


NUTRIENTS AND EUTROPHICATION
IN THE PAMLICO RIVER ESTUARY, N. C.
1971 - 1973

By

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Water Resources Research Institute
OF THE UNIVERSITY OF NORTH CAROLINA





U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF INSPECTOR GENERAL

Catalyst for Improving the Environment

Evaluation Report

EPA Needs to Accelerate Adoption of Numeric Nutrient Water Quality Standards

Report No. 09-P-0223

August 26, 2009

Overview of today's meeting

- Gain an understanding of:
 - Nutrient Criteria Development Plan (NCDP)
 - Water Quality Standards / Criteria
- Define what DWR needs from the SAC
- Introduce nutrient management challenges regarding reservoirs and lakes
 - High Rock Lake
- **Develop a path forward**

Who is Steve Kroeger?

- NCDP
 - Point of Contact
 - “Project Manager”

Why are you (SAC) here?

- Recommend scientifically defensible and economically feasible numeric nutrient criteria.
- DWR and stakeholders value the role of science.
- DENR “... *scientific conclusions must be reflective of input from a variety of legitimate, diverse and thoughtful perspectives.*”

What does DWR need from you?

Recommend scientifically defensible (and economically feasible) numeric nutrient criteria that:

1. Protect designated uses
2. Protect uses before adverse conditions occur
3. Protect downstream uses

Language

- Check for understanding of acronyms:
 - NCDP, SAC, CIC, NSAB, DWR, DENR
- Check for understanding of words, etc:
 - Impaired
 - Restoration
 - Criteria
 - Assessment
 - Classification
 - 106
 - 303(d)
 - 319
 - 401

Ask Questions!!

What is the DWR?

To protect, enhance and manage North Carolina's surface water and groundwater resources for the health and welfare of the citizens of North Carolina, and the economic well-being of the state.

- Permitting
- Monitoring

Permitting

- National Pollution Discharge Elimination System (NPDES)
- Animal Feeding Operations
- 401 Water Quality Certifications

Water Quality Monitoring

- ✓ Targeted and Random
- Physical/Chemical
 - *Ambient Monitoring System*
 - *Monitoring Coalition Program*
- Biological
 - *Benthic macroinvertebrate*
 - *Fish community*
 - *Phytoplankton*
 - *Fish tissue*

What is the NCDP?

- NCDP = Nutrient Criteria Development Plan
- All states have nutrient plans (NCDPs)
- ✓ Develop numeric nutrient criteria that apply to all bodies of surface water throughout the state by 2025

Important NCDP Points

- Not a contract
- Not a MOA
- Contains “anticipated deadlines”
- Select milestones are in EPA 106 workplans

NCDP Team Members

- **Standards:** Jeff Manning, Connie Brower and Chris Ventaloro
- **Modeling:** Pam Behm
- **NPDES Permitting:** Mike Templeton
- **Nonpoint Source:** Rich Gannon (John Huisman)
- **Ecosystems:** Carrie Ruhlman, Tammy Hill and Steve Kroeger
- ◆ **APNEP:** Jim Hawhee

North Carolina's NCDP

1. Establish Scientific Advisory Council (and CIC)

Specific Water Body	Water Body Type
2. High Rock Lake 2016, 2018	5. Reservoirs and Lakes 2022, 2024
3. Albemarle Sound 2019, 2020	6. Estuaries 2021, 2023
4. Central Cape Fear River 2019, 2021	7. Rivers and Streams 2023, 2025

Public Response on Creating a SAC

- Among those that commented on a SAC – all supported SAC
- Composition of SAC was a common theme

Public Comments on SAC

- *“... suggests that [DWR] advertise the expertise sought ... e.g. modeler, economist, stormwater professional”*
- *“support SAC with expertise in science AND members with experience with the impacts of implementation”*

Charter

- DWR and stakeholders developed charter
- Charter created:
 - Scientific Advisory Council (SAC)
 - Criteria Implementation Committee (CIC)

Why you were chosen

- Diverse backgrounds
- Broad expertise
- Interested in helping

What can the SAC expect from DWR?

- Staff Support
 - Whatever you assign*
 - Compile/summarize information
 - Provide data summaries

*within reason

Finding Information

- North Carolina's NCDP
 - Division of Water Resources NCDP website
- Numeric Nutrient Criteria
 - EPA's Nutrient Scientific Technical Exchange Partnership and Support (N-STEPS)
 - Scientific Literature
 - State Reports

Finding Information on the NCDP ncwater.org



Water Sciences

- WSS Administration
- Aquatic Toxicology Branch
- Biological Assessment Branch
- Ecosystems Branch
- Intensive Survey Branch
- Laboratory Certification Branch
- Microbiology & Inorganics Branch
- Organic Chemistry Branch
- Estuarine Monitoring Team
- Reports, Publications and Data
- NC Fish Kill Activity

Nutrient Criteria Development Plan

- Nutrient Criteria Timeline
- Scientific Advisory Council

North Carolina's Nutrient Criteria Development

Scientific Advisory Council Members

Nutrient Criteria Development Plan

The Division of Water Resources (DWR) is actively working to develop appropriate nutrient criteria for the waters of the state. The DWR's goal is to develop scientifically defensible criteria based primarily on the linkage between nutrient concentrations and protection of designated uses. The criteria for each water body will be coordinated with other water bodies to ensure consistency across the state and protect downstream uses.

steve.kroeger@ncdenr.gov

- **Nutrient Criteria Development Plan**

- Nutrient Criteria Timeline
 - Scientific Advisory Council

- **Regional Offices**



Ask a Question.

Questions?

N-STEPS



Nutrient Scientific Technical Exchange Partnership and Support

[Home](#)

[About N-STEPS](#)

[Nutrient Criteria Approach Toolbox](#)

[Nutrient News](#)

[Nutrient Criteria Information Library](#)

[Nutrient Criteria Contacts and Links](#)

[Ask the Experts](#)

[Glossary](#)

You are here: N-STEPS > Home

Welcome to N-STEPS

Nutrient News

[Society for Freshwater Science 2015 Annual Meeting](#)
OUR FRESHWATER FUTURES
Milwaukee, WI
May 17-21, 2015

[Mississippi River/Gulf of](#)



[Webcasts and Presentations](#)

[EPA Nutrient Criteria Resources](#)

[Technical Reports](#)

[Nutrient Science Bibliography](#)

[Harmful Algal Blooms](#)

[Statistical Tools](#)

[Nutrient and Response Variable Overviews](#)

[Model Descriptions](#)

 [Select Language](#) ▼

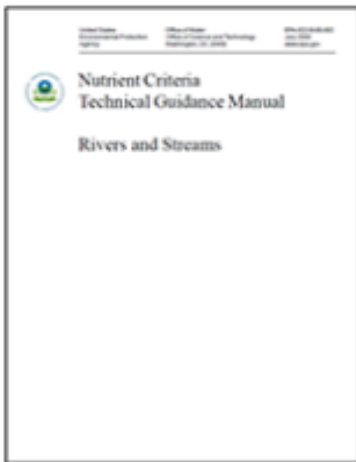
Google™ Custom §



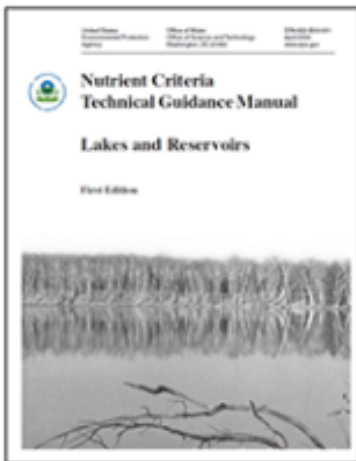
Expert Picks

[The Haber-Bosch-harmful algal bloom \(HB-HAB\) link.](#) Glibert, P.M. et al. 2014. *Environmental Research Letters*.

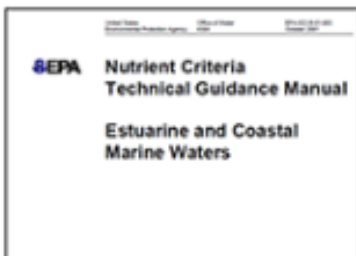
[Evolving paradigms and challenges in estuarine and](#)



Rivers and Streams (2000)



Lakes and Reservoirs (2000)



Estuarine and Coastal Marine (2001)

EPA

Combined Numeric Nutrient Criteria




Goal: Present an optional approach to nutrient criteria development that combines multiple nutrient-related thresholds into a single criterion

Combined Numeric Nutrient Criteria

EPA

Downstream Protection




Goal: Illustrate considerations and procedures associated with incorporating downstream protection into development of numeric nutrient criteria

Downstream Protection

EPA

Duration and Frequency in Numeric Nutrient Criteria




Goal: Review the importance of duration and frequency components in numeric nutrient criteria, and how to use existing scientific information to derive them

Duration and Frequency in Numeric Nutrient Criteria

EPA

Mechanistic Modeling for Deriving Numeric Nutrient Criteria




Goal: Discuss the considerations needed to use and develop mechanistic models that integrate nutrient-sensitive assessment endpoints and water quality targets to derive numeric nutrient criteria

Mechanistic Modeling for Deriving Numeric Nutrient Criteria

EPA

Using Assessment Endpoints to Link Management Goals to Numeric Criteria




Goal: Provide a framework and examples of how to quantify and illustrate the linkage between effects of nutrient pollution and support of the designated use

Using Assessment Endpoints to Link Management Goals to Numeric Criteria

EPA

Using Stressor-Response Relationships to Derive Numeric Nutrient Criteria



Goal: Discuss the technical approaches that will improve the accuracy and precision of the estimated relationship between stressor and response variables used to derive numeric nutrient criteria

Using Stressor Response Relationships to Derive Numeric Nutrient Criteria

EPA

Reference Condition Approach: Advances Since 2000



Goal: Provide key considerations on how to develop numeric criteria based on a reference condition and recent applications


Reference Condition Approach: Advances Since 2000

U.S. EPA - Office of Water - Office of Science and Technology

Guiding Principles for Developing and Implementing a Numeric Nutrient Criterion That Integrates Causal and Response Parameters ("Bioconfirmation")

Webinar Audio

- Welcome to this webinar, it will begin shortly. In the meantime, there will be silence when you join.
- You will be listening through Adobe Connect.
- Please turn up the volume on your computer speakers to hear the webinar audio.



Guiding Principles for Developing and Implementing a Numeric Nutrient Criterion (September 19, 2013)

EPA's Criteria Recommendations -

United States
Environmental Protection
Agency

Office of Water
4304

EPA 822-B-00-011
December 2000



Ambient Water Quality Criteria Recommendations

**Information Supporting the Development
of State and Tribal Nutrient Criteria**

**Lakes and Reservoirs in
Nutrient Ecoregion IX**

Identify/Summarize Approaches by other States

March 2010



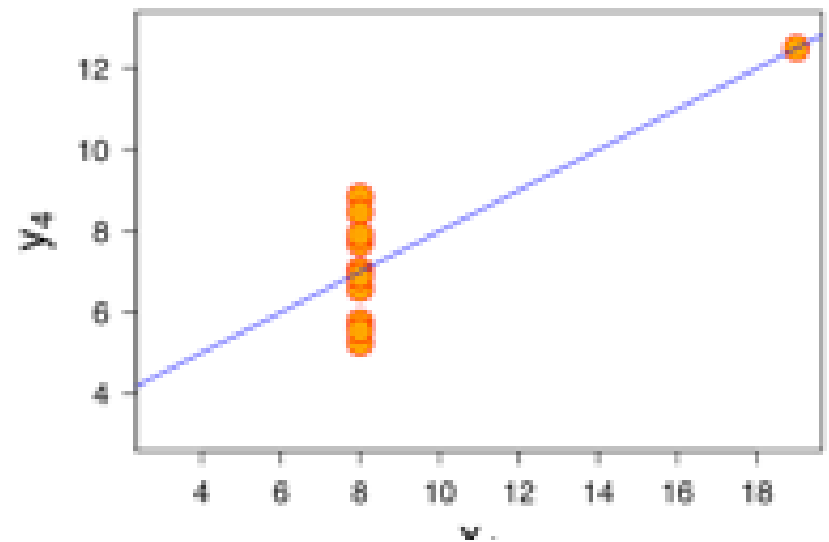
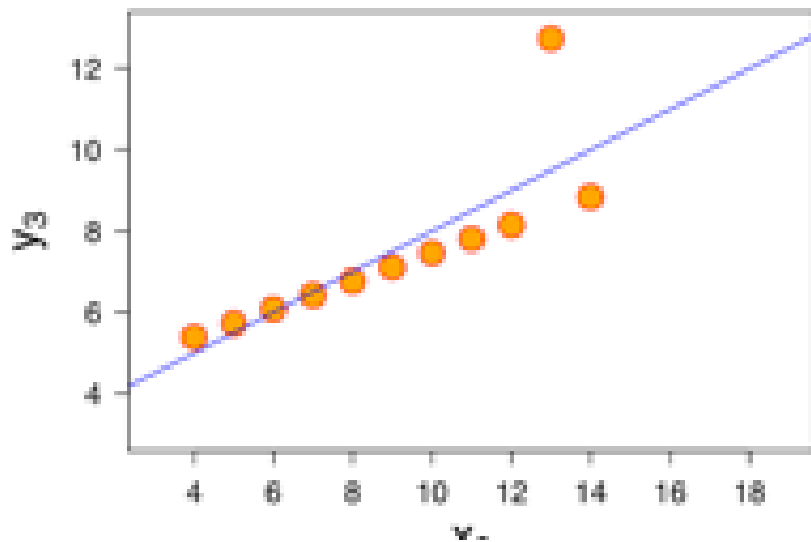
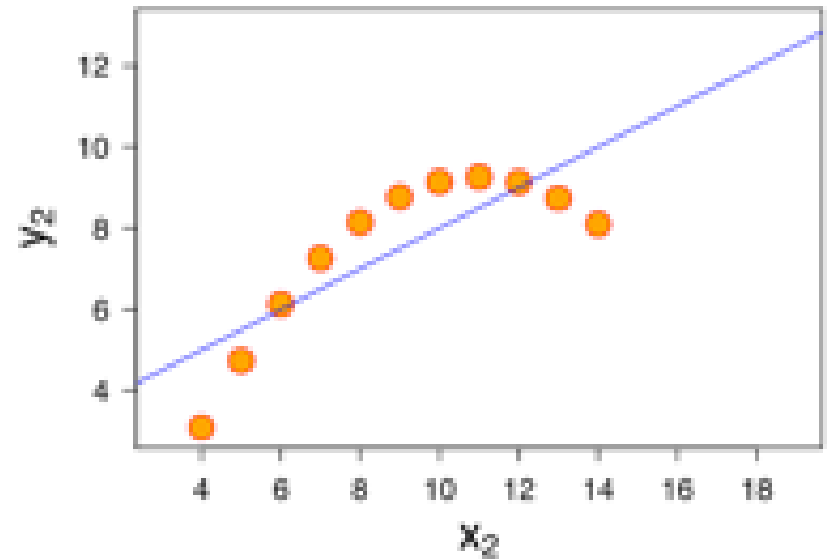
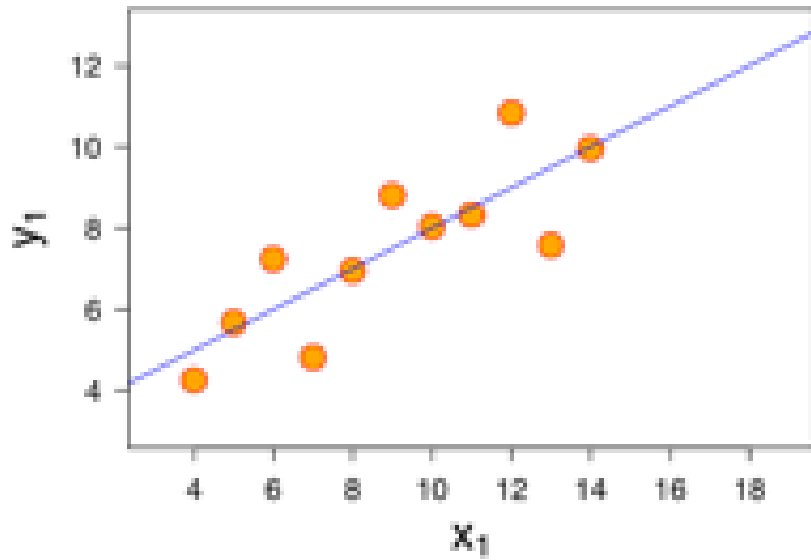
Environmental
Protection Agency

Technical Support Document:
Nutrient Criteria for Inland
Lakes in Ohio

What is meant by “scientifically defensible”?

- Statistically vs. ecologically significant?
- Causation vs. correlation?
- Do the data reasonably support the conclusions?

Anscombe's Quartet



How to track publications?

The screenshot displays the EndNote X7 interface. On the left, the 'My Library' pane shows a list of folders: Statistics (8), MY GROUPS, Albemarle Sound (1), Algae-Sampling-... (3), Aquatic Weed (8), Cape Fear (14), Cyanobacteria (8), EPA (19), HRL (4), NNC Lakes/Rese... (22), NPDES (2), Nutrients (30), and QA-QC (7). The 'Nutrients' folder is selected. The main window shows a preview of a PDF document titled 'Herlihy-2013-Using multiple approaches to deve.pdf'. The document content includes the journal information: 'Freshwater Science, 2013, 32(2):367-384', the copyright notice '© 2013 by The Society for Freshwater Science', the DOI '10.1899/11-097.1', and the publication date 'Published online: 5 February 2013'. The title of the article is 'Using multiple approaches to develop nutrient criteria for lakes in the conterminous USA'. The authors listed are Alan T. Herlihy^{1,6}, Neil C. Kamman^{2,7}, Jean C. Sifneos^{3,8}, Don Charles^{4,9}, Mihaela D. Enache^{4,10}, and R. Jan Stevenson^{5,11}. Below the authors, their affiliations are provided: ¹Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon 97331 USA; ²Monitoring, Assessment and Planning Program, Vermont Department of Environmental Conservation, Water Quality Division, Waterbury, Vermont 05671 USA; ³Department of Statistics, Oregon State University, Corvallis, Oregon 97331 USA; ⁴Patrick Center for Environmental Research, The Academy of Natural Sciences, 1900 Benjamin Franklin Parkway, Philadelphia, Pennsylvania 19103 USA.

How to track publications?



The image shows a screenshot of the Zotero website's 'Groups' page. At the top, the 'zotero' logo is displayed in a large, lowercase font, with the 'z' in red. Below the logo is a dark navigation bar with white text for 'Home', 'My Library', 'Groups', 'People', 'Documentation', 'Forums', and 'Get Involved'. The 'Groups' tab is highlighted. Below the navigation bar, the breadcrumb 'Home > Groups' is visible. The main heading is 'Zotero Groups' in a bold, black font. Underneath, there are three links: 'Browse All Groups', 'Search for Groups', and 'Create a New Group'. The section is titled 'What can groups do for you?' and contains three paragraphs of text describing the benefits of using groups.

zotero

Home My Library **Groups** People Documentation Forums Get Involved

[Home](#) > Groups

Zotero Groups

[Browse All Groups](#) · [Search for Groups](#) · [Create a New Group](#)

What can groups do for you?

With groups, you collaborate remotely with project members, set up web-based bibliographies for classes you teach, and so much more.

Share your own work or sources you have discovered with others who are working in related areas.

Collaborate with colleagues, publicly or privately, on ongoing research.

Discover other people with similar interests and the sources they are citing.

Next SAC Meeting

- Brief history of North Carolina's nutrient management strategies
 - Reservoirs
 - Presentation on High Rock Lake model
- Summary of what other states are doing for lakes and reservoirs

Next SAC Meeting

- Begin discussion on causal and response variables.
- Is the current chlorophyll-*a* standard as applied anywhere in the High Rock Lake appropriate to maintain biological integrity?
- Does the current chlorophyll-*a* standard of 40 µg/L provide for the ability of High Rock Lake to support and maintain a balanced and indigenous community of organisms?
- Read EPA Nutrient Criteria Technical Guidance Manual – Lakes and Reservoirs (EPA-B822-B00-001)

Reimbursement for SAC Members

Reimbursement is for:

- In-state travel only
- Personal or rental vehicle mileage from duty station or airport

* Lunch will be provided at in-person meetings *

DIVISION

CARDHOLDER NAME (LAST, FIRST)



**DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
TRAVEL EXPENSE REIMBURSEMENT/RECONCILIATION FORM**

PLEASE USE YOUR TAB KEY TO ACCESS AVAILABLE FIELDS

 Employee

 Boards, Councils, Commission, and Committees

 Non-DENR Employee

INSTRUCTIONS TO CLAIMANT: Submit one original to your division Travel Contact. Attach all necessary original receipts and other supporting documents to this form, including your IA and any prior written approval of excess registration, lodging and out-of-state travel. Retain one (1) copy for your records. Please complete amount, company, account, and center fields. **File no later than 30 days after month in which travel ends.** Prepare in ink or type. Make all corrections by drawing line through erroneous data and entering correct data. Do not use white-out. Initial all corrections or revisions.

Beacon ID No./Social Security No.	New Claimant:	<input checked="" type="checkbox"/>	New Address:	<input type="text"/>
B <input type="text"/>	Division/Section/Board, Title Scientific Advisory Council			
Claimant's Name (First, Middle Initial, Last)	Headquarters (City): <input type="text"/>			
<input type="text"/>	Duty Station (If different from above): <input type="text"/>			
Claimant's Home Address (Street)	Normal Work Day Hours:			
<input type="text"/>	Start: <input type="text"/>	End: <input type="text"/>	<input type="text"/>	
City, State, Zip	Period Covered by this Request:			
<input type="text"/>	From: <input type="text"/>	Through: <input type="text"/>	<input type="text"/>	

Remit Code/Message:

*Under penalties of perjury, I certify this is a true and accurate statement of the city of lodging, expenses and allowances incurred in the service of the State, and this request complies with all Department and State travel policies and regulations. **Original Signature and date required.***

*I have examined this reimbursement request and certify that funds are available in the proper accounting codes to pay this claim, and this request complies with all Department and State travel policies and regulations. **Original Signature and date required.***

(Claimant)

(Date)

(Supervisor)

(Date) Budget Officer

*P-Card Reconciliation - A copy of the approved Travel Authorization, if required, must also be attached to process this reconciliation. (Do not forget receipts.)

P-Card Number:						
	AMOUNT	COMPANY	ACCOUNT	CENTER	Accrual Code	1099
1		16	53			
2		16	53			
3		16	53			
4		16	53			
5		16	53			
6		16	53			
7		16	53			
8		16	53			
9	\$0.00	Total P-Card Expenses				

What I Need from YOU!

- Information highlighted on “Travel Expense Reimbursement/Reconciliation Form”.
 - SSN (can be called-in to Budget Office)
 - Home address
 - Duty station (work address)
 - Normal work day hours
- Signature

* If in-state, do you want mileage calculated from home or work (if out-of-state, see me)?

- Indicate on reimbursement form



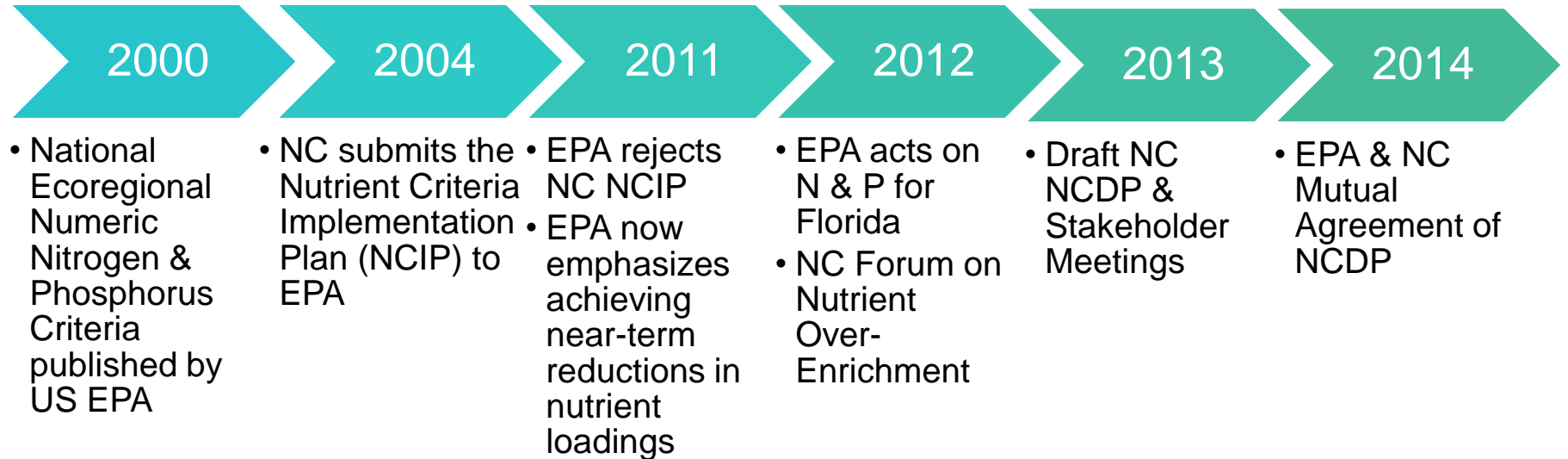
- Checks will be sent to address provided in “Claimant’s Home Address” box.
- Forms will be prepared for subsequent meetings based on info provided.
- If leaving from a different address, let me know before the meeting!

carrie.ruhlman@ncdenr.gov



An Abbreviated History of Nutrient Criteria Development in North Carolina

Timeline: Nutrients, EPA & North Carolina



Where it started – EPA’s Nutrient Criteria Development Guidance

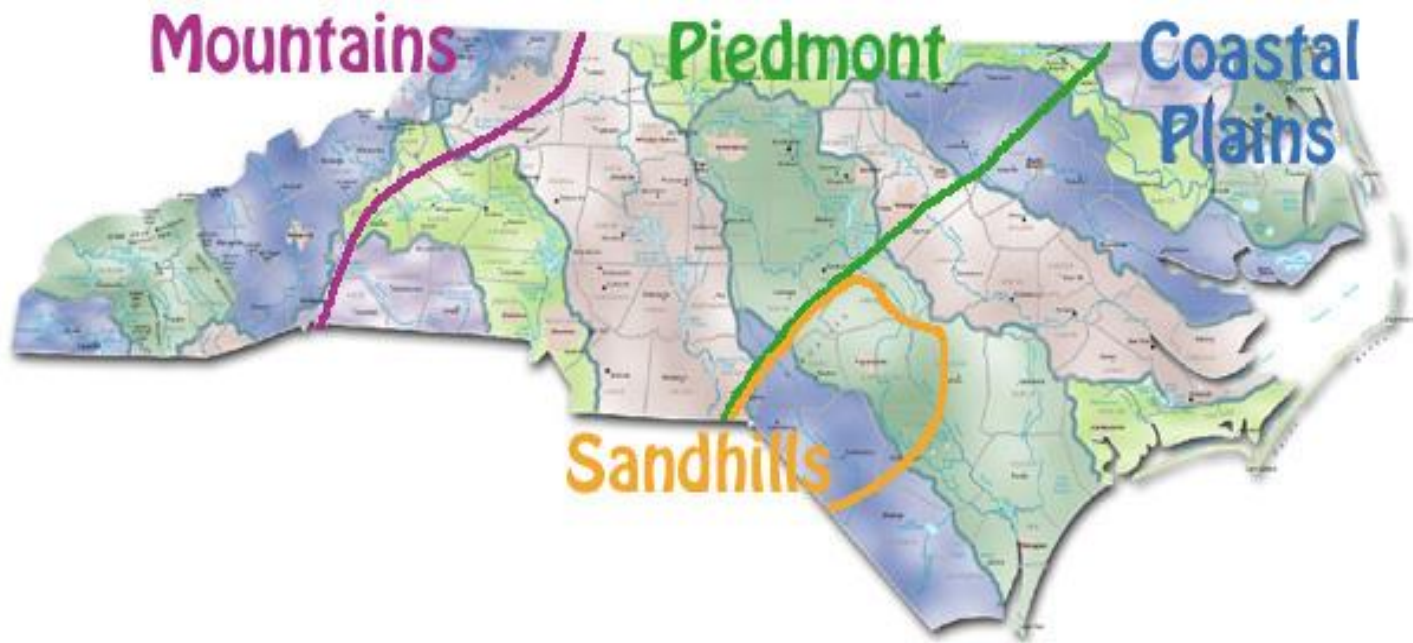
2000 - January 9, 2001 – Guidance memos issued, *Federal Register Notice* of pending water quality criteria for nutrients. Notice warns of Federal Promulgation of nutrient criteria by the end of 2004.

November 14, 2001 - States receive directive that “adoption” of nutrient criteria and/or formalization of acceptable plans is “required.”

January 6th, 2003 - EPA published nine “Section 304(a)” ecoregional nutrient criteria documents for lakes, reservoirs, rivers, and streams within specific geographic regions (**ecoregions**) of the US

What are NC Ecoregions?

Ecoregions : geographic areas that share similar **causal** (climate, geology, vegetation, etc...) and **integrative** (land use, water use, development, etc...) factors from which distinct regional ecosystems are identified



What was the EPA “Ecoregional Approach”?

Ecoregional Approach: primarily a “Reference Condition” approach

EPA’s **Ecoregional Nutrient Criteria for Rivers & Streams** contains guidance for topics such as:

- Data gathering and QA/QC
- Statistical analysis of data
- Models for predicting and verifying response parameters
- Example worksheets for developing nutrient criteria
- Tables containing refined nutrient water quality criteria
- Guidance for setting seasonal criteria
- Guidance for when data or reference conditions are lacking
- Guidance for site-specific criteria development

Establishing North Carolina's Nutrient Criteria Development Plan (NCIP → NCDP)

- June 2004 – Nutrient Criteria Implementation Plan (NCIP) submitted to EPA. Based on two-tiered threshold approach; “proactive” management
- June 2004-11 – Rule making efforts; numerous stakeholder meetings, EMC proposals
- Nov 2010 – EMC placed draft rules on hold ; advises additional considerations for staff to review
- June 2011 – EPA rejects NCIP timeline extension
- May 2012 – NC Forum on Nutrient Over-Enrichment
- Dec 2012-Feb 2013 – Public comment and Input Meetings on “new plan”
- April 2013-Early 2014 – Draft NC Nutrient Criteria Development Plan submitted to EMC, public comment, revisions, approved by EMC.
- June 2014 – EPA/NC Mutual Agreement of Nutrient Criteria Develop. Plan (NCDP)

What are the Goals of the NCDP?

North Carolina has established flexible nutrient control strategies based upon

- **Chlorophyll a criteria**
- Use of a **Nutrient Sensitive Waters** (NSW) designation

HOWEVER.....Nutrients continue to affect water quality

So, the focus of the revised strategy will be to develop (where the SAC deems appropriate) Nutrient **Criteria**, defined as a causal and/or response variables for the **designated use** of the waters:

Causal Variables: *Nitrogen, Phosphorus Others?*

Response Variables: *Chlorophyll-a; Phytoplankton, Periphyton, Macrophytes, D.O..... Others?*

What is a Water Quality Standard?

Water quality **standards** define the **goals** for a waterbody by **designating its uses**, setting **criteria** to protect those uses, and **establishing provisions** to protect water quality from pollutants.

Criteria may be *numeric* or *narrative* or *both*.

Four Components of a Water Quality Standard

1. the designated uses of the water: public water supply, recreation, propagation of aquatic life/wildlife, irrigation
2. the water quality criteria: specifies the amounts of various pollutants that may be present in those waters without impairing the designated uses. *Criteria* include any one or more of three components: *magnitude, duration, and frequency*;
3. antidegradation: requirements to maintain and protect *uses* and high quality waters, and
4. general policies: address implementation issues (e.g., low flows, variances, mixing zones)

How is Chlorophyll-a criteria implemented based on designated use?

“**Class C**” waters: “freshwaters protected for secondary recreation, fishing, aquatic life including propagation and survival, and wildlife”

- ≤ 40 ug/l for lakes, reservoirs & other waters subject to growths of macroscopic or microscopic vegetation.

“**Class C; Trout**”: “freshwaters protected for natural trout propagation and survival of stocked trout”

- ≤ 15 ug/l for lakes, reservoirs and other waters designated as trout waters

NC Water Quality Standards related to the NCDP Response Variables

Chlorophyll-*a*

- 40 ug/L – Class C (all of the state's waters)
- 15 ug/L – Trout classifications

Dissolved Oxygen

- 5.0 mg/L – Class C
- 6.0 mg/L – Trout

pH

- 6.0 – 9.0 (all waters)

Turbidity

- 50 NTUs/25 NTUs (Narrative)



Why was the Chlorophyll-*a* criteria derived?

Background

- **1970's** – **Chowan River Basin** estuaries (and other water bodies) experienced algal blooms that disrupted industrial water supplies, fishing & recreational uses.
- Public reaction created pressure on the State to correct the problem.
- **1977** – WRRRI was requested to assist/advise the state on criteria for controlling algae.
- **1978** – The Chowan again experienced massive blue-green algae growths.
- Public outcry caused the EMC to draft language to further protect waters.
- The Nutrient Sensitive Waters (NSW) designation was adopted concurrent with the Chlorophyll-*a* criteria and the Chowan River basin was designated “NSW”.

How was NC's Chlorophyll-*a* standard developed?

Class C: Lakes/Reservoirs/Rivers:

- NC originally proposed a standard of 50 ug/L.
- Studies by UNC Chapel Hill/WRRI concluded this was too high.
- NC settled on **40 ug/L** ; **noting some lakes/reservoirs could experience algal scums, growth of macrophytes & low DO.**

Trout Waters:

- NC originally proposed a standard of 20 ug/L.
- Studies by UNC Chapel Hill/WRRI concluded this was too high.
- NC settled on **15 ug/L** – but admitted that this **may or may not be** protective.

Summary

It's been a long road that...

- Began with EPA publication of Ecoregional Numeric Nutrient Criteria and Guidance,
- Led to the creation and subsequent rejection of NC's NCIP,
- Involved exploration of the problem of nutrient over-enrichment during a public forum,
- And, ultimately, led us to development of NC's most recent Nutrient Criteria Development Plan.

Questions?

North Carolina Division of Water Resources



Getting to Nutrient Criteria

A Nutrient Criteria Development Process

Based on Designated Use(s) for Waterbody, Select Management Goal(s)



Refine Management Goal(s)

* Narrative criteria or statement reflective of protecting designated use(s)



Evaluate Potential Criteria

- * Come up with way(s) to protect the use (numeric, narrative, both) - measurable & most sensitive
- * Generate recommended indicator list
- * Data gap analysis



Develop Conceptual Model

* Shows relationship between nutrients and criteria - EX: algal blooms, organic carbon, dissolved oxygen, chlorophyll a, etc.



Analysis/Approach

- * Select approach to derive criteria: reference conditions, stressor-response, mechanistic model, other...reflective of protecting designated use(s)
- * Fulfill any data/research needs



Develop Estimates for Criteria & Assessment Protocols



Evaluate Feasibility of Accomplishing Criteria

DWR Selects Scientifically Defensible, Feasible Criteria



Begin Adoption of Recommendations into Water Quality Standards

Draft Rule, Fiscal Note, Public Hearings, etc.

The Goal

Scientifically Sound
Defensible
Economically Feasible
NUTRIENT CRITERIA

Designated Use & Management Goal(s)

- **Designated use** = surface water classification
 - Already determined for each waterbody
 - Class C, Class B, Water supply, etc.
- **Management Goal(s)** = narrative statement reflective of protecting the Designated Use
 - Ex: The river shall support and maintain biological integrity

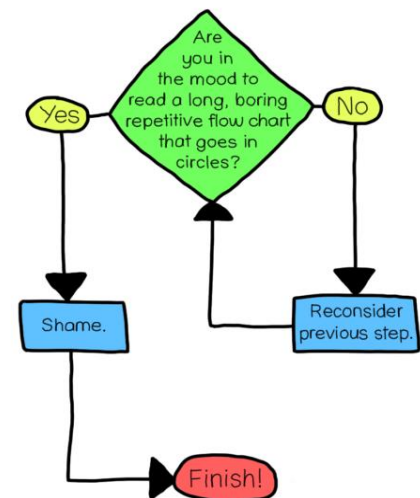
Evaluate Potential Criteria

- Come up with way(s) to protect the designated use (e.g., recreation, biology, drinking water, etc.)
 - How do we make sure the water isn't green so people can swim?
 - How do we protect the biological integrity of the stream?
- Numeric and/or Narrative
- Measurable & Most Sensitive

Conceptual Model

- Clearly explain the linkage and key relationships between nutrients, response variables and what is being protected

Ex: Leaking septic systems introduce nutrients into the stream which cause algal blooms in the downstream lake that prohibit people from swimming



Analysis/Approach

- Select approach(es) to derive nutrient criteria
 - Reference Condition
 - Stressor-Response
 - Mechanistic Modeling
 - Weight-of-Evidence
 - Best Professional Judgment
 - Other
- Perform any studies necessary



Do we have the information we need to know how much is too much in the system?

Develop Estimates for Criteria

- Number and/or Narrative statement

Ex: DO standard for all lentic waterbodies in the Piedmont shall be > 3.5 mg/L from April – October and > 5.5 mg/L November – March.

Ex: Except as due to natural conditions, nutrients shall not be allowed at concentrations that cause objectionable algal densities, nuisance aquatic vegetation or otherwise compromise the designated use of a waterbody



- Shows how the criteria will actually protect the designated use of the waterbody (causal models)
- Come up with Assessment Protocols

Consider Feasibility

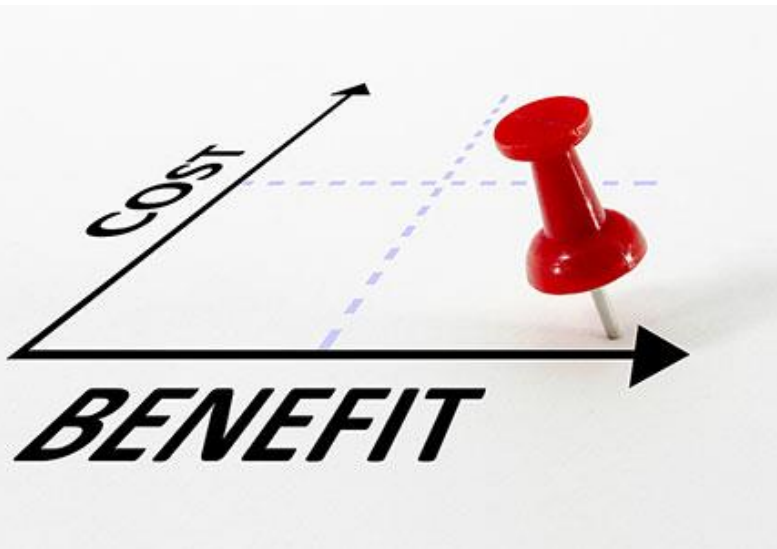


- Iterative process to discuss positive and negative aspects of proposed criteria

Is this feasible?

Are the benefits expected to outweigh the costs?

How will we consistently do this?



Criteria Selection & Standards Adoption

- Most scientifically defensible, feasible criteria will be selected
 - DWR will work with the EMC to follow the process for water quality standards rule adoption
- 
- A scenic view of a large, calm lake surrounded by dense green forest and rolling hills under a clear blue sky. The lake is the central focus, reflecting the surrounding greenery. The hills in the background are covered in thick forest, and the sky is a clear, bright blue. The overall atmosphere is peaceful and natural.

Select Management Goal(s)

Refine Management Goal(s)

* Narrative statement reflective of protecting designated use(s)

Evaluate Potential Criteria

* Come up with way(s) to protect the use (numeric, narrative, both) - measurable & most sensitive
* Generate recommended indicator list
* Data gap analysis

Develop Estimates for Criteria & Assessment Protocols

Analysis/Approach

* Select approach to derive criteria: reference conditions, stressor-response, mechanistic model, other...reflective of protecting designated use(s)
* Fulfill any data/research needs

Develop Conceptual Model

* Shows relationship between nutrients and criteria - EX: algal blooms, organic carbon, dissolved oxygen, chlorophyll a, etc.

Evaluate Feasibility of Accomplishing Criteria

Select Scientifically Defensible, Feasible Criteria

Begin Adoption of Recommendations into Water Quality Standards

Draft Rule, Fiscal Note, Public Hearings, etc.

= SAC

= DWR

= CIC

Questions?

High Rock Lake: Background and Existing Information

Pam Behm - NC Division of Water Resources

NC NCDP SAC
1st Meeting
May 6, 2015

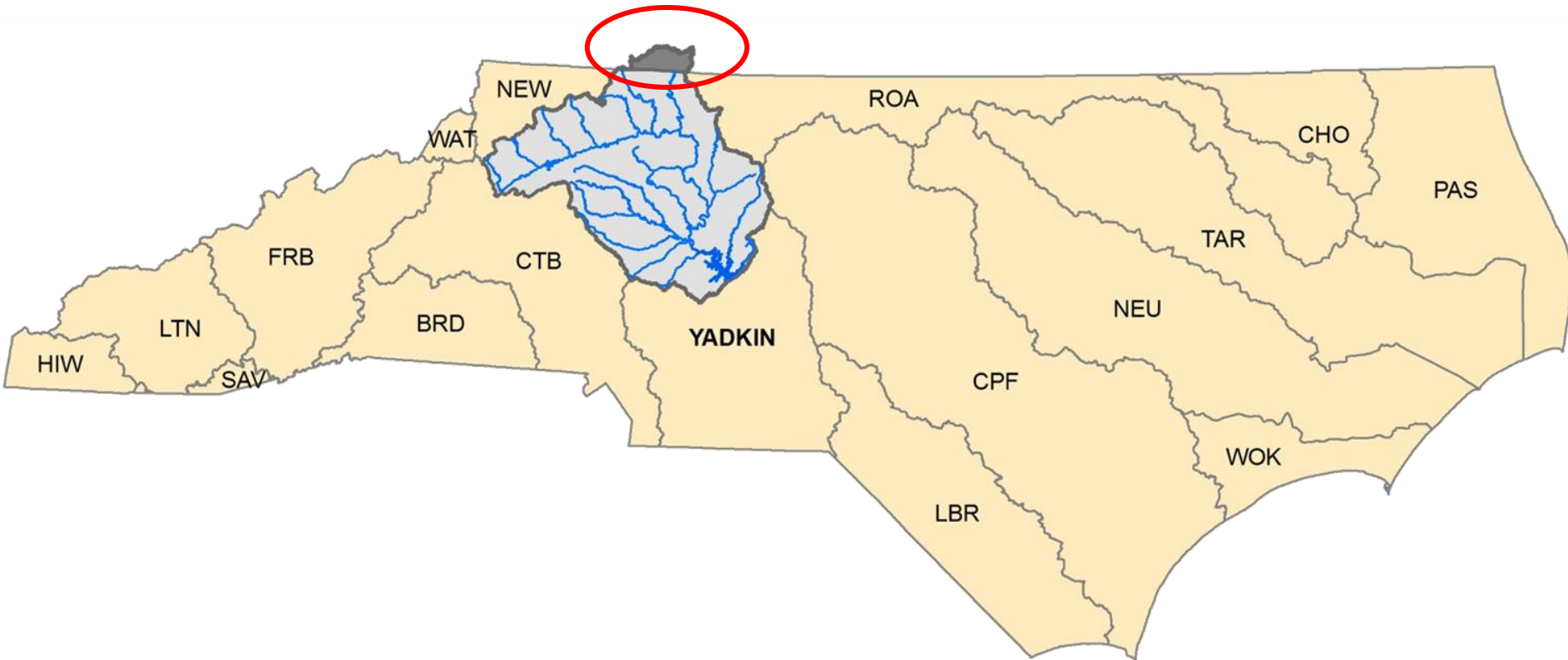
Purpose

- Provide history of eutrophication in High Rock Lake
- Describe available tools
- Describe available data

Outline

- History
- Technical Advisory Committee
- Data collection
- Development of models
- Connection to NCDP
- Next Steps

High Rock Lake Watershed

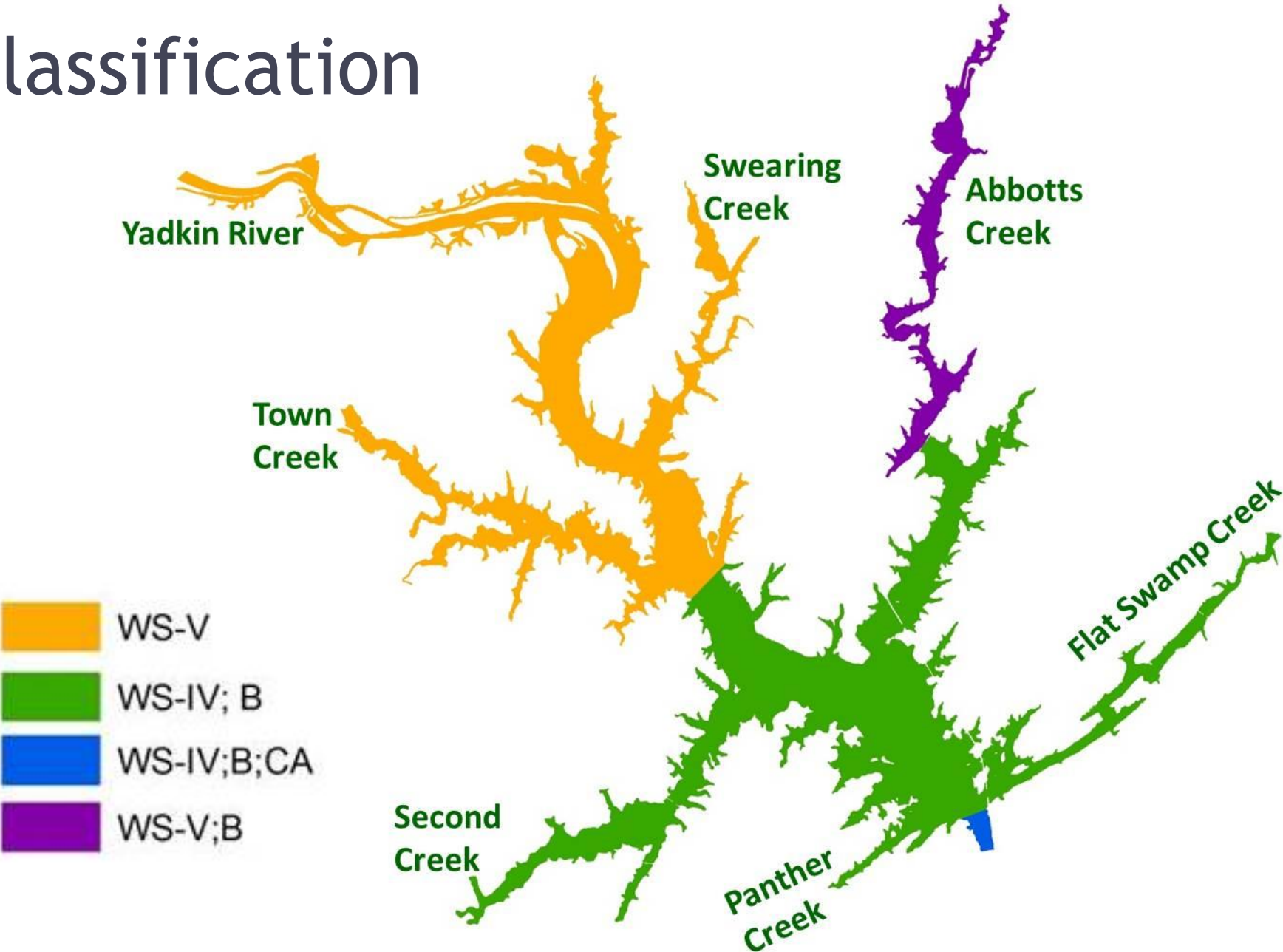


History

- 1928 - Dam construction completed
- Dam owned and operated by Alcoa Power Generating, Inc



Classification



Class C Definition

Waters protected for uses such as secondary recreation, fishing, wildlife, fish consumption, **aquatic life including propagation, survival and maintenance of biological integrity**, and agriculture. Secondary recreation includes wading, boating, and other uses involving human body contact with water where such activities take place in an infrequent, unorganized, or incidental manner.

Maintenance of biological integrity

Biological integrity means the ability of an aquatic ecosystem to support and maintain a balanced and indigenous community of organisms having species composition, diversity, population densities and functional organization similar to that of reference conditions.

NorthCarolinaSportsman.com,
June 2012
High Rock - Lake of the Month

A **tremendously fertile reservoir**,
High Rock usually carries a **nice stain**,
almost year-round "spinnerbait" color.

- Bass fishery is excellent
- Crappie fishery is excellent
- Fishery for flathead and channel catfish is excellent.

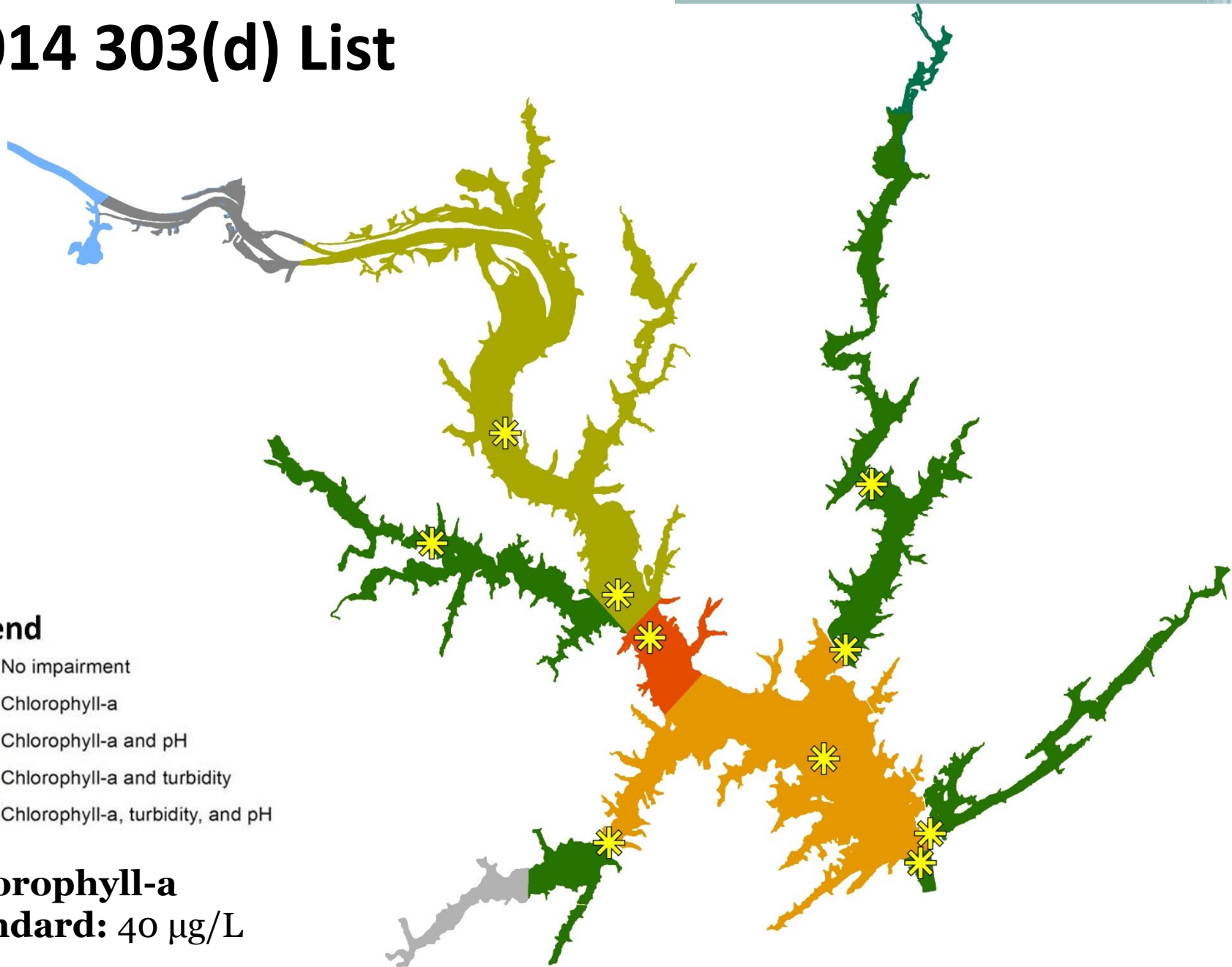


2014 303(d) List

Legend

- No impairment
- Chlorophyll-a
- Chlorophyll-a and pH
- Chlorophyll-a and turbidity
- Chlorophyll-a, turbidity, and pH

Chlorophyll-a
Standard: 40 $\mu\text{g/L}$



Addressing the Impairment

What is a Nutrient Management Strategy?

Similar to TMDL:

- Requires reductions
- Allocations to sources

Requires state rulemaking:

- Stakeholder process, public hearings
- Fiscal analysis
- EMC approval

Addressing the Impairment

Questions

- Where are the nutrients coming from and how much?
 - Tool: Watershed Model
- What reductions in nutrient loading are necessary to achieve water quality standards in the lake?
Nitrogen? Phosphorus? Both?
 - Tool: Nutrient Response Model

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Technical Advisory Committee (TAC)

PURPOSE:

Assist DWQ with the development of mathematical tools for the management of nutrients and turbidity in High Rock Lake. DWQ expects this assistance to include providing input on levels of confidence for decision making and evaluating field and modeling studies for the reservoir.

High Rock TAC Members

- Winston-Salem
- Salisbury
- Kernersville
- Duke Energy
- Alcoa
- Yadkin Riverkeeper*
(since Mar 2009)
- DWQ
- NC DOT
- DSWC
- Piedmont-Triad COG
- Keep Iredell Clean
- DEH*
(since Sept 2009)

TAC

- Modeling Training
- TAC Inputs:
 - Modeling Goals
 - Monitoring Plan
 - Model Performance Targets
 - Model Review – **“Tell us how to make it better”**



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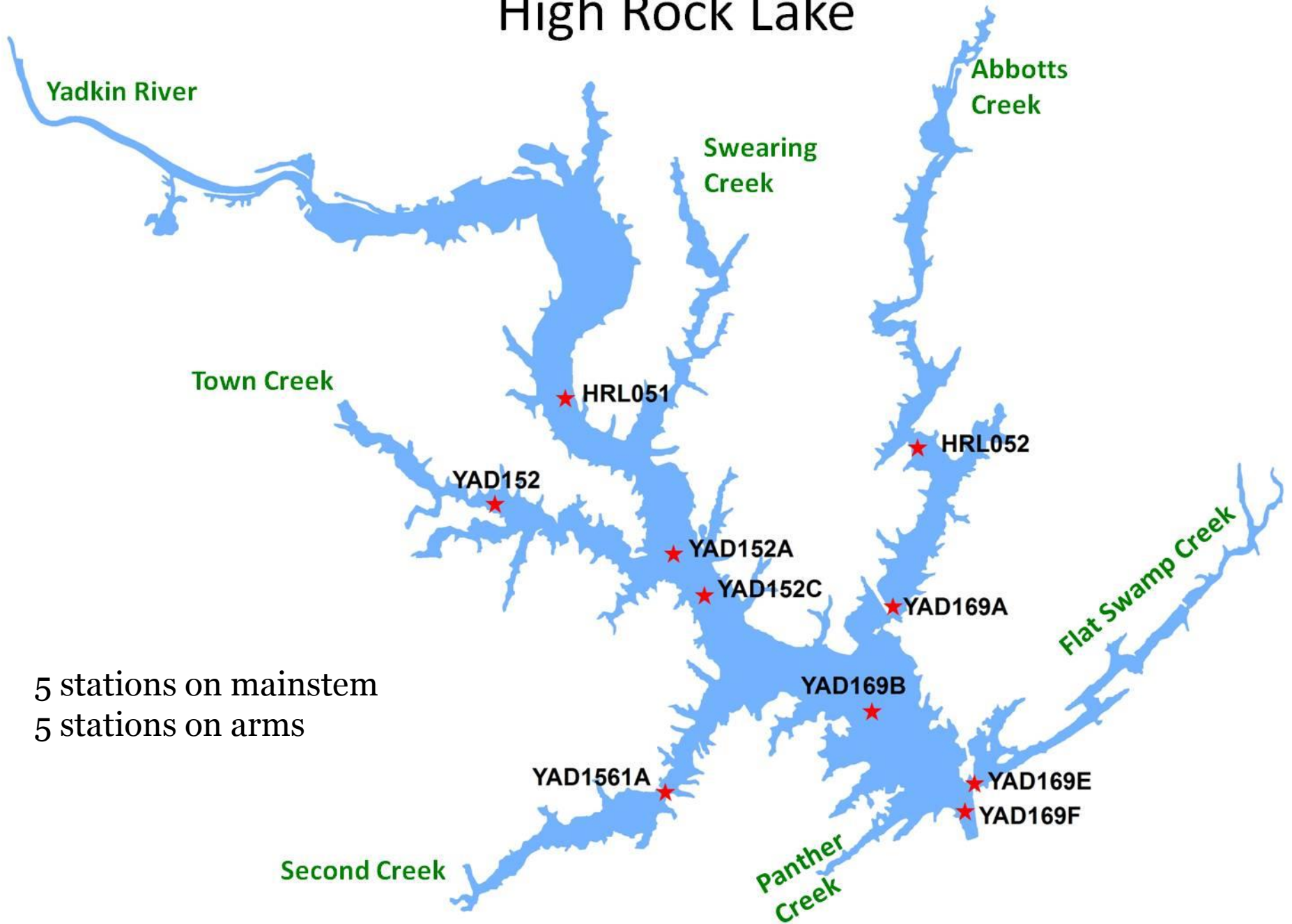
Intensive Monitoring

- 319-Funded Intensive Monitoring awarded to Yadkin Pee-Dee River Basin Association (YPDRBA) FY-2007
 - April 2008-March 2010
 - Many partners/cooperative effort
 - Included both lake and watershed
 - Included storm events
 - Database development

OVER 80,000 DATA POINTS!



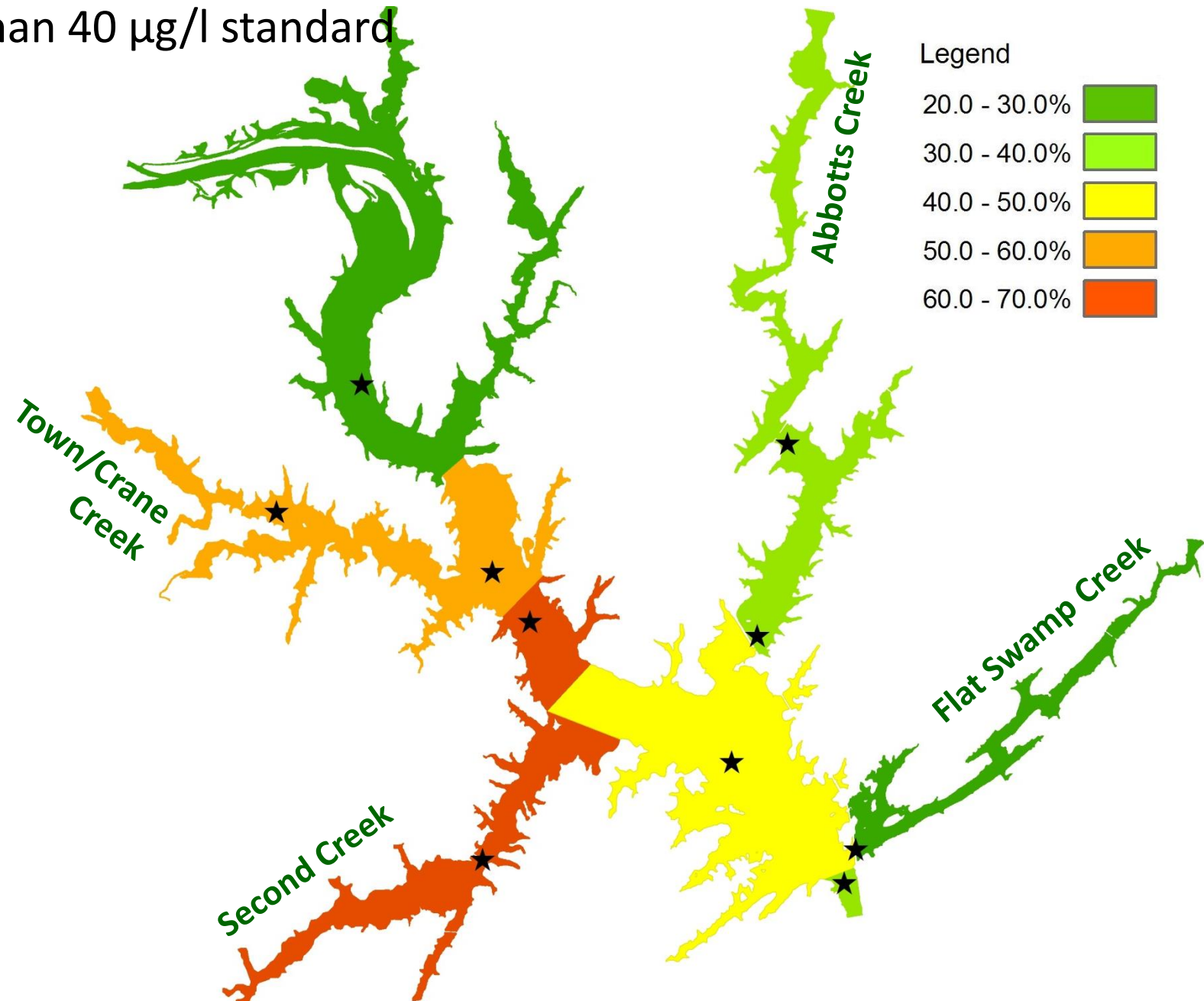
High Rock Lake



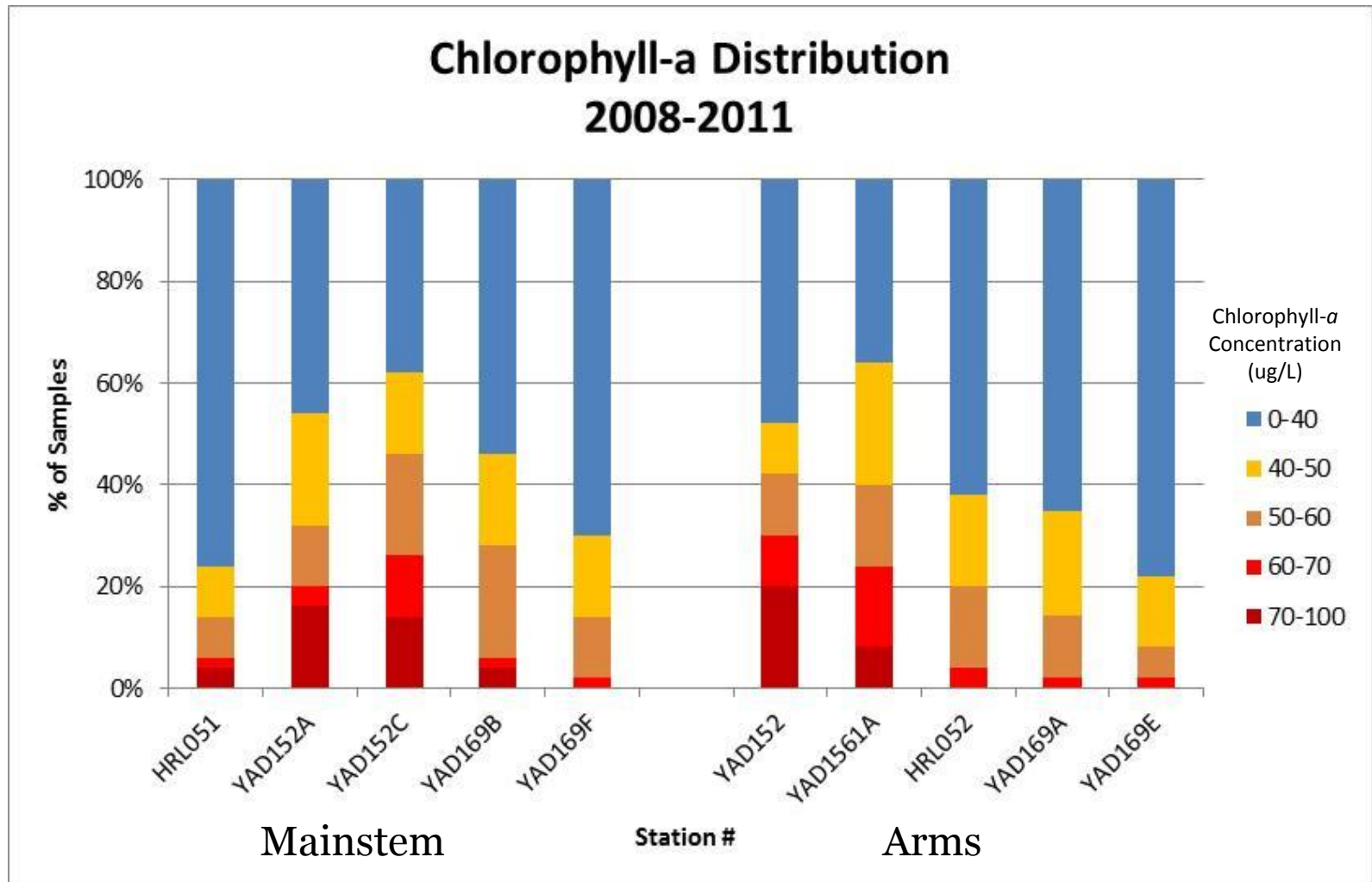
5 stations on mainstem
5 stations on arms

2014 303(d) Chlorophyll-a

% greater than 40 $\mu\text{g/l}$ standard
2008-2012

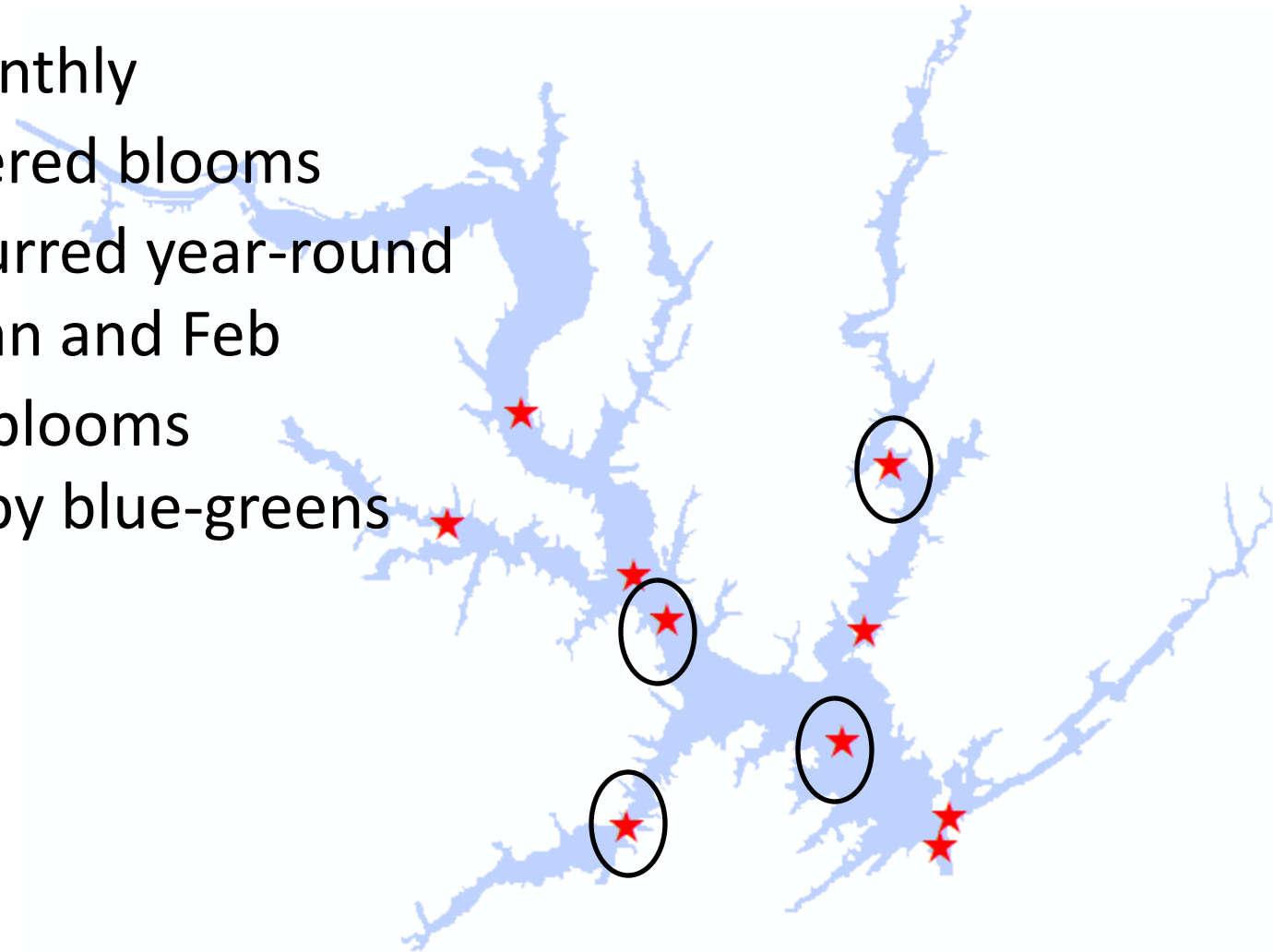


Distribution of Chlorophyll-*a* Data

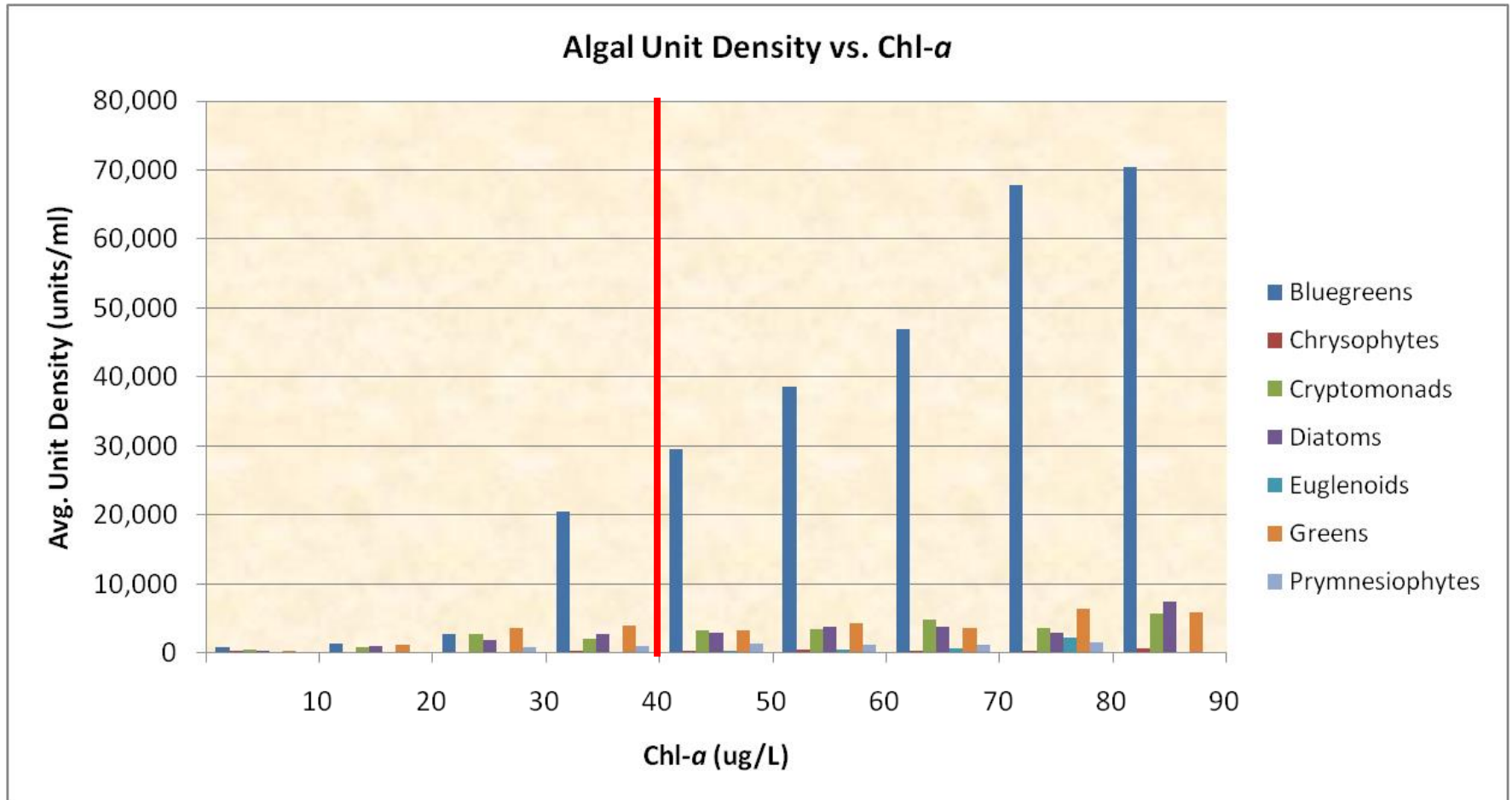


Results - Algal Assemblages

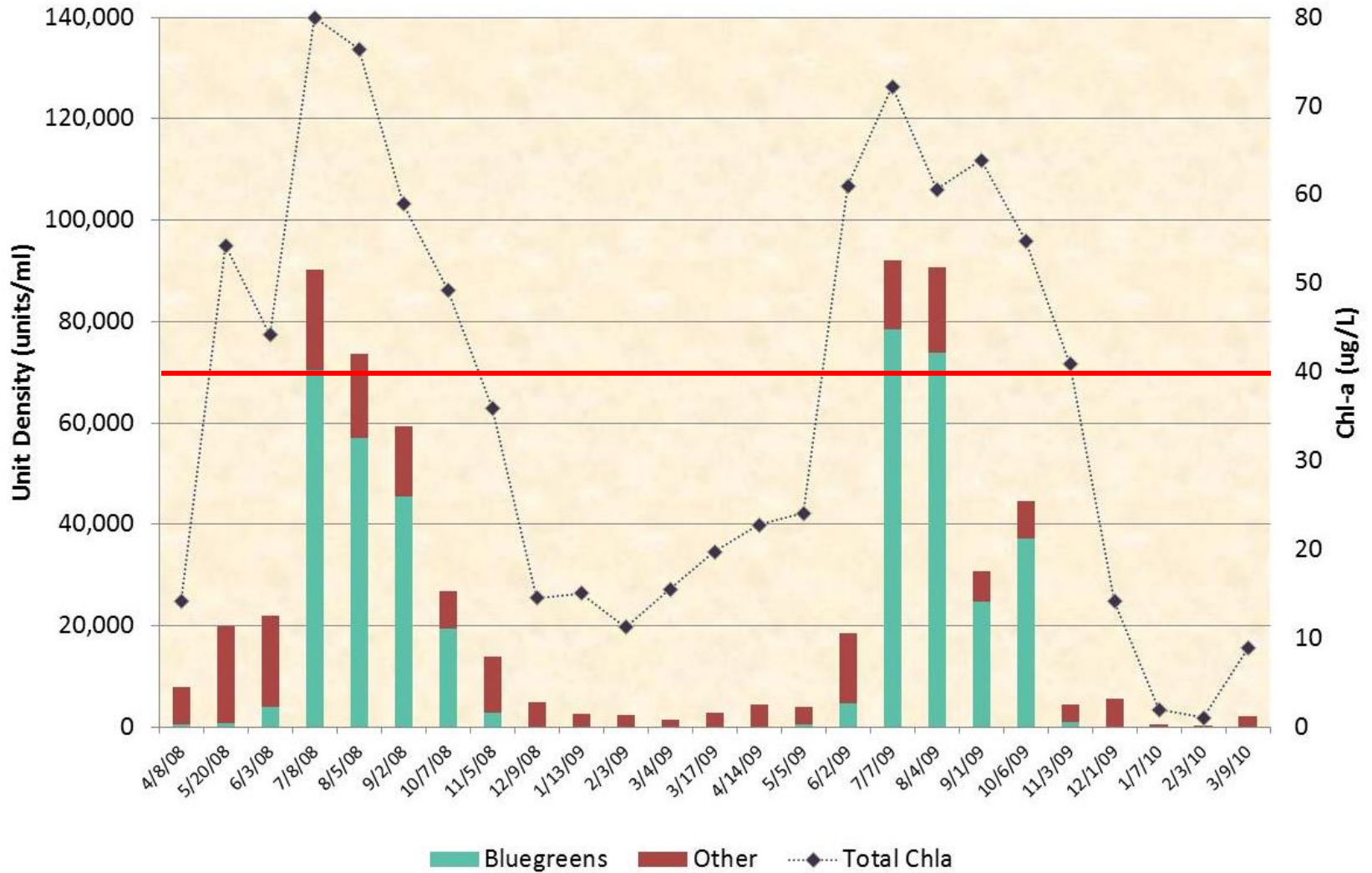
- 4 Sites – monthly
- 65% considered blooms
- Blooms occurred year-round except for Jan and Feb
- Majority of blooms dominated by blue-greens



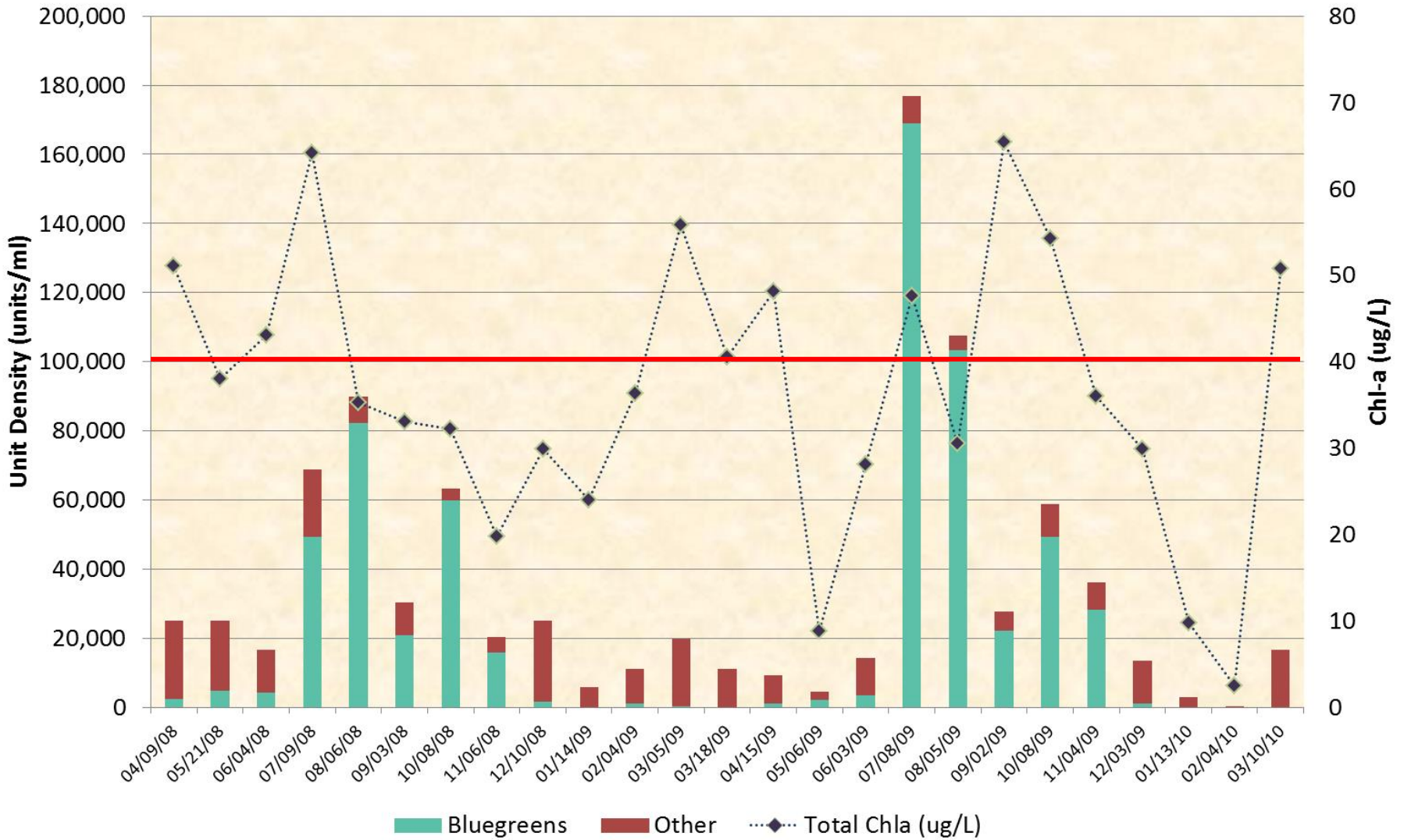
Algae / Chlorophyll-*a*



YAD152C Mainstem - Algal Unit Density



HRL052 Abbotts Creek - Algal Unit Density

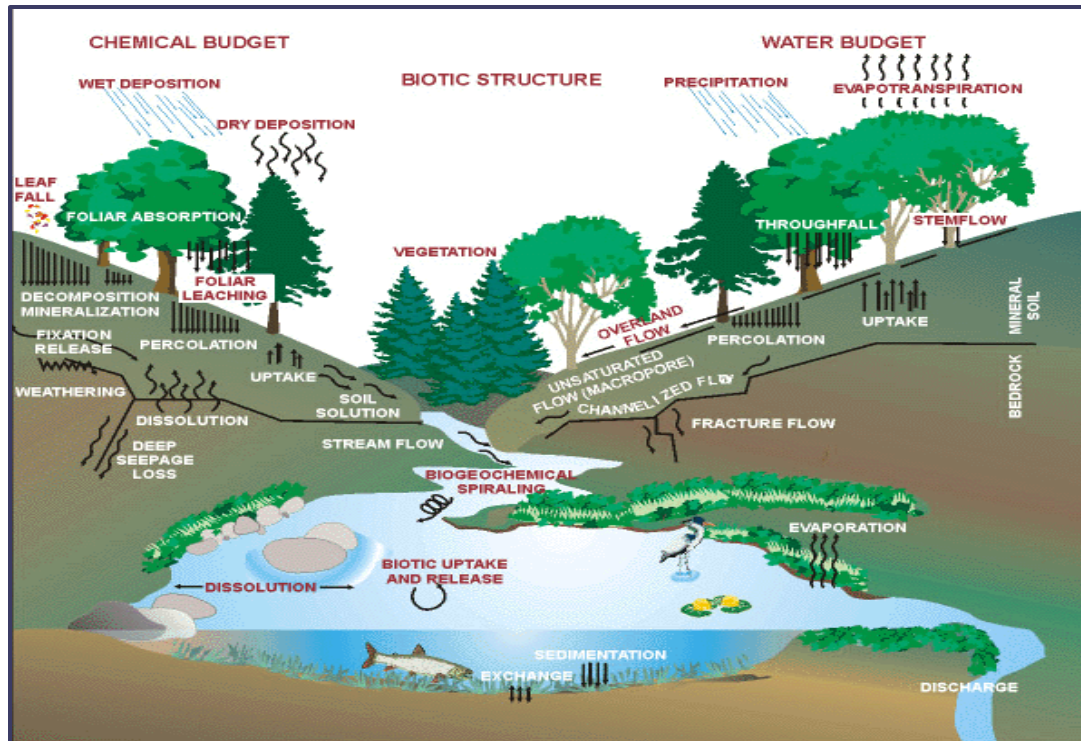


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Development of Models

- TetraTech under contract for both watershed and nutrient response model development
- Coordination with DWQ/EPA/TAC



Watershed Model 2000 - Mar 2010

- Estimates what is happening on land that results in nutrient export to receiving water (i.e. High Rock Lake)
- Provides relative loading by source (agriculture, developed, point sources, etc.)

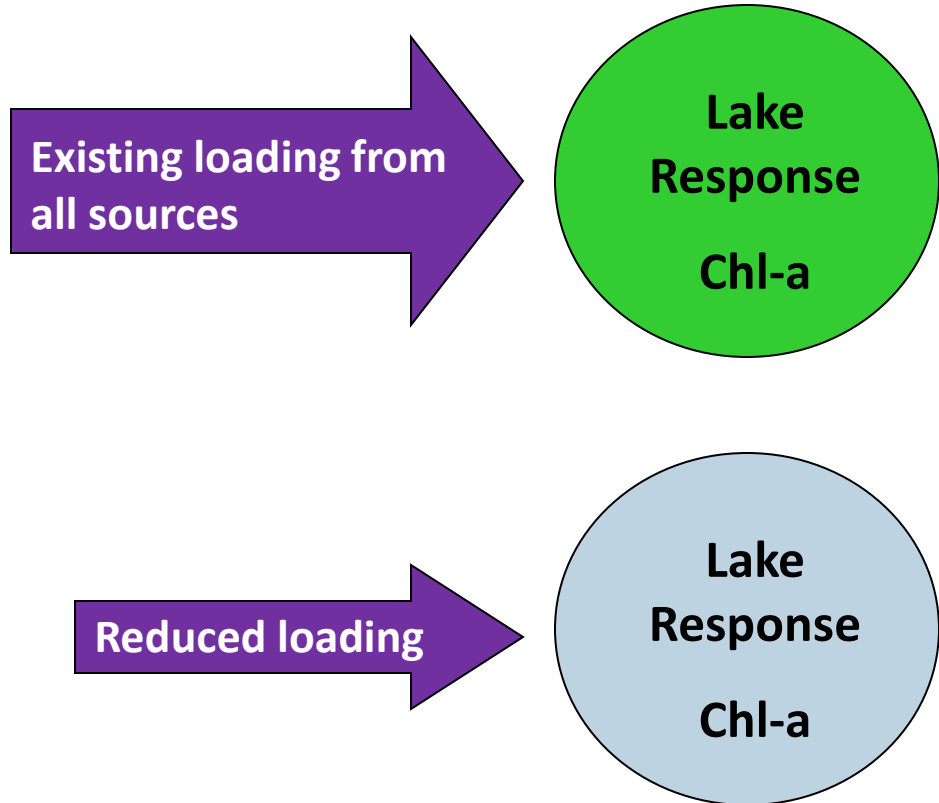


Nutrient Response Model

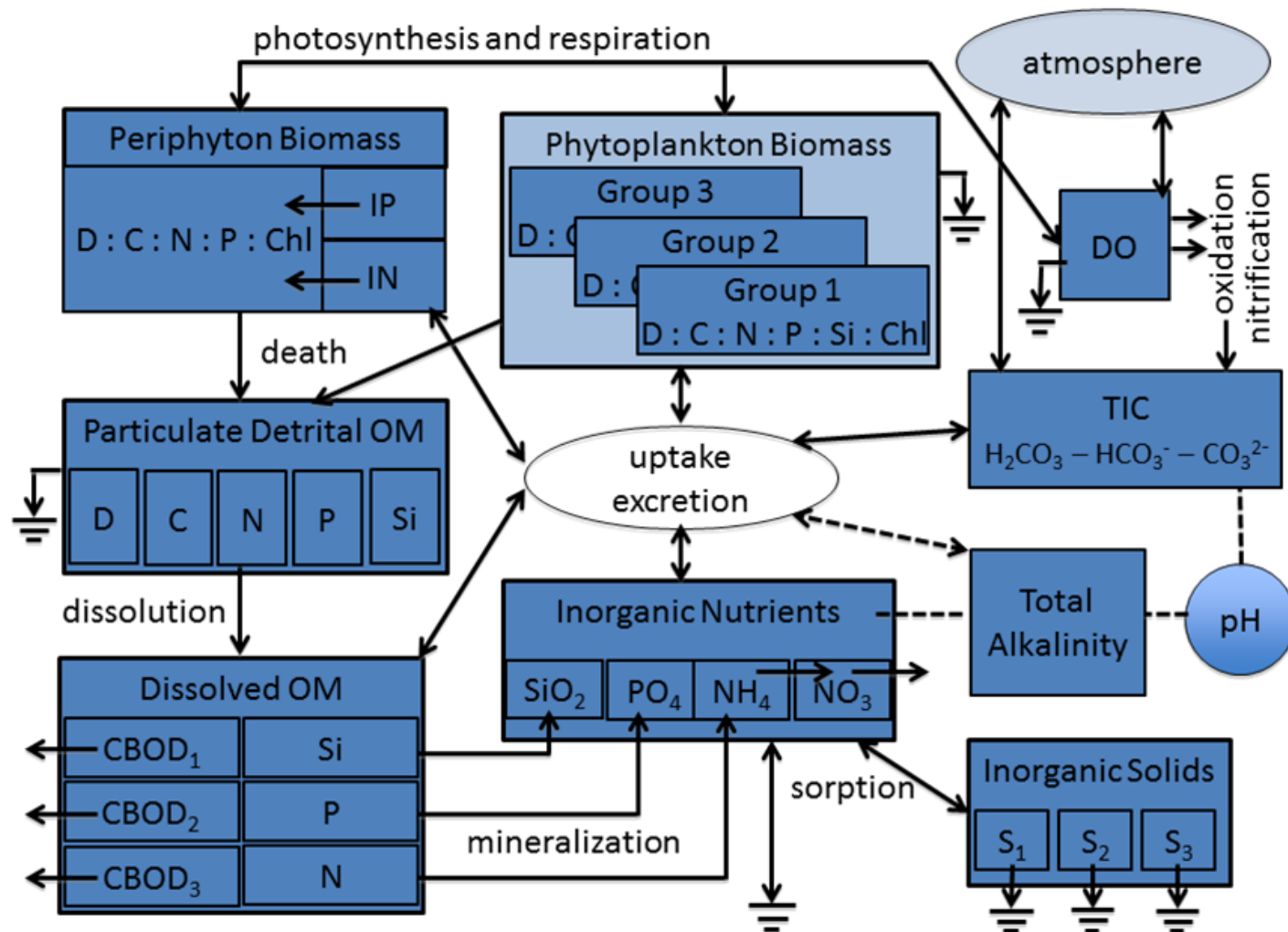
2005 - Mar 2010

Result of Model

Determines total nutrient (nitrogen and phosphorus) load reductions that will achieve water quality standards



Water Quality Analysis Simulation Program (WASP)

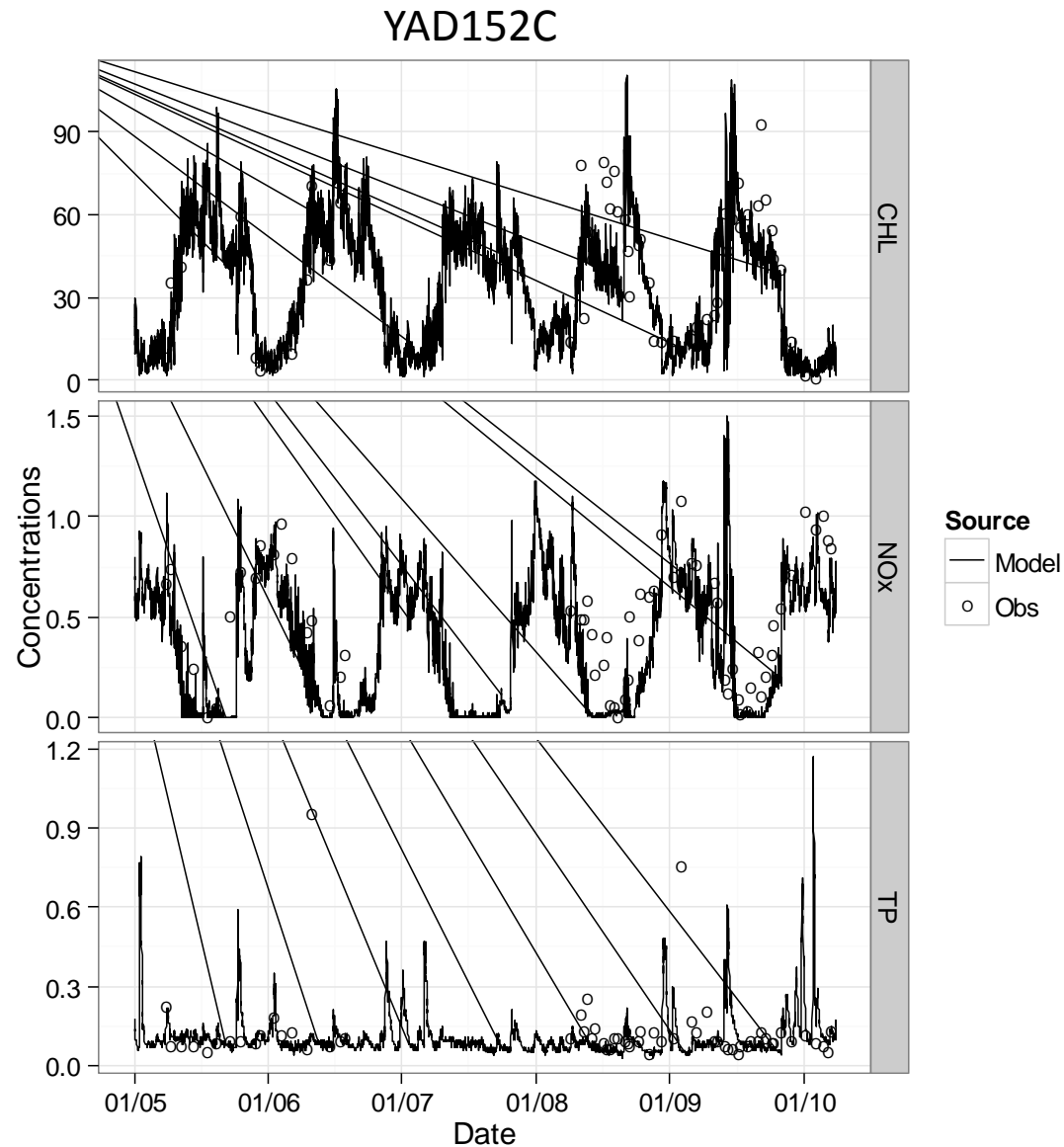


Model Status

- Calibration is complete: nutrients, chlorophyll-*a*
- TAC meeting – Apr 29
- Beginning to analyze model for purposes of target setting

Model Results

- Calibration Criteria
 - Visual
 - Statistical (e.g. relative error, coefficient of variation, correlation coefficient)



Limiting Nutrient

- Predicted by the model, supported by data
- Varies with time, space, impact of light

By location:

- Upper lake – more light limitation
- Middle lake – frequent co-limitation by nitrogen and phosphorus during growing season.
- Forebay - phosphorus is usually limiting, with some brief periods of nitrogen limitation

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Connection to NCDP

- HRL nutrient management strategy development started in 2005
- Models developed to address existing chlorophyll-*a* impairment
- NCDP developed in 2014



Connection to NCDP

- Will the resulting HRL nutrient management strategy be based on existing chl-*a* standard or some other target?



Summary

- Information available for SAC:
 - 2008-2010 intensive monitoring data
 - Historical monitoring data
- Tools available for SAC:
 - Lake nutrient response model
 - Watershed model

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WE WANT YOU!

HRL Questions

Is the current chlorophyll-*a* standard as applied (anywhere in the lake, 90/10 assessment) appropriate to maintain biological integrity? How to determine N/P?

In other words, does the standard of 40 ug/L provide for the ability of High Rock Lake to support and maintain a balanced and indigenous community of organisms?

e.g. Should blue-green algae NEVER dominate, or is it natural to expect blue-green dominance in summer months, and, if so, what is natural level of dominance/blooms? How much is too much?

Tasks for SAC

1. What concentration/frequency/duration of chlorophyll-*a* is right to protect aquatic life? How to express N&P?
2. Is chlorophyll-*a* standard enough as a response indicator? Are other response indicators appropriate?
3. Is resulting criteria translatable to other lakes?

Contact Information

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High Rock Lake Information:

<http://portal.ncdenr.org/web/wq/high-rock-lake>