Status Update for Reexamination of the Falls Lake Rules
August 2012

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August 22, 2012

Agenda

- Review Task 2 TM
- Provide status update for Task 3
- Provide status update for Task 1
- Present revised schedule
- Discussion and questions

Review of Task 2

Task 2 Objectives

- Compile master water quality database (1999-2012)
- Summarize existing reports
- Summarize available data
- Compare data sets

Key Questions for Task 2

- How do the past reports developed by the State and local governments compare? Does the master database support the findings of those reports?
- Is the data collected by the various organizations comparable? How do the field and laboratory methods differ?
- How does water quality in year 2006 (the baseline year for developing the Falls Lake Rules) compare to the water quality observed in the other years?
- What gaps are evident in the data sets available for Falls Lake and its watershed?

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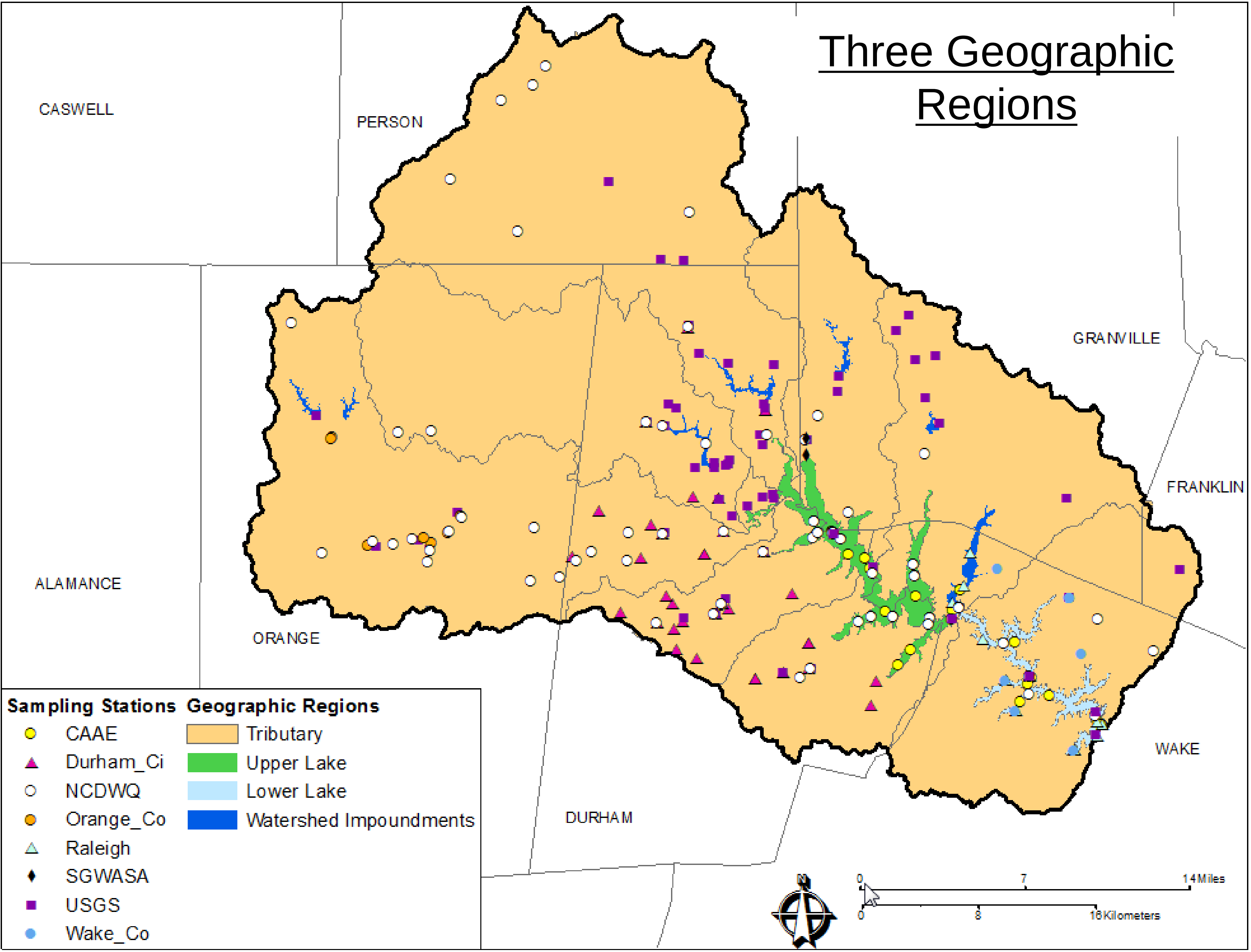
Published Studies Summarized in Task 2 TM

Agency reports

- Historic documents
- Basinwide assessment reports
- Water quality summaries
- Modeling studies

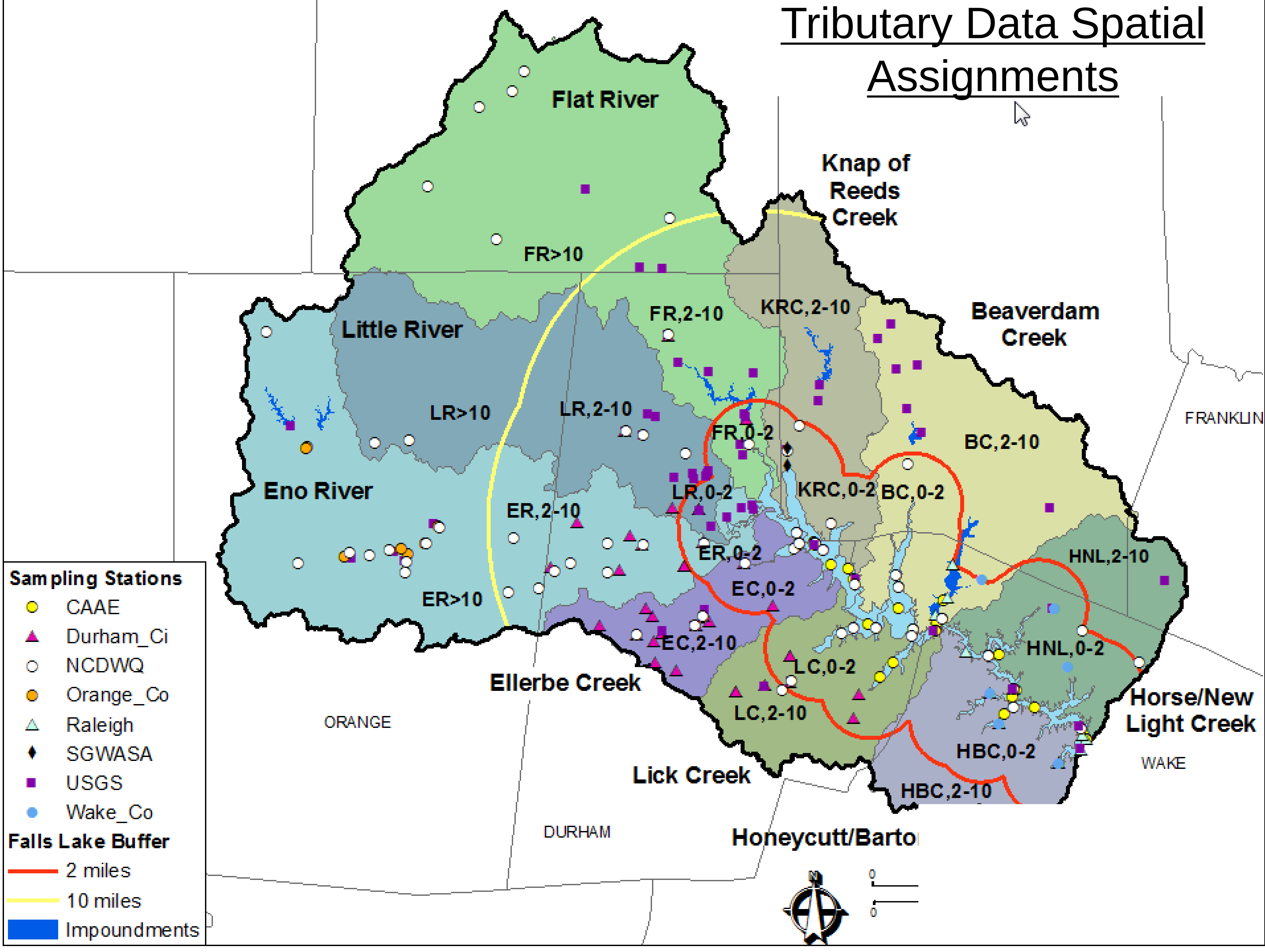
Other Relevant Studies

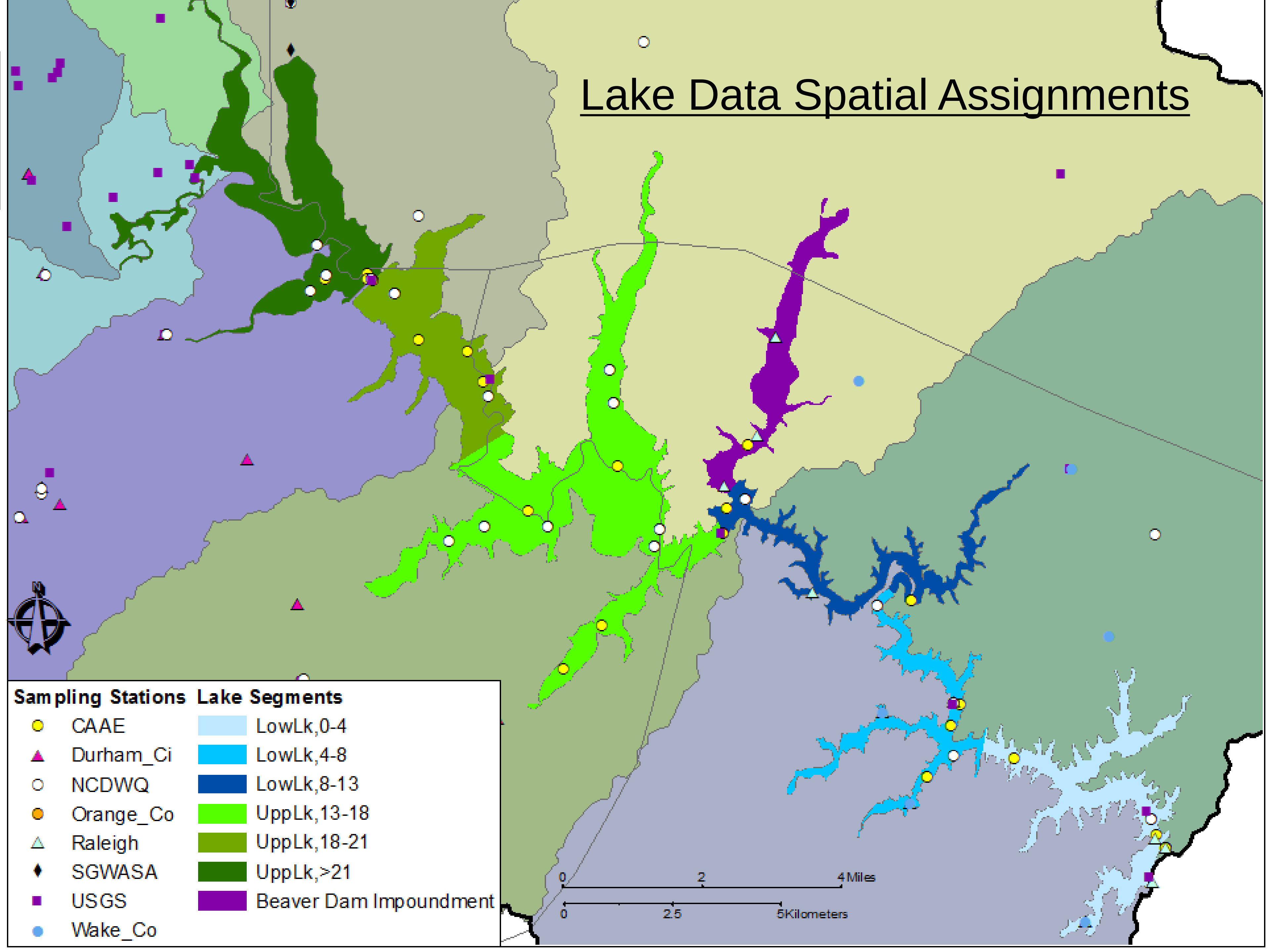
- Upper Neuse Watershed Management Plan
- City of Durham stormwater monitoring program
- City of Raleigh water quality studies
  - Chlorophyll *a*: Spirogyra,Ecoconsultants, CAAE
  - TOC: Fiscal Notes (Hazen and Sawyer), presentation to the NCLMS



Three Geographic Regions
CASWELL
PERSON
GRANVILLE
FRANKLIN
ALAMANCE
ORANGE
DURHAM
WAKE
Sampling Stations
CAAE
Durham_Ci
NCDWQ
Orange_Co
Raleigh
SGWASA
USGS
Wake_Co
Geographic Regions
Tributary
Upper Lake
Lower Lake
Watershed Impoundments
0
7
14 Miles
0
8
16 Kilometers
N

Tributary Data Spatial Assignments




Lake Data Spatial Assignments
Sampling Stations
CAAE
Durham_Ci
NCDWQ
Orange_Co
Raleigh
SGWASA
USGS
Wake_Co
Lake Segments
LowLk,0-4
LowLk,4-8
LowLk,8-13
UppLk,13-18
UppLk,18-21
UppLk,>21
Beaver Dam Impoundment
0 2 4 Miles
0 2.5 5 Kilometers
N

Who Monitored Water Quality in the Falls Lake Watershed?

- City of Durham
- City of Raleigh
- Durham County
- NCDWQ
- NCSU-CAAE
- Orange County
- USGS
- Wake County

What Parameters are Included?

- Field Data
  - Temperature
  - Dissolved Oxygen
  - pH
  - Conductivity
  - Secchi Depth
- Water Quality Data
  - Total suspended sediment
  - Ammonia nitrogen
  - Nitrate plus nitrite
  - Organic nitrogen
  - Total nitrogen
  - Orthophosphate
  - Total phosphorus
  - Chlorophyll *a*
  - Total organic carbon

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DRAFT RESULTS FOR STATUS UPDATE

Which Tributary Subwatersheds were Monitored?

(**red text indicates no 2006 data**)

Tributary	Number of Stations	Years Monitored in Database
Honeycutt/Barton	7	2008-2009
Horse/Newlight	4	2000, 2008-2009
Lick Creek	9	2001, 2006, 2008-2011
Beaverdam Creek	8	2005, 2008-2009
Ellerbe Creek	19	1999-2012
Knap of Reeds Creek	5	1999-2011
Eno River	22	1999-2011
Little River	12	1999-2011
Flat River	10	1999-2011

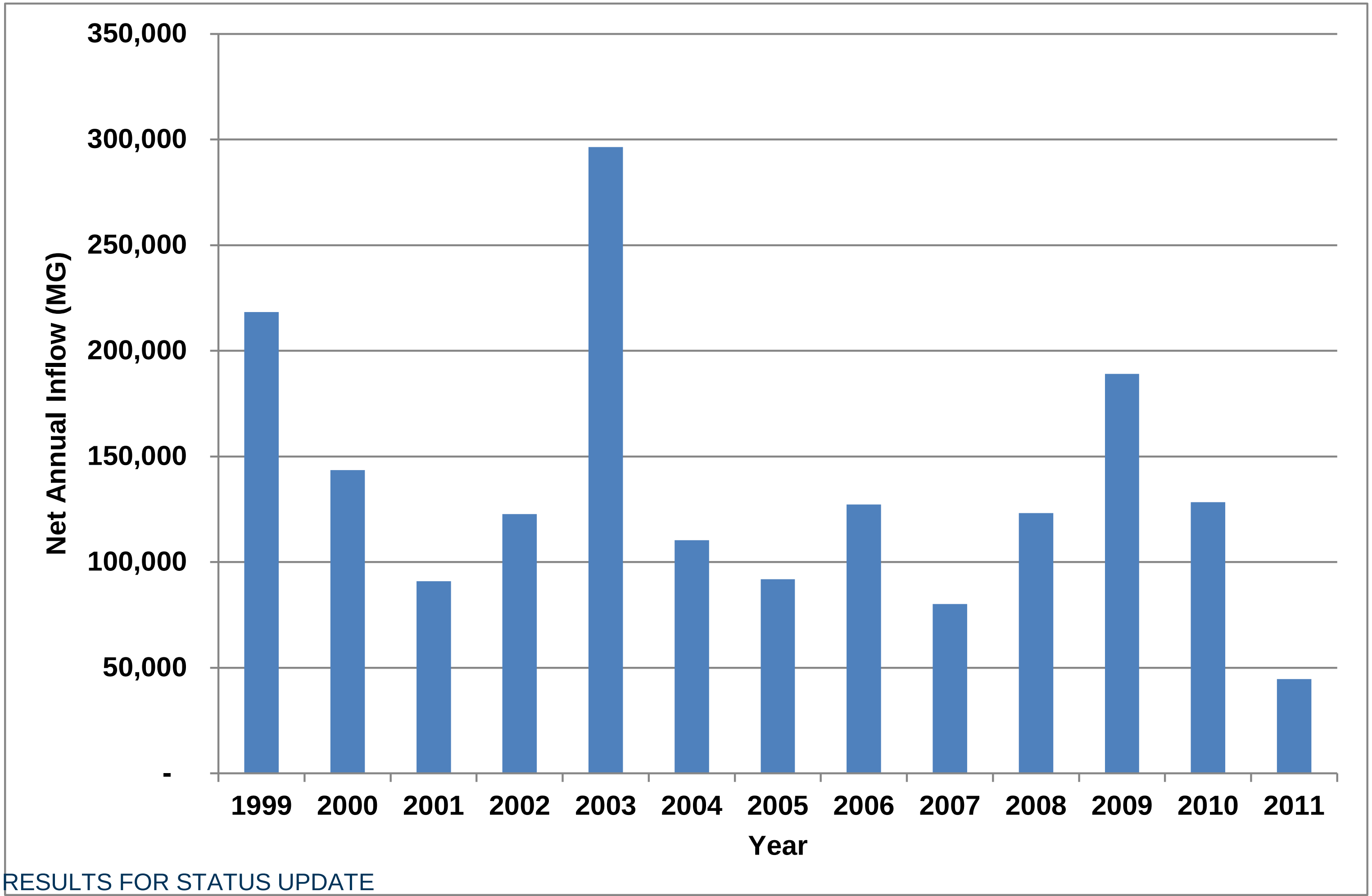
Which Lake Segments were Monitored?

Lake Segment	Number of Stations	Years Monitored in Database
Lower Lake, 0-4 mi.	**13**	**2000-2012**
Lower Lake, 4-8 mi.	**9**	**2000-2012**
Lower Lake, 8-13 mi.	**5**	**2000-2012**
Beaverdam Impoundment	**5**	**2000-2012**
Upper Lake, 13-18 mi.	**11**	**2000-2001, 2005-2012**
Upper Lake, 18-21 mi.	**4**	**2000-2001, 2004-2008, 2010-2012**
Upper Lake, >21 mi.	**13**	**2000-2012**

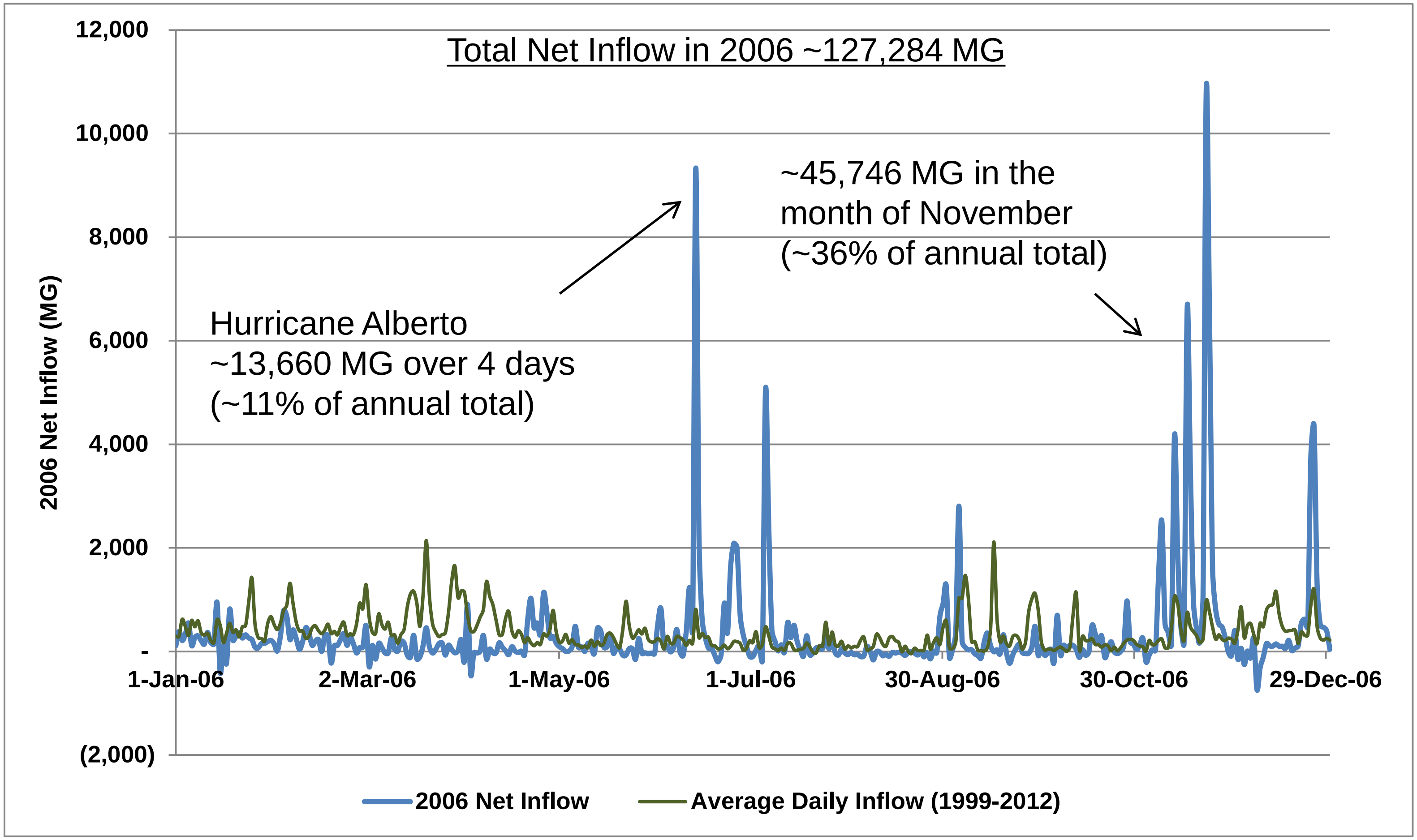
What are the Key Water Quality Parameters for Discussion?

- Nutrients (Regulated by the Rules)
  - Total nitrogen (TN)
  - Total phosphorus (TP)
- Algae
  - Chlorophyll *a*
- Other Water Quality
  - Dissolved Oxygen
  - Total organic carbon

USACE Net Inflows to Falls Lake (1999 to 2011)



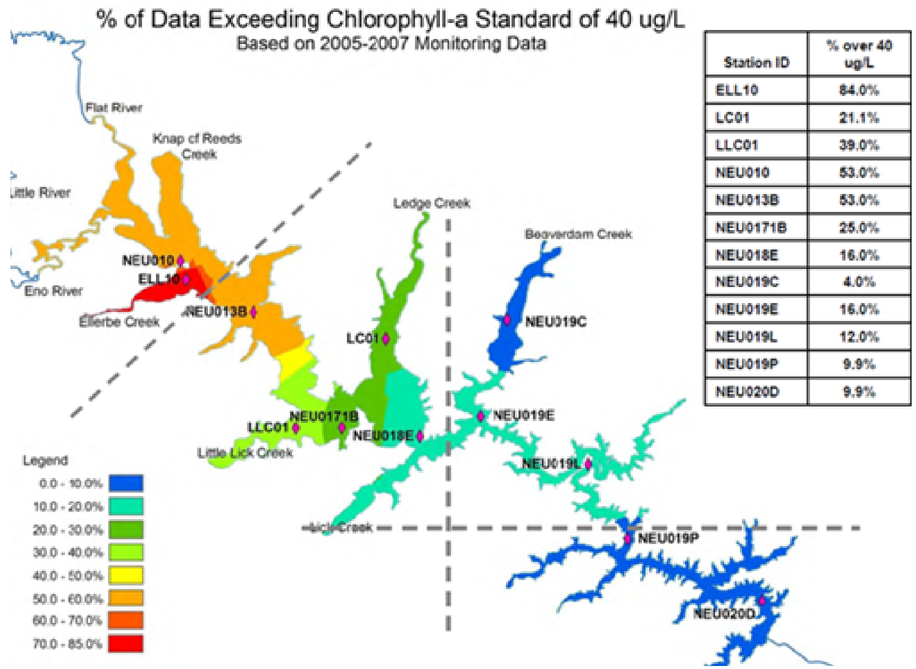
USACE Daily Net Inflows to Falls Lake for 2006



Do the Data Summaries Performed for Task 2 Support the Findings of Existing Reports?

How Do the Past Reports Developed by the State and Local Governments Compare?

- Poor water quality was anticipated in the upper part of the lake prior to construction of the dam
- Water quality improves longitudinally from the upstream to downstream end of the lake (TSS, TN, TP, chlorophyll *a*, TOC, etc.)
- Upper end of the lake is impaired
  - > Turbidity > 50 NTU
  - > Chlorophyll *a* > 40 µg/L



Station ID	% over 40 ug/L
ELL10	84.0%
LC01	21.1%
LLC01	39.0%
NEU010	53.0%
NEU013B	53.0%
NEU0171B	25.0%
NEU018E	16.0%
NEU019C	4.0%
NEU019E	16.0%
NEU019L	12.0%
NEU019P	9.9%
NEU020D	9.9%

(Huisman 2012)

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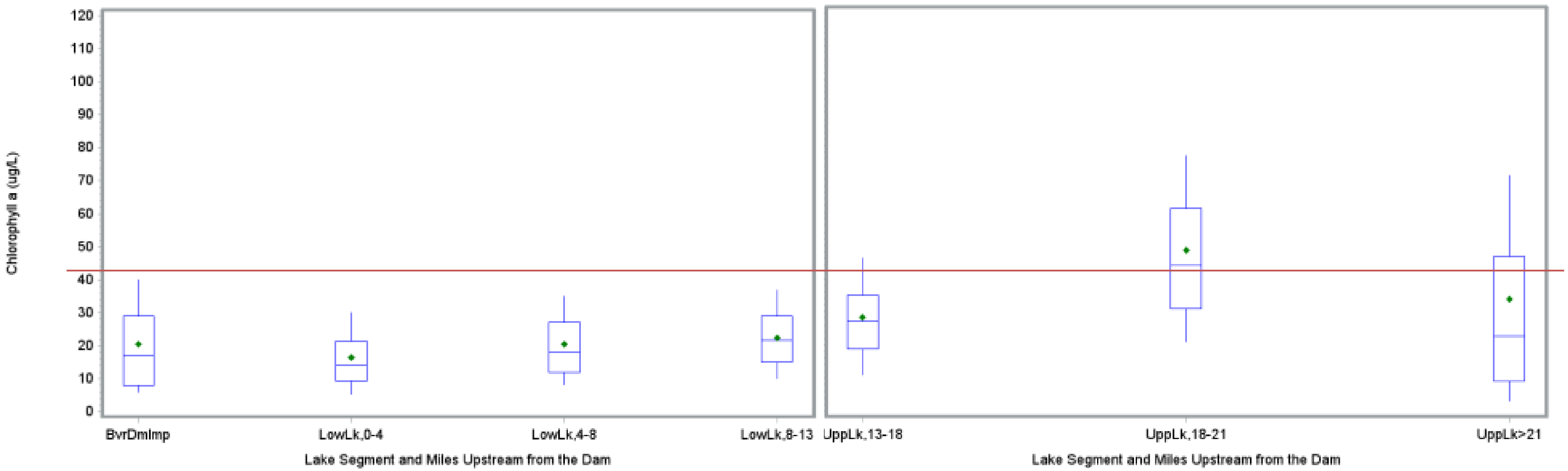
Task 2 data summaries support previous State and local reports

Chlorophyll *a* (µg/L) in Lake Segments



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How do the Field and Laboratory Methods Differ by Organization?

Protocols Provided During Data Compilation

Organization	Field SOP Provided	QAPP Provided	Laboratory QA/QC Procedures	Chain of Custody Procedures In Place	Protocol Completeness
NCDWQ	Yes	Yes	Yes	Yes	Full
USGS	Yes	Yes	Yes	Yes	Full
City of Durham	Yes	Yes	Yes	Yes	Full
City of Raleigh	No	Yes	Yes	Yes	Partial
CAAE	Yes	Yes	Yes	Yes	Full
SGWASA	No	No	Unknown	Unknown	None Provided
Orange County	Yes	No	No	Yes	Partial
Wake County	Yes	Yes	Yes	Yes	Full

Is the Data Collected by the Various Organizations Comparable?

- Structural differences in data categorized by organization
  - > Sample size
  - > Sampling location
    - – Land use
    - – WWTP discharges
    - – Location in the lake
- For most parameters, the distribution of results was not influenced by the organization collecting the data
- Consistent exceptions
  - > Wake County: small sample size for Lower Lake sampling
  - > City of Durham: majority of lake sampling occurred within Ellerbe Creek arm

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How Does Water Quality in 2006 Compare to Other Years

Tributary Data

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Tributary Water Quality

- TP concentrations were higher in 2006 than in most other years
- TN concentrations peaked in 2005 with decreases beginning in 2006 (still relatively high)
- DO concentrations were among the lowest in 2006 Chlorophyll *a* concentrations were highest in 2006

How Does Water Quality in 2006 Compare to Other Years

Lake Data

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Lake Water Quality

- Nutrient concentrations in the Lake were generally low in 2006, but increased from 2007 through 2009
- Chlorophyll *a* concentrations in 2006
  - Were typical in the Upper Lake
  - Were higher in the Lower Lake
- TOC concentrations in the lake
  - Increased from 2004 to 2008
  - Decreased from 2008 to 2010

Preliminary Identification of Data Gaps

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What Gaps are Evident in the Data Sets Available for Falls Lake and its Watershed?

- Limited data collection in all tributaries near the lake including Beaverdam Impoundment
  - > Chlorophyll *a* and TOC:
    - – DWQ used in lake concentrations to calculate loads from tributaries
    - – The lake model may be sensitive to these inputs

- Limited data collection in specific tributaries near the lake
  - > Eno River
  - > Horse/Barton/Cedar
  - > Horse/Newlight
  - > Knap of Reeds
  - > Lick Creek
  - > Little River
  - > Beaverdam Creek Subwatershed
  - > Beaverdam Impoundment

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What Parameters have a Low Sample Size (1999 to 2011) in the Tributaries Near the Lake?

Subwater-shed and Distance Upstream	TSS	Ammonia	NO2/ NO3	Organic Nitrogen	Ortho-Phosphorus	Total Phosphorus	Chlorophyll a	Total Organic Carbon
BC,0-2	**17**	**17**	**15**	**15**	**17**	**15**	**0**	**0**
EC,0-2	153	190	419	189	**10**	410	**0**	**11**
ER,0-2	58	69	115	68	**4**	118	**0**	**5**
FR,0-2	113	251	264	250	145	296	50	53
HBC,0-2	78	78	76	76	76	76	**0**	**0**
HNL,0-2	45	46	41	42	44	41	**0**	**0**
KRC,0-2	80	137	147	136	**9**	147	**0**	**10**
LC,0-2	31	36	36	36	**5**	36	**0**	**5**
LR,0-2	**0**	**3**	**0**	**3**	**3**	**3**	**0**	**0**
BvrDm Imp	**20**	**0**	56	**0**	**0**	**0**	73	56

Relevance of the Task 2 TM

- Full monitoring database confirms findings from recent reports and expected outcomes in pre-dam reports
- 2006 was not a typical year in terms of tributary water quality, hydrology, and lake response
- Distributions of results by organization are generally comparable
- Protocols and analysis methods vary by organization

Relevance of the Task 2 TM, continued

- Limited data availability in the tributaries near the lake
  - Affects model development
  - Limits ability to track changes in nutrient loading due to management strategy implementation
- Streamlined approaches for sampling and analysis are needed
  - Improve efficiency
  - Reduce costs
  - Increase consistency in laboratory procedures
  - Ensure data acceptability to NCDWQ

Task 3 – Status Update

Task 3 Objectives

- Review methods for calculating jurisdictional loads
  - Watershed Analysis Risk Management Framework (WARMF)
  - SPAtially Referenced Regression On Watershed attributes (SPARROW)
  - Nutrient Scientific Advisory Board (NSAB)
  - Simplified loading functions (e.g., EUTROMOD)
- Assess relative loading from “other” sources
  - Onsite wastewater treatment systems
  - Atmospheric deposition
  - Streambank erosion
  - Internal lake sediments

Task 3 Objectives, Continued

- Compare methods for calculating tributary loads (flow times concentration entering the lake)
  - US Army Corps of Engineers (USACE) FLUX
  - US Geological Survey (USGS) LOADEST
- Select method for calculating tributary loads from five Upper Lake tributaries
- Identify data gaps associated with jurisdictional and tributary load estimates

Review Methods for Calculating Jurisdictional Loads

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WARMF: Model Description

- Typical watershed loading model functions
- Sixteen land use categories (2001 NLCD)
  - Undisturbed: 7 various forest, wetland, grassland categories
  - Developed: 5 categories ranging from open space to high intensity and NCDOT
  - Agriculture: 2 categories for pasture and row crop
  - Other: 2 categories for barren land and open water
- Three categories for onsite wastewater disposal
  - 2 types of subsurface discharging systems (properly functioning or poorly functioning)
  - Sand filter systems simulated as point source discharges

WARMF: Model Description, Continued

- Streambank erosion
  - simulates transport capacity relative to upland loads, but does not account for scour and erosion
- Atmospheric deposition
  - Wet and dry
- Proprietary model (requires consultant to develop)

WARMF: Model Results

- Falls Lake watershed WARMF model was developed independently of the EFDC lake response model
- WARMF simulated loads from the five tributaries (2004 to 2007) are much lower than the 2006 inputs used to drive the EFDC model
  - 70 percent of the TN load
  - 50 percent of the TP load

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SPARROW: Model Description

- USGS model developed
  - 1992 version – national
  - 2002 version – regional
- Requires SAS to run (not accessible for most users)
- Predicts mean annual loads
- Output is available online
- Uses statistical regressions to identify sources with highest predictive power for calculating loads
  - Forest, for example, does not have its own loading category due to poor correlation

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SPARROW: Model Description, Continued

- Loads from onsite wastewater treatment systems and dry atmospheric deposition are lumped into urban category
- Wet deposition of nitrogen has its own category
  - ~49 % of delivered TN load from five tributaries
  - Accounts for the “small” contribution from undisturbed areas
- Background/Parent Rock
  - Correlated to streambed measurements of phosphorus content
  - ~28 % of delivered TP load from five tributaries
  - Accounts for the “small” contribution from undisturbed areas

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SPARROW: Model Results

- Sources of nitrogen loading
  - Wet deposition
  - Agriculture: fertilization of row crops and manure application
  - Urban areas
  - Point sources
- Sources of phosphorus loading
  - Urban areas
  - Background/parent rock
  - Agriculture: fertilization of row crops and manure application
  - Point sources
- Predicted TN and TP loads are much closer to those used to drive the 2006 EFDC model

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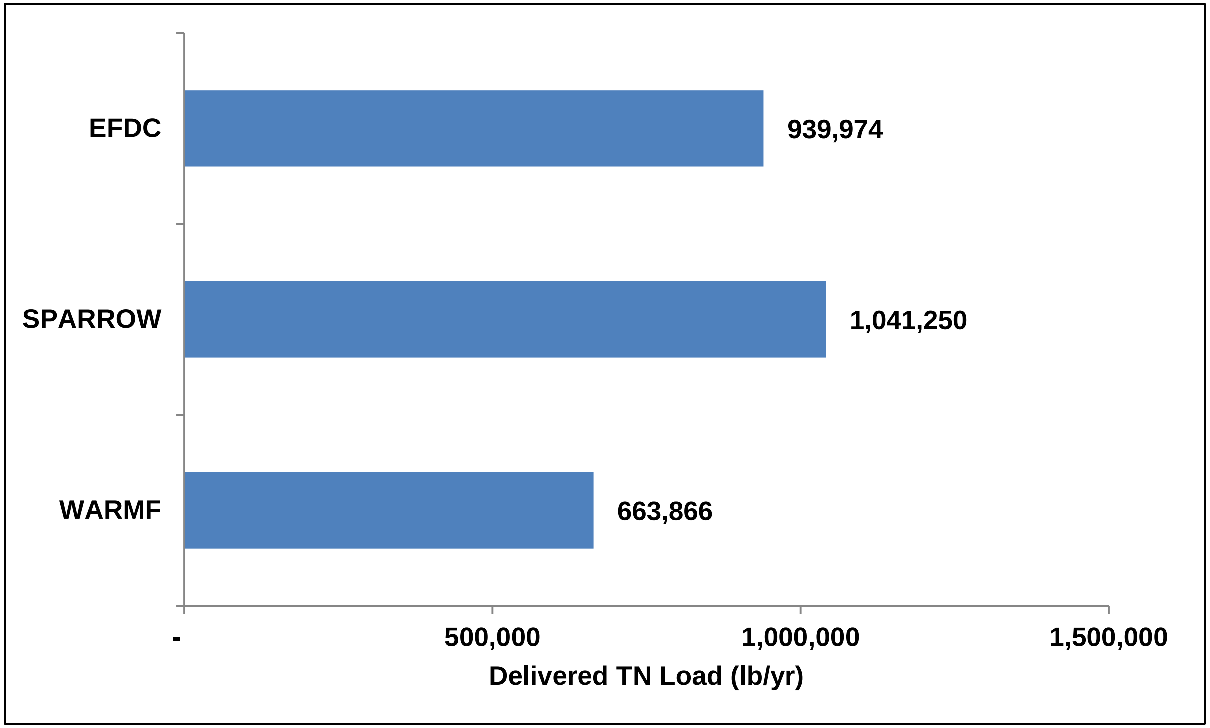
Comparison of Annual TN Loads: Five Upper Lake Tributaries



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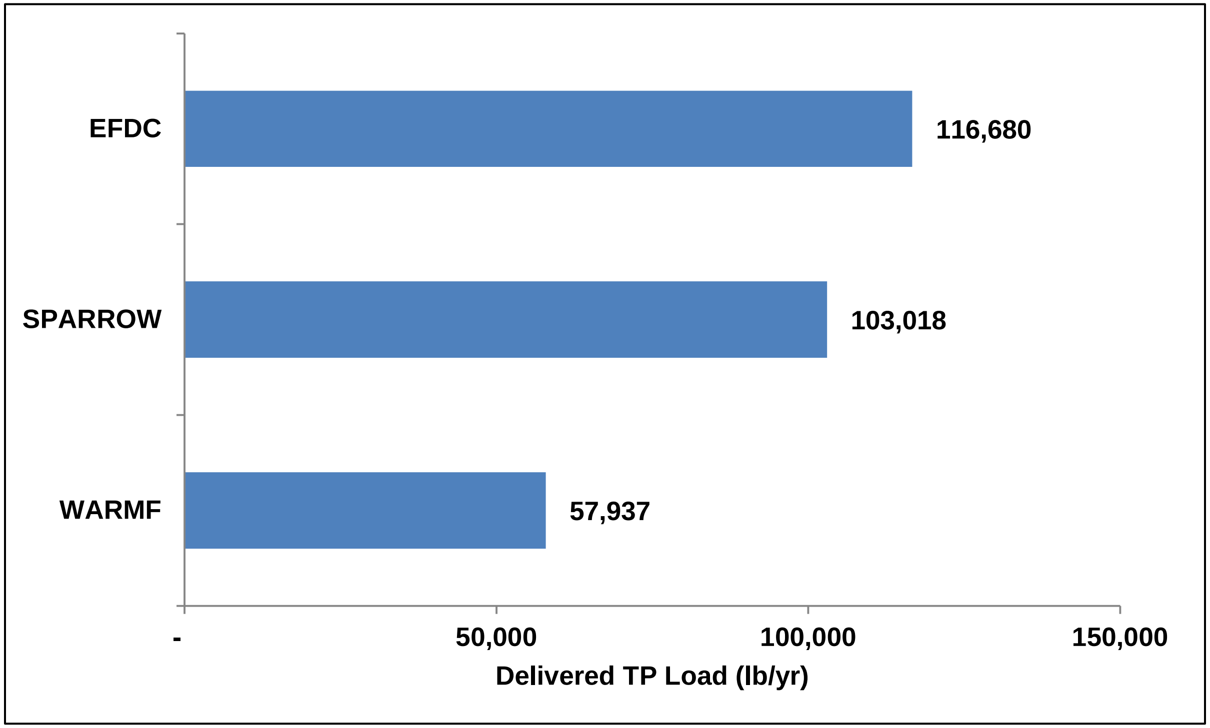
Comparison of Annual TP Loads: Five Upper Lake Tributaries



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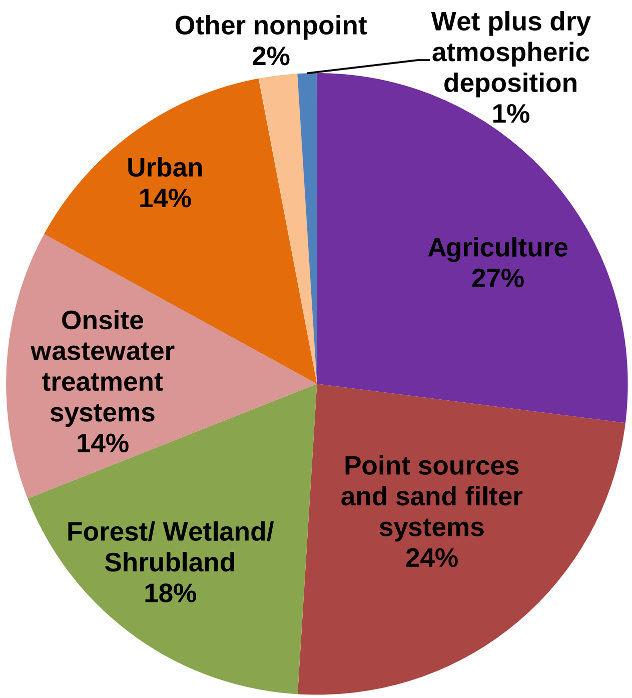
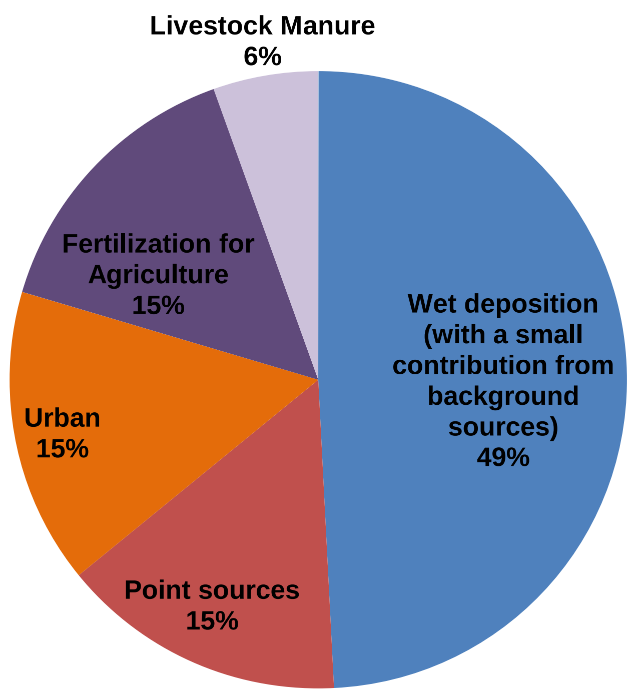
Comparison of TN Sources from Five Tributaries



WARMF Delivered TN = 663,866 lb/yr



SPARROW Delivered TN = 1,041,250 lb/yr

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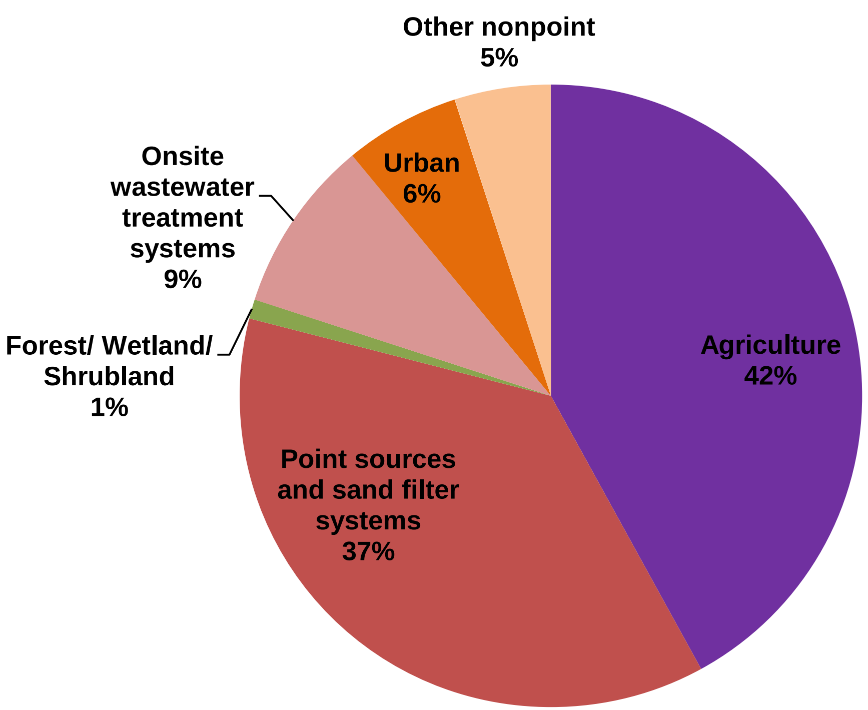
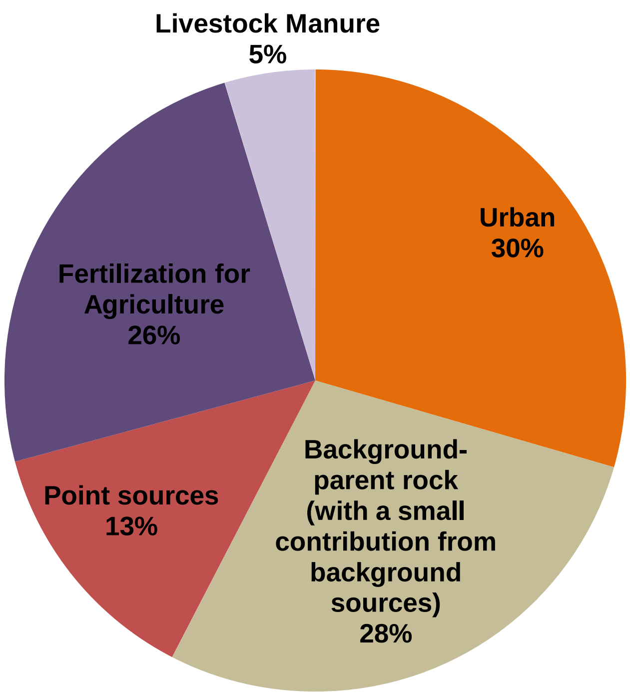
Comparison of TP Sources from Five Tributaries



WARMF Delivered TP = 57,937 lb/yr



SPARROW Delivered TP = 103,018 lb/yr

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Other Potential Approaches for Estimating Jurisdictional Loads

EUTROMOD

- Collection of spreadsheet-based nutrient loading and lake response models
- Capable of accounting for impoundments in the watershed
- Predicts annual watershed nutrient loads and growing season lake water quality
- Spreadsheet is easily be updated with land use changes
- Would require reworking to build specifically for the Falls Lake watershed
- Current version can be developed to account for BMP implementation
- Allows for uncertainty analysis
  (model error and hydrologic variability)

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Nutrient Scientific Advisory Board (NSAB) Method

- NCDWQ is currently developing a method for calculating jurisdictional loads and wants to work cooperatively with the UNRBA
- 2012 NSAB Report to Secretary
  - focuses on calculating credits for nutrient reduction
  - Provides costs and efficiency ranges for various BMPs based on NCSU work
  - Does not provide a method or guidance regarding calculation of baseline loads

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Qualitative Assessment of Loading from Other Sources

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Relative Loading from Other Sources

- Atmospheric Deposition
  - Significant contributor to TN load (49% based on SPARROW results)
  - Insignificant contributor to TP load
  - Lake deposition is approximately 14 percent of Stage II nitrogen allocation from Upper Lake
- Streambank Erosion
  - Not accounted for in WARMF
  - Accounted for in SPARROW in the background parent rock TP loads
  - Local studies are not available

Relative Loading from Other Sources, Continued

- Onsite wastewater treatment systems
  - SPARROW lumps in with urban development
  - Included in WARMF as either onsite systems or point source loading
  - Still summarizing local studies
- Internal phosphorus loading from lake sediments
  - Setting up Nurnberg models to estimate
  - Complete tributary load estimation exercise first

Methods for Calculating Tributary Loads

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Methods for Calculating Tributary Loads

- Currently reviewing methods
  - FLUX and LOADEST
- Originally planned to carry out comparative analysis on perennial and intermittent streams
- Insufficient water quality data on an intermittent channel
- Propose to use the Eno River subwatershed to test methods
  - Good mix of land use
  - USGS flow gage and water quality stations near the mouth
- Following method selection
  - Estimate loads for five upper lake tributaries
  - Year 2006 (with and without Alberto)

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Task 1 – Status Update

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Task 1 Objectives

- Identify regulatory options
- Assess costs associated with various management strategies
- Link water quality to designated uses
- Evaluate existing watershed and lake models
- Develop ES Value Tool

Reviewing Regulatory Options

- Describe various options
  - Site specific criteria
  - Variances
  - Use attainability analysis
- Provide examples of past applications
- Describe level of effort and likelihood of success for each option

Assessing Costs

- Compile various sources of cost data
  - Local government BMP cost data
  - North Carolina Ecosystem Enhancement Program (NCEEP) fee program
  - NSAB July 2012 Report to the Secretary
- Estimate ranges of costs associated with various management strategies

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Linking Water Quality to Affected Designated Uses

- Eutrophication model
  - Based on either USACE BATHTUB regressions (TN, TP, light, flushing) or EFDC simulations
  - Predicts changes in chlorophyll *a* corresponding to reductions in TN and TP
- Recreational model
  - Based on Phaneuf recreational study for Wake County
  - Predicts changes in trips based on TP, turbidity, and DO
  - Incorporates regressions based on the water quality database to predict changes in turbidity associated with water quality improvements
  - Holds DO constant

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Dealing with Designated Uses that are not Affected

- Flood storage
  - Communications with USACE indicate no changes to flood storage capacity
  - Use median annual benefit of Falls Lake flood storage
- Aquatic Life
  - Obtained Wildlife Resources Commission (WRC) fish catch data (length, weight, effort)
  - Preliminary analysis shows little difference in fish size relative to lake segment
  - DO and pH impairments are not present in the lake
  - Feasible strategies would maintain the non impaired status

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Evaluation of Existing Models

- Conducted preliminary review of EFDC and WARMF models
- Submitted questions to NCDWQ regarding setup and model development
- Incorporate NCDWQ responses into our assessment
- Provide loading comparisons of the models in the Task 3 memorandum
- Provide comparison of 2006 modeling results for EFDC model
  - With and without Hurricane Alberto

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Developing the ES Value Tool

- Framework for analyzing feasible strategies and potential outcomes
- Can be updated with future studies
- Integrate findings from existing models and data
- Link water quality and affected designated uses
- Summarize costs of management strategies
- Account for UNRBA preferences

Schedule Revisions

- Data capture took much longer than expected
  - “Called it” June 8th to proceed with the Task 2 TM
  - Still receiving metadata
  - Meetings and discussions with CAAE regarding their data
- Received much more data than anticipated
  - Filtered database is 4 times larger than expected
  - Shifted staff resources to analyzing data and writing Task 2 TM
  - Delayed beginning work on Task 3, but were able to move forward with parts of Task 1

Schedule Revisions, Continued

- Revised schedule is TBD
  - Dependent on decisions regarding Task 2 TM revisions
  - Scheduling meeting with NCDWQ to discuss methods for calculating jurisdictional loads
- Status update at November Board meeting
- Final presentation to Board in January 2013

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