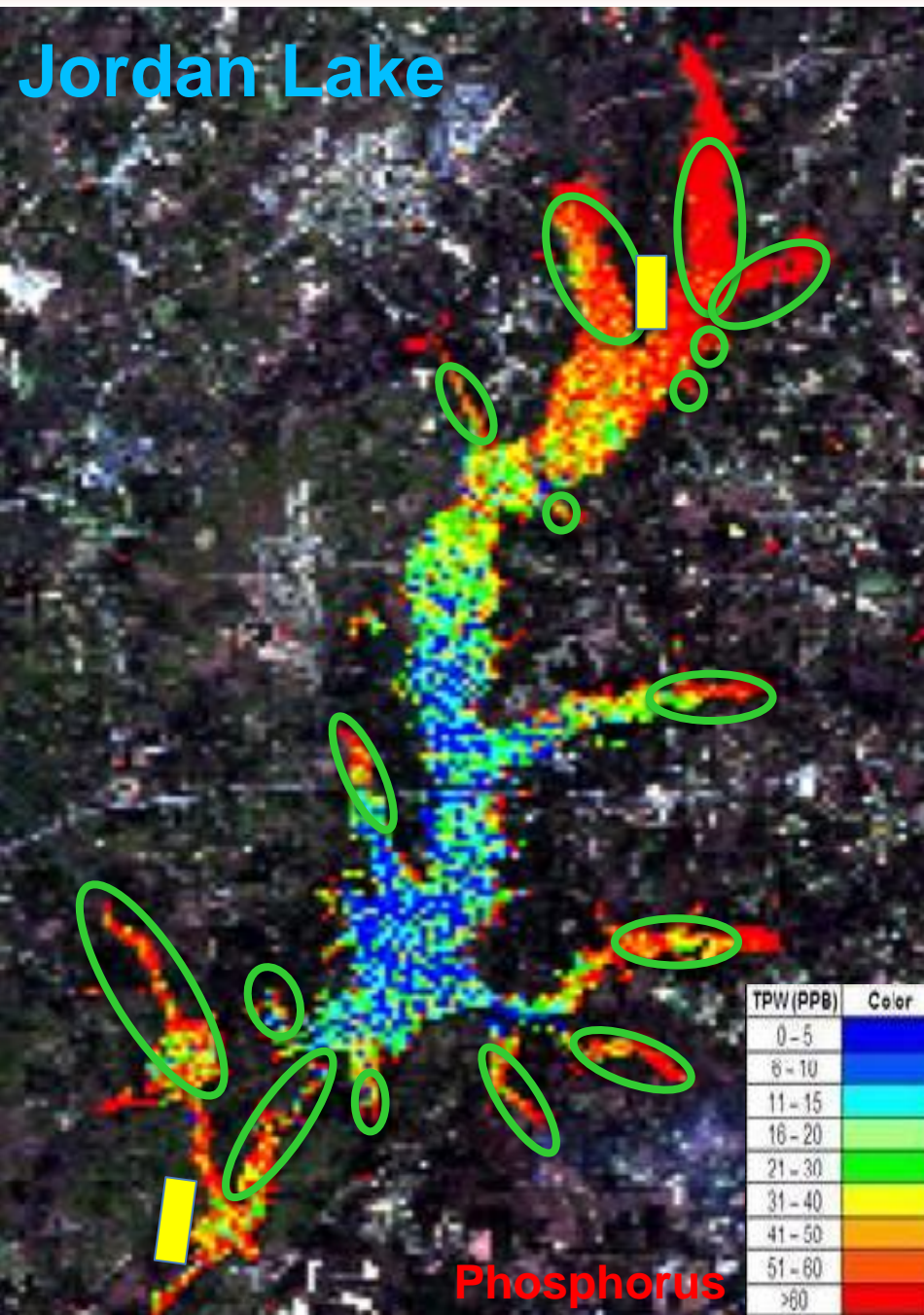
- Circulation
- Flocculants
- Bacteria
- Floating Artificial Wetlands



- Side-stream Flow Ways

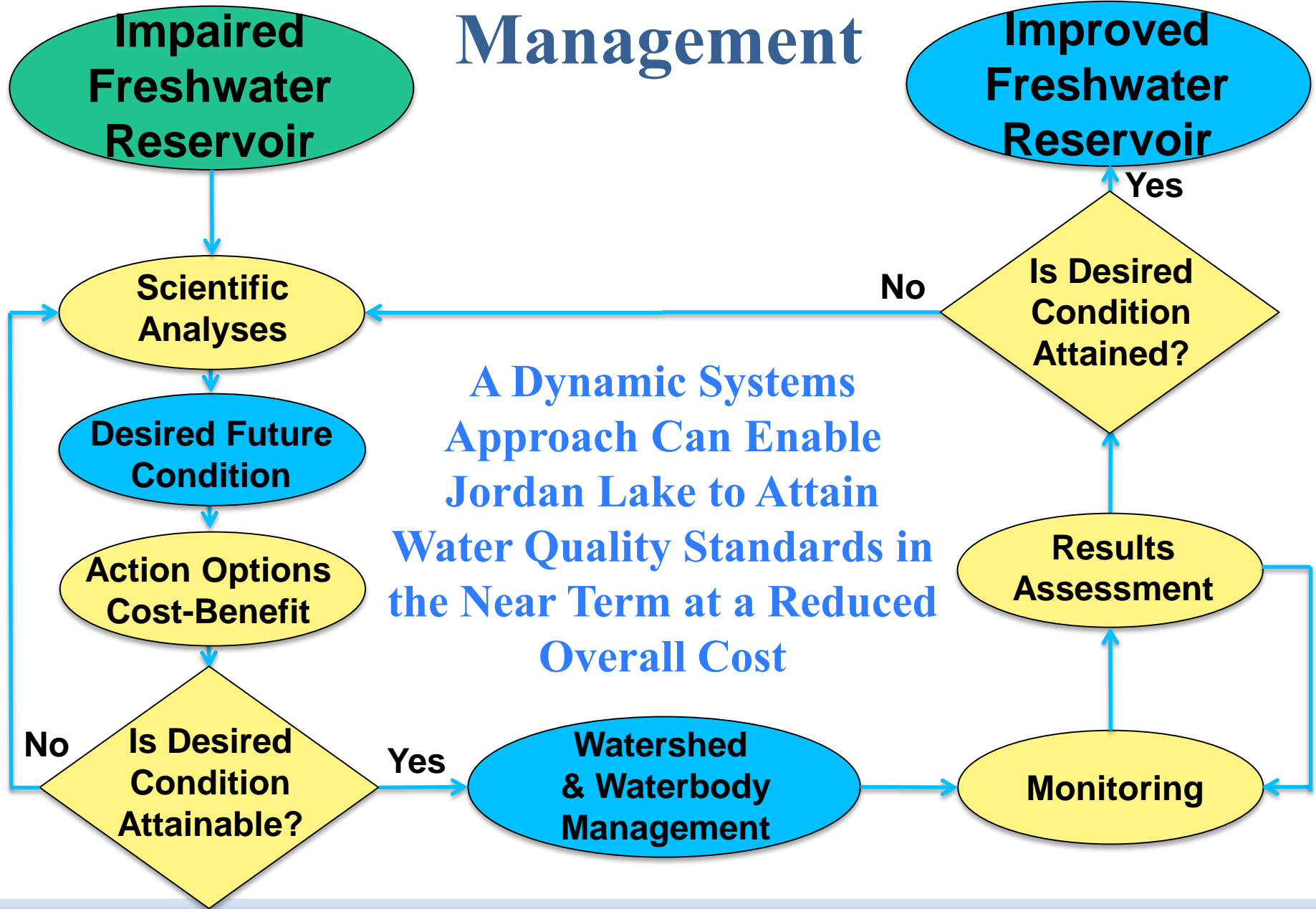


Suppress
Cyanobacteria
&
Remove
Nutrients



Jordan Lake & Watershed

Management



Before Heading Home, Thank You!

Questions?

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January 2011