NCDP Progress: An Update to the CIC

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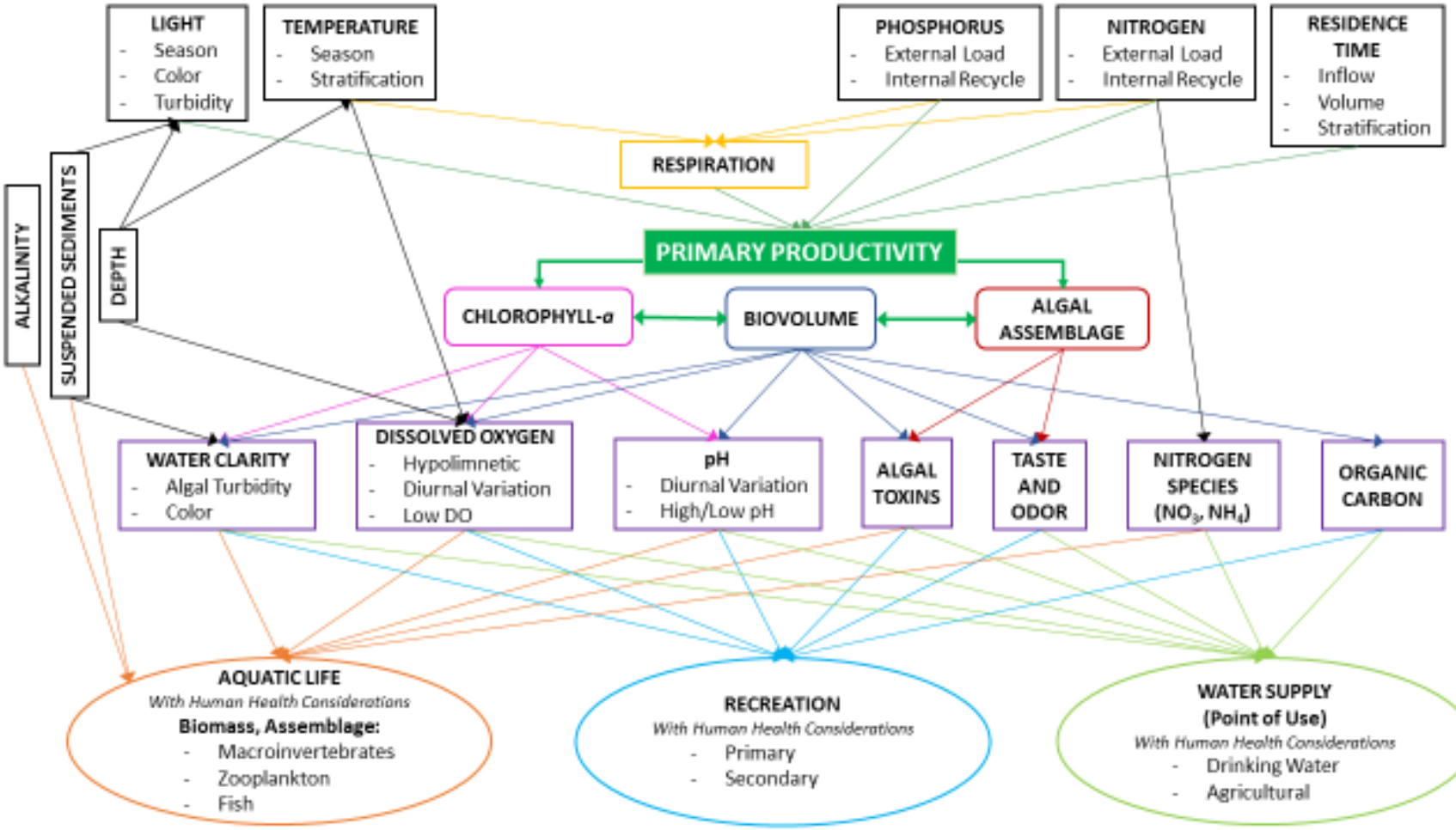
N.C. Division of Water Resources
17 April 2017

Department of Environmental Quality

SAC Meetings (12)

- May 6, 2015
  - Introductory materials
- July 21, 2015
  - Monitoring programs and trends, approaches to derive criteria
- August 18, 2015
  - N.C. Lakes Report, HRL data, modeling, and uses
- October 14, 2015
  - HRL criteria parameter evaluation, Albemarle Sound overview
- November 18, 2015
  - HRL fish data, HRL data correlations
- December 9, 2015
  - HRL drinking water use, HRL candidate indicator ranges, conceptual model development

Conceptual Model: High Rock Lake



Department of Environmental Quality

SAC Meetings (12)

- February 17, 2016
  - Narrowing indicators, conceptual model completion, HRL summer study plan
- April 20, 2016
  - HRL indicator ranges, HRL indicator viability, Cape Fear overview
- June 15, 2016
  - N & P criteria, review of criteria development approaches
- October 19, 2016
  - Alternatives to pass/fail N & P criteria, water treatment impacts from nutrients, assessment methods, SAC decision-making procedures
- January 25, 2017
  - HRL special study results, clarity and turbidity resolution, EPA cyanotoxin guidance
- March 22, 2017
  - DO resolution, pH discussion

Present Status: High Rock Lake

- Supporting research efforts nearing completion
- Tentative resolution regarding clarity, turbidity, TSS, and DO criteria
  - Clarity: potentially best addressed through chl. a, decline to adopt new criteria for now
  - Turbidity: existing criteria acceptable, weak linkage to nutrient inputs
  - TSS: weak linkage to nutrient inputs, no new criteria
  - DO: existing criteria acceptable
- Ongoing evaluation of pH criteria
- Upcoming evaluation of toxin, chlorophyll a, nitrogen and phosphorus criteria.

APNEP Nutrients Workgroup Meetings (9)

- August 5, 2014
  - Introductory materials
- October 21, 2014
  - Identify and promote research to inform Albemarle Sound criteria, establish boundary for criteria development
- April 23, 2015
  - Summary of remote sensing project, other project updates
- November 10, 2015
  - Project updates, planning for Albemarle Sound criteria review
- January 27, 2016
  - Evaluate estuarine nutrient criteria case studies

APNEP Nutrients Workgroup Meetings (9)

- March 23, 2016
  - Classification and analysis of Albemarle Sound segments, assessment and monitoring methods, prioritization of response parameters.
- May 25, 2016
  - Albemarle Sound ecology and water quality (including SAV, algae and fisheries)
- July 20, 2016
  - Evaluation of criteria and research proposals for pH, DO, clarity, TSS, and turbidity
- September 21, 2016
  - Evaluation of criteria and research proposals for toxins, chl. a, nitrogen and phosphorus

Present Status: Albemarle Sound

- Phase I completed as identified in NCDP
  - Each potential criteria parameter was discussed and evaluated
  - Additional research needs identified during evaluation process
- Additional research underway
  - Priority areas of investigation include bioassays, investigation of light attenuation models, others.
- Report on Phase I findings to be developed
- Phase II reevaluation of Albemarle Sound criteria to be conducted by SAC/CIC

Present Status: Other Areas

- Central Cape Fear
  - DWR special monitoring study planned for 2018
  - Periphyton monitoring project underway
  - Applied university research underway
- Statewide Lakes, Rivers and Estuaries
  - TBD

QUESTIONS?

Department of Environmental Quality

Role of the CIC in the NCDP: A Review

April 17, 2017

Talking Points

- **Review Previous Meeting Highlights**
- **Review Purpose and Duties of the CIC**
- **NCDP Flowchart**
- **Criteria Considerations and Advisory Examples**
- **Open Discussion**

Previous CIC Meetings

- **August 5, 2015**
  - Ground rules and charter approved
  - NCDP and SAC and CIC interaction described
  - HRL background and existing data presented
  - Priorities of the CIC identified
- **September 25, 2015**
  - Update on SAC provided
  - Two case studies (VA and FL) on development of nutrient criteria presented
  - NC's nutrient criteria implementation process described

CIC Purpose

From the CIC Charter approved 8/5/2015:

"The purpose of the NCDP CIC will be to provide advice and recommendations to the DWR, on the feasibility, application, implementation and potential implications of nutrient criteria recommended by the SAC."

CIC Duties

Also from the CIC Charter:

1. Advise DWR on the social and economic implications of implementing proposed nutrient criteria, also the relative impacts of alternative criteria and nutrient management strategies.
2. Assist DWR with fiscal note preparation.
3. Other duties as identified by the members of the CIC and the DWR.

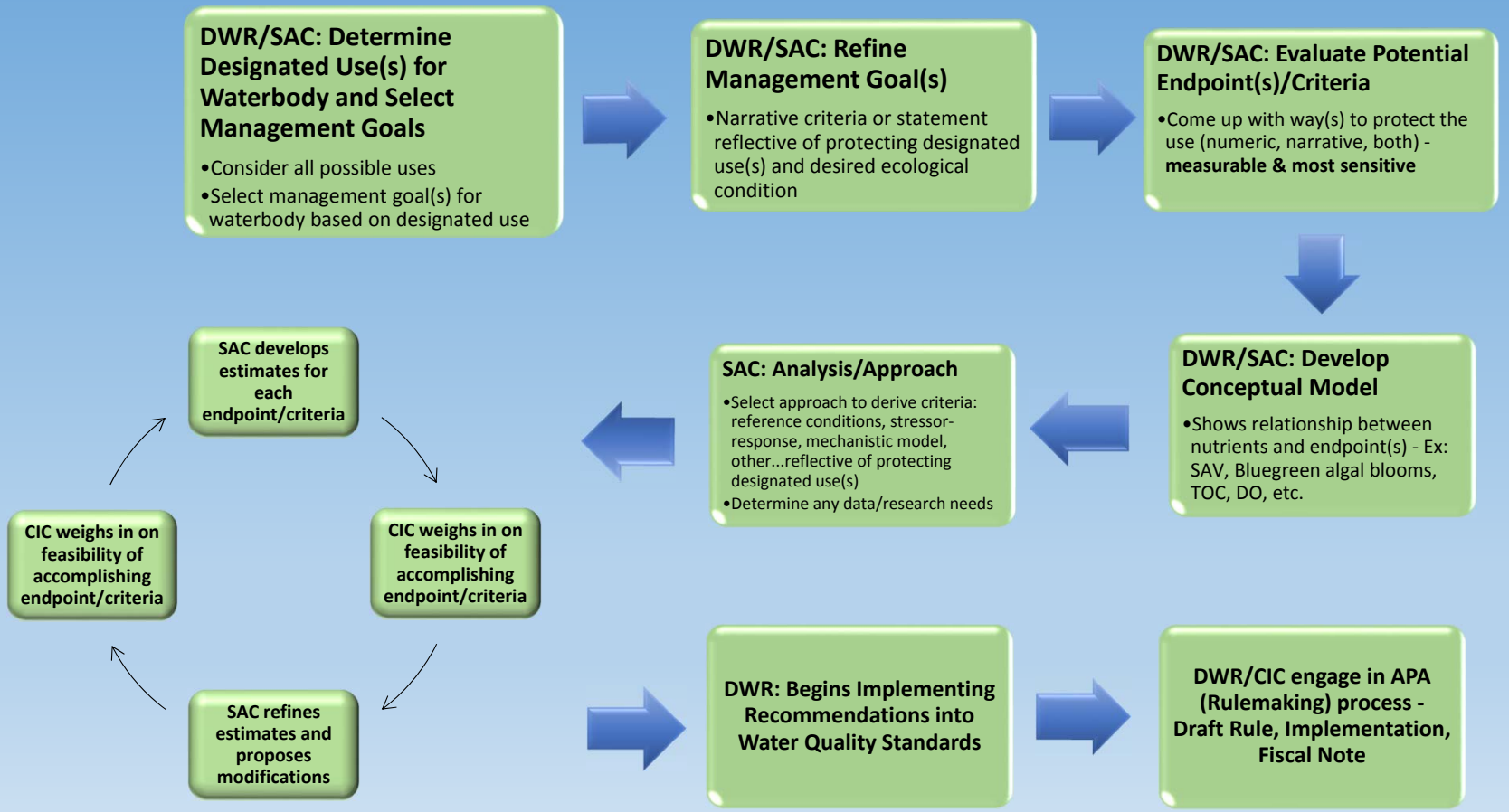
CIC Ground Rules

1. Begin and end on time.
2. Stick to the agenda – keep with task and topic.
3. For maximum efficiency, apply good communication practices: Listen attentively. Speak up in order to be heard by the Committee, audience and webinar attendees. Limit sidebar conversations at the Committee table and within the audience.
4. It's OK to disagree. Be respectful of others and their ideas.
5. Everyone participates, no one dominates.
6. Look for mutually beneficial solutions.
7. Follow through on commitments.

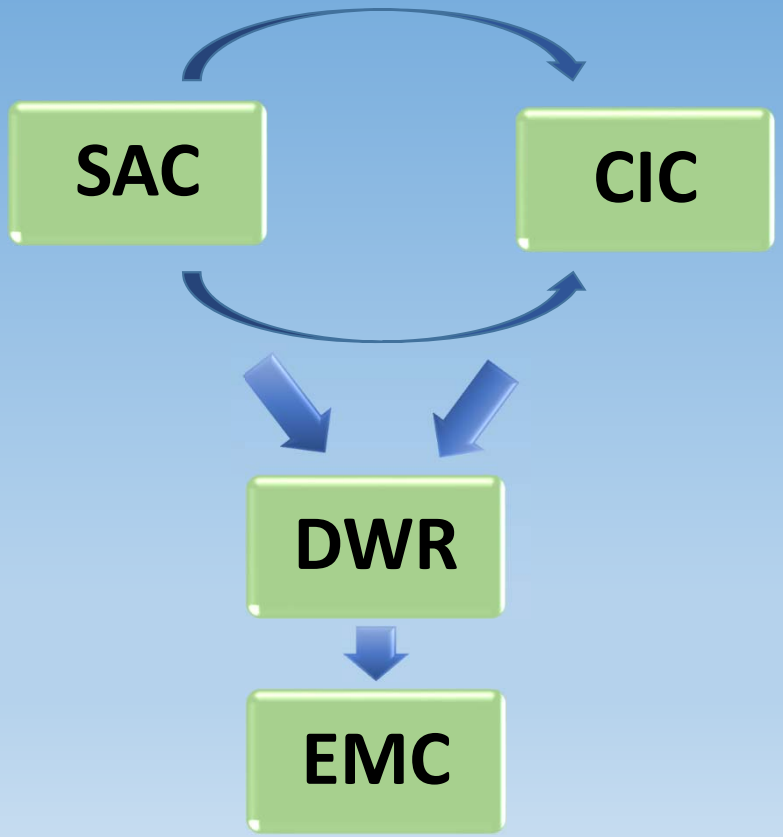
CIC Ground Rules cont'd

8. Make an effort to attend all meetings in person. Remote participation via conference call or web-based interface is acceptable. It is also acceptable for a CIC member to designate an alternate who meets similar area(s) of expertise and can participate if the member is unable to attend. If participation by an alternate becomes necessary, the CIC member will inform the Project Manager, Steve Kroeger, in advance and provide the alternate's qualifications. Alternates are encouraged to begin attending CIC meetings prior to acting in a member's stead in order to become familiar with the Committee's discussions and direction.
9. DWR NCDP staff will serve as regular participants in the CIC's discussions and will keep meeting minutes. Meeting notes will be circulated to the CIC for comments prior to posting on the NCDP website.
10. CIC meetings will be open to the public and be available via WebEx. In-person and virtual attendees will not be permitted to participate in the CIC's discussions. Questions or comments directed toward the CIC will be submitted electronically to the DWR; the pertinent ones will be raised by DWR to the CIC at appropriate times. The CIC may invite guests to provide a perspective or answer questions, and speakers with expertise on relevant topics will be invited to present at CIC meetings. Ground Rules can be added or modified at any time by the CIC.

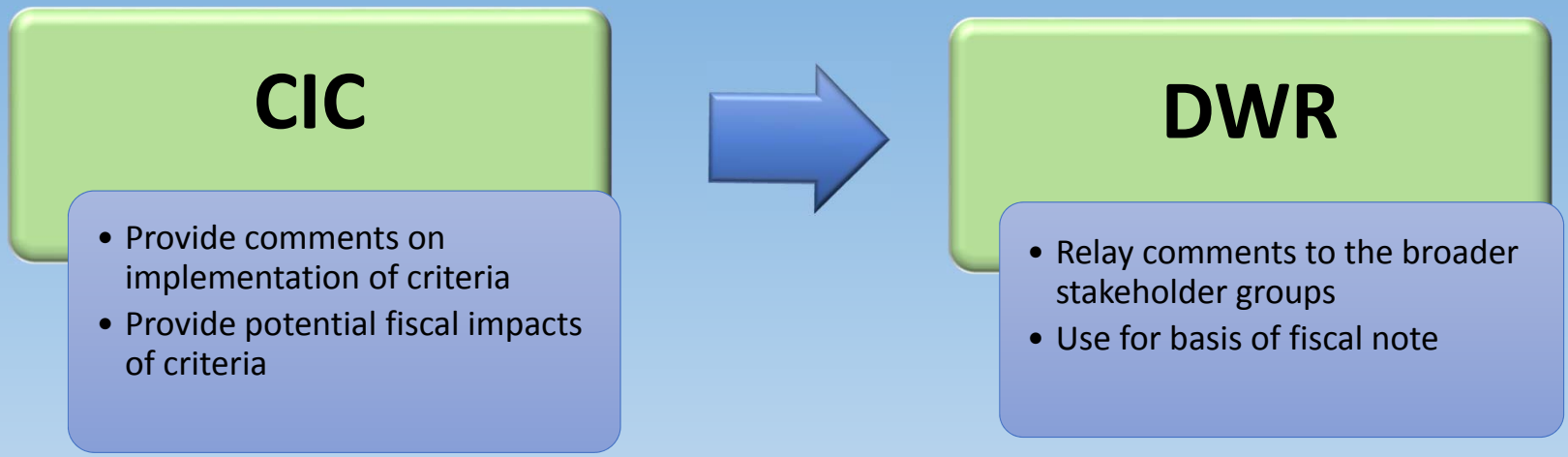
NCDP Flowchart



Interaction of SAC/CIC with DWR and EMC



CIC Deliverables



Criteria Considerations

Implementation

- Are criteria clearly written?
- Can the criteria be applied statewide with little to no modification?

Assessment

- Can water quality be measured easily and accurately for assessment purposes?
- Is the assessment method defensible?

Criteria Consideration cont'd

Costs/Benefits

- Are benefits of criteria clear and defensible?
- Are the potential costs reasonable for the benefits?

Implementation of Mgmt. Strategy

- Are the triggers for implementing a management strategy clear and unambiguous?
- Can a strategy be developed to achieve the criteria?

Example Comments

SAC presents two draft criteria:

1. Not to exceed: TN – 1.0 mg/L and TP – 0.5 mg/L, or
2. No numeric TN/TP criteria, but monthly geometric mean of Chl *a* – 35 µg/L

Helpful comments for the SAC:

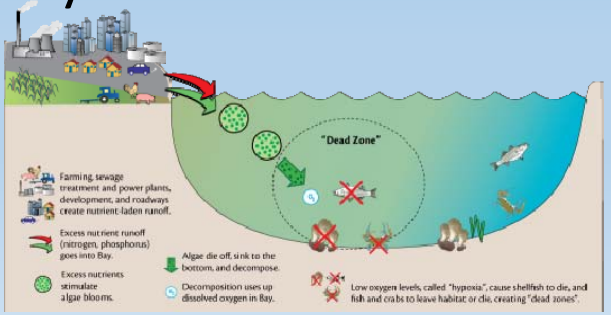
1. The proposed TN and TP criteria would present extremely high financial costs to point source dischargers in the watershed.
2. Most water bodies are monitored only once per month. Therefore, an evaluation of whether the water body is meeting the standard, in application, becomes a “not to exceed” standard, not be a geometric mean.

Example Comments cont'd

Comments that are not helpful for the SAC:

- "The proposed criteria are too stringent. A 'not to exceed' criteria of TN – 8 mg/L and TP – 1.0 mg/L is protective of uses and less burdensome on stakeholders."
- "Numeric criteria for TN and TP are not an appropriate standard to use in evaluating water quality."
- "The averaging period should be annual not quarterly."

$$\left(\prod_{i=1}^{n} a_i\right)^{1/n} = \sqrt[n]{a_1 a_2 a_3 \dots a_n}$$



Communication Process with SAC

- **Updates to CIC as SAC finalizes criteria**
- **Meeting schedule**
  - Every other month
  - As information becomes available
- **Provide comments back to SAC once the draft criteria are fully developed**
- **Comment format**

Questions?

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Stakeholder Analysis to Support Development of a High Rock Lake Nutrient Management Strategy

Nutrient Criteria Development Plan

Criteria Implementation Committee

April 17, 2017

ch2m:

Abbotts Creek, a section of High Rock Lake near Lexington, North Carolina. Source: Photo by Panda Brown. (Wife of en:User:Pharmboy)

Agenda

- Background on nutrient management issues in NC and High Rock Lake
- Why active stakeholder engagement?
- Development of a cost-estimation tool for point source nutrient removal
- Current status of nutrient criteria for High Rock Lake
- Water quality model review and revisions
- Updated point source loading estimates
- Initial sensitivity analysis of point source nutrient controls
- Next steps in development of a nutrient management strategy

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High Rock Lake Nutrient Issues



- **1970s - High Rock Lake identified as one of most eutrophic lakes in North Carolina**
- **1980s – Additional monitoring and evaluation**
  - State focused on coastal areas (Chowan River), newly impounded Falls and Jordan Lakes, and water supply protection
- **1990s – Early High Rock Lake actions**
  - 1996 Nutrient controls implemented in Abbotts Creek arm of HRL
  - 1998 Initiation of coalition monitoring through the Yadkin Pee Dee River Basin Association (YPDRBA)
- **2000s – Move to management action**
  - 2001 Creation of Yadkin-Pee Dee River Basin Association
  - 2004 Listing of High Rock Lake as impaired on 303(d) list
  - 2005 Creation of technical advisory committee (TAC)
  - 2008 – 2010 Intensive monitoring of HRL
  - 2009 to present – Development of watershed delivery models and lake nutrient response model
  - 2016 – Lake nutrient response model completed and more intensive monitoring data collected

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2014 NCDP Highlights

- **Creates Science Advisory Committee**
  - State later added a Criteria Implementation Committee
- **Designates three areas for Nutrient Criteria Development**
  - Piedmont Reservoir watershed
    - High Rock Lake
    - Planned adoption of numerical nutrient criteria (NNC) completion in July 2018
  - Estuaries
    - Albemarle Sound
    - Planned adoption of NNC by December 2020
  - Rivers/Streams
    - Central Portion of Cape Fear River Basin
    - Planned adoption of NNC by December 2021
- **Statewide Criteria**
  - Estuaries – 2023
  - Lakes – 2024
  - Rivers/streams – 2025

Key Reasons for Stakeholder Initiated Process

- Dischargers – make sure we have common goals/objectives for effort
- Opportunity to bring in other HRL stakeholders
- Get in front of DWR regarding alternatives and strategies – provide meaningful input to the process
- Develop preliminary cost information that can be considered early rather than at the end of the process
- Make sure uncertainty is considered in strategy considerations

Mission Statement

- **Created by High Rock Lake Dischargers (as a committee within the YPDRBA)**

Through active participation in the High Rock Lake Nutrient Criteria Development, we will work collectively to engage with DEQ and other stakeholders such that it results in comprehensive, cost-effective, flexible, and adaptive process and requirements.

Charter Document

- **Compiled input into Charter Document includes:**
  - Mission
  - Members
  - Deliverables & Schedule
  - Critical Success Factors
  - Benefits
- **Stakeholder signatures**
  - Some obtained council endorsement

High Rock Lake Nutrient Management Planning Process

High Rock Lake Watershed Point Source Dischargers Project Charter

Mission

Through active participation in the High Rock Lake Nutrient Criteria Development Process, we will work collectively to engage with DENR and other stakeholders such that it results in comprehensive, cost-effective, flexible, and adaptive processes and requirements.

Key Participant Groups**

- Public Utility Dischargers in the High Rock Lake Watershed
- Industrial Dischargers in the High Rock Lake Watershed
- Yadkin-Pee Dee River Basin Association
- CH2M HILL

** Representation from each group is identified on next page.

Deliverables and Schedule

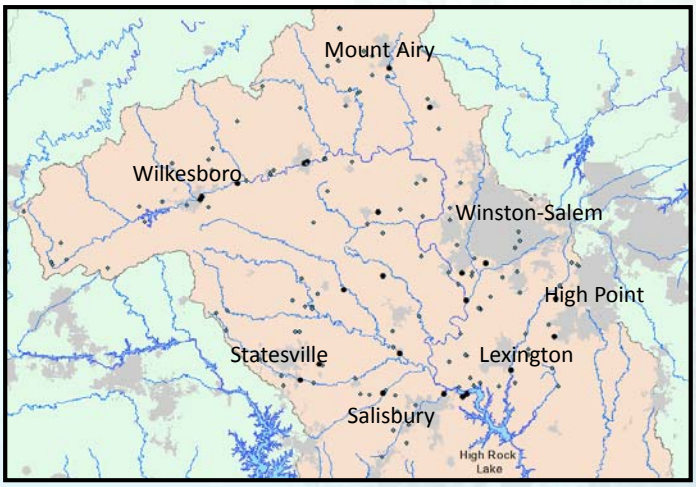
- Team Charter — October 24, 2014
- Team and Stakeholder Meetings — Eight meetings through May 30, 2015
- Screening Tool for Nutrient Removal Costs — December 30, 2014
  - Technical Memorandum summarizing approach and results
- Technical Reviews — January 30, 2015
  - Review summary of monitoring data review
  - Review summary of model documentation
  - Development of scopes for necessary technical review
- Definition of Critical Uncertainties and Alternatives — March 30, 2015
  - Technical Memorandum documenting uncertainties, conversion of reductions/responses into probabilities and development of alternatives
- Preliminary Nutrient Management Strategy (5th Meeting – May 2015) — May 31, 2015
  - Technical Memorandum presenting a preliminary portfolio of nutrient management strategies and associated numerical nutrient criteria
- Updated Workplan — June 30, 2015

Critical Success Factors

Critical Success Factors	Specific Objectives	
Stakeholder group functionality	Collective engagement of all members	Group speaks as one voice
Establish credibility with NCDENR and other stakeholders	Timely dissemination of information and engagement with NCDENR	Competent advisory representation with the member association
Focus on science-based recommendations	Understanding of non-discharge nutrient loads	Accurate assessments of known an unknown sources of nutrients and general uncertainty in modeling
Fairness	Among all stakeholders including non-dischargers	In NCDENR's willingness to listen to stakeholders
Cost-effectiveness	Ability to work with NCDENR to bring about reasonable, achievable regulations	Balance and limit costs with considerations for community benefits

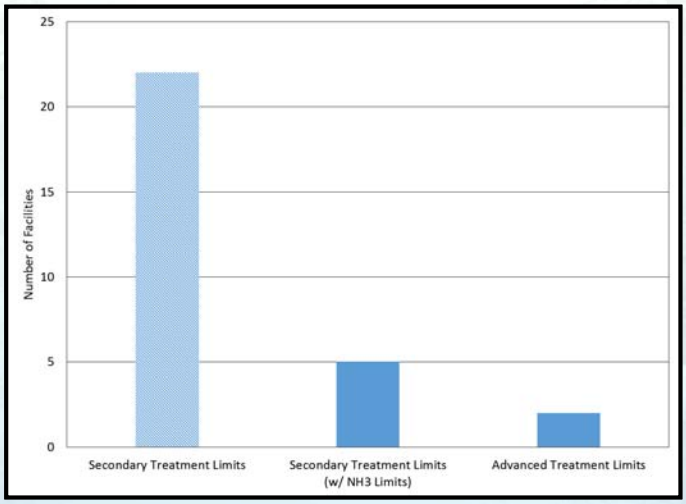
Facility Overview

- More than 150 NDPES permits holders in the HRL watershed
- Total of 29 facilities comprise 99% of the total permitted wastewater flow in the HRL basin
  - 19 Major NPDES Permits
    - >1 mgd
  - 10 Minor NDPES Permits
    - <1 mgd but >100,000 gpd



NDPES Permits

- Top 29 facilities – Permit Basis



Data Source: High Rock Lake Watershed Model Report (2012)
Data Period: 2009 - 2010

Point Source Scenarios Evaluated

- **Phosphorus Control**
  - Effluent levels based on 1, 0.5 and 0.1 mg/L
  - Assume these will be implemented as annual average loads
- **Nitrogen Control**
  - Effluent levels based on 8, 5 and 3 mg/L
  - Assume these will be implemented as annual average loads
- **Level of Current Treatment Adjustments**
  - Many facilities required upgrades to implement/improve nitrification to implement total nitrogen removal

Sources of Cost-Screening Information

- **2008 EPA Technical Report**
  - Municipal Nutrient Removal Reference Document
  - Reviews Technologies and costs
  - Developed costs (Capital, O&M, and NPW) for 1, 5, and 10 mgd facilities
- **2013 Ohio EPA Technical Report**
  - Cost of Phosphorus Removal
  - Builds upon 2008 EPA document for Phosphorus Only
- **2002 Chesapeake Bay Watershed Report**
  - Cost Estimates for Point-Source Nutrient Reduction
  - Developed cost curves for P and N removal (separately) at 0.1, 1, 10, and 30 mgd facilities
- **2003 Illinois Association of Clean Water Agencies Feasibility Report**
  - Costs to meet Nutrient Standards
  - Too site specific. Only provided costs for a representative 10 mgd facility and then extrapolated to all 814 facilities.

2002 Chesapeake Bay Watershed

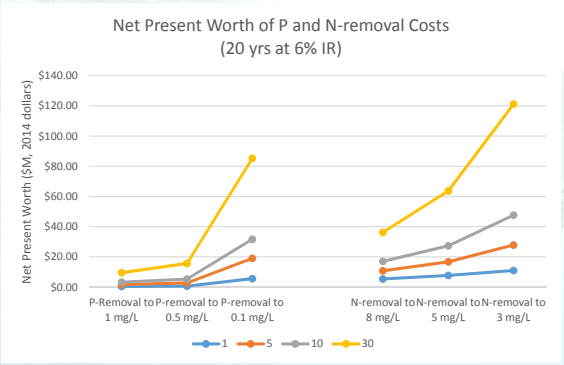
- **2002 Chesapeake Bay Report**
  - Goal – "provide cost estimates for treatment technologies associated with varying concentration levels of nitrogen and phosphorus removal…"
  - Included theoretical cost review for nutrient removal retrofit for 0.1, 1.0, and 10 mgd facility
    - P removal to 1.0, 0.5 and 0.1 mg/L (Chemical only. No filters, membranes to 0.1 mg/L)
    - N-removal to 8, 5, 3 mg/L
    - Included sludge disposal costs.
    - Realistic chemical (alum) dosages (1.5 to 2:1 molar ratio → 14.4 to 19.2 mg/L)
    - P-removal to 1.0 mg/L and N-removal to 8 mg/L based on curves developed from existing facility costs
    - Costs for higher levels of treatment based on assumed upgrades/retrofits
    - Assumes all facilities are already nitrifying
  - Overall…appears to be the best reference as it includes a range of P and N removal costs that can be updated to 2014 and beyond

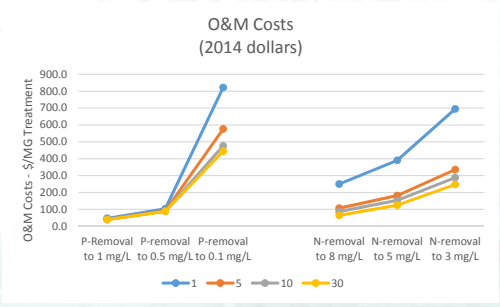
Approach Overview

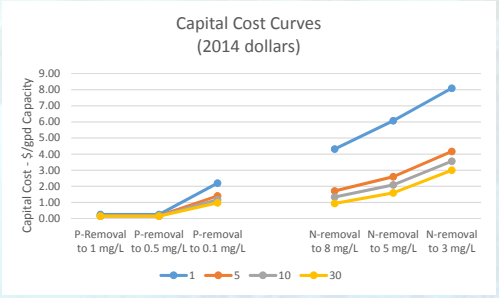
- **Used selected information to develop cost curves**
  - Goal was to develop $/gpd of design capacity for given levels of P and N control
  - Curves are meant as planning level estimates for a broad range of facilities
- **Compared selected curves versus engineering study estimates**
  - Mt. Airy
  - Winston-Salem (Muddy Creek and Archie-Elledge WWTPs)
  - Salisbury-Rowan Utilities Study
  - Include Additional Costs
  - Secondary plants require additional, estimated nitrification costs since N removal requires complete nitrification
  - Secondary treatment with current NH_3-N limits requires enhanced nitrification

Approach Overview

- **Developed Cost Curves**







Approach Overview

- **Used 2002 Chesapeake Bay Nutrient Removal Report**
  - Updated costs using ENR-CCI from July 2000 (6,225) to October 2016 (10,435)
  - P Removal – Chemical for 1 mg/L, with disc filters for 0.5 mg/L and membranes for 0.1 mg/L
  - N Removal – assumes facilities are already nitrifying

	CAPITAL - $/MGD of permitted capacity				O&M- $/MGD of permitted capacity			
No removal to…	1 MGD	5 MGD	10 MGD	30 MGD	1 MGD	5 MGD	10 MGD	30 MGD
1 mg/L TP	$268,000	$74,000	$49,700	$33,500	$50	$43	$42	$42
0.5 mg/L TP	$894,000	$394,400	$315,800	$228,000	$113	$97	$95	$94
0.1 mg/L TP	$2,330,000	$1,485,800	$1,238,400	$1,041,400	$869	$609	$503	$469
8 mg/L TN	$4,563,000	$1,809,000	$1,419,500	$992,700	$264	$113	$92	$68
5 mg/L TN	$6,426,000	$2,746,000	$2,211,600	$1,688,000	$413	$192	$162	$133
3 mg/L TN	$8,561,000	$4,408,600	$3,769,100	$3,175,500	$734	$355	$304	$262

Science Advisory Council Progress

- **Started in May 2015, ~10 meetings to date**
- **Progress so far regarding HRL**
  - **Discussion of whether HRL uses are impaired – despite values exceeding current chlorophyll *a* and pH standards**
  - Identified 8 parameters for consideration – narrowed to five
  - Focusing on several parameters for developing a criteria range to protect uses
    - Chlorophyll *a*
    - pH
    - Dissolved oxygen
    - Water clarity/turbidity
    - Algal toxins
  - Criteria ranges discussed
  - Supplemental monitoring for summer of 2016 identified as a need, was completed

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SAC Discussion: Are uses of HRL Impacted (January 2017)

- **DWR used the term "impacted" rather than "impaired" because of regulatory implications**
- **Considerable discussion**
  - No clear evidence uses aren't supported
  - Concern about significant eutrophic conditions – what might happen in future
- **Suggestion to use matrix approach**
  - Parameter by parameter
  - Comparing scientific literature versus use information

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SAC Schedule for HRL

- **January Meeting**
  - Overview of 2016 data collection
  - Decided not to recommend a water clarity criterion or change the turbidity standard – to revisit after chlorophyll a discussion in May
- **March Meeting**
  - Discussion SAC observations on 2016 HRL data
  - Review of completed algal toxin analysis – *postponed to May agenda*
  - Discussion of criteria for DO and pH
- **May Meeting**
  - Discussion of criteria for chlorophyll *a* and algal toxins
- **July Meeting**
  - Revisit need for causal criteria for N and P
  - Complete SAC criteria recommendations for HRL

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Two approaches discussed by SAC in 2016 for HRL chlorophyll *a* criteria

- Approach #1: Set a seasonal geometric mean value to balance fishery and other uses
  - Likely in 25 – 40 µg/L range

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Two approaches discussed for HRL chlorophyll *a* criteria (cont.)

- Approach #2: Set targets based on observed conditions
  - Based on conclusion that reservoir is currently meeting all uses
    - Fishery excellent
    - No reports of aesthetic problems
    - Algal toxins low…based on limited data

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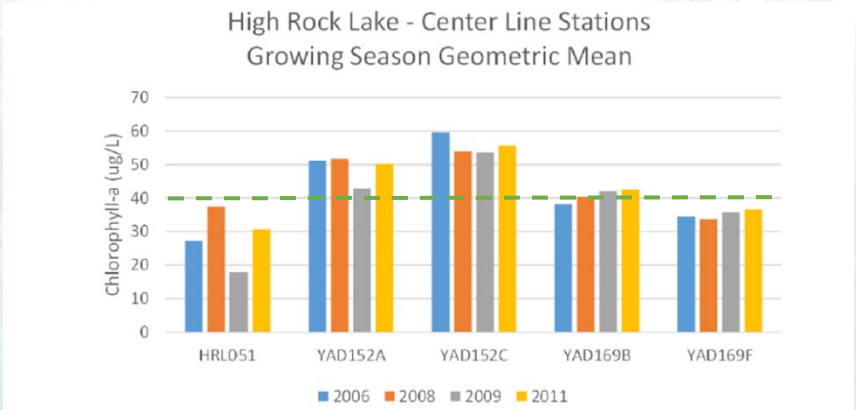
Recent historical HRL chlorophyll *a* as seasonal averages



Source: Bill Hall, 2016

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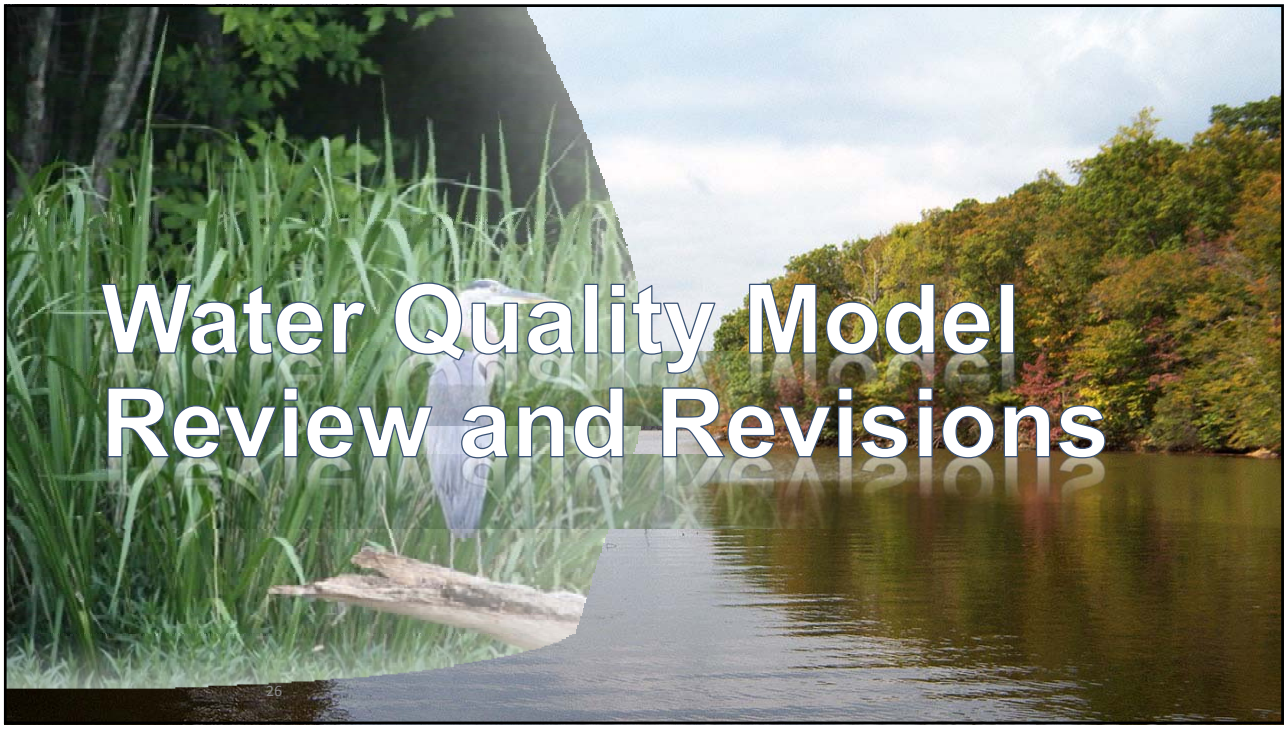

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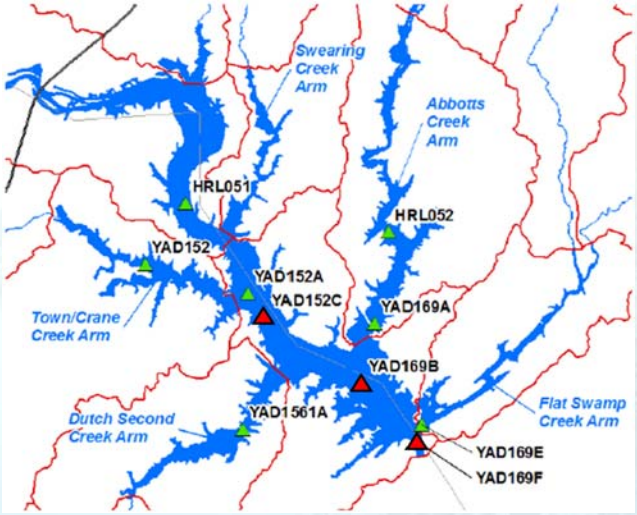
Model Review

- **Three sites evaluated:**
  - Mid-lake monitoring station (YAD152C)
  - Lower-lake monitoring station (YAD169B)
  - High Rock Lake dam forebay (near monitoring station YAD169F)



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Model Review Summary

- **YPDRBA and Riverkeeper conducted reviews**
- **Shared concerns with YPDRBA**
  - Error statistics and calibration issues
  - **Ability to model parameters at lake depths, especially DO and temperature**
  - No method for assessing how sediment nutrient releases respond to load reductions
- **Different emphasis**
  - LimnoTech – need for 3 different algal parameters to better capture behavior, temperature requirements, etc.
  - Riverkeeper – concern over model statistics and negative bias towards predicting both P and N
- **Model Adjustments by EPA**
  - Added two algal groups
  - Revised N and P calibration
  - Corrected error regarding inputs from watershed models
- **Overall, model appropriate for intended use – chlorophyll *a***
  - Calibrated well for chlorophyll *a* – from mid-lake stations to dam – especially for seasonal averages
  - Not developed for other criteria being considered by the SAC

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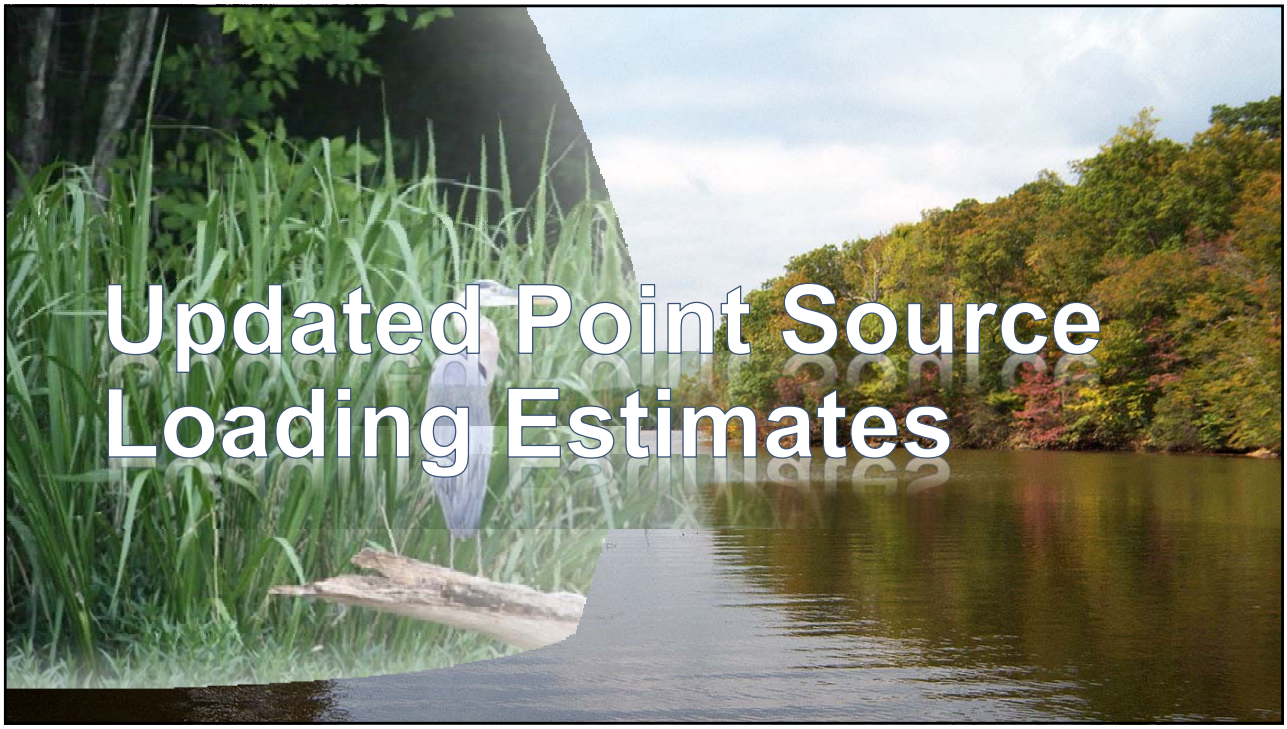
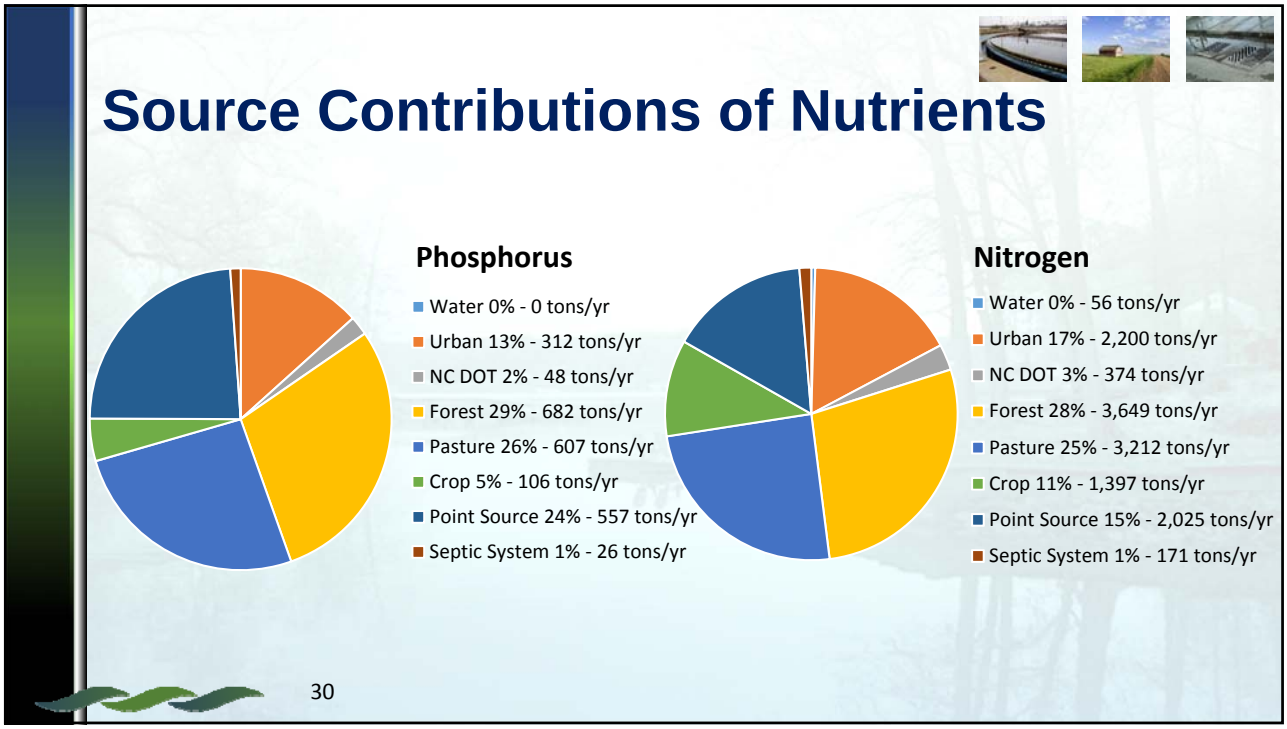

Updated Point Source
Loading Estimates


Source Contributions of Nutrients
Phosphorus
Water 0% - 0 tons/yr
Urban 13% - 312 tons/yr
NC DOT 2% - 48 tons/yr
Forest 29% - 682 tons/yr
Pasture 26% - 607 tons/yr
Crop 5% - 106 tons/yr
Point Source 24% - 557 tons/yr
Septic System 1% - 26 tons/yr
Nitrogen
Water 0% - 56 tons/yr
Urban 17% - 2,200 tons/yr
NC DOT 3% - 374 tons/yr
Forest 28% - 3,649 tons/yr
Pasture 25% - 3,212 tons/yr
Crop 11% - 1,397 tons/yr
Point Source 15% - 2,025 tons/yr
Septic System 1% - 171 tons/yr
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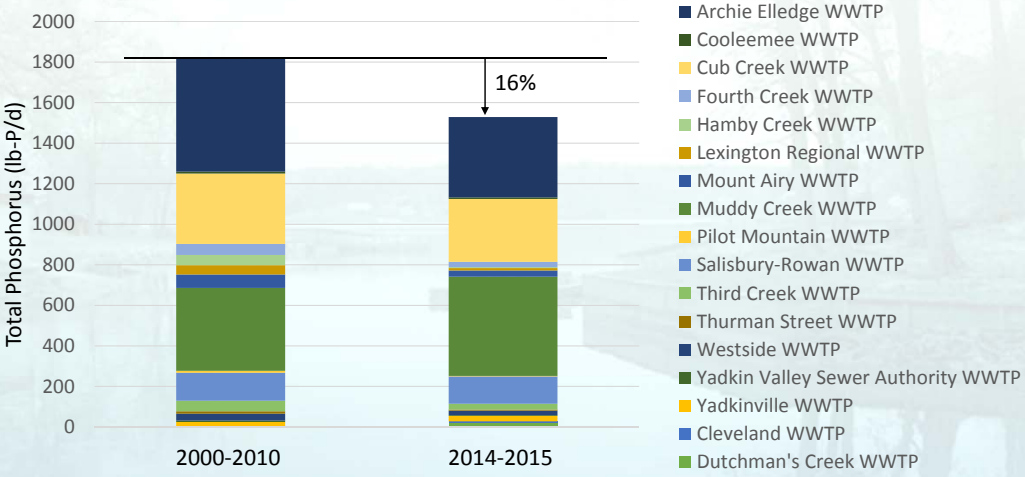
Reduction in Discharged Total Phosphorus Load



Note: 2014-2015 data includes 2 facilities using 2000-2010 data and 2 minor dischargers not accounted for in 2000-2010 data

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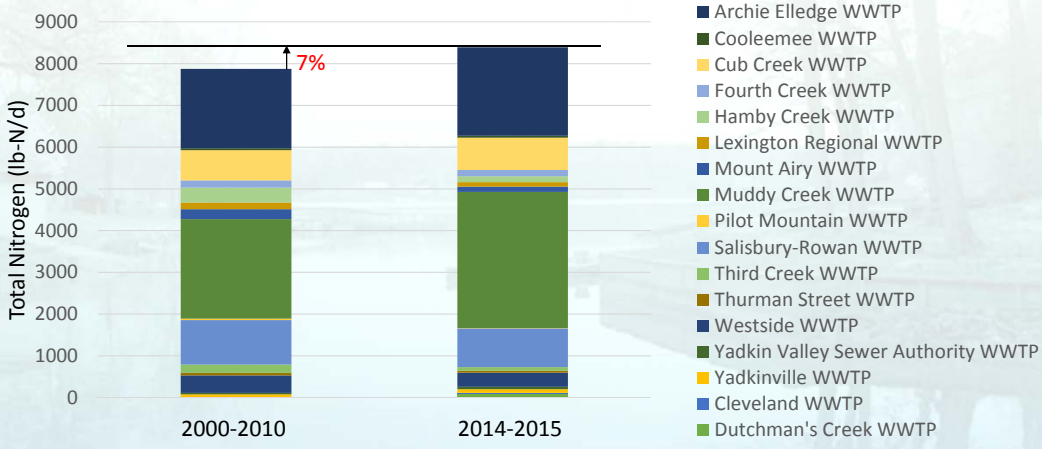
Increase in Discharged Total Nitrogen

- **Further model analysis necessary to determine effect of nitrogen loading with TP reductions**



Note: 2014-2015 data includes 2 facilities using 2000-2010 data and 2 minor dischargers not accounted for in 2000-2010 data

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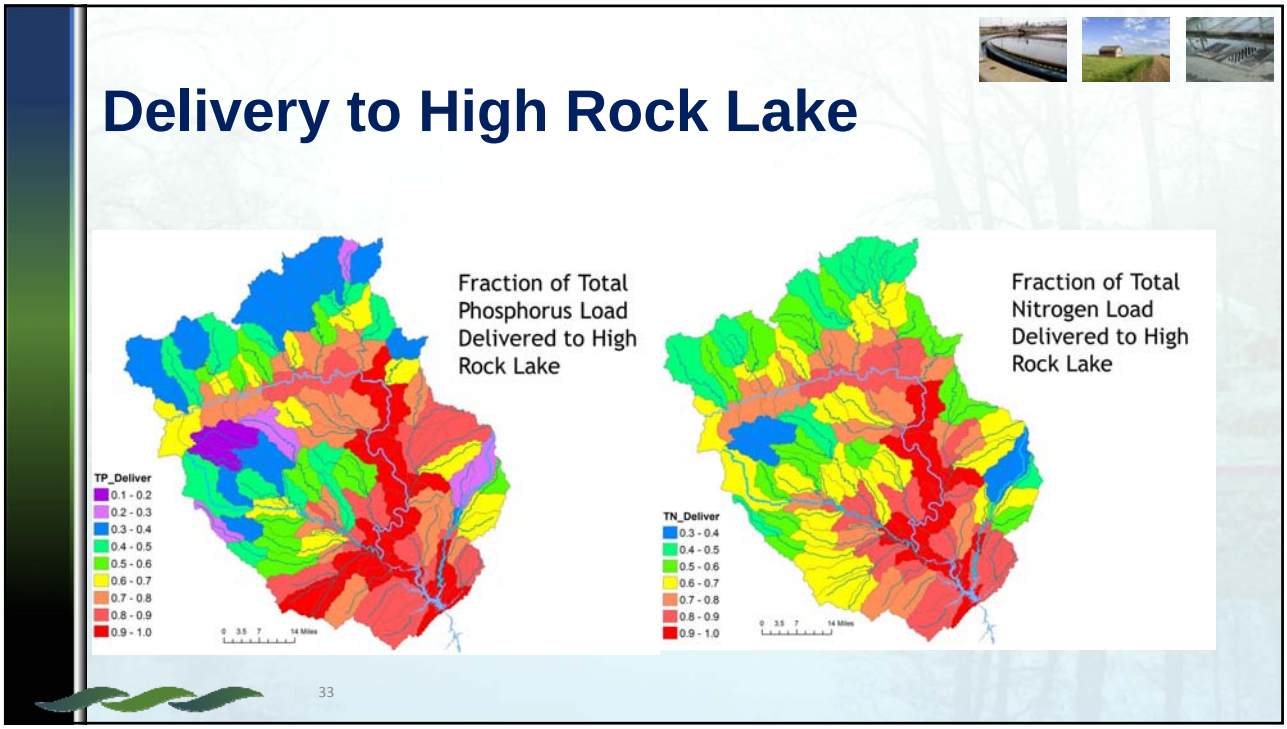
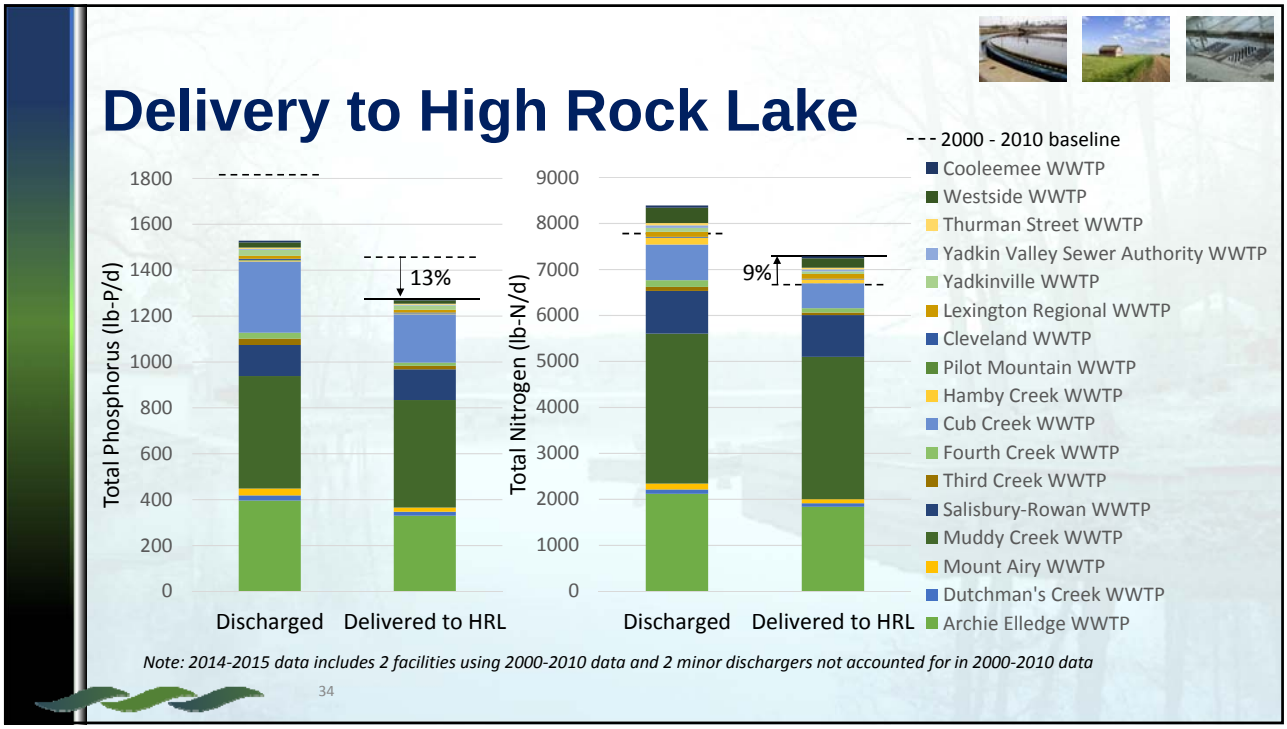

Delivery to High Rock Lake
Fraction of Total Phosphorus Load Delivered to High Rock Lake
TP_Deliver
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1.0
Fraction of Total Nitrogen Load Delivered to High Rock Lake
TN_Deliver
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1.0
33


Delivery to High Rock Lake
Total Phosphorus (lb-P/d)
1800
1600
1400
1200
1000
800
600
400
200
0
13%
Discharged
Delivered to HRL
Total Nitrogen (lb-N/d)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
9%
Discharged
Delivered to HRL
2000 - 2010 baseline
Cooleemee WWTP
Westside WWTP
Thurman Street WWTP
Yadkin Valley Sewer Authority WWTP
Yadkinville WWTP
Lexington Regional WWTP
Cleveland WWTP
Pilot Mountain WWTP
Hamby Creek WWTP
Cub Creek WWTP
Fourth Creek WWTP
Third Creek WWTP
Salisbury-Rowan WWTP
Muddy Creek WWTP
Mount Airy WWTP
Dutchman's Creek WWTP
Archie Elledge WWTP
Note: 2014-2015 data includes 2 facilities using 2000-2010 data and 2 minor dischargers not accounted for in 2000-2010 data
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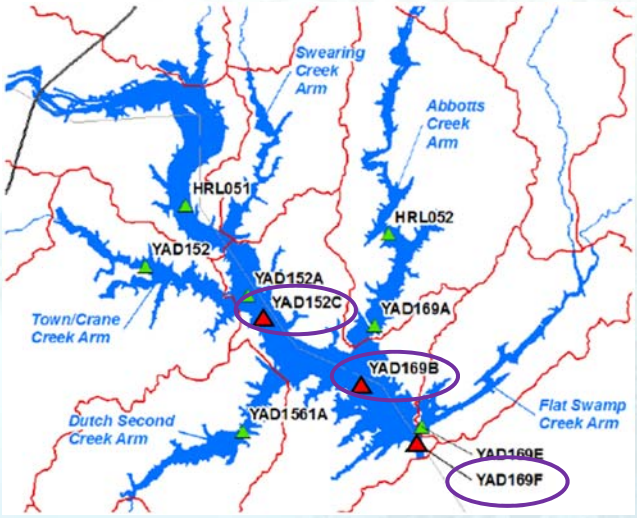
Water Quality Model

- **Three sites evaluated:**
  - Mid-lake monitoring station (YAD152C)
  - Lower-lake monitoring station (YAD169B)
  - High Rock Lake dam forebay (near monitoring station YAD169F)
- **LimnoTech performed evaluation**



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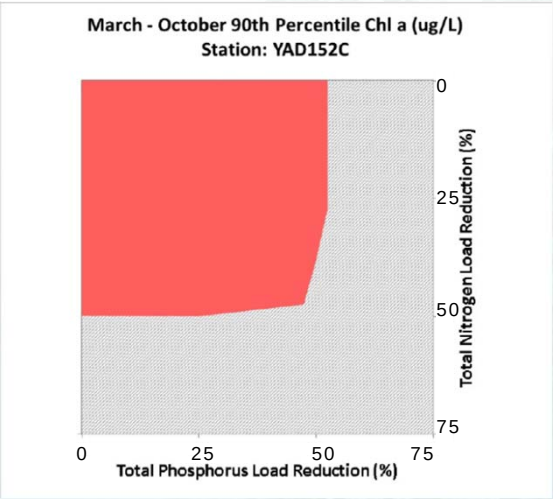
Chlorophyll *a* Load Response Curve

- At YAD152C (mid lake station)
- Red area shows nutrient load scenarios where target is not met
- Gray hatching shows load scenarios were target (40 µg/L) is met at least 90% of the time
- Concluded that a TP-focused removal strategy was feasible



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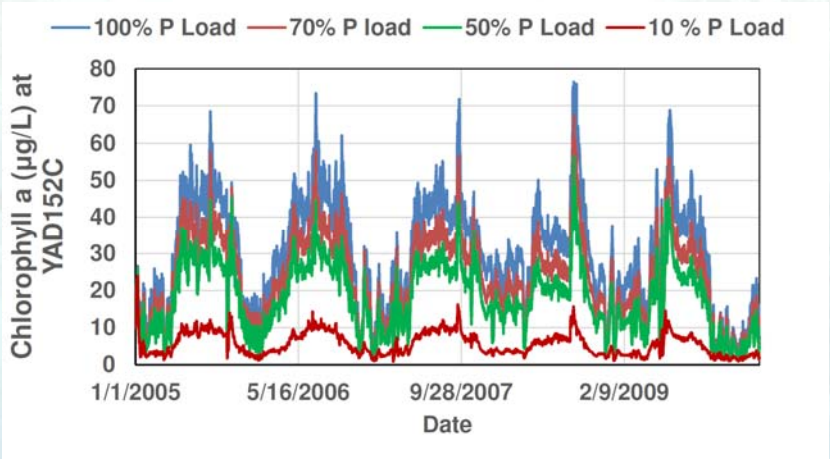
Daily Model Predictions of Chl *a* with P Load Reductions



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Chlorophyll *a* metrics considered for measuring response

1. **90th percentile**
   - Current interpretation of water quality standard (no more than 10% exceedance)
2. **Arithmetic mean during growing season**
   - Used April to October to define growing season
   - SAC discussions towards appropriateness of an average standard
   - Model results more suited to average response
3. **Geometric mean during growing season**
   - Represents central tendency of response
   - Measure suggested by DWR

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TP Load Reduction Responses

	Baseline			30% TP Load Reduction			50% TP Load Reduction		
Location	90th % chl *a* (ug/L)	Mean chl *a* (ug/L)	Geomean chl *a* (ug/L)	90th % chl *a* (ug/L)	Mean chl *a* (ug/L)	Geomean chl *a* (ug/L)	90th % chl *a* (ug/L)	Mean chl *a* (ug/L)	Geomean chl *a* (ug/L)
YAD152C (Mid-Lake)	65.9	45.9	41.8	50.8	35.5	32.5	38.7	27.3	25.1
YAD169B (Lower-Lake)	51.6	36.7	34.6	39.0	27.9	26.2	29.7	21.2	19.8
YAD169F (Near-Dam)	46.2	33.4	31.5	35.4	25.4	23.7	26.7	19.3	17.9

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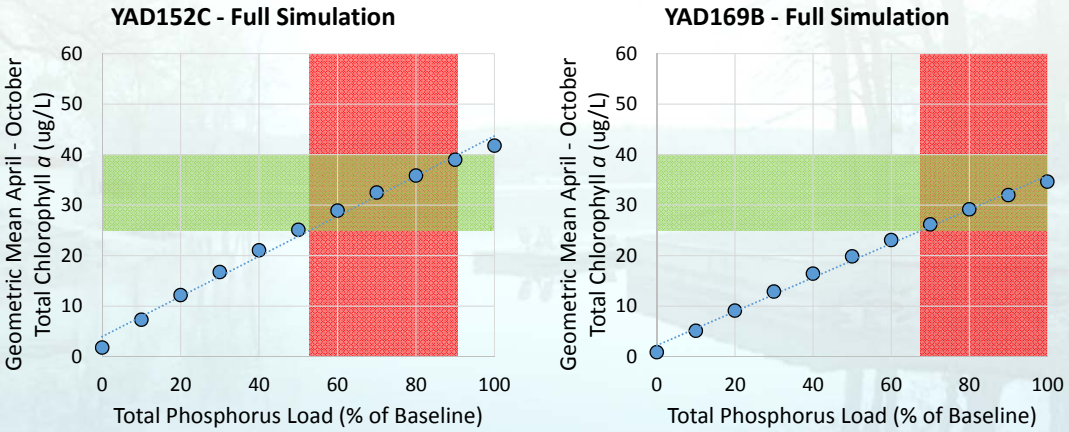
Potential range of required reduction based on geometric mean results



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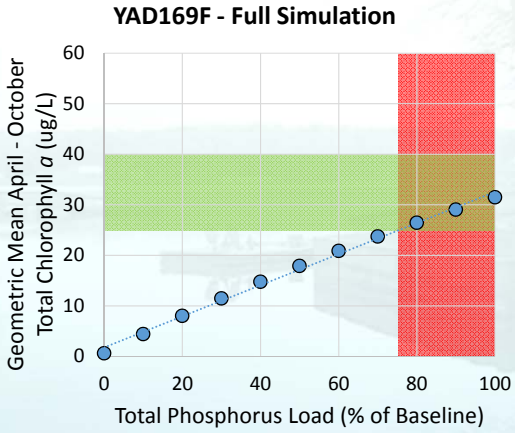
Potential range of required reduction based on geometric mean results



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Potential Point Source Permitting Scenarios

1. All point sources at a load based on permitted flow and 1 mg/L TP
2. All point sources at a load based on 80% of permitted flow and 1 mg/L TP
3. All point sources at a load based on 80% of permitted flow and 0.5 mg/L TP

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Summary – Discharged TP

Load scenario	Point Source Discharge – lb/d	Point Source Delivered – lb/d
Baseline (00-10)	1817	1466
Current (14-15)	1528	1275
Scenario 1	1012	823
Scenario 2	809	659
Scenario 3	405	329

Load scenario	Point Source Discharge – % of baseline	Point Source Delivered – % of baseline
Baseline (00-10)	100	100
Current (14-15)	84	87
Scenario 1	56	56
Scenario 2	45	45
Scenario 3	22	22

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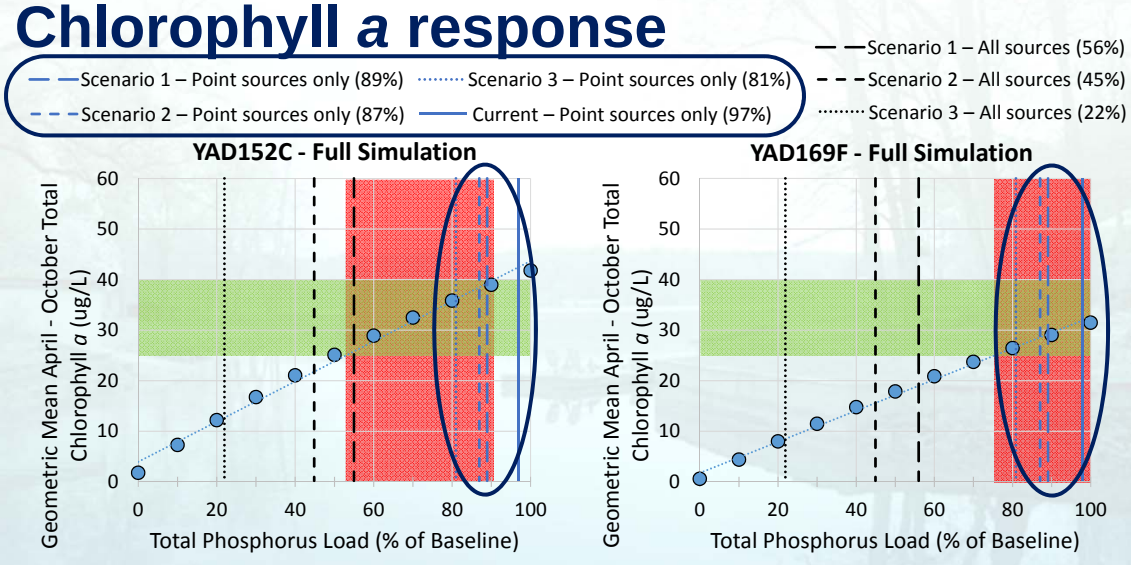
Chlorophyll *a* response



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Chlorophyll *a* reduction

- Differences seen between mid-lake and near dam stations, with mid-lake station showing more TP reduction needed to achieve same chlorophyll *a* response
- Given the linear nature of the TP reduction & chl *a* response, opportunity to evaluate how these reductions line up with load reductions from sources

Scenarios - Costs and Responses

Scenario	TP Reduction	Total Capital	Total Annual O&M	Total Net Present Value	Geomean Chl *a* (µg/L)[1] Point Source Reductions	Geomean Chl *a* (µg/L)[1] All Source Reductions
Baseline		N/A			43.7 - 32.6	43.7 - 32.6
Current	11%				42.6 - 31.7	39.1 - 29.0
1 mg/L at permitted flow	44%	$8,348,000	$1,799,100	$28,985,000	39.5 - 29.3	26.3 - 19.1
1 mg/L at 80% permitted flow	55%	$8,348,000	$1,799,100	$28,536,000	38.4 - 28.5	21.8 - 15.6
0.5 mg/L at 80% permitted flow	78%	$42,842,000	$4,057,100	$89,375,000	36.3 - 26.8	12.9 - 8.7

Notes:
1. **Assumes TN loading at baseline conditions for all scenarios**
2. **Costs updated to 10/2016 based on ENR CCI**

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Nitrogen Reduction Scenarios for Cost Comparison

- **TN load based on 8 mg/L and permitted flow**
- **TN load based on 5 mg/L and permitted flow**

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Costs for TN removal

Scenario	TN Change (+ Increase, - Decrease)	Nitrification		Nitrogen Removal		Total Net Present Value
		Total Capital	Total Annual O&M	Total Capital	Total Annual O&M	
Baseline						
Current	+21%					
8 mg/L at permitted flow	+11%	$78,585,000	$5,469,300	$186,434,000	$4,312,900	$377,220,000
5 mg/L at permitted flow	-31%	$78,585,000	$5,469,300	$288,193,000	$7,547,000	$516,074,000

Note: Costs updated to 10/2016 based on ENR CCI

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YPDRBA Plan Moving Forward

- **Conduct Sensitivity Analysis with Revised Model**
  - Validate TP reduction effectiveness with new TN loading information
- **YPDRBA in conjunction with stakeholders develop initial nutrient management strategy**
  - Focus on P reduction for dischargers
  - Understand current land uses and NPS loading
- **Implement 2017 Summer Water Quality Monitoring Program**
- **Work with other groups to initiate change in chlorophyll *a* standard to a growing season geometric mean basis**

YPDRBA Plan Moving Forward

- **Initial nutrient management strategy**
  - Winston-Salem's continued support of Soil and Water Conservation District staffing
  - Consider expansion of this approach to other HRL watershed counties with YPDRBA funding
  - Promotion of land use best management practices
  - HRL monitoring to support an adaptive management strategy

Anticipated Schedule

- **SAC – Nutrient recommendations in July**
- **HRL Stakeholders: Present strategy following their recommendations**
  - First - DWR
  - Second – CIC
  - Third – Water Quality Committee of the EMC
- **Chlorophyll a standard – promotion of a geometric mean instead of instantaneous standard**
  - SAC recommendation in May
  - Work with Water Quality Committee to promote change

Stakeholder Analysis to Support Development of a High Rock Lake Nutrient Management Strategy

Nutrient Criteria Development Plan

Criteria Implementation Committee

April 17, 2017

ch2m:

Abbotts Creek, a section of High Rock Lake near Lexington, North Carolina. Source: Photo by Panda Brown. (Wife of en:User:Pharmboy)