Eno River, photo courtesy of Kevin Frank

UPPER NEUSE WATER QUALITY MONITORING PLAN

TRIANGLE J COUNCIL OF GOVERNMENTS, SEPTEMBER 2012

TJCOG has partnered with a diverse set of stakeholders to develop a long-term water quality monitoring plan for the Upper Neuse River Basin. The plan includes a comprehensive monitoring framework and a set of monitoring design guidelines developed collaboratively with stakeholders that address discrete monitoring objectives in five broad categories (Agriculture, Background Sources, BMP Effectiveness, Stormwater and Existing Development, and Onsite Wastewater,

UPPER NEUSE WATER QUALITY MONITORING PLAN

TRIANGLE J COUNCIL OF GOVERNMENTS, SEPTEMBER 2012

PROJECT SUMMARY

Through this project, Triangle J Council of Governments (TJCOG) has partnered with a diverse set of stakeholders to develop a long-term water quality monitoring plan for the Upper Neuse River Basin.

The Upper Neuse River Basin (DWQ sub-basin 03-04-01) drains to Falls Lake, a large drinking water reservoir in the Piedmont region. Chlorophyll-*a* and turbidity levels in Falls Lake exceed state standards, and the Lake was listed as "impaired" for its designated uses on the Draft 2008 303(d) list. A Nutrient Management Strategy was approved by the N.C. Rules Review Commission (RRC) at their December 16, 2010 meeting. Subsequently, the rules were approved with an effective date of January 15, 2011.

Despite the importance of the lake, the substantial water quality issues it faces, and the expense of the measures being implemented to address these issues, water quality monitoring data for the lake and its tributaries continues to be infrequent and sparse. This condition undermines efforts to effectively implement and track effective water quality management, or to inform state and local representatives about progress and outcomes. Moreover, there are 8 other drinking water supplies in the basin and 16 water body assessment units in the basin that are listed as impaired. Consistent and appropriately located water quality monitoring is not only needed to effectively management water quality in Falls Lake, but also to manage water quality in each of the other drinking water supplies and other impaired waters.

As noted above, a long-term, consistent, and standardized water quality monitoring program has been needed to ascertain pollutant sources, track water quality changes, infer trends, and gauge the effectiveness of water quality management strategies. Furthermore, a comprehensive and collaborative approach to monitoring in the basin will encourage inter-agency cooperation, streamline data collection and reporting, and provide several key economies of scale. This project aims to develop a plan and research partnership frameworks to implement such a long-term water quality monitoring program and/or its components.

THE PROJECT

TJCOG has partnered with a diverse set of stakeholders to develop a long-term water quality monitoring plan for the Upper Neuse River Basin. The plan includes a comprehensive monitoring framework and a set of monitoring design guidelines developed collaboratively with stakeholders that address discrete monitoring objectives in five broad categories (Agriculture, Background Sources, BMP Effectiveness, Onsite Wastewater, & Stormwater/Existing Development).

This project could not have been completed without the hard work and commitment of the stakeholders involved. A special thank you goes out to all of you who contributed an extensive amount of your time and expertise to this very important work.

Finally, a huge thank you goes to the N.C. Department of Water Quality for supporting our work and funding us through a 205(j) Water Quality Management Planning Grant.

TRIANGLE J COUNCIL OF GOVERNMENTS

CLEAN AND SAFE WATER

Consistent, cohesive, objective-driven data collection provides information critical to protecting the quality of basin water resources. This project meets the goal of clean and safe water by providing a water quality monitoring plan and program framework that stakeholders can use to coordinate and streamline data collection in order to understand water quality in the Upper Neuse River Basin. Furthermore, implementation of the monitoring guidelines presented in this plan would enable local governments, municipalities, and other agencies to assess the effectiveness of the Falls Lake Nutrient Management Strategy and other water quality management strategies, as well as to adapt and improve the strategies based on scientific information. This project also directly address the Section 205(j) of the Clean Water Act (of 1987) objective of "determining the nature, extent, and causes of water quality problems…" and aims to help address the Act's objective of "identifying [the] most cost-effective and locally acceptable facility and non-point measures to meet and maintain water quality standards."

PROJECT BACKGROUND

The Falls Lake watershed or Upper Neuse River Basin (DWQ sub-basin 03-04-01) is a watershed of statewide significance. There are 9 surface water supplies in the Basin that provide drinking water to more than 600,000 residents in Raleigh, Durham, Hillsborough, Creedmoor, and Butner, in addition to Orange, Durham, Granville, and Wake Counties. These include Falls Lake, Lake Michie, Little River, Lake Holt, Lake Orange, New Hillsborough Lake, Corporation Lake, Lake Ben Johnston, and Lake Rogers. Furthermore, as of the draft 2008 303(d) list, there are 16 impaired assessment units in the Falls Lake watershed.

Assessment Unit	Water Body and Location	Parameter(s) of Interest
27-(1) WS-IV;NSW,CA	**NEUSE RIVER (Falls Lake below normal pool elevation)** From source (confluence of Eno River Arm and Flat River Arm) to I-85 bridge	Turbidity Chlorophyll a
27-(5.5) WS-IV,B;NSW,CA	**NEUSE RIVER (Falls Lake below normal pool elevation)** From I-85 bridge to dam at Falls Lake	Chlorophyll a
27-11-(0.5) WS-IV;NSW	**Lick Creek** From source to Wake County SR 1809	Ecological/Biological Integrity Benthos
27-11-(1.5) WS-IV;NSW	**Lick Creek** From Wake County SR 1809 to Falls Lake, Neuse River	Ecological/Biological Integrity Benthos
27-15-(1) WS-IV;NSW	**Upper Barton Creek** From source to a point 0.5 mile upstream of Wake County SR	Ecological/Biological Integrity Benthos
27-3-(8) WS-IV;NSW	**Flat River** From dam at Lake Michie to a point 0.2 miles upstream of Durham County SR 1004	Low dissolved oxygen
27-3-(9) WS-IV;NSW,CA	**Flat River (incl. the Flat River Arm of Falls Lake)** From a point 0.2 miles upstream of Durham County SR 1004 to Falls Lake, Neuse River	Low dissolved oxygen
27-4-(6) WS-IV;NSW	**Knap of Reeds Creek** From dam at Lake Butner to a point 1.9 miles downstream of Granville County SR 1120	Not listed
27-4-(8) WS-IV;NSW,CA	**Knap of Reeds Creek** From a point 1.9 miles downstream of Granville County SR 1120 to Falls Lake, Neuse River	Ecological/biological Integrity Benthos
27-5-(0.3) C;NSW	**Ellerbe Creek** From source to I-85 bridge	Ecological/biological Integrity Benthos
27-5-(0.7) WS-IV;NSW	**Ellerbe Creek** From I-85 Bridge to a point 0.2 mile upstream of Durham County SR 1636	Ecological/biological Integrity Benthos
27-5-(2) WS-IV;NSW,CA	**Ellerbe Creek** From a point 0.2 mile upstream of Durham County SR 1636 to Falls Lake, Neuse River	Ecological/biological Integrity Benthos
27-9-(0.5) WS-IV;NSW	**Little Lick Creek** From source to a point 0.4 mile upstream of Durham County SR 1811	Low dissolved oxygen Turbidity
27-9-(0.5)ut2 WS-IV;NSW	**UT2 to Little Lick Creek** From source to Little Lick Creek	Low dissolved oxygen
27-9-(2) WS-IV;NSW,CA	**Little Lick Creek (incl. portion of Little Lick Creek Arm of Falls Lake)** From a point 0.4 mile upstream of Durham SR 1811 to Falls Lake, Neuse River	Low dissolved oxygen Turbidity
27-9-(2)ut2 WS-IV;NSW,CA	**UT2 to Little Lick Creek (incl. portion of Little Lick Creek Arm of Falls Lake)** From a source to Falls Lake Little Lick Creek	Low dissolved oxygen

The Upper Neuse River Basin drains to Falls Lake, which is one of the largest drinking water reservoirs in the Piedmont. The City of Raleigh withdraws an average of 50 million gallons per day from Falls Lake to supply drinking water to residents and businesses throughout Wake County. Recently, the N.C. Department of Environment and Natural Resources (DENR) determined that chlorophyll-*a* and turbidity levels in Falls Lake exceed state standards, and the Lake was listed as "impaired" for its designated uses on the Draft 2008 303(d) list. In January of 2011, the Falls Lake Nutrient Management Strategy (2005 Senate Bill 981) was passed to address nutrient enrichment and algae problems.

Despite the importance of the Basin, the substantial water quality issues it faces, and the expense of the measures being implemented to redress these issues, water quality monitoring data for the lake and its tributaries continue to be infrequent and sparse, resulting in little to no information to effectively inform water quality management. Many existing monitoring stations are clustered in the major tributaries to water supply reservoirs, while other monitoring to provide local information is minimal to nonexistent. Basic questions about water quality in the basin, especially those that involve trend analysis (e.g., "is water quality getting better or worse?") or the geographic aspects of pollution, are difficult to answer conclusively without better water quality data.

A long-term, consistent, and standardized water quality monitoring program is needed to identify sources of pollution, monitor water quality changes, and gauge the effectiveness of water quality management strategies. Furthermore, a comprehensive and collaborative approach to monitoring in the basin will encourage inter-agency cooperation, streamline data collection and reporting, and provide important economies of scale.

PROJECT OBJECTIVES

The primary objective of the project has been to develop a long-term water quality monitoring plan for water bodies in the Upper Neuse River Basin. Currently, the ability of managers to assess the causes and sources of water quality degradation and effectiveness of management strategies is limited due to lack of consistent and comparable data. The development of a comprehensive monitoring plan aims to address this problem and provide managers with the tools and data necessary to inform corrective and protective actions. The plan has been developed with the involvement of potential implementing agencies and funders, such as local governments, the US Geological Survey, NC State University, research and academic institutions and the NC Division of Water Quality (DWQ). It includes a comprehensive monitoring framework and a set of monitoring design guidelines developed collaboratively with stakeholders that address discrete monitoring objectives in five broad categories (Agriculture, Background Sources, BMP Effectiveness, Onsite Wastewater, and Stormwater/Existing Development). In many instances, the monitoring design guidelines include potential sampling parameters, frequencies, locations, and partnerships, as well as considerations for QAPP/QAQC procedures and archiving and reporting protocols.

A secondary objective of the project has been to recommend potential partnership arrangements by which to fund and administer water quality monitoring programs based on the proposed monitoring plan. The resulting program could be administered and funded with cost-sharing arrangements similar to those of the Upper Cape Fear River Basin Association, the UNRBA, or Triangle Area Water Supply Monitoring Project. Other partners may elect to continue their respective collection of water quality data, but data collection will be better coordinated and housed to facilitate cross-analysis with a basinwide monitoring plan that harmonizes these efforts.

PROJECT ELEMENTS, PRODUCTS AND SCHEDULE

The main project elements include 1) project management and stakeholder administration, 2) an inventory and evaluation of current surface water quality efforts and information, 3) a determination of stakeholders' monitoring objectives, and 4) a comprehensive monitoring framework and set of monitoring design guidelines developed collaboratively with stakeholders that address discrete monitoring objectives. In many instances, the monitoring design guidelines include potential sampling parameters, frequencies, locations, and partnerships, as

well as considerations for QAPP/QAQC procedures and archiving and reporting protocols. Completed project elements are described in detail below.

Element 1. Project Management and Stakeholder Administration

A. *Solicit initial advisory group participation; set up and maintain contact information*

B. *Go over project timeline with advisory group and build support for the project, refine subtasks*

C. *Develop and maintain project web page to house meeting summaries, technical memoranda, etc.*

D. *Coordinate project and tasks among advisory group, project partners, and project staff (phone calls and incidental meetings)*

E. *Manage financial transactions and invoice DWQ quarterly*

F. *Write project final report per 205(j) grant requirements*

Products: *Quarterly invoices and final report*

Schedule: *Ongoing for duration of project*

Element 2. Inventory and evaluate relevant water quality monitoring efforts, resources, and information

A. *Update inventory of current monitoring efforts (parameters, frequencies, locations) and Mary Giorgino's basic list of monitoring gaps*

B. *Research recommendations for monitoring & data management (literature & program review)*

C. *Develop and administer stakeholder survey on monitoring lessons learned, costs, capacity, service providers, and information needs*

D. *Compile and evaluate monitoring inventory and survey results into a draft technical memorandum*

Product: *Draft technical memorandum providing a synthesis of current water quality monitoring efforts and survey results.*

Project website

Schedule: *Completion Date: 6 months (24 weeks) from contract start date*

Element 3. Determine potential monitoring objectives and research potential components of the monitoring program

A. *Share draft technical memorandum with advisory group, solicit feedback, prepare to discuss objectives and program needs*

B. *Brainstorm program objectives and possible phases of monitoring program based on needs with advisory group; Brainstorm project objectives with other stakeholders as necessary; Prioritize objectives and phases of monitoring with advisory group. Identify opportunities/need for special studies or projects*

C. *Finalize technical memorandum to add prioritized program objectives and other feedback*

D. *Determine broad set of parameters, locations, and frequencies associated with various high-priority objectives (levels of service/program phases)*

E. *Research potential data management, archiving and reporting protocols and data products (e.g., water quality indices)*

F. *Research potential QAPP/QAQC requirements and get input from DWQ*

G. Estimate costs associated with different levels of service/phases/high-priority objectives

Product: Final technical memorandum summarizing current water quality monitoring efforts and survey results, as well as prioritized objectives as determined by stakeholders.

Draft template for monitoring design guidelines for discrete objectives including potential monitoring parameters, locations, and frequencies; draft preliminary data management, archiving, and reporting protocols; draft QAPP/QACC considerations; and an evaluation of the costs associated with different levels of service and/or monitoring phases.

Schedule: Completion Date: 10 months (40 weeks) from contract start date

Element 4. Investigate funding mechanisms and institutional frameworks

A. Investigate and compile list of available funding mechanisms and pros/cons of each; share with advisory group

B. Discuss objectives, services, and funding mechanisms with advisory group; determine potential partnership frameworks (including creating a new partnership, expanding existing partnerships, etc.)

C. Review Sample Partner Agreements and share with potential program partners via email, revise as appropriate

D. Review template RFPs for contractors who would conduct monitoring for the programs

Products: Draft monitoring design guidelines for highest-priority objectives

Example Partner Agreements

Example RFPs for monitoring services

Schedule: Completion Date: 12 months (48 weeks) from contract start date

Element 5. Develop basinwide monitoring program framework and plan

A. Based on the highest-priority objectives, determine monitoring approaches (sampling locations, parameters, frequencies), and other program recommendations (partnerships, oversight, QA/QC considerations, data management and reporting, funding mechanisms), solicit advisory group input via email

B. As resources and access allow, field verify potential station locations, and revise locations as needed

C. Finalize monitoring design guidelines based on Elements 1-4. Monitoring design guidelines to include information collected in Elements 2, 3 and 4

D. Develop recommendations for coordinating with local and other monitoring efforts (volunteer, DWQ, Muddy Water Watch, etc.)

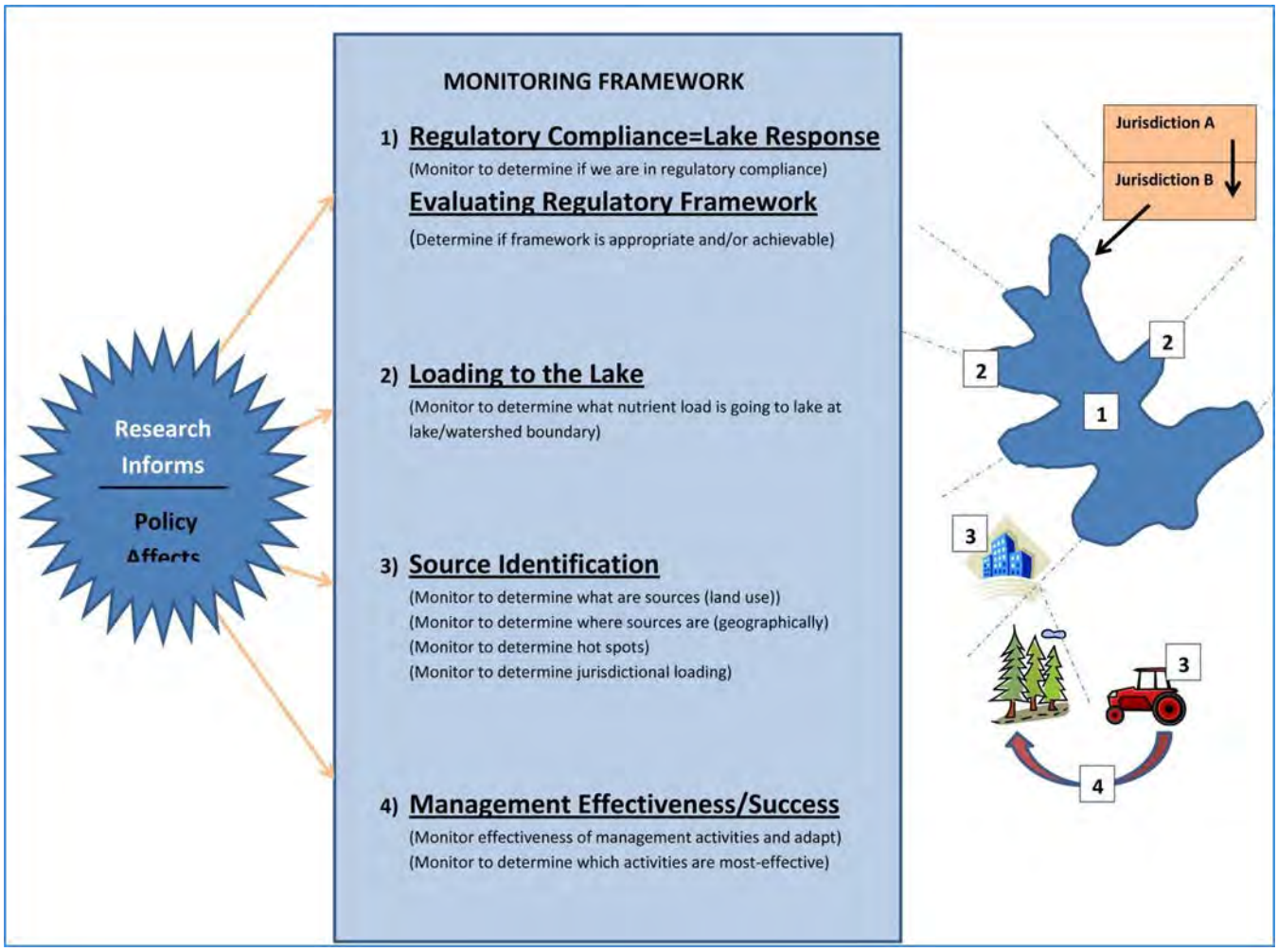
Products: Final Report describing a comprehensive long-term monitoring plan for the Upper Neuse River Basin. The Final Report will include a comprehensive monitoring framework and a set of monitoring design guidelines developed collaboratively with the stakeholders and advisory group that address discrete monitoring objectives. The monitoring design guidelines will include potential sampling parameters, monitoring frequencies, monitoring locations, and partnerships as well as considerations for QAPP/QAQC procedures and archiving and reporting protocols.

Schedule: Completion Date: 18 months (72 weeks) from contract start date

PROJECT EVOLUTION

When the project was submitted for funding, the Falls Lake Nutrient Management Strategy had not yet been approved. As the project progressed, the Falls Lake Nutrient Management Strategy was approved and stakeholder priorities for this project began to diverge.

TJCOG had originally proposed to develop a series of consecutive technical memoranda that would be combined into one final plan, applicable for all of the Upper Neuse River Basin. However, after the rules were adopted, some stakeholders felt strongly about developing a monitoring plan that would evaluate the appropriateness of the Falls Lake Nutrient Management Strategy as a regulatory framework (see 1 of the diagram below), while others felt strongly that they wanted a monitoring plan that would help them determine their source contributions and assess the effectiveness of their management activities (see 3 and 4 of the diagram below. A further discussion of the framework presented in the diagram in provided in the Section "Monitoring Framework").



The members and local governments who make up the Upper Neuse River Basin Association were interested in and well poised to work on evaluating the appropriateness of the Falls Lake Nutrient Management Strategy and decided to pursue that option independent of this project. That allowed this process to adapt its aim to focusing on the evaluation source identification and management effectiveness.

The revised work plan included a set of monitoring design guidelines that were to be developed concurrently through the project and then combined into this final plan. As TJCOG gained a better understanding that different stakeholder groups may have very different monitoring objectives, which will require different monitoring designs, the outcome of this process was adapted to better facilitate the future implementation of monitoring in the basin. As a result, stakeholders formed 5 subcommittees (agriculture, Background Sources, BMP effectiveness, Onsite Wastewater, and Stormwater and Existing Development) to work on prioritizing objectives for each of those areas and drafting Monitoring Design Guidelines based on those priorities. The proposed revision better allows different stakeholders groups to pursue funding for the specific water quality monitoring that meets their objectives, while assuring there is an overall coordination of monitoring through a comprehensive monitoring framework developed as part of this project.

STAKEHOLDERS AND SUBCOMMITTEES

During 2010, 2011, and 2012, this project has been supplemented and benefited by the participation of so many different stakeholders from so many different disciplines. A list of participating stakeholders can be found in the meeting summaries. You can locate meeting summaries in "Attachment A. Meeting Agendas, Summaries, and Presentations" or on the Project Wiki at http://upperneusewqmonitorng.wikispaces.com/Meeting+Summaries. Stakeholder representation included local governments, local watershed groups, state and federal agencies, concerned citizens, private consultants, and Councils of Government, among others.

As noted above, in addition to the large stakeholder group, many stakeholders opted to also participate in subcommittees to prioritize monitoring objectives for agriculture, background sources (such as forests, air deposition, and in-lake sediment), BMP effectiveness, onsite wastewater, and stormwater and existing development, and develop Monitoring Design Guidelines based on these priorities. . In many instances, the Monitoring Design Guidelines include potential sampling parameters, frequencies, locations, and partnerships, as well as considerations for QAPP/QAQC procedures and archiving and reporting protocols.

Subcommittees met monthly. A list of subcommittee members and activities can be found on the Project Wiki at http://upperneusewqmonitorng.wikispaces.com/. A further discussion of Monitoring Design Guidelines developed through this process is provided in "Monitoring Design Guidelines".

Project Management and Administration

Meeting agendas, summaries, and presentations have been provided in Attachment A. A basic summary of meetings and meeting objectives is provided below.

1st Large TJCOG Stakeholder Meeting (Nov 2010)

A. *Compiled objectives (100's!!)*
B. *Categorized/combined objectives into themes*

1-3 "Working Group" Meetings (Oct 2010–Mar 2011)

A. *Lake Monitoring*
B. *Existing Monitoring Efforts*
C. *Monitoring Framework/Adapting to Change*
   i. *Working group recommended that TJCOG adapt their process to inform other objectives identified through TJCOG process (such as identifying sources and tracking effectiveness)*

2nd Full Stakeholder Meeting (Sep 2011)

A. *Came back to full group to explain changes*
B. *Updates from UNRBA, Watershed Oversight Committee, NSAB*
C. *Presented Monitoring Design Guidelines Template (MDGs) to help answer prioritized objectives with regard to (3) source identification and (4) management effectiveness.*
D. *Created 5 Subcommittees to develop Monitoring Design Guidelines*
E. *Ag, Background Sources, BMP Effectiveness, Onsite Wastewater, and Stormwater and Existing D*
F. *Subcommittees started meeting regularly (~ monthly) to prioritize objectives and draft MDGs.*

3rd Full Stakeholder Meeting (Feb 2012)

A. *Wiki Tutorial*
B. *Subcommittee Updates (Agriculture, Background Sources, BMP Effectiveness, Onsite Wastewater, and Stormwater and Existing Development)*
   i. *What They've Been Doing (process and how we got where we are)*
   ii. *Progress of Monitoring Design Guidelines (if applicable)*
   iii. *Sharing Areas of Confusion and Group Feedback*
   iv. *Identify Areas of Overlap or Need for Coordination*
C. *Small Group work*
D. *Subcommittees continue meeting regularly (~ monthly) to draft MDGs*

4th Full Stakeholder Meeting (June 2012)

A. *Project review and recap*
B. *Update on Durham Atmospheric Deposition Study*
C. *NCDWQ Panel and Discussion on Implementation-Oriented Uses and Users of Water Quality Data. NCDWQ Panelists:*
   i. *Pam Behm, Modeling & TMDL Unit*
   ii. *Kathy Stecker, Modeling & TMDL Unit*
   iii. *John Huisman, Non-point Source Planning Unit*
   iv. *Rich Gannon, Non-point Source Planning Unit*

5th Full Stakeholder Meeting (September 2012)

A. *Project review and recap*
B. *Presentation of final report and Monitoring Design Guidelines*
C. *BBQ Celebration*

Inventory and Evaluation of Current Surface Water Quality Efforts and Information

One important objective of this work has been to inventory and evaluate relevant water quality monitoring efforts, resources, and information to determine what monitoring has already been done in the watershed or is currently ongoing. To this effect, a detailed memorandum was developed in order to synthesize the information gathered through this project on monitoring activities that have occurred or are occurring in the watershed. This critical piece of knowledge will help identify gaps in monitoring data, encourage regional cooperation, and avoid redundancy in monitoring efforts. The full memorandum is available as Attachment B.

Local Government/Local Partners Survey

In order to begin collecting information on monitoring activities, a survey and questionnaire was developed and sent to local governments and other resource groups active in the Upper Neuse River Basin as a "homework assignment". The questionnaire is included below.

HOMEWORK ASSIGNMENT – LOCAL MONITORING ACTIVITIES QUESTIONNAIRE

1. *Review Mary Giorgino's (of the USGS) "Current Monitoring in the Upper Neuse Basin" documents.*
   a. *Make corrections and edits as necessary using MS Word's Track Changes feature and return to Heather Saunders at hsaunders@tjcog.org.*
2. *2. If the write-up on your activities does not already address the following, please add information on:*
   a. *What parameters you are monitoring and what is the monitoring frequency*
   b. *Where are your monitoring locations?*
   c. *Your monitoring and data collection methods*
   d. *Changes in any of these aspects, and why*
   e. *Your current annual monitoring cost*
   f. *How long you have been monitoring each location and/or parameter (study duration)*
3. *In addition, please include any thoughts on the following as an addendum to the document:*
   a. *What is your current and future capacity is for monitoring?*
      i. *How much staff time do you put towards it currently on an annual basis?*
      ii. *Can you maintain this or increase your effort?*
   b. *Who are your service providers (e.g. labs)?*
      i. *Would you recommend them?*
      ii. *Are there any labs you do not recommend?*
   c. *What do you perceive as your additional data needs?*
   d. *Any additional thoughts on lessons learned as a result of your current or past monitoring experience.*
4. *Finally, please supply Heather Saunders (hsaunders@tjcog.org) with a GIS data coverage layer of your current ambient surface water monitoring locations, including any stream gages, and groundwater stations.*

Local government staff, as well as local agency staff responded by providing their current monitoring plans in PDF and GIS formats. A collection of reports on local water quality monitoring activities is provided in

Attachment B. In addition, two maps depicting water quality monitoring locations is provided in Attachment C, one with wells, and one without.

Local Government/Local Partners Presentations

Local governments and other monitoring groups were also asked to present to the Upper Neuse Water Quality Monitoring Plan stakeholders on their current monitoring activities at the 2nd Working Group meeting on February 1, 2011. Ken Reckhow, USGS, the NCDWQ, the City of Raleigh, the City of Durham, and Wake County all presented on their monitoring activities and were asked to provide some discussion on the following:

1. What monitoring you are currently doing;
2. Why you are doing it;
3. What you've learned and/or modified over time and why;
4. What are your general costs and capacities for monitoring;
5. Any thoughts on service providers; and
6. What you perceive as your missing pieces. What would you like to add?

Monitoring presentations are available on the wiki at http://upperneusewqmonitorng.wikispaces.com/Meeting+Summaries.

Determination of Stakeholders' Monitoring Objectives

During the first full stakeholder meeting in November 2010, stakeholders were asked to take time to review a list of monitoring objectives that were listed in response to the question "What goals and objectives do you or your jurisdiction have for any new monitoring or modeling of Falls Lake or the Falls Lake watershed" at a meeting hosted by Durham in September of 2010. These objectives were listed on sticky notes and placed on a whiteboard. As a result, participants wrote and added any objectives to the list as necessary. A list of these objectives is provided below and is also available in Attachment C. The group then grouped the objectives into like categories and gave each group a category. The group came up with the groupings provided below. The headings and the objectives assigned to them by the group are described in Table 1. These objectives were later refined, revised, and prioritized according to subcommittee preferences for proposed monitoring activities.

- Sources/Dynamics of Nutrient Loading
- Nutrient Mapping
- Lake Response Timeline
- Lake Characterization
- Modeling Concerns
- Institutional Oversight
- Regulatory Acceptance/QACC/QAPP
- Management Effectiveness
- Emerging Contaminates
- Use Support Analysis
- Public Education and Outreach
- Drinking Water
- Wildlife Management
- Data Consolidation

TABLE 1. OBJECTIVES FOR A WATER QUALITY MONITORING PLAN AS GROUPED INTO HEADINGS.

SOURCES/DYNAMICS OF NUTRIENT LOADING

- What is entering the lake? Chlorophyll a, other tributaries N, P and Chlorophyll *a*
- Are loads to the lake declining? (N, P and chlorophyll a)
- What is entering the lake? (Chlorophyll a, other tributaries (N, P, Chl a)
- Where is the best location (stable) to monitor inputs to the lake?
- Sources Mapping
- Unknowns: Fertilizer, septic, sediment-attached P, atmospheric deposition
- What are the impervious cover characteristics of the watershed? (Where is IC and how is it distributed?)
- Understand (soils for) onsite wastewater attenuation rates
- What are the actual loads distributed from throughout the watershed? Can we better understand sources by having a watershed model that is calibrated to measured loads at multiple locations? At jurisdictional boundaries?
- What loads come from each jurisdiction?
- Characterize internal lake load
- What is approximate nutrient loading into Falls Lake watershed from groundwater?
- Nutrient loads from groundwater discharge
- Lake boundary conditions (are loads to the lake declining (N, P, Chl a))?
- Understand how loads from agriculture (equine) differ from others (flow, composition, urban/suburban)
- Where is the best location (stable N, P, Chlorophyll a) to monitor inputs to the lake?
- Nutrient loading by source type. Base, ongoing, and current as of date.
- Distinguishing sources of different types of Nitrogen (i.e. residential, fertilizer vs. onsite wastewater)
- Watershed characterization
- Characterize sources better
- Measured load from forests (slate vs. Triassic)
- Nutrient loading by source type, 2006 base and ongoing

NUTRIENT MAPPING

- Characterize the distribution of loads
- Load distribution (at jurisdictional boundaries)
- What loads come from each jurisdiction?
- What are the actual loads distributed from throughout the watershed? Can we better understand sources by having a watershed model that is calibrated to measured loads at multiple locations? At jurisdictional boundaries?
- Know loads by jurisdiction & tributary
- Nutrient loading by jurisdiction and by subwatershed (2006 base and ongoing, current as of date certain)
- Better unit loading rates that may vary by geography and by land use
- Nutrient trading tool (USDA, lbs N, lbs P, reductions)

LAKE RESPONSE TIMELINE

- Given high internal loading in the lake, how will the lake respond to changes in the load?
- Data and analysis that can be used to forecast or "backcast" conditions
- What contribution of P (maybe N) does re-suspension have on the total nutrient load to be managed in

the lake?

Lake Characterization

- Understand current condition of the lake
- Lake Boundary Conditions (are loads to the lake declining (N, P, Chl a)
- How much does water level fluctuation contribute to internal loading in the lake?
- Forest is the largest component of the watershed. What are the actual nutrient loads from forests in the Triassic basin?
- Understand loads from forest and atmospheric deposition
- Ask Corps of Engineers to do research evaluating lake operations on water quality
- Which streams do not have intact riparian buffers?
- Atmospheric deposition—coordinate with energy & air quality efforts with regard to nutrients
- Account for atmospheric deposition

Modeling Concerns

- Monitor Rainfall
- Given that the model used rain data from RDU, would local monitoring of rainfall improve hydrologic calibration?
- Determine if modeling is as accurate as possible given state of science.
- Propose a new model(s) to address any identified deficiencies. Make sure flexible enough to incorporate new learning
- Account for lake operations in model
- Fix short-comings of the existing model
- Capability to develop our own model
- Account for atmospheric deposition
- Gather new data for remodeling in 2018 (means we need to know which model will be used)
- What does good long-term lake & watershed management look like? (account for droughts, pool re-allocation, hurricanes)
- Better definition of how data will be used to modify NMS
- What are the least number of sites that would allow a remodel and use support assessment
- Data and analysis that can be used to forecast or "backcast" conditions
- New models needed
- Better unit loading rates that may vary by geography/use

Institutional Oversight

- Analyze process needs. Get Association
- Get Association together and let them determine accounting tools (instead of the Jordan Lake stakeholders)
- Define minimum data requirements
- One testing program accepted by all stakeholders and DWQ
- Know how DWQ is going to assess nutrient reductions for BMPs. Need to know requirements before assessing in projects (site specific before/after modeling?)

Regulatory Acceptance/QACC/QAPP

- One testing program accepted by all stakeholders and DWQ

- Negotiate MOA or program with DWQ for entire monitoring program
- Neutral & unbiased monitoring, management and oversight
- Data is accepted by DWQ
- Standardized methods, consistent and state approved.
- EPA & DWQ agreement on using correct & cost-effective study methods
- Implementable (fundable) plan that DWQ will accept

Management Effectiveness

- Tell us whether management efforts are succeeding (a vigorous effort)
- Understand how management practices are affecting loads (individual and cumulative)
- Know by 2017 (at least) where we are vis-à-vis Stage I.
- Know the value of EACH individual management strategy (e.g., septic, ag). Do the BMPs work?
- Tell us whether management efforts are succeeding; track success of NMS by source (agriculture, existing development, etc.)
- Determine if BMPS are effective
- Focused sub-basin monitoring designed to isolate impacts from individual sources and improvements after BMPs implemented (to use to calibrate for basin future modeling efforts)
- Monitor BMPs

Emerging Contaminates

- Consider pollutants other than just nutrients (i.e. those that pose health risks to users of water)
- Consider emerging pollutants (endocrine disruptors, personal care products, cyanotoxins)
- Need to know levels of endocrine-disrupting chemicals, pharmaceuticals, and personal care products. Will help determine/reflect sources of input to the lake and watershed

Use Support Analysis

- Evaluate how well the land (public) meets needs (recreation) in watershed
- Evaluate Past, Present and Future Uses of the Lake
- Determine if existing water quality standards support existing uses. Are they too restrictive, too loose, or missing?
- Evaluate how well the lake meets existing uses. Water supply, aquatic life propagation, recreation (boating, swimming, fishing)
- Evaluate the degree to which the lake has, is, or can support all its authorized uses.
- Supports UAA (Use Attainability Assessment) or change in use (water quality standard) for upper Falls Lake

Public Education and Outreach

- Designation of Actions/Behaviors that residents, volunteers, and non-profits can do that won't cost taxpayers money
- Expand/Improve/Increase public awareness and participation in annual big sweep events; track totals
- Subsidize or incentivize residential composting; track # participants

Drinking Water

- Understand relationship between TOC, nutrients, and Chlorophyll a

WILDLIFE MANAGEMENT • Learn about fish populations and biota in upper and lower lake relative to chlorophyll a and turbidity (impairment) • Map urban stream syndrome (deeply incised streams)
DATA CONSOLIDATION • Make sure our data can support decisions at a high level of certainty within regulatory time frame. • Translate/compare data collected using different methods (if possible) • Stable Funding (no gaps in data collection) (timing longitudinal) • Understand current monitoring efforts • Cost-effective, well-coordinated with other efforts • Address data gaps • Assess data being collected (current monitoring plans) • Develop data standards for monitoring data and tools; convert current monitoring from various sources into a more common format • Clear system of water quality benchmarks, relevant to decision-makers and public

*Uncategorized objectives include 1) alternatives to chlorophyll a as an indicator, 2) TRUST, and 3) Work together, Do Good Things

The participants were then asked to work at their tables to come up with 5-10 specific questions that monitoring could answer and each table was assigned a category. Questions generated through this activity are described in Table 2 (also provided in Attachment C).

TABLE 2. QUESTIONS FOR A WATER QUALITY MONITORING PLAN GENERATED WITH HEADING NAMES.

Sources and Dynamics of Nutrient Loading/Nutrient Mapping

- Identify sources of nutrients within and outside our combined regulatory purview.
- For nutrients within regulatory purview, identify sources of nutrients by use and by jurisdiction.
- For modeling, accounting for transport/attenuation/uptake as they relate to streams, for different media (i.e. groundwater, types of streams).
- How might different land uses inform efficient monitoring regimes?
- Better understanding of poorly quantified nutrient sources (sources not regulated); can we trust nutrient trading tools?

Lake Response

- What short-term changes in phytoplankton and chlorophyll-a community composition occur with measured load reductions from watershed?
- How important is internal nutrient loading vs. allocthonous loading in the lake?
- What are the major influences on watershed and lake hydrology?
- What are influences of hydrology on nutrient expression in lake?

Lake Characterization

- Where are the nutrient source loads originating from within the lake and watershed?
- How does nitrogen get processed in lake?
- What level of nutrients can the lake process?
- Differentiate mass loads from different sources in watershed.

Modeling Concerns

- What type/quantity of monitoring data to use?
- What models are needed/appropriate?
- Who develops the model?
- What is the goal of the model?
- Frequency of review and recalibration?
- Who interprets data and model output?
- What is appropriate time for sampling?

Institutional Oversight and Regulatory Acceptance

- What are standards that would be acceptable to DWQ and local governments?
- Who will develop the standards?
- What organization will have oversight and will this be by consensus?

Management Effectiveness

- Perform targeted evaluations of BMP assumptions.
- Are there things we can do to evaluate model effectiveness?
- Is management effectiveness a core goal of water quality monitoring process?
- Can data on management effectiveness help feed data for compliance?
- Question of degree to which evaluating the management effectiveness a core goal?

- Different levels of evaluation.
- Are loads to lake declining?
- Goals discussed at this table:
    - Understand relationship between TOC and chlorophyll-*a*.
    - Gather data on chlorophyll-*a* and other parameters such that model can be run to determine whether Stage II is appropriate.
    - Gather data for a use attainability analysis.
    - Targeted evaluations of established BMP assumptions.

Emerging Contaminants

- Are there measurable levels of emerging contaminants? At wastewater treatment plant effluent? In Falls Lake? In drinking water?
- If so, what are the concentrations compared to other research?

Drinking Water

- Is there a correlation between TOC, nutrients, and chlorophyll-*a*?

Use Support

- What type of monitoring should be performed to determine use support?
- Can existing data generate answers for use support questions?
- What are existing uses or classes and what type of land uses help determine use, land use focus on monitoring?

Public Outreach and Education

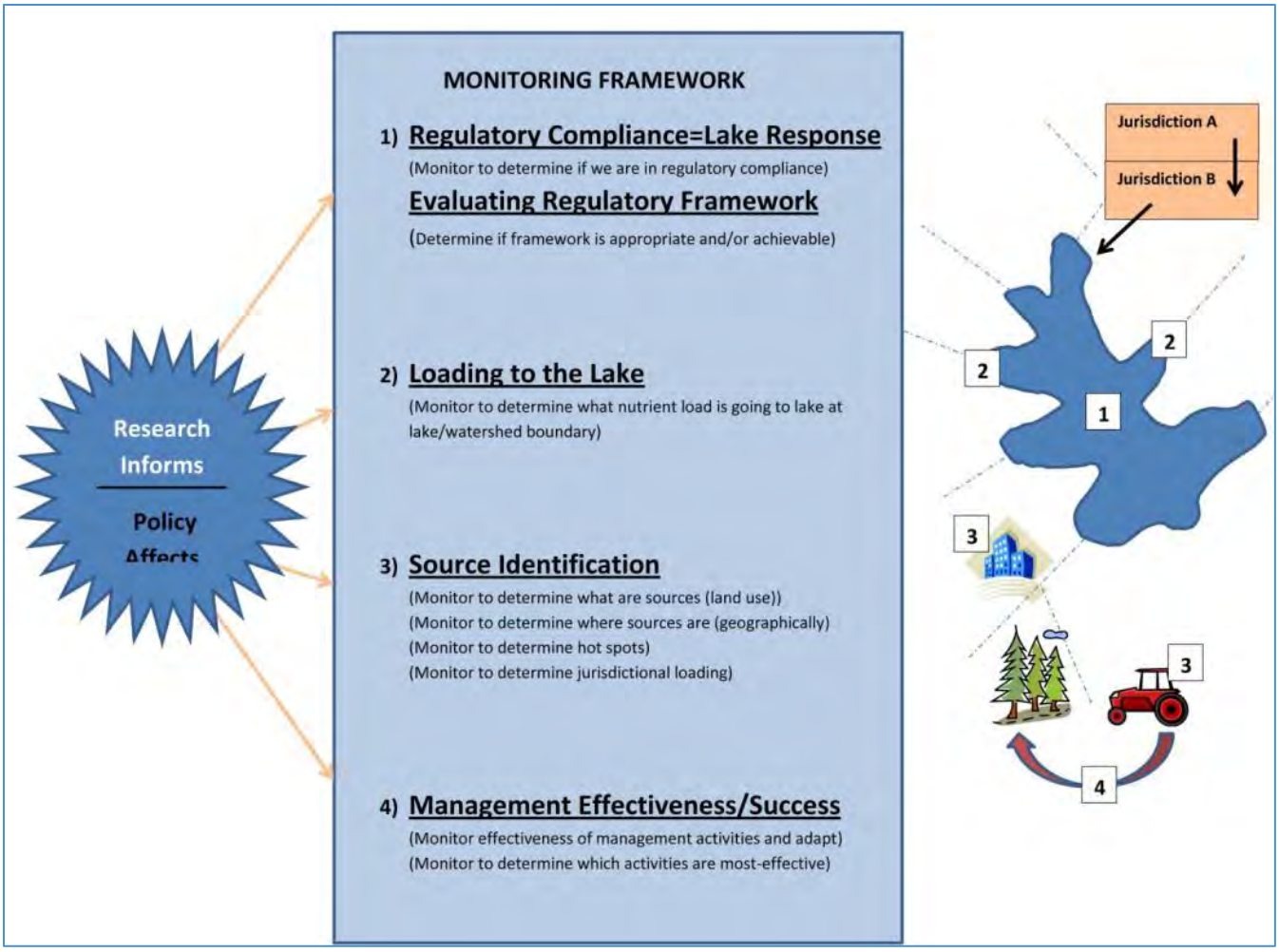
- Can monitoring generate increased participation in public outreach?
- Can monitoring determine effectiveness of public outreach involvement efforts?
- What are the priorities for public education?
- Do grassroots efforts such as residential composting produce reductions in nutrients? Is this too small a piece to measure?

Data Consolidation

- Is standardizing a test method a good way to achieve data consolidation?
- Is standardizing a test method a good way to achieve collection methods?
- Can permit regulations be modified to allow data consolidation?
- Can data consolidation be used to reduce duplication of effort and reduce overall cost?
- Can data consolidation be used to address existing data gaps?
- Can data consolidation help ensure the right data are being collected at an acceptable frequency?

Monitoring Framework

As the project progressed and evolved (see Project Evolution) TJCOG developed an illustration to be used in thinking about the context of an overall monitoring framework. In thinking about the overall intended outcomes of a monitoring plan, TJCOG identified 4 or 5 areas to be included in a comprehensive framework (see diagram below and Attachment D). The diagram was then tested by attempting to sort the listed objectives (see above) into one of the 4/5 areas. Despite a few outliers, the framework has captured most of the objectives that are monitoring related, and is thought to be a useful way of thinking about the design of a monitoring plan.



Monitoring Design Guidelines

The overall monitoring plan developed through this process is characterized by a set of Monitoring Design Guidelines (MDGs) developed collaboratively within subcommittee groups. These MDGs include (where applicable) a problem statement, background on the topic, regulatory context, a discussion of previous or existing monitoring studies related to the topic, nutrient markers, potential sampling parameters and monitoring design (frequency, location, and method), potential partnerships and/or funding organizations, as well as considerations for QAPP/QAQC procedures, and archiving and reporting protocols.

Subcommittees use the initial list of objectives identified by the stakeholders to prioritize their selections for MDGs and met monthly between September 2011 and July 2012 to work out issues collaboratively, preform literature reviews, and develop and refine the MDGs.

A list of subcommittee members and their selected Monitoring Design Guidelines is provided below. In addition, each MDG is available for review in the remaining part of this section. MDGs are meant to serve as ready-made proposals for any organization or group that is interested in pursuing funding and implementation. In addition, the list of subcommittee participants in an effort to suggest potential partners or partnerships for any interested group or agency.

Agriculture Subcommittee

	Name	Organization	Email	Phone
Secretary	Mike Dupree	Durham Soil & Water	mdupree@durhamcountync.gov	919-560-0598
	Barbara Oslond	NC Horse Council	BLOQResources@gmail.com	919-454-8162
	Tom Davis	Orange County	tdavis@co.orange.nc.us	919-245-2513
	Kathy Stecker	NC Division of Water Quality	kathy.stecker@ncdenr.gov	919-807-6422
Chairman	Anne Coan	NC Farm Bureau Federation	anne.coan@ncfb.org	919-788-1005
	Gail Hughes	Orange Soil & Water	ghughes@co.orange.nc.us	919-245-2753
	Warren Daniels	Granville Soil & Water	warren.daniel@granvillecounty.org	919-693-4603
	Kelly Ibrahim	NCDA &CS	kelly.ibrahim@ncagr.gov	919-715-9631

Agriculture Monitoring Design Guideline

1. Determining Inputs from Agriculture by Performing a Survey of Existing Monitoring Efforts

Background Sources Subcommittee

Name	Organization	Email	Phone
Jason Green	NCDWQ	jason.green@ncdenr.gov	919-743-8496
Shari Bryant	NCWRC	shari.bryant@ncwildlife.org	336-449-7103
Mike Schlegel	TJCOG	mschlegel@tjcog.org	919-295-0017
Lars Hanson	TJCOG	lhanson@tjcog.org	919-558-9392
Maverick Raber	City of Durham	maverick.raber@durhamnc.gov	919-698-2522
Johnny Boggs	US Forest Service	jboggs@ncsu.edu	919-513-2973
Jing Lin	NCDWQ	Jing.Lin@ncdenr.gov	919-807-6410
Chris Dreps	ECWA	chris@ellerbecreek.org	
Steve Bristow	Wake Co.	sbristow@co.wake.nc.us	

Background Sources Monitoring Design Guideline

1. Monitoring Design Guidelines for Determining Nutrient Inputs from Atmospheric Deposition
2. Monitoring Design Guidelines for Determining Nutrient Inputs from Forest Contributions
3. Monitoring Design Guidelines for Determining Nutrient Inputs from Monitoring of In-Lake Nutrient Flux

BMP Effectiveness Subcommittee

	Name	Organization	Email	Phone
Chair	Sarah Bruce	TJCOG	sbruce@tjcog.org	558-9343
	Kurt Smith	Wake Co. Env'l Services	kwsmith@wakegov.com	250-1062
	Andrea Thomas	DWQ Ambient Monitoring	andrea.thomas@ncdenr.gov	
	Jessica Kemp	NCEEP	jessica.kemp@ncdenr.gov	
	Watson Ross	NCEEP	watson.ross@ncdenr.gov	
	Helen Youngblood	Durham City/County Planning	helen.youngblood@durhamnc.gov	560-4137 x 245
	John Huisman	DWQ Planning	John.Huisman@ncdenr.gov	807-6436
	Dan McLawhorn	City of Raleigh	Dan.McLawhorn@raleighnc.gov	831-6560
	Tom Gerow	NC Forest Service	tom.a.gerow@ncdenr.gov	857-4824
	Sandi Wilbur	City of Durham Stormwater	sandra.wilbur@durhamnc.gov	560-4326
	Nancy Scott	Duke MEM	nancy.scott@duke.edu	703-981-2454
	Frank Thomas	Homebuilders' Association	frank@hbadoc.com	493-8899
	Robert Patterson	NC DWQ Permitting Unit	robert.patterson@ncdenr.gov	807-6375
	Ryan Winston	NCSU BAE	ryan_winston@ncsu.edu	515-8595

BMP Effectiveness Monitoring Design Guideline

1. Evaluate How Vegetated Shelf & Plant Maintenance Influences the Effectiveness of Wet Detention Basins
2. Evaluate the Influence of Clogged Media on the Effectiveness of Sand Filter Stormwater Control Measures
3. Evaluate How Soil Protection/Amendment Influences Surface Runoff, Stormwater Control Measure Performance, and Receiving Water Quality
4. Evaluate the Influence of Clogged Media on the Effectiveness of Bioretention Devices

Onsite Wastewater Subcommittee

	Name	Organization	Email	Phone
Chair	Steve Bristow	Wake County	sbristow@co.wake.nc.us	919-856-7432
	Kathryn Hobby	Wake County	kathryn.hobby@wakegov.com	919-369-4190
	Mary Giorgino	USGS	giorgino@usgs.gov	919-571-4087
	Reggie Hicks	City of Durham	reginald.hicks@durhamnc.gov	919-560-4381
	Nancy Deal	Dept. Health & Human Services	Nancy.Deal@dhhs.nc.gov	
	Bob Jordan	Durham Cty. Health Dept	rjordan@durhamcountync.gov	919-560-7812
	Maverick Raber	City of Durham	maverick.raber@durhamnc.gov	919-698-2522
	Steve Berkowitz	Dept Health & Human Services	steven.berkowitz@dhhs.nc.gov	919-715-3271
	Tom Konsler	Orange County	tkonsler@co.orange.nc.us	919-245-2370
	Mandy Hall	DWQ	mandy.hall@ncdenr.gov	919-791-4254
	Sushama Pradhan	NCSU	spradha@unity.ncsu.edu	919-515-2190

Onsite Wastewater Monitoring Design Guideline

1. Falls Lake Watershed System Survey/Performance Assessment
2. Impact of Geologic/Soil Systems upon the Fate and Transport of Nitrogen and Phosphorous within the Falls Lake Watershed
3. Determining Fate and Transport of Nutrients from On-Site Wastewater Treatment

Stormwater and Existing Development Subcommittee

	Name	Organization	Email	Phone
Chair	Mark Senior	City of Raleigh	mark.senior@raleighnc.gov	919-996-4012
	Melissa Hodges	Butner	mhodges@butnernc.org	919-575-3031
	Barry Baker	Granville County	barry.baker@granvillecounty.org	919-603-1334
	Natalee Landry	NCDWQ	natalielandry@ncdenr.gov	919-791-4258
	John Huisman	NCDWQ	john.huisman@ncdenr.gov	919-807-6436
	Betsy Pearce	Wake County	betsy.pearce@wakegov.com	919-856-7541
	Terry Hackett	Orange County	THackett@co.orange.nc.us	919-245-2588
	Raghavenderrao Badami	City of Durham	Raghavenderrao.Badami@durhamnc.gov	
	Sarah Bruce	UNRBA	sbruce@tjcog.org	919-558-9343
	Nancy Scott	Duke MEM	nancy.scott@duke.edu	703-981-2454
	Nancy Daly	NCEEP	nancy.daly@ncdenr.gov	

Stormwater and Existing Development Monitoring Design Guideline

1. Monitoring Design Guidelines for Determining Fate and Transport of Select Nutrients (Nitrogen and Phosphorous) in Streams and Soils in Order to Improve the Treatment of Stormwater for Nutrient Pollution Management.

Determining Nutrient Inputs for "Agriculture"

MONITORING DESIGN GUIDELINES FOR DETERMINING NUTRIENT INPUTS FROM AGRICULTURE

BY DAN LINE AND DEANNA OSMOND, NC STATE UNIVERSITY

BACKGROUND & PROBLEM STATEMENT

Background

According to NCDENR-DWQ's watershed modeling estimates, nonpoint sources make up approximately one-half to two-thirds of nitrogen inputs to Falls Lake Reservoir, and more than four-fifths of phosphorus inputs. Further, an estimated one-third to one-half of nitrogen and phosphorus input to the Lake originates from agricultural sources, which would make it the single largest nonpoint source contributor. Thus, reducing inputs from agricultural sources would be an essential component of a nutrient management strategy for Falls Lake.

Reducing nitrogen and phosphorus inputs to the reservoir in the most cost-effective manner will depend on implementing Best Management Practices (BMPs) that are effective on agricultural source areas that most directly affect inputs to the reservoir. According to NCDENR-DWQ estimates, there is more than 73,000 acres of cropland and pastureland within the four counties that make up the bulk of the drainage area to the Lake.

The Durham, Granville, Orange, Person and Wake County Soil and Water Conservation Districts and Local Advisory Committees (LACs) are responsible for assisting agriculture producers in meeting the nutrient reduction goals required by the Falls Lake rules that became effective January15, 2011. In order to achieve the reduction goals in the most cost-effective manner, the staff of the Soil and Water Conservation Districts (SWCDs) will need to implement agricultural BMPs that are effective at reducing nitrogen (N) and phosphorus (P) in places where they will make the greatest impact. To do this they will first need to determine which subwatersheds or sources are contributing disproportionately high nutrient concentrations/loads and then implement BMPs that are the most cost-effective at reducing the loads. A combination of information on BMP effectiveness and monitoring from past studies as well as current water quality monitoring of subwatersheds is needed to provide the basis for the BMP implementation.

Problem Statement

Because water quality monitoring is expensive and takes a considerable amount of time, discernment must be used in determining when and where to conduct the monitoring. Part of this discernment involves reviewing past and current research in order to learn from past monitoring experiences and avoid duplication. This project will review and summarize results from monitoring studies of runoff and

nitrogen, phosphorus and sediment export from agricultural land uses in the Falls and Jordan Lake watersheds. In addition, results of monitoring studies conducted to assess the effectiveness of agricultural BMPs that are appropriate for the Falls Lake watershed will be summarized with an emphasis on those studies conducted in NC and the broader southeastern U.S.

Regulatory Context

The Falls Lake rules require significant reductions in N and P loading from agricultural lands. In order to achieve these reductions in the most cost-effective manner, BMPs that are effective at reducing N and P export from the types of agricultural land/activities in the Falls Lake watershed will need to be implemented in locations where they can have the greatest impact. Results from this study will provide the basis for determining which BMPs are most effective for typical agricultural sources of N and P in the Falls Lake watershed. The study will also provide useful information for possible future monitoring activities of agricultural water quality impacts in the Falls Lake watershed.

Issue around Uncertainty

There is a considerable amount of uncertainty inherent in monitoring studies, particularly those involving nonpoint sources. Most agricultural inputs to waters are nonpoint. Quantifying the uncertainty in nonpoint source monitoring is often difficult, but a qualitative assessment of the uncertainty based on known components (i.e. duration, replications, monitoring design, etc.) of the studies reviewed will be provided.

NUTRIENT MARKERS & SOURCES

N/A

PREVIOUS & EXISTING MONITORING (STUDIES OR LONG-TERM)

Reviewing previous and existing studies is particularly important with respect to nonpoint source monitoring projects due to the difficulty, expense, and length of time required (2-5 years minimum) to achieve significant results. Previous and existing monitoring studies of agricultural runoff and N and P export from agricultural land in the Jordan and Falls Lake watersheds will be reviewed and summarized as part of this study. The focus of the review will be on studies that report pollutant loads from watersheds composed of predominantly agricultural land uses, although results from studies with combinations of agricultural and/or urban land uses in the Piedmont region of NC may be included to provide a basis for comparison. The review will involve reading the publications and evaluating the results based on the information provided and the monitoring experience of the reviewer. Nitrogen and phosphorus loading/export rates will be extracted for discussion in the study report and included in a summary table. Summary descriptions and more detailed descriptions of the uncertainty issues involved in each study will also be included.

The study will also include a review and synthesis of published BMP monitoring studies because it is important that the best documentation on the effectiveness of BMPs be available to Soil and Water Conservation District personnel. This review will include published studies from all regions of the U.S.,

but will also group studies from the southeast region and NC separately so effectiveness for this region can be presented. Many of these publications have been reviewed in a previous synthesis (2009-2010), but more recent publications will need to be added. The review will involve reading the publication and evaluating the results based on the information provided and the monitoring experience of the reviewer. Nitrogen, phosphorus, and sediment reducing efficiencies of BMPs will be extracted for discussion in the study report and included in a summary table. For each BMP a median effectiveness and a range of effectiveness will also be computed. Summary descriptions and more detailed descriptions of the uncertainty issues involved in each study will also be included.

MONITORING DESIGN

As part of this study lessons learned from past monitoring studies of agricultural impacts on water quality and of BMP effectiveness will be summarized with a particular focus on monitoring design (parameters, methods, sampling frequency and type, duration, scale, QA/QC, etc.) These lessons will be used to develop recommendations for monitoring design components that are needed to obtain statistically significant monitoring results.

FUNDING OPPORTUNITIES

Funding could be sought from foundations or organizations interested in water quality, local governments or local government affiliated organizations interested in protecting water supplies in Falls Lake, organizations or businesses interested in agriculture, state funding sources such as the NC Tobacco Trust Fund, NC Clean Water Management Trust Fund, NC Environmental Enhancement Grants Program administered by the NC Attorney General's office as part of the Smithfield Foods Agreement, NC Agricultural Foundation, Inc. at NCSU, and other similar sources.

PUBLIC EDUCATION COMPONENTS

Because the results of the study will be most useful to Soil and Water Conservation Districts (SWCDs) they will be the focus of the education or results component. Results from this study/review will provide the information SWCDs need to make informed decisions about where to focus their efforts at nutrient reductions and what BMPs would be the most effective. The results will also help Districts share with local governments and local communities the effectiveness of their activities in implementing BMPs as the effectiveness of most erosion control BMPs can be estimated using existing tools. However, to some extent nitrogen, and particularly phosphorus, reduction effectiveness of many BMPs is more difficult to estimate with existing tools. Districts interested in participating in monitoring projects will have more information about where and what type of monitoring might be needed and how to conduct the monitoring. They will also be better able to evaluate the validity of monitoring results presented by other parties. In addition, results from this study could aid Districts in outreach to landowners considering implementing BMPs. Further, results could be used to inform the broader agricultural community and researchers as to what additional monitoring or additional studies of agricultural BMPs may be needed to help achieve the objective of effective and cost-efficient water

quality improvements in the Falls Lake watershed. Results of the review will be made available to the public. Also the results may be used in presentations to water quality stakeholders and for outreach activities on this issue by the NC Cooperative Extension Service.

PROPOSED BUDGET

Description	Cost
Personnel (salary + benefits)	$11,000
Misc. (office supplies, journal access fees, etc.)	$140
Travel[1]	$60
Total	**$11,200**

[1]Includes mileage to travel to 1 meeting in the Falls Lake watershed to present results.

*Note: Additional costs not reflected here could be grant or contractor administrative and/or mandated overhead percentage costs.

Determining Nutrient Inputs by Atmospheric Deposition

MONITORING DESIGN GUIDELINES FOR DETERMINING NUTRIENT INPUTS FROM ATMOSPHERIC DEPOSITION

BACKGROUND & PROBLEM STATEMENT

Background

Falls of the Neuse Reservoir (commonly referred to as Falls Lake) has had frequent violations of the State of North Carolina Division of Water Quality (NCDWQ) standard for chlorophyll *a* (greater than 40 µg/L). To address these violations, the NCDWQ developed nutrient management strategies to reduce nitrogen and phosphorus (nutrients) loads into Falls Lake. One significant nutrient source to the lake is atmospheric deposition. A recent study performed by the United States Environmental Protection Agency (USEPA) reported nitrogen loading by atmospheric deposition to the Chesapeake Bay estuary exceeded contributions from fertilizer, manure, point sources, and septic systems (USEPA 2010).

Problem Statement

The USEPA monitors atmospheric deposition rates via a national network of stations in the National Atmospheric Deposition Program (NADP) and Clean Air Status and Trends Network (CASTNET). NADP stations monitor wet deposition while CASTNET stations monitor dry deposition. NADP and CASTNET stations are purposefully located far away from sources of pollution as this system is designed measure regional depositional characteristics. The NCDWQ utilized NADP and CASTNET data in their model of Falls Lake. These stations were located in other areas of the state or the southeast to estimate the impact of atmospheric deposition on the lake. However, these estimates may not represent local conditions in the Falls Lake drainage, particularly for urban areas that may have locally higher rates of nutrient deposition. Additionally, NADP and CASTNET stations do not measure or account for gaseous ammonia and wet organic nitrogen as they were originally developed to evaluate acidic deposition trends due to emission reduction regulations and not nutrient loading. As such, nitrogen loading estimates from NADP and CASTNET stations are low.

Regulatory Context

There are no specific regulations or limits for atmospheric deposition rates in NC. The Clean Smokestacks Act of 2002 required a 77% reduction in NOx emissions by 14 coal-fired power plants in NC by 2009. There are also requirements and inspections for automobile emissions. Additional emissions regulations for vehicle exhaust and fossil-fuel burning power plants could potentially reduce atmospheric nitrogen pollution in the Falls Lake watershed.

Issue around Uncertainty

Understanding the relative contributions of atmospheric nitrogen for loading to the lake would help managers effectively and efficiently deal with these pollutants. Much of the nitrogen pollution from vehicle exhaust is not measured at NADP and CASTNET sites (MACTEC 2011). Additionally, there are no NADP or CASTNET sites in the rural and suburban portions of the watershed itself and representative data is relies on stations located outside the watershed. The presence of a coal-burning power plant in nearby Roxboro may also affect atmospheric deposition rates in the watershed.

NUTRIENT MARKERS & SOURCES

Nitrogen deposited from the atmosphere is derived primarily from nitrogen oxides (NOx) and ammonia (NH3) (USEPA 2010). NOx is emitted to the atmosphere during the combustion of fossil fuels. Power plants and automobiles are the biggest contributors of atmospheric NOx. Power plants emissions are released higher in the atmosphere and are more widely distributed and travel further. Conversely, vehicle exhaust is emitted close to the ground and generally has a more localized effect. Livestock waste management and fertilizer manufacturing account for 90% of NH3 emissions.

PREVIOUS &EXISTING MONITORING (STUDIES OR LONG-TERM)

The City of Durham is currently conducting an atmospheric deposition study to evaluate deposition in an urban environment. Two locations are being monitored for this study, a north Durham site and a south Durham site. The north Durham site is located in the Falls Lake drainage and is being monitored for wet and dry deposition. The south Durham site is located in the Jordan Lake drainage and is being monitored for wet deposition only. Wet deposition samples are collected and analyzed for total precipitation volume, NO3- plus NO2- as nitrogen, NH3 as nitrogen, total Kjeldahl nitrogen (TKN), total phosphorus, and pH. Dry deposition samples are collected and analyzed for NO3-, NH4+, HNO3, and NH3. Data collected from these sites are used to calculate deposition rates using the Multi Layer Model (MLM). These sites are used to determine local atmospheric deposition in an urban environment.

Preliminary data from the City of Durham study indicated no difference between local urban wet inorganic nitrogen deposition and regional wet inorganic nitrogen deposition. Regional wet inorganic nitrogen deposition, based on NADP data, likely reflects inorganic nitrogen deposition rates throughout the Falls Lake watershed. Dry atmospheric deposition appeared to be locally higher in urbanized Durham than the regional estimates generated from the CASTNET data. All total phosphorus data was non-detect, indicating little to no phosphorus contributions via atmospheric deposition.

The closest and most representative NADP station for the Falls Lake watershed is NC41 (Finley Farm, Wake County, NC). This station provides weekly wet chemistry data for wet depositional flux. The most representative CASTNET station, named Prince Edward, is located approximately 65 miles to the north of the Falls Lake watershed in Prince Edward County, Virginia. Although not the closest station in proximity to the watershed, this station was considered most representative of the region based on a NC Department of Transportation (NCDOT) model study (NCDOT 2008). This station provides weekly average dry deposition data.

MONITORING DESIGN

Proposed Monitoring Activities or Studies

This study proposes the installation of a co-located wet and dry atmospheric deposition monitoring station in a representative rural setting of the Falls Lake watershed. The wet deposition site would evaluate organic nitrogen contributions only. Organic nitrogen is not measured at the NADP sites. Inorganic nitrogen would not be evaluated because the City of Durham study found no difference between local urban inorganic nitrogen wet deposition and regional inorganic nitrogen wet deposition.

The dry deposition site would evaluate whether dry deposition is higher than indicated from CASTNET data in the rural portions of the Falls Lake watershed, as was found in the City of Durham study. The dry deposition site would also evaluate gaseous ammonia, which is not measured at the CASTNET sites. The estimated cost of this study is $150,000.

Parameters, Methods and Frequency

Dry deposition samples would be analyzed for NO3-, NH4+, HNO3, and NH3 as nitrogen. Wet deposition samples would be analyzed for NH3 as nitrogen, total Kjeldahl nitrogen (TKN), and ph. Wet deposition of organic nitrogen would be estimated by subtracting ammonium from TKN. Meteorological parameters would include temperature, wind speed, wind direction, solar radiation, relative humidity, wetness, and sigma theta (i.e. the standard deviation of horizontal wind direction). Equipment and procedures for collecting dry and wet deposition samples would be consistent with NADP and CASTNET protocols. Samples would be collected weekly for a period of one year. Meteorological data would be downloaded and processed on a weekly basis, presumably when samples are collected.

Location, Scale, Watershed Type or Character (e.g. rural or urban)

Site selection criteria will include location relative to major roadways, canopy, potentially confounding sources, accessibility, availability of utilities, property ownership, zoning regulations, security, co-location with existing monitors, and consideration of guidance provided in the USEPA's *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (USEPA 2000).

Monitoring Group & Potential Partnerships

Monitoring would be performed by a qualified contractor. Sample analyses would be performed by a qualified laboratory.

QA/QC Procedures & Recommendations

Quality control will consist of preparation and calibration of sampling and meteorological equipment. Quality control for the preparation and analysis of samples will be performed as prescribed by NADP and CASTNET protocols.

Data Coordination & Use

Data generated from this study will be comparable to data collected by the City of Durham and to data from the EPA's NADP and CASTNET stations. This data could be used to gain a more accurate understanding of atmospheric deposition throughout the watershed.

FUNDING OPPORTUNITIES

N/A

PUBLIC EDUCATION COMPONENTS

N/A

Determining Nutrient Inputs for "Background Sources from Forests"

MONITORING DESIGN GUIDELINES FOR DETERMINING NUTRIENT INPUTS FROM FORESTS

BACKGROUND & PROBLEM STATEMENT

This section describes the water quality problem associated with this topic, and how monitoring can be used to improve our understanding of the topic as it relates to water quality. Furthermore, this section will include a specific problem statement and a discussion on the regulatory context. This section also includes a discussion about how to define and reduce uncertainty related to this topic.

Background

Population growth from 2000 to 2030 in Wake County, NC is projected to increase 60% from about 627,000 to 1,560,000 (North Carolina Office of State Budget and Management, 2008). This growth will not come without increased pressures on our natural resources including water, forests, and wildlife. Many pressures around hydrology and water quality are linked to forest fragmentation as a result of urban development and sprawl; a disconnected forest loses many of its beneficial functional hydrologic features (Ward and Trimble, 2004; Riley 1998; Booth et al. 2001). Scientists have found in urban catchments incidence of increased flooding, decreased base flow, degraded water quality, and limited aquatic species diversity when compared to forest catchments (Paul and Meyer, 2001; Ward and Trimble, 2004). Understanding water cycles, patterns, distribution, quantity and quality as it flows through forests catchments are of the utmost importance. There are federal, state, and local funds being allocated for monitoring hydrology, water quality, and quantity with the United States Geological Survey (USGS) spending on average $14,000 annually at each gauging station (USGS staff *personal communication*). There are approximately 275 stations in NC (USGS, 2008).

A catchment is an area of land that drains water to a particular point (i.e., stream, lake, tributary, or ocean) (Ward and Trimble, 2004) that is controlled in part by surface topography of the landscape. The flow of water in an urban catchment, however, is not defined necessarily by the topology as there can be inflows of water entering the stream channel from sources such as storm and tile drains that originate from outside the urban catchment area (Burton and Pitt, 2002).

Forest catchments are areas of land that are covered by trees that drain rainfall to a particular point. Shepard et al. (2004) reported that even though forested systems contribution to water quality degradation is low compared to other land uses, forestry has the most complete Best Management Practices (BMP) programs in the US. This is particularly interesting in that use of hydrology inflow and outflow patterns can be looked at in ways that may allow for incorporation of forested catchment hydrology into urban catchment planning. Their role as a reference watershed to understand hydrological processes can add significant value to assessing and managing hydrology and water quality concerns in urban catchments.

Urban streams are very dynamic with their structures and functions changing in space and time due in large part to the magnitude and duration of flow in the watercourse (Trimble 1997). Scouring, down-cutting, and/or increases in bed load can contribute to the degradation of urban streams (Groffman et al. 2003). Riparian buffers, reservoirs, detention basins, wet/dry swales, and constructed wetlands are routinely used to manage in-stream sediment accumulation from construction sites, reduce nutrient loading from hog farms, and decrease stormflow energy that degrades stream banks. Research must, however, move beyond these traditional areas of studying urban catchment and begin to look at links between hydrology and ecological processes (i.e. ecohydrology). Hydrology data gathered from forested catchments can help in this effort by serving to guide and inform ecological processes in urban catchment to ultimately improve water quality, understand urban eco-hydrological patterns, and govern stormflow.

Problem Statement

Range of variability in background sources is not fully quantified in the Upper Neuse River Basin. This basin contains a mix of geological features, including Carolina Slate Belt and Triassic Basin. Differences in streamflow dynamics in these geological areas may alter stream nutrient concentrations and loads, thus creating wider variance in background or baseline nutrient values. Site specific in-stream nutrient monitoring to capture this variability may help inform water resource managers with setting stream recovery targets.

Regulatory Context

N/A

Issue around Uncertainty

N/A

NUTRIENT MARKERS & SOURCES

This section includes a discussion related to identifying the nutrient sources (of on-site wastewater in this case) as distinct and differentiated from other sources (e.g. agricultural runoff)

PREVIOUS & EXISTING MONITORING (STUDIES OR LONG-TERM)

US Forest Service Southern Research Station maintains some of the longest running experimental forests in the US. Bent Creek, Calhoun, and Tallahatchie Experimental Forests and Coweeta Hydrologic Laboratory have generated research, products, and tools that are applied across US forestland to maintain and improve water quality and decrease risk to aquatics. These NC long-term research facilities have also demonstrated how forests buffer against stream sedimentation and nutrient loading. There are however, limited monitoring sites that fully quantify streamflow and water quality patterns in Carolina Slate Belt and Triassic Basin; two dominate geologic provinces in the Falls Lake Watershed, NC Piedmont. Additional monitoring sites, will further capture and refine the natural range of nutrient variability in these forested systems, and define background conditions and quality of downstream water supplies.

MONITORING DESIGN

This section describes the guidelines for designing a monitoring study that will enhance understanding and management of this topic/issue.

Proposed Monitoring Activities or Studies

Sampling Methods

Water quality measurements are to be taken in accordance with protocol established at long-term hydrologic research facilities (Coweeta Hydrologic Laboratory) and the Intensive Survey Unit Standard Operating Procedures (Appendix I). Any problems or inconsistencies encountered by our field team will be communicated to the principle investigators (PIs). The field team and PIs will review the problem and once a resolution to problem has been agreed upon, adjustments to field equipment or sampling protocol will be made. The field team has discretion to troubleshoot equipment in-field as this will reduce potential lost of valuable data and will save money in the long-term. Any changes in procedures as a result of equipment or sampling irregularities will be annotated in the field note book.

Parameters, Methods, & Frequency

Data Category	Parameters	Measurement Frequency	Methods
Meteorology	Rainfall, air temp, relative humidity, total solar radiation, wind speed	Sampled every 4 minutes, logged every hour	Micrometeorological station, Onset Company

Streamflow	Water depth (inches), streamflow rate (cubic feet per second)	10 minute intervals	Weirs or flumes and associated water level recorders, American Sigma Sampler Company
Land topography	Digital Elevation Model (DEM)	Once	USGS DEM database
Water quality (NC State University for laboratory analysis)	Total Suspended sediment, nitrate, ammonium, total Kjeldahl nitrogen, total organic carbon at watershed/stream outlets. Stream Temperature	During stormflow and base flow 10 minute intervals	Sigma Sampler programmed for stormflow sampling. Grab samples collected during base flow. Hobo Water Temp Pro V2 Logger, Onset Company

Location, Scale, Watershed Type or Character (e.g. rural or urban)

Rationale for Selection of Sampling Sites

Headwater watersheds located in the Upper Neuse River Basin that are at least 90% forested will be selected to represent background source conditions. Selecting watersheds with similar percent forest cover will increase our degree of confidence that one watershed data set can be compared to another (i.e., forest watershed vs. forest watershed). Selected forest watersheds however might vary in size, soil features, topography, slope, and species composition. This will allow us to capture the range of background variability in streamflow and water quality conditions. Careful consideration will be given to site selection with the following criteria governing final choice:

1. Sites are covered by 90% forest.
2. Sites are representative of Upper Neuse River Basin.
3. Sites are stable (i.e., no plan to harvest) and well protected.
4. Sites have easy access to install/maintain equipment, collect water samples, and download data.

5. Sites will include intermittent/perennial streams as defined by North Carolina Division of Water Quality.

Monitoring Group & Potential Partnerships

US Forest Service, Eastern Forest Environmental Threat Assessment Center is a potential source agency for collaboration that will involve equipment setup, field data collection, project monitoring, and data interpretation. The Threat Center is working on a long-term Best Management Practices study in the Upper Neuse River, Falls Lake Watershed. Their project involves State, Federal, and University researchers as well as land management agencies and regulators. Their monitoring project will produce new scientific data and usable information that quantify effectiveness of streamside management zones on protecting streams from nutrient loading and sedimentation.

QA/QC Procedures & Recommendations

Quality Objectives and Criteria

Identifies performance/measurement criteria for all information to be collected; and acceptance criteria, including project action limits and laboratory detection limits, and range of anticipated concentrations of each parameter of interest.

Data Precision, Accuracy, and Measurement Range

Express the degree to which sample results are repeatable.

Meteorology

Rainfall

- 10 cm or 0" to 5" per hour; maximum 4000 tips per interval
- Resolution: 0.2 mm and 0.01"

Air temperature

- -40° to +75°C
- ±0.7°C @ +25°C

Relative humidity

- -40° to +75°C
- ±0.7°C @ +25°C; ±3% RH over the range of 0° to +50°C; ±4% in condensing environments

Solar radiation

- 0 to 1280 W/m2
- ±10 W/m2 or ±5%, whichever is greater in sunlight. Additional temperature induced error ±0.38 W/m2 /°C from 25°C

Streamflow

Water depth/streamflow

- 0 - 5.75 feet
- ±0.1% full scale

Water quality

- Total suspended sediment and nutrients collected at watershed outlet during stormflow and base flow. Analysis completed at NC State University, see Appendix II for QAQC details.
- Sample volume repeatability, ±5% typical

Data Representativeness

Express the degree to which the data accurately represents the population or the environmental condition at the sampling location.

A watershed by definition is described as an area of land that drains water to a specific point, which might include a stream or river. A major aspect of this background monitoring study is selection of the location for water quality monitoring equipment used to assess streamflow and nutrient concentration data. Accordingly, we used specific information from section I.3 of the Intensive Survey Unit Standard Operating Procedure (Appendix I). In addition, to minimize uncertainty and error produced by bank erosion, bed scouring or coarse/fine debris deposition in measured streamflow, a flow control structure (weir and/or flume) will be used at each monitoring station. Years of research at long-term hydrologic research facilities has shown that a weir or flumes will have a reliable stage-discharge relationship, thus minimizing error associated with water quality measurements in natural channels without flow control structures. This relationship will be verified with other water quantity measurement methods to ensure validity of the relationship on each site.

Sample Handling and Custody

Identify how the samples will be physically handled, transported, and received; and describe the documentation of sample information handling and custody

Analytical Methods

Identify all analytical SOPs including field and laboratory procedures

Field measurements

Parameters	Procedures (equipment will be installed and calibrated according to manufacture's guidelines and protocols).
Rainfall	Appendix IV
Air temperature/Relative humidity	Appendix V
Solar radiation	Appendix VI
Water depth/streamflow	Appendix III
Water temperature	Appendix VII
Wind speed	Appendix VIII

Quality Control

Identify QC activities which will be used for each type of sampling, analysis, or measurement technique; for example, blanks, spikes, duplicates, etc., and at what frequency

Field activities

QC practices for all field measurements and sampling which includes equipment calibrations and standard checks can be found in the attached appendices. Field staff training on equipment use and maintenance and data collection protocols will be provided by the data manager and/or a quality field staff person. No one will be allowed to collect data until this formal training has occurred.

Laboratory activities

Documentation on the QC checks for nutrient samples and information on equipment and data accuracy/precision is available in Appendix II.

Instrument/Equipment Testing, Inspection, and Maintenance

Identify field and laboratory equipment needing periodic maintenance, and the required inspection schedule

Field equipment

The field research team will responsible for regular and routine cleaning, inspection, and maintenance of all meters, sensors and samplers. In addition, all equipment will be visually inspected biweekly for damage due to natural or animal influences. Other required maintenance is shown in table below and also see the attached appendices/manufacture's manuals.

Laboratory analytical equipment

For laboratory equipment and instrument inspection and maintenance, refer attached Appendix II.

Equipment Type	Inspection Frequency[1]	Type of Inspection
Weirs/flume	Biweekly	Visual assessment of structural integrity and flow capture and remove debris.
Automated samplers	Biweekly	Diagnostic test of sampling arm. Battery will be replaced biweekly.
Rain gauge	Biweekly	Check for blockage of funnel.
Air temperature sensor	Monthly	Visual inspection of sensor.
Relative humidity sensor	Monthly	Visual inspection of sensor.
Solar radiation sensor	Monthly	Visual inspection and cleaning of sensor.
Wind speed	Monthly	Visual inspection of sensor.
Water depth/streamflow	Biweekly	Manually verified with a ruler

sensor		and recorded in log book.
Water temperature probe	Biweekly	Visual inspection of probe.

[1]Data collection and inspection frequency will occur weekly for the first month or so to ensure that all field equipment is functioning properly. After this, we will follow the above inspection frequency.

Instrument/Equipment Calibration and Frequency

Identify equipment, tools, and instruments that should be calibrated, and the frequency and method for this calibration

Field meters

All field meters will be inspected and calibrated before each use or according to the manufacture's suggestions. Each inspection and calibration will be noted in the field note book which should also include the name of field team, date, meter/equipment calibrated and list any equipment that had to be replaced.

Laboratory instrumentation calibration

For details of laboratory requirements and methods of calibration of analytical laboratory instrumentation, refer to Appendix II.

Inspection/Acceptance of Supplies and Consumables

Identify critical supplies and consumables for field and laboratory, and acceptance criteria

Equipment/Supply	Inspection/Maintenance Activity	Acceptance Criteria
Automated sampler	Run a diagnostic test on the distributor arm to ensure it is functioning properly.	Test completed successfully.
Bottles for automated sampler and grab samples	After each bottle has been acid/soap washed and air dried, check each bottle for contaminates such as residual soil or particles or other forms of debris. If no particles are visible place cap on bottle to minimize the potential of contamination from dust.	No visible dust, soil or other particles.
Weirs/flume	Inspect the weir/flume for seepage and structural and functional capacity.	No visible signs of seepage or other compromises to the functionality of the

		weir/flume.
Weather Station	Check to ensure that station sensors are clean and level.	Visibly clean sensors and level sensors.
Laboratory equipment and supplies	See Appendix II	

Data Coordination & Use

Data Management

Describe data management scheme from field to final use and storage, and describe the process for data archival and retrieval

Data Type	Management and Storage
Meteorology, streamflow, and water temperature.	Data will be downloaded to a laptop computer and permanently stored on secured server.
Site characteristics	Field measurements will be recorded in a field note book. Within two days, those data will be transferred to a laptop and a photocopy of the notes will be made and archived.

Data Review, Verification and Validation

Describe the criteria that will be used for accepting, rejecting, or qualifying project data.

The data manager is primarily responsible for data and information review, verification and validation. Field staff and laboratory technicians will be given a copy of all equipment manuals and ISU SOP to ensure that there is continuity in handling of equipment and data. Biweekly tailgate briefings and annual refresher training on data handling and field protocol will be given to field staff by the data manager. This should minimize errors in data collection, management, and transfer.

Assessments and Response Actions

List the number, frequency, and type of assessment activities that should be conducted. Specific response actions for the situations listed below will generally apply.

Situation	Response Action
Data manager will serve as the source for ensuring water samples and field measurement are collected accurately and efficiently. Any field measurements or laboratory results that are considered	PI will consult to decide how to address data irregularities. A memo will be draft noting any changes to the statement of work or methodology. This document will be archived with

outliers should be reported to PI immediately.	the original proposal/plan of work.

Verification and Validation Methods

Describe the process for data verification and validation, providing SOPs and indicate what data validation software will be used.

Data Element	Typical Validation and Verification Methods
Field Staff	
Water quality	Every two weeks, field staff will ensure that all bottles are collected from each sigma samplers and that caps are properly secured on each bottle. Notes about field sample collection will be recorded in the field note book. All hard copy data will be transferred to soft copy within one week of collecting the samples.
Sediment and Nutrients	See laboratory Appendix II
Weather station data	Graph all data biweekly to examine data for outliers or erroneous values. The process to deal with erroneous values will be determined by the PIs and will be case based.

FUNDING OPPORTUNITIES

N/A

PUBLIC EDUCATION COMPONENTS

N/A

Improving Accounting of In-lake Nutrient Processing

MONITORING DESIGN GUIDELINES FOR DETERMINING NUTRIENT INPUTS FROM BACKGROUND SOURCES

BACKGROUND & PROBLEM STATEMENT

Background

For nearly thirty years, Falls Lake has had water quality issues, notably with high turbidity and algal blooms. In 2005, the North Carolina General Assembly passed Session Law 2005- 190 (www.ncleg.net/sessions/2005/bills/senate/html/s981v5.html), which required the EMC to study drinking water supply reservoirs and develop nutrient control criteria to manage these reservoirs. After a period of monitoring (2005 – 2007), NCDWQ created the Fall Lake Water Quality Model in order to determine the interaction of nutrient loadings, hydrologic conditions, and climatic conditions and their effect on nutrient conditions in the lake. One of the primary goals of the modeling was to understand how nutrients in the lake affect concentrations of chlorophyll-*a* (a measurement of algae density), which is the contaminant of concern causing water quality impairment in Falls Lake.
The Falls Lake Water Quality Model was used to support the development of the Falls Lake Nutrient Management Strategy and Falls Lake Rules. Quantifying source loadings of pollutants and accurately simulating in-lake dynamics with the model allows testing effectiveness of management strategies. The model was calibrated to promote the

Problem Statement

The in-lake processes that control nutrient processing and ultimately, the algal life cycle, are reasonably well understood from a scientific perspective. Despite this conceptual understanding, in Falls Lake, there have been few efforts to quantify the relevant parameters affecting this nutrient processing, especially in the sediments. While significant effort has been devoted to characterizing source loading, studies quantifying the effect of sediments on nutrient cycling have not received equal attention.

Sediment nutrient flux rates in Falls Lake, and their spatial, temporal, and situational variation have not been studied in enough detail to be confident their effects on in-lake chemistry, algal growth, and ultimately, management decisions, are being captured and modeled correctly. It should be noted that DWQ does not currently plan to remodel Falls Lake.

Additional monitoring specific to Falls Lake sediment will enable modelers, scientists, regulators, and policy makers to better quantify rates of sediment nutrient transport and flux. These studies will improve water quality models and better quantify the influence of the lake's sediments on nutrient concentrations in the lake.

Regulatory Context

The nutrient management strategy for Falls Lake is based on a water quality model of the lake, which has many built-in assumptions about background source nutrient loadings to the lake, including how the lake's sediments affect nutrient concentrations.

Issue around Uncertainty

In general, the current uncertainty about nutrient flux rates in Falls Lake is due to a lack of sampling rather than any particular methodological concerns. A monitoring plan could reduce uncertainty about the average net flux rates of phosphorus, nitrate and nitrite, ammonia, and sediment oxygen demand. Assuming a relatively constant average rate for the nutrient flux to the overlying water may or may not be appropriate for the lake as a whole.

Beyond uncertainty about the average flux rates, there is an unknown amount of variability in flux rates with respect to spatial, temporal, and lake condition (e.g. temperature, depth, stratification, sediment load) factors. These are variations in the lake sediments' processing of nutrients that are not currently accounted for in models or policy making.

NUTRIENT MARKERS & SOURCES

This monitoring design guideline focuses on identification of the contribution of sediments at the bottom of the lake to water column loadings of nutrients. The sediments themselves do not constitute a nutrient source on their own, but rather are a place where past nutrient contributions to the lake are held. Once in sediment, nutrients may enter deep burial where they are unlikely to re-enter the water column without a major hydraulic event, or they may re-enter the water column through chemical processes (desorption) or physical processes (re-suspension).

Determining the degree to which the lake's sediments act as source or a sink for nutrients, and quantifying the flux rates at which the nutrients move between sediments and the water column is important.

No single nutrient species is the focus of the monitoring design, but rather the interaction of various species insofar as the chemical and physical processes affect flux rates between sediment and water. For the purposes of the Falls Lake nutrient response model, at least four flux rates must be specified. These include:

- Ammonia (NH_3)
- Nitrate and Nitrite (NO_3 and NO_2, or more simply NO_x)
- Phosphate (PO_4)
- Sediment Oxygen Demand (SOD)

A flux is a measurement of mass passing across a given area in a given time (mass/area/time). In general, the fluxes in this monitoring study are quantified in units of grams per square meter per day ($g/m^2/d$)

PREVIOUS & EXISTING MONITORING (STUDIES OR LONG-TERM)

The only known direct observations of nutrient flux in Falls Lake were completed by DWQ in 2006 in preparation for building the Falls Lake nutrient response model. Two sites were sampled. They are labeled as NEU013B and NEU018E in Figure 1. The model's cell grid is shown in the Figure along with elevation of the lake bottom, which indicates the relative average depths of the cells.

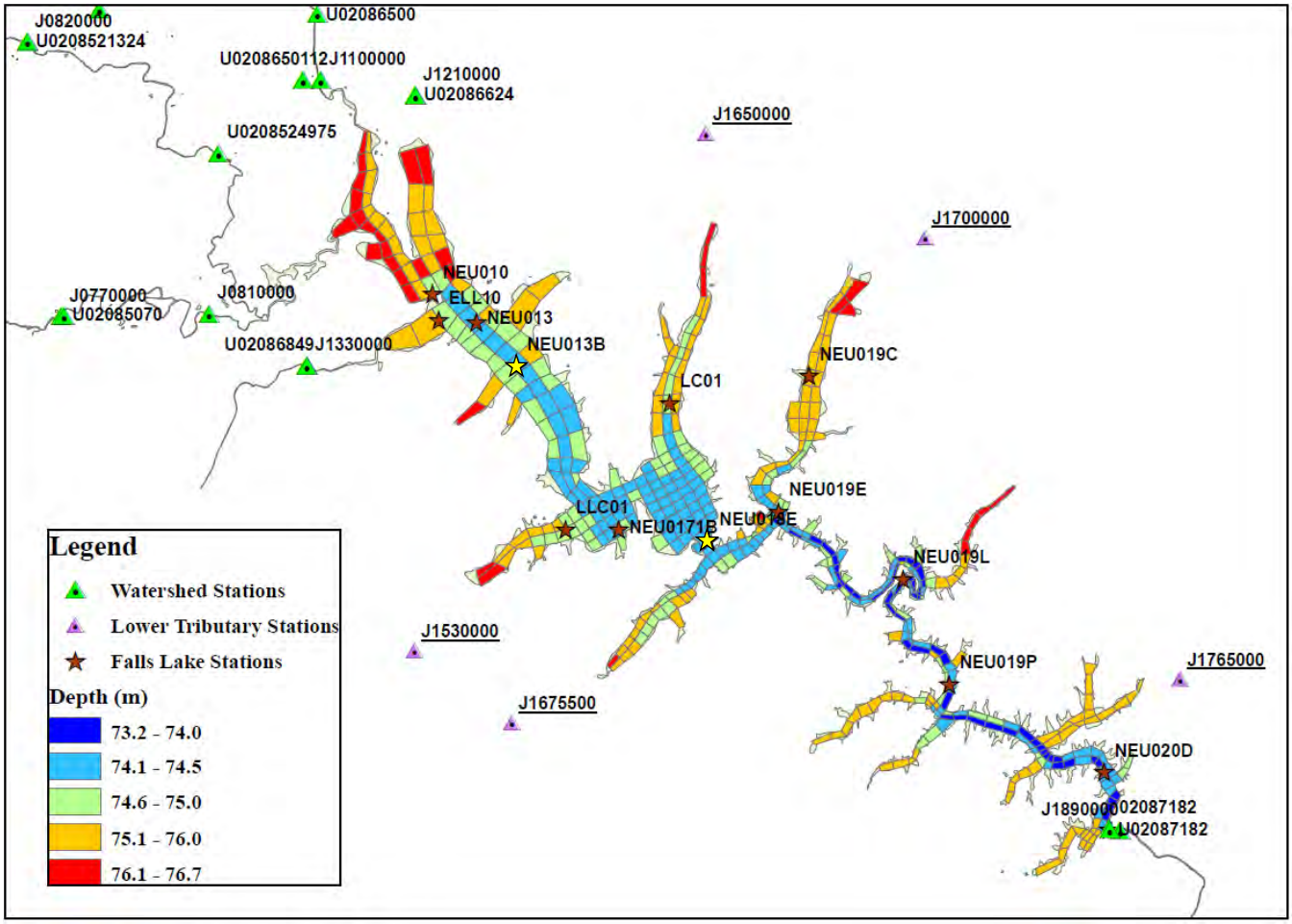


FIGURE 1. DWQ IN-LAKE SAMPLING LOCATIONS (STARS). FLUX SAMPLING LOCATIONS SHOWN WITH YELLOW STAR.

Neither site had measurable net fluxes of NO_2+NO_3 or PO_4^- For site NEU018E, the NH_3 flux was reported at 0.0103 g/m^2/d, and the SOD flux was -0.7811 g/m^2/d. For site NEU013B, the NH_3 flux was reported at 0.0501 g/m^2/d, and the SOD flux was -1.3868 g/m^2/d.

The measurements for the two sites are clearly different, perhaps indicating a difference in sediment flux rates in different parts of the lake. Ultimately, the sample size is too small to make any conclusions. As a result, the samples were not used in modeling, and flux rates were left as a calibration parameter. The *Falls Lake Nutrient Response Model Final Report* published by DWQ in November, 2009, summarized the approach that was taken in Section II.d, "Benthic Nutrient Flux" as follows:

> *"Since certain temporal and spatial variations of the nutrient flux rates were reported, and neither the spatial nor the temporal resolutions of the data were enough to develop a dynamic representation of*

sediment nutrient fluxes for model use, constant values were specified in the model. The measured nutrient flux rates were used as an indication of the ranges of the parameter values and their order of magnitudes. The exact nutrient flux values were selected through model calibration processes …"

While the measurements of nutrient flux rates were extremely limited, the monitoring in the lead up to the model did investigate other parameters in the lake's water column that may be related to nutrient flux across the sediment-water interface. Among the relevant parameters sampled were TP, NH_3, NO_x, TKN, TN, DO, TSS, TOC, and temperature, among others. Depending on the sampling site, several of these parameters were investigated at several layers.

There have been other investigations of sediment nutrient flux in North Carolina. Most notably, Hans Paerl at UNC and his group have completed benthic flux characterization studies in the Neuse River Estuary using sediment core samples. Details of the research can be found here:

http://www.unc.edu/ims/paerllab/research/mudboy/benthic_flux.html

Some interesting findings, which may not equally apply to Falls Lake as they do to the estuary, were noted by the research group:

- *SOD does vary spatially but the differences are probably not biologically significant. Ave. SOD rates for all study sites could be summarized quite well by using a value of 1.0 mmoles O^2/m^2*hr.*
- *Nutrient release is positively correlated with SOD rates.*
- *Both SOD and nutrient release rates are positively correlated with sediment carbon, nitrogen, and Chlorophyll a content.*
- *Denitrification rates have been quite variable, ranging from 0 to 7000 mmoles N/m^2*day.*

Other studies in the Eastern US have shown notable spatial and temporal variation in flux rates, notably of nitrogen and SOD.

MONITORING DESIGN

Proposed Monitoring Activities or Studies

Parameters& Methods

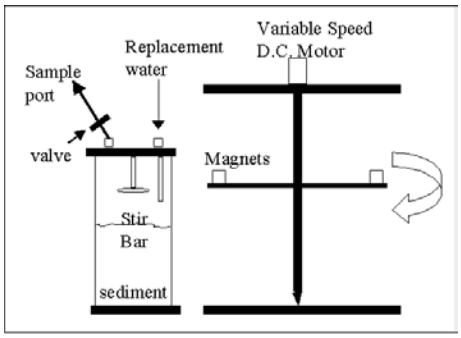
Sediment core extraction and subsequent lab analysis is the most widely accepted method of quantifying sediment nutrient flux. Concurrent water samples should also be taken to investigate water conditions at time of core extraction. The sediments are generally analyzed for nutrient concentrations.

Sediment core flux lab analysis technique here:

The basic procedure for performing a sediment core flux analysis involves:

- Collecting the sediment core with a hand push or gravity corer. At the same time, collect water from the lake bottom for the tests.

- Putting the core into a reactor assembly with ports on top for water replacement and sampling, along with a stirring apparatus. For example, see this diagram and image from the Hans Paerl lab: (from http://www.unc.edu/ims/paerllab/research/mudboy/benthic_flux.html)



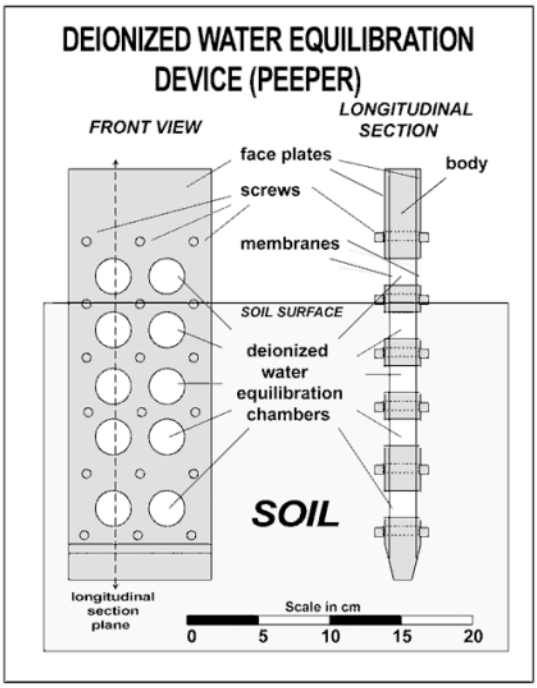
- Run the test by gently stirring the water over the sediment in the cores, and every several hours extract the water from the sample port while simultaneously replacing water from the collected lake water. Measure the nutrients and other parameters in the sampled water. The nutrient flux will account for additional nutrients in the water.
- Repeat with several cores.

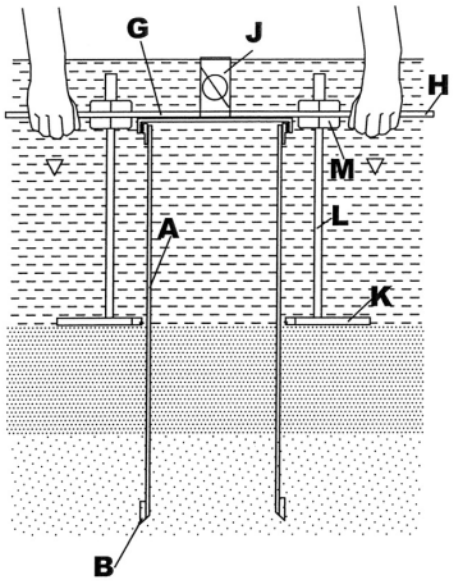
Alternative sampling methodologies exist for addressing the problem. These include:

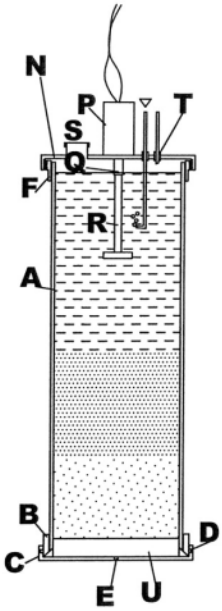
- Peepers (Pore water membrane samplers)
- In-situ chambers

Furthermore, direct grab sampling of sediments and lake water from near the lake bottom with chemical analysis of each can provide some indication of parameters which might be sufficient to estimate nutrient flux.

The following images show the various methods of sampling nutrient flux rates. A peeper at left, and corer reactor at center (core collection) and right (reactor set-up in the lab).







The flux parameters to be determined by lab analysis should include at minimum the following:

- Ammonia (NH_3)
- Nitrate and Nitrite (NO_3 and NO_2, or more simply NO_x)
- Phosphate (PO_4)
- Sediment Oxygen Demand (SOD)

If using ex-situ corer reactors, at least three cores should be taken from each location. Phosphate may also be measured through the dissolved iron method.

Additionally, the following parameters should be measured for the water just above the lake bed:

- pH
- Temperature
- Ammonia
- Nitrate, Nitrite, and TN
- Phosphate
- Dissolved Oxygen
- TOC
- TSS

Frequency

Frequency of sampling will depend on funding levels available. For the purpose of these monitoring design guidelines, frequency of sampling is guided by prioritization of monitoring study objectives. The table below describes the priorities, which can be addressed by frequency of sampling, in descending order.

#	Temporal Priority	Samples per year, per location
1	Characterize seasonal variation in nutrient flux. Determine if seasonally varying nutrient flux rates would be useful for modeling.	4, 6, 8, or 12.
2	Investigate diurnal variations in nutrient flux. Some processes (especially biological processes such as algal growth and respiration) vary over the course of the day. Should investigate whether sediment acts as a net sink or net source for nutrients at different times of day.	2, 4, or more samples every day lake is sampled
3	Event-based characterization. Does the number of days since rainfall affect nutrient flux between sediment and water? Times of rapidly changing water levels? Large events that cause scour or high turbidity? (Sample at high frequency (4/d) at start of event, then continue less frequent sampling (1/d or less) to understand longer term changes.)	5 – 60.
4	Understand changes due to hypolimnetic condition. Sample location when water is stratified and when it is well mixed. This may be achieved through regular seasonal sampling, though additional measurements	2 – 8.

	(esp. temperature vs. depth) may be necessary to document condition of lake stratification.	

Location, Scale, Watershed Type or Character (e.g. rural or urban)

All monitoring would take place in Falls Lake. The number of sampling sites will vary depending on available funding and resources. As such, the priorities for the monitoring studies are listed in descending order of importance, along with the expected number of sites needed.

#	Priority	# of sites (additional)
1	Characterize differences between the upper lake and lower lake.	2, 4, or 6. Preferably at least 4.
2	Study differences in sediment at different depths and water levels (e.g. 1 deep water (sub-hypoliminion), 1 medium depth, 1 shallow)	1 or 2 additional sites for each site in # 1.
3	Examine differences between lake areas with different hydrologic and sediment conditions. (Highly turbid areas with fast moving water and scour vs. areas with slow moving water and little re-suspension)	1 – 6. Depending on where other sites have been placed.

Proposed Study Designs

Evaluating the various temporal and spatial goals, a very wide range of studies could be performed with many different sampling methodologies and frequencies. For the sake of simplicity, three studies that address some of these objectives are summarized here.

Monitoring Group & Potential Partnerships

If ex-situ cores are used, the monitoring team will need access to a lab facility near Falls Lake, as the sediment cores need to be tested within hours of collection. The team will also need access to boats to collect the samples. A diver may be necessary if the peeper or in situ reactor methods are used. With the ex-situ core analysis method, a gravity coring device is probably sufficient.

QA/QC Procedures & Recommendations

See sampling literature.

(e.g. https://www.agronomy.org/publications/jeq/articles/32/5/1905)

Data Coordination & Use

Data from monitoring team would be reported to DWQ, who would make it available to modelers. Data would also be shared with relevant stakeholders either by request, by posting on website, or making it available through existing data sharing mechanisms. Nutrient flux rates are not a standardly shared

parameter on services like EPA STORET, but observations from concurrent water samples that are analyzed for parameters like TSS, TOC, TN, TP, etc., should be added to the relevant databases.

FUNDING OPPORTUNITIES

N/A

PUBLIC EDUCATION COMPONENTS

Studying temporal and spatial variations in sediment nutrient flux will provide useful information for better modeling in an update of a Falls Lake Nutrient Response Model. This monitoring study would fill a significant gap for modeling, but also has the opportunity to fill other gaps in understanding how Falls Lake processes nutrients and would respond to certain types of treatments. Collecting baseline information on sediment nutrient flux would be a first step in assessing the effectiveness of several in-lake nutrient reduction technologies such as aerators, alum treatments, and floating vegetative or biochemical treatment cells.

Public education on the monitoring effort should focus on 1) how sediments affect in-lake water quality, and 2) why it matters to decision makers to quantify in-lake processing of nutrients correctly. This topic is not easily explained to a broad public audience, but the messages can be targeted to interested professionals, students, and interested stakeholders. Due to the chemistry involved and the difficulty in actually accessing the lake bottom and visually depicting complex processes, this topic is probably best suited to a seminar/lecture or a poster diagram or small model exhibit. Professional society, university departmental seminars or academic conferences such as the annual WRRI conference of the NCWRA would be reasonable venues for presenting findings and educating interested professionals.

Policy makers should also be educated on the importance of this monitoring as conclusions from the study are determined. A change in the understanding of nutrient processing could have significant effects on the methods used for water quality modeling of Falls Lake. In turn, policy recommendations for Nutrient Management Strategies could be altered if rates of nutrient processing in the lake turn out to be significantly higher or lower than expected such that attainment of water quality goals is affected.

RESOURCES

- http://portal.ncdenr.org/c/document_library/get_file?uuid=99f1ed35-6533-45be-a08c-520a414b7c97&groupId=38364
- http://www.unrba.org/docs/news/news200810.pdf
- http://www.epa.ohio.gov/portals/35/guidance/sedman2001.pdf
- http://www.glsc.usgs.gov/_files/research/InlandLakesManual.pdf
- https://secure.hosting.vt.edu/www.sera17.ext.vt.edu/Documents/Methods_of_P_Analysis_2000.pdf
- http://www.apha.org/about/news/booksreleases/standardmethodsbkrelease.htm
- http://www.epa.gov/region4/sesd/reports/2000-0119.html

– http://gonzo.cbl.umces.edu/documents/sediments/Est19_562.pdf
– http://www.int-res.com/articles/meps/141/m141p229.pdf
– http://www.int-res.com/articles/meps/198/m198p051.pdf
– http://cee.unc.edu/people/graduate-students/theses/Ensign_MS.pdf
– http://www.int-res.com/articles/meps/73/m073p069.pdf
– http://www.apha.org/about/news/booksreleases/standardmethodsbkrelease.htm

Study Proposal to Evaluate the Influence of Clogged Media on the Effectiveness of Sand Filter Stormwater Control Measures

SARAH BRUCE, WATSON ROSS, ROBERT PATTERSON, RAGHAVENDERRAO BADAMI, RYAN WINSTON

BACKGROUND & PROBLEM STATEMENT

Background

Sand filters are stormwater control measures that treat influent via settling, filtering, and adsorption processes with a sand media to reduce NPS pollutants. Urban BMP, less land intensive

Problem Statement

Like all stormwater control measures, sand filters must be maintained in order to continue to provide water quality benefits. Sand filters (especially those with a smaller surface area, such as trench-type systems) are prone to developing a relatively impermeable surface layer, which can cause runoff to bypass the filter media rather than flowing through it and being treated, as the sand filter was designed to function. This can happen due to a number of factors, such as erosion in the sand filter's drainage area overwhelming its forebay or sedimentation chamber, an illicit discharge such as grease or motor oil, clogging of collection pipes, or simple accumulation of pollutants over a period of time. Clogged surface layers or clogged drainage pipes can cause anoxic conditions to develop within the device, which can strip the phosphorous from the soil, causing increased effluent concentrations of total phosphorous (DWQ BMP Manual, email communication with NCSU BAE's Ryan Winston).

Obviously, since sand filters' primary treatment mechanism is infiltration and adsorption, lack of maintenance could compromise the functionality and effectiveness of sand filters. The monitoring proposed under this design guideline would focus on quantifying the impact on effluent water quality of surface layer sand filter maintenance activities. This monitoring design guideline does not address the effectiveness of other maintenance activities, nor activities that are considered "repairs," such as media replacement.

Regulatory Context[1]

The DWQ BMP Manual provides numerous specifications for sand filter design and construction (see BMP Manual Chapter 11). According to DWQ (BMP Manual), sand filters are "highly effective at removing TSS, BOD and fecal coliform." DWQ credits sand filters for nitrogen removal (35%), phosphorous removal (45%), and TSS removal (85%). In the Jordan and Falls Lake watersheds, the NCSU Stormwater Load Accounting Tool assigns sand filters effluent concentrations of 0.92 mg/L TN and 0.14 mg/L TP.

Several maintenance activities are recommended for sand filters at specific intervals in the Manual and the O&M Guidance. In terms of sand filter media maintenance, DWQ specifies that the surface of the sand media be skimmed once a year.

Numerous other maintenance activities may be called for depending on problems that may be observed during routine inspections. Related to maintenance of the sand filter media, if water is ponding on the surface of the media for more than 40 hours after a storm, the Manual specifies that the operator "[c]heck to see if the collector system is clogged and flush if necessary. If water still ponds, remove the top few inches of filter bed media and replace."

How this Study will reduce Uncertainty

Currently, not much is known about how various levels of clogged media reduce sand filter functionality. If more were known about the effects of clogged media, more attention might be paid to maintenance and prevention, and entities faced with repairing sand filters would have more bases for prioritizing and allocating the investments necessary to bring them up to full functionality. Relatedly, it would be helpful to know at what point clogging causes total failure of the sand filter, produces significant impacts on effluent water quality, and/or necessitates a complete repair of the BMP (rather than simply replacement of the top layer of media).

This study would give quantitative information for regulators and operators on the water quality impacts in terms of nutrients, bacteria, BOD, and particulates of failing to maintain the infiltration/treatment capacity of sand filter media. Also, watersheds where sand filters have been installed might be modeled for water quality parameters more accurately, if the models included this level of detail.

POLLUTANT MARKERS & SOURCES

Sand filters typically treat small areas and are typically located in catchments with impervious surface that causes runoff in need of treatment. Therefore, pollutants to be studied would likely be those associated with runoff from impervious surfaces, such as nutrients from fertilizers, atmospheric deposition, and animal waste; hydrocarbons from vehicles; sediment from land disturbance, erosion, and roadways; bacteria from animal waste; and litter. In the Upper Neuse River Basin, nutrients are of paramount interest.

[1] Local ordinances may be stricter than the state for design, maintenance, or both, and are not reviewed here.

This monitoring design guideline recommends that sand filter influent and effluent should be monitored for quantity (flow) and phosphorous, BOD, bacteria, and particulates. Depending on the watershed of interest, nitrogen may also be monitored; however, sand filters are usually not expected to perform at a high level for N removal.

See Parameters for further information.

PREVIOUS MONITORING STUDIES

Anderson, D.L., R.L. Siegrist, and R.J. Otis. 1985. Technology Assessment of Intermittent Sand Filters: Municipal Environmental Research Laboratory, Office of Research and Development, U.S. EPA.

Bright, T. M.; Hathaway, J. M.; Hunt, W. F. III; de los Reyes, F. L. III; Burchell, M. R. II. "Impact of Storm-Water Runoff on Clogging and Fecal Bacteria Reduction in Sand Columns." JOURNAL OF ENVIRONMENTAL ENGINEERING, ASCE / DECEMBER 2010. Pp. 1435-1441.

Center for Watershed Protection (CWP). 1996. Design of Stormwater Filtering Systems. Prepared for the Chesapeake Research Consortium, Solomons, MD, and U.S. EPA Region 5, Chicago, IL, by the Center for Watershed Protection, Ellicott City, MD.

Center for Watershed Protection (CWP). 1997. Multi-Chamber Treatment Train developed for stormwater hot spots. Watershed Protection Techniques 2(3):445-449.

Claytor, R.A. and T.R. Schueler. 1996. Design of Stormwater Filtering Systems: Chesapeake Research Consortium and U.S. EPA.

Erickson, A.J., P.T. Weiss, and J.S. Gulliver. 2005a. Enhanced Sand Filtration for Storm Water Phosphorus Removal.

Erickson, A.J., P.T. Weiss, and J.S. Gulliver. 2005b. Phosphorus Capacity of Enhanced Sand for Storm Water Filtration.

Galli, J. 1990. Peat-Sand Filters: A Proposed Stormwater Management Practice for Urbanized Areas. Washington, D.C.: Metropolitan Washington Council of Governments.

Harper, H.H. and J.L. Herr. 1993. Treatment Efficiencies of Detention with Filtration Systems. Final Report: St. John's River Watershed Management District.

Herrera Environmental Consultants. 1995. Lake Sammammish Phase 2 Restoration Project, Lake Park Storm Water Treatment Facility, Task 2: Bench Scale Test Results. Memorandum to the city of Bellevue (Washington).

O'Leary, J. 2003. Potential Causes of Clogging and Remedies to the Lakemont South Filter. 5. Patrick, W.H., Jr. and R.A. Khalid. 1974. Phosphate Release and Sorption by Soils and Sediments: Effect of Aerobic and Anaerobic Conditions. Science, 186 (4158): p. 53-55.

Schueler, T. 1994. Developments in sand filter technology to improve stormwater runoff quality. Watershed Protection Techniques 1(2):47-54.

Urbonas, B. "Design of a Sand Filter for Stormwater Quality Enhancement." Water Environ. Res., 71, 102 (1999).

Weiss, Peter T.; Gulliver, John S.; Erickson, Andrew J. "Cost and Pollutant Removal of Storm-Water Treatment Practices" JOURNAL OF WATER RESOURCES PLANNING AND MANAGEMENT © ASCE / MAY/JUNE 2007. Pp. 218-229.

MONITORING DESIGN

Proposed Monitoring Activities or Studies

A longitudinal study could be conducted where a sand filter's performance is monitored over time as it is caused or allowed to clog; however, it might be challenging to know whether the BMP's age was influencing its performance. A better approach would be a paired treatment–control method, in which two sand filters with similar catchment characteristics are constructed at the same time in similar locations and monitored for a period of years. Ideally, the two study BMPs would be close to one another to reduce potential effects of spatial differences in rainfall.

Parameters & Methods

Test effluent concentrations during each storm event, and regularly test soil media for infiltration rate to record how the infiltration rate changes over time. The pollutants of greatest interest in the Falls Lake watershed are nutrients and sediment. If sampling and testing protocols permit, other pollutants such as metals, hydrocarbons, and bacteria may be added to the species being studied. Flows (inflow and outflow volumes) would also need to be monitored, both to quantify total pollutant removal as well as to assess the impact of clogged media on infiltration capacity/volume reduction per se.

Frequency

Monitor the sand filter device at every storm of the size for which the BMP was sized (typically, the 1-inch storm is used to size sand filters, however other design storms may be used).

Location, Scale, Watershed Type or Character (e.g. rural or urban)

Sand filters typically treat urban catchments. Locations would be determined according to the most suitable candidate devices for study, but highest priority should be placed on sand filters in the watershed where the study shall be applied. For example, if the purpose of the monitoring is to adjust crediting for the Falls Lake watershed, sand filters in the Upper Neuse should be examined. Next-best locations would be the Piedmont of NC, followed by the Piedmont ecoregion as a whole. Performance and clogging in both Triassic and non-Triassic soils might be studied.

Monitoring would be undertaken at the site scale. That is, the sand filters' inflow and outflow would be sampled at a specified frequency. However, a sophisticated study might incorporate data from any nearby atmospheric deposition monitoring stations to account for atmospheric pollutant contributions. Accurate precipitation data may also be required to estimate flows if gages are not established at the sand filter for that purpose.

Monitoring Group

The monitoring for this study could be coordinated by university researchers or local governments having or contracting monitoring capabilities, and could be supplemented by local volunteers and other interested stakeholders with appropriate training.

QA/QC Procedures & Recommendations

Quality assurance and quality control will include field and laboratory procedures typical of stormwater sampling protocols. These include field preservation of samples in refrigerated containers and proper labeling and storage of samples, as well as lab testing of duplicate and control samples alongside the collected samples. Once data is generated, it shall be peer-reviewed as another QA/QC measure.

Data Coordination & Use

Data and conclusions produced as part of this study would be shared with the NC DENR Division of Water Quality for potential inclusion in the NC DWQ Stormwater Best Management Practices Manual. Other users would include the NC DENR Nutrient Scientific Advisory Board for use in advising nutrient reduction strategies, the NC LID Group for use in informing LID practices throughout the state, as well as local university groups including the NC State Biological & Agricultural Engineering Stormwater Engineering Group.

FUNDING OPPORTUNITIES

- 319 grants for water bodies that are impaired for bacteria or BOD but do not have a TMDL for that impairment
- Green infrastructure grants
- Masters or Doctoral theses
- Local governments
- Watershed associations

PUBLIC EDUCATION COMPONENTS

Monitoring data and studies on this topic could be applied to enhance trainings and guidance for BMP designers, regulators, and operators so that the consequences of improper maintenance are well understood.

REFERENCES

- NC DWQ BMP Manual

Study Proposal to Evaluate How Soil Protections and/or Amendments Influence Surface Runoff, BMP Performance, and Receiving Water Quality

SARAH BRUCE, TERRY HACKETT, BETSY PEARCE

BACKGROUND & PROBLEM STATEMENT

Background & Problem Statement

Typical construction practices for developments involve topsoil removal and the compaction of soils under foundations, roadways, driveways and parking lots. Infiltration is reduced and runoff cannot permeate the soil, even if the land use is considered "pervious" under regulatory definitions. BMPs and landscaped areas are often installed without regard to these compacted soils. This could affect the health of planted vegetation, the amount of microbial activity taking place in the soils, the infiltration capacity of the site overall, and the performance of its stormwater BMPs.

Alternative practices merit evaluation for their potential to reduce runoff generated by the site, reduce NPS pollutants at the source, improve BMP performance, and/or improve the quality of the runoff leaving the site. These alternative practices could be employed, alone or in combination:

- Clear and grade only the building & infrastructure envelopes, leaving future pervious undisturbed to the maximum extent practicable
- Till or plow soils on future pervious areas to mitigate compaction
- Till or plow soils on future BMPs to mitigate compaction
- Amend and/or replace topsoil in future pervious areas
- Amend and/or replace topsoil in stormwater BMPs that do not usually specify media characteristics, such as swales and wet ponds

These practices may provide a water quality benefit by slowing runoff, increasing infiltration, and encouraging plants and their root systems to establish and thrive, thereby reducing pollutants.

If less runoff of a higher quality is being generated, it might be hypothesized that BMPs treating that runoff may perform differently (e.g., they might have a longer lifespan or require less maintenance),

and receiving water bodies might receive fewer NPS inputs. Furthermore, if these practices were implemented during construction, the site might be stabilized more quickly and water quality impacts from construction might be reduced as well.

These practices might also be used in conjunction with other emerging BMPs, such as downspout disconnection, whereby rooftop runoff is directed to "pervious" areas. Obviously, an area that is truly pervious will infiltrate this runoff more readily than an area that is underlain by compacted soils. Soil amendments might also help stream and buffer restoration projects provide more functional uplift by helping vegetation establish and thrive, stabilizing the project site more quickly, and facilitating physicochemical interactions around the water table.

Regulatory Context

Any regulatory strategy targeted at new development may benefit from research on this topic. Fore example, the new Jordan/Falls Stormwater Nutrient Load Accounting Tool assumes that inflow concentrations matter less to outflow concentrations than the BMP and its volume reduction capacities. If variations in inflow characteristics or the soil in the BMP itself influence BMP effluent, this would need to be accounted for. Also, soil protection and amendments might be a valid pollution-reducing practice on their own, and would be appropriate to credit as such, if appropriate crediting can be established based on research.

The Falls Rules will drive the use of more structural stormwater measures to reach onsite loading thresholds, which may have the result of increasing the densities of developments that may otherwise have chosen to rely on nonstructural measures. Developers and local governments may prefer to use nonstructural measures in certain situations if possible, particularly rural, low-density, and LID developments, so these measures could provide more flexibility in site design. Soil preservation might also reduce land opportunity costs for stormwater management. Reducing reliance on structural BMPs could also benefit local governments, particularly if they assume maintenance responsibilities for structural BMPs. Regardless of the reason, having more practices that can be used to reduce nutrients and excess runoff would help our region meet its water quality goals.

The Commonwealth of Pennsylvania credits practices that preserve or replace topsoil as well as revegetating disturbed areas (PA Stormwater BMP Manual, 2005).

How this Study will reduce Uncertainty, what efforts it could inform

Future watershed modeling efforts may also benefit, as sites designed in an environmentally sensitive way may be shown to have a lower nutrient loading than conventional sites, and accuracy of modeling may therefore be improved by quantification of differences. This study could also help quantify the effectiveness of preserving land from development as a stormwater control measure.

Maintaining and enhancing the infiltration capacity of pervious areas is being explored and implemented locally. For example, athletic fields are already designed to drain precipitation quickly from the surface; however, this is not yet considered a creditable stormwater practice.

POLLUTANT MARKERS & SOURCES

Nitrogen species, phosphorous variants, bacteria, metals, hydraulics (sediment transport and scour), and hydrologies should be monitored to the extent that each monitoring location and resources allow.

Monitoring on specific site should note pre-existing land use—forest vs. agriculture—as this may affect site loadings. Ideally, the study would compare two developments with similar geologies, prior land uses, degree of post-development forest cover, and other characteristics to minimize exogenous variation. At a minimum, these site characteristics should be well documented.

PREVIOUS & EXISTING MONITORING (STUDIES OR LONG-TERM)

Volumes of research are available on the effectiveness of the structural BMPs typically employed in low-impact development situations, but research on nonstructural approaches, such as protecting topsoil from removal and compaction, is virtually nonexistent, particularly for developed (nonagricultural, nonsilvicultural) land uses. Existing study designs for forestry and agriculture are one potential source of study designs that could be researched and adapted to inform study designs for developing and developed land covers. Studies on the effects of organic matter on hydrology and pollutant processing & transport would also be valuable.

Potential resources for studies and research include the NCSU Dept. of Forestry and Environmental Science, Ecohydrology and Watershed Science group, and the U.S. Forest Service research publications website (http://www.treesearch.fs.fed.us/).

Boggs, Johnny. Effectiveness of Streamside Management Zones and Stream Crossings BMPs on Water Quality Protection in North Carolina Piedmont Forested Watersheds. (Purpose: Understand the water quality and hydrologic conditions of a forested watershed in the piedmont region of the southeastern U.S. and determine the effectiveness of forestry best management practices (BMPs), including a streamside riparian buffer, in preventing nonpoint source pollution impacts from timber harvesting activities.)

Katie Price, "Effects of watershed topography, soils, land use, and climate on base flow hydrology in humid regions: A review", Progress in Physical Geography 35(4) 465–492., 2011.

Virginia DCR Stormwater Design Specification No. 4: Soil Compost Amendment. Version 1.8, March 1, 2011.

Kozlowski, T.T. Soil Compaction and Growth of Woody Plants. Scandinavian Journal of Forest Research, Volume 14, Number 6, 31 December 1999, pp. 596-619(24)

Although soil compaction in the field may benefit or inhibit the growth of plants, the harmful effects are much more common. This paper emphasizes the deleterious effects of predominantly high levels of soil compaction on plant growth and yield. High levels of soil compaction are common in heavily used recreation areas, construction sites, urban areas, timber harvesting sites, fruit orchards, agroforestry systems and tree nurseries. Compaction can occur naturally by settling or slumping of soil or may be induced by tillage tools, heavy machinery, pedestrian traffic,

trampling by animals and fire. Compaction typically alters soil structure and hydrology by increasing soil bulk density; breaking down soil aggregates; decreasing soil porosity, aeration and infiltration capacity; and by increasing soil strength, water runoff and soil erosion. Appreciable compaction of soil leads to physiological dysfunctions in plants. Often, but not always, reduced water absorption and leaf water deficits develop. Soil compaction also induces changes in the amounts and balances of growth hormones in plants, especially increases in abscisic acid and ethylene. Absorption of the major mineral nutrients is reduced by compaction of both surface soils and subsoils. The rate of photosynthesis of plants growing in very compacted soil is decreased by both stomatal and non-stomatal inhibition. Total photosynthesis is reduced as a result of smaller leaf areas. As soils become increasingly compacted respiration of roots shifts toward an anaerobic state. Severe soil compaction adversely influences regeneration of forest stands by inhibiting seed germination and growth of seedlings, and by inducing seedling mortality. Growth of woody plants beyond the seedling stage and yields of harvestable plant products also are greatly decreased by soil compaction because of the combined effects of high soil strength, decreased infiltration of water and poor soil aeration, all of which lead to a decreased supply of physiological growth requirements at meristematic sites. Many protocols have been developed, with variable success, to alleviate the adverse effects of soil compaction on the growth and development of woody plants. These include planting of compaction-tolerant species, controlling vehicular and animal traffic, amending soils by adding coarse materials and/or organic matter, replacing compacted soils with uncompacted soils, loosening soils with aerating equipment, installing drainage systems and judiciously applying fertilizers. Prevention of soil compaction before planting is usually much preferred over post-planting treatments because the latter are expensive and difficult to apply, may not be adequately effective and may injure plant roots.

Sinnett, Danielle; Poole, Jane; Hutchings, Tony R. A comparison of cultivation techniques for successful tree establishment on compacted soil. Forestry, Volume 81, Number 5, 1 December 2008, pp. 663-679(17).

Soil compaction is often responsible for the poor establishment of trees on restored brownfield sites. This paper examines the root development, survival and growth of *Alnus cordata*, *Larix kaempferi*, *Pinus nigra* and *Betula pendula* after cultivation with complete cultivation, a standard industrial ripper and a prototype ripper. The industrial ripper was used in one pass across the experimental plots and the prototype ripper in both two and four passes. While the maximum root depths, after five growing seasons, attained by trees were similar to the target soil loosening depths for the cultivation techniques, the total number of roots suggests that root development was not uniform across the soil profile. All treatments significantly increased both the maximum root depth and total number of roots compared with the untreated control; the complete cultivation had approximately double the number of roots compared with the other treatments. Larger average root diameters and a higher percentage of coarse roots also suggest that roots experienced physical restriction in the control, two-pass prototype and industrial ripper plots. Similarly, while all species had attained significantly greater height growth on the treated soils compared with the control, the height of *A. cordata*, *L. kaempferi* and *B. pendula* was greatest

after complete cultivation. The results demonstrate that complete cultivation is the most effective method of alleviating soil compaction for tree establishment.

Ponder, Felix. Nine-Year Response of Hardwood Understory to Organic Matter Removal and Soil Compaction. Northern Journal of Applied Forestry, Volume 25, Number 1, March 2008, pp. 25-31(7).

The effects of three levels of organic matter removal (OMR) and three levels of soil compaction (SC) on the development of understory vegetation in a central hardwood forest were evaluated 9 years after treatments were applied as part of a national program of long-term soil productivity research. The three levels of biomass removal (OMR) were removal of merchantable boles only (OM0), removal of the whole tree (OM1), and removal of the whole tree plus forest floor (OM2). The three levels of soil compaction (SC) were none (C0), medium (C2), and severe (C2). Weeds were controlled in all plots for the first 2 years. Understory vegetation within 81 7.9-m^2 subplots was inventoried by species and quantified into plant groups of woody (trees, shrubs, and woody vines) and herbaceous (annuals, perennials, and grasses) at year 5 (after 3 years of no weed control) and year 9 (after 7 years of no weed control). Vegetation was analyzed for nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg). OMR did not significantly affect the overall number of plants over the 5-year measurement period, but there were differences for both woody vines and grasses, which were highest in the OM0 treatment in 1999, but by 2003, they were not different. There were no differences in plant numbers among plant groups for SC in the 1999 measurement period between treatments for any plant group, but there were significantly fewer trees and woody vines in the C2 treatments than in the C0 or C1 treatments in 2003; the opposite was true for herbaceous annuals, which were highest in C1 and C2 treatments. Over the 5-year measurement period, only the height of woody vines was significantly affected by OMR, but SC significantly affected the height of all plant groups over the 5-year measurement period. Annually, however, trees were tallest in the OM0 and C0 treatment than in OM2 and C2 treatments. The annual height of other plants, excluding trees, was affected only 1 year of 5 by OMR. Fewer trees and shorter trees in the severe compaction treatment suggest that, in the short term, soil productivity has been affected on the site.

Jordan D.; Ponder F.; Hubbard V.C. Effects of soil compaction, forest leaf litter and nitrogen fertilizer on two oak species and microbial activity. Applied Soil Ecology, Volume 23, Number 1, May 2003 , pp. 33-41(9).

A greenhouse study examined the effects of soil compaction and forest leaf litter on the growth and nitrogen (N) uptake and recovery of red oak (Quercus rubra L.) and scarlet oak (Quercus coccinea Muencch) seedlings and selected microbial activity over a 6-month period. The experiment had a randomized complete block design with three replications. Ammonium ^{15}N-sulfate at 33mg ^{15}N kg^{-1} was used to quantify seedling N uptake and recovery. After 6 months, seedlings were harvested and analyzed for dry matter production, total N, ^{15}N uptake and N derived from ^{15}N labeled fertilizer (Ndff). Soil enzyme activity and soil microbial biomass C and N were measured as indicators of microbial activity. Soil compaction significantly decreased seedling

height, dry matter production, and ^{15}N recovery of both oak species. Significantly greater N losses were observed in compacted pots compared with the non-compacted pots. Less ^{15}N was immobilized in the soil microbial biomass in the compacted pots than under non-compacted conditions, probably due to greater overall ^{15}N losses in the compacted conditions. Soil compaction significantly affected microbial activity by reducing acid phosphatase. Severe soil compaction decreased young tree growth and reduced N fertilizer uptake.

MONITORING DESIGN

There are several components or sub-hypotheses that could be tested for this issue. Some combination of scale of study, parameters of interest, and treatment need to be selected:[2]

Scale of Study	Parameters of Interest	Treatment
BMP (inflow and outflow)	Pollutants: Nitrogen, phosphorous, sediments, bacteria, metals, etc. Hydrology: flow, volume, and timing	Treat or protect soils in BMPs or reach-scale restoration projects
Site or catchment (outfalls/receiving waters)		Treat or protect soils on non-BMP pervious areas

Proposed Monitoring Activities or Studies

Suggestions on study design are drawn from the NCFS study Johnny Boggs is working on, as similar parameters, frequencies, and methods may be applicable to this study's design.

Parameters & Methods

Water quality: Nitrogen (NO3, NH4, TKN), phosphorous (TP), sediments (TP), bacteria, total organic carbon (TOC), temperatures. The Boggs study is using Sigma sampler programmed for storm event sampling, grab samples, and Hobo ProV2 Logger for temperatures.

Water depth, flow rate, and flow volume in streams and/or BMPs could be measured using weirs / flumes and water level recorders.

Soil conditions and respiration, such as moisture, temperature, and carbon would also be valuable. The Boggs study used onsite thermocouples and EGM to measure these parameters.

Transpiration, or water usage by vegetation, would be important to characterize the water balance. The Boggs study is using sap flow measurements and the thermal dissipation technique to quantify water usage by trees.

Precipitation, air temperature, relative humidity, total solar radiation, and wind speed might be measured to account for meteorological effects.

To measure health of the receiving stream in physical terms, cross sections, longitudinal profiles and stream patterns should be measured before, during, and after construction of the sites.

[2] Of course, if no stormwater BMPs are installed, monitoring at the BMP scale would not be selected.

To measure the health of the receiving stream in biological terms, benthic macroinvertebrates should also be sampled before, during, and after construction of the sites using DWQ protocols.

Vegetation survival and health would also be important to quantify, since this may be an important component of stormwater treatment on the sites and in their BMPs. The NC Ecosystem Enhancement Program has a protocol that might be applicable to riparian areas, and potentially could be adapted to BMPs. See also the MDG for bioretention maintenance. A different protocol would need to be identified or developed to evaluate the health of upland vegetation.

Frequency

Frequency would depend on the study design and duration. Storm event monitoring would be important under most any design.

Location, Scale, Watershed Type or Character (e.g. rural or urban)

Location, scale, and watershed type may not be as important as matching the characteristics of the treatment area with a control area in these respects.

Monitoring Group & Potential Partnerships

Local governments and watershed associations may have sufficient interest in this topic to fund such a research effort. The partnership with USGS to monitor water quality over the long term in the Treyburn area may provide a model.

QA/QC Procedures & Recommendations

See DWQ and EPA websites.

Data Coordination & Use

This research might be applicable to future remodeling and crediting strategies/practices. It should be submitted to DWQ, NCSU, TJCOG, local governments, and NGOs working on crediting ecosystem services in the area.

FUNDING OPPORTUNITIES

– USGS, NCSU, USFS, NCFS, DENR, possibly private foundations

PUBLIC EDUCATION COMPONENTS

Research on how the roles of soils in water resource quality and quantity could be useful to science educators and stormwater educators who are engaging the public in more sophisticated outreach.

REFERENCES

Boggs, Johnny. Effectiveness of Streamside Management Zones and Stream Crossings BMPs on Water Quality Protection in North Carolina Piedmont Forested Watersheds.

Pennsylvania Stormwater Best Management Practices Manual. January 2005 Draft. Section 9: Stormwater Calculations and Methodology.

Study Proposal to Evaluate How Vegetated Shelf & Plant Maintenance Influences the Effectiveness of Wet Detention Basins

ROBERT PATTERSON, SARAH BRUCE, WATSON ROSS, RAGHAVENDERRAO BADAMI, RYAN WINSTON

BACKGROUND & PROBLEM STATEMENT

Background

A wet detention basin is a type of wet pond designed to capture stormwater for pollutant removal and peak flow mitigation through the use of extended detention. Wet detention basin designs are required to include a vegetated shelf and associated plants around the end; this feature enables the basin to act like a quasi wetland when water level rises, removing certain pollutants via plant uptake. The vegetated shelf can also make the BMP more visually appealing, reduce algal growth, limit erosion, create habitat, and reduce water warming. The plants on the shelf can also help deter geese.

Unfortunately, it can sometimes be difficult to maintain preferred plants on a vegetated shelf in a wet detention pond. Fluctuating water levels and inundation periods make for a wide variety of conditions that few plants can tolerate. Also, soils used to construct wet detention basins may not be the most conducive to plant establishment and long-term growth. Without proper maintenance, a species such as cattail may outcompete other plants, turning the basin into a monoculture and providing mosquito habitat.

The primary pollutant removal mechanism for a wet detention basin is settling; secondary mechanisms include filtering, plant uptake, chemical and biological decomposition, volatilization, and adsorption. Not having adequate vegetation on the shelf (and slopes above) can lead to an increase in erosion of the side slopes. This will in turn require more maintenance, more frequent sediment removal, and possibly lessen the pollutant removal effectiveness.

Problem Statement

Those responsible for BMPs must ensure that they are constructed as designed and maintained to ensure continued functionality. It would help those with these responsibilities to know the extent to which the maintenance of the vegetated shelf and associated plant species affect pollutant removal. If plants are indeed key to long-term functionality and performance of wet detention ponds, then additional research should be conducted to determine why the vegetation in vegetated shelves is not surviving in wet detention ponds to guide future design revisions.

One hypothesis as to the failure of vegetated shelves may involve water levels, recent climate extremes (drought), and failure to adequately account for *site specific* soil and groundwater characteristics . Because plant health is significantly influenced by water level, failure to adequately account for even one of the above variables, can significantly affect plant survival on the vegetated shelf. Some possible points of failure: Soils may be too permeable to hold water extended periods as designed, which may require a liner. The drainage area may be too small, or to pervious, to maintain the design pool. Or, recent droughts may not deliver any stormwater to the system. Tracy Stapleton at EEP doing a study on vegetation establishment.

Regulatory Context

Wet detention basins are one type of BMP that can be used to meet the stormwater requirements in NC. The current pollutant removal credits assigned by NCDENR-DWQ for this BMP are 85% TSS removal, 25% Total Nitrogen removal, and 40% Total Phosphorous removal. In the Jordan and Falls Lake watersheds, the Stormwater Load Accounting Tool assigns wet ponds an effluent concentration of 1.01 mg/L TN and 0.11 mg/L TP.

Some of the typical required maintenance includes: sediment cleanout, removal of invasive plant species, replanting of beneficial plants, stabilization of pond side slopes (from erosion, poor plant growth, or animals), removal of trash/debris, unclogging of outlet, and removal of trees and woody shrubs.

How this Study will reduce Uncertainty, what efforts it could inform

Help provide information for the types and to what level of maintenance is needed to not affect pollutant removal effectiveness for wet detention basins. Also, could help to see if the types of plant species (wetland plants, grasses, etc.) effects pollutant removal effectiveness.

POLLUTANT MARKERS & SOURCES

A study conducted to implement this monitoring recommendation would determine the degree to which wet detention basin vegetation health affects removal of key pollutants, such as nitrogen, phosphorous, and sediments. A sophisticated study might attempt to differentiate nitrogen and phosphorous entering the BMP via influent from nutrients entering the BMP via atmospheric deposition or improper fertilization within the BMP.

PREVIOUS & EXISTING MONITORING (STUDIES OR LONG-TERM)

This section includes a discussion of past, current or on-going monitoring programs that relate to this topic, preferably in North Carolina or the Southeast. A link for current monitoring programs that may be relevant can be found in the meeting summaries page of the project wiki (under Working Group Meeting 2) at http://upperneusewqmonitorng.wikispaces.com/Meeting+Summaries.

Driscoll, E. Methodology for Analysis of Detention Basins for Control of Urban Runoff Quality. EPA440/5-87-001. U. S. Environmental Protection Agency, Office of Water, Nonpoint Source Branch, Washington, DC: 1986.

Schueler, T. 1997a. Comparative pollutant removal capability of urban BMPs: A reanalysis. Watershed Protection Techniques 2(4):515.520.

Wu, J. 1989. Evaluation of Detention Basin Performance in the Piedmont Region of North Carolina. Report No. 89-248. North Carolina Water Resources Research Institute, Raleigh, NC.

Bill Hunt's (NCSU-BAE) work on wetland plant harvesting to further reduce nutrients.

MONITORING DESIGN

This section describes the guidelines for designing a monitoring study that will enhance understanding and management of this topic/issue.

Proposed Monitoring Activities or Studies

Parameters& Methods

A better approach would be a paired treatment–control method, in which two ponds with similar catchment characteristics are monitored for a period of years. Ideally, the two study SCMs would be close to one another to reduce potential effects of spatial differences in rainfall. The monitoring study should examine TSS, nitrogen, phosphorous, bacteria, metals, and plant species selection and survival. Inflow and outflow quantities would also need to be quantified in order to accurately estimate pollutant removal. Test influent and effluent concentrations during each storm event, and record the health of the vegetated shelf (this would include amount of coverage, plant species, pre/post storm water elevations, soil characteristics, and any maintenance performed).

Frequency

All storm events during the study duration, paying attention to the key design event (first flush), the 1-inch storm, or, at the typical storm size for which the bioretention device was sized if not the 1-inch storm.

Location, Scale, Watershed Type or Character (e.g. rural or urban)

Wet ponds typically treat urban or suburban catchments. Location will be determined according to the most suitable candidate devices for study, but highest priority should be placed on ponds in the Falls Lake watershed. Next-best locations would be the Piedmont of NC, followed by the Piedmont ecoregion as a whole.

Monitoring would be undertaken at the site scale. That is, the wet detention basins' inflow and outflow would be sampled at a specified frequency. However, a sophisticated study might incorporate data from any nearby atmospheric deposition monitoring stations to account for atmospheric pollutant contributions. Accurate precipitation data may also be required to estimate flows if gages are not established at the wet detention basin for that purpose.

Monitoring Group & Potential Partnerships

The monitoring for this study could be coordinated by university researchers or local governments having or contracting monitoring capabilities, and could be supplemented by local volunteers and other interested stakeholders with appropriate training.

QA/QC Procedures & Recommendations

Quality assurance and quality control will include field and laboratory procedures typical of stormwater sampling protocols. These include field preservation of samples in refrigerated containers and proper labeling and storage of samples, as well as lab testing of duplicate and control samples alongside the collected samples. Once data is generated, it shall be peer-reviewed as another QA/QC measure.

Data Coordination & Use

Data and conclusions produced as part of this study would be shared with the NC DENR Division of Water Quality for potential inclusion in the NC DWQ Stormwater Best Management Practices Manual. Other users would include the NC DENR Nutrient Scientific Advisory Board for use in advising nutrient reduction strategies, the NC LID Group for use in informing LID practices throughout the state, as well as local university groups including the NC State Biological & Agricultural Engineering Stormwater Engineering Group.

FUNDING OPPORTUNITIES

– Green infrastructure grants
– Masters or Doctoral theses
– Local governments
– Watershed associations
– Private developers, landscaping companies

PUBLIC EDUCATION COMPONENTS

General education for development, landscaping and BMP maintenance community that stormwater BMPs, including wet detention basins, must be maintained to continue functioning and treating stormwater runoff.
– Could inform knowledge about BMP performance/crediting generally
– Could help local governments rank their enforcement actions.

REFERENCES

– NC DWQ BMP Manual

Study Proposal to Evaluate How Soil Protections and/or Amendments Influence Surface Runoff, BMP Performance, and Receiving Water Quality

SARAH BRUCE, TERRY HACKETT, BETSY PEARCE

BACKGROUND & PROBLEM STATEMENT

Background & Problem Statement

Typical construction practices for developments involve topsoil removal and the compaction of soils under foundations, roadways, driveways and parking lots. Infiltration is reduced and runoff cannot permeate the soil, even if the land use is considered "pervious" under regulatory definitions. BMPs and landscaped areas are often installed without regard to these compacted soils. This could affect the health of planted vegetation, the amount of microbial activity taking place in the soils, the infiltration capacity of the site overall, and the performance of its stormwater BMPs.

Alternative practices merit evaluation for their potential to reduce runoff generated by the site, reduce NPS pollutants at the source, improve BMP performance, and/or improve the quality of the runoff leaving the site. These alternative practices could be employed, alone or in combination:

- Clear and grade only the building & infrastructure envelopes, leaving future pervious undisturbed to the maximum extent practicable
- Till or plow soils on future pervious areas to mitigate compaction
- Till or plow soils on future BMPs to mitigate compaction
- Amend and/or replace topsoil in future pervious areas
- Amend and/or replace topsoil in stormwater BMPs that do not usually specify media characteristics, such as swales and wet ponds

These practices may provide a water quality benefit by slowing runoff, increasing infiltration, and encouraging plants and their root systems to establish and thrive, thereby reducing pollutants.

If less runoff of a higher quality is being generated, it might be hypothesized that BMPs treating that runoff may perform differently (e.g., they might have a longer lifespan or require less maintenance),

and receiving water bodies might receive fewer NPS inputs. Furthermore, if these practices were implemented during construction, the site might be stabilized more quickly and water quality impacts from construction might be reduced as well.

These practices might also be used in conjunction with other emerging BMPs, such as downspout disconnection, whereby rooftop runoff is directed to "pervious" areas. Obviously, an area that is truly pervious will infiltrate this runoff more readily than an area that is underlain by compacted soils. Soil amendments might also help stream and buffer restoration projects provide more functional uplift by helping vegetation establish and thrive, stabilizing the project site more quickly, and facilitating physicochemical interactions around the water table.

Regulatory Context

Any regulatory strategy targeted at new development may benefit from research on this topic. Fore example, the new Jordan/Falls Stormwater Nutrient Load Accounting Tool assumes that inflow concentrations matter less to outflow concentrations than the BMP and its volume reduction capacities. If variations in inflow characteristics or the soil in the BMP itself influence BMP effluent, this would need to be accounted for. Also, soil protection and amendments might be a valid pollution-reducing practice on their own, and would be appropriate to credit as such, if appropriate crediting can be established based on research.

The Falls Rules will drive the use of more structural stormwater measures to reach onsite loading thresholds, which may have the result of increasing the densities of developments that may otherwise have chosen to rely on nonstructural measures. Developers and local governments may prefer to use nonstructural measures in certain situations if possible, particularly rural, low-density, and LID developments, so these measures could provide more flexibility in site design. Soil preservation might also reduce land opportunity costs for stormwater management. Reducing reliance on structural BMPs could also benefit local governments, particularly if they assume maintenance responsibilities for structural BMPs. Regardless of the reason, having more practices that can be used to reduce nutrients and excess runoff would help our region meet its water quality goals.

The Commonwealth of Pennsylvania credits practices that preserve or replace topsoil as well as revegetating disturbed areas (PA Stormwater BMP Manual, 2005).

How this Study will reduce Uncertainty, what efforts it could inform

Future watershed modeling efforts may also benefit, as sites designed in an environmentally sensitive way may be shown to have a lower nutrient loading than conventional sites, and accuracy of modeling may therefore be improved by quantification of differences. This study could also help quantify the effectiveness of preserving land from development as a stormwater control measure.

Maintaining and enhancing the infiltration capacity of pervious areas is being explored and implemented locally. For example, athletic fields are already designed to drain precipitation quickly from the surface; however, this is not yet considered a creditable stormwater practice.

POLLUTANT MARKERS & SOURCES

Nitrogen species, phosphorous variants, bacteria, metals, hydraulics (sediment transport and scour), and hydrologies should be monitored to the extent that each monitoring location and resources allow.

Monitoring on specific site should note pre-existing land use—forest vs. agriculture—as this may affect site loadings. Ideally, the study would compare two developments with similar geologies, prior land uses, degree of post-development forest cover, and other characteristics to minimize exogenous variation. At a minimum, these site characteristics should be well documented.

PREVIOUS & EXISTING MONITORING (STUDIES OR LONG-TERM)

Volumes of research are available on the effectiveness of the structural BMPs typically employed in low-impact development situations, but research on nonstructural approaches, such as protecting topsoil from removal and compaction, is virtually nonexistent, particularly for developed (nonagricultural, nonsilvicultural) land uses. Existing study designs for forestry and agriculture are one potential source of study designs that could be researched and adapted to inform study designs for developing and developed land covers. Studies on the effects of organic matter on hydrology and pollutant processing & transport would also be valuable.

Potential resources for studies and research include the NCSU Dept. of Forestry and Environmental Science, Ecohydrology and Watershed Science group, and the U.S. Forest Service research publications website (http://www.treesearch.fs.fed.us/).

Boggs, Johnny. Effectiveness of Streamside Management Zones and Stream Crossings BMPs on Water Quality Protection in North Carolina Piedmont Forested Watersheds. (Purpose: Understand the water quality and hydrologic conditions of a forested watershed in the piedmont region of the southeastern U.S. and determine the effectiveness of forestry best management practices (BMPs), including a streamside riparian buffer, in preventing nonpoint source pollution impacts from timber harvesting activities.)

Katie Price, "Effects of watershed topography, soils, land use, and climate on base flow hydrology in humid regions: A review", Progress in Physical Geography 35(4) 465–492., 2011.

Virginia DCR Stormwater Design Specification No. 4: Soil Compost Amendment. Version 1.8, March 1, 2011.

Kozlowski, T.T. Soil Compaction and Growth of Woody Plants. Scandinavian Journal of Forest Research, Volume 14, Number 6, 31 December 1999, pp. 596-619(24)

Although soil compaction in the field may benefit or inhibit the growth of plants, the harmful effects are much more common. This paper emphasizes the deleterious effects of predominantly high levels of soil compaction on plant growth and yield. High levels of soil compaction are common in heavily used recreation areas, construction sites, urban areas, timber harvesting sites, fruit orchards, agroforestry systems and tree nurseries. Compaction can occur naturally by settling or slumping of soil or may be induced by tillage tools, heavy machinery, pedestrian traffic,

trampling by animals and fire. Compaction typically alters soil structure and hydrology by increasing soil bulk density; breaking down soil aggregates; decreasing soil porosity, aeration and infiltration capacity; and by increasing soil strength, water runoff and soil erosion. Appreciable compaction of soil leads to physiological dysfunctions in plants. Often, but not always, reduced water absorption and leaf water deficits develop. Soil compaction also induces changes in the amounts and balances of growth hormones in plants, especially increases in abscisic acid and ethylene. Absorption of the major mineral nutrients is reduced by compaction of both surface soils and subsoils. The rate of photosynthesis of plants growing in very compacted soil is decreased by both stomatal and non-stomatal inhibition. Total photosynthesis is reduced as a result of smaller leaf areas. As soils become increasingly compacted respiration of roots shifts toward an anaerobic state. Severe soil compaction adversely influences regeneration of forest stands by inhibiting seed germination and growth of seedlings, and by inducing seedling mortality. Growth of woody plants beyond the seedling stage and yields of harvestable plant products also are greatly decreased by soil compaction because of the combined effects of high soil strength, decreased infiltration of water and poor soil aeration, all of which lead to a decreased supply of physiological growth requirements at meristematic sites. Many protocols have been developed, with variable success, to alleviate the adverse effects of soil compaction on the growth and development of woody plants. These include planting of compaction-tolerant species, controlling vehicular and animal traffic, amending soils by adding coarse materials and/or organic matter, replacing compacted soils with uncompacted soils, loosening soils with aerating equipment, installing drainage systems and judiciously applying fertilizers. Prevention of soil compaction before planting is usually much preferred over post-planting treatments because the latter are expensive and difficult to apply, may not be adequately effective and may injure plant roots.

Sinnett, Danielle; Poole, Jane; Hutchings, Tony R. A comparison of cultivation techniques for successful tree establishment on compacted soil. Forestry, Volume 81, Number 5, 1 December 2008, pp. 663-679(17).

Soil compaction is often responsible for the poor establishment of trees on restored brownfield sites. This paper examines the root development, survival and growth of *Alnus cordata*, *Larix kaempferi*, *Pinus nigra* and *Betula pendula* after cultivation with complete cultivation, a standard industrial ripper and a prototype ripper. The industrial ripper was used in one pass across the experimental plots and the prototype ripper in both two and four passes. While the maximum root depths, after five growing seasons, attained by trees were similar to the target soil loosening depths for the cultivation techniques, the total number of roots suggests that root development was not uniform across the soil profile. All treatments significantly increased both the maximum root depth and total number of roots compared with the untreated control; the complete cultivation had approximately double the number of roots compared with the other treatments. Larger average root diameters and a higher percentage of coarse roots also suggest that roots experienced physical restriction in the control, two-pass prototype and industrial ripper plots. Similarly, while all species had attained significantly greater height growth on the treated soils compared with the control, the height of *A. cordata*, *L. kaempferi* and *B. pendula* was greatest

after complete cultivation. The results demonstrate that complete cultivation is the most effective method of alleviating soil compaction for tree establishment.

Ponder, Felix . Nine-Year Response of Hardwood Understory to Organic Matter Removal and Soil Compaction. Northern Journal of Applied Forestry, Volume 25, Number 1, March 2008, pp. 25-31(7).

The effects of three levels of organic matter removal (OMR) and three levels of soil compaction (SC) on the development of understory vegetation in a central hardwood forest were evaluated 9 years after treatments were applied as part of a national program of long-term soil productivity research. The three levels of biomass removal (OMR) were removal of merchantable boles only (OM0), removal of the whole tree (OM1), and removal of the whole tree plus forest floor (OM2). The three levels of soil compaction (SC) were none (C0), medium (C2), and severe (C2). Weeds were controlled in all plots for the first 2 years. Understory vegetation within 81 7.9-m^2 subplots was inventoried by species and quantified into plant groups of woody (trees, shrubs, and woody vines) and herbaceous (annuals, perennials, and grasses) at year 5 (after 3 years of no weed control) and year 9 (after 7 years of no weed control). Vegetation was analyzed for nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg). OMR did not significantly affect the overall number of plants over the 5-year measurement period, but there were differences for both woody vines and grasses, which were highest in the OM0 treatment in 1999, but by 2003, they were not different. There were no differences in plant numbers among plant groups for SC in the 1999 measurement period between treatments for any plant group, but there were significantly fewer trees and woody vines in the C2 treatments than in the C0 or C1 treatments in 2003; the opposite was true for herbaceous annuals, which were highest in C1 and C2 treatments. Over the 5-year measurement period, only the height of woody vines was significantly affected by OMR, but SC significantly affected the height of all plant groups over the 5-year measurement period. Annually, however, trees were tallest in the OM0 and C0 treatment than in OM2 and C2 treatments. The annual height of other plants, excluding trees, was affected only 1 year of 5 by OMR. Fewer trees and shorter trees in the severe compaction treatment suggest that, in the short term, soil productivity has been affected on the site.

Jordan D.; Ponder F.; Hubbard V.C. Effects of soil compaction, forest leaf litter and nitrogen fertilizer on two oak species and microbial activity. Applied Soil Ecology, Volume 23, Number 1, May 2003 , pp. 33-41(9).

A greenhouse study examined the effects of soil compaction and forest leaf litter on the growth and nitrogen (N) uptake and recovery of red oak (Quercus rubra L.) and scarlet oak (Quercus coccinea Muencch) seedlings and selected microbial activity over a 6-month period. The experiment had a randomized complete block design with three replications. Ammonium ^{15}N-sulfate at 33mg ^{15}N kg^{-1} was used to quantify seedling N uptake and recovery. After 6 months, seedlings were harvested and analyzed for dry matter production, total N, ^{15}N uptake and N derived from ^{15}N labeled fertilizer (Ndff). Soil enzyme activity and soil microbial biomass C and N were measured as indicators of microbial activity. Soil compaction significantly decreased seedling

height, dry matter production, and ^{15}N recovery of both oak species. Significantly greater N losses were observed in compacted pots compared with the non-compacted pots. Less ^{15}N was immobilized in the soil microbial biomass in the compacted pots than under non-compacted conditions, probably due to greater overall ^{15}N losses in the compacted conditions. Soil compaction significantly affected microbial activity by reducing acid phosphatase. Severe soil compaction decreased young tree growth and reduced N fertilizer uptake.

MONITORING DESIGN

There are several components or sub-hypotheses that could be tested for this issue. Some combination of scale of study, parameters of interest, and treatment need to be selected:[3]

Scale of Study	Parameters of Interest	Treatment
BMP (inflow and outflow)	Pollutants: Nitrogen, phosphorous, sediments, bacteria, metals, etc. Hydrology: flow, volume, and timing	Treat or protect soils in BMPs or reach-scale restoration projects
Site or catchment (outfalls/receiving waters)		Treat or protect soils on non-BMP pervious areas

Proposed Monitoring Activities or Studies

Suggestions on study design are drawn from the NCFS study Johnny Boggs is working on, as similar parameters, frequencies, and methods may be applicable to this study's design.

Parameters & Methods

Water quality: Nitrogen (NO3, NH4, TKN), phosphorous (TP), sediments (TP), bacteria, total organic carbon (TOC), temperatures. The Boggs study is using Sigma sampler programmed for storm event sampling, grab samples, and Hobo ProV2 Logger for temperatures.

Water depth, flow rate, and flow volume in streams and/or BMPs could be measured using weirs / flumes and water level recorders.

Soil conditions and respiration, such as moisture, temperature, and carbon would also be valuable. The Boggs study used onsite thermocouples and EGM to measure these parameters.

Transpiration, or water usage by vegetation, would be important to characterize the water balance. The Boggs study is using sap flow measurements and the thermal dissipation technique to quantify water usage by trees.

Precipitation, air temperature, relative humidity, total solar radiation, and wind speed might be measured to account for meteorological effects.

To measure health of the receiving stream in physical terms, cross sections, longitudinal profiles and stream patterns should be measured before, during, and after construction of the sites.

[3] Of course, if no stormwater BMPs are installed, monitoring at the BMP scale would not be selected.

To measure the health of the receiving stream in biological terms, benthic macroinvertebrates should also be sampled before, during, and after construction of the sites using DWQ protocols.

Vegetation survival and health would also be important to quantify, since this may be an important component of stormwater treatment on the sites and in their BMPs. The NC Ecosystem Enhancement Program has a protocol that might be applicable to riparian areas, and potentially could be adapted to BMPs. See also the MDG for bioretention maintenance. A different protocol would need to be identified or developed to evaluate the health of upland vegetation.

Frequency

Frequency would depend on the study design and duration. Storm event monitoring would be important under most any design.

Location, Scale, Watershed Type or Character (e.g. rural or urban)

Location, scale, and watershed type may not be as important as matching the characteristics of the treatment area with a control area in these respects.

Monitoring Group & Potential Partnerships

Local governments and watershed associations may have sufficient interest in this topic to fund such a research effort. The partnership with USGS to monitor water quality over the long term in the Treyburn area may provide a model.

QA/QC Procedures & Recommendations

See DWQ and EPA websites.

Data Coordination & Use

This research might be applicable to future remodeling and crediting strategies/practices. It should be submitted to DWQ, NCSU, TJCOG, local governments, and NGOs working on crediting ecosystem services in the area.

FUNDING OPPORTUNITIES

– USGS, NCSU, USFS, NCFS, DENR, possibly private foundations

PUBLIC EDUCATION COMPONENTS

Research on how the roles of soils in water resource quality and quantity could be useful to science educators and stormwater educators who are engaging the public in more sophisticated outreach.

REFERENCES

Boggs, Johnny. Effectiveness of Streamside Management Zones and Stream Crossings BMPs on Water Quality Protection in North Carolina Piedmont Forested Watersheds.

Pennsylvania Stormwater Best Management Practices Manual. January 2005 Draft. Section 9: Stormwater Calculations and Methodology.

Determining Nutrient Inputs from "On-Site Wastewater Systems"

THE IMPACT OF GEOLOGIC/SOIL SYSTEMS UPON FATE AND TRANSPORT OF NITROGEN AND PHOSPHOROUS WITHIN THE FALLS LAKE WATERSHED

MONITORING DESIGN GUIDELINES FOR DETERMINING NUTRIENT INPUTS FROM ON-SITE WASTEWATER TREATMENT

BACKGROUND & PROBLEM STATEMENT

Background

The Falls Lake Watershed lies within a region of NC characterized by five distinct geologic/soil systems. These are the Felsic Crystalline System, the Carolina Slate Belt System, the Mixed Felsic System, the Triassic System, and the Mixed Felsic and Mafic System. Three of these systems predominate: the Felsic Crystalline, Slate Belt, and Triassic Basin. Each system has distinct rock and soil characteristics which could significantly affect the transport and attenuation rates of nutrients from on-site wastewater treatment systems. If this is the case, nutrient loads that reach Falls Lake from on-site wastewater systems will vary based upon the geologic/soil system through which the effluent passes. It is important that research be conducted in order to determine if these hypothesized variables exist. If they do, the findings of this research will allow a more accurate estimation of nutrient loading based upon geologic/soil systems. If geology/soils have little bearing upon nutrient loading from onsite systems, important information relevant to the southeastern piedmont will have still been obtained.

Problem Statement

It is of the utmost importance that jurisdictions spend dollars wisely to address the Falls Lake nutrient issue. Models are only as reliable as the inputs supplied to those models. Field research which quantifies loads from on-site systems is greatly needed. This information coupled with other research findings, will allow jurisdictions to calculate the cost/pound of reduction to be achieved by various methods and adopt the most cost effective strategy.

Regulatory Context

NC Session Law 2009-486 became effective on August 26, 2009 in response to impaired water quality in the Falls Lake Watershed of central North Carolina. Elevated chlorophyll-a is attributed to high levels of nitrogen and phosphorous in the lake. Major anthropogenic nutrient sources to be regulated include runoff from agricultural operations and lawn fertilizer, discharges from wastewater treatment plants, storm-water, and residential septic tank and discharging sand filter wastewater systems. Subsequently, the Falls Lake Nutrient Management Rules were approved by the N.C. Rules Review Commission (RRC) at their December 16, 2010 meeting. The rules were approved with an effective date of January 15,

2011. Nutrient loading from both soil-based dispersal systems (under NC DHHS jurisdiction) and surface discharging systems (under NC DWQ jurisdiction) are to be reduced per these rules.

Issue around Uncertainty

Most of the research to date related to the fate and transport of nutrients from on-site systems has been conducted in either the sandy coastal soils of the southeast or in other regions of the US. To date, limited studies have been conducted in southeast piedmont soils.

A University of Georgia study (Radcliffe and Bradshaw, 2011) investigating nitrogen attenuation from ground absorption septic systems in Cecil soils (a slightly expansive clay soil series present in the Falls Watershed) revealed that septic systems may reduce N by up to 90% from the concentration in the septic effluent. High clay content in other areas has also been cited as having high potential to remove N (Al-Shiekh Khalil et al, 2004; McCray et al., 2009). Similar reductions in P have also been recorded (Al-Shiekh Khalil et al, 2004; Charles et al., 2004) provided loading rates are not high (McCray et al., 2009). Based solely on the chemistry of P and the high clay, high iron content of soils in this area, P removal could be substantial (Brady and Weil, 2009). It should be noted however that despite these encouraging studies a recent WERF publication indicated predicting N and P removal rates are far from simple and that much additional research is needed (McCray et al., 2009).

The fate and transport of N and P in different piedmont geologic/soil systems is a point of speculation. A better understanding of these dynamics will allow improved cost to benefits assessments of nutrient reduction strategies.

NUTRIENT MARKERS & SOURCES

While source identification is an important issue related to nutrient loading, the focus of this study is to determine the impact of geologic/soil systems upon the fate and transport of nutrients as they move from a point of origin to neighboring bodies of water.

PREVIOUS & EXISTING MONITORING (STUDIES OR LONG-TERM)

This section includes a discussion of past, current or on-going monitoring programs that relate to this topic, preferably in North Carolina or the Southeast. A link for current monitoring programs that may be relevant can be found in the meeting summaries page of the project wiki (under Working Group Meeting 2) at http://upperneusewqmonitorng.wikispaces.com/Meeting+Summaries.

MONITORING DESIGN

Proposed Monitoring Activities or Studies

Water sampling will be conducted from tributaries in each of the three geologic/soil systems previously described. The suggested method is to select a background site within each soil system that has little or no influence from on-site wastewater systems. Communities served solely by conventional septic systems will also be selected in each region. An additional community served solely by discharging

systems will be selected in the Triassic basin. Upstream and downstream sampling will be conducted in order to calculate loading differentials.

Parameters, Methods and Frequency

Sampling Parameters

- Samples will be collected at all sites every two weeks for one year. Three samples will be collected per site per sampling event to allow for the calculation of means.
- Flow volumes and rates will be obtained at the time of sample collection.
- Samples will be collected immediately upslope of all sites (except the background sites) to allow for the calculation of load differentials.
- All samples will be analyzed for NO_2^-, NO_3^-, NH_4^+, and PO_4^+. Total Kjehdahl Nitrogen (TKN) will be measured and organic nitrogen calculated.
- Sample results will be compiled and modeled for loading from septic and sand filter systems.

Location, Scale, Watershed Type or Character (e.g. rural or urban)

Site Specifics

1. Background Sites with no known influence from residential or municipal wastewater.
2. Conventional Sites consisting solely of conventional septic systems.
3. Sand Filter Sites consisting solely of discharging sand filter systems.
   Note- The vast majority of sand filters are located in the Triassic region of Durham, and since the limited sand filters in other Falls Lake jurisdictions are likely in Triassic like material, the evaluation of sand filters will only be conducted in Triassic soil.

Study Scale- at a minimum

Felsic Crystalline Site Needs

- One background tributary
- One tributary surrounded solely by conventional systems

Carolina Slate Belt Site Needs

- One background tributary
- One tributary surrounded solely by conventional systems

Triassic Basin Site Needs

- One background tributary
- One tributary surrounded solely by conventional systems
- One tributary surrounded solely by sand filter systems

Monitoring Group & Potential Partnerships

USGS, DHHS Onsite Water Protection Branch, NC State University, UNC-CH, Durham County Environmental Health Division

QA/QC Procedures & Recommendations

QA/QC Procedures will be drafted by USGS and approved by NC DWQ prior to study.

Data Coordination & Use

All data, once collated, digitized and analyzed, will be disseminated to any interested party upon request. The data will be used in modeling, loading calculations and resource allocation on the local and state level.

FUNDING OPPORTUNITIES

Funding to support research on onsite wastewater has always been limited and resources are even scarcer at the current time. All known sources should be diligently pursued. Significant in-kind support will be provided by cooperating entities.

PUBLIC EDUCATION COMPONENTS

The public in the Falls Lake Watershed is eager to learn more about the science behind legislation enacted in their neighborhoods. All opportunities for disseminating the results of this study to the public will be pursued, including local government meetings, citizen workshops and other gatherings.

Determining Nutrient Inputs for "On-Site Wastewater Systems"

PERFORMANCE SURVEY AND GIS SUPPORT

MONITORING DESIGN GUIDELINES FOR DETERMINING NUTRIENT INPUTS FROM ON-SITE WASTEWATER TREATMENT

BACKGROUND & PROBLEM STATEMENT

The Falls Lake Nutrient Management Strategy dictates that local governments "develop inventories and characterize load reduction potential…of properly functioning and malfunctioning septic systems…" and remove illegal discharges within their jurisdictions [15A NCAC 02B .0278 (4) (d)]. This requirement and the variability among reported rates of system malfunction necessitate field verification of actual performance in local jurisdictions. Corrective action can then be selected by assessing both the feasibility and relative costs associated with each option. Jurisdictions cannot reasonably select options or effectively allocate resources to reduce loading without reliable system performance inventories.

Problem Statement

The Falls Lake Nutrient Management Strategy (FLNMS) dictates that jurisdictions collect accurate information regarding numbers of and malfunction rates for onsite wastewater treatment systems. There is little or no state guidance on these requirements and information available from jurisdictions varies in accuracy and consistency.

As defined in 15A NCAC 18A .1961, a system is malfunctioning when there is:

> (A) A discharge of sewage or effluent to the surface of the ground, the surface waters, or directly into groundwater at any time; or
> (B) A back-up of sewage or effluent into the facility, building drains, collection system, or freeboard volume of the tanks; or
> (C) A free liquid surface within three inches of finished grade over the nitrification trench for two or more observations made not less than 24 hours apart. Observations shall be made greater than 24 hours after a rainfall event.

Malfunction as described above is a water quality violation, a public health concern, or both. There may be many different options for correcting problems depending upon their nature. These might include reconnection of straight pipe discharges that bypass systems, repair/ replacement of existing systems or connection to a municipal treatment system. The approach must be selected by assessing on-site options for repair, proximity to collection systems and the relative costs associated with each option. Jurisdictions cannot effectively allocate resources to meet the FLNMS targets without

projecting the potential nutrient load reduction that would be realized by selection of any particular approach. The GIS capabilities of some jurisdictions within the watershed are either limited or non-existent and this hampers tracking, monitoring and planning efforts.

The objectives of work to be performed under this proposal are to:

1. Assist in development or improvement of the GIS capabilities of local jurisdictions;
2. Document the location of existing onsite wastewater treatment systems in the watershed;
3. Assess performance of a sufficient number of existing systems to provide a more accurate estimate of rates of malfunction, and;
4. Identify and document systems that require attention.

Regulatory Context

Single family residential onsite wastewater treatment systems incorporate either the surface or subsurface dispersal options. Systems using either dispersal option are considered 'onsite systems' since wastewater is treated on or near the point of generation, but regulatory oversight of the systems is divided between two separate state agencies. Soil-based dispersal systems are regulated at the state level by the Onsite Water Protection Branch within the Division of Public Health, Department of Health and Human Services. Surface discharging systems (primarily single-family discharging sand filters within this watershed) are regulated by the Surface Water Protection Section, Division of Water Quality, Department of Environment and Natural Resources. Permits for subsurface systems are maintained on the local level since Local Health Departments have delegated authority to enforce state regulations regarding these systems. Discharging sand filter systems are covered by NPDES General permit 550000 which was under review for renewal during the generation of this proposal (summer 2012).

Issue around Uncertainty

While rates of malfunction have been investigated in some parts of the watershed, these studies were performed by different local health departments using a variety of protocols and failure parameters. While the results include very important data, there are still areas within the watershed where system surveys have not been performed at all. Additionally, information on system inventories within the watershed is a significant variable. Records may be unavailable (for older systems) or incomplete. Some Local Health Departments have not yet converted records to a digital format and GIS capabilities vary widely among departments. With improved and uniform GIS records, information can be made readily available for visualization and analysis by governmental entities and other interested parties.

NUTRIENT MARKERS & SOURCES

While source identification is critical for jurisdictional resource allocation, the effort described here is designed to fill a different gap in the knowledge base (i.e. system inventories and rates of malfunction). Source identification should be separately pursued along with studies that focus on fate, transport and load quantification.

PREVIOUS & EXISTING MONITORING (STUDIES OR LONG-TERM)

The Falls Lake Watershed Analysis Risk Management Framework (WARMF) Final Report (NCDENR 2009) describes "properly" and "poorly" functioning systems and assumes a failure rate of 15 percent based upon the EPA Onsite Wastewater Treatment Systems Manual (2002). Other studies have reported failure rates of 11.4% (DEH, 2002), 5% (Lindbo et al., 1998), 13.3% (Deal et al., 2007), and 21% (Hinson et al., 1994). Notably, the criteria used for surveys varied and most of the cited studies were conducted in regions of North Carolina outside of the Piedmont. Reported rates are thus not directly comparable. The current model for the High Rock Lake watershed assumes an effective rate of "malfunction" (including illegal discharges) of 21% with the following breakdown:

- Ten percent are malfunctioning on the basis of effluent present on the soil surface;
- Ten percent illegally bypass the system and discharge graywater to the soil surface or surface water, and;
- One percent illegally bypasses the system and discharge sewage to surface water.

MONITORING DESIGN

Proposed Monitoring Activities or Studies

This effort focuses on developing and/or confirming system inventories as well as conducting field surveys of existing systems to assess relative performance.

Parameters & Methods

Existing inventories of systems within the watershed will be evaluated. Inventories with up to date information on system location and age could potentially be used in their current format. Counties with incomplete or non-existent inventories will receive support to finish or develop their databases. In conjunction with the inventory process, those counties without GIS capability would be identified and provided with sufficient resources to establish minimal capacity to meet DWQ requirements. Once inventories are available in appropriate GIS format, a random number of septic systems will be selected to provide a statistically representative sample of systems installed within a given jurisdiction. The list would include a sufficient number of systems to not only assess overall malfunction rate but also correlate the overall rate with parameters such as age, density, configuration and frequency/nature of maintenance. Personnel from LHDs within the watershed as well as state-level regulatory personnel will conduct field surveys. Private sector personnel will assist with evaluation of systems with proprietary components and DWQ personnel will assist with assessment of discharging sand filters. Specific protocols will be used to assess performance. Consideration will be given to potential costs that may be incurred by system owners in either correcting problems or implementing maintenance programs.

A uniform survey protocol and reporting forms will be developed. The protocol will list parameters to be evaluated, specific activities to be performed in the course of evaluation and guidelines for

determination of compliance/non-compliance. Parameters for both types of systems would include age, lot size, flow, structural integrity of components, and frequency of tank pumping, among others.

Survey teams consisting of 2 to 3 persons would conduct site visits and evaluate systems using the uniform protocol and reporting forms. Personnel from LHDs within the watershed as well as state-level regulatory personnel will conduct field surveys. Private sector personnel will assist with evaluation of systems with proprietary components and DWQ personnel will assist with assessment of discharging sand filters. Consideration will be given to potential costs that may be incurred by system owners in either correcting problems or implementing maintenance programs.

Determination of system performance would differ depending upon the dispersal method. Subsurface dispersal systems would be considered 'malfunctioning' if any of the following conditions were documented:

1. Presence of effluent on the ground surface
2. Backpressure in trenches upon probing
3. Backup of effluent into tank freeboard and possibly into the home.
4. Broken force mains or other structural integrity issues

Surface dispersal systems would be considered 'malfunctioning' if any of the following conditions were documented:

1. Presence of effluent on the ground surface over the sand filter
2. Inability to locate system outfall

Frequency

The survey of systems within the watershed would only be conducted once within the context of this effort unless additional funding was available to conduct follow-up surveys. Surveys would be conducted during the wet part of the year (typically December through April).

Location, Scale, Watershed Type or Character (e.g. rural or urban)

The randomized list of systems to be surveyed would determine this. A sufficient number of systems would be selected to provide a statistically significant overall rate of malfunction with consideration to the possibility of some sites being inaccessible and thus unusable for the survey.

Monitoring Group & Potential Partnerships

Survey teams should include persons from the appropriate regulatory sector. Additional members would include persons from either the public or private sector provided they have a basic understanding of these types of systems as well as persons with necessary GIS expertise. Potential partnerships could be developed with Local Health Departments, state level regulatory personnel, Cooperative Extension agents and private sector individuals. Where established, leaders and members

of Homeowner's Associations would be solicited for support to advertise the effort and disseminate appropriate information.

QA/QC Procedures & Recommendations

GIS-related activities will be coordinated by certified individuals. Survey protocol will be peer-reviewed prior to use. All survey teams would undergo orientation to ensure that the protocol is uniformly applied. A second team consisting of qualified individuals (for example, a Regional Soils Specialist and Engineer from the OWPB) will re-visit a percentage of surveyed systems to assess uniformity of survey implementation

Data Coordination & Use

Once data is collated, digitized and analyzed, results will be disseminated as needed. Ideally, the data will be used in modeling and resource allocation on the local and state level. Further, local personnel will use the data to track monitoring, operation and maintenance activities as appropriate.

FUNDING OPPORTUNITIES

Several Local Health Departments have already begun system inventories toward compliance with current rules, including the FLNMS. This already represents a significant in-kind contribution. Additional in-kind funding will result from participation in surveys by state and local regulatory personnel, as well as academic and private sector individuals.

Protocol used in previous field surveys will serve as a significant source of information for development of procedures to be used here. Personnel from LHDs within the watershed as well as state-level regulatory personnel have significant experience in conducting field surveys. These resources provide an advanced point of beginning for this effort and represent significant in-kind support.

PUBLIC EDUCATION COMPONENTS

It is well known that the public has a less than optimum understanding of how onsite systems work and very few system owners understand the need for appropriate use and maintenance. By default, the process of conducting field surveys offers an opportunity for public education. System owners who are present during the survey will have an opportunity to ask and answer questions. Existing printed resources will be distributed at each site. Before, during and upon completion of data collection, analysis and reporting, forums will be conducted to inform and educate private citizens and public officials about this effort.

REFERENCES

Deal, N. E., D. L. Lindbo, D. Rashash, , R. O. Coburn, M. Evans-Brunner, C. Humphrey. 2007. Evaluating Existing BMP's for Site Selection and Septic System Installation In K. Mancl (ed.) On-Site

Wastewater Treatment. Proceedings of the Eleventh National Symposium on Individual and Small Community Sewage Systems. ASABE, St. Joseph, MI.

Hinson, T.H., M.J. Hoover, and R.O. Evans. 1994. Sand lined trench septic system performance on wet, clayey soils. In E. Collins (ed.) On-Site Wastewater Treatment: Proceedings of the Seventh International Symposium on Individual and Small Community Sewage Systems, Dec. 11-13, 1994, Atlanta, GA. ASAE, St. Joseph, MI. p. 245-255.

Lindbo, D. L., T. M. Campbell, N. Deal, and R. Hollowell. 1998. Performance of sand lined trench and conventional systems within a management entity. In D. M. Sievers (ed.) On-Site Wastewater Treatment. Proceedings of the Eighth National Symposium on Individual and Small Community Sewage Systems. March 8-10, 1989, Orlando, FL. ASAE, St. Joseph, MI p. 177-185.

NCDEH. 2000. Report on the Proper Maintenance of Septic Tank Systems in Accordance with Section 13.5 of HB 1160 (Clean Water Act of 1999). Submitted by the NC Commission for Health Services to the Environmental Review Commission, North Carolina General Assembly. Division of Environmental Health, NC Department of Environment and Natural Resources. Raleigh, NC.

Tetra Tech. 2012. High Rock Lake Watershed Model Second Revised Draft, March, 7, 2012. Research Triangle Park, NC.

Determining Nutrient Inputs for "On-Site Wastewater Systems"

MONITORING DESIGN GUIDELINES FOR DETERMINING FATE AND TRANSPORT OF NUTRIENT INPUTS FROM ON-SITE WASTEWATER TREATMENT

BACKGROUND & PROBLEM STATEMENT

Background

Anthropogenic nutrient contribution is one of the most common reasons for surface water impairment in North Carolina. Basin management plans and TMDLs for nutrients are becoming more prevalent as a means of managing nutrient loading to surface waters. Due to the individual nature of on-site systems, impacts of on-site systems on the quality of groundwater and surface water are relatively unknown, particularly their comprehensive impacts in a watershed. Part of the reason for this uncertainty is the lack of plume tracking for field data collection to confirm on-site wastewater contributions in typical Piedmont geologies/soils/streams. Due to the lack of field based on-site systems information, estimated values have been used in developing TMDLs.

The nutrient transport model developed for decentralized systems during this project will help affected parties, local government decision-makers and regulators to visualize environmental benefits and water quality impacts. This study provides more accurate input datasets for TMDL modeling. It also produces an updated modeling method (ArcSWAT 2009) for assessing on-site wastewater treatment system delivered nutrients. Due to the current lack of related information, DWQ modelers are using literature values and/or estimated numbers in assessing impacts of on-site systems on surface water quality in watershed scale.

Problem Statement

It is believed that on-site systems can potentially be a substantial contributor of nitrogen to surface waters in the Piedmont. In a portion of a subwatershed of Falls Lake, on-site systems are said to contribute more than 20% of the total nitrogen. But others disagree with that assessment and there remains much uncertainty about the actual surface water delivery of nutrients by onsite systems. The disagreement arises due to the lack of field based data on nutrient transport and nutrient reduction dynamics relative to the fate and transport of on-site system derived nutrients in the sods and groundwater regime of the Piedmont Physiographic Province. It is also unknown how the distance traveled by treated wastewater and N and P loadings to surface water from on-site systems affects nutrient exports to stream and other water bodies. The Falls Lake nutrient management strategy report, 2010, clearly states that one of the major limitations of the Falls Lake Watershed model was uncertainly associated with estimated population using septic systems and concentrations of septic systems in the watershed.

Regulatory Context

Currently, there are no watershed-based nutrient requirements for on-site technologies in NC regulatory environments. Other regulatory jurisdictions in the U.S. are in the process of implementing on-site technology nutrient reduction requirements, performance standard and/or density limitations.

Issue around Uncertainty

Because the efficacy of on-site wastewater treatment is directly impacted by factors like type of soils, landscape position, level of pretreatment, wastewater dispersal methods and depth to groundwater tables, pollutant loadings from systems in various locations can differ tremendously, making an estimate of their cumulative impacts difficult. In addition to these factors, others such as age of the systems, types of the systems, relative percentage of "functioning" versus "failing" (surface discharging) systems, and other factors can have impacts on pollutant contributions as well. As a result, the current approach in NC of using literature values and/or estimated values without having site specific on-site system data increases TMDL model output uncertainty by a couple of orders of magnitude.

NUTRIENT MARKERS & SOURCES

This section includes a discussion related to identifying the nutrient sources (of on-site wastewater in this case) as distinct and differentiated from other sources (e.g. agricultural runoff)

a. Biological marker such as fecal *Bacteroides* genetic markers associated with humans, antibiotic resistance analysis

B. Nitrogen Isotopes, optical brighteners, groundwater geochemistry and more

PREVIOUS &EXISTING MONITORING (STUDIES OR LONG-TERM)

"Development Infrastructure Impacts on Wastewater-Derived Nutrients in the Piedmont Streams" – on going project

MONITORING DESIGN

Proposed Monitoring Activities or Studies

Parameters, Methods and Frequency

Nutrient transport from on-site systems to surface waters will be measured by using groundwater monitoring wells and/or piezometers. An intensive monitoring network with nests of monitoring wells installed at different depths will be needed to track wastewater plumes. Nutrient transport from sand filter surface discharges will be assessed using surface water samplers, in ditches and not within ditches as appropriate for that particular study site. Also, nutrient contribution from surface failing on-site systems will be assessed using surrogate monitoring procedure. This approach will allow for both concentration and mass loading assessments. Septic tank effluent, groundwater and surface water samples will be collected biweekly to monthly for 12 months.

Sampling strategies

Sample Type	Parameters	Frequencies
Septic Tank Effluent (on-site system and sand filter)	pH, Temp., DO, BOD5, NO3, NO2, TKN, TN, NH4, OP and TP,	Bi-weekly to monthly
Groundwater (on-site system)	pH, Temp., DO, ORP, Turbidity, Sp. Conductivity, NO3, NO2, , TKN, TN, NH4, OP and TP	Bi-weekly to monthly
Surface water (on-site system and sand filter)	pH, Temp., DO, ORP, Turbidity, Sp. Conductivity, NO3, NO2, , TKN, TN, NH4, OP and TP	Bi-weekly to monthly

Location, Scale, Watershed Type or Character (e.g. rural or urban)

N/A

Monitoring Group & Potential Partnerships

N/A

QA/QC Procedures & Recommendations

N/A

Data Coordination & Use

The monitoring/environmental data (nutrient transport and nutrient reduction dynamics relative to distance traveled by treated wastewater and N and P loadings to surface water) collected will be useful for following purposes, including but not limited to:

1. Evaluating the impact of decentralized systems upon surface water quality (Falls Lake),

2. Providing needed decentralized systems related data e.g. fate and transport of N and P from septic systems, sand filters and surface failing on-site systems.

FUNDING OPPORTUNITIES

N/A

PUBLIC EDUCATION COMPONENTS

Citizens, community leaders and field practitioners can be educated by sharing research results regarding to the breadth of water quality advantage/disadvantage of on on-site systems N and P mass loadings. Education, training and outreach can be delivered using multiple educational models, such as conducting educational programs in County NC Cooperative Extension meetings, Environmental Health District education meetings, state EHS supervisor meetings and the annual NC On-Site Water Protection Conference.

Determining Nutrient Fate & Transport in Streams of the Piedmont Ecoregion to Improve Stormwater Management

MONITORING DESIGN GUIDELINES FOR DETERMINING FATE AND TRANSPORT OF SELECT NUTRIENTS (NITROGEN AND PHOSPHOROUS) IN STREAMS AND SOILS IN ORDER TO IMPROVE THE TREATMENT OF STORMWATER FOR NUTRIENT POLLUTANT MANAGEMENT.

BACKGROUND & PROBLEM STATEMENT

Background

While great efforts and expenditures have been made, and are expected to continue, on controlling and managing polluted stormwater runoff, there remain questions as to the degree to which the treated stormwater contributes to the overall nutrient loading or nutrient cycling within stream systems. The Piedmont ecoregion of the southeastern U.S. is widely forecasted to sustain a substantial increase in population growth and commensurate land development activities over the next 20 to 50 years. With increased development comes an increasing need to manage and control stormwater runoff in a manner that is effective, affordable, and reliable for the purposes of sustaining water quality standards for human use and ecological function.

Problem Statement

Stormwater control measures (SCMs) and/or affiliated stormwater best management practices (BMPs) can be designed and implemented to manage stormwater volume, flow duration, and pollutant constituents (primarily sediments, solids, and macro-nutrients such as nitrogen-N and phosphorous-P). Understanding nutrient cycling, fate, transport, and mobility within the unique soil and hydrologic systems of the Piedmont ecoregion will allow for the improvement of SCM and BMP design specifically for the purposes of treating stormwater to improve the management or control of nutrient pollutants.

Regulatory Context

North Carolina has several regulatory standards relating to the amount of nutrients (N and P) which can be discharged into certain surface waters as a means of managing and controlling N and P in an overall watershed or river system. Multiple management approaches have been implemented via regulatory standards regarding land-use practices and the management of stormwater from developed sites. Many of the N and P discharge limits are based upon calculated models which require a significant degree of assumptions in order to function. And given the short time period with the nutrient

management regulatory standards must be implemented, many of the assumptions are not sufficiently vetted or grounded upon empirical evidence specific to the ecoregion or hydrologic unit that is within the regulated area. Additional research and investigations are warranted to understand the overall fate and transport of N and P in both a natural (background) setting as well as a setting which includes analysis of stormwater that has been treated by a SCM/BMP.

How this Study will Reduce Uncertainty

Much research has attempted to understand the level of N and P reduction that is possible from a variety of SCM/BMP devices. But understanding the fate and transport of N and P within the overall hydrologic system can allow a practitioner to better recognize the type, frequency, and longevity of a SCM/BMP that is specifically targeted at N and P management. Understanding how N and P interact in the terrestrial and aquatic environment after stormwater is discharged from a SCM/BMP device can lead to improved designs and perhaps even site-placement attributes related to SCM/BMP installation. Recognizing the natural processes which influence N and P cycling may allow for a broader interpretation of suitable measures or BMPs which could positively control or manage N and P within a specific catchment or watershed. Such research would then ideally serve as a foundation for adapting or modifying regulatory standards in a manner which more closely aligns with empirical evidence.

NUTRIENT MARKERS & SOURCES

Evaluating fate and transport of a naturally-occurring element in the environment is a challenging proposition, and usually requires some level of in-situ, long-term monitoring. This degree of basic knowledge research can be costly and time consuming. Often the ability to physically or chemically identify the pollutants of interest requires complicated methodologies of isotopic tracking and/or substantial water sampling and analysis.

PREVIOUS & EXISTING MONITORING (STUDIES OR LONG-TERM)

At this time, the NC Forest Service and US Forest Service are partnering on a watershed study which should provide data regarding natural N and P loading contributions from natural (background) forested settings. This study duration is expected to last through 2013, and has been ongoing since 2007-2008.

See the Resources section for additional related studies that have been identified.

MONITORING DESIGN

Proposed Monitoring Activities or Studies

Parameters& Methods

Significant sampling and analysis of water would be needed. Such methodologies have been proven in the scientific process and can be replicated or transferred to studies on this subject matter.

Frequency

N/A

Location, Scale, Watershed Type or Character (e.g. rural or urban)

Ideally a series of studies would be conducted which attempted to tease out specific factors which may directly influence N and P cycling. Some specific factors and types of sites may include:

- Urbanized settings, versus rural/natural settings
- Different soil geology (i.e.: Triassic soils, versus other predominant soil families)
- Monitoring stormwater that has been treated via a SCM, versus un-treated stormwater

Monitoring Group & Potential Partnerships

N/A

QA/QC Procedures & Recommendations

N/A

Data Coordination & Use

N/A

FUNDING OPPORTUNITIES

There are number of potential project funding opportunities from grant award programs, although in recent years, the available funds from grants for research projects has been limited or reduced.

North Carolina Programs

– NC Clean Water Management Trust Fund; http://www.cwmtf.net/
– NC Nonpoint Source Section 319 Grant Program, via N.C. Division of Water Quality; http://portal.ncdenr.org/web/wq/ps/nps/319program
– NC Water Resources Development Grant Program, via N.C. Division of Water Resources; www.ncwater.org
– Water Resources Research Institute of the UNC; http://www.ncsu.edu/wrri/

National or Regional Programs

– National Council on Air and Stream Improvement (NCASI), Water Quality Program; http://www.ncasi.org/programs/areas/water/default.aspx
– National Science Foundation; http://www.nsf.gov/
– NOAA Estuary Restoration Act; http://www.era.noaa.gov/information/funding.html
– Southeast Aquatic Resources Partnership (SARP); http://www.southeastaquatics.net/
– Southern Regional Water Program (formerly CSREES); http://srwqis.tamu.edu/default.aspx
– USDA-Forest Service, State & Private Forestry Redesign Grant Program; http://www.fs.fed.us/spf/redesign/
– USDA National Institute of Food and Agriculture (NIFA); http://www.nifa.usda.gov/
– USGS Cooperative Water Program; http://water.usgs.gov/coop/

PUBLIC EDUCATION COMPONENTS

The primary focus of outreach from results of related studies would be aimed at professionals in the world of stormwater management, municipal planning, and government policy makers. While there are certainly benefits to raising public awareness about activities which can prevent or minimize incremental nutrient loading, the main emphasis is to better understand how the N and P interact within the environment before, during and after treatment from SCM/BMP devices; and determining if more enhanced treatment options exist, either conventional structural methods or non-structural actions.

RESOURCES

Studies in NC: Identified from WRRI website
www.ncsu.edu/wrri/code/research/projects.htm
(You will likely need to contact WRRI or the P.I.'s to obtain a copy of the full report)

Factors Controlling Microbial Nitrogen Removal Efficacy in Constructed Stormwater Wetlands

Start Date and End Date: April, 1, 2011 to March 31, 2012

Dr. Bongkeun Song, Associate Professor, Department of Biology and Marine Biology,
University of North Carolina Wilmington, 5600 Marvin K. Moss Lane, Wilmington, NC 28409.
Tel: 910-962-2326, e-mail: songb@uncw.edu
Dr. Michael A. Mallin, Research Professor, Center for Marine Sciences,
University of North Carolina Wilmington, 5600 Marvin K. Moss Lane, Wilmington, NC 28409.
Tel: 910-962-2358, e-mail: mallinm@uncw.edu

Stormwater runoff is considered to be a major cause of water quality degradation in receiving water bodies in the United States. In order to reduce runoff and remove pollutants such as suspended solids, nutrients and fecal bacteria in stormwater runoff, constructed stormwater wetlands (CSWs) are gaining popularity as cost effective passive attenuation systems. Among various pollutants, nitrogen (N) removal in CSWs is primarily mediated by microbial processes such as denitrification (nitrate conversion to N2) and ANAMMOX (ammonium conversion to N2), while organic particle settling and uptake by macrophytes and algae are recycling processes of N. Depending on factors influencing denitrification and ANAMMOX, overall N removal capacity is likely to vary in different CSW systems. Thus, it is necessary to understand what factors influence N removal capacity by denitrification and ANAMMOX in CSWs in order to construct optimally-functioning CSWs. Our objectives are 1) to quantify the seasonal N removal rates via denitrification and ANAMMOX in different CSW systems using an 15N stable isotope technique, 2) to determine spatial variation of N removal capacity within the test CSW systems and define optimal areas of N removal, and 3) to examine shifts in denitrification and ANAMMOX rates in response to observed changes in seasonal, meteorological, physical, chemical and microbial parameters as well as vegetation. In order to achieve our proposed objectives, we will utilize stable isotope and molecular microbial techniques to detect and measure denitrification and ANAMMOX, and concurrently monitor geochemical parameters of water and sediments, and vegetation characterization. Two different CSWs located within the City of Wilmington, NC will be examined as our study sites. One CSW is the large (3 ha) regional JEL Wade wetland, constructed in 2007, that treats about 8% of the stormwater runoff entering N-limited Hewletts Creek. The second system is the Kerr Avenue wetland, constructed in 2000, smaller at 0.3 ha, that treats runoff within the Burnt Mill Creek watershed. Results from this study can be applied to improve CSW design specifications, complete/refine N budgets for wetland ecosystems, and can be used by NCDENR to calibrate future TMDL models.

Nitrogen Retention in Urban Streams: Implications for Ecologically Based Stream Restoration

Start Date: 03/01/2010 End Date: 02/28/2011

Dr. Sara K. McMillan, Assistant Professor, University of North Carolina at Charlotte, Department of Engineering Technology, 9201 University City Blvd, Charlotte, NC 28223. Phone: 704-687-6585. Fax: 704-687-6577. Email: smcmillan@uncc.edu.

Dr. Gregory D. Jennings, Professor and Extension Specialist, North Carolina State University, Department of Biological and Agricultural Engineering, Weaver Laboratory Box 7625, Raleigh, NC 27695. Phone: 919-600-4790. Fax: 919-515-7760. Email: jennings@ncsu.edu.

The central hypothesis of this proposed research is that inclusion of specific stream restoration strategies can enhance nitrogen removal in previously degraded urban streams. Through this research, we will better understand and predict the effects of ecologically based stream restoration elements on nitrogen retention in urban headwater streams. Headwater streams have consistently been identified as hot spots for retention and removal of nitrogen because of their close proximity to terrestrial landscapes, high inputs of organic material and increased water contact with biota (e.g. microbes, algae and vegetation). However, in degraded urban streams, nitrogen removal efficiency is reduced because of channelization, straightening and removal of geomorphic features (e.g. debris dams, riffle-pool sequences). In North Carolina and across the region, efforts are underway to move away from channel-hardening stabilization techniques such as rip-rap and rock walls toward ecologically-based restoration strategies. These efforts seek to provide stream stability while reestablishing diversity of plant and animal life, improve water quality and overall ecosystem function (e.g. nutrient processing, organic matter cycling and ecosystem metabolism). We hypothesize that timescales for reestablishing nitrogen retention can be achieved relatively quickly and greatly impacted by the type of restoration strategy employed. We will investigate the linkage between reestablishment of instream geomorphic features and nitrogen retention through a comprehensive approach of field assessment of stream morphology, quantification of whole stream nitrogen uptake and measurement of microbially mediated biogeochemistry (e.g. denitrification and nitrification). The proposed project will improve our fundamental understanding of the biogeochemical mechanisms driving nitrogen retention in urban streams. By including a range of restoration strategies and ages of restoration projects, this research will also improve our understanding of the recovery response of nitrogen retention after the restoration project is completed and as the ecosystem matures.

Studies outside of NC: identified from *www.ingentaconnect.com*

(These require that you pay to download a copy of the full report)

Nitrogen uptake and transformation in a Midwestern U.S. stream: A stable isotope enrichment study

Authors: Hamilton S.K.[1]; Tank J.L.[2]; Raikow D.F.[3]; Wollheim W.M.[4]; Peterson B.J.[4]; Webster J.R.[5]

Source: Biogeochemistry, Volume 54, Number 3, July 2001, pp. 297-340(44)

This study presents a comprehensive analysis of nitrogen (N) cycling in a second-order forested stream in southern Michigan that has moderately high concentrations of ammonium (mean, 16 μg N/L) and nitrate (17 μg N/L). A whole-stream ^15NH_4^+ addition was performed for 6 weeks in June and July, and the tracer ^15N was measured downstream in ammonium, nitrate, and detrital and living biomass. Ancillary measurements included biomass of organic matter, algae, bacteria and fungi, nutrient concentrations, hydraulic characteristics, whole-stream metabolism, and nutrient limitation assays. The results provide insights into the heterotrophic nature of woodland streams and reveal the rates at which biological processes alter nitrogen transport through stream systems.

Ammonium uptake lengths were 766–1349 m and uptake rates were 41–60 μg N m^−2min^−1. Nitrate uptake could not be detected. Nitrification rates were estimated from the downstream increase in ^15N-

enriched nitrate using a simulation model. The ammonium was removed by nitrification (57% of total uptake), heterotrophic bacteria and fungi associated with detritus (29%), and epilithic algae (14%). Growth of algae was likely limited by light rather than nutrients, and dissolved O_2 revealed that the stream metabolism was heterotrophic overall (P:R = 0.2). Incubations of detritus in darkened chambers showed that uptake of ^15N was mostly heterotrophic.

Microbial N in detritus and algal N in epilithon appeared to reach isotopic steady state with the dissolved ammonium, but the isotopic enrichment of the bulk detritus and epilithon did not approach that of ammonium, probably due to a large fraction of organic N in the bulk samples that was not turning over. The actively cycling fraction of total N in organic compartments was estimated from the isotopic enrichment, assuming uptake of ammonium but not nitrate, to be 23% for epilithon, 1% for fine benthic organic matter, 5% for small woody debris, and 7% for leaves. These percentages agree with independent estimates of epilithic algal biomass, which were based on carbon: chlorophyll ratios in bulk samples and in algal fractions separated by density-gradient centrifugation in colloidal silica, and of microbial N in the detritus, which were based on N released by chloroform fumigations.

Affiliations: 1: Kellogg Biological Station and Department of Zoology, Michigan State University, 3700 E. Gull Lake Dr., Hickory Corners, MI 49060, U.S.A. (Author for correspondence; e-mail: hamilton@kbs.msu.edu) **2:** Department of Biological Sciences, University of Notre Dame, Notre Dame, IN 46556, U.S.A. **3:** Kellogg Biological Station and Department of Zoology, Michigan State University, 3700 E. Gull Lake Dr., Hickory Corners, MI 49060, U.S.A. **4:** Ecosystems Center, Marine Biological Laboratory, Woods Hole, MA 02543, U.S.A. **5:** Department of Biology, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, U.S.A.
Publication date: 2001-07-01

STREAM NITRATE RESPONDS RAPIDLY TO DECREASING NITRATE DEPOSITION

Authors: Dolly N. Kothawala, Shaun A. Watmough, Martyn N. Futter, Leiming Zhang and Peter J. Dillon
Source: Ecosystems. Volume 14, Number 2. Page 274-286.
http://www.springerlink.com/content/0p53705766171757/

Ecosystem acidification and eutrophication resulting from increased deposition of dissolved inorganic nitrogen (DIN) are issues of increasing global concern. Consequently, costly policy decisions are being implemented to decrease nitrogen oxide (NO_x) emissions. Although declining DIN deposition along with rapid declines of DIN in surface waters have been reported in parts of Europe, the same observation is just emerging in North America. Here we find a significant decline in bulk deposition NO_3^- during the later part of a 28-year record in south-central Ontario, Canada. Despite high N retention and substantial inter-annual variability in the long-term record due to periods of drought, we find significant declines in annual NO_3^- concentrations and export at six out of 11 streams that drain upland-dominated catchments. In contrast, five streams draining primarily wetland-dominated catchments with lower levels of NO_3^- show no decreasing trend in NO_3^- concentration or export. The rapid response in stream NO_3^- to declining atmospheric inputs was observed at sites with historically moderate inputs of DIN (~870 mg m^{-2} y^{-1}) in bulk deposition. Topographic features such as slope, and related catchment features including wetland cover, appear to influence which catchments will respond positively to declining DIN deposition. These findings force us to revise our original conceptualization of the N saturation status of these catchments.

Affiliations: 1: Chemistry Department, Trent University, 1600 West Bank Drive, Peterborough, Ontario, K9J 7B8, Canada, Email: dkothawala@gmail.com **2:** Environmental Resource Studies Program, Trent University, 1600 West Bank Drive, Peterborough, Ontario, K9J 7B8, Canada, Email: swatmough@trentu.ca **3:** Department of Aquatic Sciences and Assessment, Swedish University of Agricultural Sciences, Uppsala, 75007, Sweden, Email: martyn.futter@vatten.slu.se **4:** Air Quality Research Division, Science and Technology Branch, Environment Canada, 4905 Dufferin St., Toronto, Ontario, M3H 5T4, Canada, Email:

leiming.zhang@ec.gc.ca **5:** Chemistry Department, Trent University, 1600 West Bank Drive, Peterborough, Ontario, K9J 7B8, Canada, Email: pdillon@trentu.ca
Publication date: 2011-03-01

Nutrient Uptake in Streams Draining Agricultural Catchments of the Midwestern United States

Authors: MELODY J. BERNOT[1], JENNIFER L. TANK[1], TODD V. ROYER[2], MARK B. DAVID[3]
Source: Freshwater Biology. Volume 51, Issue 3. Page 499-509. March 2006

1. Agriculture is a major contributor of non-point source pollution to surface waters in the Midwestern United States, resulting in eutrophication of freshwater aquatic ecosystems and development of hypoxia in the Gulf of Mexico. Agriculturally influenced streams are diverse in morphology and have variable nutrient concentrations. Understanding how nutrients are transformed and retained within agricultural streams may aid in mitigating increased nutrient export to downstream ecosystems.
2. We studied six agriculturally influenced streams in Indiana and Michigan to develop a more comprehensive understanding of the factors controlling nutrient retention and export in agricultural streams using nutrient addition and isotopic tracer studies.
3. Metrics of nutrient uptake indicated that nitrate uptake was saturated in these streams whereas ammonium and phosphorus uptake increased with higher concentrations. Phosphorus uptake was likely approaching saturation as evidenced by decreasing uptake velocities with concentration; ammonium uptake velocity also declined with concentration, though not significantly.
4. Higher whole-stream uptake rates of phosphorus and ammonium were associated with the observed presence of stream autotrophs (e.g. algae and macrophytes). However, there was no significant relationship between measures of nutrient uptake and stream metabolism. Water-column nutrient concentrations were positively correlated with gross primary production but not community respiration.
5. Overall, nutrient uptake and metabolism were affected by nutrient concentrations in these agriculturally influenced streams. Biological uptake of ammonium and phosphorus was not saturated, although nitrate uptake did appear to be saturated in these ecosystems. Biological activity in agriculturally influenced streams is higher relative to more pristine streams and this increased biological activity likely influences nutrient retention and transport to downstream ecosystems.

Affiliations: 1: Department of Biological Sciences, University of Notre Dame, Notre Dame, IN, U.S.A. **2:** Department of Biological Sciences, Kent State University, Kent, OH, U.S.A. **3:** Department of Natural Resources, University of Illinois, Urbana-Champaign, Urbana, IL, U.S.A.
Publication date: 2006-03-01

Nitrogen Removal in Streams of Agricultural Catchments - A Literature Review

Authors: Birgand, François[1]; Skaggs, R. Wayne[2]; Chescheir, George M.[2]; Gilliam, J. Wendell[3]
Source: Critical Reviews in Environmental Science and Technology.
Vol.37, No.5, Sept. 2007, pp. 381-487(107)

Excess nutrient loads have been recognized to be the major cause of serious water quality problems recently encountered in many estuaries and coastal waters of the world. Agriculture has been recognized in many regions of the world to be the largest single source of nitrogen emissions to the aquatic environments, and best management practices have been proposed to reduce nutrient losses at the field edge. As a result, there is growing awareness that nutrient management must be handled at the watershed scale. However, the key to nutrient management at the watershed scale is the understanding and quantification of the fate of nutrients both at the field scale and after they enter the aquatic environment. There has been widespread evidence since the late 1970s that nitrogen can be removed from water during its downstream transport in watersheds or basins. Although this information is becoming crucial, no overview has been proposed, so far, to qualitatively as well as quantitatively summarize available information in the literature. For this reason, we propose a review on the

biogeochemical processes involved in nitrogen removal in streams, the rates of removal reported, and the factors influencing those rates. Nitrogen removal rates in agricultural streams should be expected to vary between 350 and 1250 mg N m-2 day-1. Mass transfer coefficients (coefficient evaluating intrinsic ability of a stream to remove nitrogen) values in agricultural streams may vary between 0.07 and 0.25 m day-1, although these values correspond to values obtained from reach scale studies. Reviewing values obtained from different measurement scales has revealed that results from incubations or experiments performed in the laboratory clearly underestimate mass transfer coefficients compared to those reported at the reach scale, from several-fold to more than one order of magnitude. Nitrogen removal rates and efficiency in streams are the highest in the summer, and this is critical for receiving ecosystems, which are most sensitive to external inputs at this period of the year. Removal efficiency is the lowest in winter in temperate climates due to high flow and loading combined with lowest removal rates. In-stream processes, on an annual basis, may remove at the watershed scale as much as 10 to 70% of the total N load to the drainage network.

Affiliations: 1: ~~Cemagref, Parc de Tourvoie, Antony Cedex, France~~ ***(NOTE: Francois is now on faculty at NCSU Bio & Ag Engineering***) **2:** Department of Biological and Agricultural Engineering, North Carolina State University, Raleigh, North Carolina, USA **3:** Department of Soil Science, North Carolina State University, Raleigh, North Carolina, USA
Publication date: 2007-09-01

Fate and Transport of Organic Nitrogen in Minimally Disturbed Montane Streams of Colorado, USA

Authors: Kaushal, Sujay[1]; Lewis, William[2]
Source: Biogeochemistry, Volume 74, Number 3, June 2005 , pp. 303-321(19)

In two montane watersheds that receive minimal deposition of atmospheric nitrogen, 15–71% of dissolved organic nitrogen (DON) was bioavailable in stream water over a 2-year period. Discharge-weighted concentrations of bulk DON were between 102 and 135 μg/l, and the C:N ratio differed substantially between humic and non-humic fractions of DON. Approximately 70% of DON export occurred during snowmelt, and 40% of that DON was biologically available to microbes in stream sediments. Concentrations of bioavailable DON in stream water were 2–16 times greater than dissolved inorganic nitrogen (DIN) during the growing season, and bioavailable DON was depleted within 2–14 days during experimental incubations. Uptake of DON was influenced by the concentration of inorganic N in stream water, the concentration of non-humic DON in stream water, and the C:N ratio of the non-humic fraction of dissolved organic matter (DOM). Uptake of DON declined logarithmically as the concentration of inorganic N in stream water increased. Experimental additions of inorganic N also caused a decline in uptake of DON and net production of DON when the C:N ratio of non-humic DOM was high. This study indicates that the relative and absolute amount of bioavailable DON can vary greatly within and across years due to interactions between the availability of inorganic nutrients and composition of DOM. DOM has the potential to be used biotically at a high rate in nitrogen-poor streams, and it may be generated by heterotrophic microbes when DIN and labile DOM with low relative nitrogen content become abundant.

Affiliations: 1: Center for Limnology, Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO, 80309-0216, USA, Email: kaushalS@ecostudies.org **2:** Center for Limnology, Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO, 80309-0216, USA,
Publication date: 2005-06-01

The effect of land use on dissolved organic carbon and nitrogen uptake in streams

Authors: JOHNSON, LAURA T.; TANK, JENNIFER L.; ARANGO, CLAY P.

Source: Freshwater Biology, Volume 54, Number 11, November 2009 , pp. 2335-2350(16)

1. Agricultural and urban land use may increase dissolved inorganic nitrogen (DIN) concentrations in streams and saturate biotic nutrient demand, but less is known about their impacts on the cycling of organic nutrients. To assess these impacts we compared the uptake of DIN (as ammonium, NH_4^+), dissolved organic carbon (DOC, as acetate), and dissolved organic nitrogen (DON, as glycine) in 18 low-gradient headwater streams in southwest Michigan draining forested, agricultural, or urban land-use types. Over 3 years, we quantified uptake in two streams in each of the three land-use types during three seasons (spring, summer and autumn).
2. We found significantly higher NH_4^+ demand (expressed as uptake velocity, V_f) in urban compared to forested streams and $NH_4^+V_f$ was greater in spring compared to summer and autumn. Acetate V_f was significantly higher than NH_4^+ and glycine V_f, but neither acetate nor glycine V_f were influenced by land-use type or season.
3. We examined the interaction between NH_4^+ and acetate demand by comparing simultaneous short-term releases of both solutes to releases of each solute individually. Acetate V_f did not change during the simultaneous release with NH_4^+, but $NH_4^+V_f$ was significantly higher with increased acetate. Thus, labile DOC V_f was not limited by the availability of NH_4^+, but $NH_4^+V_f$ was limited by the availability of labile DOC. In contrast, neither glycine nor $NH_4^+V_f$ changed when released simultaneously indicating either that overall N-uptake was saturated or that glycine and NH_4^+ uptake were controlled by different factors.
4. Our results suggest that labile DOC and DON uptake can be equivalent to, or even higher than NH_4^+ uptake, a solute known to be highly bioreactive, but unlike NH_4^+ uptake, may not differ among land-use types and seasons. Moreover, downstream export of nitrogen may be exacerbated by limitation of NH_4^+ uptake by the availability of labile DOC in headwater streams from the agricultural Midwestern United States. Further research is needed to identify the factors that influence cycling of DOC and DON in streams.
Publication date: 2009-11-01

Effects of Land Use and Land Cover, Stream Discharge, and Interannual Climate on the Magnitude and Timing of Nitrogen, Phosphorus, and Organic Carbon Concentrations in Three Coastal Plain Watersheds

Author: Lehrter, John C

Source: Water Environment Research, Volume 78, Number 12, November 2006 , pp. 2356-2368(13)

In-stream nitrogen, phosphorus, organic carbon, and suspended sediment concentrations were measured in 18 subbasins over 2 annual cycles to assess how land use and land cover (LULC) and stream discharge regulate water quality variables. The LULC was a primary driver of in-stream constituent concentrations and nutrient speciation owing to differences in dominant sources and input pathways associated with agricultural, urban, and forested land uses. Stream discharge was shown to be a major factor that dictated not only the magnitude of constituent concentrations, but also the chemical form. In high discharge agricultural subbasins, where nitrate was the dominant nitrogen form, there was a negative correlation between discharge and nitrate concentration indicating groundwater inputs as the dominant pathway. In urban settings, however, nitrate was positively correlated with discharge, and, in forested subwatersheds, where dissolved organic nitrogen (DON) was the dominant nitrogen form, there was a positive correlation between discharge and DON, indicating washoff from the watershed as the dominant input pathway. Similarly, phosphorus concentrations were strongly regulated by LULC, discharge, and seasonality. This comparative study highlights that different mechanisms regulate different forms of nitrogen, phosphorus, and carbon, and thus field programs or water quality models used for regulatory purposes must assess these nutrient forms to accurately apply management plans for nutrient reductions.
Publication date: 2006-11-01

Individuals & research in related topics, found via internet search:

Baltimore Ecosystem Study
http://www.beslter.org/index.html
The Baltimore Ecosystem Study (BES) conducts research on metropolitan Baltimore as an ecological system. The program integrates biological, physical, and social sciences. As a part of the National Science Foundation's Long-Term Ecological Research Network, BES seeks to understand how Baltimore's ecosystems change over time.

- **Nitrogen Fluxes and Retention in Urban Watershed Systems.** Groffman, Peter M., et.al. 2004.
http://www.ecostudies.org/reprints/Groffman_et_al_2004_Nitrogen_Fluxes_Ecosystems.pdf

---

Jordan Cove Watershed Project
2007, Univ. of Connecticut. Prepared by John C. Clausen.
http://jordancove.uconn.edu/jordan_cove/publications/final_report.pdf

EXECUTIVE SUMMARY
BMP Watershed: The volume of stormwater runoff from the BMP Watershed decreased (-97%) during the construction period and remained lower than expected (-74%) during the post-construction period. During construction, the concentrations of TSS, NO3-N, NH3-N, TKN, and TP increased. Following construction, TSS, NO3-N, TP, and TKN concentrations remained higher than expected but metals decreased. NH3-N concentrations were also lower but near detection limits. Concentration peaks during construction were associated with turfgrass development. Exports from the BMP watershed generally did not change during the construction period, except for TSS and TP which increased and Zn which decreased. Following construction, exports generally decreased except TSS and TP, which increased.
Traditional Watershed: During construction and following construction, stormwater runoff from the traditional watershed increased. During construction, concentrations either did not change, or for TKN and TP, declined. Following construction, TSS, TKN, and TP concentrations declined. However, exports increased for all variables during both construction and post-construction periods, except for Pb following construction. The increase in flow controlled these export increases. The erosion and sediment controls used during construction appeared to work at this site.
Driveway Runoff Study: Stormwater runoff and mass export of solids, nutrients, and metals was greater from the asphalt than the pavers than the crushed stone driveways. Concentrations of solids, nutrients and metals were lower in runoff from the paver driveways than the asphalt driveways. Concentrations of TP and Pb were lower in runoff from the crushed stone driveways than from the asphalt driveways.
Lawn Nutrient Study: NO3-N desorbed from AEM strips, soil water NO3-N concentrations and plant reflectance all indicate that the BMP lawns being monitored have lower values than the non-BMP lawns**.** Soil P concentrations in the BMP watershed were ranked medium during the study.
Household Survey: The survey of residents in the three watersheds revealed little differences among their behaviors. BMP residents mulch their leaves and mow their own lawns compared to the control watershed. No differences in fertilizer habits were observed. There were also no differences in behaviors across years within each watershed.
Conclusions and Recommendations: The BMPs used were able to keep runoff volume and peak at predevelopment levels, which was a project goal. Reduced N and P export goals were also met but TSS export goals were not met. For future projects, cluster designs, LID-based regulations and stormwater disconnects are recommended. Future construction projects should control compaction, maximize undisturbed soils, and use on-site supervision. Earthen berms were and effective BMP. Sediment control for swales and following soil test recommendations are important. Following construction, maintenance of bioretention areas, infiltrating pavers, turf dams, and appropriate grass mixes is needed. Further study is needed of groundwater effects, behavioral social indicators, the economics of LID, and soil testing.

Topic: Urban Stormwater Runoff Phosphorus Loading and BMP Treatment Capabilities
Scott Perry(1), CPSWQ; Joel Garbon(2), Brian Lee(3)
1 Imbrium Systems Corporation – Rockville, Maryland
2 Imbrium Systems Corporation – Portland, Oregon
3 Imbrium Systems Incorporated – Toronto, Canada
Corresponding author e-mail: sperry@imbriumsystems.com
http://www.imbriumsystems.com/pdf/UrbanStrmwtrRunoff_BMP.pdf

Topic: Alternative Stormwater Sorption Media for the Control of Nutrients
Marty Wanielista; Ni-Bin Chang
Stormwater Management Academy
University of Central Florida: September 2008
http://www.stormwater.ucf.edu/research/Final%20Report%20Sept%2026.pdf

Topic: Florida Everglades Interim Report: Effectiveness and Optimization of Stormwater Treatment Areas for Phosphorus Removal
Michael J. Chimney and M. Zaki Moustafa
For South Florida Water Management District
http://mytest.sfwmd.gov/portal/page/portal/pg_grp_sfwmd_sfer/portlet_prevreport/interimrpt_98/chpt6.pdf

Topic: Fate of Pathogens in Transportation Runoff and Stormwater Collection Systems
Belinda Sturm, Ph.D.: Assistant Professor
Civil, Environmental, & Architectural Engineering: University of Kansas
Phone: (785) 864-1739. Email: bmcswain@ku.edu
http://www.kutri.ku.edu/research/project/bsturm.html

Topic: Biosolid application and effects on water quality.
Dr. Gary Felton, Univ. of Maryland
Tel: (301) 405-8039. Email: gfelton@umd.edu
Website: http://enst.umd.edu/People/Felton/index.cfm
Nutrient Fate and Transport Research Group: http://www.bre.umd.edu/felton/index.html

Topic: N&P fate and transport from Vegetative Treatment Systems off of CAFO (beef cattle lots)
Daniel Andersen, Graduate Research Assistant: Iowa State University.
Email: dsa@iastate.edu. Phone: 515-294-3153
"Nutrient Transport and Fate in Vegetative Treatment Systems"
http://water.usgs.gov/wrri/10grants/progress/2010IA150B.pdf

Topic: "Measuring and modeling the source, transport, and bioavailability of phosphorous in agricultural watersheds."
Lathrop, Richard C.; et.al.
Univ. of Wisconsin, Wisc. DNR, SUNY-Buffalo, USEPA.
http://bse.wisc.edu/wi_nutsci_epa_stargrant/index.htm

Topic: Primary area of research is the cycling, fate, and transport of phosphorus and nitrogen in soils and the development of profitable, environmentally sound agricultural nutrient management practices
Dr. Tom Sims: Deputy Dean for Academic Programs and Research
College of Agriculture and Natural Resources, Univ. of Delaware
Email: jtsims@udel.edu. Phone:302-831-2698
Website: http://ag.udel.edu/plsc/faculty/jtsims.html

AGENDA

UPPER NEUSE RIVER BASIN WATER QUALITY MONITORING PLAN
STAKEHOLDER MEETING

1:30 PM
November 3, 2010

Durham Water Management & Maintenance Facility
1600 Mist Lake Drive
Durham, NC 27704
Phone: (919) 560-4381

1:30-1:50	Introductions	(Heather Saunders)
1:50-2:10	Project Overview • Current situation • Project purpose • Project tasks and schedule	(Heather Saunders)

2:10-2:55	Stakeholder Process
	• Stakeholder Purpose
	• Ground Rules
	• Roles
	  o TJCOG and KTCOG
	  o Stakeholder group
	  o Working group
	  o How the groups will work together
		(Heather Saunders with Group)

2:55-4:15	Monitoring Objectives	(Heather Saunders with Group)
4:15-4:25	Homework	(Heather Saunders)
4:25-4:30	Next Steps	(Group)
4:30	Adjourn	

Upper Neuse Water Quality Monitoring Plan

Stakeholder Kick-off Meeting
November 3, 2010
Durham Mist Lake Facility

Introductions, Overview, and Housekeeping

Heather Saunders, Triangle J Council of Governments (TJCOG)

- Heather welcomed the group, described her role as the facilitator and briefly described the participant roles. See Participant Roles attachment.
- TJCOG, with input from the Upper Neuse River Basin Association (UNRBA) and in partnership with the Kerr-Tar Council of Governments (KTCOG), was awarded a 205(j) grant from the NC Division of Water Quality (DWQ) using American Recovery and Reinvestment Act funding.
- Heather informed the group that she is participating in the Natural Resource Leadership Institute (NRLI) program, which trains participants in environmental leadership, collaboration and conflict resolution, and she hopes that the group can have fun with this process.
- Heather thanked the group for coming and expressed appreciation for their willingness to participate in this very challenging process of finding agreement on a water quality monitoring plan for the Upper Neuse river basin.
- Heather reviewed the meeting agenda and mentioned that she is committed to start and end meetings on time, but that the timing of individual agenda items may be flexible depending on the desires of the group.
- The group went around and introduced themselves, stated their organizational affiliations, and mentioned one thing about themselves.

Meeting Attendees

Name	Affiliation	Email Address
Aaron Cain	Durham City-County Planning	aaron.cain@durhamnc.gov
Amy Axon	NC Source Water Assessment Program	amy.axon@ncdenr.gov
Amy Pickle	Duke University, Nicholas Institute	amy.pickle@duke.edu
Andrea Thomas	NCDWQ, Ambient Monitoring Coordinator	andrea.thomas@ncdenr.gov
Barbara Osland	NC Horse Council	boslund@solution-ies.com
Barry Baker	Granville County, Planning	barry.baker@granvillecounty.org
Bill Diuguid	NCDWQ, Permitting	bill.diuguid@ncdenr.gov
Bill Swartley	NC Forest Service, Hydrogeology	bill.swartley@ncdenr.gov
Bob Jordan	Durham County, Environmental Health	rjordan@ph.co.durham.nc.us
Britt Stoddard**	Wake County, Environmental Services	britt.stoddard@wakegov.com
Chris Roberts**	Durham County, Engineering	croberts@co.durham.nc.us
Drew Long		wolongtree@yahoo.com
Drew Cummings**	Durham County Manager's Office	dcummings@co.durham.nc.us
Ed Duke	Wake County, Environmental Services	eduke@wakegov.com
Emily Hill	NC State Parks, Natural Resources Program	emily.hill@ncdenr.gov
Frank Thomas	Durham-Orange-Chatham Homebuilders' Assc	frank@hbadoc.com
Gail Bledsoe	NCDFR, Water Quality & Wetlands	gail.bledsoe@ncdenr.gov
Gloria Ferrell	US Geological Survey	gferell@usgs.gov

Harold Kelly	Person County, Environmental Health	hkelly@personcounty.net
Haywood Phthistic	Neuse River Compliance Association/LNBA	hmp3rd@aol.com
Heather Saunders**	Triangle J Council of Governments	hsaunders@tjcog.org
Jason Greene	NCDWQ Intensive Survey Unit Coordinator	jason.green@ncdenr.gov
Jeff Mahagan**	Town of Hillsborough, WWTP	jeff.mahagan@hillsboroughnc.org
Jessica Kemp	NC Ecosystem Enhancement Program	jessica.kemp@ncdenr.gov
Jim Wise	News and Observer	wise207w@nc.rr.com
Jim Wrenn	Attorney; SGWASA, Butner, Granville County	jcw@hopperhickswrenn.com
Joann Burkholder**	NC State Center for Applied Aquatic Ecology	joann_burkholder@ncsu.edu
Karen Rindge	WakeUP Wake County	krindge@earthlink.net
Kathryn Hobby	Wake County, Environmental Services	kaythryn.hobby@wakegov.com
Kathy Stecker**	NC Division of Water Quality	kathy stecker.stecker@ncdenr.gov
Kenny Waldroup**	City of Raleigh, Public Utilities	kenneth.waldroup@ci.raleigh.nc.us
Lars Hanson	Triangle J Council of Governments	lhanson@tjcog.org
Linda Ehrlich	Spirogyra, Inc.	spirogyra@juno.com
Lindsay Mize**	South Granville Water & Sewer Authority	lmize@sgwasa.org
Lorrie Pocher	DENR, On-Site Water Protection Section	lorrie.pocher@ncdenr.gov
Mark Senior	City of Raleigh, Stormwater Services	mark.senior@raleighnc.gov
Mary Giorgino**	US Geological Survey	giorgino@usgs.gov
Melinda Clark**	Wake County, Environmental Services	melinda.clark@wakegov.com
Melissa Hodges	Town of Butner, Planning	mhodges@butnernc.org
Michele Drostin	NC Ecosystem Enhancement Program	michele.drostin@ncdenr.gov
Michelle Woolfolk**	City of Durham, Stormwater Services	michelle.woolfolk@durhamnc.gov
Mike Ciriello	Kerr-Tar Council of Governments, Planning	mciriello@kerrtarcog.org
Mike Dupree**	Durham County, SWCD	mdupree@durhamcountync.gov
Mike Schlegel	Triangle J Council of Governments	mschlegel@tjcog.org
Mike Schifflet	Ellerbe Creek Watershed Association	mwshiflett@hotmail.com
Nancy Daly	NC Ecosystem Enhancement Program	nancy.daly@ncdenr.gov
Nicole Ard	Town of Hillsborough, Manager's Office	nicole.ard@hillsboroughnc.org
Nora Deamer	NCDWQ, Basinwide Planning	nora.deamer@ncdenr.gov
Pam Hemminger	Orange County, Board of Cty Commissioners	phemminger@bellsouth.net
Paula Murphy	Person County, Planning	pmurphy@personcounty.net
Reggie Hicks**	City of Durham, Water Management	reginald.hicks@durhamnc.gov
Rick Bollick	NCDWQ Hydrogeologist	rick.bolich@ncdenr.gov
Rick Flowe	City of Creedmoor, Planning	rflowe@cityofcreedmoor.org
Robert Reed	NC State Center for Applied Aquatic Ecology	robert_reed@ncsu.edu
Rochelle Araujo	City of Durham, Env. Advisory Board	araujo.rochelle@epamail.epa.gov
Sarah Bruce**	Upper Neuse River Basin Association	sbruce@tjcog.org
Steve Berkowitz**	NC Division of Environmental Health	steven.berkowitz@ncdenr.gov
Steve Bristow	Wake County, Environmental Services	sbristow@wakegov.com
Steve Kroeger**	NCDWQ	steve.kroeger@ncdenr.gov
Terry Hackett	Orange County, Sediment & Erosion Control	thackett@co.orange.nc.us
Tom Davis**	Orange County	tdavis@co.orange.nc.us
Tom Mercer	City of Creedmoor, Manager's Office	tmercer@cityofcreedmoor.org
Will Wilson	Durham Farmland Preservation Board	wgw@duke.edu

** = volunteered for Working Group

Project Overview and Schedule

Heather Saunders, TJCOG

- Heather went over the reasons for the project ("Current Situation"), including:
  - there are nine drinking water supplies in the watershed and sixteen impaired water body segments in the Upper Neuse river basin;
  - water quality monitoring date is sometimes infrequent and sparse;
  - there is a need for better data coordination;
  - with the existing data, it is difficult to inform management and financial decisions;
  - with the existing data, it is difficult to determine water quality trends and geographic distinctions; and
  - A need to evaluate the effectiveness of the Falls Lake nutrient management strategy (NMS).

- Heather reviewed the project tasks with the group, including:
  - the attached task breakdown that lays out a process to develop a long-term water quality monitoring plan for the Upper Neuse river basin;
  - opportunities throughout the process for stakeholders to provide input;
  - project tasks build on one another, and the stakeholders will have a chance to reflect on what the Working Group proposes. The process is designed to give everyone an opportunity to participate and provide input.

- Heather described the attached project timeline with the group.
  - The project as proposed specifies a completed monitoring plan in July 2012.
  - Kenneth Waldroup mentioned that unless the hearing officers push Stage II of the NMS back, the timeline presented might not allow enough time to gather data sufficient to inform a remodeling effort. He mentioned that the timeline should be tied to recommendations of EMC and the hearing officers. As presented, the monitoring plan time frame does not meet Stage II deadlines.
  - Drew Cummings mentioned that significant new funding will be required to conduct additional monitoring. Monitoring could start in July, which is the beginning of a fiscal year. If the plan is not done until July 2012, then the local governments would have to seek funding for the following fiscal year. Funding for monitoring would not be available until July 2013 (the start of fiscal year 2014), which seems unnecessarily long for starting monitoring. We should have a goal that is much sooner to allow for slippage. More data is better.
  - It was discussed that on the proposed timeline, the "Draft Funding Programs" in Dec '11/Jan '12 seems reasonable to start in July '12 with funding.
  - Kathy Stecker questioned whether waiting for the monitoring plan to be finalized in July '12 was a wise idea. She wondered if we would be missing good monitoring time.
  - It was asked if we needed to wait until after the final plan to get funding, or whether funders could be approached with a draft plan that could be subject to some change.
  - Heather presented an alternative (condensed) timeline, which would have a draft monitoring plan in January 2012 and a final plan in April 2012.
  - Heather emphasized that it will take a substantial effort from the project staff and Working Group to achieve the project within the condensed timeline.
  - Mike Schlegel asked about the timing of contracting for monitoring and wondered if there was sufficient time for contracting after funding commitments were secured. He wondered how long the contracting process might take, and he asked if contracting for monitoring services could be accomplished while plan is being finalized.
  - Michelle Woolfolk mentioned that contracting for services would depend on the vehicle for funding.

- Kenny Waldroup mentioned the need to decide on a funding agency sooner. He mentioned several options including TJCOG, UNRBA, or a new organization.
- Steven Berkowitz asked if we are reorganizing what's being collected now and mentioned that there are organizations already doing monitoring.
- Heather agreed that many people doing monitoring, and this would not be an entirely new plan.
- Kenny Waldroup suggested that trying to coordinate with existing monitoring could throw the process off track here. He mentioned that we've already answered many of these questions about existing monitoring. There are six or seven groups collecting data, but that all but maybe one was determined by DWQ to be not suitable for modeling. He mentioned that this has been discussed.
- Kathy Stecker mentioned to keep in mind that when designing a monitoring plan, there is need to balance funding.
- Jim Wrenn asked if we could start monitoring in the summer of 2011.
- Will Wilson suggested there could be an adaptive monitoring plan that might include some early data and be adjusted later.
- There was agreement among those present that they prefer a shorter planning timeline. ***Heather agreed to convene the working group to decide how to accomplish the plan in a shorter timeframe. An online wiki will be used to help the Working Group share their efforts with the larger group of stakeholders***.
- Bob Jordan brought up the local government budgeting process. Winter is when proposals get drawn up for following fiscal year, so if we are asking for money to conduct monitoring during fiscal year 2012 (i.e. from July 2011-June 2012) we'd need to have figures to approach local government within two months.

Show of hands: Roughly 2/3 would prefer a shorter timeline. ***Will set-up a Wiki to do communication on scheduling****.*

- Jeff Mahagan asked if the goal was to get data that can feed into remodel using the existing model.
- Heather mentioned the objective is to answer as many questions as possible.

Stakeholder Process

Heather Saunders, TJCOG

- Heather presented that the purpose of the stakeholder process was "to engage stakeholders with a diverse range of interests in the development of a long-term water quality monitoring plan for the Falls Lake Watershed."

- Michelle Woolfolk requested that the "Falls Lake Watershed" phrase be changed to "Upper Neuse Watershed." ***Heather will make this change***.

- The group was asked to recommend ground rules for the meetings. The recommendations included:
    - Basic trust; assume good intentions
    - Work together to improve everyone's water quality
    - Be clear on whether you're expressing an opinion or a fact
    - Honor and respect past & current monitoring efforts
    - No cell phone "sounds"
    - Be respectful of your fellow stakeholders
    - Start and end meetings on time
    - Don't criticize ideas
    - It's ok to disagree
    - Be prepared to represent your organization in the process
    - Be prepared to participate; do your homework
    - Get materials to people in time for them to prepare themselves (facilitator)
    - Represent what's best for the region; work <u>together</u>
    - Work toward mutually beneficial (win-win) solution

- Heather presented the participant roles.
    - She presented the attached stakeholder responsibilities, which includes many parallels to the ground rules recommended by the stakeholders.
    - She also presented the attached working group responsibilities and asked participants to let her know by the end of November if you are going to commit to participating in the working group.
    - Heather described how the groups will work together and the feedback mechanisms.
    - Melissa Hodges asked whether the working group participants needed a lot of technical expertise.
    - Heather suggested that they need either technical expertise and/or funding ability.
    - A participant proposed three working group subcommittees: funding, data collection and data analysis/processing.
    - Heather asked if those tasks <u>can</u> be separated, because there is much overlap with data collection and processing/analysis.
    - It was recommended that the funders could split out of working group to focus on funding (after the meeting Sarah Bruce offered to provide staff support for this sub-group, because she is already tasked to help draft the technical memorandum on institutional options.)
    - A participant asked if there should be a third smaller group within the working group for data processing issues.
    - Michelle Woolfolk suggested it seemed reasonable to split the funding and finance, but that the monitoring and processing roles should be kept together.
    - Kathy Stecker suggested to have the working group meet together initially, then split off. Gail Bledsoe expressed her support for this idea.

Objectives for Monitoring Program

Group

- The group took some time to review the monitoring objectives that were listed in response to the question "What goals and objectives do you or your jurisdiction have for any new monitoring or modeling of Falls Lake or the Falls Lake watershed" at a meeting hosted by Durham in September of 2010. These objectives were listed on sticky notes and placed on the whiteboard.

- Participants wrote and added any objectives to the list as necessary. A list of these objectives is provided below.

- The group then grouped the objectives into like categories and gave each group a category. The group came up with the following groupings:
    - Sources/Dynamics of Nutrient Loading
    - Nutrient Mapping
    - Lake Response Timeline
    - Lake Characterization
    - Modeling Concerns
    - Institutional Oversight
    - Regulatory Acceptance/QACC/QAPP
    - Management Effectiveness
    - Emerging Contaminates
    - Use Support Analysis
    - Public Education and Outreach
    - Drinking Water
    - Wildlife Management
    - Data Consolidation

- The headings and the objectives assigned to them by the group are described in Table 1.

Table 1. Objectives for a water quality monitoring plan as grouped into headings.

Sources/Dynamics of Nutrient Loading
• What is entering the lake? Chlorophyll a, other tributaries N, P and Chlorophyll *a*
• Are loads to the lake declining? (N, P and chlorophyll a)
• What is entering the lake? (Chlorophyll a, other tributaries (N, P, Chl a)
• Where is the best location (stable) to monitor inputs to the lake?
• Sources Mapping
• Unknowns: Fertilizer, septic, sediment-attached P, atmospheric deposition
• What are the impervious cover characteristics of the watershed? (Where is IC and how is it distributed?)
• Understand (soils for) onsite wastewater attenuation rates
• What are the actual loads distributed from throughout the watershed? Can we better understand sources by having a watershed model that is calibrated to measured loads at multiple locations? At jurisdictional boundaries?
• What loads come from each jurisdiction?
• Characterize internal lake load
• What is approximate nutrient loading into Falls Lake watershed from groundwater?
• Nutrient loads from groundwater discharge
• Lake boundary conditions (are loads to the lake declining (N, P, Chl a))?

- Understand how loads from agriculture (equine) differ from others (flow, composition, urban/suburban)
- Where is the best location (stable N, P, Chlorophyll a) to monitor inputs to the lake?
- Nutrient loading by source type. Base, ongoing, and current as of date.
- Distinguishing sources of different types of Nitrogen (i.e. residential, fertilizer vs. onsite wastewater)
- Watershed characterization
- Characterize sources better
- Measured load from forests (slate vs. Triassic)
- Nutrient loading by source type, 2006 base and ongoing

Nutrient Mapping

- Characterize the distribution of loads
- Load distribution (at jurisdictional boundaries)
- What loads come from each jurisdiction?
- What are the actual loads distributed from throughout the watershed? Can we better understand sources by having a watershed model that is calibrated to measured loads at multiple locations? At jurisdictional boundaries?
- Know loads by jurisdiction & tributary
- Nutrient loading by jurisdiction and by subwatershed (2006 base and ongoing, current as of date certain)
- Better unit loading rates that may vary by geography and by land use
- Nutrient trading tool (USDA, lbs N, lbs P, reductions)

Lake Response Timeline

- Given high internal loading in the lake, how will the lake respond to changes in the load?
- Data and analysis that can be used to forecast or "backcast" conditions
- What contribution of P (maybe N) does re-suspension have on the total nutrient load to be managed in the lake?

Lake Characterization

- Understand current condition of the lake
- Lake Boundary Conditions (are loads to the lake declining (N, P, Chl a)
- How much does water level fluctuation contribute to internal loading in the lake?
- Forest is the largest component of the watershed. What are the actual nutrient loads from forests in the Triassic basin?
- Understand loads from forest and atmospheric deposition
- Ask Corps of Engineers to do research evaluating lake operations on water quality
- Which streams do not have intact riparian buffers?
- Atmospheric deposition—coordinate with energy & air quality efforts with regard to nutrients
- Account for atmospheric deposition

Modeling Concerns

- Monitor Rainfall
- Given that the model used rain data from RDU, would local monitoring of rainfall improve hydrologic calibration?
- Determine if modeling is as accurate as possible given state of science.
- Propose a new model(s) to address any identified deficiencies. Make sure flexible enough to incorporate new learning
- Account for lake operations in model
- Fix short-comings of the existing model
- Capability to develop our own model

- Account for atmospheric deposition
- Gather new data for remodeling in 2018 (means we need to know which model will be used)
- What does good long-term lake & watershed management look like? (account for droughts, pool re-allocation, hurricanes)
- Better definition of how data will be used to modify NMS
- What are the least number of sites that would allow a remodel and use support assessment
- Data and analysis that can be used to forecast or "backcast" conditions
- New models needed
- Better unit loading rates that may vary by geography/use

Institutional Oversight

- Analyze process needs. Get Association
- Get Association together and let them determine accounting tools (instead of the Jordan Lake stakeholders)
- Define minimum data requirements
- One testing program accepted by all stakeholders and DWQ
- Know how DWQ is going to assess nutrient reductions for BMPs. Need to know requirements before assessing in projects (site specific before/after modeling?)

Regulatory Acceptance/QACC/QAPP

- One testing program accepted by all stakeholders and DWQ
- Negotiate MOA or program with DWQ for entire monitoring program
- Neutral & unbiased monitoring, management and oversight
- Data is accepted by DWQ
- Standardized methods, consistent and state approved.
- EPA & DWQ agreement on using correct & cost-effective study methods
- Implementable (fundable) plan that DWQ will accept

Management Effectiveness

- Tell us whether management efforts are succeeding (a vigorous effort)
- Understand how management practices are affecting loads (individual and cumulative)
- Know by 2017 (at least) where we are vis-à-vis Stage I.
- Know the value of EACH individual management strategy (e.g., septic, ag). Do the BMPs work?
- Tell us whether management efforts are succeeding; track success of NMS by source (agriculture, existing development, etc)
- Determine if BMPS are effective
- Focused sub-basin monitoring designed to isolate impacts from individual sources and improvements after BMPs implemented (to use to calibrate for basin future modeling efforts)
- Monitor BMPs

Emerging Contaminates

- Consider pollutants other than just nutrients (i.e. those that pose health risks to users of water)
- Consider emerging pollutants (endocrine disruptors, personal care products, cyanotoxins)
- Need to know levels of endocrine-disrupting chemicals, pharmaceuticals, and personal care products. Will help determine/reflect sources of input to the lake and watershed

Use Support Analysis

- Evaluate how well the land (public) meets needs (recreation) in watershed
- Evaluate Past, Present and Future Uses of the Lake
- Determine if existing water quality standards support existing uses. Are they too restrictive, too loose, or

missing? • Evaluate how well the lake meets existing uses. Water supply, aquatic life propagation, recreation (boating, swimming, fishing) • Evaluate the degree to which the lake has, is, or can support all its authorized uses. • Supports UAA (Use Attainability Assessment) or change in use (water quality standard) for upper Falls Lake
Public Education and Outreach • Designation of Actions/Behaviors that residents, volunteers, and non-profits can do that won't cost taxpayers money • Expand/Improve/Increase public awareness and participation in annual big sweep events; track totals • Subsidize or incentivize residential composting; track # participants
Drinking Water • Understand relationship between TOC, nutrients, and Chlorophyll a
Wildlife Management • Learn about fish populations and biota in upper and lower lake relative to chlorophyll a and turbidity (impairment) • Map urban stream syndrome (deeply incised streams)
Data Consolidation • Make sure our data can support decisions at a high level of certainty within regulatory time frame. • Translate/compare data collected using different methods (if possible) • Stable Funding (no gaps in data collection) (timing longitudinal) • Understand current monitoring efforts • Cost-effective, well-coordinated with other efforts • Address data gaps • Assess data being collected (current monitoring plans) • Develop data standards for monitoring data and tools; convert current monitoring from various sources into a more common format • Clear system of water quality benchmarks, relevant to decision-makers and public

- Uncategorized objectives
    - Alternatives to chlorophyll a as an indicator
    - TRUST
    - Work together, Do Good Things

Table Discussions on Monitoring Questions

Group

- The participants were asked to work at their tables to come up with 5-10 specific questions that monitoring could answer and each table was assigned a category. Questions generated through this activity are described in Table 2.

Table 2. Questions for a water quality monitoring plan generated with heading names.

Sources and Dynamics of Nutrient Loading/Nutrient Mapping • Identify sources of nutrients within and outside our combined regulatory purview. • For nutrients within regulatory purview, identify sources of nutrients by use and by jurisdiction. • For modeling, accounting for transport/attenuation/uptake as they relate to streams, for different media (i.e. groundwater, types of streams). • How might different land uses inform efficient monitoring regimes? • Better understanding of poorly quantified nutrient sources (sources not regulated); can we trust nutrient trading tools?
Lake Response • What short-term changes in phytoplankton and chlorophyll-a community composition occur with measured load reductions from watershed? • How important is internal nutrient loading vs. allocthonous loading in the lake? • What are the major influences on watershed and lake hydrology? • What are influences of hydrology on nutrient expression in lake?
Lake Characterization • Where are the nutrient source loads originating from within the lake and watershed? • How does nitrogen get processed in lake? • What level of nutrients can the lake process? • Differentiate mass loads from different sources in watershed.
Modeling Concerns • What type/quantity of monitoring data to use? • What models are needed/appropriate? • Who develops the model? • What is the goal of the model? • Frequency of review and recalibration? • Who interprets data and model output? • What is appropriate time for sampling?
Institutional Oversight and Regulatory Acceptance • What are standards that would be acceptable to DWQ and local governments? • Who will develop the standards? • What organization will have oversight and will this be by consensus?
Management Effectiveness • Perform targeted evaluations of BMP assumptions. • Are there things we can do to evaluate model effectiveness? • Is management effectiveness a core goal of water quality monitoring process? • Can data on management effectiveness help feed data for compliance?

- Question of degree to which evaluating the management effectiveness a core goal?
- Different levels of evaluation.
- Are loads to lake declining?
- Goals discussed at this table:
    - Understand relationship between TOC and chlorophyll-*a*.
    - Gather data on chlorophyll-*a* and other parameters such that model can be run to determine whether Stage II is appropriate.
    - Gather data for a use attainability analysis.
    - Targeted evaluations of established BMP assumptions.

Emerging Contaminants

- Are there measurable levels of emerging contaminants? At wastewater treatment plant effluent? In Falls Lake? In drinking water?
- If so, what are the concentrations compared to other research?

Drinking Water

- Is there a correlation between TOC, nutrients, and chlorophyll-*a*?

Use Support

- What type of monitoring should be performed to determine use support?
- Can existing data generate answers for use support questions?
- What are existing uses or classes and what type of land uses help determine use, land use focus on monitoring?

Public Outreach and Education

- Can monitoring generate increased participation in public outreach?
- Can monitoring determine effectiveness of public outreach involvement efforts?
- What are the priorities for public education?
- Do grassroots efforts such as residential composting produce reductions in nutrients? Is this too small a piece to measure?

Data Consolidation

- Is standardizing a test method a good way to achieve data consolidation?
- Is standardizing a test method a good way to achieve collection methods?
- Can permit regulations be modified to allow data consolidation?
- Can data consolidation be used to reduce duplication of effort and reduce overall cost?
- Can data consolidation be used to address existing data gaps?
- Can data consolidation help ensure the right data are being collected at an acceptable frequency?

Heather said that these questions will be posted on a project wiki and folks can add to and work with the topics there. Then, the working group will refine, prioritize and start developing options for a monitoring network.

Homework

Heather asked the meeting participants to review Mary Giorgino's monitoring summary and provide additional information on their monitoring programs. She asked participants to email GIS files of monitoring locations. The due date for these materials is December 17.

Next Steps

- Heather will send out a meeting summary; if there is a comment or correction, email Heather and she will include it as an Addendum to the meeting summary.

- Heather will convene the working group in December or January. Folks who want to participate on this group are asked to let her know by the end of November.

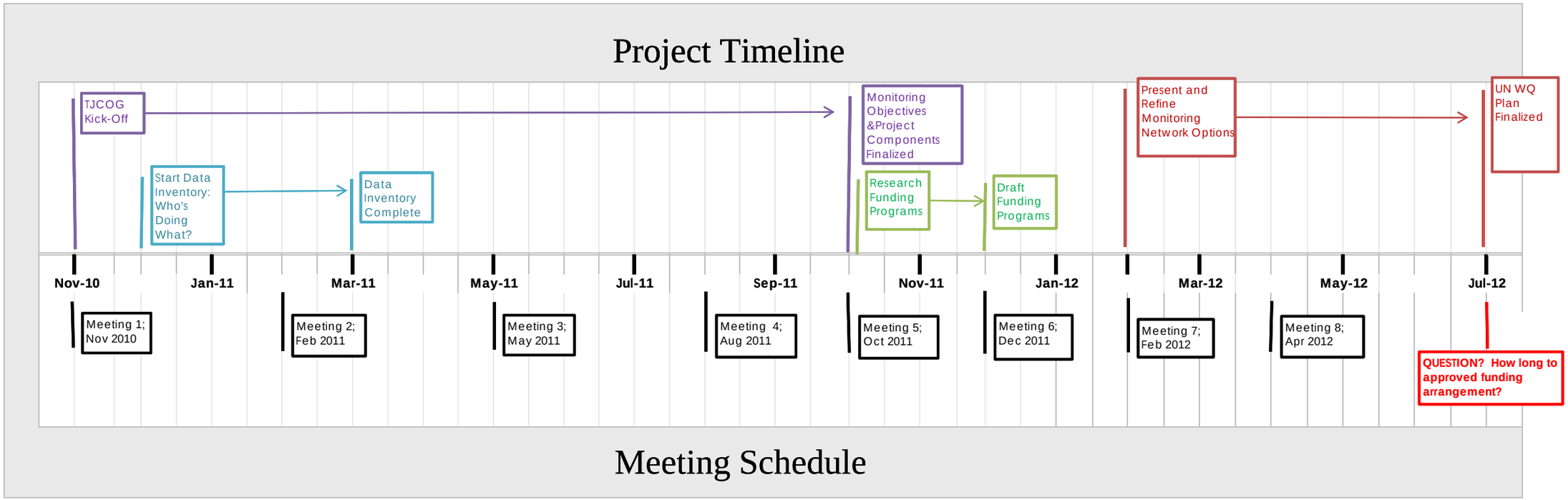
- Heather will also set up a wiki for the project.

205(j) Upper Neuse Monitoring Plan Proposal - DRAFT Project Tasks & Budget

28-Oct-10

Element 1. Project Management and Stakeholder Administration	
1a.	Solicit initial stakeholder and working group participation; set up and maintain contact information
1b.	Go over project timeline with stakeholder group and build support for the project, refine subtasks
1c.	Develop and maintain project web page to house meeting summaries, technical memoranda, etc.
1d.	Coordinate project and tasks among stakeholders, working group, and project staff (phone calls and incidental meetings)
1e.	Manage financial transactions and invoice DWQ quarterly
1f.	Write project final report per 205(j) grant requirements
Element 2. Inventory and evaluate relevant wq monitoring efforts, resources, and information	
2a.	Update inventory of current monitoring efforts (parameters, frequencies, locations) and Mary Giorgino's basic list of monitoring gaps
2b.	Research recommendations for monitoring & data management (literature & program review)
2c.	Develop and administer survey on current monitoring efforts, lessons learned, costs, capacity, service providers, and information needs
2d.	Compile and evaluate monitoring inventory, survey results, literature review, etc. into **draft TECH MEMO 1 (Working Group)**
Element 3. Determine potential monitoring objectives and research potential components of the monitoring program	
3a.	Share **draft TECH MEMO 1** with stakeholder group, solicit feedback, prepare to discuss objectives and program needs
3b.	Brainstorm program objectives and possible phases of monitoring program based on needs with stakeholder group; Organize and prioritize objectives and phases of monitoring with Working Group. Identify opportunties/need for special studies or projects
3c.	**Finalize TECH MEMO 1** to add prioritized program objectives (what we want additional data to tell us) and other feedback
3d.	Determine parameters, locations, and frequencies associated with various high-priority objectives (levels of service/program phases) (**draft TECH MEMO 2**) **(Working Group)**
3e.	Draft data management, archiving and reporting protocols and data products (e.g., water quality indices)
3f.	Draft QAPP/QAQC requirements and get input from DWQ (**revise TECH MEMO 2**) **(Working Group)**
3g.	Estimate costs associated with different levels of service/phases/high-priority objectives; include feedback on reporting protocals and data management (Task 3e.); include revised QAPP/QACC requirements with input from DWQ (Task 3f)
3h.	Present draft Tech Memo 2 to stakeholder group for input; Revise as necessary **(finalize TECH MEMO 2)**
Element 4. Investigate funding mechanisms and institutional frameworks	
4a.	Investigate and compile list of all available funding mechanisms and pros/cons of each (**draft TECH MEMO 3**) **(Working Group)**; share with stakeholder group
4b.	Discuss objectives, services, and funding mechanisms with stakeholder group; determine appropriate institutional framework (decide whether to create a new partnership, expand existing partnership, etc.)
4c.	**Finalize TECH MEMO 3** to reflect mechanisms determined to be most feasible
4d.	Draft **Sample Partner Agreement** and share with potential program partners via email, revise as necessary
4e.	**Draft RFP** for contractors who would conduct monitoring for the program
Element 5. Develop basinwide monitoring program framework and plan	
5a.	Based on TECH MEMOS 1, 2, and 3, propose final objectives, monitoring approaches (sampling locations, parameters, frequencies), and other program components (oversight, QA/QC requirements, data management and reporting, funding mechanisms) (**draft TECH MEMO 4**) **(Working Group)**, solicit stakeholder group input via email
5b.	Field verify potential station locations, revise locations as needed (**revise TECH MEMO 4**)
5c.	Present TM 4, obtain stakeholder input, and **revise TECH MEMO 4** with confirmed objectives, phases, and specific parameters, frequencies, and locations to be monitored
5d.	Finalize data management, archiving and reporting requirements, and data products (e.g., water quality indices) (**finalize TECH MEMO 4**)
5e.	Develop recommendations for coordinating with local and other monitoring efforts (volunteer, DWQ, MWW, etc.) (**TECH MEMO 5**)

Meeting 1	Stakeholders	Project overview and process; brainstorm/organize objectives
Meeting 2	Working Group	Refine objectives, review data inventory
Meeting 3	Working Group	Begin work on monitoring options/costs
Meeting 4	Stakeholders	Present refined objectives, results of data inventory, gap analysis, and broad monitoring options/costs
Meeting 5	Working Group	Revise objectives and monitoring objectives based on input from Stakeholders; parameters, frequencies/locations; begin work on funding arrangements
Meeting 6	Stakeholders	Present objectives, potential networks, and funding mechanisms to group
Meeting 7	Working Group	Incorporate feedback and continue to develop plan that incorporates objectives, networks, costs, and funding
Meeting 8	Stakeholders	Present Final Plan
		Working Group will revise as necessary through July 2012



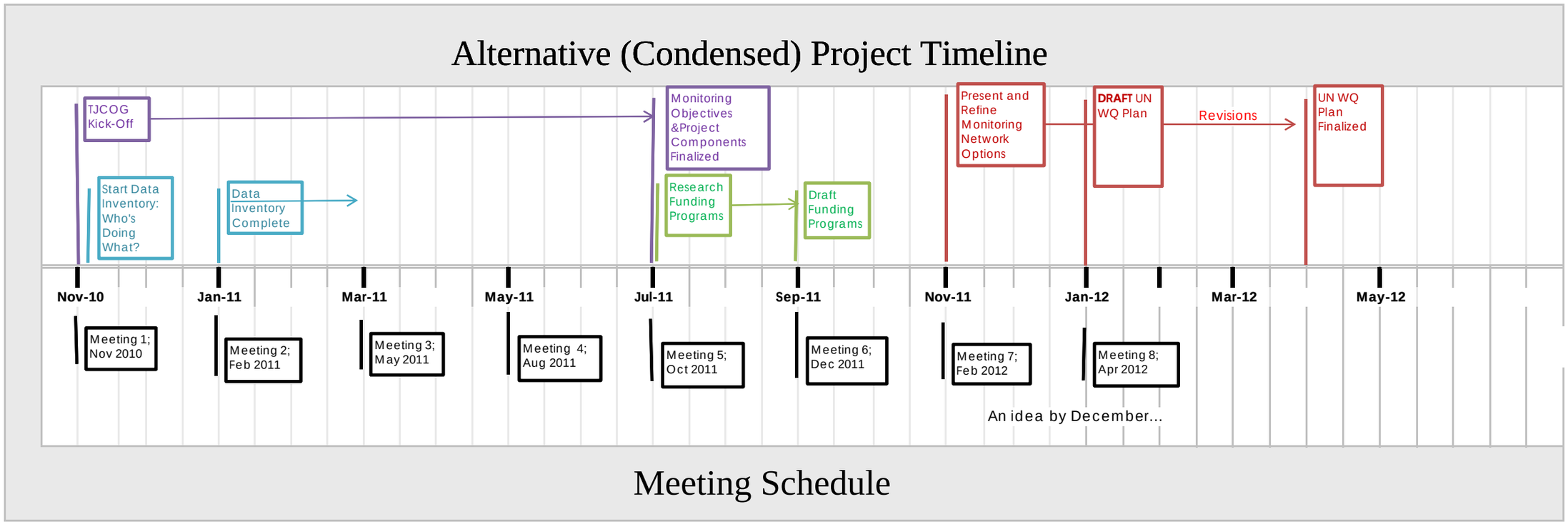
Potential/Possible Schedule for Falls Lake Remodel (1)

2021	EMC adopts amended rules
2020	DWQ recommends to EMC changes in the rules
2019	SAB recommends to DWQ/stakeholders changes in needs to achieve compliance
2018	Data analysis complete on sampling information and modeling has been done
2017	Data from sampling completed to support new model runs
2012	Monitoring starts so there is at least 5 years of data to support the model

Potential/Possible Schedule for Falls Lake Remodel (2)

2023	EMC adopts amended rules
2022	DWQ recommends to EMC changes in the rules
2021	SAB recommends to DWQ/stakeholders changes in needs to achieve compliance
2020	Data analysis complete on sampling information and modeling has been done
2019	Data from sampling completed to support new model runs
2014	Monitoring starts so there is at least 5 years of data to support the model

Meeting 1	Stakeholders	Project overview and process; brainstorm/organize objectives
Meeting 2	Working Group	Refine objectives, review data inventory
Meeting 3	Working Group	Begin work on monitoring options/costs
Meeting 4	Stakeholders	Present refined objectives, results of data inventory, gap analysis, and broad monitoring options/costs
Meeting 5	Working Group	Revise objectives and monitoring objectives based on input from Stakeholders; parameters, frequencies/locations; begin work on funding arrangements
Meeting 6	Stakeholders	Present objectives, potential networks, and funding mechanisms to group
Meeting 7	Working Group	Incorporate feedback and continue to develop plan that incorporates objectives, networks, costs, and funding
Meeting 8	Stakeholders	Present Final Plan
		Working Group will revise as necessary through July 2012



UPPER NEUSE RIVER BASIN WATER QUALITY MONITORING PLAN

DEFINING THE SITUATION AND OUR PURPOSE AND GOALS

CURRENT SITUATION/CHALLENGE

1. Despite the importance of the lake, the substantial water quality issues it faces, and the expense of the measures being implemented to address these issues, water quality monitoring data for the lake and its tributaries continue to be infrequent and sparse. This condition undermines efforts to effectively implement and track effective water quality management, or to inform state, local, and public representatives about progress and outcomes.

2. There are 8 other drinking water supplies in the basin and 16 water body assessment units in the basin that are listed as impaired. Consistent and appropriately located water quality monitoring is needed to effectively management water quality in Falls Lake, but also to manage water quality in each of the other drinking water supplies and other impaired waters.
    - Often we are responding to impairments rather than applying preventative actions. However, in order to prevent, we need a set of reliable indicators.

3. Basic questions about water quality in the basin, especially those that involve trend analysis (is water quality getting better or worse?) or the geographic aspects of pollution (upper vs. lower lake portions), are difficult to answer conclusively without additional, consistent, and comparable water quality data.

4. A long-term, consistent, and standardized water quality monitoring program is needed to identify sources of pollution, monitor water quality changes, and gauge the effectiveness of water quality management strategies.

5. How to define the problem. Terms like water quality, impairment, nutrients, and others all have different meanings and connotations to different people.

PURPOSE AND GOALS

1. To complete a data inventory of current monitoring efforts.

2. To determine a set of long-term water quality monitoring objectives.

3. To develop a long-term water quality monitoring plan for water bodies in the Upper Neuse River Basin.

4. To sketch out potential institutional arrangements by which to fund and administer the water quality monitoring program based on the proposed monitoring plan.

5. To develop appropriate QAPP and QACC procedures for applicable components of the monitoring plan in coordination with NCDWQ.
    - Given concerns expressed during the Falls Lake Nutrient Management Strategy Stakeholder Process, it is anticipated that ascertaining and verifying modeled sources of nutrient and sediment pollution will be a primary objective of the plan and the resulting program. Having consistent data will support this objective and will help managers track changes in pollutant loadings and sources as management strategies are introduced.

UPPER NEUSE RIVER BASIN WATER QUALITY MONITORING PLAN

PARTICIPANT ROLES

TJCOG/KTCOG

- Support everyone to do their best thinking
    - Encourage full participation
    - Promote mutual understanding
    - Foster inclusive solutions
    - Cultivate shared responsibility
- Coordinate and facilitate meetings
- Provide meeting summaries
- Coordinate data inventory
- Develop a long-term monitoring plan
- Build buy-in to the greatest extent possible
- Provide a space for fair participation among stakeholders

STAKEHOLDERS

- Fully participate
- Foster mutual understanding
- Build inclusive solutions
- Share responsibility (come to meetings prepared; review meeting materials, represent local entity and relay information accordingly)
- Provide input and guidance
- Provide technical expertise
- Illuminate objectives and interests
- Provide a broad perspective on the problem and potential solutions
- Provide practical knowledge concerning limitation and opportunities
- Attend meetings
- Be respectful of fellow participants
- Voice concerns about the process at meetings

WORKING GROUP

- Translate stakeholder input and guidance into potential monitoring networks
- Prepare suite of monitoring options (parameters, locations, frequencies, etc)
- Research and prepare cost estimates for monitoring options
- Assist TJCOG/KTCOG with data inventory efforts
- Research and prepare options for cost-sharing programs
- Present monitoring and fiscal options to larger group

    - Must be willing to provide staff time and technical support
    - Must be able and willing to attend all Working Group meetings
    - Must be able to commit to approximately 2 hours of staff time every week to:
        - Research and prepare monitoring, cost, and funding options,
        - Work with project staff to write technical memorandums,
        - Develop presentations for large stakeholder group, and
        - Review/Revise technical memorandums based on input from large stakeholder group.

Upper Neuse River Basin Water Quality Monitoring Plan

PROJECT OVERVIEW

Triangle J Council of Governments

Current Situation

- We have lots of water quality questions and data can be infrequent and sparse.
- Many groups are monitoring, but we need better coordination
- Management decisions
  - Difficult to implement and track effective WQ management (what's working and what isn't?)
  - Difficult to inform state, local, and public representatives about progress/outcomes.
    - Financial decisions
- Basic questions about trend or the geographic aspects of pollution are difficult to answer
- Many impairments in the basin. Need to know how to manage for all of them. Often responding to impairments and need a set of reliable indicators.
- How to define the problem.

Project Purpose

To develop a "*long-term water quality monitoring plan for water bodies in the Upper Neuse River Basin*" of course!

Project Tasks

How are we going to achieve this? We are going to:

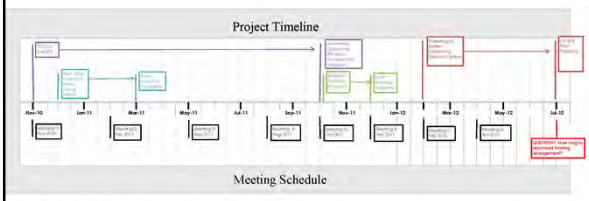
- Complete a data inventory of current monitoring efforts.
- Determine a set of long-term water quality monitoring objectives.
- Develop a long-term monitoring network (set of locations, parameters, methods and frequencies) to meet a variety of monitoring objectives.
- Sketch out potential institutional arrangements to fund and administer the water quality monitoring plan.
- Develop appropriate Quality Assurance and Control procedures for applicable components of the monitoring plan in coordination with NCDWQ.

Project Tasks

205(j) Upper Neuse Monitoring Plan Proposal - DRAFT Project Tasks & Budget
26-Oct-10

Element 1. Project Management and Stakeholder Administration	
1a.	Solicit initial stakeholder and working group participation: set up and maintain contact/information
1b.	Go over project timeline with stakeholder group and build support for the project, refine subtasks
1c.	Develop and maintain project web page to house meeting summaries, technical memoranda, etc
1d.	Coordinate project and tasks among stakeholders, working group, and project staff (phone calls and incidental meetings)
1e.	Manage financial transactions and invoice DWQ quarterly
1f.	Write project final report per 205(j) grant requirements
Element 2. Inventory and evaluate relevant wq monitoring efforts, resources, and information	
2a.	Update inventory of current monitoring efforts (parameters, frequencies, locations) and Mary Cheyron's basic list of monitoring gaps
2b.	Research recommendations for monitoring & data management (literature & program review)
2c.	Develop and administer survey on current monitoring efforts: lessons learned, costs, capacity, service providers, and information needs
2d.	Compile and evaluate monitoring inventory, survey results, literature review, etc. into **draft TECH MEMO 1 (Working Group)**
Element 3. Determine potential monitoring objectives and research potential components of the monitoring program	
3a.	Share **draft TECH MEMO 1** with stakeholder group; solicit feedback, prepare to discuss objectives and program needs
3b.	Brainstorm program objectives and possible phases of monitoring program based on needs with stakeholder group. Organize and prioritize objectives and phases of monitoring with Working Group. Identify opportunities/need for special studies or projects
3c.	Finalize **TECH MEMO 1** to add prioritized program objectives (what we want additional data to tell us) and other feedback
3d.	Determine parameters, locations, and frequencies associated with various high-priority objectives (levels of service/program phases) **(draft TECH MEMO 2) (Working Group)**
3e.	Draft data management, archiving and reporting protocols and data products (e.g., water quality indices)
3f.	Draft QAPP/QA/QC requirements and get input from DWQ (review **TECH MEMO 2**) **(Working Group)**
3g.	Estimate costs associated with different levels of service/phases/high-priority objectives; include feedback on reporting protocols and data management (Task 3e.); include revised QAPP/QA/QC requirements with input from DWQ (Task 3f)
3h.	Present draft Tech Memo 2 to stakeholder group for input. Revise as necessary **(finalize TECH MEMO 2)**
Element 4. Investigate funding mechanisms and institutional frameworks	
4a.	Investigate and compile list of all available funding mechanisms and pro/cons of each **(draft TECH MEMO 3) (Working Group)**; share with stakeholder group
4b.	Discuss objectives, services, and funding mechanisms with stakeholder group; determine appropriate institutional framework (decide whether to create a new partnership, expand existing partnership, etc.)
4c.	Finalize **TECH MEMO 3** to reflect mechanisms determined to be most feasible
4d.	Draft **Sample Partner Agreement** and share with potential program partners via email, revise as necessary
4e.	**Draft RFP** for contractors who would conduct monitoring for the program
Element 5. Develop basinwide monitoring program framework and plan	
5a.	Based on TECH MEMOS 1, 2, and 3, propose final objectives, monitoring approaches (sampling locations, parameters, frequencies), and other program components (oversight, QA/QC requirements, data management and reporting, funding mechanisms) **(draft TECH MEMO 4) (Working Group)**; solicit stakeholder group input via email
5b.	Field verify potential station locations, revise locations as needed (**revise TECH MEMO 4**)
5c.	Present TM 4, obtain stakeholder input, and **revise TECH MEMO 4** with confirmed objectives, phases, and specific parameters, frequencies, and locations to be monitored
5d.	Finalize data management, archiving and reporting requirements, and data products (e.g., water quality indices) **(finalize TECH MEMO 4)**
5e.	Develop recommendations for coordinating with local and other monitoring efforts (volunteer, DWQ, MWW, etc.) **(TECH MEMO 5)**

DRAFT Project Timeline &Meeting Schedule



Meeting Schedule

Meeting 1	Stakeholders	Project overview and process; brainstorm/organize objectives
Meeting 2	Working Group	Refine objectives, review data inventory
Meeting 3	Working Group	Begin work on monitoring options/costs
Meeting 4	Stakeholders	Present refined objectives, results of data inventory, gap analysis, and broad monitoring options/costs
Meeting 5	Working Group	Revise objectives and monitoring objectives based on input from Stakeholders; parameters, frequencies/locations; begin work on funding arrangements
Meeting 6	Stakeholders	Present objectives, potential networks, and funding mechanisms to group
Meeting 7	Working Group	Incorporate feedback and continue to develop plan that incorporates objectives, networks, costs, and funding
Meeting 8	Stakeholders	Present Final Plan
		Working Group will revise as necessary through July 2012

Upper Neuse River Basin Water Quality Monitoring Plan

STAKEHOLDER PROCESS

Triangle J Council of Governments

Stakeholder Process Purpose

"To engage stakeholders with a diverse range of interests in the development of a long-term water quality monitoring plan for the Falls Lake Watershed."

Ground Rules

Participant Roles

TJCOG/KTCOG

- Support everyone to do their best thinking!!
  - Encourage full participation, promote mutual understanding, foster inclusive solutions, and cultivate shared responsibility
- Coordinate and facilitate meetings
- Provide meeting summaries
- Coordinate data inventory
- Develop a long-term monitoring plan
- Build buy-in to the greatest extent possible
- Provide a space for fair participation among stakeholders

Participant Roles

STAKEHOLDERS

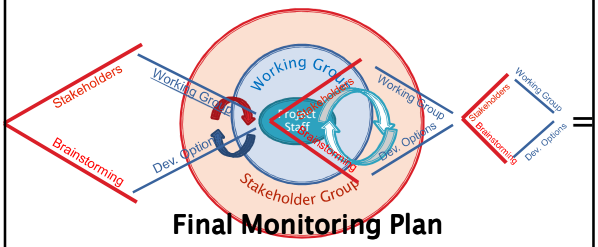
- Fully participate
- Foster mutual understanding and build inclusive solutions
- Share responsibility (come to meetings prepared; review meeting materials, represent local entity and relay information accordingly)
- Provide input, guidance, and technical expertise
- Illuminate objectives and interests
- Provide a broad perspective on the problem and potential solutions
- Provide practical knowledge concerning limitation and opportunities
- Attend meetings
- Be respectful of fellow participants
- Voice concerns about the process at meetings

Participant Roles

WORKING GROUP

- Translate stakeholder input and guidance into potential monitoring networks
- Prepare suite of monitoring options (parameters, locations, frequencies, etc)
- Research and prepare cost estimates for monitoring options
- Assist TJCOG/KTCOG with data inventory efforts
- Research and prepare options for cost-sharing programs
- Present monitoring and fiscal options to larger group
- **Must be willing and able to :**
  - **Provide staff time and technical support**
  - **Attend all Working Group meetings**
  - **Spend approximately 2 hours of staff time every week to:**
    - **Research and prepare monitoring, cost, and funding options,**
    - **Work with project staff to write technical memorandums,**
    - **Develop presentations for large stakeholder group, and**
    - **Review/Revise technical memorandums based on input from large stakeholder group.**

How Will We Work Together?



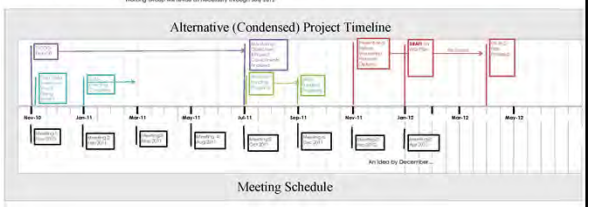
Final Monitoring Plan

Questions on Project or Process?

Reserve Slides

Alt. Condensed Project Timeline &Meeting Schedule

Meeting 1	Stakeholders	Project overview and process; brainstorm/organize objectives
Meeting 2	Working Group	Refine objectives, review data inventory
Meeting 3	Working Group	Begin work on monitoring options/costs
Meeting 4	Stakeholders	Present refined objectives, results of data inventory, gap analysis, and broad monitoring options/costs
Meeting 5	Working Group	Revise objectives and monitoring objectives based on input from Stakeholders; parameters, frequencies/locations; begin work on funding arrangements
Meeting 6	Stakeholders	Present objectives, potential networks, and funding mechanisms to group
Meeting 7	Working Group	Incorporate feedback and continue to develop plan that incorporates objectives, networks, costs, and funding
Meeting 8	Stakeholders	Present Final Plan
		Working Group will revise as necessary through July 2012



AGENDA

UPPER NEUSE RIVER BASIN WATER QUALITY MONITORING PLAN
WORKGIN GROUP MEETING #1

1:30 PM
December 15, 2010

TJCOG
4307 Emperor Boulevard, Suite 110
Durham, NC 27703
Phone: (919) 549-0551

1:30-1:40	Introductions and Announcements	(Heather Saunders)
1:40-2:50	EMC Adoption of Falls Rules • Application to monitoring • Translating rules into objectives • Translating rules into a timeline • Prioritization of Objectives	(Heather Saunders/Group)
2:50-3:50	Lake Monitoring Plans • DWQ Lake Monitoring Plan • Additional monitoring needed? • Who is responsible for monitoring what? • City of Raleigh Monitoring Proposal	(Group)
3:50-4:30	Data Collection and Regulatory Compliance • How do we ensure data collected will be accepted by DWQ?	(Group)
4:30	Adjourn	

Upper Neuse Water Quality Monitoring Plan

Working Group Meeting 1
December 15, 2010
TJCOG Large Conference Room

Introductions and Agenda

Heather Saunders, Triangle J Council of Governments (TJCOG)

- Heather welcomed the group, went over the agenda and ground rules.
- Meeting participants introduced themselves.

Meeting Attendees

Name	Affiliation	Email Address
Britt Stoddard	Wake County, Environmental Services	britt.stoddard@wakegov.com
Chris Roberts	Durham County, Engineering	croberts@co.durham.nc.us
Drew Cummings	Durham County Manager's Office	dcummings@co.durham.nc.us
Heather Saunders	Triangle J Council of Governments	hsaunders@tjcog.org
Ed Buchan	City of Raleigh Public Utilities	Edward.Buchan@raleighnc.gov
Jeff Mahagan	Wastewater Treatment Plant Superintendent	jeff.mahagan@hillsboroughnc.org
Jim Wrenn	Attorney; SGWASA, Butner, Granville County	jcw@hopperhickswrenn.com
Joann Burkholder	NC State Center for Applied Aquatic Ecology	joann_burkholder@ncsu.edu
Kathryn Hobby	Wake County, Environmental Services	kaythryn.hobby@wakegov.com
Kathy Stecker	NC Division of Water Quality	kathy stecker.stecker@ncdenr.gov
Kenny Waldroup	City of Raleigh, Public Utilities	kenneth.waldroup@ci.raleigh.nc.us
Lindsay Mize	South Granville Water & Sewer Authority	lmize@sgwasa.org
Mary Giorgino	US Geological Survey	giorgino@usgs.gov
Melinda Clark	Wake County, Environmental Services	melinda.clark@wakegov.com
Michelle Woolfolk	City of Durham, Stormwater Services	michelle.woolfolk@durhamnc.gov
Mike Dupree	Durham County, SWCD	mdupree@durhamcountync.gov
Mike Schlegel	Triangle J Council of Governments	mschlegel@tjcog.org
Nancy Daly	NC Ecosystem Enhancement Program	nancy.daly@ncdenr.gov
Robert Reed	NC State Center for Applied Aquatic Ecology	robert_reed@ncsu.edu
Sarah Bruce	Upper Neuse River Basin Association	sbruce@tjcog.org
Steve Berkowitz	NC Division of Environmental Health	steven.berkowitz@ncdenr.gov
Tom Davis	Orange County	tdavis@co.orange.nc.us

EMC Adoption of Falls Rules

Heather Saunders, TJCOG

- Heather announced that the Falls Rules had been approved to go into temporary effect on January 15, 2011. She also noted that Rules Review Commission (RRC) would be meeting that week to consider approving the rules for adoption or legislative consideration (contingent on the number of objections received). ***Since the meeting, the rules have been approved by the RRC with no objections and will go into effect as permanent rules on January 15, 2011.***

- Heather asked that the group to discuss how the Falls Lake Rules applied to monitoring and then asked the group to work together to try to translate the **Falls Rules** into ***monitoring*** objectives.

The table below lists the monitoring objectives the group believed to be implicitly required by the rule language.

1.	Determine load concentrations and loads into the lake from the watershed.
2.	Monitoring to perform periodic use-support assessments.
3.	Determine if lake is meeting standards. Where? Progress?

It was difficult to have a focused discussion on the monitoring objectives explicitly stated in the rules without talking about additional objectives. It was noted that the rules themselves open the door for other types of monitoring. Many suggested that these additional monitoring objectives may be better associated with a re-look for Stage II, such as determining sources. However, many in the group believed that determining sources was key to Stage I, as well as Stage II. Because the idea of adaptive management is to use the data collected to more intelligently reduce the loads and concentrations, many argued that awareness about sources and loads would allow local government to fine-tune their efforts sooner rather than later, by figuring out where nutrient loads are coming from. There was some debate over whether this was applicable now or more in a re-look of the strategy for Stage II.

The goal of this agenda item was to determine if DWQ's lake monitoring plan was sufficient to meet the requirements of the rules, so the group tried to come back to that discussion. Participants wanted to know if DWQ thought that their lake monitoring plan was sufficient to meet the monitoring objectives outlined in the rules. Many believed that it would be productive to monitor any additional data that the DWQ perceived as important, but would be unproductive and inefficient to focus on collecting data that the DWQ would not accept.

Heather Saunders asked if it would still be useful to local governments to collect additional data. Participants acknowledged that this was a complex issues, suggesting that there were multiple issues at hand, one being that the rules set out requirements for reductions in loads to the lake, but that others still need to know (and have to pay for) what is happening in the watershed and where the loads are really coming from. Some suggested that the monitoring plan should have two arms; one that focuses on lake monitoring and one that focuses on watershed monitoring.

This led to some discussion about the objectives for the day. Many wanted to start talking about additional (watershed-related) monitoring needs; however the agenda was to determine if the lake monitoring plan was sufficient. Some wanted to know if the group would be able to still discuss other monitoring objectives in the future. In response, Heather Saunders noted that the monitoring plan is a scalable effort. She explained the reason for focusing on the Falls Lake Rules as a starting point, stating that the rules had been passed and so had become a common and critical path for all represented. That is why the agenda was focusing on teasing out those objectives first (Working Group Meeting 1). TJCOG believed that the objectives associated with the rules would most likely be the easiest to tease out, while any discussions on other monitoring objectives would be much more difficult. However, she noted that additional monitoring objectives would be discussed in future working group meetings.

Some participants noted that they believed DWQs monitoring plan was sufficient to meet the rules, but not most of the objectives that were listed during the first stakeholder meeting (see Meeting Summary 1). The issue of determining sources and baseline loading was brought up repeatedly and a question put forward as to whether or not DWQ was really in a position to a play a key role in compliance in the lake. It was noted again that determining baselines in both Stage I and II is important. A discussion evolved from this on what we consider in

terms of compliance. Many thought that simply referring to "uses" in terms of compliance was not sufficient to the participants.

Many noted that they had felt from the beginning that this monitoring effort should not focus on the lake, where an exhaustive list of agencies were already monitoring, but rather should be emphasized on determining sources in the watershed. One participant noted that the agriculture community is considered to be 50% of the problem, so from an agricultural perspective, there needs to be more monitoring upstream and not in the lake. Questions were put forward such as: "How much is going to cost? How much are we willing to pay? What are the parameters? How are we going to define jurisdictional boundaries?"

Some discussion then occurred regarding the Consensus Principles, with many local governments feeling that they needed to work within the constructs of the legislation, and the Consensus Principles. Some participants thought that the regulatory framework had already been determined, and based on such, the focus of reducing nutrients to the lake was about meeting water quality standards. Participants noted that a Nutrient Management Strategy is the state equivalent to a federal Total Maximum Daily Load (TMDL), and so they argued that our first step should be to make sure that the current monitoring meets the requirements of the regulatory framework. Some argued that the next priority would be to figure out what data we need to collect in order to take a "re-look" in the future.

The group agreed to finish the discussion on the sufficiency of the lake monitoring plan so that we could move on to a broader discussion of additional objectives.

Lake Monitoring Plans

DWQ noted that the current lake monitoring plan is continuing the monitoring that was done to build the Falls Lake models. It was also mentioned that DWQ is still doing watershed ambient monitoring and they have measured loads from the upper five watersheds. Their goal is to be able to go back and compare differences.

It was also noted that DWQ will take any data from anybody. DWQ requirements for water quality data, as well as modeling submittal requirements are posted online and people can contact Kathy Stecker with questions. Kathy Stecker suggested that more data is always better and they are happy to look at any additional data that may be submitted.

There was then some discussion about the fact that DWQ's watershed monitoring only focuses on the upper five watersheds, and so may not accurately portray loads to the entire lake.

Throughout the ensuing discussion, the group decided that some immediate monitoring objectives associated with meeting the requirements established through the Falls Lake Rules include:

1.	Adding a station at the Lick Creek cove,
2.	Maintaining current stream gages (based on the concern that DWQ will lose some funding), and
3.	Increasing storm event monitoring on tributaries.

In addition, monitoring issues that still need to be addressed include (not exhaustive):

1.	Total organic carbon
2.	Determining sources
3.	Determining baselines,

4.	Chlorophyll *a* monitoring,
5.	Jurisdictional monitoring, and
6.	Increased lake monitoring (what frequency?/using what method?)

As a result of these objectives, a conversation was started concerning verbiage and defining what we mean by certain terms. It was decided that in order to have a consistent and well-understood conversation about our objectives, we would first need to clearly define the following:

1.	"Re-assess"
2.	"Re-look"
3.	"Re-evaluation"
4.	"Remodel"
5.	"Use-attainability"
6.	"Storm event"

Heather agreed to put these definitions on the wiki so people could start discussing these terms (they are available here).

There was also some discussion about compliance with the rules. Kathy noted that reductions will be based on monitoring of the tributaries. Jeff Mahagan asked what would happen if no reductions were achieved. Someone noted that there is language in the rules that allows for "additional rule-making" if DWQ determines that sufficient reductions have not been made. In reviewing the rules, it appeared that this language had been stricken from the rules. There are some inconsistencies with this and a review of the language is needed to determine consistency.

The group also decided that we would begin to prioritize the additional objectives listed in the first meeting and to work on prioritizing this through discussions on the wiki.

Next Steps

- Heather will send out a meeting summary; if there is a comment or correction, email Heather and she will include it as an Addendum to the meeting summary.
- The working group will have two more meetings (January and February) before meeting with the larger stakeholder group.
- Heather will convene the working group in January and February.
- Heather will set up a wiki for the project and invite Working Group members to join.
    - The wiki will include a section on definitions.
    - The wiki will also include the objectives determined in the first meeting.

AGENDA

UPPER NEUSE RIVER BASIN WATER QUALITY MONITORING PLAN
WORKGIN GROUP MEETING #2
1:30 PM
February 1, 2011

Durham Water Management & Maintenance Facility (directions)
1600 Mist Lake Drive, Durham, NC

Rolling breaks as needed

1:30-1:40 Introductions and Announcements

1:40-1:45 Review of Working Group Meeting 1 & Recommendations

1:45-1:55 Project Process/Timeline
- Review scope/tasks
- What will strive to accomplish at each meeting?
- When should we report back to larger group?

1:55-2:05 Review of Wiki

2:05-3:45 Current Watershed Monitoring Presentations
- Ken Reckhow (RTI)
- Mary Giorginio (USGS)
- Lindsay Mize (SGWASA)
- Ed Buchan (City of Raleigh)
- Melinda Clark/Kathryn Hobby (Wake County)
- Michelle Woolfolk (City of Durham)
- Kathy Stecker (NCDWQ)

3:45-4:20 Discussion on Presentations
- Parking Lot Questions (from presentations)

4:20-4:30 Next Steps
- Information synthesis/Tech Memo 1
- Next meeting
  - Literature review
  - Based on current monitoring, are there obvious data gaps?
  - Based on current monitoring, are there some objectives that already being answered?
  - Which of our objectives are long-term and which are short-term/research related?
- Homework=WIKI

4:30 Adjourn

Upper Neuse Water Quality Monitoring Plan

Working Group Meeting 2
February 1, 2011
Durham Mist Lake Facility

Introductions and Agenda

Heather Saunders, Triangle J Council of Governments (TJCOG)

- Heather welcomed the group and reviewed the agenda.
- Meeting participants introduced themselves.

Meeting Attendees

Name	Affiliation	Email Address
Britt Stoddard	Wake County, Environmental Services	britt.stoddard@wakegov.com
Chris Roberts	Durham County, Engineering	croberts@co.durham.nc.us
Dan McLawhorn	City of Raleigh	Dan.mclawhorn@raleighnc.gov
Drew Cummings	Durham County Manager's Office	dcummings@co.durham.nc.us
Heather Saunders	Triangle J Council of Governments	hsaunders@tjcog.org
Ed Buchan	City of Raleigh Public Utilities	Edward.Buchan@raleighnc.gov
Ibrahim Alameddine	Duke University	Ima4@duke.edu
Jim Wrenn	Attorney; SGWASA, Butner, Granville County	jcw@hopperhickswrenn.com
Kathryn Hobby	Wake County, Environmental Services	kaythryn.hobby@wakegov.com
Kathy Stecker	NC Division of Water Quality	kathy stecker.stecker@ncdenr.gov
Ken Reckhow	RTI	kreckhow@rti.org
Lars Hanson	Triangle J Council of Governments	lhanson@tjcog.org
Lindsay Mize	South Granville Water & Sewer Authority	lmize@sgwasa.org
Marc Reckenwald	NC Ecosystem Enhancement Program	Marc.reckenwald@ncdenr.gov
Mary Giorgino	US Geological Survey	giorgino@usgs.gov
Melinda Clark	Wake County, Environmental Services	melinda.clark@wakegov.com
Michelle Woolfolk	City of Durham, Stormwater Services	michelle.woolfolk@durhamnc.gov
Mike Dupree	Durham County, SWCD	mdupree@durhamcountync.gov
Mike Schlegel	Triangle J Council of Governments	mschlegel@tjcog.org
Reginald Hicks	City of Durham	Reginald.Hicks@durhamnc.gov
Sarah Bruce	Upper Neuse River Basin Association	sbruce@tjcog.org
Steve Berkowitz	NC Division of Environmental Health	steven.berkowitz@ncdenr.gov
Steve Kroeger	NC Division of Water Quality	steve.kroeger@ncdenr.gov
Tom Davis	Orange County	tdavis@co.orange.nc.us

Review of Working Group Meeting #1

Heather reviewed the outcomes of the first working group meeting and presented the immediate monitoring objectives associated with meeting the requirements established through the Falls Lake Rules that the group agreed on which included 1) Adding a station at the Lick Creek cove; 2) Maintaining current stream gages (based on the concern that DWQ will lose some funding); and 3) Increasing storm event monitoring on tributaries.

Heather also reviewed the monitoring issues that the group agreed still need to be addressed including, but not limited to: 1) total organic carbon; 2) determining sources; 3) determining baselines; 4) chlorophyll a monitoring; 5) jurisdictional monitoring; and 6) increased lake monitoring.

Finally, Heather reviewed the terms the group decided were necessary to define in order to have a consistent and well-understood conversation about our objectives (these definitions are available for comment on the wiki) including : 1) re-asses; 2) re-look; 3) re-evaluation; 4) remodel; 5) use-attainability; and 6) storm event.

Review of Meeting Goal and Timeline

Heather pointed out the goal of the meeting which was to "Increase our understanding of what's currently being monitored and why, and lessons learned to better inform our process."

Heather reviewed the project scope and tasks in light of the meeting schedule. Meeting agenda items correspond to tasks in the scope. If agenda items are not able to be wrapped up at a given meeting, they may get pushed back. There will be a break in meetings in July.

Mike asked the group if they wanted to set a standing recurring meeting time or whether the group wants to be polled each time. The group preferred to be polled about the meeting times 2 months in advance. Heather agreed to send out doodle polls for the next several upcoming meetings.

Wiki

The project wiki is essential to developing the plan in a condensed time frame. Heather reviewed the wiki pages and explained the purpose of each. Heather acknowledged that the first step is to sign up on the wiki and to sign up to be notified. It was noted that the only way to see who has made edits to something is to either view the history of the page (shows changes but not who made them) or to use the discussion pages (which does show who says what).

It was suggested that we really need to define the ambiguous terminology before we can move on.

The group participants discussed the need to get more specific about the objectives and it was acknowledged that we will be talking more specifically about objectives in the March 2011 meeting. It was pointed out that the monitoring objectives were a bit scattered and were difficult to answer and that the laundry list of needs and wants should be pared down. One way to do this would be to identify what we already know enough about that we don't need to discuss further. There will be an opportunity in the next meeting to discuss which of these objectives are being met through current monitoring, where there are data gaps, and which objectives are research-related or monitoring-related based on the presentations provided at the current meeting and other data inventorying efforts (i.e. the homework). This will be one way in which we can pare down on our objectives.

Someone stated that we need to filter objectives on the wiki. An idea was put forward to reformulate for each major heading what will be addressed including the following: 1) is it feasible (cost, location); 2) what is the metric you want to measure for a given endpoint; 3) what do people care about and value; and 4) given these values, what information do we have to assess how management affects the values? The group decided to include their top three monitoring objectives on the wiki, and Heather agreed to start discussion pages for the major objective headings. The raw objectives from the brainstorming session are superseded by the questions; therefore, participants were encouraged to review the objectives and work on the questions some more.

Current Monitoring Presentations

Working Group participants were asked to spend between 5 and 12 minutes sharing their current monitoring programs with the rest of the group. Presenters were asked to address the following questions during their talks and also to discuss values as part of their presentations; therefore, we could decide how to frame the wiki after we heard from the presenters. Questions to address included:

1. What are the objectives of your monitoring program (e.g. to meet regulatory compliance, permits, basic knowledge, etc.)
2. How do you use the data (trend analysis, reports, etc.)?
3. Have you had to adapt your programmatic objectives over time? How and why?
4. What monitoring changes have you made as a result?
5. How do you make decisions about your monitoring program (who provides input)?
6. How flexible is your program? Are you authorized to make changes?
7. What changes to your monitoring program are you anticipating in the near future? Cuts, additions, other? Do you have the time/staff/resources to expand it?
8. What have been your greatest lessons learned?

The group from 8 participants on current monitoring efforts including Ken Reckhow of RTI, Mary Giorgino of USGS, Lindsay Mize of SGWASA, Ed Buchan of the City of Raleigh, Kathryn Hobby of Wake County, Michelle Woolfolk of the City of Durham, Reginald Hicks of the City of Durham, and Kathy Stecker of the DWQ. Detailed notes from each presentation are included as an Appendix (A) at the end of this document. Available presentations have also been uploaded with the meeting summary on the wiki.

Next Steps

The group decided to spend last 20 min on wrap-up and get a brief tutorial on how to use the wiki and also how to start a discussion. Help participants ID topics for discussion.

- Ken Reckhow offered to host a workshop on decision making matrices for the group. Ken agreed to provide some materials to help the group decide whether he should do it. Heather will follow up with Ken.
- Finish getting ideas on how to organize wiki / tackle objectives.
    - All discussions are wiki-wide, not particular to a wiki page. Michelle agreed to start some discussions. Heather agreed to create discussion pages for each Outreach topic.

- Someone asked about DWQ cost sharing for monitoring – there is some.
    - DWQ does use USGS monitoring data. Could DWQ monitoring be expanded with more money? Complicated – they need more money to do more work. USGS has better flexibility. State would not be hired to do contract work. Can state lab analyze outside samples? State does accept outside data. Mike asked about costs of state and USGS efforts. USGS has $ avail to match that they are having a hard time to spend because match is required. Make it adaptive, start small.
- Start a discussion for online data (people will upload links to their online data). Heather will create this page.
- Cost information: individual programs add their own to Michelle's discussion (group will respond to Michelle's post).
- New wiki page for folks' objectives: Participants will list their three top objectives and identify an underlying value of why they are important.
    - Identifying the top 3 objectives will help identify areas where there is overlap and limit folks' wish lists
- Next meeting: Review questions generated in the first stakeholder meeting. Identify data gaps, ID objectives already being met through current monitoring.

Adjourn

The group adjourned at 4:30pm.

Appendix A. Detailed notes from monitoring presentations

Ken Reckhow's Presentation (RTI)

- Most monitoring programs are data rich and information poor.
- 305(b) reporting: probability sampling (allows you to infer to the condition of the population). Kathy said this is in place but hasn't been reported on yet. Big improvement on fixed location, which only tells you info about that location.
- 303(d) listing. Need to reduce uncertainty with regard to compliance. Uncertainty is lowest at the extremes for compliance. It's the middle are that requires the most data.
- NPDES permitting –Should we be sampling effluent? Should we be sampling stream downstream of discharge points?
- Location, frequency, data storage, methods & parameters.
- Existing plan and proposed expansion.
- If we have no prior knowledge, put stations equidistant. You can use interpolation to ID where stations would best reduce uncertainty and capture OTHER objectives as well as characterizing spatial variability.
- OBJECTIVES determine DESIGN. Design is a statistical exercise to account for spatial and temporal variations. REDUCE redundancies; account for entropy.
    - Couple flow monitoring with other gaging stations.
    - Use rainfall runoff monitoring with smaller streams.
    - Suggest moving from monthly to biweekly temporal resolution.
    - Storm monitoring might not be useful in meeting monitoring plan goals.
    - *Are we interested more in compliance or modeling?*
- Dealing with small creeks is challenging and expensive. Ken and Ibrahim propose to couple flow monitoring with some additional modeling. Install additional gages at select creeks; use a rainfall run-off model with parameter regionalization using watershed characteristics. Calculate load using models.
- Monitoring frequency: frequency very key for reported results. No clear guidance on sampling frequency. Sampling the extremes won't help much with compliance modeling.
- Should we sample over entire vertical profile? Compliance may not require this but it may be important for modeling.

Questions

- A question was asked about new/expanded monitoring – If objective is to minimize spatial and temporal error in statistical interpolation for modeling, equidistant makes sense. Ken is talking about compliance and how it is determined by state should drive how monitoring is conducted. Characterization of loads to help you determine load reductions is a different design. An optimized monitoring program needs an objective, a cost constraint, and a statistical analysis.
- What do we need to know that we don't know we need to know?
- Another piece of Consensus Principles is whether the state has the right standards for Chl-a. N? P?
- Should we question the existing water quality standard?

Comments

- A comment was made that under the rules, the monitoring information drives the model choice. Group agreed we should flip this: Objectives should drive the model, which should drive data collection.

Mary Giorgino's Presentation (USGS)

- USGS' objective as an agency is to generate data and help public manage waters of the US. USGS is a science agency for DOI (non-regulatory). Tasks are largely accomplished through cooperative water program. USGS provides up to a 50% federal match to generate data and interpretations needed. Use nationally consistent and well documented lab protocols. All reports are peer reviewed and are permanently and openly accessible.
- USGS runs ongoing monitoring networks as well as specific investigations.

- USGS has surface water gages; 4 only collect stage (due to likelihood of a poor record due to a shift channel, low flow, or other conditions) but 12 collect both flow and stage.
- USGS has a WaterAlert that will alert anyone to receive an email or text notifying users if particular flows or stages are reached. This helps USGS greatly with storm event monitoring.
- Uses of flow data: computing loads of various pollutants, develop TMDLs and waste-load allocations, support water supply allocations for DWR, drought monitoring, flood forecasting and response. Flow is absolutely necessary to understand water quality.
- Historic data for 58 sites in the UN Basin, 1954 to 2011. USGS is currently sampling 8 lake sites and 11 stream sites between the two projects conducting monitoring in the Upper Neuse (Treyburn and TAWSMP). (NWQAP sites in Neuse are all below the dam.) Treyburn has been monitored for 23 years.
- Provisional data are available daily from the labs after they've been QA'd.
- USGS processes their own precipitation data, not from the Weather Service.
- TAWSMP and partners. Started in 1988; partners have come and gone, but usually a core group. Steering Committee and Interagency Assistance.
- Map of TAWSMP study area. Includes parts of Jordan Lake watershed, e.g. OWASA reservoirs.
- 8 lake sites. 1 stream site: Eno River, plus high flow sampling of an additional stream sites.
- Changes: SGWASA and Raleigh opting out for FY12. Will reduce the number of lake and stream sites monitored in FY12. ***Question:*** How do you decide which to drop? ***Answer:*** Maintaining consistency over time is paramount. Make changes only for a good reason (e.g. you know your samples are being contaminated somehow). ***Question:*** Are there 4 sites with longitudinal data in lake that will be lost? ***Answer:*** USGS won't continue to monitor these, however, Raleigh or DWQ may be monitoring these sites. Storm event sampling will decline around Lake Holt.
- Heather mentioned that the TAWSMP is meeting in late Feb to discuss changes in the monitoring network.
- Background on Treyburn: how land use influences water quality. This trend analysis will be getting updated.
- Lessons: Things don't ever go quite as you planned. But consistent monitoring helps partners prioritize issues and areas for further study. Distinguish trends from short-term fluctuations. Changes can be detected before they become violations of water quality standards.
- Collaborative monitoring benefits; see slides; Observations
- Needs change over time; Partnership helps; Science and methods evolve.
- Continuous flow data is in 15 min increments, so plan ahead for data management – you can generate a lot. Fortunately assistance is available. Universities, USGS, etc. Mary assured the group that assistance on the monitoring specifics is available once objectives have been defined.
- Data management is an important part of monitoring effort.
- Welcome to call Mary G. to get data.
- Most samples sent to USGS water quality lab in Colorado.
- New report: Contributions of phosphorus for groundwater
- Precip: USGS keeps its own rainfall data for certain purposes. USGS precip data do not always go to state climate office.
- Stream sites 1 + 5 infrequent.
- Raleigh and SGWASA are dropping out. Will see a reduction in lake and stream sites will drop out.
- Nutrients have been a primary objective over time. (Pesticides and PAHs, and cryptosporidium have been at some times, but not a huge focus now).
- Reports available: http://nc.water.usgs.gov/projects/triangle
- Murphy's law in effect…Consistent long-term monitoring helps.
- You can understand changes in WQ without the regulatory structure, when you have monitoring data to look at.

Questions/Comments:

- There was a huge push on the local level to increase monitoring in late 80s – state monitoring declined. 1988 also was state ban on phosphate detergents and required upgrades to WWTPs. Natural variability overwhelms changes and hinders statistical analysis.
- What about trend analysis? State does some trend analysis – parking lot issue. ***Answer:*** Mary is in process of doing another trend analysis, and another scientist is doing a loading analysis.
- Isn't it important to maintain the longer term sites with better records? ***Answer:*** Try not to change monitoring sites without a reason. Best to maintain sites with longer continuous record.
- What about the four sites that have good longitudinal data in the Lake. Will those be maintained? ***Answer:*** No, they won't be under TAWSMP. Raleigh is doing some monitoring, and don't want to duplicate efforts.

Lindsay Mize's Presentation (SGWASA):

- Lindsay handed out a map of monitoring points for SGWASA.
- Point-source discharge monitoring. In permit: 4,275 feet below discharge and 300 feet above discharge. Focus is narrow: compliance with a NPDES permit.
- Sampling and lab work runs about 70k per year. Most of samples are internal quality control samples. SGWASA created in 2005 and took over in 2006. Revamping how WWTP is operated. With increased internal efficiencies, SGWASA is now meeting Stage I limits with current flows. Form of N is changing and trending seasonally.
- SGWASA seeking funding to design plant upgrades.

Questions/Comments:

- Someone asked about how much point-source cares about incoming loads. ***Answer:*** National Pre-Treatment Program deals with incoming constituents. They have to have a sub-permit. Main load is N & P. If an industry needs to come in, they can so long as they meet zero N and P in their discharge. Stage II numbers might mean regulating discharge at the household discharge.
- SGWASA has added hardness sampling up & downstream to deal with new metals standards.
- Someone asked about publication of data. ***Answer:*** DMRs are on file in state. A potential source of information. DWQ maintains a central electronic database (different system from STORET). Concentration only, so by itself won't help determine loads. State is piloting an electronic DMR. Drinking water plants have already gone electronic.

Ed Buchan Presentation (City of Raleigh):

- City's focus is on treatability (specifically TOC). Has lab at WTP. Automated RTRM platforms run by Joann B / NCSU CAAE – new one just added near I-85. Not published for public use.
- Ed showed Joann's proposed network; they may undertake this study on their own. Also ID's location for sub impoundments/creek mouth locations. Don't want to force these sites on this group.
- Raleigh pulled out of TAWSMP in 1995 and they did miss the data, so they are taking steps to ensure that this doesn't happen again (e.g. using same methods)

Questions/Comments:

- Question: Do you reduce frequency rather than cutting stations if cost savings are necessary? ***Answer:*** If they take on monitoring, they are likely to do MORE frequent. For trend, if you go more than monthly, you get redundancy. For other objectives, more frequent monitoring may be a good idea.
- Things are proceeding in parallel right now with this process.
- Cove sites would likely be valuable to all communities for loading, so would be valuable to capture high-flow events.
- Raleigh will be keeping with same methods
- How can we incorporate and/or expand on Raleigh's proposal in this monitoring plan?

Kathryn Hobby Presentation (Wake County Environmental Services):

- County has been reorganized. 11-digit HUCs are assigned to various watershed managers, who oversee a number of aspects of watershed management within that HUC.
- Wake County Watershed Management Plan.
- Falls Lake 319 grant was started in 2007 to address watershed restoration and LT management for habitat and water quality. The county contracted with Dan Line/NC State to sample 7 subwatersheds and 4 tributaries for flow proportionate samples. Stage-discharge relationships were also developed.
- 2/month grab samples until 2008; After 2008, it will be monthly samples.
- Black Horse Run WQ Project: Horses had access to stream formerly so a series of BMPs were introduced. Monitoring up & downstream of this site and plan to continue for another year.
- WQ report card: grades A through F as indices. ID trends, coordinate data collection for future efforts.
- Wake-Johnston LWP: Joint effort with EEP. The idea is to reproduce this effort with different partners over time.
- Recreational water quality sampling program: adopted WMP recs regarding recreational uses and waterborne illnesses.
- Priorities: collect data on streams nearing impaired status or that are already impaired.
- Started a survey of stream cross sections.
- Share data with basinwide planning and use assessment.
- In the process of getting their lab fully certified.
- Wake County plans to continue monitoring the locations they are currently doing even after 319 grant ends.

Michelle Woolfolk's (City of Durham) Presentation:

- Durham Stormwater Services has 3 program components for monitoring:
    - Benthic macroinvertebrate
    - Ambient chemistry
    - Rainfall & Streamflow
    - Plus special studies as needed.

- **Ambient chemistry:** Each station is reviewed annually (calendar year basis) by the entire department and occasionally moved. Other departments sometime have requests. A few stations have a long record. Monitored for an entire year on a monthly basis. Large changes require checking in with officials and citizens. Goals generally get handed down from management.
    - Monitor 50 sites (not sure exactly how many in Neuse generally versus U/S of falls lake)
    - Fund rainfall and streamflow monitoring through chemistry.
    - Have key stations in network that will be kept in perpetuity, but all others are up being moved each year. Depends on what station's monitoring goal is.
    - Once station is in the network, it is monitored monthly for one year.
    - Kept for a year, but reevaluate each year
    - 50 % error bars in some measurements,
    - Reevaluate which stations may need more monitoring to catch high flow events, etc.
    - ***Question:*** Is there a lingering effect of having SSOs by bacteria surviving in sediment?
        - Bacteria attenuation study

- **Special studies:**
    - Current special study to reduce uncertainty of load estimates: 6x a month. A few stations were catching high flows, some weren't, so they re-evaluated and moved some mid-year.
    - Sediment & bacteria study.
    - Bacteria attenuation study to assess lingering effects of sanitary sewer overflows (there is one).
    - Sand filter demo project: ID a system that was extremely failed. Got lots of private partners to revamp their system with a super fancy one. UV and P. tracking system for nutrient removal.

  - Atm dep sites: 1 in Neuse and 1 in Jordan: coming.

- **Lessons learned:**
  - Need trained staff
  - Use a pole to sample thalweg
  - Often they intend to sample a site but have to drop it due to extremely low summer flows
  - S Durham lab does ambient chemistry analysis
  - 40k for contract lab
  - 70 man hrs per mo doing ambient monitoring, not incl special studies
  - Metals studies: samples need to be field-filtered, not lab filtered. Even-odd basin schedule. 50 hrs/mo now (reduced)
  - Fecal readings are used to ID SSOs and hotspots: over 60k/40 CFUs indicates a sewage leak. Lab lets them know the day after sample is received.
  - Altered Goals: If we alter a goal or remove one, have to start moving that decision up the chain to town council level. Sometimes goals get handed down from higher level.
  - Changes depend a lot on new rules, new permits. Durham will do whatever they need to do.

Reggie Hicks (City of Durham) Presentation:

- Durham Water Management: monitoring requirements determined by NPDES permit.
- Reggie listed their monitoring sites and parameters.
- Raw water monitored at Lake Michie and Little River.
- Frequencies dictated in NPDES permit.
- Some seasonality: April through October: downstream 3 and 4 are weekly.
- June – Sep for upstream 1 and 2: 1/week

Kathy Stecker (NCDWQ) Presentation:

- DWQ focuses on fish consumption (tissue) and aquatic life, and less on drinking water use.
- Assessment of use support.
- Compliance means one thing in lake (standard) and another in watershed (load reductions based on calculations in models).
- Program not very flexible.
- Presentation is wrong about groundwater monitoring – there is one site.

Overall Questions and Comments about Presentations:

- It was commented that we need a way for folks to be able to access others' data. Compile links in a single place, especially until we get a single repository.
- Heather articulated the challenge of working with such a complex set of drivers and objectives, and applauded the group for attempting a coordinated framework.

AGENDA

UPPER NEUSE RIVER BASIN WATER QUALITY MONITORING PLAN
WORKGIN GROUP MEETING #3

1:30 PM
March 21, 2011

TJCOG
4307 Emperor Boulevard, Suite 110
Durham, NC 27703
Phone: (919) 549-0551

1:30-1:40	Introductions and Announcements	(Heather Saunders)
1:40-1:50	Project Achievements to Date	(Heather Saunders/Group)
1:50-4:00	Future Project Direction	(Heather Saunders/Group)
	• Recent UNRBA Developments	(Sarah Bruce/Michelle Woolfolk)
	• Review objectives and preliminary framework	
	• Determine project focus and direction	
	• Determine next steps	
4:00	Adjourn	

Upper Neuse Water Quality Monitoring Plan

Working Group Meeting 2
February 1, 2011
Durham Mist Lake Facility

Introductions and Agenda

Heather Saunders, Triangle J Council of Governments (TJCOG)

- Heather welcomed the group and reviewed the agenda.
- Meeting participants introduced themselves.

Meeting Attendees

Name	Affiliation	Email Address
Britt Stoddard	Wake County, Environmental Services	britt.stoddard@wakegov.com
Chris Roberts	Durham County, Engineering	croberts@co.durham.nc.us
Dan McLawhorn	City of Raleigh	Dan.mclawhorn@raleighnc.gov
Drew Cummings	Durham County Manager's Office	dcummings@co.durham.nc.us
Heather Saunders	Triangle J Council of Governments	hsaunders@tjcog.org
Ed Buchan	City of Raleigh Public Utilities	Edward.Buchan@raleighnc.gov
Ibrahim Alameddine	Duke University	Ima4@duke.edu
Jim Wrenn	Attorney; SGWASA, Butner, Granville County	jcw@hopperhickswrenn.com
Kathryn Hobby	Wake County, Environmental Services	kaythryn.hobby@wakegov.com
Kathy Stecker	NC Division of Water Quality	kathy stecker.stecker@ncdenr.gov
Ken Reckhow	RTI	kreckhow@rti.org
Lars Hanson	Triangle J Council of Governments	lhanson@tjcog.org
Lindsay Mize	South Granville Water & Sewer Authority	lmize@sgwasa.org
Marc Reckenwald	NC Ecosystem Enhancement Program	Marc.reckenwald@ncdenr.gov
Mary Giorgino	US Geological Survey	giorgino@usgs.gov
Melinda Clark	Wake County, Environmental Services	melinda.clark@wakegov.com
Michelle Woolfolk	City of Durham, Stormwater Services	michelle.woolfolk@durhamnc.gov
Mike Dupree	Durham County, SWCD	mdupree@durhamcountync.gov
Mike Schlegel	Triangle J Council of Governments	mschlegel@tjcog.org
Reginald Hicks	City of Durham	Reginald.Hicks@durhamnc.gov
Sarah Bruce	Upper Neuse River Basin Association	sbruce@tjcog.org
Steve Berkowitz	NC Division of Environmental Health	steven.berkowitz@ncdenr.gov
Steve Kroeger	NC Division of Water Quality	steve.kroeger@ncdenr.gov
Tom Davis	Orange County	tdavis@co.orange.nc.us

Review of Working Group Meeting #1

Heather reviewed the outcomes of the first working group meeting and presented the immediate monitoring objectives associated with meeting the requirements established through the Falls Lake Rules that the group agreed on which included 1) Adding a station at the Lick Creek cove; 2) Maintaining current stream gages (based on the concern that DWQ will lose some funding); and 3) Increasing storm event monitoring on tributaries.

Heather also reviewed the monitoring issues that the group agreed still need to be addressed including, but not limited to: 1) total organic carbon; 2) determining sources; 3) determining baselines; 4) chlorophyll a monitoring; 5) jurisdictional monitoring; and 6) increased lake monitoring.

Finally, Heather reviewed the terms the group decided were necessary to define in order to have a consistent and well-understood conversation about our objectives (these definitions are available for comment on the wiki) including : 1) re-asses; 2) re-look; 3) re-evaluation; 4) remodel; 5) use-attainability; and 6) storm event.

Review of Meeting Goal and Timeline

Heather pointed out the goal of the meeting which was to "Increase our understanding of what's currently being monitored and why, and lessons learned to better inform our process."

Heather reviewed the project scope and tasks in light of the meeting schedule. Meeting agenda items correspond to tasks in the scope. If agenda items are not able to be wrapped up at a given meeting, they may get pushed back. There will be a break in meetings in July.

Mike asked the group if they wanted to set a standing recurring meeting time or whether the group wants to be polled each time. The group preferred to be polled about the meeting times 2 months in advance. Heather agreed to send out doodle polls for the next several upcoming meetings.

Wiki

The project wiki is essential to developing the plan in a condensed time frame. Heather reviewed the wiki pages and explained the purpose of each. Heather acknowledged that the first step is to sign up on the wiki and to sign up to be notified. It was noted that the only way to see who has made edits to something is to either view the history of the page (shows changes but not who made them) or to use the discussion pages (which does show who says what).

It was suggested that we really need to define the ambiguous terminology before we can move on.

The group participants discussed the need to get more specific about the objectives and it was acknowledged that we will be talking more specifically about objectives in the March 2011 meeting. It was pointed out that the monitoring objectives were a bit scattered and were difficult to answer and that the laundry list of needs and wants should be pared down. One way to do this would be to identify what we already know enough about that we don't need to discuss further. There will be an opportunity in the next meeting to discuss which of these objectives are being met through current monitoring, where there are data gaps, and which objectives are research-related or monitoring-related based on the presentations provided at the current meeting and other data inventorying efforts (i.e. the homework). This will be one way in which we can pare down on our objectives.

Someone stated that we need to filter objectives on the wiki. An idea was put forward to reformulate for each major heading what will be addressed including the following: 1) is it feasible (cost, location); 2) what is the metric you want to measure for a given endpoint; 3) what do people care about and value; and 4) given these values, what information do we have to assess how management affects the values? The group decided to include their top three monitoring objectives on the wiki, and Heather agreed to start discussion pages for the major objective headings. The raw objectives from the brainstorming session are superseded by the questions; therefore, participants were encouraged to review the objectives and work on the questions some more.

Current Monitoring Presentations

Working Group participants were asked to spend between 5 and 12 minutes sharing their current monitoring programs with the rest of the group. Presenters were asked to address the following questions during their talks and also to discuss values as part of their presentations; therefore, we could decide how to frame the wiki after we heard from the presenters. Questions to address included:

1. What are the objectives of your monitoring program (e.g. to meet regulatory compliance, permits, basic knowledge, etc.)
2. How do you use the data (trend analysis, reports, etc.)?
3. Have you had to adapt your programmatic objectives over time? How and why?
4. What monitoring changes have you made as a result?
5. How do you make decisions about your monitoring program (who provides input)?
6. How flexible is your program? Are you authorized to make changes?
7. What changes to your monitoring program are you anticipating in the near future? Cuts, additions, other? Do you have the time/staff/resources to expand it?
8. What have been your greatest lessons learned?

The group from 8 participants on current monitoring efforts including Ken Reckhow of RTI, Mary Giorgino of USGS, Lindsay Mize of SGWASA, Ed Buchan of the City of Raleigh, Kathryn Hobby of Wake County, Michelle Woolfolk of the City of Durham, Reginald Hicks of the City of Durham, and Kathy Stecker of the DWQ. Detailed notes from each presentation are included as an Appendix (A) at the end of this document. Available presentations have also been uploaded with the meeting summary on the wiki.

Next Steps

The group decided to spend last 20 min on wrap-up and get a brief tutorial on how to use the wiki and also how to start a discussion. Help participants ID topics for discussion.

- Ken Reckhow offered to host a workshop on decision making matrices for the group. Ken agreed to provide some materials to help the group decide whether he should do it. Heather will follow up with Ken.
- Finish getting ideas on how to organize wiki / tackle objectives.
    - All discussions are wiki-wide, not particular to a wiki page. Michelle agreed to start some discussions. Heather agreed to create discussion pages for each Outreach topic.

- Someone asked about DWQ cost sharing for monitoring – there is some.
    - DWQ does use USGS monitoring data. Could DWQ monitoring be expanded with more money? Complicated – they need more money to do more work. USGS has better flexibility. State would not be hired to do contract work. Can state lab analyze outside samples? State does accept outside data. Mike asked about costs of state and USGS efforts. USGS has $ avail to match that they are having a hard time to spend because match is required. Make it adaptive, start small.
- Start a discussion for online data (people will upload links to their online data). Heather will create this page.
- Cost information: individual programs add their own to Michelle's discussion (group will respond to Michelle's post).
- New wiki page for folks' objectives: Participants will list their three top objectives and identify an underlying value of why they are important.
    - Identifying the top 3 objectives will help identify areas where there is overlap and limit folks' wish lists
- Next meeting: Review questions generated in the first stakeholder meeting. Identify data gaps, ID objectives already being met through current monitoring.

Adjourn

The group adjourned at 4:30pm.

Appendix A. Detailed notes from monitoring presentations

Ken Reckhow's Presentation (RTI)

- Most monitoring programs are data rich and information poor.
- 305(b) reporting: probability sampling (allows you to infer to the condition of the population). Kathy said this is in place but hasn't been reported on yet. Big improvement on fixed location, which only tells you info about that location.
- 303(d) listing. Need to reduce uncertainty with regard to compliance. Uncertainty is lowest at the extremes for compliance. It's the middle are that requires the most data.
- NPDES permitting –Should we be sampling effluent? Should we be sampling stream downstream of discharge points?
- Location, frequency, data storage, methods & parameters.
- Existing plan and proposed expansion.
- If we have no prior knowledge, put stations equidistant. You can use interpolation to ID where stations would best reduce uncertainty and capture OTHER objectives as well as characterizing spatial variability.
- OBJECTIVES determine DESIGN. Design is a statistical exercise to account for spatial and temporal variations. REDUCE redundancies; account for entropy.
    - Couple flow monitoring with other gaging stations.
    - Use rainfall runoff monitoring with smaller streams.
    - Suggest moving from monthly to biweekly temporal resolution.
    - Storm monitoring might not be useful in meeting monitoring plan goals.
    - *Are we interested more in compliance or modeling?*
- Dealing with small creeks is challenging and expensive. Ken and Ibrahim propose to couple flow monitoring with some additional modeling. Install additional gages at select creeks; use a rainfall run-off model with parameter regionalization using watershed characteristics. Calculate load using models.
- Monitoring frequency: frequency very key for reported results. No clear guidance on sampling frequency. Sampling the extremes won't help much with compliance modeling.
- Should we sample over entire vertical profile? Compliance may not require this but it may be important for modeling.

Questions

- A question was asked about new/expanded monitoring – If objective is to minimize spatial and temporal error in statistical interpolation for modeling, equidistant makes sense. Ken is talking about compliance and how it is determined by state should drive how monitoring is conducted. Characterization of loads to help you determine load reductions is a different design. An optimized monitoring program needs an objective, a cost constraint, and a statistical analysis.
- What do we need to know that we don't know we need to know?
- Another piece of Consensus Principles is whether the state has the right standards for Chl-a. N? P?
- Should we question the existing water quality standard?

Comments

- A comment was made that under the rules, the monitoring information drives the model choice. Group agreed we should flip this: Objectives should drive the model, which should drive data collection.

Mary Giorgino's Presentation (USGS)

- USGS' objective as an agency is to generate data and help public manage waters of the US. USGS is a science agency for DOI (non-regulatory). Tasks are largely accomplished through cooperative water program. USGS provides up to a 50% federal match to generate data and interpretations needed. Use nationally consistent and well documented lab protocols. All reports are peer reviewed and are permanently and openly accessible.
- USGS runs ongoing monitoring networks as well as specific investigations.

- USGS has surface water gages; 4 only collect stage (due to likelihood of a poor record due to a shift channel, low flow, or other conditions) but 12 collect both flow and stage.
- USGS has a WaterAlert that will alert anyone to receive an email or text notifying users if particular flows or stages are reached. This helps USGS greatly with storm event monitoring.
- Uses of flow data: computing loads of various pollutants, develop TMDLs and waste-load allocations, support water supply allocations for DWR, drought monitoring, flood forecasting and response. Flow is absolutely necessary to understand water quality.
- Historic data for 58 sites in the UN Basin, 1954 to 2011. USGS is currently sampling 8 lake sites and 11 stream sites between the two projects conducting monitoring in the Upper Neuse (Treyburn and TAWSMP). (NWQAP sites in Neuse are all below the dam.) Treyburn has been monitored for 23 years.
- Provisional data are available daily from the labs after they've been QA'd.
- USGS processes their own precipitation data, not from the Weather Service.
- TAWSMP and partners. Started in 1988; partners have come and gone, but usually a core group. Steering Committee and Interagency Assistance.
- Map of TAWSMP study area. Includes parts of Jordan Lake watershed, e.g. OWASA reservoirs.
- 8 lake sites. 1 stream site: Eno River, plus high flow sampling of an additional stream sites.
- Changes: SGWASA and Raleigh opting out for FY12. Will reduce the number of lake and stream sites monitored in FY12. ***Question:*** How do you decide which to drop? ***Answer:*** Maintaining consistency over time is paramount. Make changes only for a good reason (e.g. you know your samples are being contaminated somehow). ***Question:*** Are there 4 sites with longitudinal data in lake that will be lost? ***Answer:*** USGS won't continue to monitor these, however, Raleigh or DWQ may be monitoring these sites. Storm event sampling will decline around Lake Holt.
- Heather mentioned that the TAWSMP is meeting in late Feb to discuss changes in the monitoring network.
- Background on Treyburn: how land use influences water quality. This trend analysis will be getting updated.
- Lessons: Things don't ever go quite as you planned. But consistent monitoring helps partners prioritize issues and areas for further study. Distinguish trends from short-term fluctuations. Changes can be detected before they become violations of water quality standards.
- Collaborative monitoring benefits; see slides; Observations
- Needs change over time; Partnership helps; Science and methods evolve.
- Continuous flow data is in 15 min increments, so plan ahead for data management – you can generate a lot. Fortunately assistance is available. Universities, USGS, etc. Mary assured the group that assistance on the monitoring specifics is available once objectives have been defined.
- Data management is an important part of monitoring effort.
- Welcome to call Mary G. to get data.
- Most samples sent to USGS water quality lab in Colorado.
- New report: Contributions of phosphorus for groundwater
- Precip: USGS keeps its own rainfall data for certain purposes. USGS precip data do not always go to state climate office.
- Stream sites 1 + 5 infrequent.
- Raleigh and SGWASA are dropping out. Will see a reduction in lake and stream sites will drop out.
- Nutrients have been a primary objective over time. (Pesticides and PAHs, and cryptosporidium have been at some times, but not a huge focus now).
- Reports available: http://nc.water.usgs.gov/projects/triangle
- Murphy's law in effect…Consistent long-term monitoring helps.
- You can understand changes in WQ without the regulatory structure, when you have monitoring data to look at.

Questions/Comments:

- There was a huge push on the local level to increase monitoring in late 80s – state monitoring declined. 1988 also was state ban on phosphate detergents and required upgrades to WWTPs. Natural variability overwhelms changes and hinders statistical analysis.
- What about trend analysis? State does some trend analysis – parking lot issue. ***Answer:*** Mary is in process of doing another trend analysis, and another scientist is doing a loading analysis.
- Isn't it important to maintain the longer term sites with better records? ***Answer:*** Try not to change monitoring sites without a reason. Best to maintain sites with longer continuous record.
- What about the four sites that have good longitudinal data in the Lake. Will those be maintained? ***Answer:*** No, they won't be under TAWSMP. Raleigh is doing some monitoring, and don't want to duplicate efforts.

Lindsay Mize's Presentation (SGWASA):

- Lindsay handed out a map of monitoring points for SGWASA.
- Point-source discharge monitoring. In permit: 4,275 feet below discharge and 300 feet above discharge. Focus is narrow: compliance with a NPDES permit.
- Sampling and lab work runs about 70k per year. Most of samples are internal quality control samples. SGWASA created in 2005 and took over in 2006. Revamping how WWTP is operated. With increased internal efficiencies, SGWASA is now meeting Stage I limits with current flows. Form of N is changing and trending seasonally.
- SGWASA seeking funding to design plant upgrades.

Questions/Comments:

- Someone asked about how much point-source cares about incoming loads. ***Answer:*** National Pre-Treatment Program deals with incoming constituents. They have to have a sub-permit. Main load is N & P. If an industry needs to come in, they can so long as they meet zero N and P in their discharge. Stage II numbers might mean regulating discharge at the household discharge.
- SGWASA has added hardness sampling up & downstream to deal with new metals standards.
- Someone asked about publication of data. ***Answer:*** DMRs are on file in state. A potential source of information. DWQ maintains a central electronic database (different system from STORET). Concentration only, so by itself won't help determine loads. State is piloting an electronic DMR. Drinking water plants have already gone electronic.

Ed Buchan Presentation (City of Raleigh):

- City's focus is on treatability (specifically TOC). Has lab at WTP. Automated RTRM platforms run by Joann B / NCSU CAAE – new one just added near I-85. Not published for public use.
- Ed showed Joann's proposed network; they may undertake this study on their own. Also ID's location for sub impoundments/creek mouth locations. Don't want to force these sites on this group.
- Raleigh pulled out of TAWSMP in 1995 and they did miss the data, so they are taking steps to ensure that this doesn't happen again (e.g. using same methods)

Questions/Comments:

- Question: Do you reduce frequency rather than cutting stations if cost savings are necessary? ***Answer:*** If they take on monitoring, they are likely to do MORE frequent. For trend, if you go more than monthly, you get redundancy. For other objectives, more frequent monitoring may be a good idea.
- Things are proceeding in parallel right now with this process.
- Cove sites would likely be valuable to all communities for loading, so would be valuable to capture high-flow events.
- Raleigh will be keeping with same methods
- How can we incorporate and/or expand on Raleigh's proposal in this monitoring plan?

Kathryn Hobby Presentation (Wake County Environmental Services):

- County has been reorganized. 11-digit HUCs are assigned to various watershed managers, who oversee a number of aspects of watershed management within that HUC.
- Wake County Watershed Management Plan.
- Falls Lake 319 grant was started in 2007 to address watershed restoration and LT management for habitat and water quality. The county contracted with Dan Line/NC State to sample 7 subwatersheds and 4 tributaries for flow proportionate samples. Stage-discharge relationships were also developed.
- 2/month grab samples until 2008; After 2008, it will be monthly samples.
- Black Horse Run WQ Project: Horses had access to stream formerly so a series of BMPs were introduced. Monitoring up & downstream of this site and plan to continue for another year.
- WQ report card: grades A through F as indices. ID trends, coordinate data collection for future efforts.
- Wake-Johnston LWP: Joint effort with EEP. The idea is to reproduce this effort with different partners over time.
- Recreational water quality sampling program: adopted WMP recs regarding recreational uses and waterborne illnesses.
- Priorities: collect data on streams nearing impaired status or that are already impaired.
- Started a survey of stream cross sections.
- Share data with basinwide planning and use assessment.
- In the process of getting their lab fully certified.
- Wake County plans to continue monitoring the locations they are currently doing even after 319 grant ends.

Michelle Woolfolk's (City of Durham) Presentation:

- Durham Stormwater Services has 3 program components for monitoring:
    - Benthic macroinvertebrate
    - Ambient chemistry
    - Rainfall & Streamflow
    - Plus special studies as needed.

- **Ambient chemistry:** Each station is reviewed annually (calendar year basis) by the entire department and occasionally moved. Other departments sometime have requests. A few stations have a long record. Monitored for an entire year on a monthly basis. Large changes require checking in with officials and citizens. Goals generally get handed down from management.
    - Monitor 50 sites (not sure exactly how many in Neuse generally versus U/S of falls lake)
    - Fund rainfall and streamflow monitoring through chemistry.
    - Have key stations in network that will be kept in perpetuity, but all others are up being moved each year. Depends on what station's monitoring goal is.
    - Once station is in the network, it is monitored monthly for one year.
    - Kept for a year, but reevaluate each year
    - 50 % error bars in some measurements,
    - Reevaluate which stations may need more monitoring to catch high flow events, etc.
    - ***Question:*** Is there a lingering effect of having SSOs by bacteria surviving in sediment?
        - Bacteria attenuation study

- **Special studies:**
    - Current special study to reduce uncertainty of load estimates: 6x a month. A few stations were catching high flows, some weren't, so they re-evaluated and moved some mid-year.
    - Sediment & bacteria study.
    - Bacteria attenuation study to assess lingering effects of sanitary sewer overflows (there is one).
    - Sand filter demo project: ID a system that was extremely failed. Got lots of private partners to revamp their system with a super fancy one. UV and P. tracking system for nutrient removal.

  - Atm dep sites: 1 in Neuse and 1 in Jordan: coming.

- **Lessons learned:**
  - Need trained staff
  - Use a pole to sample thalweg
  - Often they intend to sample a site but have to drop it due to extremely low summer flows
  - S Durham lab does ambient chemistry analysis
  - 40k for contract lab
  - 70 man hrs per mo doing ambient monitoring, not incl special studies
  - Metals studies: samples need to be field-filtered, not lab filtered. Even-odd basin schedule. 50 hrs/mo now (reduced)
  - Fecal readings are used to ID SSOs and hotspots: over 60k/40 CFUs indicates a sewage leak. Lab lets them know the day after sample is received.
  - Altered Goals: If we alter a goal or remove one, have to start moving that decision up the chain to town council level. Sometimes goals get handed down from higher level.
  - Changes depend a lot on new rules, new permits. Durham will do whatever they need to do.

Reggie Hicks (City of Durham) Presentation:

- Durham Water Management: monitoring requirements determined by NPDES permit.
- Reggie listed their monitoring sites and parameters.
- Raw water monitored at Lake Michie and Little River.
- Frequencies dictated in NPDES permit.
- Some seasonality: April through October: downstream 3 and 4 are weekly.
- June – Sep for upstream 1 and 2: 1/week

Kathy Stecker (NCDWQ) Presentation:

- DWQ focuses on fish consumption (tissue) and aquatic life, and less on drinking water use.
- Assessment of use support.
- Compliance means one thing in lake (standard) and another in watershed (load reductions based on calculations in models).
- Program not very flexible.
- Presentation is wrong about groundwater monitoring – there is one site.

Overall Questions and Comments about Presentations:

- It was commented that we need a way for folks to be able to access others' data. Compile links in a single place, especially until we get a single repository.
- Heather articulated the challenge of working with such a complex set of drivers and objectives, and applauded the group for attempting a coordinated framework.

AGENDA

UPPER NEUSE RIVER BASIN WATER QUALITY MONITORING PLAN
STAKEHOLDER MEETING 2

1:30 PM
September 27, 2011

Durham Water Management & Maintenance Facility
1600 Mist Lake Drive
Durham, NC 27704
Phone: (919) 560-4381

1:30-1:45	Introductions	(Heather Benson)
1:45-2:05	Project Review • Working group meetings • What's been happening?	(Heather Benson)
2:05-2:20	UNRBA RFP Process Update	(Michelle Woolfolk/Sarah Bruce)
2:20-2:35	Agricultural Oversight Committee Update	(John Huisman)
2:35-2:50	Nutrient Scientific Advisory Board Update	(John Huisman)
2:50-3:00	Break	
3:00-3:30	Going Forward • Our Goal • Subcommittees and structures • "Monitoring Design Guidelines" • Timeline	(Heather Benson)
3:30-4:15	Choose Committees • Self-select chair • Meeting schedule and location (if applicable) • Review draft template and discuss • Review recommended 1st meeting agenda	(Groups)
4:30	Adjourn	

Upper Neuse Water Quality Monitoring Plan

Full Stakeholder Meeting #2

September 27, 2011

Durham Mist Lake Facility

Introductions, Overview, and Housekeeping

Heather Saunders Benson, Triangle J Council of Governments (TJCOG). Heather welcomed the group, described the format of the meeting, and went over the agenda:

1. Project Review
2. UNRBA RFP Process Update
3. Agricultural Oversight Committee Update
4. Nutrient Scientific Advisory Board Update
5. Going Forward
6. Choose Committees

Meeting Attendees

Name	Affiliation	Email Address
Andrea Thomas	NCDWQ, Ambient Monitoring Coordinator	andrea.thomas@ncdenr.gov
Barbara Osland	NC Horse Council	boslund@solution-ies.com
Barry Baker	Granville County, Planning	barry.baker@granvillecounty.org
Don Greeley	City of Durham	Don.greeley@durhamnc.gov
Drew Cummings**	Durham County Manager's Office	dcummings@co.durham.nc.us
Heather Saunders**	Triangle J Council of Governments	hsaunders@tjcog.org
Jason Greene	NCDWQ Intensive Survey Unit Coordinator	jason.green@ncdenr.gov
Jessica Kemp	NC Ecosystem Enhancement Program	jessica.kemp@ncdenr.gov
John Huisman	NC Division of Water Quality	John.huisman@ncdenr.gov
Kathryn Hobby	Wake County, Environmental Services	kaythryn.hobby@wakegov.com
Kathy Stecker	NC Division of Water Quality	kathy stecker.stecker@ncdenr.gov
Lars Hanson	Triangle J Council of Governments	lhanson@tjcog.org
Kurt Smith	Wake County	kwsmith@wakegov.com
Mark Senior	City of Raleigh, Stormwater Services	mark.senior@raleighnc.gov
Mary Giorgino	US Geological Survey	giorgino@usgs.gov
Maverick Raber	City of Durham	Maverick.raber@durhamnc.gov
Melissa Hodges	Town of Butner, Planning	mhodges@butnernc.org
Michelle Woolfolk	City of Durham, Stormwater Services	michelle.woolfolk@durhamnc.gov
Mike Dupree	Durham County, SWCD	mdupree@durhamcountync.gov
Mike Schlegel	Triangle J Council of Governments	mschlegel@tjcog.org
Nancy Daly	NC Ecosystem Enhancement Program	nancy.daly@ncdenr.gov
Natalee Landry	NC Division of Water Quality	Natalee.landry@ncdenr.gov
Reggie Hicks	City of Durham, Water Management	reginald.hicks@durhamnc.gov
Sarah Bruce	Upper Neuse River Basin Association	sbruce@tjcog.org
Shari Bryant	NC Wildlife Resources Commission	Shari.bryant@ncwildlife.org
Tom Davis	Orange County	tdavis@co.orange.nc.us

1. Project Review

Participants introduced themselves and Heather reminded the group of the participation ground rules. The purpose of this meeting was to discuss what's been done relating to the project, provide updates on what is happening now, and discuss next steps.

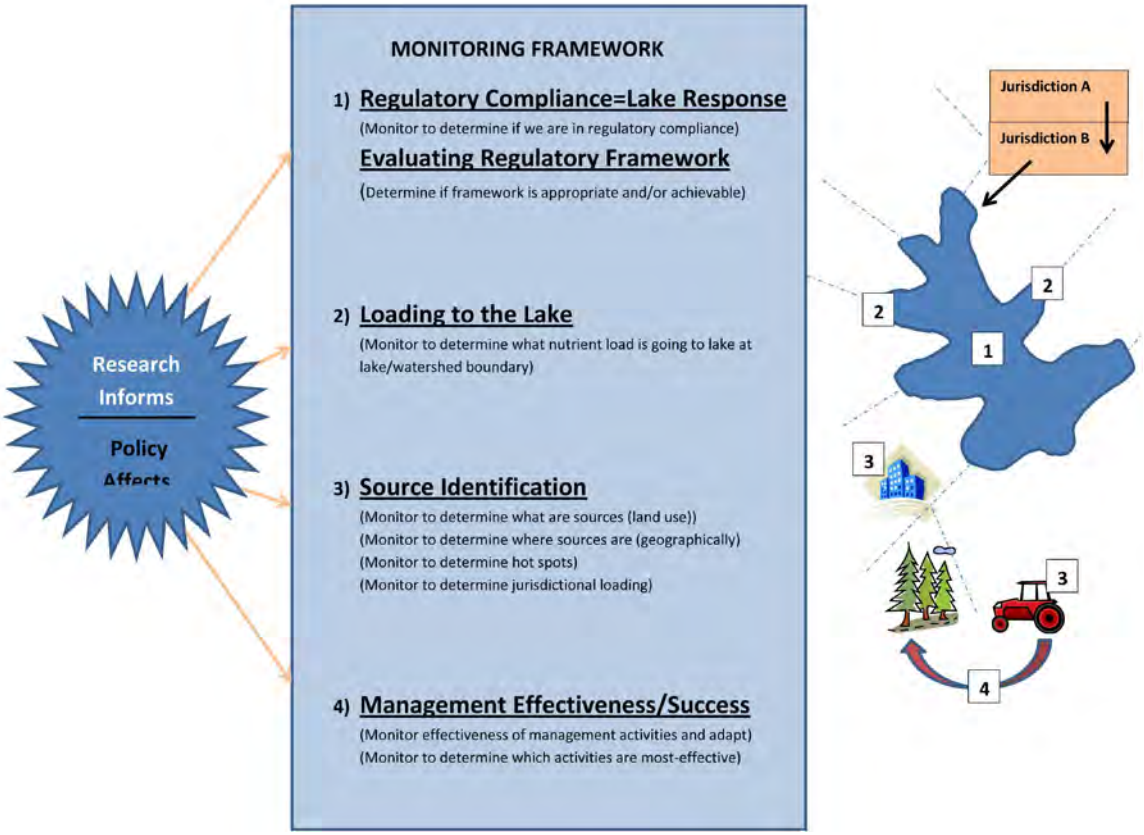
Heather indicated that interim funding was provided by the City of Durham, Upper Neuse River Basin Association, and TJCOG. Now that the grant has begun, the 205(j) program is the source of funding for this project.

Heather noted that objectives were brainstormed at the first major stakeholder meeting in November 2010 and a wiki has been developed to facilitate collaboration between meetings. The wiki includes pages for concepts to be fleshed out collaboratively. Also, all project documents such as handouts, presentations, and meeting summaries are available on the wiki. Users can subscribe to changes to specific pages or the entire wiki.

The project Working Group has met three times since November 2010. The first Working Group meeting focused on lake monitoring. At the first meeting, the working group reviewed the DWQ monitoring plan and made a few suggestions (maintain gages, add station at Lick Creek, and increase storm event monitoring).

The focus of the second Working Group meeting was past and current monitoring efforts. At the second WG meeting, presentations were given on various existing monitoring efforts from USGS, local municipalities, and RTI.

The focus of the third Working Group meeting was monitoring frameworks. At the third Working Group meeting, the group decided to split up the objectives based on their purpose (See handout on Water Quality Monitoring Framework with categories for objectives based on scale of monitoring effort.) The project has been adapted to focus on source identification (3) and evaluating management effectiveness (4) (see below).



2. UNRBA Update (Michelle Woolfolk and Sarah Bruce)

Michelle Woolfolk of the City of Durham and Sarah Bruce of the Upper Neuse River Basin Association (UNRBA) provided an update of UNRBA activities. Because the Falls Lake Nutrient Management Strategy (NMS) rules have a specific timeline for gathering data sufficient to remodel the watershed and/or the lake response, the UNRBA is moving forward quickly to lay the groundwork for future data collection efforts to examine Falls Lake and loads to it.

Called the Path Forward project, this effort will also examine the nutrient targets in Rule and the regulatory framework applied to Falls Lake. An RFP was issued in July and contractor selected by the UNRBA Board of Directors on September 19. The RFP describes 4 main tasks for the project: 1) develop a framework for the reexamination; 2) review existing data and reports to summarize existing knowledge and identify gaps; 3) review methods for calculating existing and delivered jurisdictional loads in light of Stage I and Stage II reduction needs; and 4) recommend a framework for future monitoring and modeling to examine Falls Lake uses and water quality.

Sarah articulated that there were valid questions about sources and management of nutrients would not be addressed under the UNRBA Path Forward project, and that the UNRBA project was focused on Falls Lake loads per se. The group discussed the instances of overlapping monitoring objectives, and participants expressed a desire to coordinate the efforts such that studies and other activities related to Categories 3 and 4 be conducted in such a way as to inform Categories 1 and 2 (also, UNRBA's Path Forward project may or may not do the actual calculations for jurisdictional loads). Kathy Stecker pointed out that no single effort would achieve all monitoring objectives, further underscoring the importance of coordinating efforts.

3. John Huisman Update on Nutrient Scientific Advisory Board

John Huisman gave a handout on and described the Nutrient Scientific Advisory Board (NSAB). Essentially, the NSAB is tasked with coming up with jurisdictional loading and nutrient accounting methodologies for developed lands (excluding agriculture and forestry). The NSAB is working on an updated watershed model for Jordan Lake to inform jurisdictional loads. An update could involve adding other data that existed during the baseline period (also the case in Falls Lake). The bigger tie-in with Falls Lake is with the efforts toward accounting and crediting methodologies. Additional monitoring (e.g. to meet the management effectiveness objectives) could certainly inform these. Some jurisdictions are able to do calculations for Stage I whereas others (e.g. those not subject to Neuse stormwater rules) are less well prepared to do this work. Methodologies may differ between Stage I and Stage II. The URL for the NSAB is http://portal.ncdenr.org/web/wq/nutrient-scientific-advisory-board. DWQ is required to work with the local governments to develop the load calculations as well as credits for load-reducing activities. John added that the table of creditable activities included both activities for which adequate data exist to inform accounting and activities that are insufficiently informed by data. This project could feed into the scientific basis for establishing credits for these latter activities or to help inform the appropriateness of extending traditional practices into new situations, and possibly improve the accounting tool over time. A participant asked about revising based on data which is tricky because it's hard to separate out sources. Compliance for individual entities will be based on the accounting tool, but compliance with the strategy as a whole is based on monitoring.

4. John Huisman update on Watershed Oversight Committee

There purpose of the Watershed Oversight Committee (WOC) is to assist with implementing the agriculture rule for the Falls and Jordan NMSs; with similar responsibilities for each but different issues and timelines. John gave a handout describing membership and representation for this group also. The WOC is charged with guiding the implementation of the agricultural rule and working with the farming community on implementation. In addition, the WOC is tasked with developing nutrient accounting methodologies for agriculture. The Neuse and Tar-Pam Basins had similar entities and a Nitrogen accounting tool has been maintained (Nitrogen Loss Evaluation

Worksheet (generates edge-of-field loading). Phosphorous remains the biggest question. For both baseline figures and crediting, it behaves very differently in the environment than N. Local Advisory Committees work at the level of each county; coincident with the levels at which agriculture is regulated under the rule. The second major responsibility of the WOC is to provide annual reporting to the EMC. The third WOC responsibility is to determine trading: methodologies for allowable trades and propose them to DWQ, develop credit and accounting (requires knowledge of fate and transport; edge-of-field is insufficient), figure out how to use the monitoring data, and develop a P accounting tool.

Michelle Woolfolk asked about the NSAB's work on jurisdictional loading and modifying the model and whether or not they intend to include agriculture. John indicated that it has come up but so far the dots have not been connected.

A comparable tool for agriculture is being developed similar to the New Development (New D) tool. A question was raised as to whether or not the two tool processes were working and/or collaborating together. John answered that DWQ has been involved in both, but that there is some separation between tools. Agricultural accounting gets dinged in reporting because there is less data to back it up in general. They are both maintained and DWQ does try to maintain some consistency between the two, but this is getting more complicated. The agriculture tool uses different components to come up with credit (e.g. application and land use change are factors). Also the New D tool is now based on effluent concentrations and not removal efficiencies. The Jordan and Falls tool includes pre-development conditions as well as post-development. Numbers are being generated in the Jordan/Falls tool based on lit values and should be similar to agriculture numbers. John agreed a closer look is needed, and the New D tool needs to be updated anyway.

As an aside, in the Falls Lake Watershed, farmers don't have to meet nutrient reduction goals before they can sell credits (as they must do in Jordan). Each individual farmer can make this call.

5. Project Going Forward (Heather)

Heather explained to the group that the purpose of the project going forward would be to develop a suite of Monitoring Design Guidelines or monitoring design studies that will aim to inform source identification and management effectiveness. In addition, this project will aim to coordinate with other parallel efforts that are complimentary and informative.

The finished Monitoring Design Guidelines are meant to serve as potential mini-grants that partners can implement where applicable and when need and funding is available. In order to develop the Monitoring Design Guidelines, the stakeholder will work through focused sub-committees. The subcommittee topics include:

- Agriculture;
- Onsite Wastewater;
- Background Sources (air deposition, forests, lake sediment);
- Stormwater and Existing Development; and
- BMP Effectiveness

A potential template for the Monitoring Design Guidelines was presented and is included below. Subcommittees will meet once a month through July 2012 to complete the guidelines, and the project is expected to be finalized in September 2012. This will give the stakeholders two months to review, edit, and finalize the grant products.

Determining Nutrient Inputs for "On-Site Wastewater Systems"

MONITORING DESIGN GUIDELINES FOR DETERMINING NUTRIENT INPUTS FROM ON-SITE WASTEWATER TREATMENT

BACKGROUND & PROBLEM STATEMENT

This section describes the water quality problem associated with this topic, and how monitoring can be used to improve our understanding of the topic as it relates to water quality. Furthermore, this section will include a specific problem statement and a discussion on the regulatory context. This section also includes a discussion about how to define and reduce uncertainty related to this topic.

Background

Problem Statement

Regulatory Context

Issue around Uncertainty

NUTRIENT MARKERS & SOURCES

This section includes a discussion related to identifying the nutrient sources (of on-site wastewater in this case) as distinct and differentiated from other sources (e.g. agricultural runoff)

PREVIOUS & EXISTING MONITORING (STUDIES OR LONG-TERM)

This section includes a discussion of past, current or on-going monitoring programs that relate to this topic, preferably in North Carolina or the Southeast. A link for current monitoring programs that may be relevant can be found in the meeting summaries page of the project wiki (under Working Group Meeting 2) at http://upperneusewqmonitorng.wikispaces.com/Meeting+Summaries.

MONITORING DESIGN

This section describes the guidelines for designing a monitoring study that will enhance understanding and management of this topic/issue.

Proposed Monitoring Activities or Studies

Parameters& Methods

Frequency

Location, Scale, Watershed Type or Character (e.g. rural or urban)

Monitoring Group & Potential Partnerships

QA/QC Procedures & Recommendations

Data Coordination & Use

FUNDING OPPORTUNITIES

This section addresses known or potential funding opportunities, partnerships, and arrangements that could be employed to implement this monitoring. When applicable, this section includes existing studies or partnerships that may be leveraged, modified, or expanded to include components of this study.

PUBLIC EDUCATION COMPONENTS

This section addresses existing gaps in knowledge and/or behavior. Furthermore, it includes a discussion on existing or potential opportunities for outreach and public education related to this topic.

6. Subcommittee Selection

Participants were asked to self-select for a subcommittee and choose a chair for each sub-committee. Each subcommittee was provided with a draft Work Plan (see below) and was asked to start working on choosing potential monitoring design topics. A copy of each draft Work Plan is available on the wiki on each subcommittee page. Please visit http://upperneusewqmonitorng.wikispaces.com/ for more details.

SUB-COMMITTEE WORK PLAN

UPPER NEUSE RIVER BASIN WATER QUALITY MONITORING PLAN

"X" Sub-Committee Work Plan

Sub-Committee Purpose

To develop monitoring design guidelines related to…

_____

_____

Sub-Committee Members

Name	Organization	Email	Phone	Area of Expertise

Goals and Objectives of Monitoring Design Study(ies) (*use Monitoring Objectives and Framework handout*)

- _____
  _____
- _____
  _____
- _____
  _____

Meeting Schedule

Sub-Committee Group Email: _____

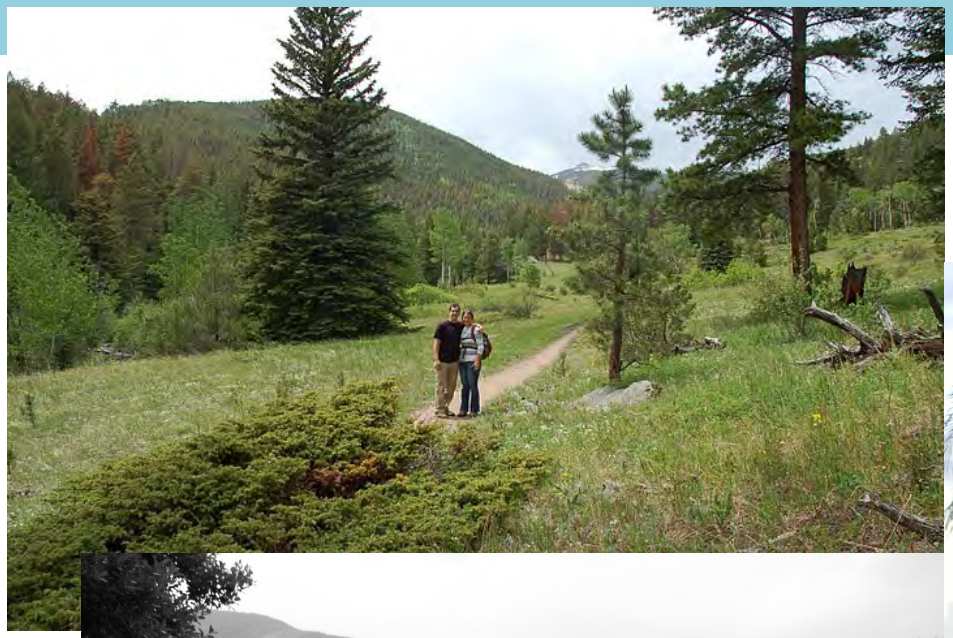
Sub-Committee Wikispace Page Link: _____

7. Next Steps

- Heather will develop a wiki page for each subcommittee.
- Heather will upload the draft Work Plan for each subcommittee to its respective wiki page
- Heather will send out two potential meeting dates for both October and November that subcommittees can meet at TJCOG and be provided with space, a computer, and a projector. Each day will have 3-4 time slots available.
- Subcommittees will choose meeting dates for October and November and; chairs will be responsible for organizing their own committees.

8. Meeting Adjourned at 4:15

Welcome Back!



Purpose of Today's Meeting?

1. **Review what's been done so far on this project.**
2. **Hear updates as to what is happening now.**
3. **Discuss project going forward.**
4. **Recruit sub-committee participation.**

Some Background and What's Been Happening

- **Initial Purpose for Monitoring Plan**
  - Inform Falls NMS
  - Multiple mon. efforts but not comparable data & not all data used
  - Still not enough data or enough consistent data
  - Needed better data coordination
  - Wanted to track sources and effectiveness of rules
- **Funding**
  - **DWQ 205(j) Grant Project**
  - **Interim**: TJCOG, UNRBA, City of Durham
  - **Current**: 205j Grant

Some Background and What's Been Happening

- **Durham hosted their own meeting Sept 2010**
  - **Solicited monitoring/modeling needs in Upper Neuse**
- **1 Large TJCOG Stakeholder Meeting**
  - TJCOG held meeting to kick off TJCOG process November 2010
    - Compiled objectives (100's!!)
    - Categorized/combined objectives into themes
- **Developed Wiki!**

UN WQ Monitoring Wiki

UpperNeuseWQMonitorng

guest · Join · Help · Sign In · wikispaces

★home PAGE HISTORY NOTIFY ME PROTECTED

- Wiki Home
- Join this Wiki
- Discussion
- Recent Changes
- Manage Wiki

Search Wiki

All Pages
- home
- Definitions and Verbiage
- Frequencies, Parameters, and Duration
- Meeting Summaries
- MonitoringObjectives
- test_page_1
- Visitors

Welcome to the Upper Neuse Water Quality Monitoring Online Wiki!

This online wiki is a shared space where stakeholders can collaborate online to *create, edit and discuss* the development for a Upper Neuse Water Quality Monitoring Plan.

It is easy to *add to this site* and increase our collective understanding.

To get started, Create a Wikispaces Username that ***clearly indicates your identity***,
Then request to Join this Wiki, and once approved,
You can Edit this Page, or Create a New Page.

First things first, please the Visitor's Page and add your name to the wiki visitors list.
Thank you for participating in this very important project!

You can receive notifications of changes to the wiki or discussions.

You can choose to receive notifications via email or RSS feed
to any changes made to this wiki or any of the dicusions
by selecting your preference on the Notify Page

Definitions and Verbiage

Working Group Meetings

WG Meeting 1 (Dec 15, 2010)

Theme: Lake Monitoring

- DWQ presented lake monitoring plan
- DWQ believes lake monitoring plan is sufficient to meet conditions of NMS
- WG developed additional recommendations for lake monitoring
  - Maintain gages (assuming $ cutbacks at DWQ)
  - Add station at Lick Creek cove
  - Increase storm event monitoring

WG Meeting 2 (Feb 1, 2011)

Theme: Existing Monitoring Efforts

- Heard presentations from groups that are currently doing monitoring. Presenters were asked to focus on objectives, goal setting, data usage, lessons learned, and obstacles.
- Ken Reckhow, Local Governments, USGS, DWQ

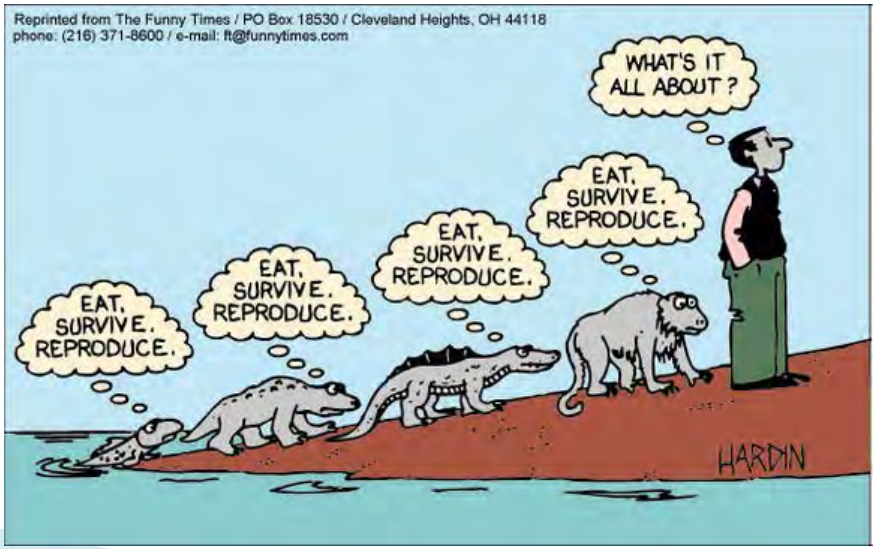
Working Group Meetings

WG Meeting 3 (March 21, 2011)

Theme: TJCOG Framework; Outcome: Evolution of Process

- Regulated communities (subject to NMS) had specific need for subset of information and a more pressing timeline
  - Phase II/Re-look was immediate driver that required them to speed up process
  - Interested in evaluating appropriateness of regulatory framework (NMS)

- The TJCOG process was not structured to meet details of what they needed and ++ objectives identified by stakeholders in Meeting 1



Working Group Meetings

WG Meeting 3 (March 21, 2011)

Theme: TJCOG Framework; Outcome: Evolution of Process

- UNRBA decided to pursue this immediate need (evaluate NMS)
- Presented monitoring framework to help visualize and distinguish differences
- Working group recommended that TJCOG adapt their process to inform other objectives identified through TJCOG process (such as identifying sources and tracking effectiveness)

Water Quality Monitoring Framework

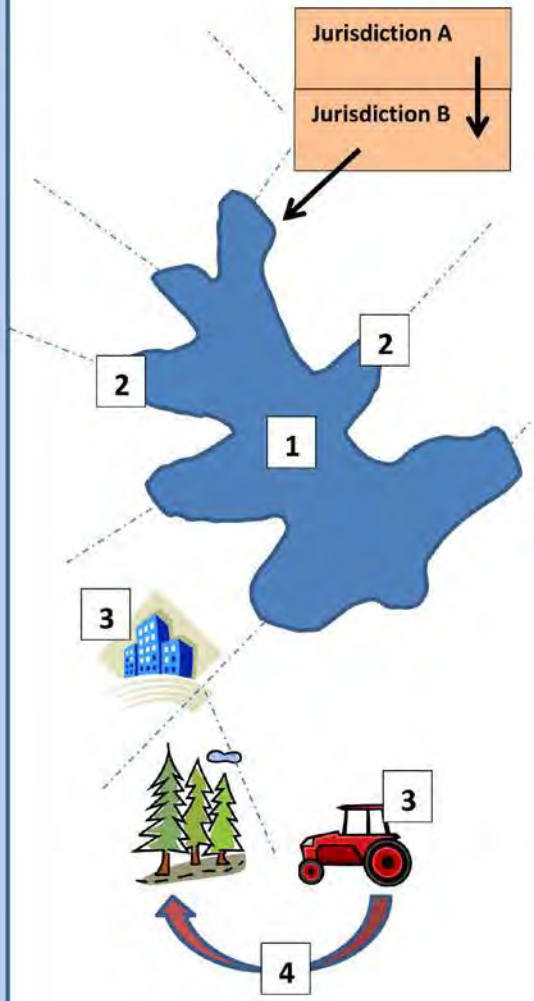
MONITORING FRAMEWORK

1) **Regulatory Compliance=Lake Response**
   (Monitor to determine if we are in regulatory compliance)
   Evaluating Regulatory Framework
   (Determine if framework is appropriate and/or achievable)

2) **Loading to the Lake**
   (Monitor to determine what nutrient load is going to lake at lake/watershed boundary)

3) **Source Identification**
   (Monitor to determine what are sources (land use))
   (Monitor to determine where sources are (geographically)
   (Monitor to determine hot spots)
   (Monitor to determine jurisdictional loading)

4) **Management Effectiveness/Success**
   (Monitor effectiveness of management activities and adapt)
   (Monitor to determine which activities are most-effective)



Products and Outcomes so Far

1. Developed comprehensive list of monitoring objectives
2. Started wiki
3. Discussed/evaluated current lake monitoring efforts
4. Developed an inventory of monitoring activities
5. Developed conceptual monitoring framework
6. Met with DWQ to re-craft scope to focus on:
   - (3) **source identification** and
   - (4) **tracking management effectiveness**
7. Modified deliverables to be set of **"monitoring design guidelines"** (*as opposed to conceptural monitoring plan*)
8. Determined process for developing "mon. design guidelines"

Other Program Updates

- In the context of the watershed, there are other groups working on NMS that may have a relationship to monitoring
- Asked these groups to come and give us an update on their programs and how their activities relate to monitoring
  - UNRBA
  - Ag Oversight Committee
  - Nutrient Scientific Advisory Board

BREAK!

OK BAND! Bring it back to the last position! RUN!
Look at how sluggish they are! They have no energy whatsoever! Bunch of...
Hmm... Watch this...
TEN MINUTE BREAK!
YEEEAAAHHH!

Going Forward…Goals

Purpose:

Develop Monitoring Design Guidelines and

Coordinate with other parallel efforts that are complimentary and informative

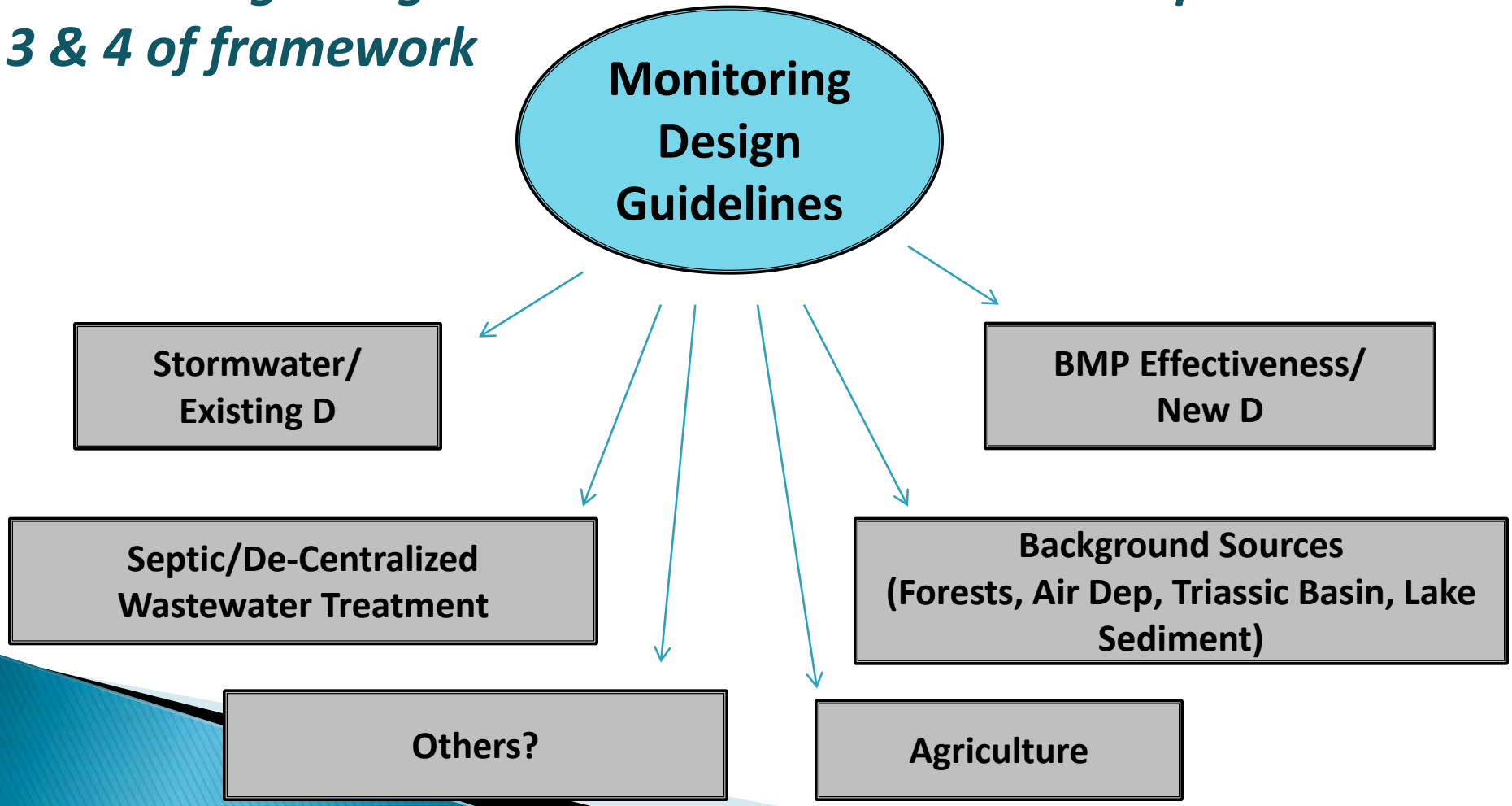
Intended Outcome:

Partners implement monitoring designs where applicable and when need and funding is available

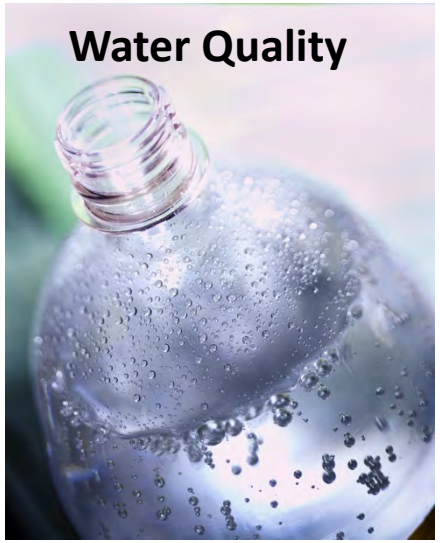
Subcommittees

Process:

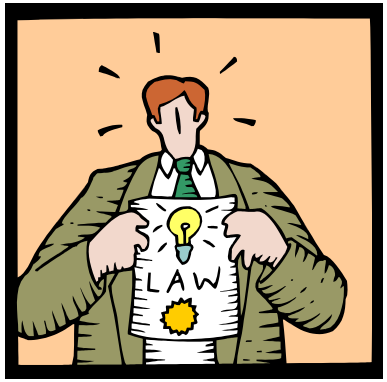
Work through focused sub-committees to develop the Monitoring Design Guidelines that relate to components 3 & 4 of framework

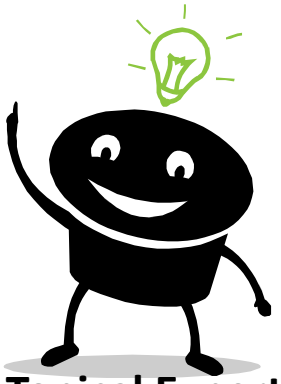


Subcommittee Structure



Regulatory Representation





Topical Expertise

Potential Template for "Monitoring Design Guidelines"

I. Background on Issue/Problem Statement
II. Regulatory Context
III. Nutrient Markers & Sources
IV. Existing Monitoring (studies or long-term)
V. Monitoring Design
   a) Proposed Monitoring Activities or Studies
   b) Where, frequency, type (surface, benthic, etc.)
   c) Who would implement study/potential partnerships
   d) QA/QC
   e) Data coordination/use
VI. Funding Opportunities
VII. Public Education Components
VIII. Issues Around Uncertainty

Timeline

- One year to complete (yikes!)
  - Completion by September 30, 2012
- Subcommittees need to meet 1x/month
  - October to July
  - TJCOG will offer two days (8 time slots) per month to host sub-committee meetings; Heather will inform chairs of time slots
  - If sub-committees want to meet independently, no problem
- Quarterly stakeholder meetings
  - January 2011, March, June, & September 2012
  - Committee chairs update on progress for each topic
    - Solicit feedback
    - Information/peer sharing
- Finalizing/Editing August & September 2012

Self-Select for Sub-committees

- Choose a sub-committee you are interested in and can also provide technical guidance on.
- Remember meetings will be once/month. Only commit to what you can actually do.
- <u>Tasks:</u>
  - Select a sub-committee chair
  - Review monitoring design template, begin sub-committee work plan, review meeting 1 agenda

"NEXT ITEM - CARRYING OUT OUR OBJECTIVE SELF-ASSESSMENT"

Next Steps

- Leave sub-committee work plans with Heather
- TJCOG will post meeting summary
- TJCOG will create sub-committee **listserv** for communication and a sub-committee **wiki page** for collaboration
- Sub-committees will meet in October & November

AGENDA

UPPER NEUSE RIVER BASIN WATER QUALITY MONITORING PLAN
STAKEHOLDER MEETING 3

1:30 PM
February 9, 2012

Durham Water Management & Maintenance Facility
1600 Mist Lake Drive
Durham, NC 27704
Phone: (919) 560-4381

1:30-1:40 **Introductions and Project Review**

1:40-1:50 **Wiki Tutorial**

1:50-3:40 **Subcommittee Updates**
Updates from 1) Agriculture, 2) Background Sources, 3) BMP Effectiveness, 4) Onsite Wastewater, and 5) Stormwater and Existing Development

- What We've Been Doing (process and how we got where we are)
- Progress of Monitoring Design Guidelines (if applicable)
- Sharing Areas of Confusion and Group Feedback
- Identify Areas of Overlap or Need for Coordination

3:40-3:50 **Break**

3:50-4:20 **Small Group Work Session**

- Coordinate with other subcommittees where necessary
- Identify questions about data submittal for regulatory contexts

4:20-4:30 **Next Steps and Timeline**

4:30 Adjourn

Upper Neuse Water Quality Monitoring Plan

Stakeholder Meeting #3

February 9, 2012

Durham Mist Lake Facility

Introductions, Overview, and Housekeeping

Heather Saunders Benson, Triangle J Council of Governments (TJCOG)

- Heather welcomed the group, gave a brief recap of the project (see attached PowerPoint), and went over the agenda.

- Participants introduced themselves and Heather reminded the group of the participation ground rules. The purpose of today's meeting was to discuss what's been done relating to the project, hear from subcommittees about their progress and prioritized Monitoring Design Guidelines, provide an opportunity for group feedback, collaborate where there are overlaps and parallel efforts, and lay out next steps.

Meeting Attendees

Name	Affiliation	Email Address
Alix Matos	Cardno Entrix	Alix.matos@cardno.com
Andrea Thomas	NCDWQ, Ambient Monitoring Coordinator	andrea.thomas@ncdenr.gov
Anne Coan	NC Farm Bureau	anne.coan@ncfb.org
Barry Baker	Granville County, Planning	barry.baker@granvillecounty.org
Beth McGee	CWMTF	beth.mcgee@ncdenr.gov
Chris Roberts	Durham County	croberts@co.durham.nc.us
Dan McLawhorn	City of Raleigh	Dan.McLawhorn@raleighnc.gov
Danny Smith	DENR/Division of Water Quality	Danny.Smith@ncdenr.gov
Ed Buchan	City of Raleigh, Public Utilities	Edward.buchan@raleighnc.gov
Eddie Culberson	Durham Soil and Water Conservation District	eculberson@durhamcountync.gov
Ed Duke	Wake County/Environmental Health	eduke@wakegov.com
Forrest Westall	Upper Neuse River Basin Association	forrest.westall@mcgillengineers.com
Frank Thomas	HBA: Durham, Orange, Chatham	frank@hbadoc.com
Haywood Phthistic	Lower Neuse Basin Association	hmp3rd@aol.com
Heather Saunders**	Triangle J Council of Governments	hsaunders@tjcog.org
Jeff Mahagan	Town of Hillsborough	jeff.mahagan@hillsboroughnc.org
John Huisman	NC Division of Water Quality	John.huisman@ncdenr.gov
Johnny Boggs	US Forest Service	jboggs@ncsu.edu
Lance Fontaine	City of Durham, Stormwater	Lance.fontaine@durhamnc.gov
Lars Hanson	Triangle J Council of Governments	lhanson@tjcog.org
Kirk Rundle	NC Wildlife Resources Commission	kirk.rundle@ncwildlife.org
Kurt Smith	Wake County	kwsmith@wakegov.com
Lisa Creasman	Conservation Trust for North Carolina	lisa@ctnc.org
Mark Senior	City of Raleigh, Stormwater Services	mark.senior@raleighnc.gov
Melissa Hodges	Town of Butner, Planning	mhodges@butnernc.org
Michelle Woolfolk	City of Durham, Stormwater Services	michelle.woolfolk@durhamnc.gov
Mike Dupree	Durham County, SWCD	mdupree@durhamcountync.gov
Mike Schlegel	Triangle J Council of Governments	mschlegel@tjcog.org
Nancy Daly	NC Ecosystem Enhancement Program	nancy.daly@ncdenr.gov
Nancy Deal	DHHS OWPB	Nancy.Deal@ncdenr.gov
Raghavenderrao Badami	City of Durham, Stormwater	Raghavenderrao.Badami@durhamnc.gov

Reggie Hicks	City of Durham, Water Management	reginald.hicks@durhamnc.gov
Robert Jordan	Durham County	rjordan@durhamcountync.gov
Sandi Wilbur	City of Durham, Stormwater	Sandra.Wilbur@durhamnc.gov
Sarah Bruce	Triangle J Council of Governments	sbruce@tjcog.org
Scott Gentry	APNEP	Scott.gentry@ncdenr.gov
Scott Miles	Town of Wake Forest	smiles@wakeforestnc.gov
Shari Bryant	NC Wildlife Resources Commission	Shari.bryant@ncwildlife.org
Steve Bristow	Wake County	sbristow@co.wake.nc.us
Terry Hackett	Orange County	thackett@co.orange.nc.us
Tom Davis	Orange County	tdavis@co.orange.nc.us
Tom Gerow	NC Division of Forest Resources	tom.a.gerow@ncagr.gov
Warren Daniel	Granville County	warren.daniel@granvillecounty.org
Watson Ross	NC EEP	watson.ross@ncdenr.gov
Will Wilson	Duke University	wgw@duke.edu

1. **SUBCOMMITTEE UPDATES**

The Subcommittees were asked in advance to prepare presentations that touched on the following items:

1. **Process**: What you've been doing and how you got here. What have most of your discussions focused on? What were your biggest questions or concerns? How did you decide to tackle the issue(s)?

2. **Monitoring Design Guidelines**: Update on the progress of prioritizing your objectives and determining which Monitoring Design Guidelines (research questions) to pursue. What studies have you decided on? How far along in developing them are you? How many did you choose? Why?

3. **Opportunity for Feedback**: Share areas of confusion. Are you struggling with some aspects? Are there questions you would like to ask the group and get feedback on? Would you like recommendations for someone to solicit as a resource? Do you think there is overlap with another group?

Stormwater & Existing Development Subcommittee (Mark Senior) (See attached PowerPoint)

Mark Senior started talking about how a Raleigh NURP study may provide (monitoring data) information on land use loading and wondered if it still needed to be studied further. An interesting finding was that the first flush was lower than expected for nutrients, which may be explained by the fact that pervious areas don't start running off until they are saturated, which may occur at a later period of the storm.

Challenges

Mark reviewed the list of characteristics that affect loading. He acknowledged that their group had gotten into the weeds and had had difficulty deciding what to select in terms of questions, which diverged into a discussion of what parameters to monitor for. Mark suggested that one challenge is that there are so many variables to control for in monitoring any given land use. Examples included communities on sewer vs. communities not on sewer, curb and gutter communities vs. ditches, communities with BMPS vs. communities without them. The list of variables keeps growing, which raised the question of whether small studies should be pursued or larger studies that can help answer bigger questions.

Group Feedback

Mark queried the group as to whether they suggested looking at developments with BMPs or developments without them? Sarah Bruce said that her group, the BMP Effectiveness Subcommittee, would be looking at effluent at the site scale, not ambient environmental indicators at the landscape or catchment scale. A question of BMP maintenance has arisen in both groups as a relevant question, and could be answered at both scales. Mark then asked, of all the parameters to monitor, which are the most important? Imperviousness was suggested and Mark responded that different types of impervious cover will have different effects on loading (rooftops vs. parking lot), which is another thing to consider.

Sandi Wilbur suggested reviewing the land uses in the SLAT for additional monitoring data that could be contributed. She then asked where the loads are coming from and suggested that the design studies should be designed to figure this out. It was suggested that this might have to be a two-tiered process, the first tier aiming at a broad assessment and the second tier aimed at refining the study to get detailed answers.

Dan McLawhorn also suggested that it was important to consider the pattern of these land uses in the basin, which could help drive prioritization. He suggested started with general sources and focusing on the biggest known components.

Frank Thomas asked if there were any jurisdictions that don't currently have inspection & maintenance programs for BMPs. It was suggested that jurisdictions that were not subject to the Neuse Rules may not have had requirements to do BMPs and that Phase II was a driver for many of the post-construction maintenance requirements.

BMP Effectiveness Subcommittee (Sarah Bruce) (See Attached PowerPoint)

This subcommittee plans to examine questions related to performance of site-based post-construction stormwater management Best Management Practices.

Sarah began by listing the participants in the subcommittee and describing the process the group had gone through to date. The subcommittee had met three times, discussed the NSAB's list of candidate practices, met with Bill Hunt to hear progress on BMP research. The subcommittee's questions revolve around two basic Objectives: 1) Increase the number of BMPs that are available / creditable by DWQ and 2) Refine the performance accounting for currently credited as well as future BMPs in terms of soils, design, construction, maintenance, and lifespan considerations.

Challenges

Challenges and intermediate issues being looked into further include DWQ's BMP review process, what issues are being covered by the Stormwater Subcommittee, and how to define a BMP for our purposes.

Group Feedback

Will Wilson asked whether the BMP Effectiveness subcommittee was looking at how metals and pH might affect BMP processes and performance. Tom Gerow asked about the factors most important to BMP performance to help us rule out some and help prioritize the most important for detailed examination.

Agriculture Subcommittee (Anne Coan) (See Attached PowerPoint)

Challenges

Anne Coan presented the Agriculture Subcommittee's draft list of needs and mentioned that there are very few BMPs left. She mentioned that now a minimum of 5 horses is needed to be considered agriculture, but they are not typical and are not easy to identify (e.g. they don't know where these operations are). In addition, there typically aren't many BMPs for horses.

Anne indicated that the agriculture community regularly revises BMP crediting and tries to use the most current data available. She noted that there are lots of BMPs used for sediment that have not been evaluated for P removal. She also noted that it is very hard to find a watershed to monitor that is all agriculture and no other land uses. Anne also mentioned the nutrient legacy issue and that is can take anywhere from 30-50 years to get nutrients out of the system and into a surface water. This has significant consequences when you consider the timeline for implementing (and getting reductions) the Falls Lake Nutrient Management Strategy. Anne noted that it takes time for nutrients to move from groundwater and that the agriculture community assesses this as

part of their "BMP Effectiveness Assessment". Anne agreed to give Sarah a link to the "Guidance on Agriculture BMP Effectiveness Assessment", which is used for all of NC and is arranged by soil type.
Another challenge Anne note is bio-solids application limits which are N-based. This is challenging because Phosphorous loads in bio-solids can also be quite high.

Anne noted that Deanna Osmond is working in the Jordan Lake watershed on trading for non-point sources and Anne mentioned that this will require good data on BMP Effectiveness. In addition, Raleigh has done some research on nitrogen groundwater transfer and might have some Phosphorous information as well.

Background Sources Subcommittee (Mike Schlegel, Johnny Boggs, & Lars Hanson) (See Attached PowerPoints)
Mike Schlegel (TJCOG)
Mike gave a brief introduction to the work that the Background Sources committee is doing, which was followed by presentations from Johnny Boggs and Lars Hanson. Mike noted that three very different topic areas being considered within this broad topic including atmospheric deposition, forest contributions, and in-lake (sediment) nutrient fluxes. Maverick Raber with the City of Durham is leading on the atmospheric deposition study as an addendum to the atmospheric work that he is already doing for the City of Durham. Maverick is working on expanding the spatial scale of that study to cover the basin. There are also a couple of national air quality studies going on. Unfortunately, the closest research point isn't that close, but the numbers will be considered anyway.

Johnny Boggs with the USFS
In 2006 the USFS was contracted by the North Carolina Forest Service, which obtained a multi-year 319-Grant, to design and manage a forestry BMP effectiveness paired watershed study. The study examines hydrologic and water quality effects between an un-harvested forested watershed and a watershed that has had a clear-cut timber harvest completed, while retaining appropriate stream buffers in the harvest area in accordance with the Neuse River riparian buffer rules.

For their research, they collected baseline and background data, and are now in a post-monitoring phase. Johnny noted that this will fit nicely into a monitoring guideline for this project. The design of the study included two locations: The NCSU-Hill Forest in the Carolina Slate Belt, and the NCDA&CS-Umstead Research Farm in the Triassic Basic. So far, two years of data have been collected on parameters including TSS, TKN, N, P, ammonium, and TOC. Their study has revealed that managing runoff on Triassic soils will present a larger challenge. There remains about 2 years of data sampling to complete the study.

Lars Hanson (TJCOG)
Lars presented on in-lake sediment re-suspension and noted that NCDWQ had measured nutrient-sediment flux at two sites for the Falls Nutrient Response Model, which assumes flux to be mass per area per time. Lars noted that there were not many samples for these two sites. Subsequently, the modelers couldn't put in a number confidently, so they filled in the fluxes as a constant over the entire lakebed for all parameters based on the lake's calibration. Subsequently, the parameters were used to set boundary limits. One question that was raised was if the flux rates vary spatially or temporally, and in what conditions. Lars noted that a study design to measure flux should look at dissolved core samples in water and/or using in-situ measurements.

Lars suggested that the temporal sampling priorities should include an approach for quantifying nutrient response in the model (that will improve it). Another question that was raised was how rates vary seasonally. For example, how do dissolved oxygen, water temperature, or other variables effect nutrient fluxes. In addition, are there diurnal effects based on light or event-based characterizations such as droughts or significant precipitation events. Furthermore, do limnetic conditions such as lake stratification have an effect?

Lars then suggested that spatial sampling should consider the differences between the Upper and Lower Lake, depth variations, and lake conditions (where turbidity could vary by water velocity). Eventually, the group hopes to present a prioritized list of location recommendations for in-lake monitoring to determine nutrient flux.

A study by Dr. Benjamin Howten at Unrba-Cal Davis –explored the growth rate of trees depending on media being sedimentary or not. Results demonstrated that foliage from sedimentary materials had a 50% higher nitrogen rate, and that rock weathering caused nitrogen to leak into the water table.

Group Feedback

Tom Gerow suggested asking power companies with limnologists for data and technical support.

Onsite Wastewater Subcommittee (Nancy Deal) (See Attached PowerPoint)

Nancy Deal presented for the Onsite Wastewater Subcommittee's work, which is chaired by Steve Bristow. Nancy indicated that they have been discussing issues such as fate and transport, source identification, and performance data. Nancy said that counties are required to conduct system inventories and wondered about the viability of keeping them current. She posed a question about what variables will be used to characterize potential reductions. Nancy also indicated that the group had spent a lot of time defining systems and malfunctions.

The group had spent some time discussing whether or not discharging sand filters should be covered through their subcommittee. One potential challenge was that they could not locate Monitoring requirements for surface-discharging sand filters. In order to help with these questions, they solicited Mandy Hall with DWQ to join the group to help answer these questions.

Nancy noted that surface systems [sand filters] are overseen by DWQ and that subsurface systems are overseen by the Onsite Water Protection Branch, which used to be under DENR but has now been moved to the Department of Health & Human Services. Nancy indicated that this move has made coordination challenging. Nancy indicated that in both surface and subsurface systems, the owner is the operator. The group decided to take on sand filters because they are onsite and are not being addressed otherwise.

Nancy then spent some time defining various types of systems so that everyone was operating with the same understanding. She noted that many systems are designed to actually create nitrate, and that they also generate phosphorous. She noted that soils in Piedmont can fix Phosphorous due to clay content, but also suggested that this capacity is not unlimited.

Nancy described discharging systems as having a septic tank, just like a subsurface system, but it is combined with a sand filter and then a discharge. A lot of these systems were installed in Durham County and in the Upper Neuse generally prior to 1976 when other types of systems would not work on Triassic soils, and were under the purview of the local health departments.

In 1981, the Ground Absorption Act separated surface and subsurface systems into two different departments. Subsequently, NCGS 55 required maintenance for all systems. Nancy noted that complaints and property transfers are the most common means of identifying failing systems

On Jan 24, the group took a field trip with Mandy to look at sand filters systems.

Nancy suggested that the gaps in knowledge base are well identified. She noted that there is a USGS study in Durham County that is focusing on optical brighteners as a source identification tool, and that there are lots of jurisdictions and agencies who provided funds to do the work. Gloria Ferrel is looking at periods of streamflow recession (as flow is subsiding after a storm). There is also a 319 grant study in High Rock Lake to look at septic fate and transport that is very relevant to this subcommittee. The group is currently doing a literature review on soils and attenuation rates.

Nancy mentioned that at their last subcommittee meeting, Kathryn Hobby presented the Nutrient Scientific Advisory Board's (NSAB) current questions related to onsite wastewater (see attached presentation). It seemed to all of the subcommittee members that all of the NSAB questions required good numbers on loading. Nancy noted that for each NSAB question, important information to determine included: what is existing research and can we attribute it to human sources (tracers, specific nutrient parameters)?

Group Feedback:

A stakeholder inquired about the lifespan of sand filters? Nancy said many sand filters and onsite systems were installed and intended as a temporary measure until sewer would be provided. Bob Jordan said sand filter beds are designed to last about a decade before their media needs to be replaced. Danny Smith said he'd heard these numbers and higher, but they are subject to highly variable demands so their lifespan can vary a lot.

NPDES general permits for Sand Filters do not impose any extra restrictions for a nutrient-sensitive water body. Research conducted under this subcommittee's recommendations could result in enhanced Operations and Management requirements, for example. Currently, only certain types of more complex subsurface dispersal require a certified operator.

Take Home Ideas

Start a lit review to id where focus on the gaps

Find a study someone has already designed that is related to yours and start there

2. TIMELINE

- The Monitoring Design Guidelines need to be completed by July of 2012.
- Subcommittees will continue to meet monthly in March and April
- The next large stakeholder meeting will be in May

3. MAY MEETING

Many stakeholders have indicated that they have multiple data sets already and/or are planning to collect more data that they would like to see used in regulatory processes. That being said, TJCOG has decided to invite NCDWQ to our May meeting in order to answer questions about data submittal. Heather asked everyone to write down specific questions for NCDWQ so we can get help with writing our QAQCs.

In addition, Heather noted that the NSAB is struggling with some of these questions, and there is a lot of information being developed through this process that could help inform their process. Rich Gannon (of NCDWQ) and Heather are discussing how to better coordinate these processes, especially in light of the fact that NCDWQ will be initiating a remodel of Jordan Lake.

4. WIKI

Mike Schlegel demonstrated a brief tutorial for using the wiki and uploading documents*. His instructions were as follows:

1) Join and/or sign in to the project wiki (http://upperneusewqmonitorng.wikispaces.com/Using+the+Wiki)
2) At the upper left-hand corner, follow the Pages and Files link
3) At the upper right-hand corner:, hit the "Upload a file" button
4) A "Check Mark" shows when it's been uploaded
5) Go to "Page" where you want it to show up
6) Click the "Edit button" (if button does not show up, you're not signed in)
7) Click "File" button
8) Select the file you want to upload
9) Click Save

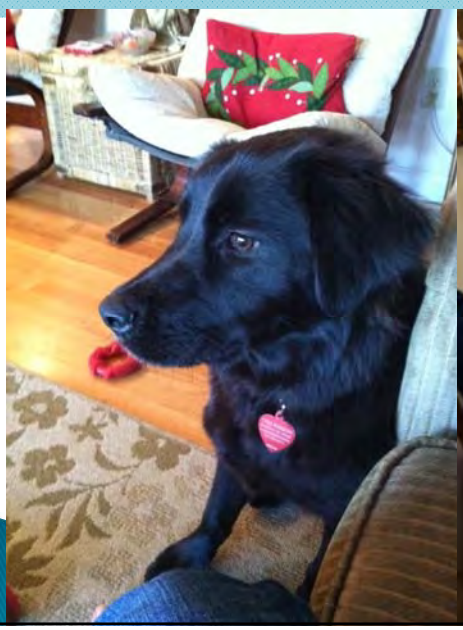
*The Onsite Wastewater Subcommittee decided to set up their own wiki, so those folks need to be a member of both wikis in order to be able to edit them.

5. SMALL GROUPS

Subcommittees that had questions for other subcommittee members or those who needed to collaborate among different groups were given time to mingle and discuss issues.

The meeting was adjourned at 4:30

Welcome Back!



Brief Recap of Activities

-
-
-

MONITORING FRAMEWORK

1) **Regulatory Compliance=Lake Response**
(Monitor to determine if we are in regulatory compliance)
Evaluating Regulatory Framework
(Determine if framework is appropriate and/or achievable)

2) **Loading to the Lake**
(Monitor to determine what nutrient load is going to lake at lake/watershed boundary)

3) **Source Identification**
(Monitor to determine what are sources (land use))
(Monitor to determine where sources are (geographically)
(Monitor to determine hot spots)
(Monitor to determine jurisdictional loading)

4) **Management Effectiveness/Success**
(Monitor effectiveness of management activities and adapt)
(Monitor to determine which activities are most-effective)

Brief Recap of Activities

- 2nd Full Stakeholder Meeting (Sep 2011)
  - Came back to full group to explain changes
  - Updates from UNRBA, Watershed Oversight Committee, NSAB
  - Presented Monitoring Design Guidelines Template (MDGs) to help answer prioritized objectives with regard to (3) source identification and (4) management effectiveness.
  - Created 5 Subcommittees to develop Monitoring Design Guidelines
    - Ag, Background Sources, BMP Effectivness, Onsite Wastewater, and Stormwater and Existing D
- Subcommittees meeting regularly since Sep to prioritize objectives and begin drafting MDGs.

Template for "Monitoring Design Guidelines"

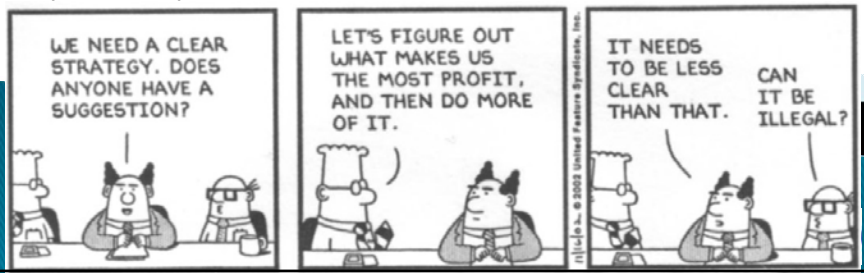
I. Background on Issue/Problem Statement
II. Regulatory Context
III. Nutrient Markers & Sources
IV. Existing Monitoring (studies or long-term)
V. Monitoring Design
   a) Proposed Monitoring Activities or Studies
   b) Where, frequency, type (surface, benthic, etc.)
   c) Who would implement study/potential partnerships
   d) QA/QC
   e) Data coordination/use
VI. Funding Opportunities
VII. Public Education Components
VIII. Issues Around Uncertainty

Products and Outcomes so Far

1. Developed comprehensive list of monitoring objectives
2. Started wiki
3. Discussed/evaluated current lake monitoring efforts
4. Developed an inventory of monitoring activities HS4
5. Developed conceptual monitoring framework
6. Met with DWQ to re-craft scope to focus on (3) **source identification** and (4) **tracking management effectiveness**
7. Modified deliverables to be set of **"monitoring design guidelines"** (*as opposed to conceptual monitoring plan*)
8. Determined process for developing "mon. design guidelines"
9. Set up subcommittees to develop MDGs
10. Subcommittees meeting regularly

Purpose of Today's Meeting?

1. **Review what's been done so far**
2. **Go over how to use the wiki**
3. **Give subcommittees an opportunity to share their progress and ideas for MDGs and get feedback from the group**
4. **Give subcommittees the opportunity to ask for advice from others**
5. **Give subcomittees time to collaborate where appropriate or delegate if there are overlaps**
6. **Prepare for May meeting and develop questions about QAQC procedures**
7. **Lay out next steps**



Slide 5

HS4 Be sure this term is consistent throughout
Heather Saunders, 9/23/2011

Subcommittee Presentations

BREAK!

Next Steps

- Continue to work with subcommittees
- Be sure to upload meeting summaries and draft documents to the wiki
- **Need to have Monitoring Design Guidelines completed by July 2012!!**
- May Meeting
  - Will include a discussion on QAQC procedures and getting feedback from DWQ
  - Consider ways to potentially coordinate with the NSAB or make research ideas and/or outcomes available to group.

AGENDA

UPPER NEUSE RIVER BASIN WATER QUALITY MONITORING PLAN
STAKEHOLDER MEETING 4

1:30 PM
June 26, 2012

1:30-2:00 **Introductions, Agenda, and Project Review**

2:00-2:25 **Update on Durham Atmospheric Deposition Study**

2:25-3:00 **Implementation-Oriented Uses and Users of Water Quality Data**
Overview from DWQ Panelists

- Pam Behm, Modeling & TMDL Unit
- Kathy Stecker, Modeling & TMDL Unit
- John Huisman, Non-point Source Planning Unit
- Rich Gannon, Non-point Source Planning Unit

3:00-3:10 **Break**

3:10-4:20 **Implementation-Oriented Uses and Users of Water Quality Data Continued**
Q&A with Large Group

4:20-4:30 **Next Steps and Wrapping Up the Project**

4:30 **Adjourn**

Upper Neuse Water Quality Monitoring Plan

Stakeholder Meeting #4

June 26, 2012

Durham Mist Lake Facility

Introductions, Overview/Recap, and Housekeeping

Heather Saunders Benson, Triangle J Council of Governments (TJCOG)

- Heather welcomed the group and went over the agenda. The purposes of the meeting were to learn about the Air Deposition Study AMEC is working on for the City of Durham, gain understanding from the Division of Water Quality regarding potential uses and users of water quality data, and lay out next steps as we complete the project.
- Participants introduced themselves, Heather gave a brief recap of the project (see attached PowerPoint), and subcommittees briefly reported on progress related to Monitoring Design Guidelines.
    - Anne Coan reported that the Agriculture Subcommittee was doing more of a review and gap analysis with collaboration from Dan Line at NCSU.
    - Sarah Bruce reported that the BMP Effectiveness subcommittee was largely focusing on issues related to maintenance determined to be significant by local experts.
    - The Onsite Wastewater subcommittee reported that they propose to study both functioning and non-functioning systems to determine loads.

Meeting Attendees

Name	Affiliation	Email Address
Andrea Thomas	NCDWQ, Ambient Monitoring Coordinator	andrea.thomas@ncdenr.gov
Anne Coan	NC Farm Bureau	anne.coan@ncfb.org
Carrie Ruhlman	NCDWQ, Monitoring Coalition Program	carrie.ruhlman@ncdenr.gov
Chris Roberts	Durham County	croberts@co.durham.nc.us
Frank Thomas	HBA of Durham, Orange, Chatham	frank@hbadoc.com
Heather Saunders**	Triangle J Council of Governments	hsaunders@tjcog.org
Helen Youngblood	City of Durham, Planning	Helen.Youngblood@durhamnc.gov
John Huisman	NC Division of Water Quality	John.huisman@ncdenr.gov
Jim Wrenn	Hopper, Hicks, and Wrenn	jcw@hopperhickswrenn.com
Lars Hanson	Triangle J Council of Governments	lhanson@tjcog.org
Lindsay Mize	SGWASA	LMize@sgwasa.org
Kathryn Hobby	Wake County, Environmental Services	kathryn.hobby@wakegov.com
Kathy Stecker	NCDWQ, Modeling Unit	Kathy.Stecker@ncdenr.gov
Kirk Rundle	NC Wildlife Resources Commission	kirk.rundle@ncwildlife.org
Maverick Raber	City of Durham, Stormwater Services	maverick.raber@durhamnc.gov
Michelle Woolfolk	City of Durham, Stormwater Services	michelle.woolfolk@durhamnc.gov
Mike Dupree	Durham County, SWCD	mdupree@durhamcountync.gov
Mike Hoover	NCSU	mike_hoover@ncsu.edu
Pam Behm	NCDWQ, Modeling Unit	pamela.behm@ncdenr.gov
Robert Jordan	Durham County	rjordan@durhamcountync.gov
Sandi Wilbur	City of Durham, Stormwater	Sandra.Wilbur@durhamnc.gov
Sarah Bruce	Triangle J Council of Governments	sbruce@tjcog.org
Steve Bristow	Wake County	sbristow@wakegov.com
Terry Hackett	Orange County	thackett@co.orange.nc.us
Tom Davis	Orange County	tdavis@co.orange.nc.us
Watson Ross	NC EEP	watson.ross@ncdenr.gov

1. DURHAM AIR DEPOSITION STUDY

Kate Morrison and Art Werner with AMEC presented an update on the study they are conducting for the City of Durham on atmospheric deposition to watersheds (see attached PowerPoint), which has been shown to be a significant (44%) contributor to nitrogen loading in the Chesapeake Bay watershed. The purpose of the City of Durham study is to estimate the amount of nitrogen and phosphorus deposition to the Falls Lake and Jordan Lake watersheds by measuring deposition at sites in each watershed. The Durham study is unique in that it included a site in an urban area (most monitoring of air deposition is being done in rural areas). Many monitoring programs in other areas were begun in the 1980s to look at acid rain, so there may in some cases be many years of data, but not necessarily on nutrients. Methods used for both wet and dry deposition are comparable with national monitoring programs.

Ms. Morrison described the two monitoring locations in Durham, one in each river basin. Sites were prepped and testing equipment installed by experts. The City reviewed and approved their QAPP. AMEC's data were compared to other National Atmospheric Deposition Program (NADP) sites in North Carolina. Ms. Morrison presented charts showing concentrations of various species and showing proportion of wet vs. dry deposition, which appear to be consistent with distributions for comparison locations.

Sampling was done weekly with a tipping bucket rain gage and rainfall sensor. Phosphorous was always below detection limits in this study's samples. Ammonia and ammonium depositions are significantly higher in Spring and Summer. Mobile source emissions were found to be high at the urban site. The annual difference in rainfall at the two sites (within 5 miles of one another) can vary by as much as 30-40%. Weekly dry and wet nitrate showed no significant difference from rural stations. Weekly dry and wet ammonia were slightly higher than rural.

The group asked about and discussed the various potential sources of the pollutants monitored and the timing with which they could be volatilized, transported, and captured with monitoring. Acid rain programs may have altered the balance and composition of pollutant species over the years.

2. USERS AND USES OF WATER QUALITY MONITORING DATA

Heather introduced the DWQ staff presenting and participating on the panel and suggested some objectives for the discussion:

- Help group understand DWQ's role and what types of data they receive and use;
- Help group understand DWQ's research priorities as they relate to the Falls Watershed (if any);
- Help everyone understand how data can and/or will be incorporated into an adaptive management approach;
- Help DWQ understand what types of data may be generated from proposed Monitoring Design Guidelines;
- Help group understand data submittal requirements for different types of uses and DWQ's preferred coordination schedule (if coordination needed); and
- Help everyone recognize the multiple potential uses for data and know how to determine the appropriate end user and data receptor for different projects.

First, **John Huisman** presented on adaptive implementation provisions within the Falls Rules (see attached PowerPoint presentation). The rules specify how progress will be measured and evaluated against goals. The rules require 5-year reports to the EMC and public reports summarizing applicable information and data on water quality. In response to supplemental modeling conducted by a third party, the EMC may elect to initiate new

rulemaking. Adaptive implementation means that the can change based on other information submitted by local governments and others interested in Falls Lake.

John shared that Rich Gannon suggested that the NPS Unit is particularly interested in data on monitoring that informs management, such as source characterization and management measure effectiveness (e.g., NSAB candidate practices; BMP toolboxes for nutrient management), particularly for existing development. Specific topics of interest include loadings from onsite wastewater, various land covers, and groundwater.

Heather asked a question to clarify whether NPS unit wants to be involved in developing study plans for their issues (besides the remodeling); John responded that DWQ is still interested in studies that they were not involved in, such as studies conducted in other states on the topics mentioned above.

Next, **Pam Behm** discussed monitoring data uses and data submittal (see attached PowerPoint presentation). Data on water quality may be collected to characterize sources, determine effectiveness of implementation, characterize waters (changes/trends over time), identify existing or emerging water quality problems, or gather information to design specific pollution prevention or remediation programs. The monitoring design begins with determining what questions need to be answered. Pam said that DWQ is interested in both data (spreadsheets of data point values) and information (reports and other materials), but for different purposes.

Pam then gave examples of data and information uses and users as well as how water quality data are currently coordinated to produce the 303(d) and 305(b) Integrated Report. Pam then reviewed and discussed the DWQ websites, which contains a lot of resources and instructions on submitting data to DWQ for various purposes.

3. DISCUSSION ON USERS AND USES OF WATER QUALITY MONITORING DATA

After a break, Heather facilitated a discussion structured by questions on the agenda topic that had been submitted via email and index cards.

Q: Can citizens (e.g., backyard scientists, students) submit data for regulatory purposes?
A: Yes, but it depends on the question that the data were meant to answer. If they are designed to answer an acute problem, Kathy recommends they contact the DENR regional office. Kathy recommends using the website to develop a QAPP or to contact the DWQ to find out if it makes sense to go through that process.

Q: What are the requirements for a local government septic system inventory?
A: A spreadsheet is sufficient for the number and type, but DWQ doesn't need actual addresses. DWQ (NPS Unit) wants to know how many units and the population served, primarily. Some field investigations are expected to help quantify failure rates.

Q: How might monitoring studies to evaluate the benefits of pollution prevention programs be set up? Is there any alternative to paired watershed studies (treatment and control)?
A: DWQ requested folks talk to the NPS unit. Studies could also be pre/post design. With street sweeping, you collect a mass of material that can be weighed; nutrient content of sweepings varies by region and soil. Michelle Woolfolk mentioned that Durham is considering monitoring this.

Q: Section 5(a) of the Purpose and Scope rule says that "The Division … shall accept reservoir water quality monitoring data provided by other parties that meet Division standards and quality assurance protocols." And that, "The Division shall utilize this data to estimate load reduction achieved…"

1) How and when should entities work with DWQ if they want to collect and submit data for DWQ to use for this purpose?
2) How can reservoir data be used to estimate load reductions? Wouldn't data used to estimate load reduction need to be collected on incoming waterways as opposed to the lake itself? It seems like lake data would only be able to determine whether the lake is attaining its water quality standards?

A: This part of the rule could have been written better; this was put into the rule to be explicit (they would accept this data anyway), but this provision is not specific to Falls Lake. In-lake data is used to evaluate use support, but Kathy said that in-lake and loading data would both be accepted.

Q: Is there a statutory requirement that DENR accept USGS data? Would a linkage with USGS, and/or using their lab, increase likelihood that DENR would accept the data?
A: This concept probably originated from the list of data state should CONSIDER for use support. DWQ does routinely accept USGS data because they believe their QA to be adequate/comparable, especially for flow. A linkage to USGS is NOT required for other data to be submitted accepted to DWQ. However, state-certified labs are required for data that will be used for use support determinations.

Q: What would make research of fate and transport (% of nutrients making it to lake) data be acceptable to DWQ? (e.g. loadings from failing septic field)?
A: DWQ would consider this research and other research from around the country for setting watershed model parameters, particularly when a judgment call is required.

Q: What opportunity is there for DWQ to consider monitoring data that would reduce uncertainty about in-lake nutrient flux from lake sediment? How and when should entities work with DWQ if they want to collect and submit data for DWQ to use for this purpose?
A: This is more applicable to third-party remodeling (5A NCAC 02B .0275 5(f)).

Q: What are the data quality requirements that must be met to meet .0275(5)(b) results of studies evaluating sources?
A: There are very few requirements to be included in this report. DWQ welcomed the opportunity to discuss proposed studies to help them be as useful as possible to the Division.

Q: Does DWQ have any use for information on amounts of loading from particular sources (particularly onsite wastewater), or is that kind of data only useful to regulated entities for designing their management programs at this point? For example, could data on onsite wastewater loading be used in models for future nutrient strategies? If DWQ can use data on source loads, do they prefer it to be for loads at edge-of-field or received to stream?
A: The format needed depends on the model. Many models are based on edge of field, so fate and transport data are always useful, but either is useful on accounting side. With modeling, data may not be used to drive the model, but might help DWQ make a judgment call. There is an especially dire need for data on septic loadings, for a number of purposes (modeling, accounting). Kathy emphasized that you can't use the same model you used to develop the goals to do the progress accounting (quantifying benefits of implementation of individual practices).

Q: In .0275(5)(f), does the supplemental modeling have to address ONLY the five calibrated watersheds? If not, or if included as part of a larger area, how can it be compared to the DWQ model?
A: There are few scenarios where outputs from one model could be compared to another, particularly if new data are used. On-the-ground progress will be better demonstrated using in-stream data, not large-scale modeling. Small-scale models will be useful to track progress in terms of outputs (projects implemented).

Q: If an entity wants to collect data [for source identification and relative contribution] from certain parts of the watershed, what should that entity do to ensure that their data are useful, particularly in watersheds where there is no USGS gage and there is no existing water quality data?
A: In general, this would be accepted as information, not data. If data are accepted, DWQ would be most likely to use them for 303(d) listing, not so much to regulate individual sources. An ongoing problem is to identify hotspots of pollutants for source reduction. If it's the information that's more important (e.g., loadings from a previously unsampled watershed), don't submit the data.

Q: How much in advance does DWQ need to receive studies for inclusion in the 5-Year Reports?
A: Don't wait until the year the report is due, but DWQ NPS Unit doesn't have a specific set of guidelines in place yet. In the meantime, 2 years before would be good to plan on. Report has to be drafted well in advance in order to go through review processes.

Q: If studies that are intended for DWQ to use as DATA not as INFORMATION, should folks huddle with DWQ first?
A: Yes, but make sure there is clarity that DWQ can use it for what data generator intends it to be used for.

The group discussed supplemental modeling. Folks who wish to submit data for supplemental modeling need to coordinate with the UNRBA and their consultant, Cardno Entrix. Michelle Woolfolk updated the group that UNRBA/Cardno is reviewing data on the Upper Neuse. Recommendations on monitoring and modeling should be provided by Cardno Entrix by the end of the year, including model selection. UNRBA has not yet decided whether the it will undertake a re-do of the watershed model; some members are interested in doing and others are not.

Heather clarified that regulated entities have reductions to make regardless of future remodeling efforts, thus this project is to inform strategy implementation and management strategies.

4. NEXT STEPS

Heather needs final monitoring design guidelines by July 31. The September meeting will be a short presentation of the Plan, the monitoring design guidelines, and a celebration of our collective accomplishments.

Welcome Back!

And Heather's Latest Update?....

Today's Purpose and Agenda

1. Introductions
2. Recap of where we've been and where we're going
3. Hear update on initial results of Durham's Air Deposition Study
4. Group Discussion (with DWQ) on "Implementation-Oriented Uses and Users of Water Quality Data"

   (With Break)
5. Next Steps and Wrapping Up

Brief Recap of Activities

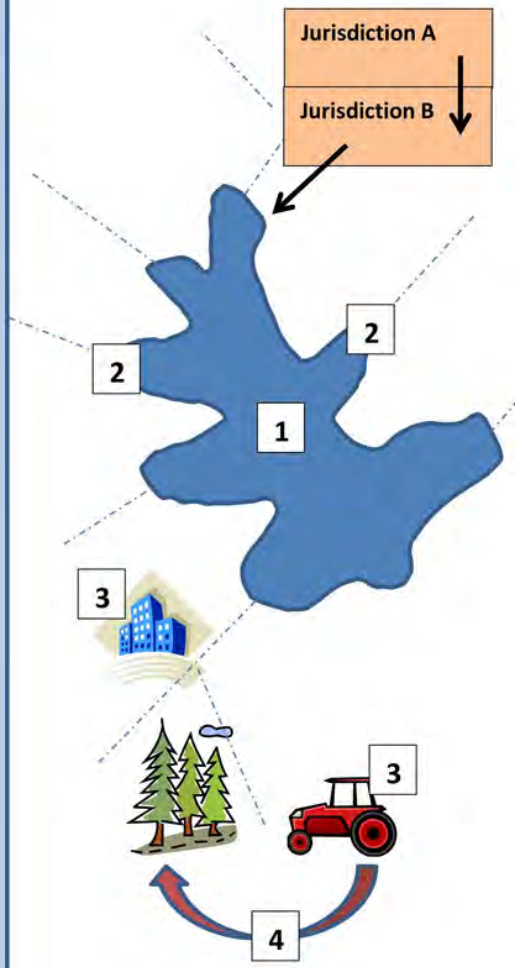
MONITORING FRAMEWORK

1) **Regulatory Compliance=Lake Response**
(Monitor to determine if we are in regulatory compliance)
Evaluating Regulatory Framework
(Determine if framework is appropriate and/or achievable)

2) **Loading to the Lake**
(Monitor to determine what nutrient load is going to lake at lake/watershed boundary)

3) **Source Identification**
(Monitor to determine what are sources (land use))
(Monitor to determine where sources are (geographically)
(Monitor to determine hot spots)
(Monitor to determine jurisdictional loading)

4) **Management Effectiveness/Success**
(Monitor effectiveness of management activities and adapt)
(Monitor to determine which activities are most-effective)



Brief Recap of Activities

- 2nd Full Stakeholder Meeting (Sep 2011)
  - Came back to full group to explain changes
  - Updates from UNRBA, Watershed Oversight Committee, NSAB
  - Presented Monitoring Design Guidelines Template (MDGs) to help answer prioritized objectives with regard to (3) source identification and (4) management effectiveness.
  - Created 5 Subcommittees to develop Monitoring Design Guidelines
    - Ag, Background Sources, BMP Effectivness, Onsite Wastewater, and Stormwater and Existing D
- Subcommittees started meeting regularly (~ monthly) to prioritize objectives and draft MDGs.

Brief Recap of Activities

- **3rd Full Stakeholder Meeting (Feb 2012)**
  - **Wiki Tutorial**
  - **Subcommittee Updates (Agriculture, Background Sources, BMP Effectiveness, Onsite Wastewater, and Stormwater and Existing Development)**
    - **What They've Been Doing (process and how we got where we are)**
    - **Progress of Monitoring Design Guidelines (if applicable)**
    - **Sharing Areas of Confusion and Group Feedback**
    - **Identify Areas of Overlap or Need for Coordination**
  - **Small Group work**
- **Subcommittees continue meeting regularly (~ monthly) to draft MDGs**

Products and Outcomes so Far

1. Comprehensive list of monitoring objectives
2. Wiki
3. Discussed/evaluated current lake monitoring efforts
4. Developed an inventory of monitoring activities
5. Developed conceptual monitoring framework
6. Re-crafted scope; focus on (3) **source identification** and (4) **tracking management effectiveness**
7. Deliverables to be set of **"monitoring design guidelines"**
8. Determined process for developing "mon. design guidelines"
9. Set up subcommittees to develop MDGs
10. Subcommittees meeting regularly
11. **Drafted 12 Monitoring Design Guidelines!!**

Draft Monitoring Design Guidelines

Agriculture

1. Review of Monitoring Studies for Determining Nutrient Inputs from Agriculture

Background Sources

1. Atmospheric Deposition
2. Forest Contributions
3. Monitoring of in-lake nutrient flux

Draft Monitoring Design Guidelines

BMP Effectiveness

1. Evaluate How Vegetated Shelf & Plant Maintenance Influences the Effectiveness of Wet Detention Basins
2. Evaluate the Influence of Clogged Media on the Effectiveness of Sand Filter Stormwater Control Measures
3. Evaluate How Soil Protection/Amendment Influences Surface Runoff, Stormwater Control Measure Performance, and Receiving Water Quality
4. Evaluate the Influence of Clogged Media on the Effectiveness of Bioretention Devices

Draft Monitoring Design Guidelines

Onsite Wastewater

1. Falls Lake Watershed System Survey/Performance Assessment
2. Impact of Geologic/Soil Systems upon the Fate and Transport of Nitrogen and Phosphorous within the Falls Lake Watershed
3. Assessment of On-site Wastewater Treatment Systems Derived Nutrients Transport/Reduction Dynamics in Falls Lake Watershed
4. Effects of Soil Compaction

Air Deposition Presentation

'You two need to go inside and get some fresh air.'

Implementation-Oriented Uses and Users of Water Quality Data

FORMAT

- Panel discussion with DWQ
  - Please be generating content-related questions on the index cards provided during the overviews
  - Limit questions at this time to clarification issues (not content)
- Break
- Q&A with Whole Group

Implementation-Oriented Uses and Users of Water Quality Data

OBJECTIVES

1. Help group understand DWQ's role and what types of data they receive and use;
2. Help group understand DWQ's research priorities as they relate to the Falls Watershed (if any);
3. Help everyone understand how data can and/or will be incorporated into an adaptive management approach;
4. Help DWQ understand what types of data may be generated from proposed Monitoring Design Guidelines;
5. Help group understand data submittal requirements for different types of uses and DWQ's preferred coordination schedule (if coordination needed); and
6. Help everyone recognize the multiple potential uses for data and know how to determine the appropriate end user and data receptor for different projects.

BREAK!

OK BAND! Bring it back to the last position! RUN!
Look at how sluggish they are! They have no energy whatsoever! Bunch of...
Hmm... Watch this...
TEN MINUTE BREAK!
YEEEAAAHHH!

Next Steps

- **Need to have Monitoring Design Guidelines completed by July 31, 2012!!**
- September Meeting
  - Present final Monitoring Design Guidelines
  - Present final Report
  - **CELEBRATE!!**

Welcome Back!

And Heather's Latest Update?....

Today's Purpose and Agenda

1. Introductions
2. Recap of where we've been and where we're going
3. Hear update on initial results of Durham's Air Deposition Study
4. Group Discussion (with DWQ) on "Implementation-Oriented Uses and Users of Water Quality Data"

   (With Break)
5. Next Steps and Wrapping Up

Brief Recap of Activities

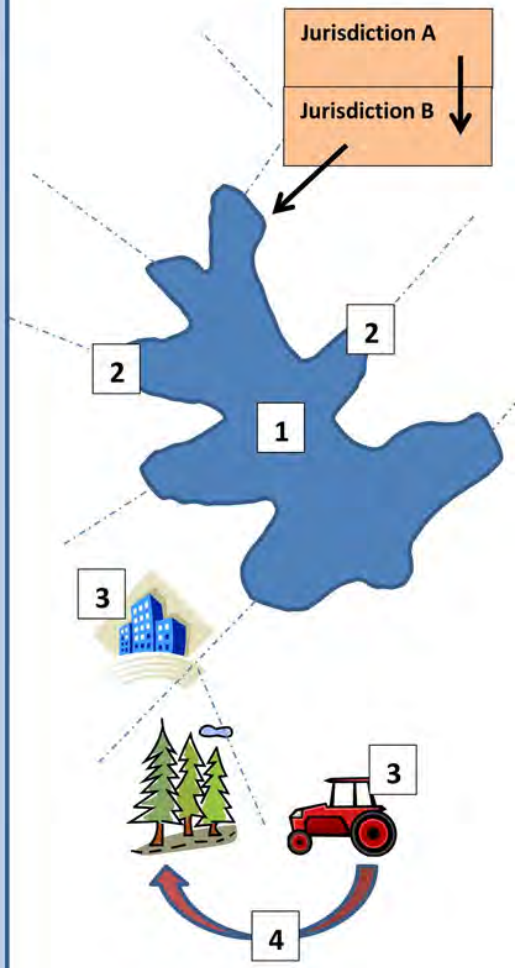
MONITORING FRAMEWORK

1) **Regulatory Compliance=Lake Response**
(Monitor to determine if we are in regulatory compliance)
Evaluating Regulatory Framework
(Determine if framework is appropriate and/or achievable)

2) **Loading to the Lake**
(Monitor to determine what nutrient load is going to lake at lake/watershed boundary)

3) **Source Identification**
(Monitor to determine what are sources (land use))
(Monitor to determine where sources are (geographically)
(Monitor to determine hot spots)
(Monitor to determine jurisdictional loading)

4) **Management Effectiveness/Success**
(Monitor effectiveness of management activities and adapt)
(Monitor to determine which activities are most-effective)



Brief Recap of Activities

- 2nd Full Stakeholder Meeting (Sep 2011)
  - Came back to full group to explain changes
  - Updates from UNRBA, Watershed Oversight Committee, NSAB
  - Presented Monitoring Design Guidelines Template (MDGs) to help answer prioritized objectives with regard to (3) source identification and (4) management effectiveness.
  - Created 5 Subcommittees to develop Monitoring Design Guidelines
    - Ag, Background Sources, BMP Effectivness, Onsite Wastewater, and Stormwater and Existing D
- Subcommittees started meeting regularly (~ monthly) to prioritize objectives and draft MDGs.

Brief Recap of Activities

- **3rd Full Stakeholder Meeting (Feb 2012)**
  - **Wiki Tutorial**
  - **Subcommittee Updates (Agriculture, Background Sources, BMP Effectiveness, Onsite Wastewater, and Stormwater and Existing Development)**
    - **What They've Been Doing (process and how we got where we are)**
    - **Progress of Monitoring Design Guidelines (if applicable)**
    - **Sharing Areas of Confusion and Group Feedback**
    - **Identify Areas of Overlap or Need for Coordination**
  - **Small Group work**
- **Subcommittees continue meeting regularly (~ monthly) to draft MDGs**

Products and Outcomes so Far

1. Comprehensive list of monitoring objectives
2. Wiki
3. Discussed/evaluated current lake monitoring efforts
4. Developed an inventory of monitoring activities
5. Developed conceptual monitoring framework
6. Re-crafted scope; focus on (3) **source identification** and (4) **tracking management effectiveness**
7. Deliverables to be set of **"monitoring design guidelines"**
8. Determined process for developing "mon. design guidelines"
9. Set up subcommittees to develop MDGs
10. Subcommittees meeting regularly
11. **Drafted 12 Monitoring Design Guidelines!!**

Draft Monitoring Design Guidelines

Agriculture

1. Review of Monitoring Studies for Determining Nutrient Inputs from Agriculture

Background Sources

1. Atmospheric Deposition
2. Forest Contributions
3. Monitoring of in-lake nutrient flux

Draft Monitoring Design Guidelines

BMP Effectiveness

1. Evaluate How Vegetated Shelf & Plant Maintenance Influences the Effectiveness of Wet Detention Basins
2. Evaluate the Influence of Clogged Media on the Effectiveness of Sand Filter Stormwater Control Measures
3. Evaluate How Soil Protection/Amendment Influences Surface Runoff, Stormwater Control Measure Performance, and Receiving Water Quality
4. Evaluate the Influence of Clogged Media on the Effectiveness of Bioretention Devices

Draft Monitoring Design Guidelines

Onsite Wastewater

1. Falls Lake Watershed System Survey/Performance Assessment
2. Impact of Geologic/Soil Systems upon the Fate and Transport of Nitrogen and Phosphorous within the Falls Lake Watershed
3. Assessment of On-site Wastewater Treatment Systems Derived Nutrients Transport/Reduction Dynamics in Falls Lake Watershed
4. Effects of Soil Compaction

Air Deposition Presentation

'You two need to go inside and get some fresh air.'

Implementation-Oriented Uses and Users of Water Quality Data

FORMAT

- Panel discussion with DWQ
  - Please be generating content-related questions on the index cards provided during the overviews
  - Limit questions at this time to clarification issues (not content)
- Break
- Q&A with Whole Group

Implementation-Oriented Uses and Users of Water Quality Data

OBJECTIVES

1. Help group understand DWQ's role and what types of data they receive and use;
2. Help group understand DWQ's research priorities as they relate to the Falls Watershed (if any);
3. Help everyone understand how data can and/or will be incorporated into an adaptive management approach;
4. Help DWQ understand what types of data may be generated from proposed Monitoring Design Guidelines;
5. Help group understand data submittal requirements for different types of uses and DWQ's preferred coordination schedule (if coordination needed); and
6. Help everyone recognize the multiple potential uses for data and know how to determine the appropriate end user and data receptor for different projects.

BREAK!

OK BAND! Bring it back to the last position! RUN!
Look at how sluggish they are! They have no energy whatsoever! Bunch of...
Hmm... Watch this...
TEN MINUTE BREAK!
YEEEAAAHHH!

Next Steps

- **Need to have Monitoring Design Guidelines completed by July 31, 2012!!**
- September Meeting
  - Present final Monitoring Design Guidelines
  - Present final Report
  - **CELEBRATE!!**

TRIANGLE J COUNCIL OF GOVERNMENTS

World Class Region

TECHNICAL MEMORANDUM

To: NC Department of Natural Resources

From: Heather Saunders Benson, Senior Planner – Water Resources

Cc: Upper Neuse Water Quality Monitoring Plan Participants

Date: July 26, 2012

Re: Upper Neuse Monitoring Activities Inventory

In 2010, Triangle J Council of Governments began work to partner with stakeholders in the Upper Neuse River Basin to develop a long-term water quality monitoring plan for the Upper Neuse River Basin. This project has aimed directly address the Section 205(j) of the Clean Water Act (of 1987) objective of "determining the nature, extent, and causes of water quality problems…" and also aims to help address the Act's objective of "identifying [the] most cost-effective and locally acceptable facility and non-point measures to meet and maintain water quality standards."

The primary objective of the project is to develop a long-term water quality monitoring plan for water bodies in the Upper Neuse River Basin. Currently, the ability of managers to assess the causes and sources of water quality degradation and effectiveness of management strategies is limited due to lack of consistent and comparable data. The development of a comprehensive monitoring plan aims to address this problem and provide managers with the tools and data necessary to inform corrective and protective actions. The plan has been developed with the involvement of potential implementing agencies and funders, such as local governments, the US Geological Survey, NC State University, research and academic institutions and the NC Division of Water Quality (DWQ). Work being done on the project includes a comprehensive monitoring framework and a set of monitoring design guidelines developed collaboratively with the stakeholders and self-elected subcommittees that address discrete monitoring objectives in five broad categories (Agriculture, Background Sources, BMP Effectiveness, Onsite Wastewater, and Stormwater/Existing Development) .

One important objective of this work has been to inventory and evaluate relevant water quality monitoring efforts, resources, and information to determine what monitoring has already been done in the watershed or is currently ongoing. This memorandum aims to synthesize the information gathered through this project on monitoring activities that have occurred or are occurring in the watershed. This critical piece of knowledge will help identify gaps in monitoring data, encourage regional cooperation, and avoid redundancy in monitoring efforts.

www.tjcog.org

Mailing Address: PO Box 12276, Research Triangle Park, NC 27709
4307 Emperor Boulevard, Suite 110, Durham, NC 27703

919.549.0551
Fax: 919.549.9390

LOCAL GOVERNMENT/LOCAL PARTNERS SURVEY

In order to begin collecting information on monitoring activities, a survey and questionnaire was developed and sent to local governments and other resource groups active in the Upper Neuse River Basin as a "homework assignment". The questionnaire is included below.

HOMEWORK ASSIGNMENT – LOCAL MONITORING ACTIVITIES QUESTIONNAIRE

1. Review Mary Giorgino's (of the USGS) "Current Monitoring in the Upper Neuse Basin" documents (Attachment A). Make corrections and edits as necessary using MS Word's Track
Changes feature and return to Heather Saunders at hsaunders@tjcog.org.

2. If the write-up on your activities does not already address the following, please add information on:
   a. What parameters you are monitoring and what is the monitoring frequency
   b. Where are your monitoring locations?
   c. Your monitoring and data collection methods
   d. Changes in any of these aspects, and why
   e. Your current annual monitoring cost
   f. How long you have been monitoring each location and/or parameter (study duration)

3. In addition, please include any thoughts on the following as an addendum to the document:
   a. What is your current and future capacity is for monitoring?
      i. How much staff time do you put towards it currently on an annual basis?
      ii. Can you maintain this or increase your effort?
   b. Who are your service providers (e.g. labs)? Would you recommend them? Are there any labs you do not recommend?
   c. What do you perceive as your additional data needs?
   d. Any additional thoughts on lessons learned as a result of your current or past monitoring experience.

4. Finally, please supply Heather Saunders (hsaunders@tjcog.org) with a GIS data coverage layer of your current ambient surface water monitoring locations, including any stream gages, and groundwater stations.

Local government staff, as well as local agency staff responded by providing their current monitoring plans in PDF and GIS formats. A collection of reports on local water quality

monitoring activities is provided in Attachment B. In addition, two maps depicting water quality monitoring locations is provided in Attachment C, one with wells, and one without.

LOCAL GOVERNMENT/LOCAL PARTNERS PRESENTATIONS

Local governments and other monitoring groups were also asked to present to the Upper Neuse Water Quality Monitoring Plan stakeholders on their current monitoring activities at the 2nd Working Group meeting on February 1, 2011. Ken Reckhow, USGS, the NCDWQ, the City of Raleigh, the City of Durham, and Wake County all presented on their monitoring activities and were asked to provide some discussion on the following:

1. What monitoring you are currently doing;
2. Why you are doing it;
3. What you've learned and/or modified over time and why;
4. What are your general costs and capacities for monitoring;
5. Any thoughts on service providers; and
6. What you perceive as your missing pieces. What would you like to add?

Monitoring presentation are available on the wiki at http://upperneusewqmonitorng.wikispaces.com/Meeting+Summaries and are also provided in Attachment D.

ATTACHMENT A. CURRENT MONITORING IN THE UPPER NEUSE RIVER BASIN (USGS, 2005, PROVISIONAL)

CURRENT MONITORING IN THE UPPER NEUSE BASIN

Program and Contact Info.	Purpose of Monitoring	No. Sites	Frequency	Description	Data Availability
DWQ Ambient Monitoring System Andrea Thomas NCDENR-DWQ 1621 Mail Service Center Raleigh, NC 27699-1621 919-733-9960 andrea.thomas@ncmail.net	Site--specific, long-term information on significant rivers and streams. Data are evaluated relative to State WQ standards and action levels, and support several DWQ programs, including basinwide planning, 305(b) and 303(d) reporting to EPA, TMDL development, and NPDES permitting.	7	Monthly (biweekly during 2005-2006); Metals & residue quarterly	Typically measure temperature, specific conductance, turbidity, total suspended residue, DO, metals (As, Cd, Cr, Cu, Fe, Pb, Ni, Zn, Al, Hg), fecal coliform, and weather conditions. Additional indicators may be included depending on site-specific concerns. Examples include salinity, Secchi depth, flow, nutrients (NH3, NO2+NO3, TKN, TP), fluoride, sulfate, manganese, color, oil and grease, chlorophyll *a*. Ambient Monitoring System home page (http://h2o.enr.state.nc.us/esb/ams.html) contains a link to a guidance document for downloading data from STORET.	EPA STORET database: www.epa.gov/storet/, or go directly to the Data Warehouse: http://www.epa.gov/storet/dw_home.html DWQ Basin Assessment Reports (may be up to 5 years out of date): http://www.esb.enr.state.nc.us/bar.html
DWQ Ambient Lakes Monitoring Debra Owen or Dianne Reid NCDENR-DWQ 1621 Mail Service Center Raleigh, NC 27699-1621 919-733-6510 debra.owen@ncmail.net dianne.reid@ncmail.net	To collect and analyze data from significant lakes in North Carolina to determine water quality conditions and trends in support of EPA's Clean Lakes Program and Clean Water Initiative; for 305(b) reporting and 303(d) determinations and for other DWQ needs.	23 sites on 8 lakes Rogers Butner/Holt Michie Orange Corporation Ben Johnston Little R Res Falls	Neuse basin is sampled once every 5 years. Each lake is sampled 3 times during the summer (Jun-Aug). Special studies are conducted as needed.	PRIMARY: Temperature, pH, DO, conductance, secchi, TSS, TDS, turbidity, chlorophyll a, total P, ammonia, nitrite+nitrate, TKN, phytoplankton, macrophytes SECONDARY: Metals, chloride, fluoride, calculated total hardness, fecal coliform bacteria, BOD5, pesticides, volatile organics, and water samples for EPA Algal Growth Potential Tests (AGPT); inclusion based on lake classification, known or suspected problems, or DWQ management needs Trophic State Index is computed.	These data are maintained in-house and are used in the DWQ basin assessment reports and in the biennial 305(b) reports to EPA, but not uploaded to STORET. Basin Assessment Reports (may be up to 5 years out of date): http://www.esb.enr.state.nc.us/bar.html or on request to DWQ.
DWQ Benthic Macroinvertebrate Monitoring Eric Fleek or Trish MacPherson NCDENR-DWQ 1621 Mail Service Center Raleigh, NC 27699-1621 919-733-6946	To collect and analyze data from over 1000 sites in North Carolina to assess biological water-quality conditions. Data are used for 305(b) reporting and 303(d) determinations, basinwide assessment summaries, and other DWQ programs.	42 (not all active)	Sites in the Neuse basin are sampled once every 5 years during the summer (Jun-Aug), and next will be sampled in 2005. Special	Sample collection began in 1978. Protocols for sampling different stream types and management purposes are in SOP document at: http://h2o.enr.state.nc.us/esb/BAUwww/benthossop.pdf. Streams are assigned bioclassification ratings of Excellent, Good, Good/Fair, Fair, or Poor based on taxa richness and pollution tolerance values (http://h2o.enr.state.nc.us/esb/BAU.html).	DWQ keeps records in-house. Data are incorporated in the DWQ basin assessment reports and in the biennial 305(b) reports to EPA, but not uploaded to STORET. Benthos data are available online in the DWQ Basin Assessment Reports:

CURRENT MONITORING IN THE UPPER NEUSE BASIN

eric.fleek@ncmail.net trish.macpherson@ncmail.net			studies are conducted as needed, such as for TMDLs or EEP targeted watersheds.	Results are used to assess the impacts of point and non-point sources of pollution as part of the basinwide monitoring program; to define High Quality or Outstanding Resource Waters; to support enforcement of stream standards; and to measure improvements associated with management actions. Temperature, conductivity, pH, DO), and habitat characteristics (since 1999) also are measured during benthic sampling.	http://www.esb.enr.state.nc.us/bar.html or on request to the DWQ.
DWQ Fish Community Monitoring Bryn Tracy or Trish MacPherson NCDENR-DWQ 1621 Mail Service Center Raleigh, NC 27699-1621 919-733-6946 bryn.tracy@ncmmail.net trish.macpherson@ncmail.net	To assess the ecological integrity of streams and rivers by evaluating fish communities. Data are used for 305(b) reporting and 303(d) determinations, basinwide assessment summaries, and other DWQ programs.	8 active; 5 inactive	Active sites are sampled once every 5 years during April, and next will be sampled in 2005. Special studies also are conducted as needed.	At each stream site, fish within a 200-meter reach are collected with the aid of backpack electrofishing equipment. Standard Operating Procedures are followed: http://h2o.enr.state.nc.us/esb/BAUwww/IBI%20Methods%202001.pdf. Fish community metrics are computed and compiled into an Index of Biotic Integrity (IBI) score. Metrics include measures of species richness, community and trophic composition, abundance, and health/condition.	DWQ keeps records in-house. Data are incorporated in the DWQ basin assessment reports and in the biennial 305(b) reports to EPA, but not uploaded to STORET. Data are available online in the DWQ Basin Assessment Reports: http://www.esb.enr.state.nc.us/bar.html or on request to the ESB.
DWQ Fish Tissue Monitoring Mark Hale or Trish MacPherson NCDENR-DWQ 1621 Mail Service Center Raleigh, NC 27699-1621 919-733-6946 mark.hale@ncmmail.net trish.macpherson@ncmail.net	To assess levels of selected contaminants in fish tissue. Data are used for 305(b) reporting and 303(d) determinations, basinwide assessment summaries, other DWQ programs, and by the Department of Health to set fish-consumption advisories.	6	Each of the sites has been sampled once. More than one species may have been collected at each site.	Metals--mercury, arsenic, chromium, copper, nickel, lead, zinc; Organics--dioxin, pesticides, and PCBs. Standard Operating Procedures are followed: http://h2o.enr.state.nc.us/esb/BAUwww/IBI%20Methods%202001.pdf. Analytical results are compared to FDA action levels, EPA screening values, or criteria set by the NC Health Director.	Results can be viewed at: http://h2o.enr.state.nc.us/esb/fish_tissue_results.html. Current fish-consumption advisories in North Carolina are posted at: http://www.epi.state.nc.us/epi/fish/. Data are incorporated in the Basin Assessment Reports: http://www.esb.enr.state.nc.us/bar.html.

CURRENT MONITORING IN THE UPPER NEUSE BASIN

NPDES Discharge In-stream Monitoring NCDENR-DWQ Central Files Archdale Building 512 N. Salisbury St. Raleigh, NC 27604 NCDENR-DWQ Point Source Compliance and Enforcement Unit 1617 Mail Service Center Raleigh, NC 27699-1617 919 733-5083 dwqpscu@ncmail.net	Compliance with NPDES permit requirements. Extensive effluent sampling is required. In-stream monitoring of points upstream and downstream from outfalls varies considerably among permittees	16 NPDES wastewater permits 14 with in-stream monitoring	Varies among permittees, constituents, and season. Most frequent is 3 times per week; least frequent is monthly	Municipal or domestic wastewater dischargers usually monitor water temperature and dissolved oxygen in receiving waters, both upstream and downstream from their outfalls. Larger dischargers, including the Hillsborough WWTP and North Durham WRF, monitor fecal coliforms and conductance upstream and downstream; North Durham also monitors nutrients and chlorophyll *a* at a downstream site in Ellerbe Creek. Water treatment plants monitor turbidity weekly or quarterly. Groundwater remediation permittees have no in-stream monitoring requirements.	In-stream monitoring data are not available online or electronically. These data are reported to the DWQ Point Source Compliance and Enforcement Unit via facility daily monitoring reports, and hard copies are stored in Central Files in the Archdale Building, Raleigh. Effluent data are available online via the NC Basinwide Information Management System. Dischargers maintain data files for several years.
DEH Public Water Supply Monitoring Linda Raynor Public Water Supply Section Div. of Env. Health 1634 Mail Service Center Raleigh, NC 27699-1634 919-715-3225 linda.raynor@ncmail.net	Each public water supplier monitors its raw and finished water. The PWS reviews results to assess performance in removing contaminants of concern and to ensure compliance with drinking-water regulations. The PWS also tracks turbidity and bacteria in source water for the Area Wide Optimization Program, whose goal is to produce ultra-low turbidity finished water.	8 surface-water systems; Numerous ground-water systems, which were not included in this study	Influent--once to several times a day for most constituents Ambient Source Water monitoring is extremely variable.	Most raw-water influents are monitored daily for temperature, pH, turbidity, color, carbon dioxide, total alkalinity, total hardness, dissolved oxygen, iron, manganese, fluoride, chloride, total phosphate, total coliform; paired set of TOC at least once per month. Facilities report daily averages to the PWS Compliance Branch via their monthly operating reports. Ambient monitoring of source waterbodies is more variable. Hillsborough samples Lake Ben Johnston daily; Durham samples Lake Michie and Little River Reservoir monthly; Raleigh samples 4 sites in Falls Lake quarterly.	Raw and source-water data are not available online. Raw-water TOC, DOC and UV254 data are electronically tabulated (Martha Fillinger at 919-715-3243). The Compliance Branch tracks source-water turbidity and total coliforms in an electronic database (Brad Cole, 919-715-3221). Recent source-water data reside in paper reports at the PWS Central Files, Parker Lincoln Building, 2728 Capital Blvd, Raleigh, NC, 27604. Files older than 5 years are archived off-site. EPA downloads the PWS database quarterly, which includes raw-water TOC, UV254, DOC (if collected), and all finished-water data. Each treatment plant also keeps copies of monitoring records.

CURRENT MONITORING IN THE UPPER NEUSE BASIN

Hillsborough Water Plant Russell Bateman, Superintendent City of Hillsborough PO Box 429 Hillsborough, NC 27278 919-732-3621	Support daily operations; compliance reports to DEH PWS	1 at Lake Ben Johnston Intake	Daily	Temperature, pH, turbidity, total alkalinity, total hardness, iron, manganese, fecal coliform, TOC	Report to DEH Public Water Supply monthly. Keep data on file in Engineering (3 years) and at Water Plant (indefinitely). Data are not available electronically or online.
Durham Water Supply and Treatment Renee Lawrence, Superintendent Water Supply and Treatment Division Department of Water Management 1600 Mist Lake Drive Durham, NC 27704 919-560-4349	Support daily operations; compliance reports to DEH PWS	1 at Lake Michie intake and 1 at Little River Reservoir intake	Monthly	Monthly at reservoirs—physical parameters, metals, pH, DO, UV254, TOC, DOC. Raw influent is measured daily at the treatment plants for metals & the usual constituents (temperature, pH, turbidity, color, carbon dioxide, total alkalinity, total hardness, dissolved oxygen, iron, manganese, fluoride, chloride, total phosphate, total coliform); weekly for TOC, DOC, and UV254.	Results are reported to PWS monthly. Data are not available online. For general information, see Durham Water Supply and Treatment Division web page: http://www.ci.durham.nc.us/departments/environ/water_supply.cfm. Durham's annual water quality report, *Tap Into Quality*, presents updates on Durham's drinking water and treatment processes, but no raw-water data.
Raleigh Public Utilities Dale Crisp Public Utilities Dept One Exchange Plaza 219 Fayetteville St. Mall, Suite 620 Raleigh, NC 27601 919-857-4540 dale.crisp@ci.raleigh.nc.us	Support daily operations; compliance reports to DEH PWS	4 sites in Falls Lake	Quarterly	Constituents include VOCs, SOCs, nutrient fractions, inorganics, trace metals, TOC, DOC, bromide, chlorophyll a, physical parameters, secchi, alkalinity, turbidity, phytoplankton community, fecal coliform, enterococcus. In addition, Raleigh Public Utilities monitors enterococcus monthly at 4 reservoir sites.	Ambient monitoring data are summarized annually and are for in-house use only. These data are not reported to any other agencies, published, or made available online.

CURRENT MONITORING IN THE UPPER NEUSE BASIN

Raleigh Stormwater Management Mac Smith 222 W. Hargett St. P.O. Box 590 Raleigh, NC 27602 919-890-3030	To examine storm water impacts on stream biology at 23 sites in the Raleigh area	1 in the Upper Neuse	Annually	Relative abundance and taxonomic analysis. Site is a Lower Barton Creek.	Could not find data nor access details on the program online. Organizational structure and web pages have changed since 4/2004
Durham Stormwater Ambient Chris Outlaw Durham Stormwater Services 101 City Hall Plaza Durham, NC 27701 919-560-1230, ext. 223 chris.outlaw@durhamnc.gov	Ambient monitoring of selected physical, chemical and microbiological parameters is conducted at 34 sites on a monthly basis. Data are used to assess trends and to help determine causes of stream impairment.	19 in the Upper Neuse	Monthly sampling beginning in 2004; quarterly prior to 2004 (program began in 1996)	Constituents include water temperature, DO, pH, conductivity, turbidity, BOD, TSS, ammonia, nitrite+nitrate, TKN, TON, total phosphorus, hardness, copper, zinc, fecal coliform bacteria. Samples are analyzed at the South Durham WRF (Farrington Plant). When water-quality problems are observed, the City may follow-up with intensive monitoring (of fecal coliforms) to locate "hotspots" or illicit discharges. They use benthic and chemistry data to compute a water-quality index rating for stream sites. At present, this is used only in-house, but may eventually be posted on the web to inform the general public.	The data are maintained in an electronic database and paper copies but are not available online. Report elements required for NPDES Phase I permit compliance to DWQ.
Durham Stormwater Benthic Robert Louque Durham Stormwater Services 101 City Hall Plaza Durham, NC 27701 919-560-1230, ext. 222 robert.louque@durhamnc.gov	The City uses biological assessment of benthic macroinvertebrates at 19 sites in the Durham area to assess stream biological conditions and to compute water-quality index ratings..	10 in the Upper Neuse	Annually, beginning in 2000	Sites are monitored at least annually in the summer, following the DWQ protocol for full-scale benthic sampling. Counts and taxonomic analysis are performed. Biological specimens are archived.	The data are maintained in an electronic database and paper copies but are not available online. The data are not published or reported to another agency at this time.

CURRENT MONITORING IN THE UPPER NEUSE BASIN

USGS Real-Time Streamflow Ramona Traynor, Information Officer U.S. Geological Survey 3916 Sunset Ridge Road Raleigh, NC 27607 919-571-4096 rtraynor@usgs.gov	Monitor stream stage and discharge for use by multiple agencies	7 (10 were active in 2003) 1 site non-RT	Continuous at 15-minute intervals	Stream stage and discharge are measured every 15 minutes. Historical records and statistics also are available. 1 site (Falls Lake) is a stage-only gage. Electronic records are maintained in local and national databases in perpetuity. Paper records are maintained on-site for 10 years, and then are archived at the Federal Records Center in Atlanta, Georgia.	Data are entered into the National Water Information System and can be accessed online at: http://waterdata.usgs.gov/nwis/rt (national data) or http://waterdata.usgs.gov/nc/nwis/current/?type=flow (NC sites only). The Information Officer will provide assistance with data requests.
USGS Water Quality Ramona Traynor, Information Officer U.S. Geological Survey 3916 Sunset Ridge Road Raleigh, NC 27607 919-571-4096 rtraynor@usgs.gov	Monitor water quality at selected sites in cooperation with local and state agencies. Data are used for assessment of water-quality conditions and long-term trends and loads, and to assess the effects of large- and small-scale management actions.	9 active 3 more discont., but with recent data	Varies from 4 to 9 times per year.	The active sites have been monitored since 1988, as part of the Triangle Area Water Supply Monitoring and the Treyburn projects. The 3 NAWQA sites were sampled only a few times, but for a broad suite of constituents. Physical parameters, nutrients, suspended sediment, major ions, metals, stream stage and discharge are measured. Three sites were sampled for emerging contaminants in 2004. Electronic records are maintained in local and national databases in perpetuity. Paper records are maintained on-site for 10 years, and then are archived at the Federal Records Center in Atlanta, Georgia.	Data are entered into the National Water Information System and can be accessed online at: http://waterdata.usgs.gov/nwis/ The Information Officer will provide assistance with data requests. Data are also published in annual data reports and in interpretive project reports.

CURRENT MONITORING IN THE UPPER NEUSE RIVER BASIN

Contact: **NCDWQ Ambient Monitoring System** Date: March. 7, 2005

1. Table with list of site names and location information

Station Number	Station Location	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	County	Stream Classification	Date Established
J0770000	ENO RIV AT US 501 NR DURHAM	36.07197	-78.90864	DURHAM	WS-IV NSW	8/7/1968
J0810000	ENO RIV AT SR 1004 NR DURHAM	36.07254	-78.8627	DURHAM	WS-IV NSW	8/7/1968
J0820000	LITTLE RIV AT SR 1461 NR ORANGE FACTORY	36.14159	-78.9193	DURHAM	WS-II NSW CA	6/1/1988
J1070000	FLAT RIV AT SR 1614 NR QUAIL ROOST	36.20021	-78.88615	DURHAM	WS-III NSW	11/26/1980
J1100000	FLAT RIV AT SR 1004 NR WILLARDSVILLE	36.13186	-78.82784	DURHAM	WS-IV NSW	1/25/1979
J1210000	KNAP OF REEDS CRK AT WWTP OUTFALL NR BUTNER	36.12797	-78.79852	GRANVILLE	WS-IV NSW CA	12/4/1968
J1330000	ELLERBE CRK AT SR 1636 NR DURHAM	36.05949	-78.83224	DURHAM	WS-IV NSW CA	8/14/1968

For information on the Ambient Monitoring System and links to site lists by basin: http://h2o.enr.state.nc.us/esb/ams.html.
Includes link to STORET for data retrieval & the DWQ's QAPP

2. Brief description of why and how these sites are monitored

Purpose: The AMS provides site-specific, long-term water quality information on significant rivers, streams, and estuaries throughout the state. Data are evaluated relative to State WQ standards and action levels, and support several DWQ programs, including Basinwide Water Quality Management Plan development, biennial 305(b) and 303(d) reporting to EPA, TMDL development, and development of NPDES permit limits.

No. of sites: 7 in Upper Neuse

Begin date: Varies; as early as 1968 for some sites

Frequency: Usually monthly; more frequent as needed for specific management issues (currently bi-weekly for nutrients, TSS, physical parameters through Dec. 2006). Metals and residue are sampled quarterly.

Constituents: The following core indicators are measured at all stations: water temperature, specific conductance, turbidity, total suspended residue, DO, metals (As, Cd, Cr, Cu, Fe, Pb, Ni, Zn, Al, Hg), fecal coliform, and weather conditions. Additional indicators may be included depending on site-specific concerns such as stream classification, discharge types, and historical or suspected issues. Examples of

these site-specific indicators include salinity, Secchi depth, flow, nutrients (NH3, NO2+NO3, TKN, TP), fluoride, sulfate, iron, manganese, color, oil and grease, chlorophyll *a*. Metals and residue are sampled quarterly at all stations. All other indicators are sampled at least monthly.

3. Contact person in the organization for monitoring information.
Name: Andrea Thomas
Address: NCDENR-DWQ Environmental Sciences Branch
1621 Mail Service Center
Raleigh, NC 27699-1621
Phone: 919-733-9960
Email: andrea.thomas@ncmail.net

4. How long do you keep WQ data records on-site?
At least 5 years, at DWQ Environmental Sciences Branch, 4401 Reedy Creek Road, Raleigh, NC 27607

5. To whom are the data reported and is it available online?
Data are uploaded to EPA's Modernized STORET database: www.epa.gov/storet/

6. Web address for online data or publications from your monitoring efforts.
EPA STORET database: www.epa.gov/storet/, or go directly to the Data Warehouse: http://www.epa.gov/storet/dw_home.html .

Ambient Monitoring System home page (http://h2o.enr.state.nc.us/esb/ams.html) contains a link to a guidance document for downloading AMS data from STORET.

Statistical summaries (n, min, max, 10, 25, 50, 75, 90 percentiles) are available in the DWQ Basin Assessment Reports: http://www.esb.enr.state.nc.us/bar.html, but may be up to 5 years out of date.

CURRENT MONITORING IN THE UPPER NEUSE RIVER BASIN

Contact: **NC DWQ Ambient Lakes Monitoring** Date: Jan. 31, 2005

1. Table with list of site names and location information
Provided by Debra Owen, email dated; phone 919-733-6510:

Lake	Site	Latitude (North)	Longitude (West)
Falls of the Neuse Reservoir	NEU010	36.0772083	78.7922309
	NEU013	36.0709344	78.7794415
	NEU013B	36.0624886	78.7712715
	NEU0171B	36.0217637	78.7415448
	NEU018E	36.0294927	78.7154544
	NEU019C	36.0547705	78.6754455
	NEU019E	35.0214461	78.6851910
	NEU019L	35.9996257	78.6516765
	NEU019P	35.9787538	78.6328542
	NEU020D	35.9532102	78.5840726
Lake Rogers	NEU017A	36.1308382	78.7038201
Lake Butner	NEU007B	36.1690130	78.7721904
Lake Michie	NEU0061G	36.1712194	78.8584613
	NEU0061J	36.1605949	78.8402947
	NEU0061L	36.1580727	78.8262296
Lake Orange	NEU00B2	36.1568926	79.1427157
	NEU00B4	36.1480432	79.1497453
Corporation Lake	NEU00C	36.0931983	79.1426488
	NEU00C1	36.0848608	79.1415684
Lake Ben Johnson	NEU00D	36.0711070	79.1308853
Little River Reservoir	NEU006S	36.1349453	78.8905080
	NEU006T	36.1272249	78.8744844
	NEU006U	36.2244683	78.8766433

2. Brief description of why and how these sites are monitored

Purpose: To collect and analyze data from approximately 160 significant lakes in North Carolina to determine water quality conditions and trends in support of EPA's Clean Lakes Program and Clean Water Initiative. Status and trends in lake water quality for 305(b) reporting and 303(d) determinations; Trophic State Index is computed.

No. of sites: Approximately 1300 sites on 160 lakes; 23 sites on 8 lakes in Upper Neuse

Begin date: Late 1960's

Frequency: Routine ambient sampling is conducted on a river basin schedule, with each river basin sampled once every five years. Approximately 35 lakes per year are monitored 3 times during the summer sampling season (June through August). Special lake water quality studies also are conducted as needed.

Constituents or classes:

PRIMARY: Temperature, pH, DO, conductance, secchi, TSS, TDS, turbidity, chlorophyll a, total P, ammonia, nitrite+nitrate, TKN, phytoplankton, macrophytes

SECONDARY: Metals, chloride, fluoride, calculated total hardness, fecal coliform bacteria, BOD5, pesticides, volatile organics, and water samples for EPA Algal Growth Potential Tests (AGPT); inclusion based on lake classification, known or suspected problems, or DWQ management needs

3. Contact person in the organization for monitoring information.

Name: Debra Owen or Dianne Reid
Address: NCDENR-DWQ Environmental Sciences Branch
1621 Mail Service Center
Raleigh, NC 27699-1621
Phone: 919-733-6510
Email: debra.owen@ncmail.net or dianne.reid@ncmail.net

4. How long do you keep WQ data records on-site?

Indefinitely. Access and Excel databases are maintained in the DWQ Environmental Sciences Branch

5. To whom are the data reported, and is it available online?

DWQ keeps records in-house. Data are incorporated in the DWQ basin assessment reports and in the biennial 305(b) reports to EPA, but not uploaded to STORET

6. Web address for online data or publications from your monitoring efforts.

Raw data are available online in the DWQ Basin Assessment Reports: http://www.esb.enr.state.nc.us/bar.html or on request to the ESB. Basin reports may be up to 5 years old.

CURRENT MONITORING IN THE UPPER NEUSE RIVER BASIN

Contact: **NCDWQ Benthic Macroinvertebrate Monitoring** Date: March 11, 2005

1. Table with list of site names and location information.
Provided by Mark Hale, NCDWQ Biological Assessment Unit, phone 919-733-6946
See attached pages from 2001 Neuse Basinwide Assessment Report.

2. Brief description of why and how these sites are monitored
Bioclassification criteria have been developed by the NCDWQ Biological Assessment Unit (http://h2o.enr.state.nc.us/esb/BAU.html). Criteria are based on taxa richness and pollution tolerance values. Streams are assigned bioclassification ratings of Excellent, Good, Good/Fair, Fair or Poor. These bioclassifications are used to assess the impacts of point and non-point sources of pollution and are an integral part of the basinwide monitoring program. Biological information is also used to define High Quality or Outstanding Resource Waters, to support enforcement of stream standards, and to measure improvements associated with management actions.

Purpose: To collect and analyze data from over 1000 sites in North Carolina to assess biological water-quality conditions. Data are used for 305(b) reporting and 303(d) determinations, basinwide assessment summaries, and other DWQ programs.
No. of sites: Approximately routine 600-700 sites in NC; __ sites in Upper Neuse
Begin date: First samples were collected in 1978
Frequency: Routine sampling is conducted on a river basin schedule, with each river basin sampled once every five years. Approximately 120-140 sites per year are monitored during the summer season (June-August). Special studies also are conducted as needed, such as for TMDL development or EEP targeted watershed studies.
Constituents or classes: Temperature, conductivity, pH, DO), habitat characteristics (since 1999), in addition to benthos collection. They have 5 different benthic-sampling protocols for different stream types and management purposes (see SOP document)

The benthic macroinvertebrate SOP (PDF format) can be accessed at:
http://h2o.enr.state.nc.us/esb/BAUwww/benthossop.pdf.

3. Contact person in the organization for monitoring information.
Name: **Eric Fleek** or Trish MacPherson
Address: NCDENR-DWQ Environmental Sciences Branch
1621 Mail Service Center
Raleigh, NC 27699-1621
Phone: 919-733-6946
Email: eric.fleek@ncmail.net

4. How long do you keep WQ data records on-site?
Indefinitely—electronic and hard copy. Databases are maintained in the DWQ Environmental Sciences Branch.

5. To whom are the data reported, and is it available online?
DWQ keeps records in-house. Data (including the in-stream WQ data) are incorporated in the DWQ basin assessment reports and in the biennial 305(b) reports to EPA, but are not uploaded to STORET.

6. Web address for online data or publications from your monitoring efforts.
Benthos data are available online in the DWQ Basin Assessment Reports: http://www.esb.enr.state.nc.us/bar.html or on request to the ESB. Basin reports may be up to 5 years old. The basin sampling schedule can be viewed at: http://h2o.enr.state.nc.us/basinwide/basinwide_wq_planning.htm.

CURRENT MONITORING IN THE UPPER NEUSE RIVER BASIN

Contact: **NC DWQ Fish Community Monitoring** Date: March 11, 2005

1. Table with list of site names and location information.
Provided by Mark Hale, phone 919-733-6946, 2000

Waterbody	Location	County
Deep Creek	SR 1734	Person
Eno River	SR 1336	Orange
North Fork Little River	SR 1461	Durham
North Flat River	SR 1715	Person
South Fork Little River	SR 1461	Durham
South Flat River	NC 157	Person
Smith Creek	SR 1710	Granville
Upper Barton Creek	NC 50	Wake

2. Brief description of why and how these sites are monitored

Purpose: To assess the ecological integrity of streams and rivers by evaluating fish communities. Data are used for 305(b) reporting and 303(d) determinations, basinwide assessment summaries, and other DWQ programs.
No. of sites: 8 active sites in Upper Neuse; 5 inactive sites
Begin date: Varies by site. Earliest is Deep Creek in 1990. Several others sampled in 1995, a few in 1998 and 1999, and all active sites sampled in 2000.
Frequency: Routine sampling is conducted on a river basin schedule, with each river basin sampled once every five years. All active sites are sampled during April, weather permitting. Special studies also are conducted as needed.
Constituents or classes: Fish community metrics are computed and compiled into an Index of Biotic Integrity (IBI) score. Metrics include measures of species richness, community and trophic composition, abundance, and health/condition.

At each stream site, fish within a 200-meter reach are collected with the aid of backpack electrofishing equipment. Standard Operating Procedures are followed: http://h2o.enr.state.nc.us/esb/BAUwww/IBI%20Methods%202001.pdf.

3. Contact person in the organization for monitoring information.
Name: **Bryn Tracy**
Address: NCDENR-DWQ Environmental Sciences Branch
1621 Mail Service Center
Raleigh, NC 27699-1621
Phone: 919-733-6946
Email: bryn.tracy@ncmail.net

4. How long do you keep WQ data records on-site?
Indefinitely. Databases are maintained in the DWQ Environmental Sciences Branch.

5. To whom are the data reported, and is it available online?
DWQ keeps records in-house. Data are incorporated in the DWQ basin assessment reports and in the biennial 305(b) reports to EPA, but not uploaded to STORET.

6. Web address for online data or publications from your monitoring efforts.
Data are available online in the DWQ Basin Assessment Reports: http://www.esb.enr.state.nc.us/bar.html or on request to the ESB. Basin reports may be up to 5 years old. The basin sampling schedule can be viewed at: http://h2o.enr.state.nc.us/basinwide/basinwide_wq_planning.htm.

CURRENT MONITORING IN THE UPPER NEUSE RIVER BASIN

Contact: **NC DWQ Fish Tissue Monitoring** Date: March 11, 2005

1. Table with list of site names and location information.
Provided by Mark Hale, phone 919-733-6946

SITE DESCRIPTION	COUNTY	DATE SAMPLED
Little River at Orange Factory	Durham	4/18/1990
Deep Creek at SR-1734	Person	7/19/1990
Falls of the Neuse Reservoir	Wake	8/31/1990
Falls Lake at NC-50	Wake	5/22/1995
Ellerbe Cr. at SR 1632	Durham	7/25/1995
Eno River off SR1004	Durham	7/21/2003

2. Brief description of why and how these sites are monitored

Screening (or Tier I) studies and Intensive (Tier II) studies are conducted as needed. Screening studies identify sites where commonly eaten fish species are contaminated. Intensive studies seek to characterize the magnitude and geographical extent of contamination. Analytical results are compared to FDA action levels, EPA screening values, or criteria set by the NC Health Director.

Purpose: To assess levels of selected contaminants in fish tissue. Data are used for 305(b) reporting and 303(d) determinations, basinwide assessment summaries, other DWQ programs, and by the Department of Health to set fish-consumption advisories.
No. of sites: 6 sites in the Upper Neuse
Begin date: 1990
Frequency: Each of the sites has been sampled once. More than one species may have been collected at each site.
Constituents or classes: Metals-- mercury, arsenic, chromium, copper, nickel, lead, zinc; Organics, including dioxin, pesticides, and PCBs.
Standard Operating Procedures are followed:
http://h2o.enr.state.nc.us/esb/BAUwww/IBI%20Methods%202001.pdf.
Electrofishing is used to collect sufficient fish to make up a sample.

3. Contact person in the organization for monitoring information.
Name: **Mark Hale**
Address: NCDENR-DWQ Environmental Sciences Branch
1621 Mail Service Center
Raleigh, NC 27699-1621
Phone: 919-733-6946
Email: mark.hale@ncmail.net

4. How long do you keep WQ data records on-site?
Indefinitely. Databases are maintained in the DWQ Environmental Sciences Branch

5. To whom are the data reported, and is it available online?
DWQ keeps records in-house. Data are incorporated in the DWQ basin assessment reports and in the biennial 305(b) reports to EPA, but not uploaded to STORET

6. Web address for online data or publications from your monitoring efforts.
A listing of fish tissue contaminant samples organized by river basin can be viewed at: http://h2o.enr.state.nc.us/esb/fish_tissue_results.html.
These data also are used by the NC Department of Health for issuing fish consumption advisories. Current fish-consumption advisories in North Carolina are posted at: http://www.epi.state.nc.us/epi/fish/.

Data also are incorporated in the DWQ Basin Assessment Reports: http://www.esb.enr.state.nc.us/bar.html. Basin reports may be up to 5 years old. The basin sampling schedule can be viewed at: http://h2o.enr.state.nc.us/basinwide/basinwide_wq_planning.htm.

CURRENT MONITORING IN THE UPPER NEUSE RIVER BASIN

Contact: **NPDES Compliance Monitoring (DWQ)** Date: March. 10, 2005
DWQ Point Source Compliance and Enforcement Unit:
http://h2o.enr.state.nc.us/psceu/index.htm

1. Table with list of site names and location information.
Obtained from DWQ Basinwide Information Management System:
http://h2o.enr.state.nc.us/bims/

FACILITY	COUNTY	TYPE_	RECEIVING_	IN-STREAM MONITORING
Wildwood Green WWTP	Wake	100% Domestic < 1MGD	Lower Barton Creek	D,U; temperature, DO; weekly winter, 3X/week summer
Hawthorne Subdivision WWTP	Wake	100% Domestic < 1MGD	Upper Barton Creek	D,U; temperature, DO; weekly
Waterfall Plantation WTP	Wake	Water Plants and Water Conditioning	Horse Creek	D,U; turbidity; quarterly
W P Ballard & Company	Durham	Groundwater Remediation	Ellerbe Creek	none
Arbor Hills Mobile Home Park	Orange	100% Domestic < 1MGD	Stony Creek	D,U; temperature, DO; weekly
Lake Ridge Aero Park	Durham	100% Domestic < 1MGD	Panther Creek	D,U; temperature, DO; weekly
Days Inn - Durham	Durham	100% Domestic < 1MGD	Ellerbe Creek	D,U; temperature, DO; weekly
Durham Quarry	Durham	Groundwater Remediation	Eno River	none
Orange-Alamance Water System WTP	Orange	Water Plants and Water Conditioning	Eno River	D,U; turbidity; weekly
Heather Glen WTP	Durham	Water Plants and Water Conditioning	Sevenmile Creek	D,U; turbidity; weekly
Grande Oak Subdivision WWTP	Durham	Discharging 100% Domestic < 1MGD	Crooked Creek	D,U; DO; weekly
Creedmoor WTP	Granville	Water Plants and Water Conditioning	Ledge Creek	D,U; turbidity; weekly
John Umstead WTP	Granville	Water Plants and Water Conditioning	Knap of Reeds Creek	D,U; turbidity; weekly
Eaton Corp - Roxboro	Person	Industrial Process & Commercial WW	North Flat River	D; temperature; monthly
North Durham WRF	Durham	Municipal Wastewater, Large	Ellerbe Creek	D,U: temp., DO, cond., fecal coli. weekly in winter and 3X/week in summer; D: temp., DO, cond., fecal coli., ammonia, total P, ortho P, total N, TKN, chl a weekly or 3X/week in summer
Hillsborough WWTP	Orange	Municipal Wastewater, Large	Eno River	D,U: temperature, DO, conductance, fecal coliform weekly in winter and 3X/week in summer
John Umstead Hospital WWTP	Granville	Municipal Wastewater, Large	Knap of Reeds Creek	D,U; temperature, DO; weekly winter, 3X/week summer

2. Brief description of why and how these sites are monitored
Purpose: Effluents and receiving waters are monitored to ensure compliance with permit limits and in-stream water-quality standards.
No. of sites: 16 active permittees; 14 with in-stream monitoring requirments
Begin date: Varies among facilities

Frequency/Process: Monitoring requirements depend on the class of facility and thus vary a great deal in terms of parameters and frequency. Upstream/downstream monitoring requirements are assigned during permit issuance (Point Source Branch, Eastern NPDES Program), as are the effluent monitoring requirements. Each month, facilities report results to the DWQ Point Source Compliance and Enforcement Unit using the required "Daily Monitoring Report" (DMR) forms (http://h2o.enr.state.nc.us/NPDES/documents/DMRU-D.pdf).

Constituents or classes: Municipal or domestic wastewater dischargers usually monitor water temperature and dissolved oxygen in receiving waters, both upstream and downstream from their outfalls. Larger dischargers, including the Hillsborough WWTP and North Durham WRF, monitor fecal coliforms and conductance upstream and downstream; North Durham also monitors nutrients and chlorophyll *a* at a downstream site in Ellerbe Creek. Water treatment plants monitor turbidity weekly or quarterly. Groundwater remediation permittees have no in-stream monitoring requirements.

3. Contact person in the organization for monitoring information (raw water).
Name: Shannon Langley
Address: NCDENR-DWQ Point Source Compliance and Enforcement Unit
1621 Mail Service Center
Raleigh, NC 27699-1621
Phone: 919-733-5083
Email: shannon.langley@ncmail.net

4. How long do you keep WQ data records on-site?
DMR's are permanently stored in DWQ Central Files, organized by NPDES permit number and year. Central Files is located in the basement of the Archdale Building in Raleigh.

5. To whom are the data reported, and is it available online?
Each NPDES facility completes its DMR's and mails them to DWQ Central Files, where they are date-stamped upon arrival. The DMR's then are sent to data processing assistants in DWQ for manual entry into BIMS. Only effluent data are entered into the database. NPDES upstream/downstream monitoring data are not available in BIMS. These data are currently available only through Central Files in hard copy form. DWQ Central Files is located in the basement of Archdale Building, 512 N. Salisbury Street, Raleigh.

6. Web address for online data or publications from your monitoring efforts.
NPDES upstream/downstream monitoring data are not available online. To view effluent data, access the BIMS web site: http://h2o.enr.state.nc.us/bims/.

Dischargers have to keep data on file at their facilities for an established period (3-5 years), so one could also contact them directly for their monitoring data.

CURRENT MONITORING IN THE UPPER NEUSE RIVER BASIN

Contact: **NCDENR Public Water Supply Branch of DEH** Date: March. 10, 2005
http://www.deh.enr.state.nc.us/pws/index.htm

Amy Axon, Source Water Protection Program, 715-0674
Brad Cole, Compliance Branch, 715-3221
Diane Williams, Compliance Branch, 715-3220
Bob Midgette, Protection and Enforcement Branch 715-3224
Linda Raynor, Compliance Branch , 715-3225
Michael Douglas, Raleigh Regional Office, 571-4700, ext. 299; 3/9/05
Sherry MacQueen, Source Water Protection Program, 715-9563; 3/9/05

1. Table with list of site names and location information.
(Obtained from DWQ. We included only surface-water intakes.)

PWSID	STREAM NAME	CLASS	MONITORING	CONTACT
0368020	Eno River (Corporation Lake)	WS-II NSW	Daily, influent--pH, temperature, turbidity, alkalinity, hardness, iron, manganese, total coliform, TOC (weekly), NOT nitrate, phosphate, or DO. Keep 10 years worth of data on-site, then dispose of it.	Orange-Alamance Water System Inc.; Fay Metcalf, 919-563-6212; 5900 US 79 Hwy, Mebane; Roger Hellard, Water Plant Supervisor, 919-732-7812
0368015	Eno River (Lake Ben Johnston)	WS-II NSW	Detailed, daily monitoring at the raw water pump station. See Hillsborough summary.	Kenny Keel, Town Engineer/Utilities Director, Hillsborough, 919-732-1270 ext. 75, kenny.keel@hillsboroughnc.org; Russell Bateman is the WTP Superintendent, 919-732-3621
0332010	Eno River (Lower)	WS-IV NSW	Durham emergency WS near Teer Quarry; No monitoring	Renee Lawrence, Superintendent, Div. of Water Supply and Treatment, 919-560-4349; James Fuller, Superintendent, Brown WTP, 919-560-4362
0392010	Falls Lake	WS-IV NSW	Detailed, daily monitoring of influent. Quarterly monitoring at 4 ambient sites in Falls Lake. See Raleigh Public Utilities summary.	Larry McMillan, City of Raleigh, Public Utilities, E.M. Johnson Water Treatment Plant, 919-870-2870. For data, contact Dale Crisp, Director, Public Utilities, 919-857-4540, dale.crisp@ci.raleigh.nc.us
0332010	Flat River (Lake Michie)	WS-III NSW	Detailed, daily monitoring of influent. Monthly monitoring at intake site in Lake Michie. See Durham Water Treatment summary.	Renee Lawrence, Superintendent, Div. of Water Supply and Treatment, 919-560-4349; James Fuller, Superintendent, Brown WTP, 919-560-4362
0239107	Knap of Reeds Creek (Lake Butner, a.k.a. Holt Reservoir)	WS-II NSW	At intake on Holt Reservoir--measure alkalinity and TOC monthly for DBP report, physical parms at spring turnover; once per year for VOCs and SOCs; no data online	Mike Duke, Chief Plant Operator, Butner WTP, 919-575-3118
0239015	Ledge Creek (Lake Rogers)	WS-II NSW	No monitoring at the lake; Influent monitoring for monthly operations reports to PWS	(Lake Rogers) Creedmoor WTP, Lynwood Hicks, 919-528-0038
0332010	Little River (Little River Reservoir)	WS-II NSW	Detailed, daily monitoring of influent. Monthly monitoring at intake site in Little River Reservoir. See Durham Water Treatment summary.	Renee Lawrence, Superintendent, Div. of Water Supply and Treatment, 919-560-4349; James Fuller, Superintendent, Brown WTP, 919-560-4362

2. Brief description of why and how these sites are monitored

Purpose: Raw and finished water is monitored to assess performance in removing contaminants of concern and to ensure compliance of public water suppliers with drinking-water regulations (Safe Drinking Water Act). The PWS also tracks selected constituents like turbidity and bacteria in source water for the Area Wide Optimization Program, whose goal is to produce ultra-low turbidity finished water. They rank systems by raw-water turbidity and coliform concentrations, among other factors like violations, finished-water characteristics, etc.

No. of sites: Eight surface-water water-supply sites are located in the Upper Neuse. There are many more ground-water sites which were not included in the WET project.

Begin date: Surface plants have been doing some kind of raw-water monitoring since at least the 1980's, but requirements have evolved over time.

Frequency/Process: Facilities monitor source water once to several times a day for most constituents and report daily averages to the PWS Compliance Branch via their monthly operating reports (some may report maximum daily turbidity). The monthly operations report forms that contain source-water data can be accessed as PDF or Excel files at http://www.deh.enr.state.nc.us/pws/forms/forms_%20pg.htm, and include:

DENR 1940, Part II, Report of Physical Tests and Chemical Analysis
DENR 3398, Report of Operation (expanded form)
DENR 3763, Microbiological Operations Report
DENR DBP-2, Report of Operation (Bromate/Bromide)
DENR DBP-3 or 3E, Report of DBP Treatment Technique Compliance

After forms are received, 3 supervisors in the PWS Compliance Branch review various results for compliance and performance—the DBP/TTHMs Rule Manager, Bacteriological Contaminants Rule Manager, and the Surface Water Treatment Rule Manager.

Constituents or classes: Most surface-water sites are monitored for temperature, pH, turbidity, color, carbon dioxide, total alkalinity, total hardness, dissolved oxygen, iron, manganese, fluoride, chloride, total phosphate, total coliform; paired set of TOC at least once per month.

3. Contact person in the organization for monitoring information (raw water).

Name: Compliance Services Branch Head (currently Linda Raynor)
Address: Public Water Supply Section
Division of Environmental Health
1634 Mail Service Center
Raleigh, NC 27699-1634
Phone: 919-715-3225
Email: linda.raynor@ncmail.net

4. How long do you keep WQ data records on-site?
Recent monthly operational reports are stored in PWS Central Files. Every 5 years, the records are boxed and archived off-site. Currently, data from 2000 to present are at Central Files.

5. To whom are the data reported, and is it available online?
Public Water Supply Section
Division of Environmental Health
1634 Mail Service Center
Raleigh, NC 27699-1634
phone: 919-733-3225 (Compliance Services)

PWS reports finished-water violations to EPA quarterly. EPA downloads the PWS database quarterly, which includes raw-water TOC, UV254, DOC (if collected), and all finished-water data.

6. Web address for online data or publications from your monitoring efforts.
The public can view monitoring requirements for each treatment plant online via the Public Water Supply Section web page: http://www.deh.enr.state.nc.us/pws/index.htm. On this page, under "Data Review" heading, click on "Monitoring Schedule, Sampling Schedule, & Entry Point." Follow links to view the most recent dates that monitoring results were reported to PWS and when the next sample is due.

Raw or source-water data are not available online, and most are not available in an electronic database. Raw-water TOC data are available; some facilities also submit DOC and UV254 data (Martha Fillinger can get those data, 919-715-3243). The Compliance Branch tracks some of the data for relative turbidity and total coliform levels (contact Brad Cole, 919-715-3221). Recent source-water data reside in paper reports at the PWS Central Files, Parker Lincoln Building, 2728 Capital Blvd, Raleigh, NC, 27604.

Each treatment plant also keeps copies of monitoring records.

CURRENT MONITORING IN THE UPPER NEUSE RIVER BASIN

Contact: **Town of Hillsborough** Date: March. 4, 2005

1. Table with list of site names and location information.
Site list provided by Kenny Keel, email dated 3/29/2004; phone 919-732-1270, ext. 75.
Other information provided by Russell Bateman, Hillsborough Water Plant

2. Brief description of why and how these sites are monitored
Purpose: Support daily operations; Also State DEH tracks TOC, iron and manganese removal percentages
No. of sites: 1 at Lake Ben Johnston intake
Begin date: Not sure
Frequency: Daily, report monthly
Constituents or classes: Temperature, pH, turbidity, total alkalinity, total hardness, iron, manganese, fecal coliform, TOC

3. Contact person in the organization for monitoring information.
Name: Russell Bateman, Superintendent
Address: City of Hillsborough
PO Box 429
Hillsborough, NC 27278
Phone: 919-732-3621
Email:

4. How long do you keep WQ data records on-site?
Keep it on file in Engineering (3 years) and at Water Plant (indefinitely).

5. To whom are the data reported, and is it available online?
Report monthly to:
Public Water Supply Section
Division of Environmental Health
1634 Mail Service Center
Raleigh, NC 27699-1634
phone: 919-733-3225 (Compliance Services)

6. Web address for online data or publications from your monitoring efforts.
Not available online.

CURRENT MONITORING IN THE UPPER NEUSE RIVER BASIN

Contact: **City of Durham Water Supply and Treatment Div.** _ Date: March. 10, 2005
http://www.ci.durham.nc.us/departments/environ/water_supply.cfm

James Fuller, Brown Water Treatment Plant, 919-560-4362 (**Pat Evans** is the technician who does the sampling)
Renee Lawrence, Division Superintendent, located at the Williams Plant, 919-560-4349 (contact for permission to obtain data)

1. Table with list of site names and location information.
Obtained intake sites from DWQ.

2. Brief description of why and how these sites are monitored
Purpose: Support daily operations; compliance reports to DEH PWS
No. of sites: 1 at Lake Michie intake and 1 at Little River Reservoir intake
Begin date: Lake Michie was built in 1926. Little River Reservoir was completed in 1988.
Frequency: Monthly at reservoirs—physical parameters, metals, pH, DO, UV254, TOC, DOC. Raw intake water is measured daily at the treatment plants for metals & the usual constituents; weekly for TOC, DOC, and UV254. Results are reported to PWS monthly.
Constituents or classes: Temperature, pH, turbidity, color, carbon dioxide, total alkalinity, total hardness, dissolved oxygen, iron, manganese, fluoride, chloride, total phosphate, total coliform, TOC, DOC, and UV254.

3. Contact person in the organization for monitoring information.
Name: Renee Lawrence, Superintendent
Address: Water Supply and Treatment Division
Department of Water Management
1600 Mist Lake Drive
Durham, NC 27704
Phone: 919-560-4349
Email:

4. How long do you keep WQ data records on-site?
Indefinitely. Records are kept at both the Brown and Williams treatment plants and in the administrative offices of the Department of Water Management (919-560-4381).

5. To whom are the data reported?
Report monthly to:
Public Water Supply Section
Division of Environmental Health
1634 Mail Service Center
Raleigh, NC 27699-1634
phone: 919-733-3225 (Compliance Services)

6. Web address for online data or publications from your monitoring efforts.
Data are not available online. For general information, see Durham Water Supply and Treatment Division web page:
http://www.ci.durham.nc.us/departments/environ/water_supply.cfm. Durham's annual water quality report, *Tap Into Quality*, presents updates on Durham's drinking water and treatment processes, but no raw-water data.

CURRENT MONITORING IN THE UPPER NEUSE RIVER BASIN

Contact: **City of Raleigh Public Utilities** Date: March. 10, 2005
http://www.raleighnc.gov/portal/server.pt/gateway/PTARGS_0_2_306_204_0_43/http%3B/pt03/DIG_Web_Content/dept/public/Dept-AboutUs-PubUtil.html
Larry McMillan, E.M. Johnson Water Treatment Plant, 919-870-2870
Linda Ehrlich**,** Spirogyra Diversity, does the quarterly ambient monitoring in the lake

1. Table with list of site names and location information.
Obtained intake sites from SWAP; In-lake sites were obtained from Larry McMillan.

2. Brief description of why and how these sites are monitored
Purpose: Support daily operations; compliance reports to DEH PWS
No. of sites: Falls Lake raw-water influent (1); 4 ambient sites in lake
Begin date: Falls Lake was completed in 1981. Ambient monitoring by Spirogyra began in 1995; from 1988-1995, the USGS collected ambient data in the lake.
Frequency: Raw-influent water is measured daily in the treatment plants for the usual constituents, TOC, DOC, and UV254. Results are reported to PWS monthly. The 4 reservoir sites are sampled quarterly.
Constituents or classes: Influent: temperature, pH, turbidity, color, carbon dioxide, total alkalinity, total hardness, dissolved oxygen, iron, manganese, fluoride, chloride, total phosphate, total coliform, TOC, DOC, and UV254. Reservoir sites: VOCs & SOCs, nutrient fractions, inorganics, trace metals, TOC, DOC, bromide, chlorophyll a, physical parameters, secchi, alkalinity, turbidity, phytoplankton community, fecal coliform, enterococcus. In addition, Raleigh Public Utilities monitors enterococcus monthly at 4 reservoir sites.

3. Contact person in the organization for monitoring information.
Name: Dale Crisp
Address: Public Utilities Department
One Exchange Plaza
219 Fayetteville Street Mall, Suite 620
Raleigh, NC 27601
Phone: 919-857-4540
Email: dale.crisp@ci.raleigh.nc.us

4. How long do you keep WQ data records on-site?
Indefinitely. Records are kept at the treatment plant. Spirogyra provides data on CD as well as hard copies. Raleigh's daily monitoring records are kept electronically in-house (laboratory information management system).

5. To whom are the data reported ?
Report monthly to:
Public Water Supply Section
Division of Environmental Health
1634 Mail Service Center
Raleigh, NC 27699-1634
phone: 919-733-3225 (Compliance Services)

Ambient monitoring data are for in-house use only. These data are not reported to any other agency.

6. Web address for online data or publications from your monitoring efforts.
The monitoring data are not available online.
The Consumer Confidence Report describes the use of Falls Lake for source water, the treatment process, and an annual summary of finished-water analyses:
http://www.raleighnc.gov/portal/server.pt/gateway/PTARGS_0_2_10376_0_0_18/Consumer_Confidence_Report-2003.pdf.

CURRENT MONITORING IN THE UPPER NEUSE RIVER BASIN

Contact: **Raleigh Storm Water Div. (Benthic Monitoring)** Date: March 11, 2005
Public Works Department, Stormwater Management Division, Water Quality Section

1. Table with list of site names and location information.
Provided by Mac Smith, phone 919-890-3030, 4/2/04

Lower Barton Creek at Norwood Road

2. Brief description of why and how these sites are monitored
Purpose: To examine storm water impacts on stream biology.
No. of sites: 1 site in the Upper Neuse; 23 sites total
Begin date: Summer 1999
Frequency: Once per year. 7/99, 6/00, 9/01, 11/02, 7/03, ?/04
Constituents or classes: Relative abundance and taxonomic analysis

3. Contact person in the organization for monitoring information.
Name: Mac Smith
Address: 222 W. Hargett Street
P.O. Box 590
Raleigh, NC 27602
Phone: 919-890-3030
Email:

4. How long do you keep WQ data records on-site?

5. To whom are the data reported, and is it available online?
(As of March 11, 2005, could not find data online, nor access details on the program. Organizational structure and web pages have changed since 4/04).

6. Web address for online data or publications from your monitoring efforts.
For general information on the Stormwater Management Division:
http://www.raleighnc.gov/portal/server.pt/gateway/PTARGS_0_0_306_204_0_43/http;/pt03/DIG_Web_Content/dept/public/PubWorks/Dept-AboutUs-PubWorks-StormWtrMgt.html

CURRENT MONITORING IN THE UPPER NEUSE RIVER BASIN

Contact: **Durham Stormwater (Ambient WQ)** Date: March 11, 2005
Public Works Department, Stormwater Services Division, Water Quality Program

1. Table with list of site names and location information.
Provided by John Cox, phone 919-560-1230, ext. 224

2. Brief description of why and how these sites are monitored
Purpose: Ambient monitoring of selected physical, chemical and microbiological parameters is conducted at 34 sites on a monthly basis. Data are used to assess trends and to help determine causes of stream impairment. When water-quality problems are observed, the City may conduct follow-up, intensive monitoring, focusing on indicators of bacterial contamination (fecal coliforms), to determine "hotspot" locations for illicit discharge identification and elimination work.
No. of sites: 19 sites in the Upper Neuse
Begin date: 1996
Frequency: Monthly sampling beginning in 2004; quarterly prior to 2004
Constituents or classes: Temperature, DO, pH, conductivity, turbidity, BOD, TSS, ammonia, nitrite+nitrate, TKN, TON, total phosphorus, hardness, copper, zinc, fecal coliform bacteria. Samples are analyzed at the South Durham WRF (Farrington Plant).

3. Contact person in the organization for monitoring information.
Name: **Chris Outlaw**
Address: Durham Stormwater Services
101 City Hall Plaza
Durham, NC 27701
Phone: 919-560-1230, ext. 223
Email: chris.outlaw@durhamnc.gov

4. How long do you keep WQ data records on-site?
Indefinitely, in an electronic database and paper copies.

5. To whom are the data reported, and is it available online?
John Cox reports what's required for NPDES Phase I permit compliance to DWQ. Stormwater Services also computes a water-quality index that uses benthic data and chemistry data to compute a stream rating. At present, this information is used only in-house, but may eventually be posted on the web to inform the general public.

The monitoring data are not available online.

6. Web address for online data or publications from your monitoring efforts.
For general information on the Stormwater Water Quality Program:
http://www.ci.durham.nc.us/departments/works/stormwater_water_quality.cfm#monitoring

CURRENT MONITORING IN THE UPPER NEUSE RIVER BASIN

Contact: **Durham Stormwater (Benthic Monitoring)** Date: March 11, 2005
Public Works Department, Stormwater Services Division, Water Quality Program

1. Table with list of site names and location information.
Provided by John Cox, phone 919-560-1230, ext. 224

2. Brief description of why and how these sites are monitored
Purpose: The City uses biological assessment of benthic macroinvertebrates at 19 sites in the Durham area. Sites are monitored at least annually in the summer, following the DWQ's protocol for full-scale benthic sampling.
No. of sites: 10 benthic sites are located in the Upper Neuse
Begin date: 2000
Frequency: Once per year
Constituents or classes: Counts and taxonomic analysis

3. Contact person in the organization for monitoring information.
Name: Robert (Bobby) Louque
Address: 101 City Hall Plaza
Durham, NC 27701
Phone: 919-560-1230, ext. 222
Email: Robert.louque@durhamnc.gov

4. How long do you keep WQ data records on-site?
Indefinitely, in an electronic database and as paper copies. Biological specimens are archived.

5. To whom are the data reported, and is it available online?
The data are used to assess stream biological conditions and to compute water-quality index ratings. The data are not published or reported to another agency at this time, nor is it available on the internet.

6. Web address for online data or publications from your monitoring efforts.
For general information on the Stormwater Water Quality Program:
http://www.ci.durham.nc.us/departments/works/stormwater_water_quality.cfm#monitoring

CURRENT MONITORING IN THE UPPER NEUSE RIVER BASIN

Contact: **USGS Real-time Streamflow Gages** Date: March 11, 2005

1. Table with list of site names and location information.
Currently active (2005) sites:

Site Number	Site Name	Latitude	Longitude	lat/long datum
02085000	ENO RIVER AT HILLSBOROUGH, NC	36°04'16"	79°05'44"	NAD83
02085070	ENO RIVER NEAR DURHAM, NC	36°04'20"	78°54'28"	NAD83
0208521324	LITTLE RIVER AT SR1461 NEAR ORANGE FACTORY, NC	36°08'30"	78°55'09"	NAD83
0208524975	LITTLE R BL LITTLE R TRIB AT FAIRNTOSH, NC	36°06'46"	78°51'35"	NAD27
02085500	FLAT RIVER AT BAHAMA, NC	36°10'58"	78°52'44"	NAD83
02086500	FLAT RIVER AT DAM NEAR BAHAMA, NC	36°08'55"	78°49'44"	NAD83
02087182	FALLS LAKE ABOVE DAM NR FALLS, NC	35°56'24"	78°34'51"	NAD83

2. Brief description of why and how these sites are monitored
Purpose: Monitor stream stage and discharge for use by multiple agencies.
No. of sites: 7 sites in Upper Neuse; 10 were active in WY2003 (3 ULUG). In addition, site 0208524090 (Mountain Creek at SR 1617 near Bahama) is a non-RT site
Begin date: varies by site
Frequency: Continuous monitoring at 15-minute intervals
Constituents or classes: Stream stage and discharge. Historical records and statistics also are available.

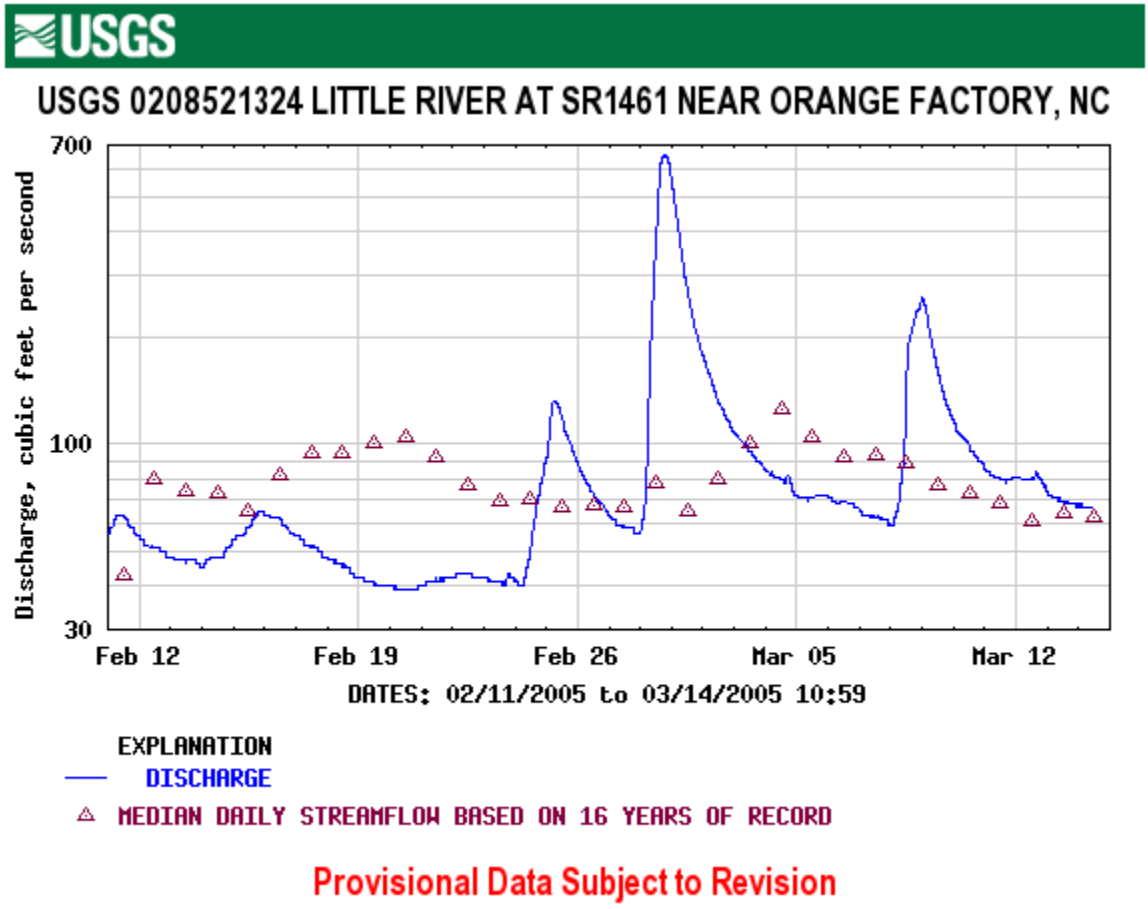
3. Contact person in the organization for monitoring information.
Name: Ramona Traynor, Information Officer
Address: U.S. Geological Survey
3916 Sunset Ridge Road
Raleigh, NC 27607
Phone: 919-571-4096
Email: rtraynor@usgs.gov

4. How long do you keep WQ data records on-site?
Data records are maintained on-site for 10 years, and then paper records are archived at the Federal Records Center in Atlanta, Georgia. Electronic records are maintained in local and national databases in perpetuity.

5. To whom are the data reported, and is it available online?
Data are incorporated into the National Water Information System and can be accessed via the internet.

6. Web address for online data or publications from your monitoring efforts.
Real-time National Water Information System data can be accessed online at:
http://waterdata.usgs.gov/nwis/rt (national data) or
http://waterdata.usgs.gov/nc/nwis/current/?type=flow (NC sites only).

Example of real-time data, retrieved on March 14, 2005:



Data collected since October 2000 can be viewed online in .pdf tables at:
http://water.usgs.gov/pubs/wdr/wdr_nc/ .

CURRENT MONITORING IN THE UPPER NEUSE RIVER BASIN

Contact: **USGS Water Quality Monitoring** Date: March 11, 2005

1. Table with list of site names and location information.

Site number	Site name
02085000	Eno River at Hillsborough
0208500600	Cates Creek near Hillsborough
0208501535	Strouds Creek at Saint Marys Road near Hillsborough
0208521324	Little River at Secondary Road 1461 near Orange Factory
0208524090	Mountain Creek at Secondary Road 1617 near Bahama
0208524845	Little River Reservoir at dam near Bahama
0208524950	Little River tributary at Fairntosh
0208524975	Little River below Little River tributary at Fairntosh
02085430	Deep Creek near Moriah
02085500	Flat River at Bahama
02086490	Lake Michie at Dam near Bahama
0208650112	Flat River tributary near Willardville

2. Brief description of why and how these sites are monitored

Purpose: Monitor water quality at selected sites in cooperation with local and state agencies. Data are used for assessment of water-quality conditions and long-term trends, and to assess the effects of large- and small-scale management actions. These sites are part of the Triangle Area Water Supply Monitoring project, the Treyburn project, and the Albemarle-Pamlico NAWQA program.

No. of sites: 9 active sites in Upper Neuse; 3 more with recent data

Begin date: Varies by site. Most sites have been monitored since 1988.

Frequency: Triangle stream sites are monitored 6 times each year, and lake sites are monitored 4 times each year. Treyburn sites are sampled 9 times per year. The 3 NAWQA sites were sampled only a few times, but for a broad suite of constituents.

Constituents or classes: Physical parameters, nutrients, suspended sediment, major ions, metals, stream stage and discharge (except at NAWQA sites).

3. Contact person in the organization for monitoring information.

Name: Ramona Traynor, Information Officer
Address: U.S. Geological Survey
3916 Sunset Ridge Road
Raleigh, NC 27607
Phone: 919-571-4096
Email: rtraynor@usgs.gov

4. How long do you keep WQ data records on-site?

Data records are maintained on-site for 10 years, and then paper records are archived at the Federal Records Center in Atlanta, Georgia. Electronic records are maintained in local and national databases in perpetuity.

5. To whom are the data reported, and is it available online?
Data are incorporated into the National Water Information System and can be accessed via the internet.

6. Web address for online data or publications from your monitoring efforts.
National Water Information System data can be accessed online at:
http://waterdata.usgs.gov/nwis/ .

Published reports can be searched online by river basin at:
http://nc.water.usgs.gov/pubs/bib/basins.html .

ATTACHMENT B. LOCAL GOVERNMENT/LOCAL PARTNERS WATER QUALITY MONITORING PLANS

Water Quality Monitoring and Assessment Plan
NPDES Permit Number NCS000249
Annual Update

Submitted by:
City of Durham
Public Works Department, Stormwater Services Division
101 City Hall Plaza
Durham, NC 27701
(919) 560-4326

Submitted to:
NC Division of Water Quality
Wetlands and Stormwater Section
1617 Mail Service Center
Raleigh, NC 27699-1617

Main Document Update: June 2010
Appendix A Update: June 2010
Appendix B Update: June 2010
Appendix C Update: June 2010

Table of Contents

1 Purpose 3
2 Background 3
2.1 State Monitoring and Assessments 5
3 Monitoring Program Design 6
3.1 Ambient Chemistry 7
3.2 Biological 8
3.3 Field Screening 9
4 Sample and Data Analysis 10
4.1 Quality Assurance 11
4.2 Record Keeping 11
5 Data Evaluation and Assessment 11
5.1 Methods for Evaluating and Assessing Data 12
5.2 Reporting 13
6 References 13

Attachment A. Stormwater Services Ambient and Benthic Monitoring Locations
Attachment B. Selected 2009 Water Quality Assessments
Attachment C. Summaries of Ongoing and Completed Special Studies

City of Durham
Water Quality Monitoring & Assessment Plan

1 Purpose

This Water Quality Monitoring & Assessment Plan was prepared to comply with Section I of the City of Durham's National Pollution Discharge Elimination System (NPDES) Permit for stormwater dischargers issued June 4, 2007. The schedule for the Water Quality Assessment and Monitoring Plan is as follows:

- Within 12 months of the effective date of the permit, develop a Water Quality Assessment and Monitoring Plan to be submitted to DWQ. The Plan shall include a schedule for implementing the proposed assessment and monitoring activities.
- The permittee shall implement the Water Quality Assessment and Monitoring Plan within 12 months of receiving Plan approval from DWQ. In accordance with the implementation schedule, the permittee shall provide in subsequent annual reports a summary of the assessment and monitoring activities performed within the reporting period.
- The permittee shall review annually, amend as appropriate, and submit to DWQ for approval the Water Quality Assessment and Monitoring Plan.

The City of Durham Water Quality Monitoring & Assessment Program has several goals, as follows:

- to evaluate the water quality impacts of urban stormwater on area streams,
- to identify illicit discharges to area streams.
- to assess the quality of streams within the City of Durham,
- to produce monitoring data that is comparable to data collected by the state, and
- to assess compliance with state water quality programs, including Total Maximum Daily Loads (TMDLs) and nutrient management strategies.

Information gained from this program may be used to help identify and eliminate sources of pollution, track short-term and long-term trends, and, where possible, gauge the effectiveness of stormwater management efforts and programs.

2 Background

The City of Durham received a stormwater permit in 1994. As part of the first permit, the City of Durham was required to conduct screening of all storwmater outfalls in the city, perform wet weather monitoring, and water quality investigations. The permit and the stormwater program have evolved since 1997 and now the City has a regular monitoring program in place. This program is used to produce information for residents of the City of Durham and to address state and federal regulatory requirements.

The City of Durham sits along a high point, or ridge line, between two major river basins, the Cape Fear and the Neuse River Basins. Waters to the south and west of the Durham Freeway (Highway 147) are generally in the Cape Fear River Basin. These waters flow first to B. Everett Jordan Lake (i.e., Jordan Lake), the Cape Fear River, and finally the Cape Fear Estuary near Wilmington, NC. The exception is Stirrup Iron Creek in Durham and Research Triangle Park, which flows into Crabtree Creek and the Neuse River. Waters north and east of the Durham Freeway are in the Neuse River Basin. These waters flow first to Falls Lake, the Neuse River and finally the Albemarle-Pamlico Sound. Since the City sits along a high

point, streams generally originate within the City. Thus, the City controls the hydrology and water quality of these streams. The exceptions to this are the Eno River and New Hope Creek, both of which originate in Orange County. The City of Durham has eleven independent drainage areas, as listed in Table 1 and mapped in Figure 1.

Table 1. City of Durham Watersheds

Cape Fear River Basin Watersheds	Neuse River Basin Watersheds
New Hope Creek	Eno River (a)
Little Creek	Ellerbe Creek
Third Fork Creek	Panther Creek
Crooked Creek	Little Lick Creek
Northeast Creek	Lick Creek
	Stirrup Iron Creek

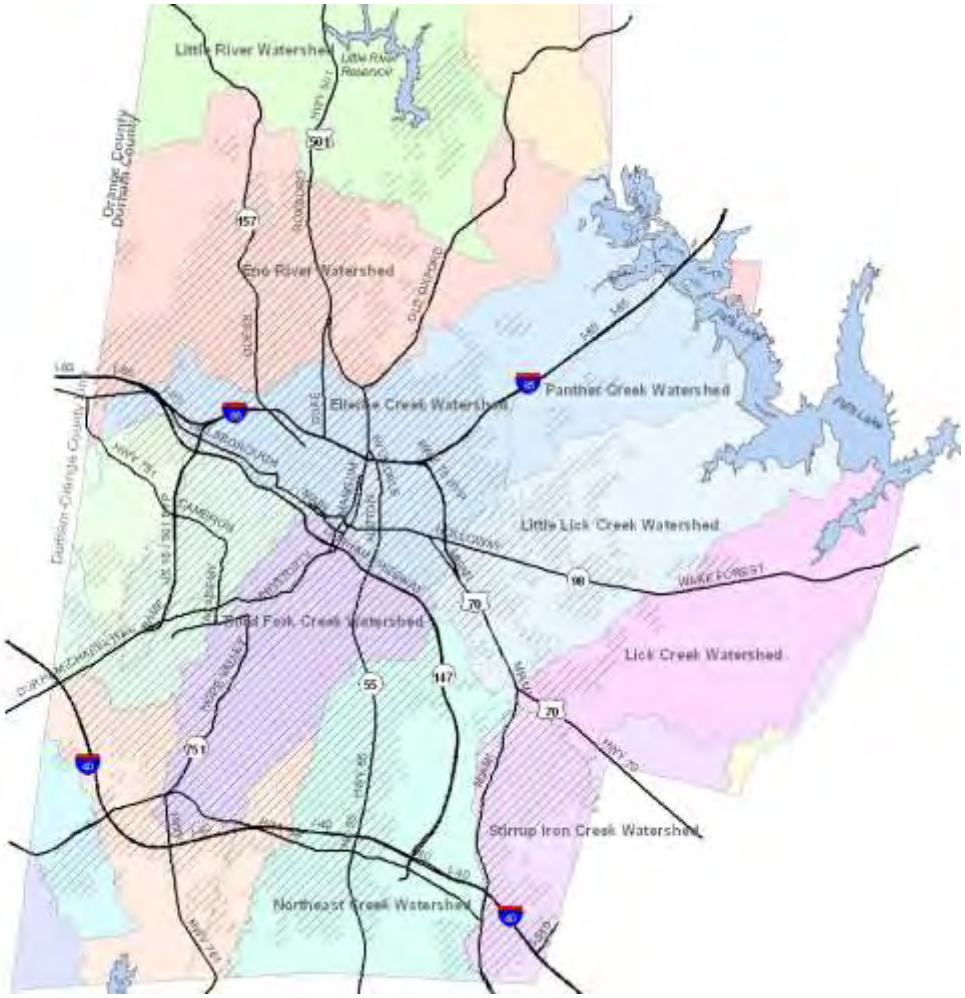


Figure 1. City of Durham Watersheds

The City of Durham monitoring program has evolved since the 1990s. Per permit requirements, initial monitoring was designed to generate pollutant loading rates by land use and to evaluate outfalls located throughout the City. Subsequent monitoring has been designed toward characterizing stream conditions, including storm events. The current

program is similar to the NCDWQ ambient monitoring program with samples collected regularly for specific parameters. Monitoring data have been summarized annually for the NPDES report and provided to the NC DWQ.

2.1 State Monitoring and Assessments

The NC DWQ utilizes a statewide monitoring network to evaluate water quality. The NC DWQ uses a combination of chemical, biological and bacteriological monitoring techniques for streams, lakes, and estuaries. The NC DWQ uses this data to assess water quality through the 305(b) and 303(d) processes. As a result of these assessments, waters are identified as impaired and placed on the state 303(d) List. Eight streams located in or near the City of Durham are included on the draft 2010 list of impaired waters (NC DWQ 2010), as shown in Table 2. The state is required to develop a TMDL for each of these waters and each reason for listing.

Table 2. 2010 Draft North Carolina 303(d) List of Impaired Waters

Stream name	Reason(s) for Listing	Year Listed
Neuse River Basin		
Ellerbe Creek from source to Falls Lake, Neuse River	Biological criteria exceeded Zinc	1998 2008
Little Lick Creek from source to Falls Lake, Neuse River	Low dissolved oxygen Turbidity	2008 2008
Tributary to Little Lick Creek from source to Little Lick Creek	Low dissolved oxygen	2008
Lick Creek from source to Falls Lake, Neuse River	Biological criteria exceeded	1998, 2004
Cape Fear River Basin		
New Hope Creek from a point 0.3 miles upstream of Durham County SR2220 to the confluences with Morgan Creek Arm of New Hope River Arm of B. Everett Jordan Lake	Low dissolved oxygen Turbidity Fecal coliform	2006 2006,2008 1998
Third Fork Creek from a point 2 miles upstream of Highway 54 to New Hope Creek	Low dissolved oxygen Copper Zinc	2008 2008 2008
Little Creek source in Orange County to a point 0.7 miles downstream of Durham County SR 1110	Biological criteria exceeded	2000
Northeast Creek from US Highway 55 to Durham County Triangle WWTP (a)	Turbidity Low dissolved oxygen Copper	2006 2006 2008

(a) Downstream portions of Northeast Creek lie outside the City limits and include additional pollutants.

Two TMDLs have been developed and approved for streams in the City of Durham and Durham County. Third Fork and Northeast Creeks in the Cape Fear River Basin each have approved TMDLs, as listed in Table 3. Per permit requirements in Section J (NC DWQ 2007), Water Quality Recovery Programs must be developed for each of these TMDLs within 24 months of the effective date of the permit. Other TMDLs the City of Durham is subject to include the B. Everett Jordan Lake Chlorophyll *a* TMDL (approved September 20, 2007) and the Neuse River Estuary Total Nitrogen TMDL (updated and approved March 19, 2002).

Table 3. EPA Approved TMDLs for City of Durham Surface Waters

Stream name	Pollutant(s)	Date(s) Approved by USEPA	TMDL and/or Percent Reduction

Third Fork Creek	Turbidity	January 11, 2005	0.75 tons/day (52% reduction)
Northeast Creek	Fecal coliform	September 12, 2003	(92% reduction) (a)
(a) Reduction assigned to the City of Durham MS4.			

TMDLs for reservoirs and estuaries encompass a much larger watershed area and may include an entire drainage basin. The Neuse Estuary TMDL and the subsequent nutrient management strategy rules developed to meet nitrogen reduction targets are one example. The nutrient management strategy addresses excessive algal growth within the Neuse Estuary; nitrogen has been found to be the critical component to control algal growth. Similar efforts are underway for B. Everett Jordan Lake and Falls Lake.

Table 4. Other US EPA Approved TMDLs to which the City of Durham is Subject

Stream name	Pollutant(s)	Date(s) Approved by USEPA	TMDL and/or Percent Reduction
Neuse River Estuary	Total nitrogen	Phase II TMDL, March 19, 2002	30%
B. Everett Jordan Lake	Chlorophyll a (a)	September 20, 2007	35% Nitrogen (641,021 pounds/yr) 5% Phosphorus (82,883 pounds/yr)

Table 5. Nutrient Management Strategies affecting the City of Durham

Description	Pollutant(s) addressed	Date effective
Neuse River Estuary (Neuse River Basin)	Total nitrogen	August 1, 1998
B. Everett Jordan Lake	Total nitrogen Total phosphorus	June 30, 2009 and August 26, 2009
Falls of the Neuse Reservoir (Falls Lake)	Total nitrogen Total phosphorus	In progress

3 Monitoring Program Design

The City of Durham has modeled the stream monitoring program after the NC DWQ ambient monitoring program. Two different types of monitoring are conducted for City of Durham streams, chemical and biological. These two different types of monitoring allow the City of Durham not only the opportunity to evaluate streams independently of the State, but also to verify results obtained by the State. Certainly, one goal is to produce data that is compatible with State data in the event that it is desirable or necessary to combine data for decision-making purposes.

Stormwater Services re-evaluates the monitoring program annually, generally corresponding with the end of the calendar year. Monitoring sites are reviewed to determine if any should be added or removed. New potential stations are then evaluated in the field to ensure safety and access. All staff of the Water Quality Unit of Stormwater Services work to ensure that scheduled monitoring is completed.

Special studies are conducted by stormwater staff as needed and may include either or both ambient chemistry and benthic monitoring. In the past, these studies have been conducted to support state monitoring results, provide additional information to state decision making

processes, and to collaborate on new methods of determining sources of pollution. Special studies may be generated throughout the Stormwater Services Division of Public Works.

The Stormwater Services monitoring program includes both ambient chemistry and biological monitoring. The methodology, frequency and locations of monitoring vary based upon the type of monitoring. The following sections discuss Ambient Chemistry and Biological monitoring separately, providing detail for each part of the monitoring program.

3.1 Ambient Chemistry

The ambient chemistry portion of the monitoring program focuses on the surface water, and in some cases sediment chemical properties. The ambient chemistry program provides snapshots of water quality through the analysis of selected parameters either at a laboratory or in the field. These snapshots can be used to identify short and long-term trends and sources of pollution. The following sections briefly describe the methods, monitoring frequency, and site locations for the ambient chemistry program.

3.1.1 Methods

Ambient chemistry monitoring consists primarily of grab samples for analysis at a laboratory and collection of field parameters (e.g., temperature, dissolved oxygen, pH, conductivity and turbidity) using probes, meters and pens. Stormwater Services is revising the Quality Assurance Monitoring Program Plan into the EPA Quality Assurance Project Plan (QAPP) format. The QAPP will outline procedures to ensure quality data collection and analysis for different types of samples, including field parameters, grab samples, composite samples and field screening.

Cleaned sample containers are obtained from the South Durham Water Reclamation facility (WRF) prior to monitoring. After collecting a grab sample from the thalweg, filled sample containers are placed on ice immediately. The Stormwater Services program utilizes the laboratory services of the South Durham WRF for analysis of surface water samples. Samples are delivered to the laboratory, with a chain of custody form, within four hours of sample collection or by noon (i.e., 12:00 pm) on the day sampled. Samples are maintained at a temperature of 4 °C or less until delivery to the laboratory.

3.1.2 Frequency

Samples are collected from the Neuse River basin during the second week of each month. Cape Fear River Basin monitoring is conducted during the third week of each month. A total of 12 samples should be collected for each location during a one year period, although several of the streams in the City of Durham are headwater or first order streams and may cease flowing during dry periods. Sampling is performed by two teams in order to collect as many samples as possible on each day. By assigning a specific day during each month, a wide variety of flow conditions should be monitored over the five-year permit cycle.

3.1.3 Site Locations

Monitoring site locations are selected based on a number of criteria. In general, the City of Durham seeks to have each independent watershed within the City Limits included in the monitoring program. Monitoring locations are then considered using a variety of criteria, including the following:

- <u>Locations of historical monitoring locations or locations monitored by other agencies</u>. Historical monitoring stations offer the unique perspective of how conditions have changed over time. It is important for any monitoring program to establish a subset of stations just for this purpose. These historical locations may be associated with City monitoring programs or state monitoring programs.

- Accessibility and safety. Generally, monitoring locations are selected near road crossings or at sites within public lands (e.g., parks). Locations that would place City staff on crowded highways generally receive a lower priority.
- Locations of stream flow monitoring. The U.S. Geological Survey maintains two (2) stream flow monitoring locations in the City of Durham. Combining water quality data with stream flow data provides the most complete picture of water quality.
- Historical, existing, or suspected sources of pollution. Monitoring locations are typically located in areas where sanitary sewer overflows and spills occur frequently or where other suspected sources of pollution exist.
- City special studies or initiatives. Special studies initiated within Stormwater Services may include the establishment of long or short-term ambient monitoring locations.
- State management strategies. State nutrient management strategies for the Neuse River Estuary and B. Everett Jordan Lake, and the forthcoming Falls Lake strategy, influence the location of monitoring. Additionally, future and existing TMDLs influence monitoring locations. Those TMDLs that attribute stormwater from the City of Durham as a source of pollution are particularly considered.

Monitoring locations are modified each calendar year. Thus a map including current year monitoring locations is provided in Attachment A, as is a list of stations. Updates to Attachment A may be provided to the NC DWQ as stations are modified, generally on an annual basis.

3.2 Biological

The City of Durham uses benthic macroinvertebrate monitoring as a way of assessing the ability of our streams to support aquatic life. Benthic macroinvertebrates are found in all aquatic environments, are less mobile than many other groups of organisms (e.g., forage fish), and are of a size that makes them easily collectible. Benthic macroinvertebrates show responses to a wide variety of potential pollutants, including those with synergistic or antagonistic effects. In many cases, the collection of benthic macroinvertebrates is less costly than regular chemical analysis of a complex mixture of pollutants. The DWQ benthic macroinvertebrate monitoring program is recognized nationally for the history of scientific techniques specifically for the state of North Carolina. The City of Durham program is modeled after the DWQ benthic macroinvertebrate program. As of 2008, the City of Durham Aquatic Identification Laboratory is certified by the DWQ for benthic macroinvertebrate collections and identification.

3.2.1 Methods

Samples are collected as described in the City of Durham's Standard Operating Procedures for Benthic Macroinvertebrates (Durham 2008). Organisms are collected in the field, preserved, and taken to the Aquatic Identification Laboratory for processing. Identifications of the benthic macroinvertebrates are conducted in-house within the City's certified laboratory. For details concerning the benthic monitoring program see City of Durham's Standard Operating Procedures for Benthic Macroinvertebrates (Durham 2008), available on the Stormwater Services web site and attached to this document. Field parameters such as pH, specific conductivity, turbidity, dissolved oxygen (%,mg/L) and temperature are collected during each sampling event. A majority of the benthic macroinvertebrate sites are co-located with ambient chemistry monitoring stations.

3.2.2 Frequency

Benthic monitoring sites will be visited once per year between June and September. Storwmater Services staff will be investigating the use of winter and spring collections for Triassic basin streams. These collections may occur between February and April.

3.2.3 Site Locations

Monitoring site locations are selected based on a reduced number of criteria when compared to the ambient monitoring. In general, the City of Durham seeks to have each independent watershed within the City Limits included in the monitoring program. Criteria used for biological/ benthic macroinvertebrate monitoring sites are similar to those for ambient chemistry monitoring and include the following:

- Locations of historical monitoring locations or locations monitored by other agencies. Historical monitoring stations offer the unique perspective of how conditions have changed over time. It is important for any monitoring program to establish a subset of stations just for this purpose. These historical locations may be associated with City or state monitoring programs.
- Accessibility and safety. Generally, monitoring locations are selected near road crossings or at sites within public lands (e.g., parks). Locations that would place City staff on crowded highways generally receive a lower priority.
- Locations of stream flow and ambient water quality monitoring. Benthic macroinvertebrate sites are prioritized in order to provide a more complete picture of water quality, including the health of aquatic life, the water chemistry (i.e., ambient monitoring program) and the stream flow (i.e., USGS stream flow monitoring).
- City special studies or initiatives. Special studies initiated within Stormwater Services may include synoptic sampling of a defined watershed in any particular year. Special studies investigating techniques may also be performed.

A map including monitoring locations is provided in Attachment A, as is a list of locations. Updates to Attachment A may be provided to the NC DWQ as monitoring locations are modified.

3.3 Field Screening

Field screening monitoring programs include the illicit discharge detection program, the outfall screening program, stream forensics studies, and response to sewer spills. Each of these programs requires rapid analysis of surface water to determine if a particular analyte or parameter is present and to what degree. However, the methods used for monitoring are similar. Small samples of water are collected and analyzed in the field to determine water quality conditions.

The Stormwater Services staff utilize a CHEMETRICS field chemistry kit to provide support for real-time pollution tracking. The use of the CHEMETRICS field screening methods is described in the Stormwater Services QAPP.

On a case-by-case basis, there may be a need for detailed or precise measurements such as those provided by a chemistry laboratory. When these cases arise, grab samples may be collected per the QAPP and delivered to the South Durham WRF.

Field screening methods are performed on an as-needed basis and thus frequency and site location cannot be specified in advance. Frequency may consist of before and after monitoring to characterize the problem and resolution. More frequent analysis may be needed if an ongoing problem has been identified. Similarly, monitoring locations may vary. Monitoring locations may include outfalls or other discharge pipes, ditches, storm sewers and surface waters. In the case of outfall screening or illicit discharge detection, documentation of frequency and locations will be provided in the Stormwater Services water quality investigations database.

4 Sample and Data Analysis

Samples collected from City of Durham streams are analyzed both in the field and at a state certified laboratory. Field parameters are analyzed using field meters that measure the parameter while outside. Other parameters are analyzed by the laboratory using a sample of water collected from a monitoring location. Parameters for which samples are analyzed in the laboratory are determined based on state assessments and management strategies, and historic monitoring. Field parameters are shown below in Table 6.

Table 6. Field parameters measured by Stormwater Services

Parameter	Equipment used	Range of measurement	Precision	Accuracy
Temperature	YSI 550A	-5 to 45°C	0.1 °C	± 0.3 °C
Dissolved oxygen	YSI 550A	0 to 50 mg/L	0.01 mg/L	±0.03 mg/L
Conductivity	Oakton ECTestr low Oakton TDSTestr3	0 – 1999 µS 0 – 1990 µS	1 µS 10 µS	± 1% ± 1%
pH	Oakton WP pH Tester 2	-1.0 – 15.0	0.1	± 0.2
Turbidity	Hach Model 2100P (a)	0 – 1000 NTU	± 2%	0.01 NTU
(a) This meter meets EPA Method 180.1 specifications.				

Parameters analyzed in the laboratory are selective as laboratory analysis costs can be prohibitive. State assessments and management strategies are integral to the selection of parameters to be analyzed. Parameters included on the North Carolina 303(d) list of impaired waters (NC DWQ 2008a) were highlighted for inclusion in regular monitoring. Other explanatory parameters were also included in order to determine potential sources and/or degradation rates. As described in Section 1, dissolved oxygen, turbidity, fecal coliform bacteria, total nitrogen and total phosphorus are parameters of concern based on current and previous 303(d) listings.

During the initial phases of the stormwater program in the 1990s, a large number of pollutants were analyzed in surface water and storm water samples. This included the analysis of the following classes of chemical compounds: volatiles, semi-volatiles, metals, and organophosphate pesticides. Only a subset of pollutants in these classes of chemicals these were actually detected in surface water or stormwater. This initial monitoring demonstrated that regular analysis of many of these chemicals was not needed. Some of these chemical classes continue to be monitored on an infrequent basis through special studies.

A list of all those parameters for which the laboratory routinely analyzes surface water and stormwater is provided in Table 7. The primary laboratory for these parameters is the South Durham WRF, which is state certified for all parameters listed in Table 7 (Certification # 176). The laboratory QAPP is available upon request. Information for special studies is provided in Attachment C.

Table 7. Laboratory quantitation limits

Parameter (Analyte)	Quantitation Limit	Units	Method
Ammonia-Nitrogen	0.05	mg/L	SM 4500-NH3-N D
Biochemical Oxygen Demand, 5-day	2	mg/L	SM 5210 B
Cadmium	1	µg/L	EPA 200.8
Calcium	1	mg/L	EPA 200.8
Copper	5	µg/L	EPA 200.8
Fecal Coliform Bacteria	1	cfu/100mL	SM 9222D

Magnesium	1	mg/L	EPA 200.8
Nitrate+Nitrite-Nitrogen	0.10	mg/L	EPA 300.0
Nitrogen, Total Kjeldahl	0.25	mg/L	EPA 351.2
Phosphorus, Total	0.03	mg/L	SM 4500 P E
Solids, Total Suspended	2.5	mg/L	SM 2540 D
Zinc	10	µg/L	EPA 200.8

All locations are not monitored for all parameters. Resource availability limits the total number of samples the South Durham WRF Laboratory can process. Samples from all ambient monitoring locations are analyzed for fecal coliform bacteria. For the purposes of evaluating sources of nonpoint source pollution, fecal coliform bacteria analysis combined with field parameters is often sufficient to identify problems. A subset of samples are analyzed for other parameters listed in Table 7. Samples from ambient monitoring locations that include full analyses are identified in Attachment A.

4.1 Quality Assurance

Stormwater Services is committed to producing quality data for a variety of planning and assessment uses. As such, the development of an Ambient Monitoring QAPP and maintenance of the Standard Operating Procedures for Benthic Macroinvertebrates are high priorities. As previously mentioned, the Stormwater Services Quality Assurance Monitoring Program plan is currently under revision to development a QAPP using the EPA format. The QAPP describes, in detail, the sampling process design and methods, sample handling and custody, analytical methods, and instrument testing, inspection, maintenance, and calibration. In lieu of repeating that information in this document, the draft QAPP is available upon request.

4.2 Record Keeping

A variety of forms are retained by Stormwater Services describing various aspects of monitoring. Field sheets, chain of custody forms, and hard copies of the laboratory summary sheets are retained by Stormwater Services for all ambient monitoring. Similar forms and sheets are retained for special studies, although file folders will be labeled separately. For benthic macroinvertebrate sampling, field sheets and invertebrate identification sheets are retained for each site. All data recorded on the field sheets will be maintained in a spatially referenced electronic database.

Laboratory log books, bench sheets, QA documentation will be retained at the South Durham WRF per the laboratory QAPP.

Stormwater Services will retain ambient and biological records on-site for a minimum of 5-years. Records may be maintained off-site for up to 12 years. Monitoring data is stored in one of several MS Access® databases. Data entry is verified quarterly to correct transcription errors.

5 Data Evaluation and Assessment

Stormwater Services has performed several data evaluations and assessments in the past. These have been reported in previous annual NPDES reports and summarized in the State of Our Streams report since 2004. EPA guidance on data quality assessments suggests a review of the objectives and sampling design and preliminary data review as the first two steps of a statistical data review (EPA 2006).

Stormwater Services utilizes a systematic planning process when evaluating monitoring for the coming year. In most cases, the sampling design will provide adequate data for the data evaluation. Special studies may require a post-monitoring review to ensure that objectives are met. As described in Section 4.2, databases are verified on a regular basis, ensuring that analytical or statistical comparisons use proper and correct data. In general, EPA guidance (EPA 2006) recommends validation of data, calculating basic statistics and generating graphs. Each of these types of review is performed by Stormwater Services, as described below.

5.1 Methods for Evaluating and Assessing Data

Stormwater Services routinely evaluates water quality data to determine representativeness and feasibility. This includes preparing time-series graphs, determining measures of central tendency, and evaluating distributions at each site and over all sites. However, there are specific evaluations that are performed quarterly or annually to assess water quality conditions. These specific evaluations are described below:

Water Quality Index: Stormwater Services created a water quality index to relay surface water chemistry information to the citizens of Durham in an easily understood format. The water quality index is unique to Durham and accounts for the following chemical and physical parameters: dissolved oxygen, turbidity, fecal coliform, total nitrogen, total phosphorus, 5-day biochemical oxygen demand, dissolved copper and dissolved zinc. The annual average water quality index is provided in a summary table with comparison to NC water quality standards.

Comparison to NC Water Quality Standards: Several parameters measured by Stormwater Services have NC Water Quality standards to which data are directly compared. Water quality standards for dissolved oxygen, turbidity, and fecal coliform bacteria will be compared to instream measurements. The criterion continuous concentration is compared to instream measurements in lieu of the action level standards for copper and zinc. These comparisons will be presented in a tabulated form that also includes average nutrient levels. An example of this summary table is presented in Attachment B.

NC Biotic Index and Water Quality Rating: The Stormwater Services benthic macroinvertebrate monitoring program reports results on an annual basis. This program, which obtained state certification in 2008, includes the collection, identification and enumeration of macroinvertebrate species. A NC Biotic Index, Biotic Rating and Water Quality Rating is calculated for each site on an annual basis using DWQ methodology. Results are summarized in tabular form, as shown in Attachment B.

Comparison of sites: City staff compare all data collected at each site to determine sites that unusually higher or lower concentrations of a variety of constituents. Box and whiskers plots are used to make these rapid comparisons. Box and whiskers plots are summary plots of the distribution of a parameter that provide information on the median, interquartile range, highs and lows. Visual examination of box plots allows identification of sites with unusually high or low concentrations or sites that appear to have different characteristics from others. The City of Durham finds comparisons of box plots to be particularly useful for parameters without water quality standards, typically nutrients and TSS. An example of box plots is presented in Attachment B.

Other evaluations: Other evaluations and assessment can be made using the water quality data collected by Stormwater Services. These can range from a multitude of statistical analyses and tests to process-based water quality modeling. These other

evaluations will be reported in annual NPDES reports as needed, but will not be provided in each annual report. Two such evaluations that may be included every other year include the determination of annual nutrient loads and statistically significant trends, as described below.

- Annual nutrient loads: Annual nutrient loads may be calculated at locations with US Geological Survey (USGS) continuous discharge monitoring and water quality monitoring by Stormwater Services. Annual loading will be determined using one of the following publicly available programs.
  - FLUX: Maintained by the US Army Corps of Engineers and provided within the BATHTUB lake modeling software, and
  - LOADEST: Maintained by the USGS and available on the USGS web site.
- Assessment of trends: Assessing steady trends of improvement or worsening are a goal of the City of Durham monitoring program. Per Schwarz (2008), the recommended sample size for such analyses are 60 samples with at least five seasonal cycles. Thus many monitoring locations are not suitable for trend analysis.

5.2 Reporting

Stormwater Services provides regular updates of water quality to the public and to DWQ. There are two primary methods of reporting annual water quality assessments. The first is through the annual State of Our Streams report. The State of Our Streams report summarizes the water quality index, fecal coliform bacteria, and water clarity in a simplified format. These reports, which are available on the Stormwater Services website, also include other information regarding water quality protection efforts made by the City of Durham. The State of Our Streams reports are available beginning 2004.

The second method of communicating water quality is through the NPDES annual report. Several different matrices are generated for the NPDES annual report with a higher focus on reporting implementation efforts. However, there is some overlap with the State of Our Streams report in terms of water quality reporting. A summary table, such as that shown in Attachment B, is provided in each annual NPDES report. A similar summary table is provided for benthic macroinvertebrate monitoring results. These two tables have been provided in past annual NPDES reports. Future reports will also contain comparisons of monitoring locations for selected parameters, including box and whiskers plots of DO, conductivity, turbidity, TSS, TN, and TP.

6 References

City of Durham (Durham). 2008. Standard Operating Procedures for Benthic Macroinvertebrates. Stormwater Services, Water Quality Section. March

City of Durham (Durham). 2008. Quality Assurance Project Plan. DRAFT–In Preparation. Stormwater Services, Water Quality Section.

Federal Register 61(155):41697-41699. August 9, 1996. Interpretive Policy Memorandum on Reapplication Requirements for Municipal Separate Storm Sewer Systems.

NC Division of Water Quality (DWQ). 2007. NPDES Permit Number NCS000249. City of Durham. June 4

NC Division of Water Quality(DWQ). 2007. Neuse River Basin Ambient Monitoring System Report: September 1, 2000 through August 31, 2005. Environmental Sciences Section. Raleigh, NC

NC Division of Water Quality (DWQ). 2008a. North Carolina 303(d) List of Impaired Waters. Planning Section. Raleigh, NC

NC Division of Water Quality (DWQ). 2008b. DRAFT NPDES Discharge Monitoring Coalition Program. Field Monitoring Guidance. Version 1.0. Environmental Sciences Section. March

Schwarz, C.J. 2008. Sampling, Regression, Experimental Design and Analysis for Environmental Scientists, Biologists, and Resource Managers. Chapter 13. Course Text for STAT-650. Department of Statistics and Actuarial Science. Simon Fraser University, British Columbia

US Environmental Protection Agency (EPA). 1992. NPDES Storm Water Sampling Guidance Document. EPA 833-B-92-001. Office of Water.

US Environmental Protection Agency (EPA). 2002. Guidance on Choosing a Sampling Design for Environmental Data Collection. EPA QA/G-5S. Office of Environmental Information. Washington, DC

US Geological Survey. 2004. Load Estimator (LOADEST): A FORTRAN Program for Estimating Constituent Loads in Streams and Rivers. Techniques and Methods Book 4, Chapter A5. By R. Runkel, C. Crawford and T. Cohn.

Attachment A.
Stormwater Services Ambient and Benthic Monitoring Locations
Updated June 2010

The following figures and tables identify monitoring locations for calendar year 2010.

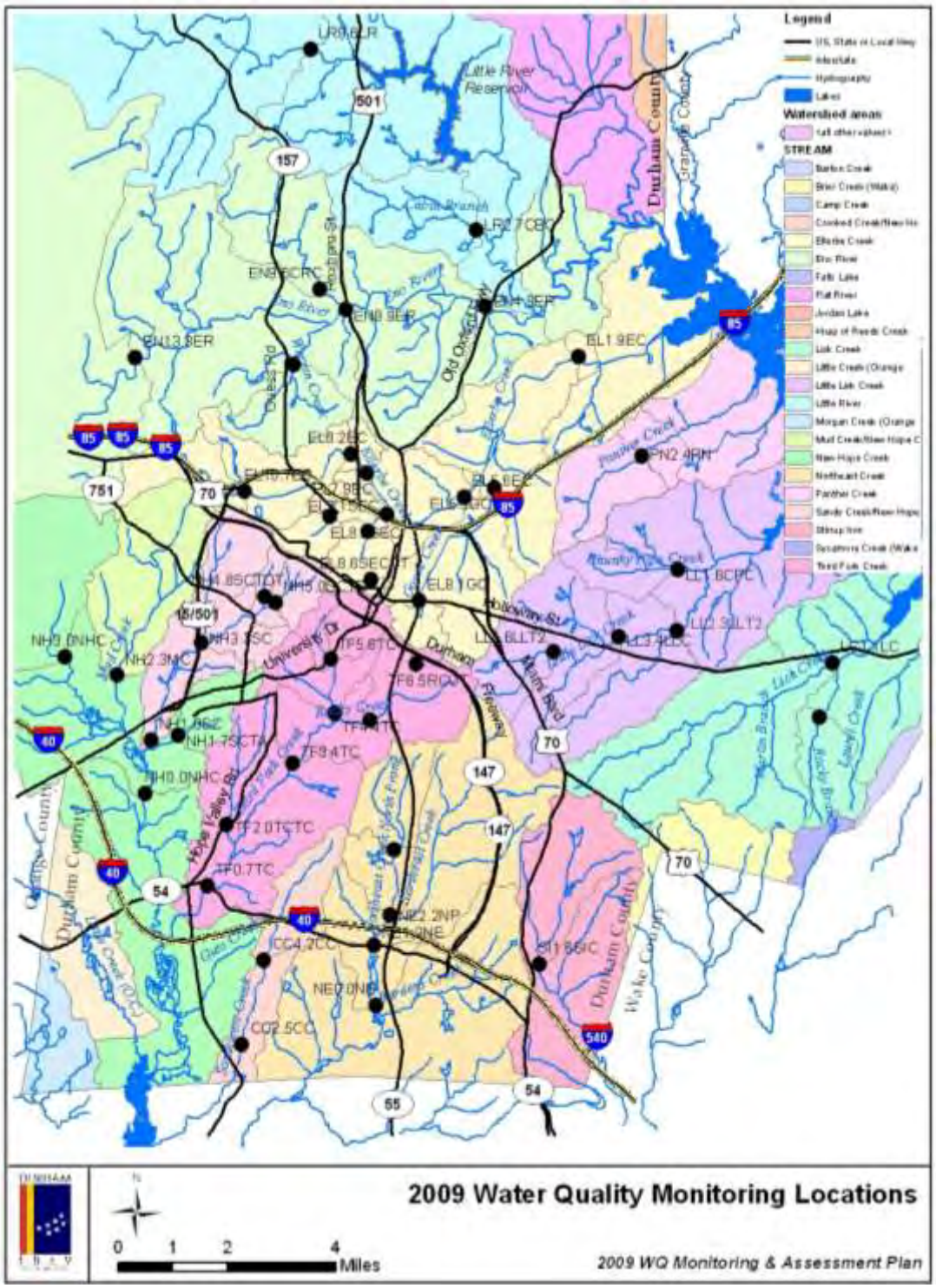


Table A-1. 2010 Stormwater Services Ambient Monitoring Locations

Site ID	Location (Street)	Basin	Ambient Chemistry	Benthic Macroinvertebrates
CC2.5CC	Scott King Rd. @ 1st stream crossing east of Fayetteville Rd	Cape Fear	Fecal	-
CC4.2CC	Massey Chapel Road	Cape Fear	Fecal	
NE0.0NE	Sedwick Rd	Cape Fear	Full	Yes
NE1.2NE	Bridge on Hwy 54 just west of Hwy 55 intersection	Cape Fear	Fecal	-
NE2.2NP	Meridian Pkwy @ 1st stream crossing	Cape Fear	Full	-
NE3.3NP	Odyssey Dr	Cape Fear	Fecal	
NH0.0NHC	Chapel Hill Rd	Cape Fear	Full	-
NH1.0SC	Garrett Rd	Cape Fear	Full	Yes
NH1.7SCTA	Ivy Creek Blvd	Cape Fear	Full	
NH2.3MC	Pickett Rd	Cape Fear	Full	Yes
NH3.0NHC	Erwin Rd	Cape Fear	Full	-
NH3.3SC	East of 15/501 on Cornwallis Rd	Cape Fear	Full	-
NH4.8SCTDT	Duke University Rd. just West of intersection w/ Anderson St	Cape Fear	Fecal	-
NH5.0SCTD	Anderson St	Cape Fear	Fecal	-
NH8.8NHC	Turkey Farm Rd	Cape Fear	Full	Yes
NH9.8NHC	Mount Sinai Road	Cape Fear	–	Yes
TF0.0TC	HWY 751 south of 54 & north of I-40	Cape Fear	Full	Yes
TF2.0TCTC	Hope Valley Rd @ Rugby Rd	Cape Fear	Full	-
TF1.2TC	South Roxboro St	Cape Fear	-	Yes
TF3.4TC	Martin Luther King Pkwy @ PWOC	Cape Fear	Full	-
TF4.4TC	Weaver St	Cape Fear	Fecal	-
TF5.1RC	Elmira St	Cape Fear	Fecal	-
TF5.6TC	University Dr. (Forest Hills Park)	Cape Fear	Full	-

Site ID	Location (Street)	Basin	Ambient Chemistry	Benthic Macroinvertebrates
TF6.5RCUT	Sima Ave	Cape Fear	Special	-
EL1.9EC	Glenn Rd	Neuse	Full	Yes
EL10.7EC	Bellevue Ave - main channel / above Trib from the Northside	Neuse	Fecal	-
EL5.5GC	Camden Ave.	Neuse	Fecal	Yes
EL5.6EC	Midland Terrace above Camden Ave	Neuse	Full	Yes
EL7.1SEC	Off the End of Glendale Ave. South side of Club Blvd	Neuse	Full	-
EL7.6SECT	Knox St. between Ruffin and Washington St	Neuse	Fecal	-
EL7.9EC	Murray Ave near Museum Life & Science	Neuse	Full	Yes
EL8.1GC	Holloway St. one block east of Alston Ave	Neuse	Full	-
EL8.2EC	Stadium Drive west of Duke St	Neuse	Special	
EL8.5SEC	Club Blvd @ Onslow St. (Walltown Park)	Neuse	Yes	-
EL8.6SECUT	Corner of Foster and Hunt St. @ Iron Bridge	Neuse	Special	-
EN10.3WC	East of Guess Rd. on Horton Rd	Neuse	Full	-
EN13.3ER	Cole Mill Rd	Neuse	Full	-
EN4.9ER	Snow Hill Rd	Neuse	Fecal	Yes
EN8.9ER	Roxboro Rd. (West Pt. on the Eno)	Neuse	Full	Yes
EN9.6CRC	West of Roxboro Rd. on Latta Rd	Neuse	Fecal	-
FR13.0FR	State Forest Rd. (SR 1614)	Neuse	Full	Yes
LC1.1LC	Southview Rd. south of Hwy 98	Neuse	Full	Yes
LC2.0RBC	Kemp Rd. @ intersection w/ Southview Rd.	Neuse	Fecal	-
LL2.3LLUT	Stallings Rd	Neuse	Fecal	
LL3.4LLC	Mineral Springs Rd. just north of 98	Neuse	Full	Yes
LL4.6LLT2	Lynn Rd. south of NC 98 Hwy	Neuse	Full	Yes
LR4.4CBC	Glenoaks Dr	Nesue	Full	

Site ID	Location (Street)	Basin	Ambient Chemistry	Benthic Macroinvertebrates
LR9.6LR	South of intersection of Patrick Rd. and Johnson Mill Rd	Neuse	Full	Yes
PN2.4PN	Burton Rd. between Geer St. and Cheek Rd	Neuse	Full	Yes
SI1.6SIC	Chin Page Rd	Neuse	Full	-

Fecal: Parameters monitored include physicals, turbidity, and fecal coliform.
Full: Parameters monitored include physicals, turbidity, fecal coliform, metals, and nutrients.
Special: Parameters monitored include physicals, turbidity and selected metals. May include other parameters depending upon the problem under investigation.

Appendix B.
Selected 2009 Water Quality Assessments
Updated June 2010

1. Ambient summary table
2. Benthic summary table
3. Example box plots for DO, turbidity and temperature
4. Nutrient load table

2009

CITY OF DURHAM AMBIENT STREAM SAMPLING

SUMMARY OF COMPLIANCE WITH WATER QUALITY STANDARDS AND CRITERIA

Parameters of concern shown in ***Bold***

						Fecal Coliform (FC)		Dissolved Oxygen (DO)			Nutrients		Dissolved Metals		Turbidity		
		Major Stream	Site ID	# of samples	Avg WQI	GeoMean FC (cfu/100mL)	Percent of FC samples > 400 cfu/100mL	Percent of DO Samples < 4.0 mg/L	Average DO (mg/L)	Average BOD (mg/L)	Average Total Nitrogen (mg/L)	Average Total Phosphorous (mg/L)	Percent of Cu samples > EPA CCC	Percent of Zn samples > EPA CCC	Average Turbidity (NTU)	Percent of Samples > 50 NTU	Average Conductivity (µS/cm)
Neuse River Basin	Falls Lake Watershed	Flat River	FR13.0FR	12	86	249	**33%**	0%	9.1	1.58	0.56	0.03	0%	0%	28	**25%**	81
		Cabin Branch Crk	LR2.7CBC	11		182	**27%**	9%	7.1						30	**18%**	140
		Little River	LR9.6LR	12	84	254	**33%**	0%	9.5	1.75	0.74	0.02	0%	0%	47	**25%**	80
		Eno River	EN4.9ER	12	86	173	**33%**	0%	8.7	1.42	0.61	0.02	0%	0%	37	**25%**	123
		Eno River	EN8.9ER	12	89	153	**25%**	0%	9.7	1.42	0.61	0.02	0%	0%	30	**25%**	118
		Eno River	EN13.3ER	11	88	114	**36%**	0%	8.8	1.45	0.55	0.06	0%	0%	36	**27%**	115
		Eno River	EN9.6CRC	12	83	667	**58%**	0%	9.7	1.58	0.59	0.02	0%	0%	48	**17%**	144
		Eno River	EN10.3WC	11		345	**36%**	**27%**	7.4						23	**18%**	167
		Ellerbe Creek	EL1.9EC	12	73	**1026**	**67%**	0%	8.4	1.83	**3.33**	0.07	8%	0%	30	**17%**	354
		Ellerbe Creek	EL5.6EC	12	78	506	**55%**	0%	8.7	2.42	0.61	0.06	**18%**	0%	35	**18%**	184
		Ellerbe Creek	EL7.9EC	12	79	405	**58%**	**17%**	8.6	2.17	0.55	0.07	**17%**	0%	26	**17%**	181
		Ellerbe Creek	EL8.2EC	11				0%	9.9						14	9%	190
		Ellerbe Creek	EL10.7EC	12	76	607	**58%**	**25%**	7.0	2.00	0.49	0.08	9%	0%	18	8%	149
		Goose Creek	EL5.5GC	12		763	**58%**	**17%**	7.7						48	**25%**	209
		Goose Creek	EL8.1GC	12	68	**2622**	**75%**	0%	8.0	3.00	0.85	**0.12**	**25%**	0%	**64**	**17%**	275
		So Ellerbe Crk	EL7.1SEC	11	69	**1832**	**64%**	**17%**	7.6	2.58	0.85	0.03	**55%**	0%	21	**17%**	237
		So Ellerbe Crk	EL7.6SECT	12		**2773**	**75%**	**17%**	6.8						18	8%	239
		So Ellerbe Crk	EL8.5SEC	12		**1795**	**75%**	8%	8.1						12	0%	214
		So Ellerbe Crk	EL8.6SECUT	12		**4334**	**92%**	0%	8.1						10	0%	467
		Panther Creek	PN2.4PN	7	84	237	14%	**14%**	8.7	1.57	0.69	0.02	**14%**	0%	32	**14%**	128
		Chunky Pipe Crk	LL1.6CPC	5		312	**40%**	0%	9.6						43	**20%**	70
		Little Lick Crk	LL2.3LLUT	9		551	**56%**	0%	8.6						**61**	**44%**	127
		Little Lick Crk	LL3.4LLC	10	79	686	**60%**	0%	8.2	1.8	0.82	0.02	**33%**	0%	47	**30%**	155
		Little Lick Crk	LL4.6LLT2	9	78	**1152**	**89%**	0%	9.2	2	0.76	0.04	**22%**	0%	31	**22%**	230
		Lick Creek	LC1.1LC	9	82	409	**33%**	0%	9.3	1.33	0.64	0.04	**11%**	0%	**61**	**22%**	128
		Lick Creek	LC2.0RBC	9	81	614	**56%**	0%	8.8	2.22	0.77	0.05	0%	0%	26	**22%**	150
		Stirrup Iron Crk	SI1.6SIC	12	69	215	**33%**	**25%**	6.4	2.25	0.79	0.03	**92%**	0%	32	**17%**	148
Cape Fear River Basin	Jordan Lake Watershed	Crooked Creek	CC2.5CC	12		343	**42%**	0%	9.0						**60**	**17%**	141
		Crooked Creek	CC4.2CC	12		276	**33%**	**17%**	6.9						34	**17%**	160
		New Hope Crk	NH0.0NHC	12	86	121	8%	**17%**	7.29	1.42	0.55	0.04	8%	0%	22	8%	182
		New Hope Crk	NH3.0NHC	12	92	61	8%	**17%**	8.59	1	0.41	0.03	0%	0%	15	8%	122
		New Hope Crk	NH8.8NHC	12	86	176	17%	**17%**	8.52	1.08	0.41	0.07	0%	0%	30	**17%**	130
		New Hope Crk	NH2.3MC	10	83	433	**40%**	0%	9.2	1.6	1.27	0.08	0%	0%	**52**	**22%**	141
		Sandy Creek	NH1.0SC	12	89	104	8%	**17%**	8.18	1.25	0.49	0.05	8%	0%	41	**17%**	243
		Sandy Creek	NH1.7SCTA	12		**1107**	**67%**	**17%**	6.76						24	**17%**	343
		Sandy Creek	NH3.3SC	12	87	223	**25%**	0%	8.26	1.58	0.70	0.03	8%	0%	34	8%	272
		Sandy Creek	NH4.8SCTDT	12		**1020**	**67%**	0%	7.32						16	**17%**	232
		Sandy Creek	NH5.0SCTD	10		**1027**	**70%**	0%	9.47						**62**	**20%**	230
		Third Fork Crk	TF0.7TC	12	77	744	**50%**	8%	7.0	1.83	0.70	0.04	**17%**	0%	28	8%	219
		Third Fork Crk	TF3.4TC	12	69	**961**	**50%**	**42%**	5.9	1.92	0.72	0.05	**17%**	0%	27	**25%**	284
		Third Fork Crk	TF4.4TC	11		**2466**	**82%**	9%	7.9						40	9%	246
		Third Fork Crk	TF5.6TC	10	71	**2834**	**80%**	10%	8.5	2.6	0.67	0.06	10%	0%	19	10%	295
		Third Fork Crk	TF2.0TCTC	11	71	**943**	**45%**	10%	6.4	2.91	0.89	0.08	**20%**	0%	22	**20%**	251
		Rock Creek	TF5.1RC	12		**999**	**58%**	8%	8.3						21	8%	272
		Rock Creek	TF6.5RCUT	11	75	**1548**	**64%**	9%	8.5	1.5	0.94	0.03	0%	0%	8	0%	414
		Northeast Crk	NE0.0NE	12	74	194	**33%**	**25%**	5.6	2.25	0.85	0.06	**25%**	0%	48	**17%**	189
		Northeast Crk	NE1.2NE	12		257	**33%**	**33%**	5.8						**55**	**17%**	198
		Northeast Crk	NE2.2NP	11	70	**1140**	**64%**	10%	7.8	2.33	1.58	0.04	10%	0%	**55**	**27%**	199
		Northeast Crk	NE3.3NP	11		**1026**	**55%**	9%	7.6						**59**	**27%**	187

Benthic Collections for 2009 (Winter and Summer)

Biological Assessment Results												
Site Information							Monitoring Results 2009					
SubBasin/ Stream Name	Site	Segment Miles in Durham Co	Stream Order	Drain. Area (sq mi)	River Basin	Eco-Region	Total Taxa	Total EPT	EPT Diversity	Biotic Index	Biotic Rating	Water Quality Rating
Little River	LR9.6LR		5	77.8	Neuse	Slate Belt	64	25	Good	5.76	Good	Good
*Flat River	FR13.0FR		4		Neuse	Slate Belt	n/a	n/a	n/a	n/a	n/a	n/a
New Hope	NH8.8NHC	1.6	4	22.0	Cape Fear	Slate Belt	41	13	Fair	6.26	Good-Fair	Fair
Eno River	EN8.9ER	4.4	5	140.8	Neuse	Slate Belt	62	18	Good-Fair	5.70	Good	Good-Fair
Eno River	EN4.9ER	8.9	5	148.3	Neuse	Slate-Triassic	50	17	Good-Fair	5.79	Good-Fair	Good-Fair
**New Hope/ Mud Creek	NH2.3MC	5.3	3	5.3	Cape Fear	Triassic Basin	55	6	Poor	7.61	Poor	Poor
**Lick Creek	LC1.1LC			10.0	Neuse	Triassic Basin	23	6	Poor	7.45	Fair	Fair
Panther Creek	PN2.4PN			2.5	Neuse	Triassic Basin	39	8	Fair	7.11	Fair	Fair
*New Hope/ Sandy Creek	NH1.0SC	4	3	6.8	Cape Fear	Triassic Basin	43	5	Poor	7.52	Poor	Poor
**Ellerbe Creek	EL1.9EC	3.7	4	21.9	Neuse	Triassic Basin	51	5	Poor	7.61	Poor	Poor
*Northeast Crk	NE0.0NE	4.6	3	13.1	Cape Fear	Triassic Basin	n/a	n/a	n/a	n/a	n/a	n/a
*Third Fork Crk	TF0.0TC			16.5	Cape Fear	Triassic Basin	n/a	n/a	n/a	n/a	n/a	n/a
**Third Fork Crk	TF1.2TC	5.6	3		Cape Fear	Triassic Basin	45	3	Poor	7.43	Fair	Poor
**Ellerbe Crk/ Goose Creek	EL5.5GC	2.9	3	5.0	Neuse	Triassic Basin	29	2	Poor	7.82	Poor	Poor
**Ellerbe Creek	EL5.6EC	2.3	3	10.7	Neuse	Triassic Basin	33	3	Poor	7.80	Poor	Poor
Little Lick Crk	LL3.4LLC	3.4	3	5.8	Neuse	Triassic Basin	41	4	Poor	7.96	Poor	Poor
Ellerbe Creek	EL7.9EC	3.5	3	5.2	Neuse	Triassic Basin	34	2	Poor	7.48	Fair	Poor
#Ellerbe Creek	EL8.2EC				Neuse	Triassic Basin	20	2	Poor	7.53	Poor	Poor
***Ellerbe Creek	EL10.7EC				Neuse	Triassic Basin	37	3	Poor	7.97	Poor	Poor
Little Lick Crk	LL4.6LLT2	1.2	3	1.8	Neuse	Triassic Basin	25	2	Poor	7.79	Poor	Poor

*Not sampled due to low or high flows

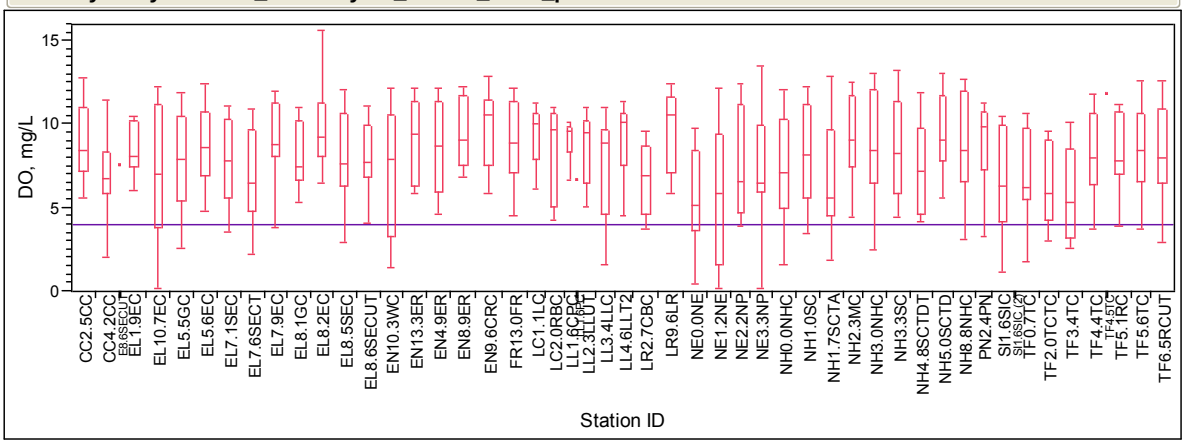
**Switched to winter sampling (+0.1 added to NCBI)

*** New site added 2009

Restarted sampling site

Example Box Plots Comparing All Stations, CY2009

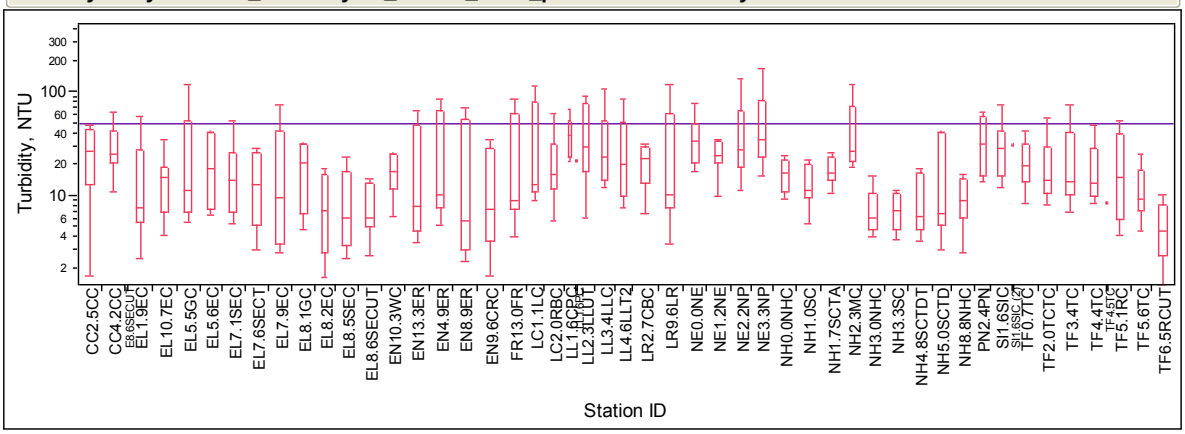
Oneway Analysis of dbl_result By str_station_id str_parameter=Dissolved O2



Missing Rows 1

Excluded Rows 258

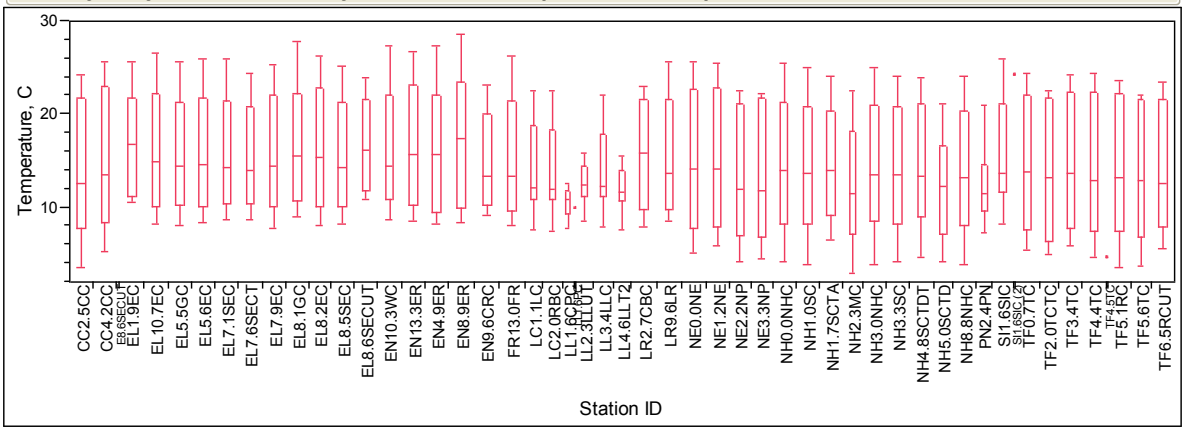
Oneway Analysis of dbl_result By str_station_id str_parameter=Turbidity



Missing Rows 1

Excluded Rows 258

Oneway Analysis of dbl_result By str_station_id str_parameter=Temperature



Excluded Rows 259

2009 Estimated Nutrient Loads

Calendar year mean estimated 2009 nitrogen and phosphorus loads are shown in the table below. These loads are based on monthly monitoring by Stormwater Services, but may be supplemented by Upper Cape Fear River Basin Association or NC Division of Water Quality monthly monitoring data.

A nutrient yield number was determined for each site using the drainage area to that site. To illustrate uncertainty to loads as estimated using the adjusted maximum likelihood procedure, the upper and lower 95th confidence limit on loads is reported for Ellerbe Creek at Club Blvd and Third Fork Creek at Hwy 54.

Monitoring location	Drainage area (acres)	Nitrogen		Phosphorus	
		Load (lbs)	Yield (lbs/acre)	Load (lbs)	Yield (lbs/acre)
Ellerbe Creek at Glenn Rd	14,016	268,801	19.2	8,432	0.60
Ellerbe Creek at Club Blvd	3,846	12,097	3.15	1,712	0.45
Eno River at Roxboro Rd (a)	90,240	207,388	2.30	5,496	0.06
Third Fork Creek at Hwy 54	9,466	28,706	3.03	446	0.05

(a) The Eno River watershed at Roxboro Road includes over 77,000 acres of drainage from Orange County and the Town of Hillsborough, or approximately 85% of the watershed at Roxboro Road.

Load uncertainty

Monitoring location	Nitrogen		Phosphorus	
	Mean load (lbs)	95% LCL and UCL	Mean load (lbs)	95% LCL and UCL
Ellerbe Creek at Club Blvd	12,097	6,733 20,217	1,712	1,060 2,642
Third Fork Creek at Hwy 54 (a)	28,708	11,502 60,416	446	125 1,174

LCL = Lower confidence limit
UCL = Upper confidence limit
(a) Stormwater Services nitrogen data were supplemented with Upper Cape Fear River Basin Association Data.

Appendix C.
Summaries of Ongoing and Completed Special Studies
Updated June 2010

The Water Quality Unit began two special studies under using a laboratory contract established in mid-2009. These studies are as follows:

1. Ambient Sediment Bacteria Study. This study includes quarterly monitoring of surface water and sediment in order to determine the potential for sediment to be a significant contributor of bacteria to the surface water. If legacy sources of bacteria remain present or bacteria growth/propagation is occurring, management of urban stormwater may be insufficient to reduce concentrations of bacteria in streams. Monitoring of surface water and sediment was conducted at 13 sites. Parameters included fecal coliform bacteria, *E. coli*, and organic carbon in surface water and sediment. Total suspended solids and *enterococci* in surface water and bulk density in sediment were also measured. The field study began in July 2009; field work is expected to be completed in April 2010.
2. Bacteria Attenuation Study. This goal of this study is to monitor the reduction of bacteria concentrations in surface waters following an unintentional sewage release to surface waters. Bacteria concentrations will be measured weekly for seven weeks following two different sewage releases. The study includes measurements of fecal coliform bacteria, *E. coli*, and organic carbon in surface water from areas upstream of the release, within the release area but in a side channel/eddy, and downstream of the release. The field portion of this study began in 2010.

Stormwater Services staff continued to work on two studies related to biological/benthic macroinvertebrate monitoring. These include the Benthic Split Sampling Study and the evaluation of benthic monitoring techniques.

1. Benthic Split Sampling Study. This study includes both winter/spring and summer monitoring of benthos at a variety of monitoring sites. Using the existing list of monitoring sites, a subset of sites is monitored during both seasons to determine how much seasonality affects the results. The field portion of the 3-year study is anticipated to be completed in the spring of 2010.
2. Benthic Sampling Methods Study. In the past, Stormwater Services has used a full collection method to obtain the necessary organisms for taxonomic analysis. However, the NC DWQ has other, less field intensive, methods that may be suitable for the Stormwater Services monitoring program. The field portion of this study is also anticipated to be completed in 2010.

Under a new laboratory contract, Stormwater Services will be conducting field work on the following additional special studies in 2010:

1. Nutrient Loading Study. As demonstrated in the above summary of nutrient loads, monthly ambient monitoring is insufficient to obtain a reasonable estimate of annual load. In 2010, nutrient concentrations will be collected two to three times per month in order to refine the nutrient loading estimate from six locations, including many of those listed in the Attachment B table of loading estimates. Nutrient concentrations will be obtained from both the SDWRF laboratory and a contract laboratory. The field portion of this study is anticipated to be complete in March 2011. Nutrient loads will be calculated for CY2010 in mid-2011.
2. Northeast Creek Metals Study. A Northeast Creek Watershed Management Plan is scheduled for development in 2011-2012. In support of this plan and using

feedback from the City's consultant on the Third Fork Creek plan, additional field work will be conducted in advance of the plan. This field work will include additional monitoring of metals and polycyclic aromatic hydrocarbons in sediment. Field work is anticipated to begin in June 2010 and complete in March 2011.

Town of Hillsborough
Review of and Response to "Current Monitoring in the Upper Neuse River Basin"
December 12, 2010

1. Review Mary Giorgino's (of the USGS) "Current Monitoring in the Upper Neuse Basin" documents (Attachment A). Make corrections and edits as necessary using MS Word's Track Changes feature and return to Heather Saunders at hsaunders@tjcog.org.

On Page 3 of USGS "Current Monitoring in the Upper Neuse Basin"
within the NPDES Discharge In-stream Monitoring section, the information for Town of Hillsborough WWTP, NPDES permit number NC0026433 is not correct.

Page 4. As for the Town of Hillsborough Water Plant:
Location - Lake Ben Johnston Intake (correct on form)
Parameters listed are correct, however TOC is monitored only once per month, not daily.

2. If the write-up on your activities does not already address the following, please add information on:

a. What parameters you are monitoring and what is the monitoring frequency

Parameters monitored:
Dissolved Oxygen
Temperature
pH

Frequency:
3 times per week June through September
1 time per week August through May

b. Where are your monitoring locations

Actual Locations:
NC Highway 86 (Churton Road in Hillsborough)
NCSR 1561 (Lawrence Rd, Orange County)
NCSR 1401 (Cole Mill Rd, Durham County)

c. Your monitoring and data collection methods

All samples gathered are grab samples

d. Changes in any of these aspects, and why

The Town has requested changes in the locations of in-stream monitoring to better reflect the impacts of the wastewater discharge on the Eno River.

e. Your current annual monitoring cost

All NPDES monitoring for the wastewater plant is done in-house so cost is minimal.

f. How long you have been monitoring each location and/or parameter (study duration)

>17 years

3. In addition, please include any thoughts on the following as an addendum to the document:

a. What is your current and future capacity is for monitoring?

i. How much staff time do you put towards it currently on an annual basis?

140 FTEs per year

ii. Can you maintain this or increase your effort?

Increase in number of parameters may be fine but limited staff due to hiring freeze would make additional monitoring difficult.

b. Who are your service providers (e.g. labs)? Would you recommend them? Are there any labs you do not recommend?

We currently use Meritech Inc and I would recommend them.

c. What do you perceive as your additional data needs?

Unsure what parameters will be most helpful, but the most important thing is making sure whatever data is collected is processed using a method that will be applicable to the chosen model.

d. Any additional thoughts on lessons learned as a result of your current or past monitoring experience.

None right now, I still have much to learn before having a credible opinion.

4. Finally, please supply Heather Saunders (hsaunders@tjcog.org) with a GIS data coverage layer of your current ambient surface water monitoring locations, including any stream gages, and groundwater stations.

NA

Orange County/Hillsborough Eno River Sampling Project

Purpose:

To aid in the identification of potentially illegal discharges to the streams in the Hillsborough area (upstream and down stream) and to provide baseline data to assist with nutrient management strategies.

Description:

Collect biweekly samples for one year (26 sampling events) at seven locations. Locations were selected to compare surface water quality flowing into and out of Hillsborough.

Field Parameters

- PH using Standard Method 16 423
- Dissolved Oxygen using Standard Method 4500-O-G
- Conductivity using EPA Method 120.1
- Temperature using EPA Method 170.1

Laboratory Analytes

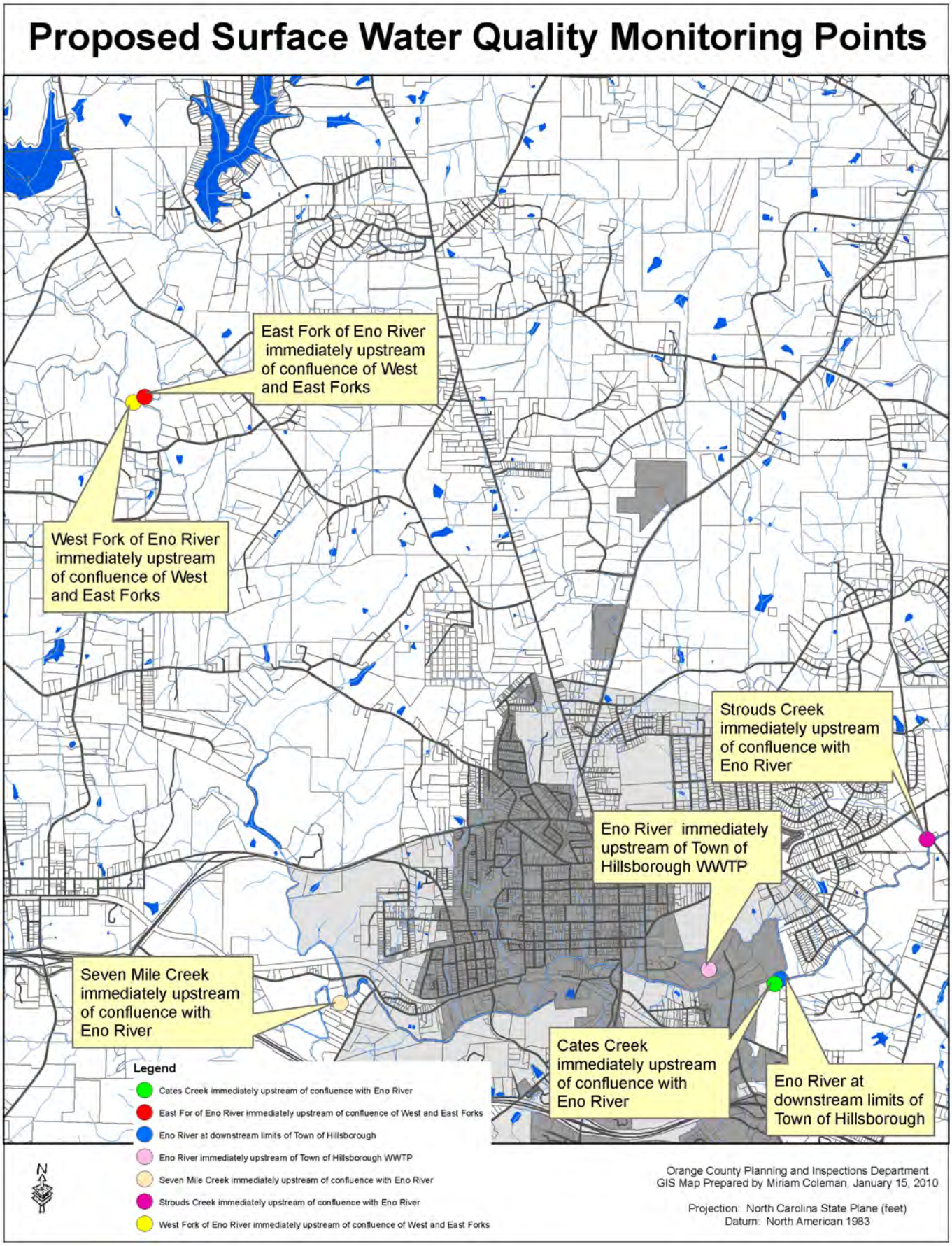
- Fecal coliform bacteria using Standard Method 9222D
- Enterococci bacteria using EPA Method 1600 or 1106.1
- Fecal coliform bacteria using Standard Method 9222D
- Chlorophyll a using ASTM Method D37318 or EPA Method 445.0
- Total suspended solids using EPA Method 160.2
- Turbidity using EPA Method 180.1
- Ammonia using EPA Method 350.1
- Total Kjeldahl nitrogen using EPA Method 351.2
- Nitrate/nitrite-nitrogen using EPA Method 353.2
- Total phosphorus using EPA Method 365.1

Sampling Locations:

1. West Fork of Eno River immediately upstream of confluence of West and East Forks
2. East Fork of Eno River immediately upstream of confluence of West and East Forks
3. Seven Mile Creek immediately upstream of confluence with Eno River*
4. Eno River immediately upstream of Town of Hillsborough WWTP
5. Cates Creek immediately upstream of confluence with Eno River
6. Eno River at downstream limits of Town of Hillsborough
7. Strouds Creek immediately upstream of confluence with Eno River

*This location was changed to just downstream of the Seven Mile Creek confluence with the Eno River due to access.

Orange County/Hillsborough Eno River Sampling Project



City of Raleigh
Current Water Quality Monitoring Activities in Falls Lake
December 12, 2010

Contact: **City of Raleigh Public Utilities**

Vannessa Barnes, E.M. Johnson Water Treatment Plant, 919-870-2870

Linda C. Ehrlich, Ph.D.**,** Spirogyra Diversified Environmental Services, performed monthly and quarterly ambient monitoring in the lake from 1999-2009

http://www.raleighnc.gov/portal/server.pt/gateway/PTARGS_0_2_306_204_0_43/http%3B/pt03/DIG_Web_Content/dept/public/Dept-AboutUs-PubUtil.html

1. Table with list of site names and location information.

Obtained intake sites from SWAP; In-lake sites were obtained from NCDWQ. From 1999-2007, 4 in-lake monitoring sites included: MM#10, MM#6, MM#4, City of Raleigh Intake.

From 2007 forward, 5 in-lake monitoring sites included: MM#17, MM#13, MM#10, MM#4, City of Raleigh Intake. All sites were accessed by boat.

2007-2009: Beaverdam Lake

2009: single monitoring event including creek sites: Ellerbe Creek, Knap of Reeds, Ledge

2. Brief description of why and how these sites are monitored

Purpose: Monitor long term trends in lake water quality; Support daily operations; reports to DEH PWS, NCDWQ

No. of sites: Falls Lake at City of Raleigh Intake (1); 4 other ambient sites in lake

Begin date: Falls Lake was completed in 1981. Ambient monitoring by Spirogyra began in 1999; from 1988-1995, the USGS collected ambient data in the lake.

Frequency: Raw-influent water is measured daily in the treatment plants for the usual constituents, TOC, DOC, and UV254. Results are reported to PWS monthly.

Composite sampling: accomplished via LabLine Integrating sampler or peristaltic pump with time based compositing. The 4 reservoir sites were sampled quarterly. Initially, all SDES monitoring was quarterly; supplemental monthly monitoring by SDES was added to the quarterly monitoring in 2003.

Constituents or classes: Reservoir sites, including intake: in situ temperature, pH, turbidity, dissolved oxygen, specific conductance, in vivo chlorophyll a, in vivo phycocyanin (blue-green algae) , secchi depth, quantum radiometer. Laboratory analyses were performed on photic zone composite samples (photic zone = 2X Secchi depth per DWQ protocol) for the following

parameters: Total alkalinity, total hardness, , toxic metals, secondary metals, fluoride, major ions, micronutrients, macronutrients, TOC, DOC, and UV254, VOCs & SOCs, oil and grease, inorganics, trace metals, , bromide, extractive (in vitro) chlorophyll a, turbidity, phytoplankton quality and quantity. Cyanotoxins. Laboratory analyses were performed on surface grab samples for fecal coliform, enterococcus.

The above in situ and laboratory parameters were monitored at all 5 sites quarterly. From 2003 forward, monthly monitoring, including in situ parameters, nutrients, and DBP (disinfection by-products TOC, DOC, UV_{254}) was added at MM#4 and the City of Raleigh Intake. From 2005 forward, in situ parameters were added monthly at all 5 sites. From 2007 forward, monthly monitoring, including in situ parameters, nutrients, DBP parameters, and extractive chlorophyll a was added for all 5 sites.

Quarterly sampling for extractive chlorophyll a included discrete depth samples collected at the City of Raleigh Intake

Special project monitoring: specialized sampling at City of Raleigh intake during 2007 drought comprised of discrete depth water sampling above sediments and sediment sampling for SOC's using horizontal Van Dorn Sampler and Eckman dredge

Phytoplankton Community Analytical Method: Inverted Microscope Method (per Standard Methods; DWQ); Sedgewick-Rafter Method (per Standard Methods)

Most recent annual monitoring cost: $110,140

In addition, Raleigh Public Utilities monitors enterococcus monthly at 4 reservoir sites.

3. Contact person in the organization for monitoring information.

Name: Ed Buchan
Address: Public Utilities Department
One Exchange Plaza
219 Fayetteville Street Mall, Suite 620
Raleigh, NC 27601
Phone: 919-857-4540
Email: Edward.Buchan@raleighnc.gov

4. How long do you keep WQ data records on-site?

Indefinitely. Records are kept at the treatment plant. Spirogyra provides data on CD as well as hard copies. Raleigh's daily monitoring records are kept electronically in-house (laboratory information management system).

5. To whom are the data reported ?

Report monthly to:
Public Water Supply Section
Division of Environmental Health
1634 Mail Service Center
Raleigh, NC 27699-1634
phone: 919-733-3225 (Compliance Services)
USGS—Provisional, subject to revision Page 19 3/18/2005
Ambient monitoring data are for in-house use only. These data are not reported to any other agency.

6. Web address for online data or publications from your monitoring efforts.

PUBLICATIONS

1. Ehrlich LC,[1] Gholizadeh A,[2] Wolfinger ED,[3] Wolfinger RD[4] & McMillan L[5]. 2005. A progressive comparison of cyanobacterial populations with raw and finished water microcystin levels in Falls Lake Reservoir. In: Cyanobacterial Harmful Algal Blooms: State of the Science and Research Needs, H. Kenneth Hudnell, ed. Advances in Experimental Medicine and Biology, Springer, New York, 619:563.

2. Ehrlich LC and L. McMillan. 2003. Water Quality Monitoring in the Falls Lake Reservoir and its Relevance to Water Treatment. Water Environment Federation Journal, Vol. 6, 2003.Technical Papers Presented at the 2003 NC AWWA/WEA Conference, November 17-20, Greensboro, NC

3. Ehrlich LC. (2010). Sampling and Identification: Methods and Strategies. In : Algae: Source to Treatment, AWWA.

4. Ehrlich, L.C. 2010. Algae control. Opflow. Vol. 36, No. 8, August, 2010, AWWA.

PRESENTATIONS

1. Ehrlich, L.C. 2010. Falls Lake Nutrient Management Strategy: How did we get here? Presented to a Duke University Focus Program class, November 17, 2010, Durham, NC.

2. Ehrlich, L.C. 2009. Beware the post-drought TOC. Presented at the North Carolina AWWA-WEA Drought Lessons Learned Seminar, February 24, 2009, Greensboro, NC.

3. Ehrlich, L.C. 2008. Water Quality Monitoring in the City of Raleigh Reservoir System: Falls Lake, Beaverdam Lake, Wake Forest Reservoir, Lake Wheeler, Lake Benson. Presented to City of Raleigh Department of Public Utilities, July 6, 2008, Raleigh, NC.

4. Ehrlich, L.C. and L. McMillan. 2007. Monitoring Water Supply Reservoirs for Public Health: The Falls Lake Example. Poster presented at the Water Resources Research Institute of North Carolina Annual Conference, Raleigh, March, 2007.

5. Ehrlich, L.C. and L. McMillan. 2007a. Experiences with the Use of Fluorometric In Situ Detection of Phycocyanin. Presented at the AWWA: 2007 Water Quality Technology

Conference Workshop: SUN2 Avoiding Complaints: Technologies for Early Warning of Aesthetic Issues, Charlotte, November 4, 2007.

6. Ehrlich, L.C. 2007b. Algal Toxicity Issues in Reservoirs of the Upper Cape Fear River Basin. Presented for the: Upper Cape Fear River Basin Association, Orange Water and Sewer Authority, Carrboro, North Carolina, January 23, 2007.
7. Ehrlich, L.C. 2006. Water Quality Monitoring in the Lower Falls Lake Reservoir. Presented at the Falls Immersion Day Conference, February, 2006, TJCOG, RTP, NC.
8. Ehrlich, L.C. 2006a. Development of a Standard Algal Identification and Enumeration Method for the USEPA Unregulated Contaminant Monitoring Rule. Presented at the NALMS 14th Annual Southeastern Lakes Management Conference, Asheville, North Carolina, April, 2006.
9. Ehrlich, L.C. 2006b. Algal Training Workshops for Water Plant Operators: Overview of Limnology. Workshop presented at E.M. Johnson WTP, December 11 and 15, 2006, City of Raleigh, Raleigh, NC.
10. Kearns, G., A. Berte, L.C. Ehrlich. 2005. Assessment of the value of source water and treatment plant monitoring data in enhancing the prediction of spring algal blooms. Presented at the North American Lake Management Society Annual Conference, November, 2005, Madison, Wisconsin.
11. Ehrlich, L.C. and L. McMillan. 2004. Use of Water Quality Monitoring in the Falls Lake Reservoir to Detect Impacts of the Drought of 2002. 13th Annual Southeastern Lake Management Conference, March 7-9, 2004,Charleston, South Carolina.
12. Ehrlich, L.C. 2004a. Are the BG's Stayin' Alive? (and Other Reservoir Management Questions). Presented at "Your Water, Your Health, Your Community", NCDENR Division of Environmental Health,October 19, 2004, Statesville, North Carolina.
13. Ehrlich, L.C. 2003. Water Quality Monitoring in the Lower Falls Lake Reservoir. Presented at: NC Public Water Supply Section Meeting on TTHM Compliance in the Aftermath of the Drought of 2002. OWASA, 2003.
14. Ehrlich, L.C. and L. McMillan. 2003. Ecology of Toxigenic Cyanobacteria in Southeastern Temperate Zone Reservoirs. Accepted for presentation at the International Symposium for Aquatic Invasive Species, June, 2003, Ontario, Canada.
15. Glasgow, H.B., J.M. Burkholder, B.W. Touchette, L.C. Ehrlich, D. Knappe, E.H. Allen. 2002c. Impacts of Toxigenic Cyanobacteria on North Carolina Waterways. Presented at: "A River Runs Through It" Conference, Elon University, September, 2002, Burlington, NC.
16. Ehrlich, L.C. and L. McMillan. 2002b. Ecology of Cylindrospermopsis (Nostocales, Cyanobacteria) in Temperate Zone Reservoirs: Evidence of Thermal Adaptibility. Presented at the Florida Lake Management Society 13th Annual Symposium, June 10-13, 2002, Naples, Florida.
17. Ehrlich, L.C. and L. McMillan. 2002a. Water Quality in the Lower Falls Lake Reservoir 1999 -2001: Consistency and Change. Presented at the Water Resources Research Institute of North Carolina Annual Conference, April 9, 2002, Raleigh, North Carolina.

18. Ehrlich, L.C. and R. Li. 2002. Distribution of Cyanobacteria in Water Supply Reservoirs in the Neuse and Cape Fear River Basins.Presented at the NALMS Eleventh Annual Southeastern Lakes Management Conference, March 18-20, 2002, Winston-Salem, North Carolina.
19. Ehrlich, L.C. and L. McMillan. 2000. Ecology of the Genus Cylindrospermopsis in Falls Lake, North Carolina, USA. Presented at the 20th Annual North American Lake Management Society Symposium, November 8-10, Miami, Florida.
20. Ehrlich, L.C. and L. McMillan. 2000a. Phytoplankton Dynamics as a Barometer of Water Quality Changes in the Water Supply Reservoir and Treatment Plant for the City of Raleigh, North Carolina. Presented at the Water Resources Research Institute of North Carolina Annual Conference, Raleigh, March, 2000.

The monitoring data are not available online. The Consumer Confidence Report describes the use of Falls Lake for source water, the treatment process, and an annual summary of finished-water analyses: http://www.raleighnc.gov/portal/server.pt/gateway/PTARGS_0_2_10376_0_0_18/Consumer_Confidence_Report-2003.pdf.

ADDENDUM:

1. Current and future capacity for monitoring
    a. *No current Falls Lake monitoring*
    b. *All staff and equipment resources used before are currently available*
    c. *We have the capacity and willingness to increase the monitoring effort over and above the previous effort, including stormwater and stream monitoring*
    d. *SDES is in the process of establishing in-house field parameter certification (EPA Lab Code# NC01938), as well as certification for extractive chlorophyll a analysis. We have hands on experience with all NC certified methods for chl a analysis. Further, we intend to upgrade microscopy capabilities for enhanced identification and documentation of algal and bacterial populations. We plan to accomplish this through use of a unique imaging system, the Faber Biomedical System, which combines reflected light fluorescence and transmitted light DIC.*
2. Labs
    a. *Environment 1, Inc., Greenville, NC- Recommended: inorganic, organic chemistries; chl a*
    b. *EMSL, Cary, NC-Recommended: fecal coliform, enterococcus*
    c. *Microbac Labs, Wilson, NC – Recommended: sediment analysis*
    d. *Greenwater Lab, Palatka, FL: cyanotoxins*
    e. *Not recommended: Meritech, Reidsville, NC*

3. GIS coverage

Station	Latitude	Longitude
Intake	35° 57.01" N	78° 34.55" W
Mile Marker #4	35° 58.48" N	78° 37.59" W
Mile Marker #6	36° 00.19" N	78° 38.48" W
Mile Marker #10	36° 01.10" N	78° 41.01" W
Mile Marker #13	36° 01. 32"N	78° 44. 01"W
Mile Marker #17	36° 04. 07"N	78° 46. 43"W
Beaverdam Lake	36° 01. 30"N	78° 41. 22"W
Ellerbe Creek	36° 03. 49	78° 48.194
Knap of Reeds Creek	36° 05. 05	78° 47. 477
Ledge Creek	36° 03. 448	78° 42. 816

USGS Real-time Monitoring Stations in the Upper Neuse River Basin

USGS Station No.	Station Location	Types Surface-water level ("stage")
03020201 Upper Neuse		
02085000	ENO RIVER AT HILLSBOROUGH, NC	X
02085039	ENO RIVER AT COLE MILL RD NR HUCKLEBERRY SPRING	X
360334078584145	RAINGAGE AT ENO RIVER NEAR HUCKLEBERRY SPRING, NC	
02085070	ENO RIVER NEAR DURHAM, NC	X
360419078543145	RAINGAGE AT ENO RIVER NEAR DURHAM, NC	
0208521324	LITTLE RIVER AT SR1461 NEAR ORANGE FACTORY, NC	X
0208524090	MOUNTAIN CREEK AT SR1617 NR BAHAMA, NC	X
0208524975	LITTLE R BL LITTLE R TRIB AT FAIRNTOSH, NC	X
02085500	FLAT RIVER AT BAHAMA, NC	X
02086500	FLAT RIVER AT DAM NEAR BAHAMA, NC	X
0208650112	FLAT RIVER TRIB NR WILLARDVILLE, NC	X
02086624	KNAP OF REEDS CREEK NEAR BUTNER, NC	X
0208675010	ELLERBE CREEK AT CLUB BOULEVARD AT DURHAM, NC	X
02086849	ELLERBE CREEK NEAR GORMAN, NC	X
0208700550	LITTLE LICK CREEK AT NC HWY 98 AT OAK GROVE, NC	X
355856078492945	RAINGAGE AT LTL LICK CR AT NC HWY 98 OAK GROVE, NC	
0208706575	BEAVERDAM CREEK AT DAM NEAR CREEDMOOR, NC	X
02087182	FALLS LAKE ABOVE DAM NR FALLS, NC	X
02087183	NEUSE RIVER NEAR FALLS, NC	X
355659078411401	WK-375 NORWOOD OAKS, RALEIGH, NC	
360143078540945	RAINGAGE AT WEST MURRAY AVENUE AT DURHAM, NC	

s of real-time data collected at station

Streamflow	Water Quality (temperature)	Precip-itation	Ground-water level
X			
		X	
X			
		X	
X			
X			
X			
X			
X			
X			
X			
X			
		X	
		X	
	X	X	
X			
	X		X
		X	

WAKE COUNTY

CURRENT MONITORING IN THE UPPER NEUSE RIVER BASIN

Contact: **Wake County Division of Water Quality** Date: December 2010

Table with list of sampling site names and location information

Site Name	Site ID	Longitude (decimal degrees)	Latitude (decimal degrees)	Neuse River Sub-Basin	Date Established
UT Honeycutt*	1060401	-78.603968	35.924272	Falls Lake	7-29-08
Cedar*	1060402	-78.628569	35.943911	Falls Lake	7-29-08
Lower Barton*	1060201	-78.659737	35.943662	Falls Lake	7-29-08
Upper Barton*	1060202	-78.687560	35.951783	Falls Lake	7-29-08
Beaverdam*	1060301	-78.655168	36.046558	Falls Lake	7-29-08
New Light Creek*	1060101	-78.600946	36.027279	Falls Lake	7-29-08
Horse Creek*	1060302	-78.561602	35.978967	Falls Lake	7-29-08
Black Horse Run Upper[2]		-78.705762	35.951862	Falls Lake (Upper Barton Creek)	10-28-09
Black Horse Run Lower[2]		-78.704161	35.949797	Falls Lake (Upper Barton Creek)	10-28-09
Hasentree®	1060303	-78.592052	35.991413	Falls Lake	3-25-09
Hawk Hollow®	1060203	-78.676545	36.000608	Falls Lake	3-11-09
Trib of Smith Austin Creek	1070201	-78.489280	35.981121	Lower Neuse	2-12-09
Sanford Creek	1070202	-78.507248	35.937779	Lower Neuse	2-12-09
Cedar Fork	1150101	-78.387124	35.913839	Little River	2-12-09
N. Buffaloe Creek	1150201	-78.440577	35.897081	Little River	2-12-09
Harris Creek	1070301	-78.488413	35.852605	Lower Neuse	2-12-09
Beddingfield Creek	1110301	-78.479885	35.695126	Lower Neuse	2-12-09
Poplar Creek®	1110302	-78.477327	35.731113	Lower Neuse	2-12-09
S. Buffaloe Creek®		-78.383667	35.775773	Lower Neuse	2-12-09
Swift Creek	2011101	-78.604047	35.646195	Swift Creek	2-29-09
Middle Creek South	1090201	-78.666911	35.591508	Middle Creek	2-29-09
Middle Creek South	1090101	-78.804348	35.661117	Middle Creek	2-29-09
Black Creek	1120101	-78.675464	35.566810	Middle Creek	2-29-09

*denotes monitoring that began within Wake County's 319 Grant: Watershed Management in Selected Subwatersheds of the Falls Lake Reservoir

[2]denotes monitoring associated with a 319 Water Quality project: Black Horse Run BMP & Stream Bank Stabilization

®denotes additional monitoring points yet to have staff gauges installed

Brief description of why and how these sites are monitored

Purpose: The purpose is to conduct short-term and long-term monitoring of the tributaries to assess current water quality conditions and aquatic life in the watershed. This monitoring will include the collection of water samples for chemical analysis and macroinvertebrates for biological assessment of the tributaries. These and other data will be used to recommend immediate management strategies at the subwatershed level and to aid in the development of long term management strategies. A stage-discharge relationship or flow rating tables will be developed for all sampling stations to conduct continuous discharge monitoring.
No. of Sites: 11
Monitoring Duration: varies, most began in mid-2008; all locations continue to be monitored
Frequency: Monthly; 4 of the 319 monitoring sites had storm sampling
Parameters: nutrients (TKN, NH_3-N, NOx-N, diss. P, and TP), sediment (TSS), and bacteria as well as measurement of physical parameters including turbidity, DO, pH, conductivity, temperature, and discharge. In addition, up to 7 samples may be analyzed for selected major ions (4 per sample from list including Fe, Mn, Na, Cu, Zn, K, SO_4, or Cl) if there is evidence of concern.
Methods: monthly grab samples and in situ measure of physical parameters; 4 tributary stream monitoring stations had automated samplers for the collection of flow-proportional samples during at least 3 storm events

Cost:

	Monthly	**Annually**
Wake County WQ Personnel	$550	$6600
YSI Calibration Supplies	$70	$835
YSI Parts Maintenance		$250
Lab Supplies		

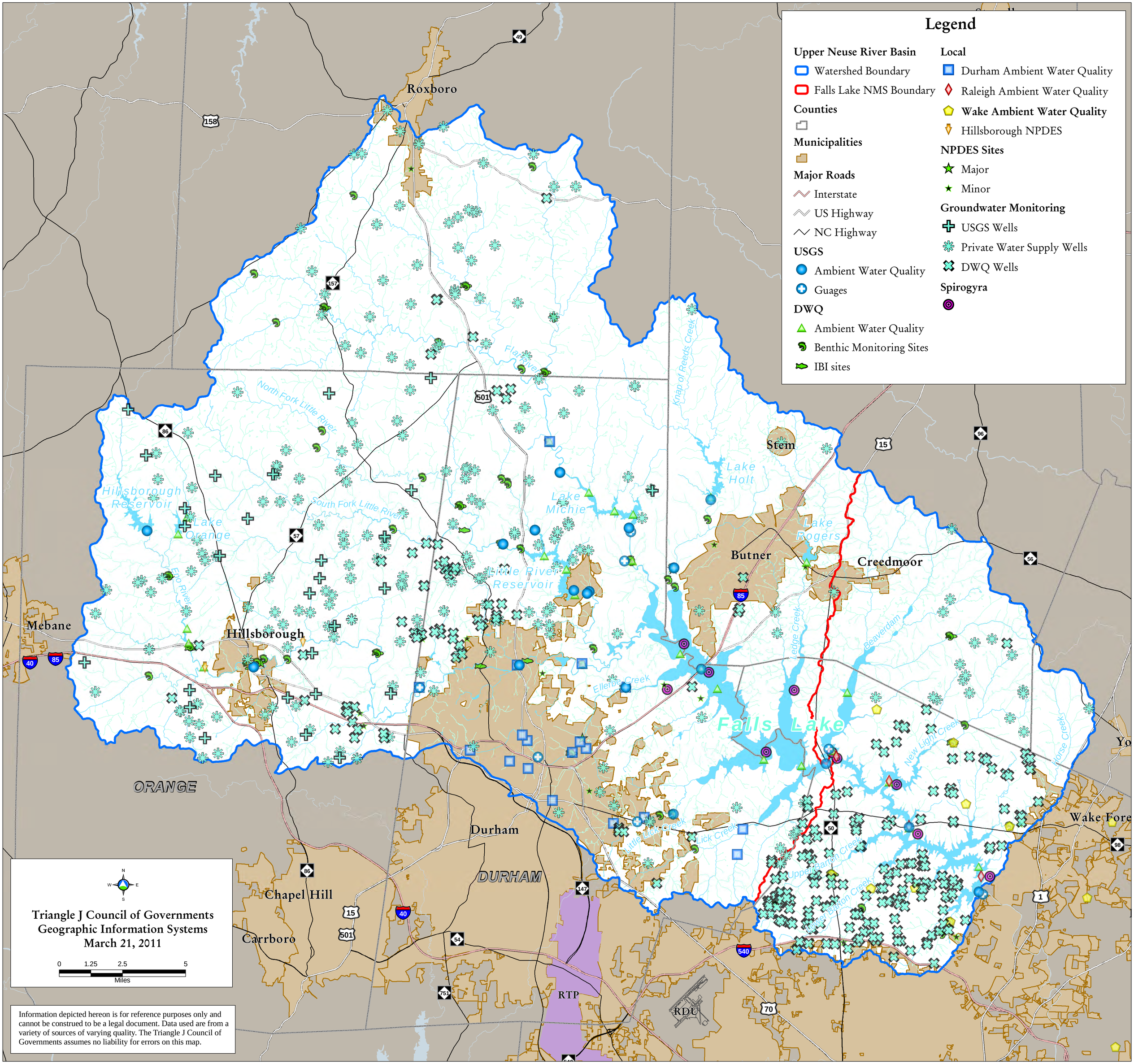
Additional Info:
In 2007, the County created a new Watershed Management initiative which is designed to integrate stormwater management, erosion and sediment control, buffers, floodplain management and environmental monitoring under one cohesive unit, known collectively as Watershed Management. Wake County has the ability to significantly increase its monitoring efforts. Increased monitoring by this group will continue to detect problems, measure the effectiveness of regulation and best management practices (BMPs), as well as monitor the effectiveness of watershed improvements.

Wake County intends to use the current service provider, Wake County Human Services Laboratory, which is owned and operated to provide county services.

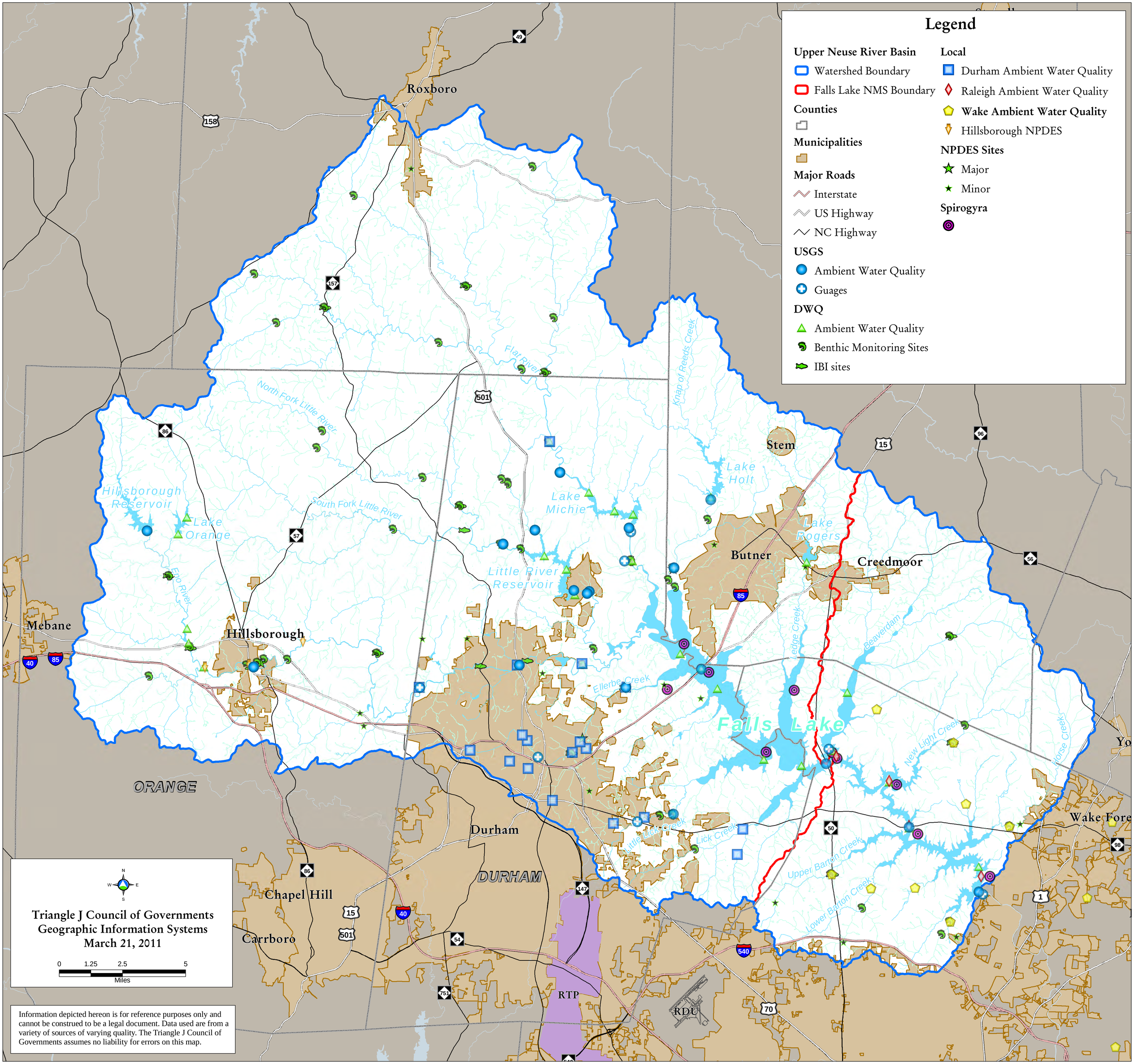
The County's data needs enviably will hinge on the development of a Memorandum of Agreement with DENR. The MOA should identify the criteria for site selection, lab qualifications, parameter selection, and frequency. Any monitoring data needs include increasing the number of sites and reliable storm data.

ATTACHMENT C. MAP OF WATER QUALITY MONITORING LOCATIONS

Upper Neuse River Basin Monitoring Sites

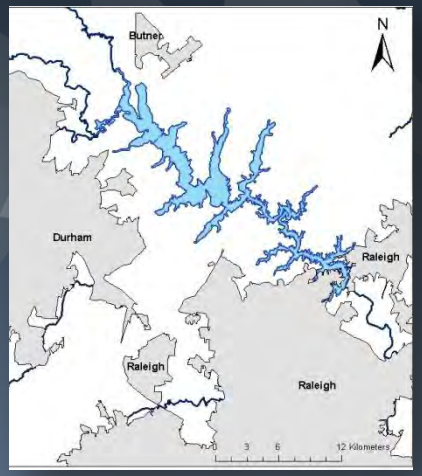


Upper Neuse River Basin Monitoring Sites



ATTACHMENT D. LOCAL GOVERNMENT/LOCAL PARTNERS WATER QUALITY MONITORING PRESENTATIONS

FALLS LAKE MONITORING PLAN



Dr. Kenneth Reckhow

Chief Scientist for Global Climate Change & Environmental Sciences

RTI International

Ibrahim Alameddine

PhD Candidate, Nicholas School of the Environment

Duke University

Feb 1 2011

RTI INTERNATIONAL | turning knowledge into practice

Monitoring: Data versus Information

- Why do we monitor:
  - Gain a better understanding of the system being monitored
  - Reduce the uncertainty about the environment of interest
- Most monitoring programs face the "data-rich but information-poor" syndrome described by Ward, Loftis et al. (1986)

Monitoring Objectives and Design Strategies

- *305(b) reporting*

  Probability sampling

- *303(d) listing*

  Sample at locations with greatest uncertainty of standards compliance.

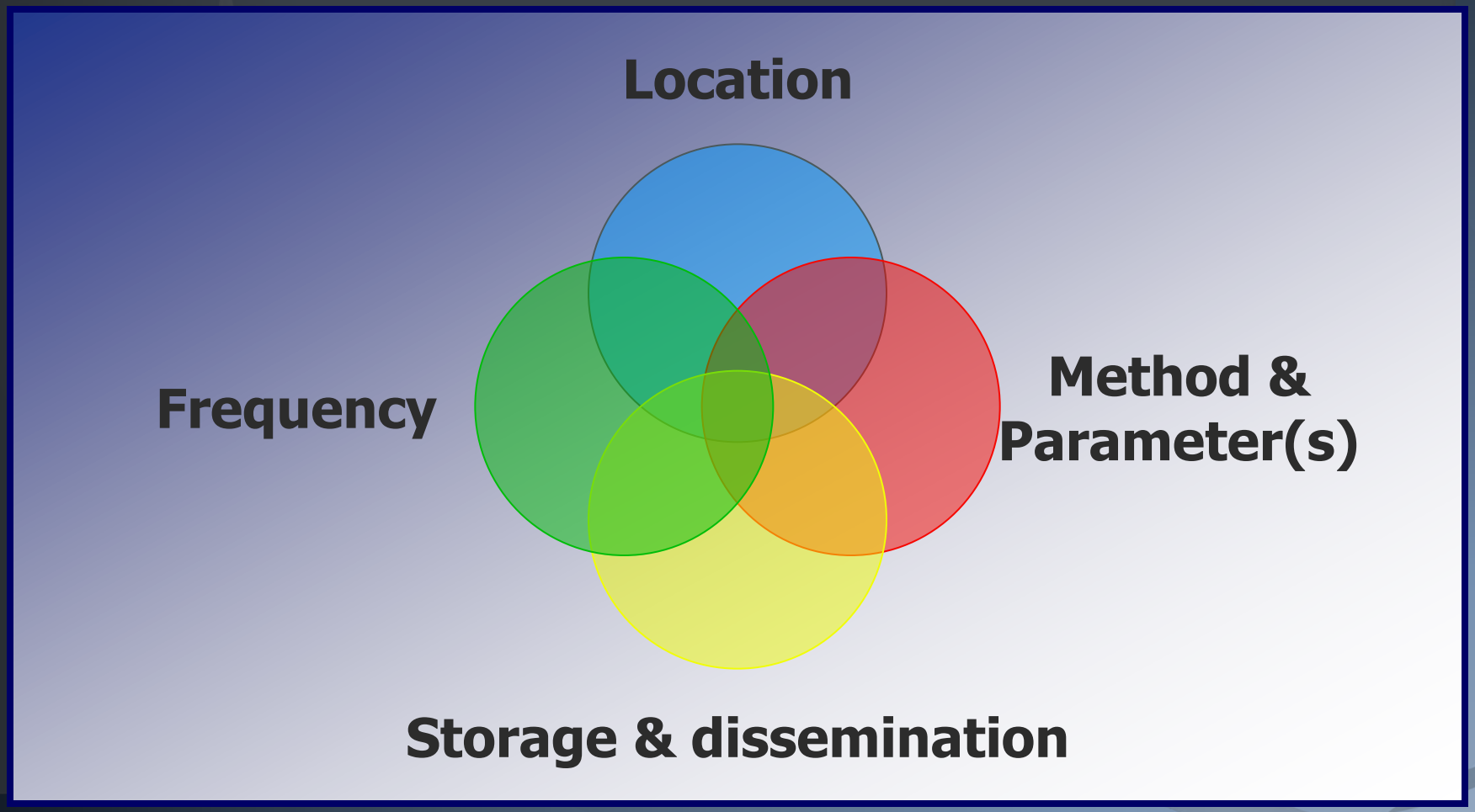
- *NPDES permits*

  Sample effluent or downstream of discharge points

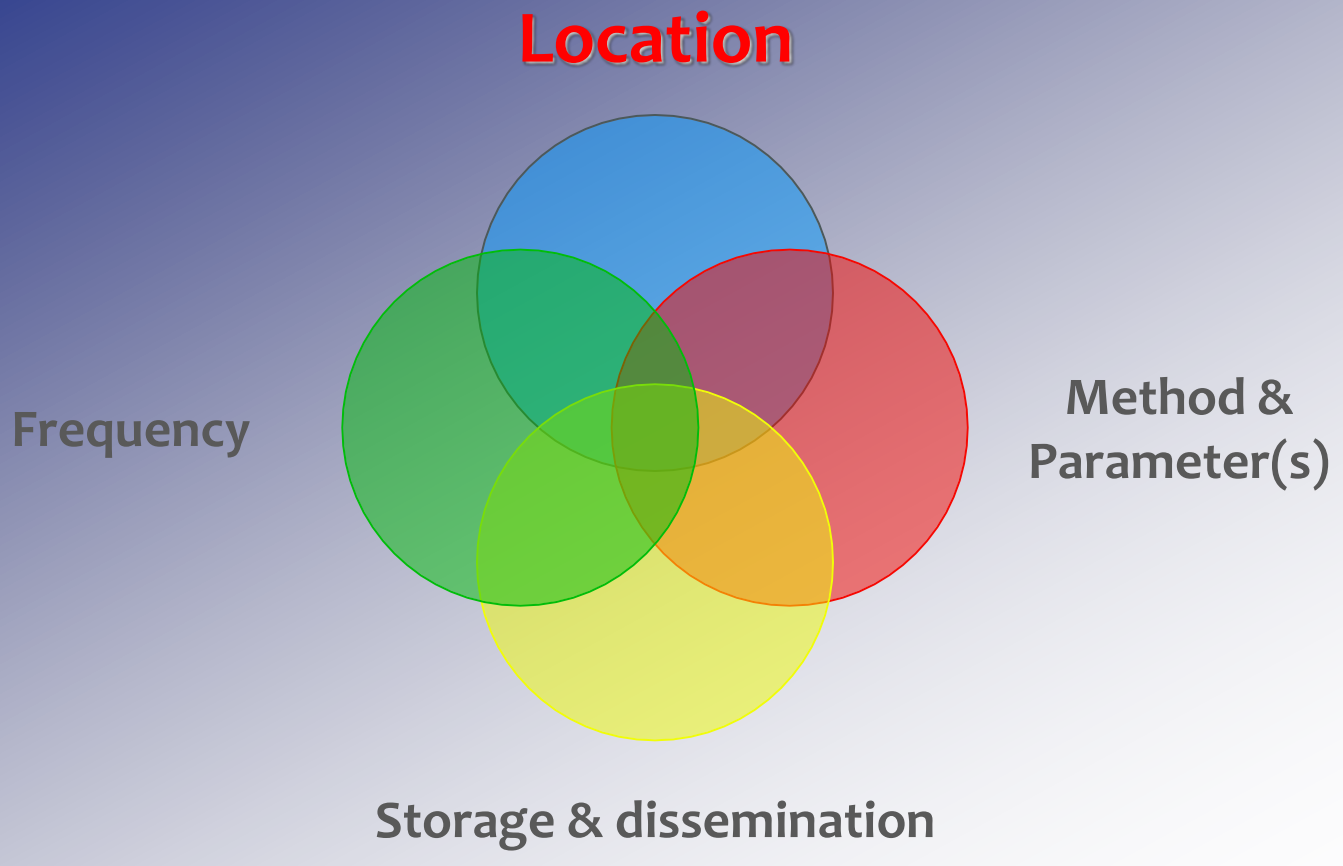
- *Public perception*

  Paint "DWQ" on boat and sample during holiday weekends.

Elements of a Monitoring Program

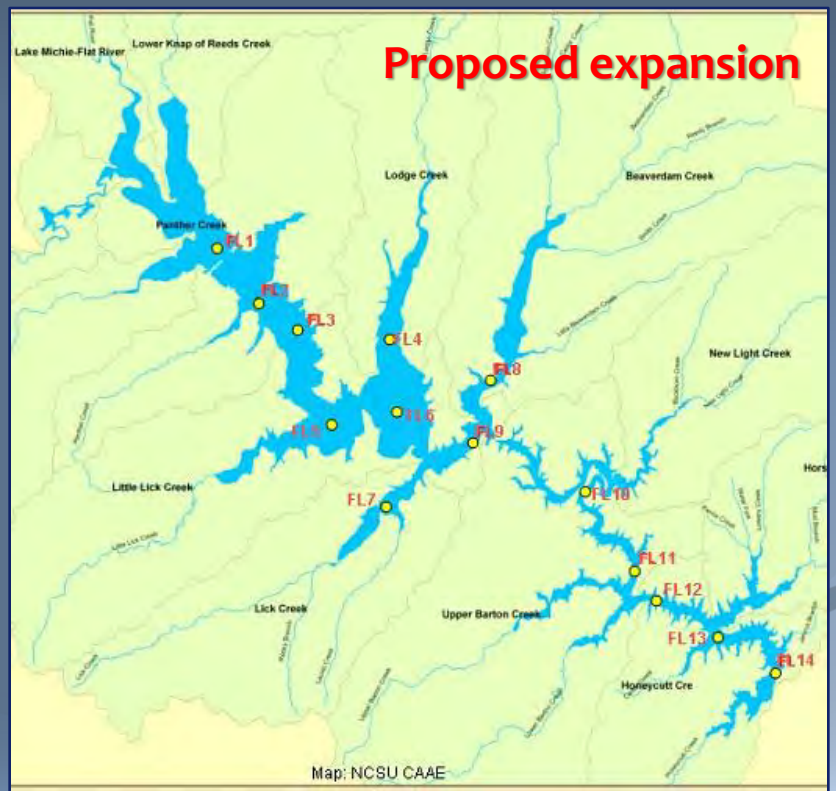


Elements of a Monitoring Program



Where to monitor?

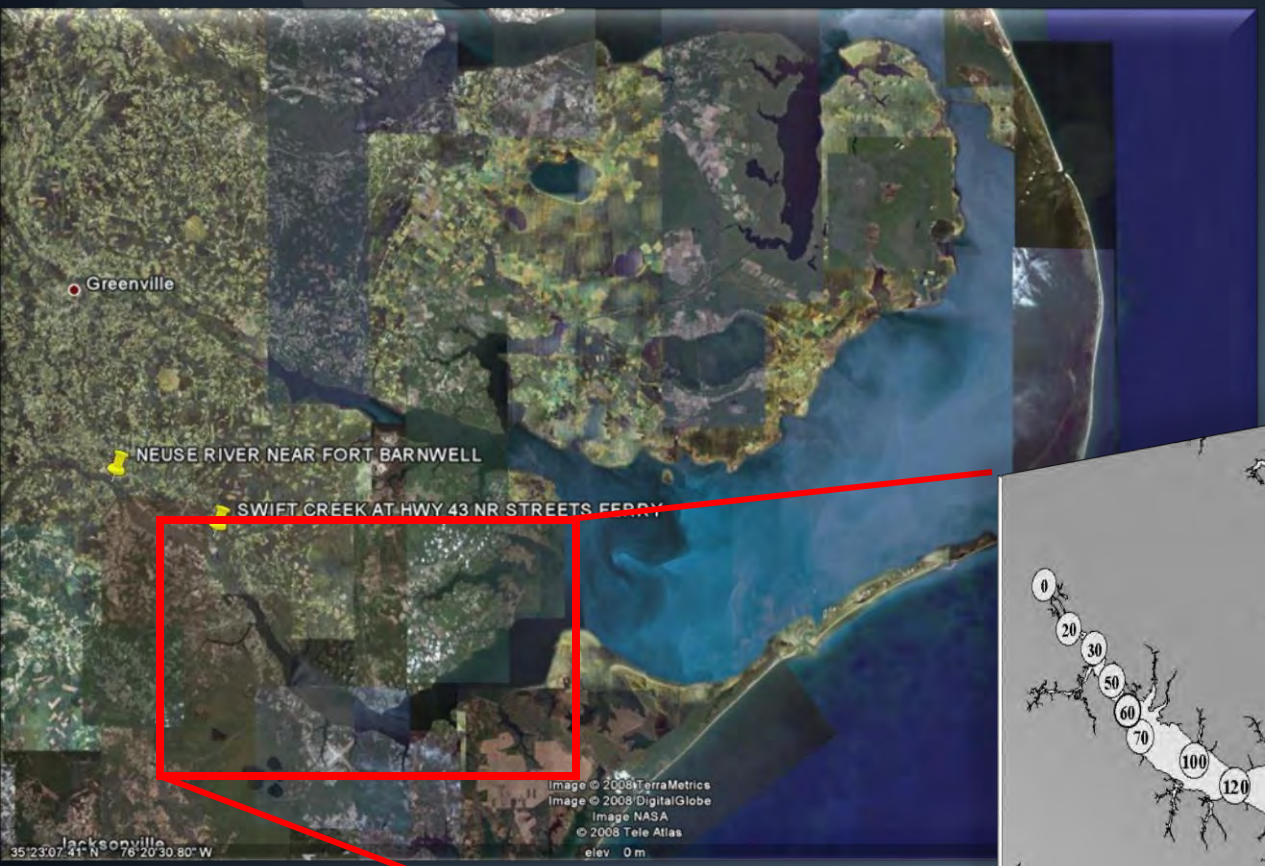
- In the absence of prior knowledge and data → place monitoring stations equidistantly from each other
  - Approach adopted for locating exiting stations
  - Approach proposed by the Burkholder plan for the planned expansion



Where to monitor?

- If we have prior information from previous sampling work then we can adopt a more **targeted and informed** approach towards network expansion
- This is done by accounting for:
  - The **spatial and temporal correlations** in the selected environmental variables
  - The correlations between the selected environmental variables
- This approach will **reduce redundancies** in the monitoring network and highlight the areas with the **largest uncertainties**

Case study: The Neuse Estuary's ModMon



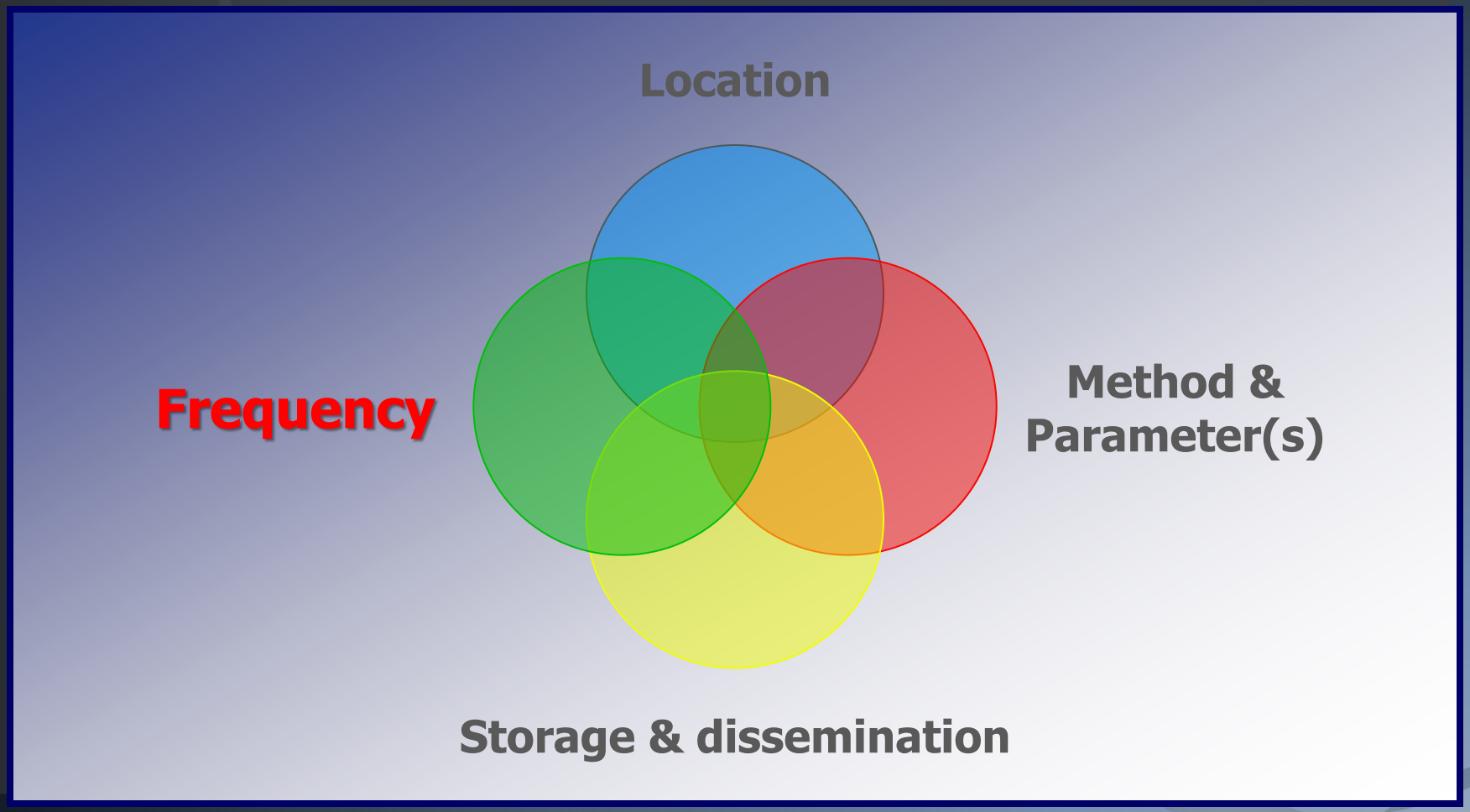
Flexible methodology:
Can base the optimization on different criteria:
(e.g. Entropy)

Load and Flow Monitoring

- The proposed load estimation plan entails a considerable investment in daily flow measurements at 13 small creeks feeding into Falls Lake
- Accurate flow data from small creeks is both challenging & expensive

- More effective to couple flow monitoring with modeling:
  - Identify nearby USGS gauged creeks (+ install a couple of gauges at selected number of creeks)
  - Use a rainfall-runoff model (e.g. IHACRES) with parameter regionalization based on watershed characteristics
- Calculate load using: mass load estimates, LOADEST/FLUX MASTER models, ratio weighted, & flow-concentration models

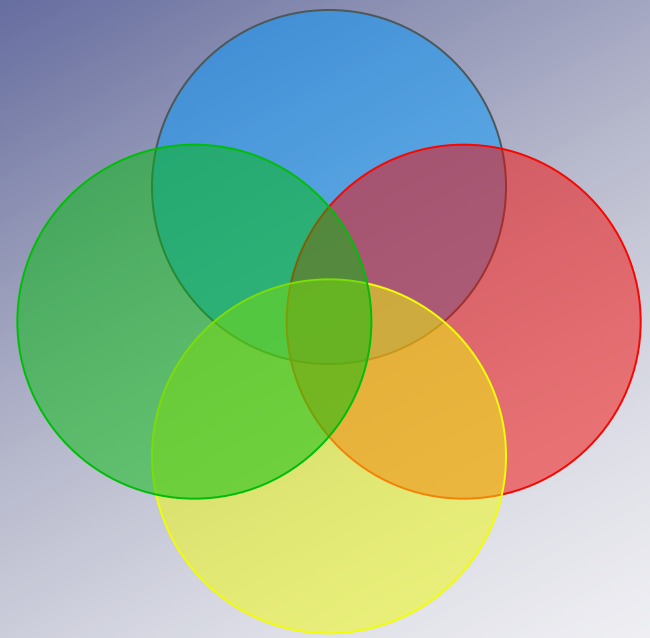
Elements of a Monitoring Program



Monitoring Frequency

- Changes in the monitoring frequency may result in significant changes in reported results
- For the sake of assessing water quality criteria attainment:
  - Applicable NC water quality standards do not specify a specific sampling frequency
- Bi-weekly sampling frequency would help better capture the varying dynamics in the lake
- Proposed intensification of sampling within the lake following large rain events (> 2 inches) or a drought will not add much value from an attainment perspective

Elements of a Monitoring Program

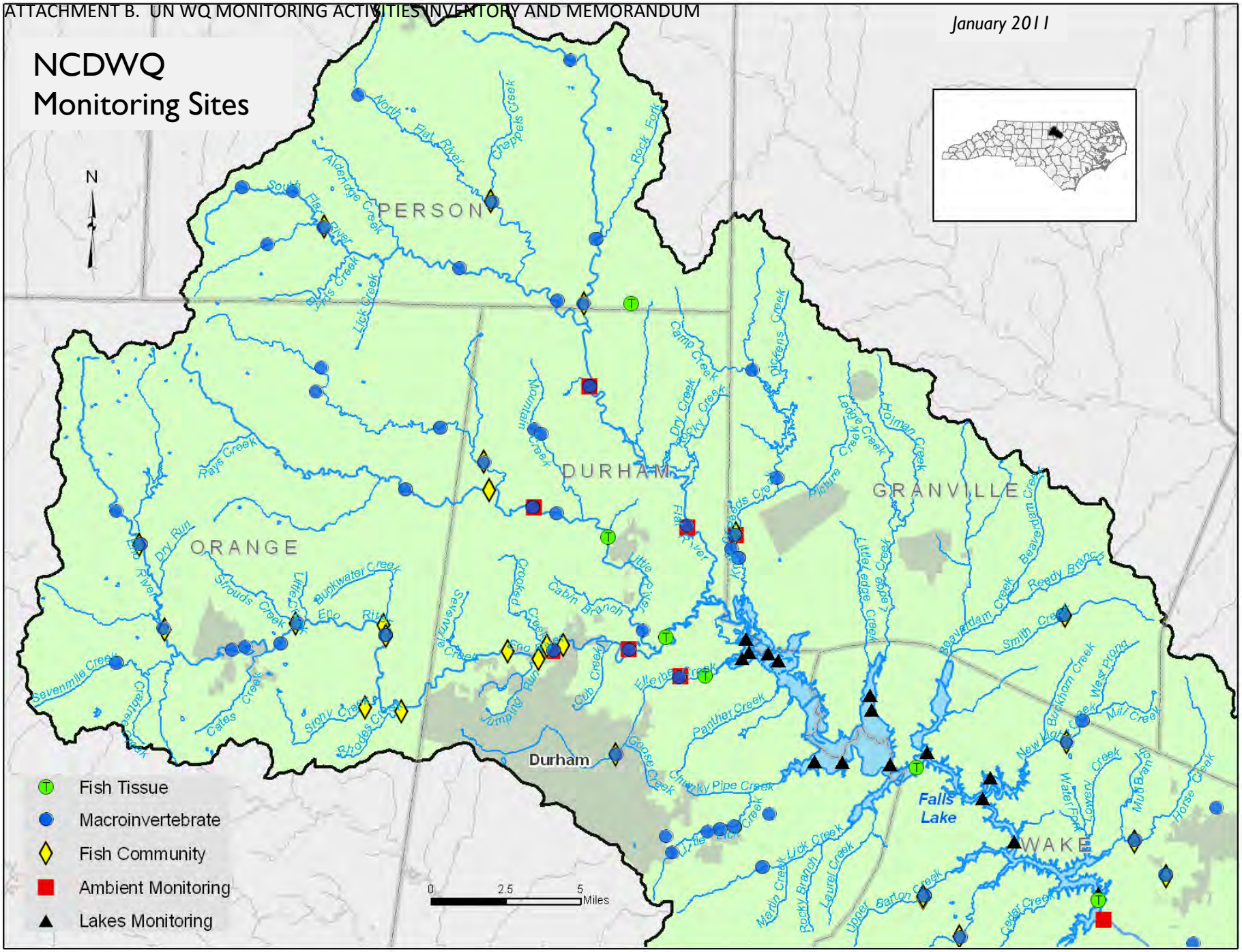


What to monitor and for what reason?

- We need to tie the monitoring program to the ongoing modeling work, the applicable standards, & the ultimate end points of the project
- Need to make informed decisions on what to monitor:
  - N and P are not water quality criteria, but they are important for water quality model development for the chlorophyll water quality criterion
  - HAB monitoring is not linked to applicable NC water quality standards. Should we monitor?
  - Do we need to take samples over the entire water profile? Compliance VS modeling…

Thank you

NCDWQ Water Quality Monitoring Program


NCDWQ
Monitoring Sites
January 2011
N
PERSON
DURHAM
ORANGE
GRANVILLE
WAKE
Durham
Falls Lake
North Flat River
Chappels Creek
Rock Fork
Alderidge Creek
South Flat River
Lick Creek
Camp Creek
Dry Creek
Rocky Creek
Dickens Creek
Mountain Creek
Lodge Creek
Holman Creek
Flat River
Little River
Cabin Branch
Cooked Creek
Seventy Six Creek
Eno River
Ellerbe Creek
Cub Creek
Panther Creek
Goose Creek
Chunky Pipe Creek
Little Lick Creek
Martin Creek
Lick Creek
Rocky Branch
Laurel Creek
Upper Barton Creek
Cedar Creek
Little Ledge Creek
Beaverdam Creek
Ready Branch
Smith Creek
New Hope Creek
Burkhorn Creek
West Prong
Mill Creek
Water Fork
Lowerd Creek
Mud Branch
Horse Creek
Pays Creek
Dry Run
Buckwater Creek
Strouds Creek
Little Creek
Sevenmile Creek
Cates Creek
Stony Creek
Rhodes Creek
Fishing Creek
Fish Tissue
Macroinvertebrate
Fish Community
Ambient Monitoring
Lakes Monitoring
0
2.5
5
Miles

DWQ Monitoring in Upper Neuse

- Generally part of overall statewide assessment
  - Fish tissue
  - Macroinvertebrates
  - Fish community
- Statewide + Falls Lake-specific
  - Ambient monitoring
  - Lakes monitoring

DWQ Monitoring in Upper Neuse

- Falls Lake
  - Locations based on original findings of impairment
  - Track WQ improvements
  - Assess use support
  - Meet requirements of Falls rules
- Falls Lake watershed
  - Locations based on load reduction requirements in rules
  - Calculate actual load reductions
  - Assess use support
  - Meet requirements of Falls rules

DWQ Monitoring in Upper Neuse

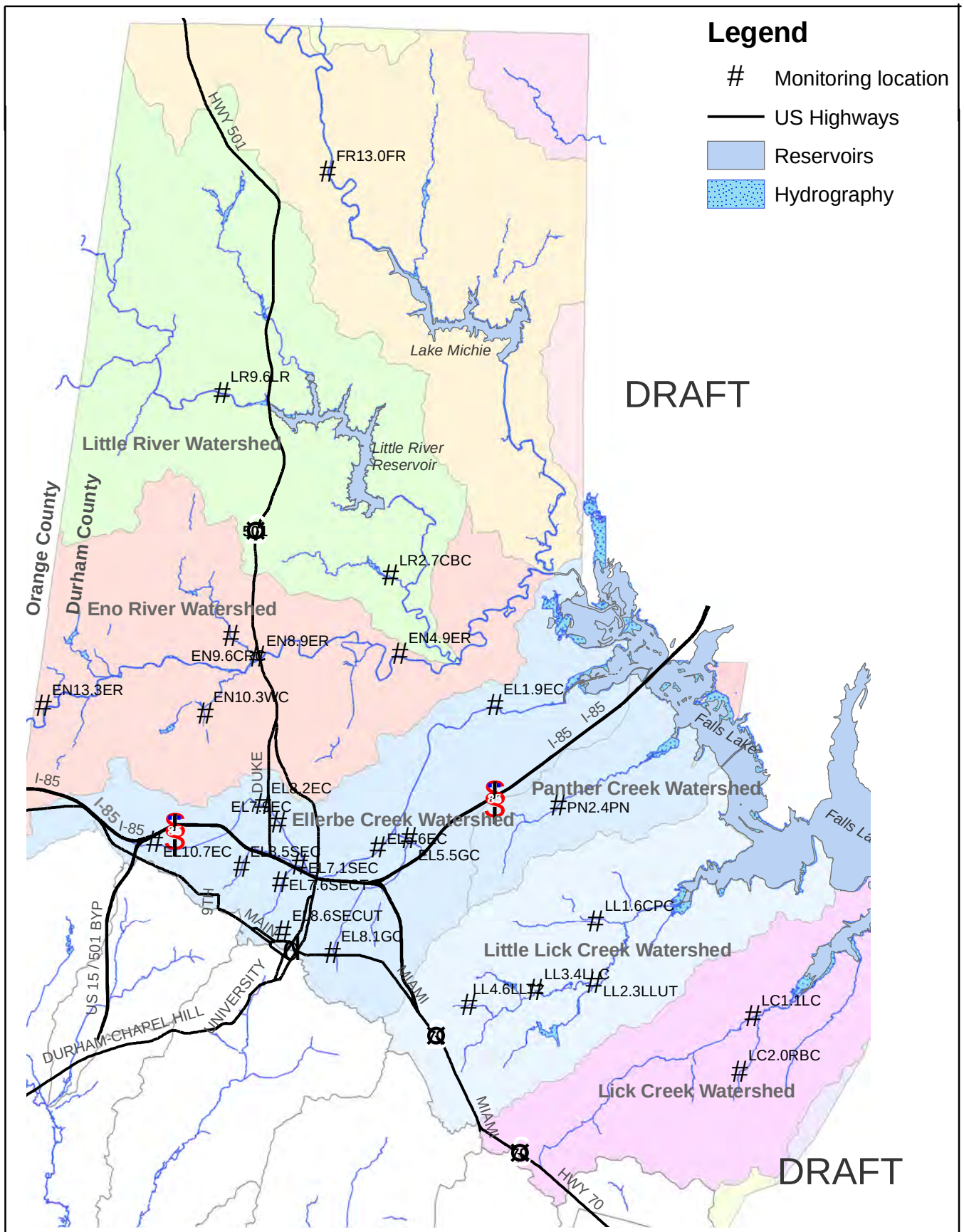
- *"How flexible is your program?"*
  - **Not very.**
- *"Do you have the time, staff, & resources to expand it?"*
  - **Surely you can't be serious.**
- *"I am serious. And don't call me Shirley."*

DWQ Monitoring in Upper Neuse

- What about groundwater?
  - Historical and public water supply wells
  - No *current* groundwater quality monitoring wells

City of Durham Water Quality Monitoring Program

ATTACHMENT B. UN WQ MONITORING ACTIVITIES INVENTORY AND MEMORANDUM



2009 Falls Lake Watershed Monitoring Stations

City of Durham Storwmater Services

Durham Stormwater Services Monitoring Program Components

Base Monitoring	Ambient Chemistry	Benthic Macroinvertebrates	Rainfall & Streamflow		
Special Studies	Nutrient Loads	Sediment Bacteria	Bacteria Attenuation	Sand Filter Demo	Atmospheric Deposition

draft

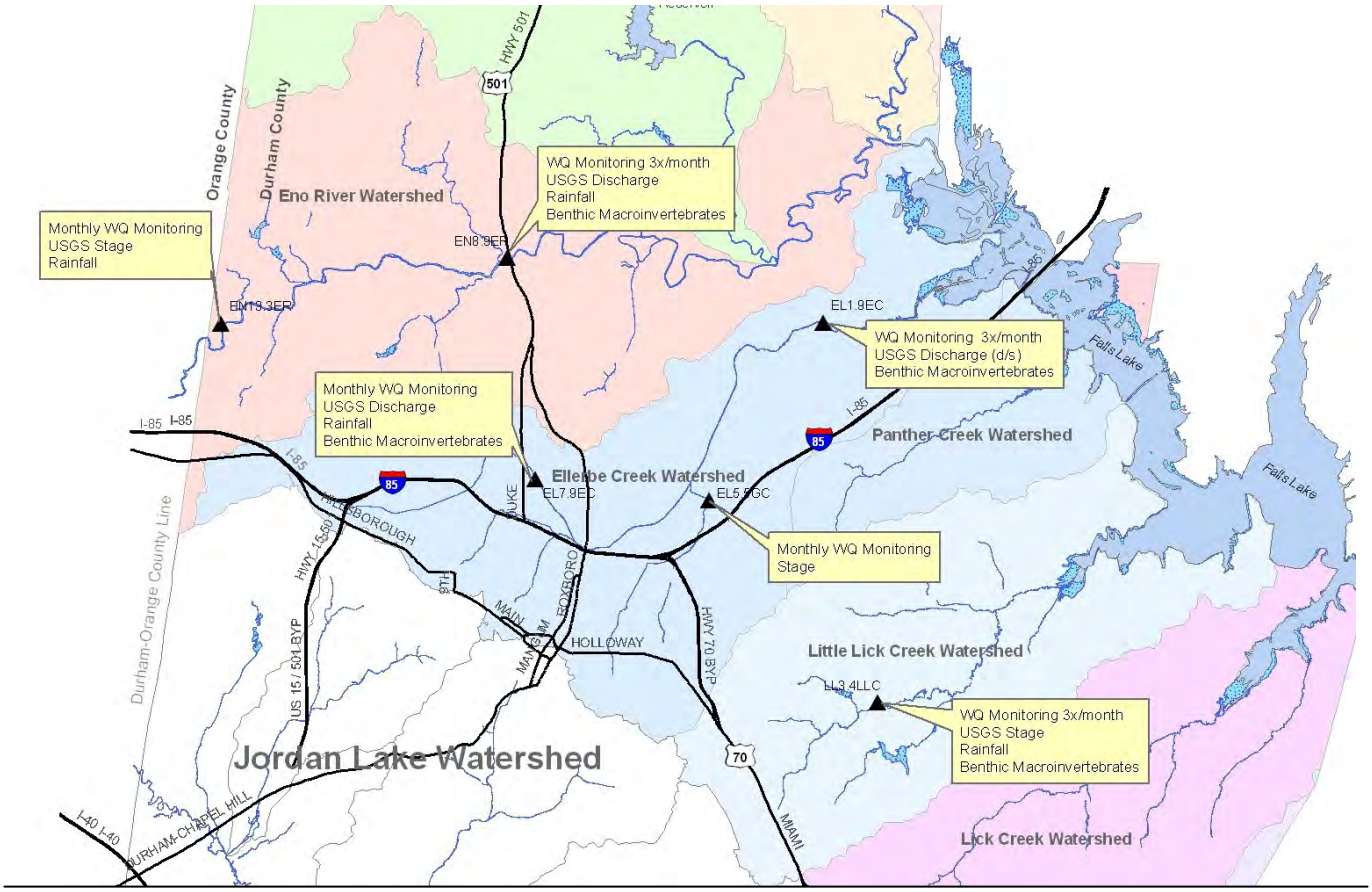
2009 Ambient monitoring program description:

Fixed monthly monitoring at 49 stations; only the Falls Lake watershed stations are shown on the previous map. Collected field parameters (i.e., temperature, DO, pH, conductivity, turbidity). All samples analyzed for fecal coliform bacteria. Select samples analyzed for nutrients (TKN, NO2+NO3, Ammonia, TP), metals (Cd, Cu, Zn, Pb, Ni, Cr), and other conventional pollutants (TSS, calcium, magnesium, hardness). All samples are sent to the South Durham Water Reclamation Facility (SDWRF) Laboratory. The SDWRF Laboratory may analyze samples in-house or send samples to a contract laboratory.

Modifications in 2010. Cabin Branch Creek station moved upstream. Chunky Pipe Creek station dropped.

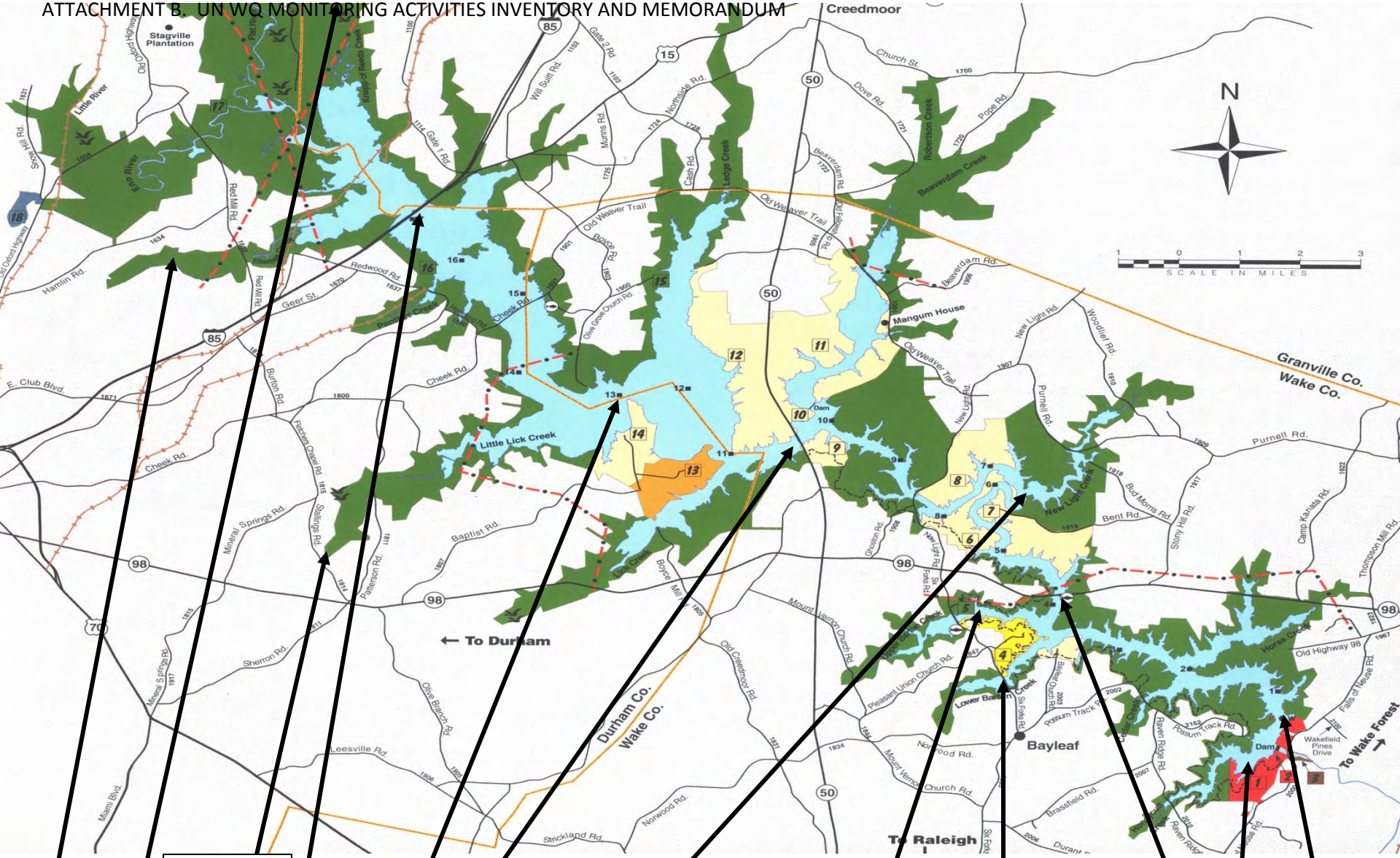
Modifications in 2011. Moved to biennial rotating watersheds. In 2011, the Ellerbe and Panther Creek watersheds will be monitored. In 2012, the Eno River, Little River, Little Lick Creek and Lick Creek watersheds will be monitored.

Key Falls Lake Watershed Monitoring Stations:



City of Raleigh Water Quality Monitoring Program

ATTACHMENT B. UN WQ MONITORING ACTIVITIES INVENTORY AND MEMORANDUM



Ellerbe Crk
USGS (storm)

Knap of Reeds
USGS (storm)

Little Lick Crk
USGS (storm)

HWY 85:
USGS, NCSU

MM #13
NCSU

IHWY 50:
USGS, NCSU

New Light Creek
PUD

Upper Barton Crk
PUD

Lower Barton Crk
PUD

HWY 98: PUD
USGS

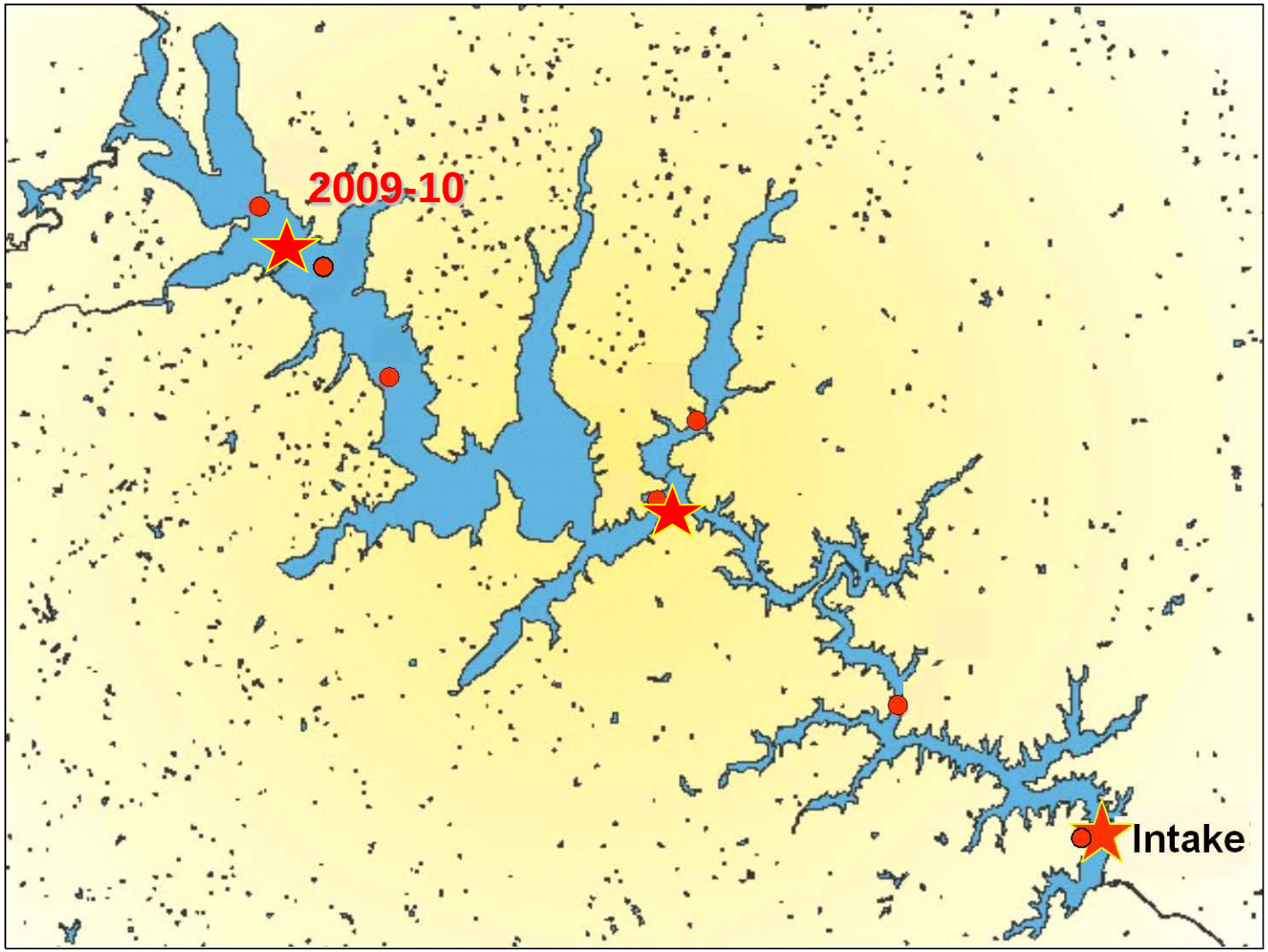
Honeycutt Creek
PUD

Intake: PUD,
USGS, Eco,
NCSU

ATTACHMENT B. UNIWQ MONITORING ACTIVITIES INVENTORY AND MEMORANDUM

Group	DBP (TOC, DOC, UV)	Metals	Org (VOCs & TOC)	Inorg	Crypt Gia	Pest SOC (Sim & Atra by ELSIA)	Chlor A	Micro Ana-toxin Clind	Phys Para	Nutri And Major ion NH3, TKN NO2, NO3, TP	Bact e.Coli Enter	phyto	MIB IPMP IBMP Geo
Eco							Monthly (in situ)	Bi-weekly (Mar-Oct) @ WTP Monthly @ intake	Monthly Profiles & storm events @intake			Monthly @ WTP	Bi-weekly (Mar-Oct) @ WTP Monthly @ intake
PUD		Monthly at 5 sites & intake	Monthly at 5 sites & intake	Monthly at 5 sites & intake	Monthly at intake and as needed at other sites	Monthly @ 5 sites & intake		Monthly @ 5 sites & intake	Monthly @ 5 sites & intake	Monthly @ 5 sites & intake	Monthly @ 45sites & intake	weekly @ intake & monthly at various sites	pending
NCSU							Monthly (in situ + Extracted)		Continual at 2 platforms; Monthly @ 8 sites (April-Sep): biweekly at intake	Monthly @ 8 sites (April-Sep): biweekly at intake		Monthly @ 8 sites (April-Sep): biweekly at intake	
Wake Co.											Weekly at 16 sites in summer		
USGS	Bi-monthly 3 sites & Intake & streams + storms	Bi-monthly 3 sites & Intake & streams + storms		Bi-monthly 3 sites & Intake & streams + storms			Bimonthly Extracted 3 sites & Intake & streams + storms		Bi-monthly 3 sites & Intake & streams + storms	Bi-monthly 3 sites & Intake & streams + storms		Bi-monthly 3 sites & Intake	

City of Raleigh's network of automated RTRM platforms to track environmental conditions in the upper, middle, and lower Falls Lake water supply (temp., pH, DO, turbidity, chla, phycocyanin…)



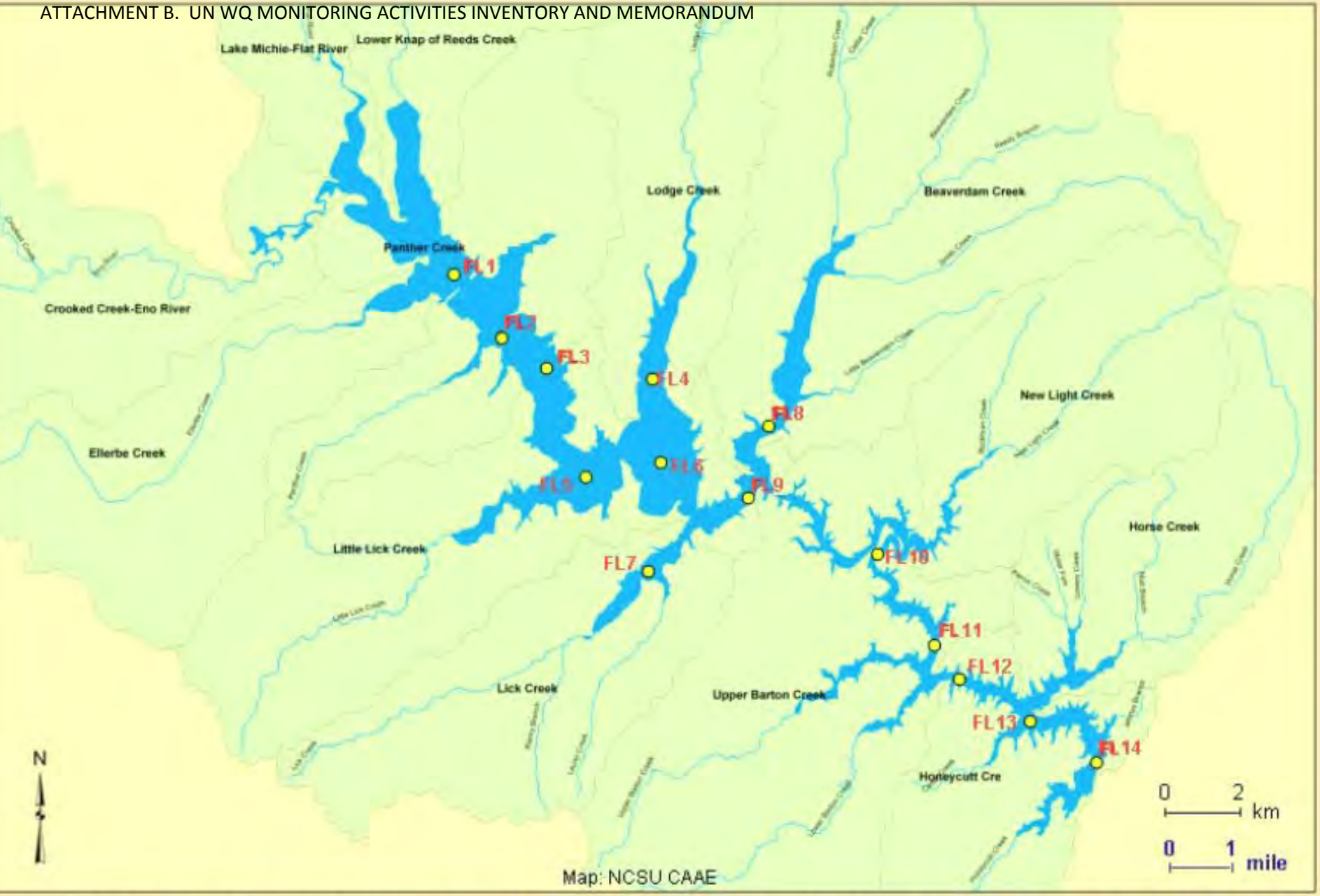


Figure 1. Map showing the locations of the 14 stations included in this alternate plan for monitoring Falls Lake to adequately assess whether water quality supports the lake's designated uses.

W3) Crooked Creek - Eno River
W4) Ellerbe Creek
W5) Panther Creek
SW8) Beaverdam Creek
SW9) Lick Creek
SW10) New Light Creek
SW12) Horse Creek
SW13) Honeycutt Creek

Figure 2. Map showing the locations of 14 streams, representing 13 sub-watersheds draining

All Real-time Stations

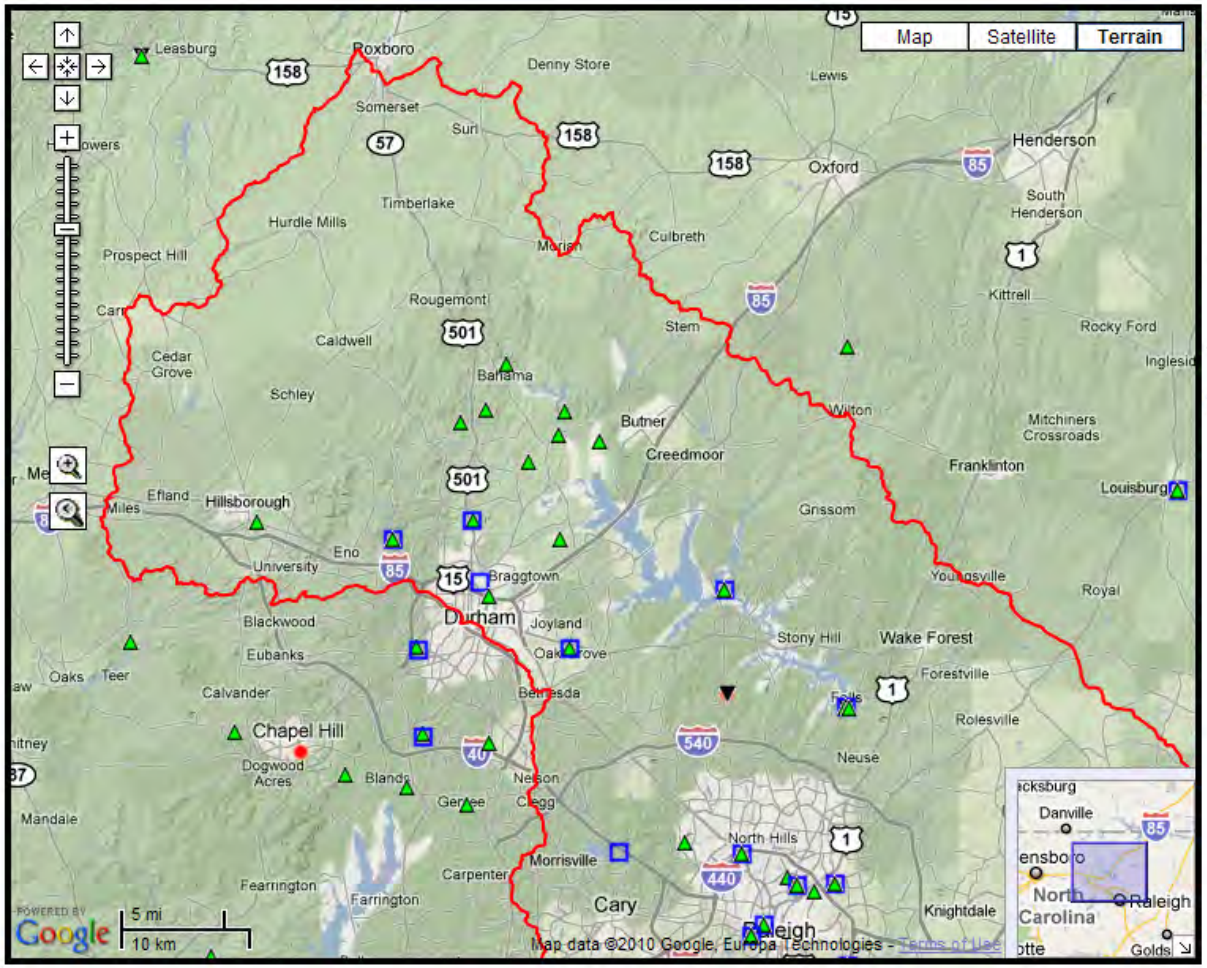
USGS
science for a changing world

USGS Home
Contact USGS
Search USGS

North Carolina Water Science Center

Home | Information/Data | Projects | Publications | Drought | Floods | Podcasts | About Us | Contact | *Internal*

Real-Time Water Data for Neuse Watershed (030202)



Data Types: **Status:**

- ☑ Surface Water ✔
- ☑ Groundwater ✔
- ☑ Water Quality ✔
- ☑ Precipitation ✔

✔ =Download Successful
✘ =Data Missing From Map

If missing data persists, please try again later.

View By Watershed:

- Basin Map
- All North Carolina
- Broad
- Cape Fear
- Catawba
- Chowan-Pasquotank
- French Broad
- Hiwassee
- Little Tennessee
- Lumber
- *Neuse*
- New
- Roanoke
- Savannah
- Tar-Pamlico
- Watauga
- Yadkin-Peedee

Real-time Stage and(or) Streamflow Stations

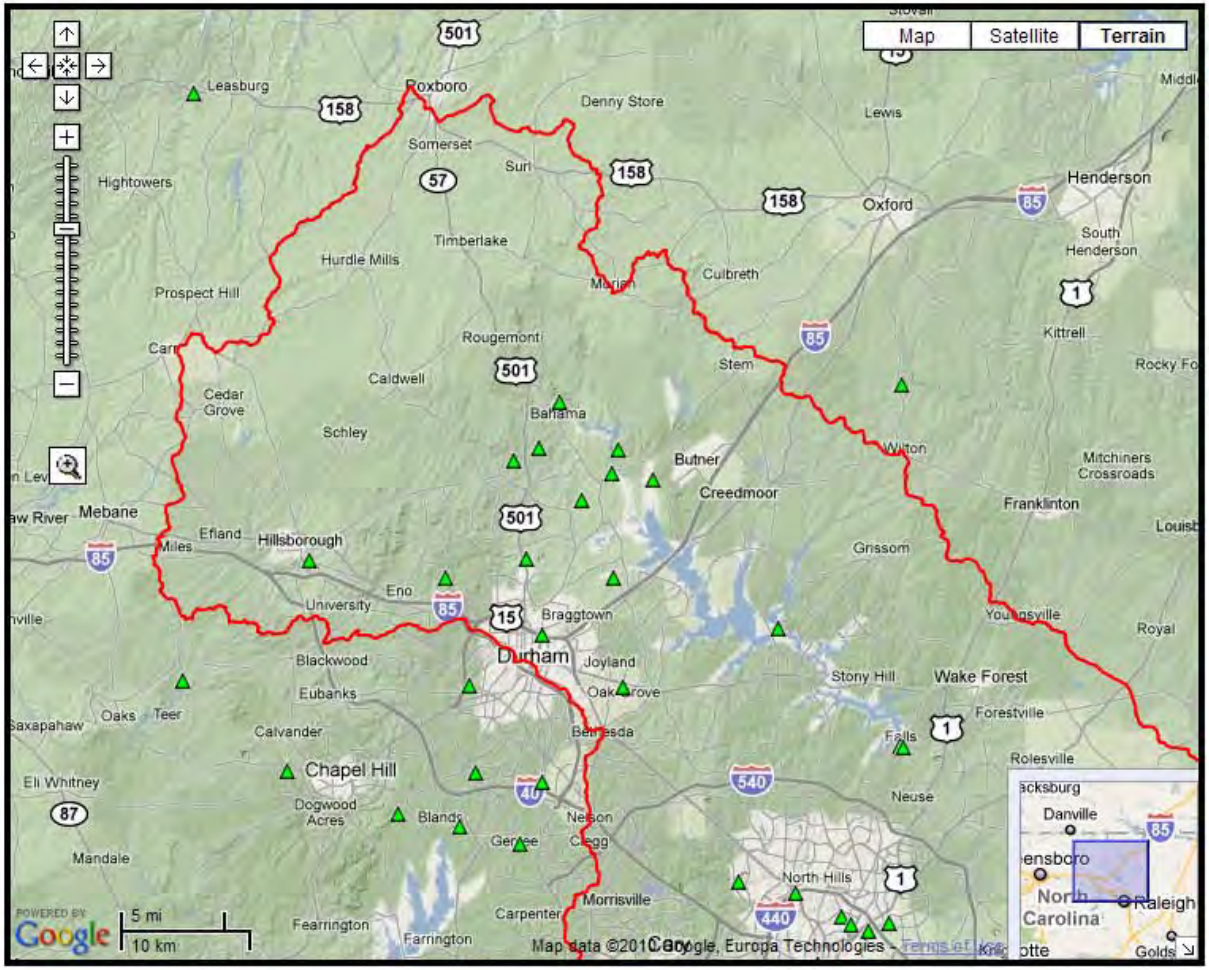
USGS
science for a changing world

USGS Home
Contact USGS
Search USGS

North Carolina Water Science Center

Home | Information/Data | Projects | Publications | Drought | Floods | Podcasts | About Us | Contact | *Internal*

Real-Time Water Data for Neuse Watershed (030202)



Data Types: **Status:**

- ☑ Surface Water ✔
- ☐ Groundwater ✔
- ☐ Water Quality ✔
- ☐ Precipitation ✔

✔ =Download Successful
✖ =Data Missing From Map

If missing data persists, please try again later.

View By Watershed:

- Basin Map
- All North Carolina
- Broad
- Cape Fear
- Catawba
- Chowan-Pasquotank
- French Broad
- Hiwassee
- Little Tennessee
- Lumber
- *Neuse*
- New
- Roanoke
- Savannah
- Tar-Pamlico
- Watauga
- Yadkin-Peedee

Real-time Water Quality Stations

USGS
science for a changing world

USGS Home
Contact USGS
Search USGS

North Carolina Water Science Center

Home | Information/Data | Projects | Publications | Drought | Floods | Podcasts | About Us | Contact | *Internal*

Real-Time Water Data for Neuse Watershed (030202)

Data Types: **Status:**

- ▲ ☐ Surface Water ✔
- ● ☐ Groundwater ✔
- ▼ ☑ Water Quality ✔
- ☐ ☐ Precipitation ✔

✔ =Download Successful
✘ =Data Missing From Map
If missing data persists, please try again later.

View By Watershed:

- Basin Map
- All North Carolina
- Broad
- Cape Fear
- Catawba
- Chowan-Pasquotank
- French Broad
- Hiwassee
- Little Tennessee
- Lumber
- *Neuse*
- New
- Roanoke
- Savannah
- Tar-Pamlico
- Watauga
- Yadkin-Peedee

Real-time Precipitation Stations

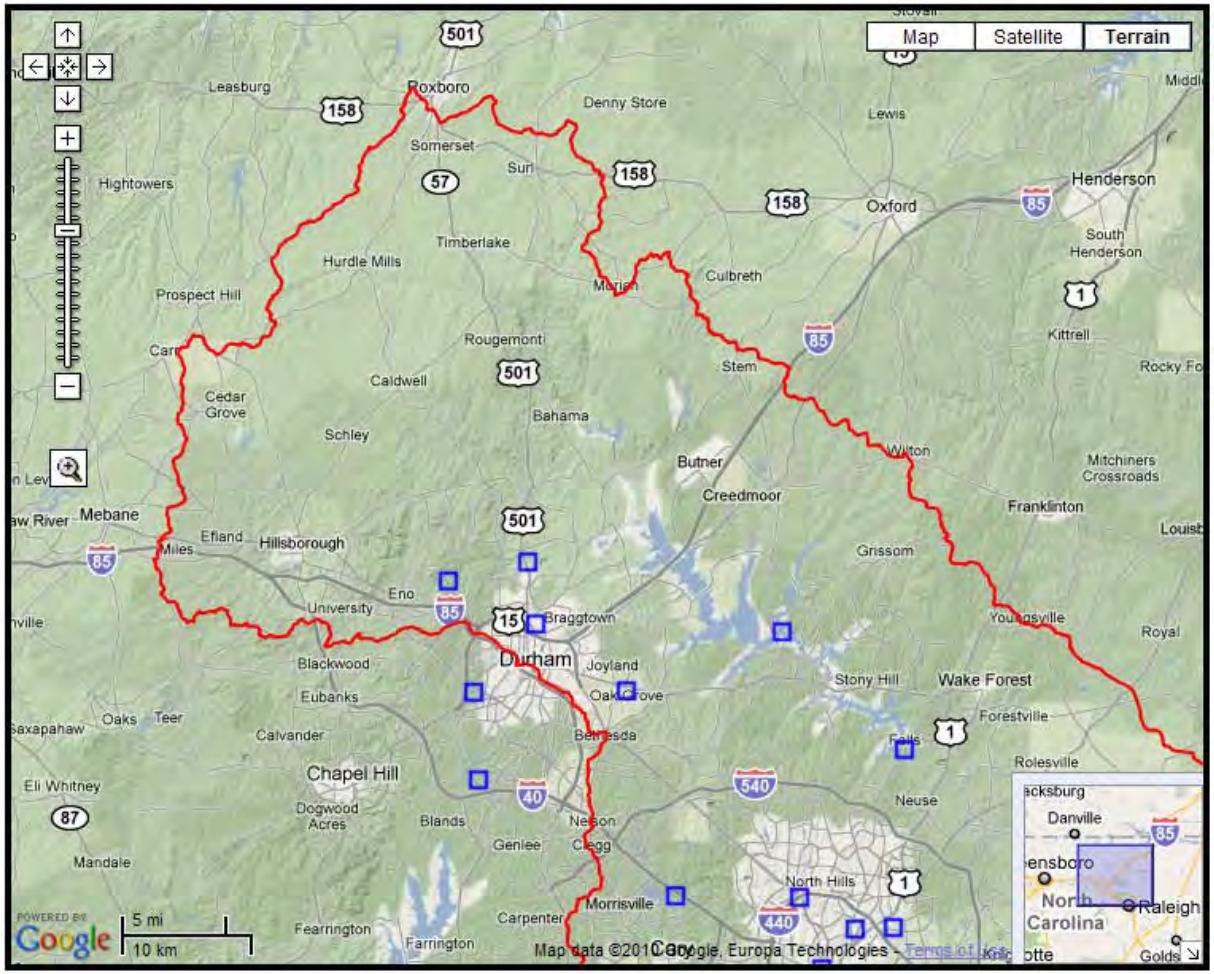
USGS
science for a changing world

USGS Home
Contact USGS
Search USGS

North Carolina Water Science Center

Home | Information/Data | Projects | Publications | Drought | Floods | Podcasts | About Us | Contact | *Internal*

Real-Time Water Data for Neuse Watershed (030202)



Data Types: **Status:**

- ☐ Surface Water ✔
- ☐ Groundwater ✔
- ☐ Water Quality ✔
- ☑ Precipitation ✔

✔ =Download Successful
✘ =Data Missing From Map

If missing data persists, please try again later.

View By Watershed:

- Basin Map
- All North Carolina
- Broad
- Cape Fear
- Catawba
- Chowan-Pasquotank
- French Broad
- Hiwassee
- Little Tennessee
- Lumber
- *Neuse*
- New
- Roanoke
- Savannah
- Tar-Pamlico
- Watauga
- Yadkin-Peedee

Real-time Groundwater Stations

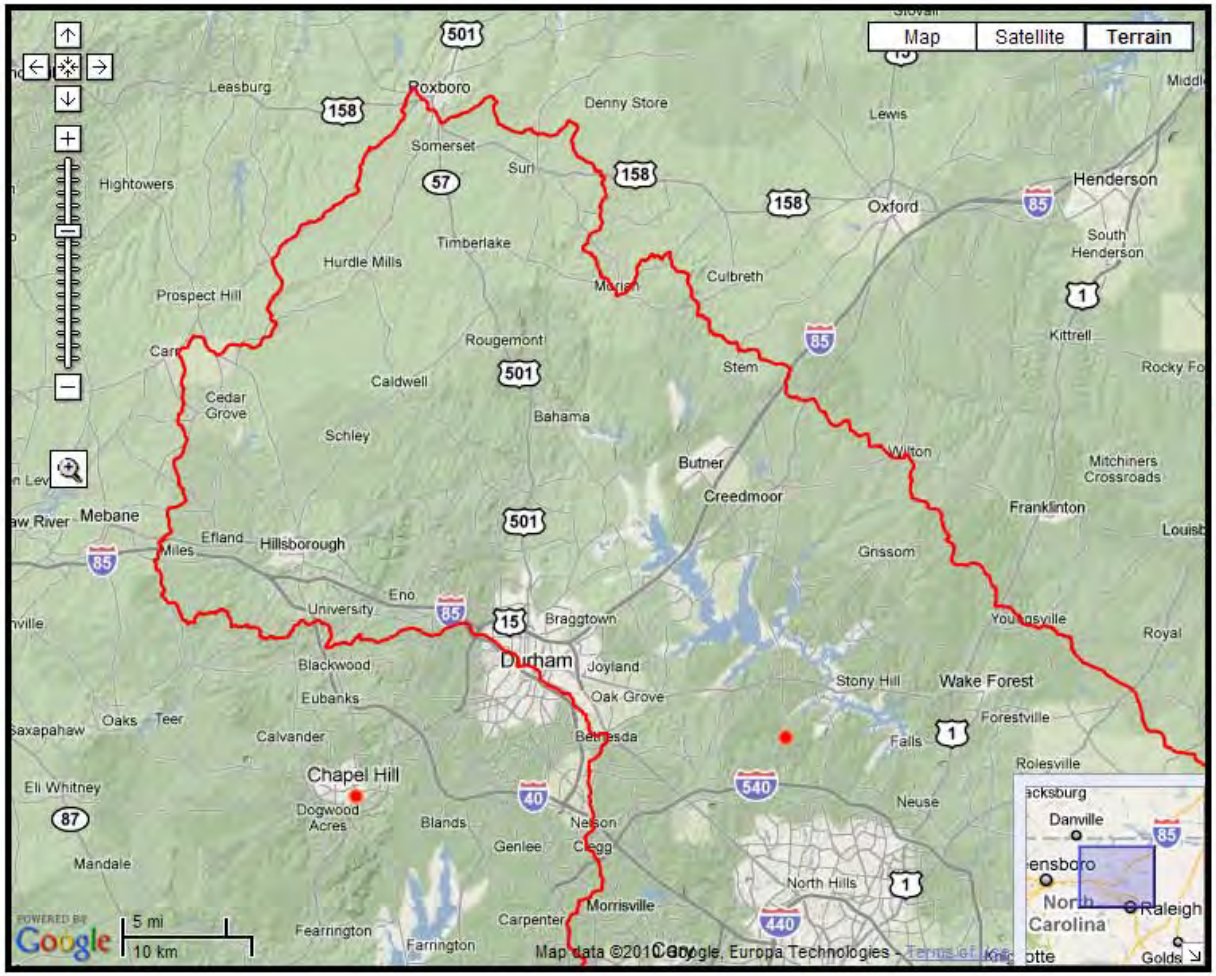
USGS
science for a changing world

USGS Home
Contact USGS
Search USGS

North Carolina Water Science Center

Home | Information/Data | Projects | Publications | Drought | Floods | Podcasts | About Us | Contact | *Internal*

Real-Time Water Data for Neuse Watershed (030202)



Data Types: **Status:**

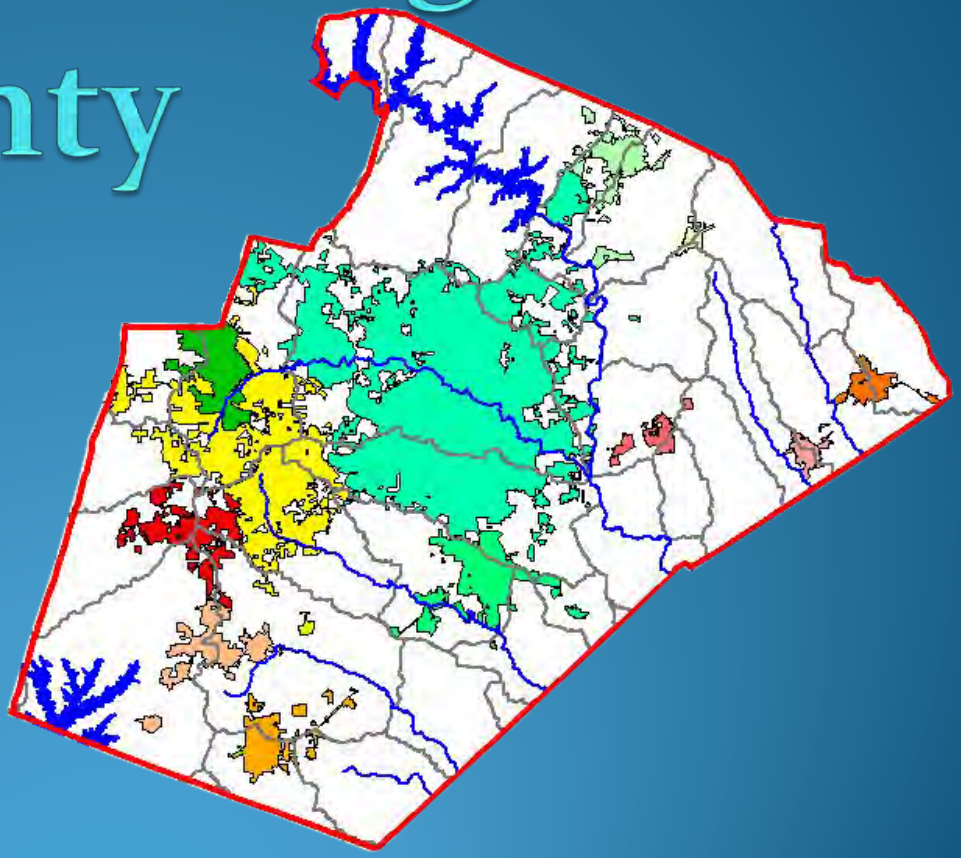
- ▲ ☐ Surface Water ✔
- ● ☑ Groundwater ✔
- ▼ ☐ Water Quality ✔
- ☐ ☐ Precipitation ✔

✔ =Download Successful
✖ =Data Missing From Map
If missing data persists, please try again later.

View By Watershed:

- Basin Map
- All North Carolina
- Broad
- Cape Fear
- Catawba
- Chowan-Pasquotank
- French Broad
- Hiwassee
- Little Tennessee
- Lumber
- *Neuse*
- New
- Roanoke
- Savannah
- Tar-Pamlico
- Watauga
- Yadkin-Peedee

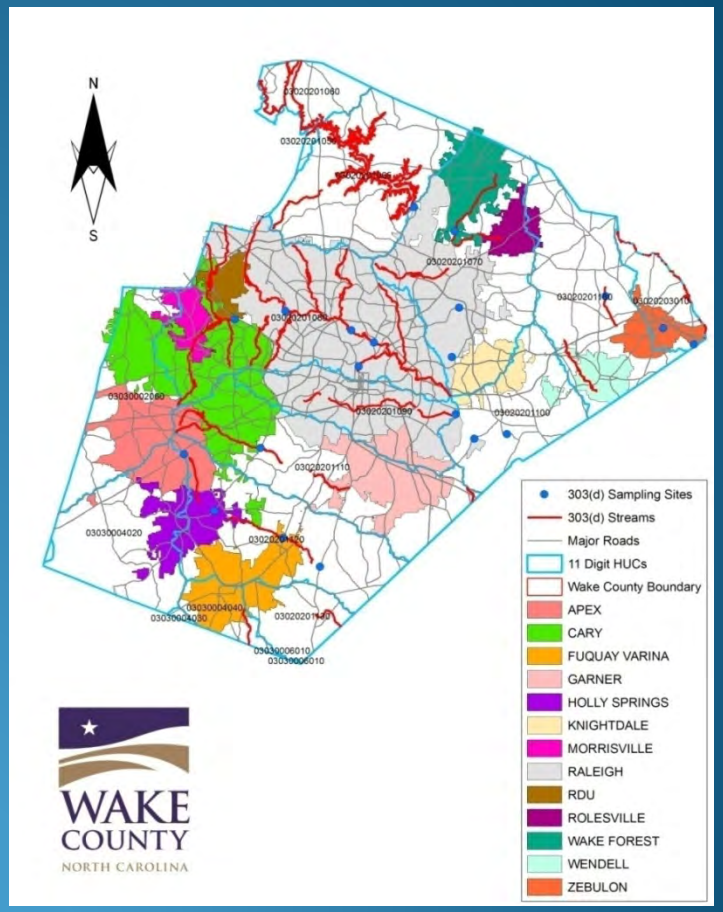
Watershed Management
Wake County



WAKE COUNTY
NORTH CAROLINA

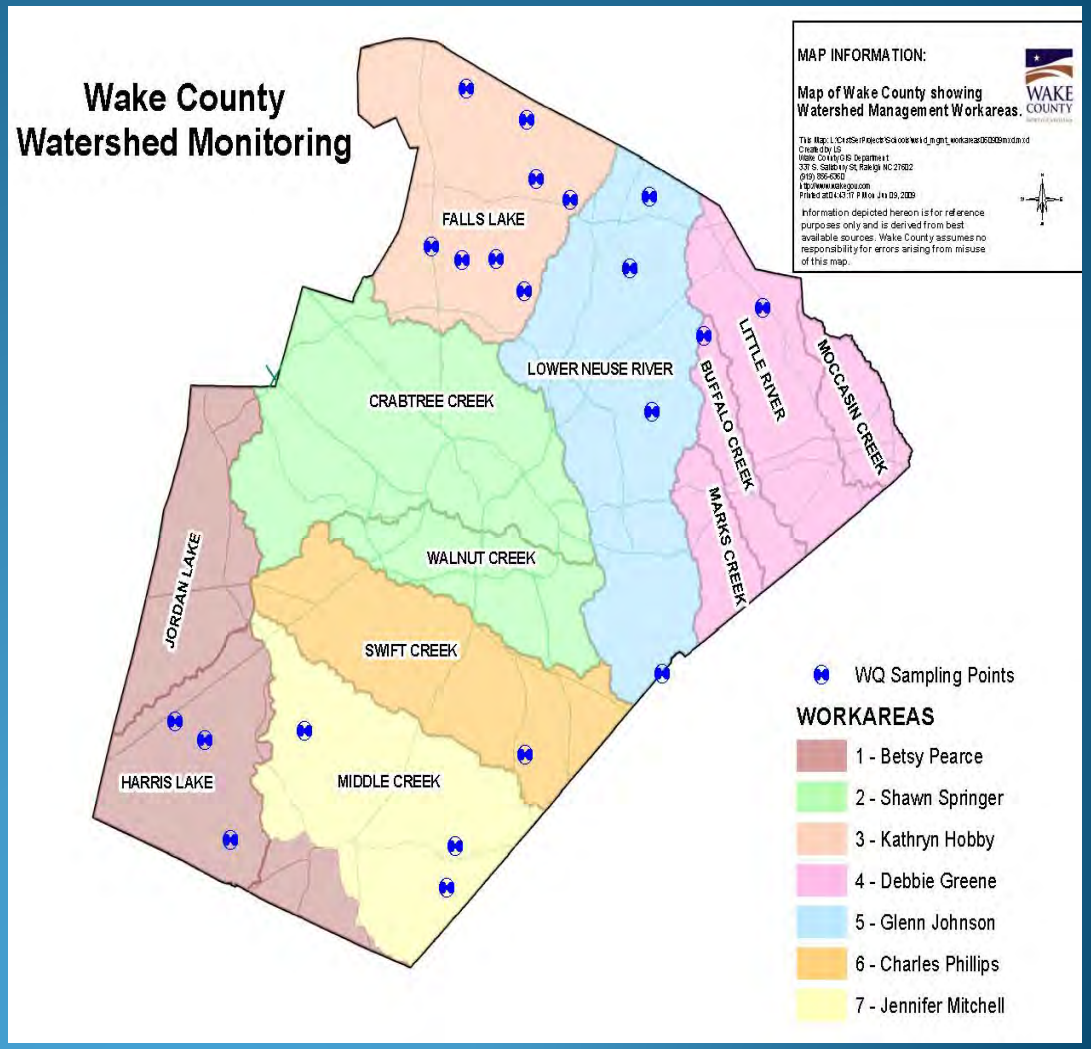
Monitoring Drivers

- 2003 Watershed Plan
- Pollutant loads & trends
- Assess programs
- Develop strategies and projects
- Regulatory compliance



Monitoring Points

- Falls watershed in 2007
- Other watersheds 2009



Watershed Monitoring Parameters

- Nutrients
- Sediment
- Bacteria
- Physical parameters

SAMPLE SITE	HUC	CHEMICAL WATER QUALITY PARAMETERS					
		TKN (mg-N/L)		Nitrite+Nitrate (NO2+NO3) (mg-N/L)		Total Nitrogen (mg-N/L)	Ammonia (NH_4) (mg-N/L)
		Meas.	Reported	Meas.	Reported		
UT Honeycutt	1060401	0.05	0.05	3.96	3.96	4.01	<0.05
Cedar	1060402	0.61	0.61	0.27	0.27	0.88	0.12
Lower Barton	1060201	0.01	<0.05	0.45	0.45	0.46	<0.05
Upper Barton	1060202	0.00	<0.05	1.04	1.04	1.04	<0.05
Little Beaverdam	1060301	0.04	<0.05	3.47	3.47	3.51	<0.05
New Light	1060101	0.08	0.08	0.09	<0.10	0.17	<0.05
Horse	1060302	0.11	0.11	0.47	0.47	0.58	<0.05
Black Horse Run Up		0.05	0.05	1.62	1.62	1.67	<0.05
Black Horse Run Down		0.00	<0.05	0.38	0.38	0.38	<0.05
Hasentree	1060303	0.24	0.24	0.39	0.39	0.63	0.05
UT Honeycutt	1060401	0.27	0.27	0.35	0.35	0.62	<0.05
Cedar	1060402	0.50	0.50	0.39	0.39	0.89	0.07
Lower Barton	1060201	0.30	0.30	0.58	0.58	0.89	<0.05
Upper Barton	1060202	0.21	0.21	0.52	0.52	0.73	<0.05
Little Beaverdam	1060301	0.07	0.07	0.07	<0.10	0.14	<0.05
New Light	1060101	0.10	0.10	0.30	0.30	0.40	<0.05
Horse	1060302	0.21	0.21	0.29	0.29	0.51	<0.05

319 Grant Goals

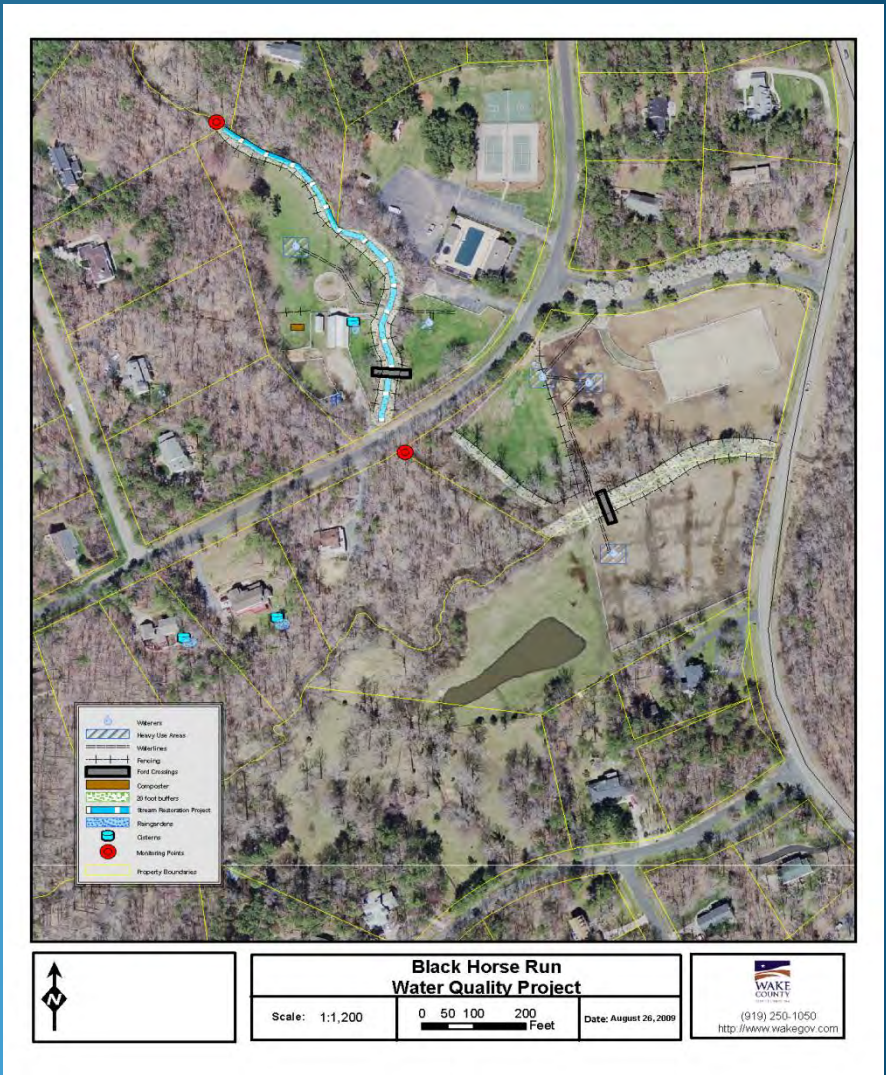
- Monitoring, restoration and management plan
- ID restoration, enhancement and preservation projects
- Gauge effectiveness of site specific projects

319 Falls Project Specifics

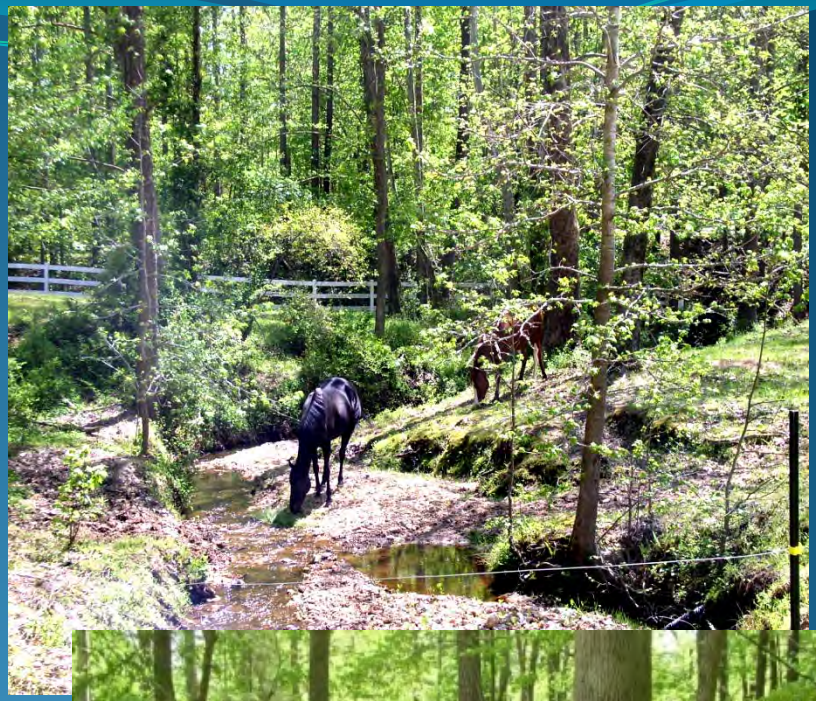
- Grab samples Falls Lake
- Automated samplers ; flow-proportional samples
- Benthic community assessed
- A stage-discharge relationship developed

Black Horse Run Water Quality Project

- Eroded banks Upper Barton Creek and an unnamed tributary
- BHR HOA showed interest in pursuing some BMPs
- Utilized cost-shared funds from the Community Conservation Assistance Program (CCAP)



BHR Project Features



- Pasture BMP's
- Stormwater BMP's
- Riparian Buffer Plantings
- Bank Stabilization

WQ Report & Report Card

- Report findings
- Identify water quality conditions and trends
- Provide easily understood information
- Present a framework for coordinating future data collection and reporting efforts

Falls Lake South

Impervious Surface: 7.9%

Size of Watershed: 27,743 Acres

Miles of Stream: 341

Description

Falls Lake is an important part of the system managed by the City of Raleigh and the Army Corps of Engineers which provides drinking water to the majority of Wake County's citizens. This portion of the Falls Lake Watershed contains four main sub-watersheds: Upper and Lower Barton's Creek, Cedar Creek, and Honeycutt Creek. The area is serviced largely by individual septic systems, on large lots. A number of open space purchases have been made in conjunction with the Triangle Land Conservancy and the City of Raleigh to further protect the area. Wake County has received an EPA 319 grant that provided a great deal of water quality data and a number of water quality improvement projects on Upper Barton's Creek.

Summary

The percentage of impervious surfaces (7.9%) in the Falls Lake South area was slightly less than the level commonly thought to impact water quality (10%). The population density was 0.88/ac and the number

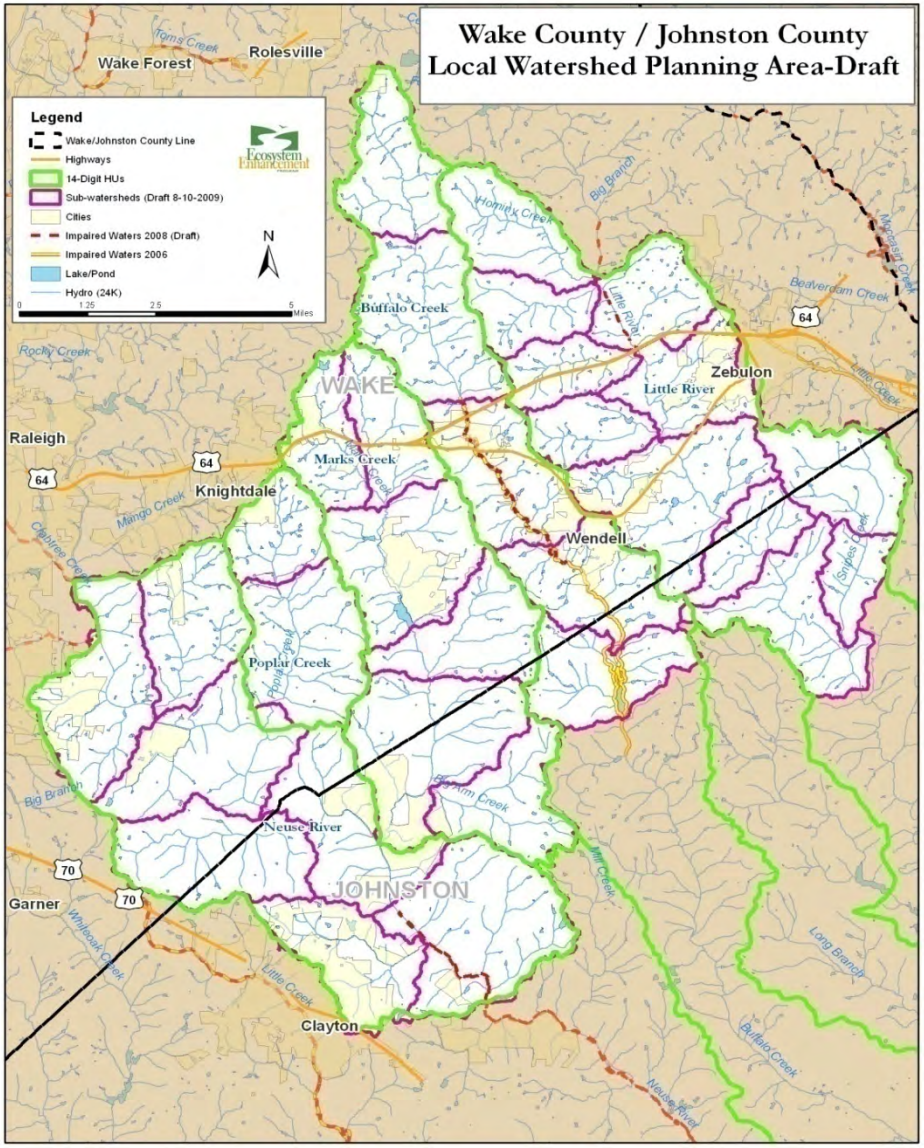
Overall Grade: C

Falls Lake South Report Card

Landscape			
Indicator	**Comments**	**Grade**	**Trend**
Impervious Cover	Overall 7.9% with 47% of the impervious surfaces being roads	B	n/a
Forest	Overall less than 10% of the area is forest	n/a	n/a
Riparian Buffers	Unknown	n/a	n/a
Wastewater	Area contains greatest density of septic systems (0.29/ac) in the county as well as at least 2 package WWTPs, which are significant sources of N and P	F	n/a
Population	There were 0.88 persons/ac.	n/a	n/a

Water Quality			
Indicator	**Comments**	**Grade**	**Trend**
Dissolved Oxygen	Means ranged 8.3-10.0 mg/L, never below 5 mg/L	A	-
pH	Means ranged 6.8-7.2	A	-
Conductivity	Means ranged 70-230 µS/cm with 3 sites >100 µS/cm	B	-
Temperature	Means ranged 15.5-16.8 °C	A	-
Phosphorus (Total)	Means ranged 0.03-0.05 mg/L, except for UBC at 0.17 mg/L. Elevated	B/D	-

Collaborative Local Watershed Plan



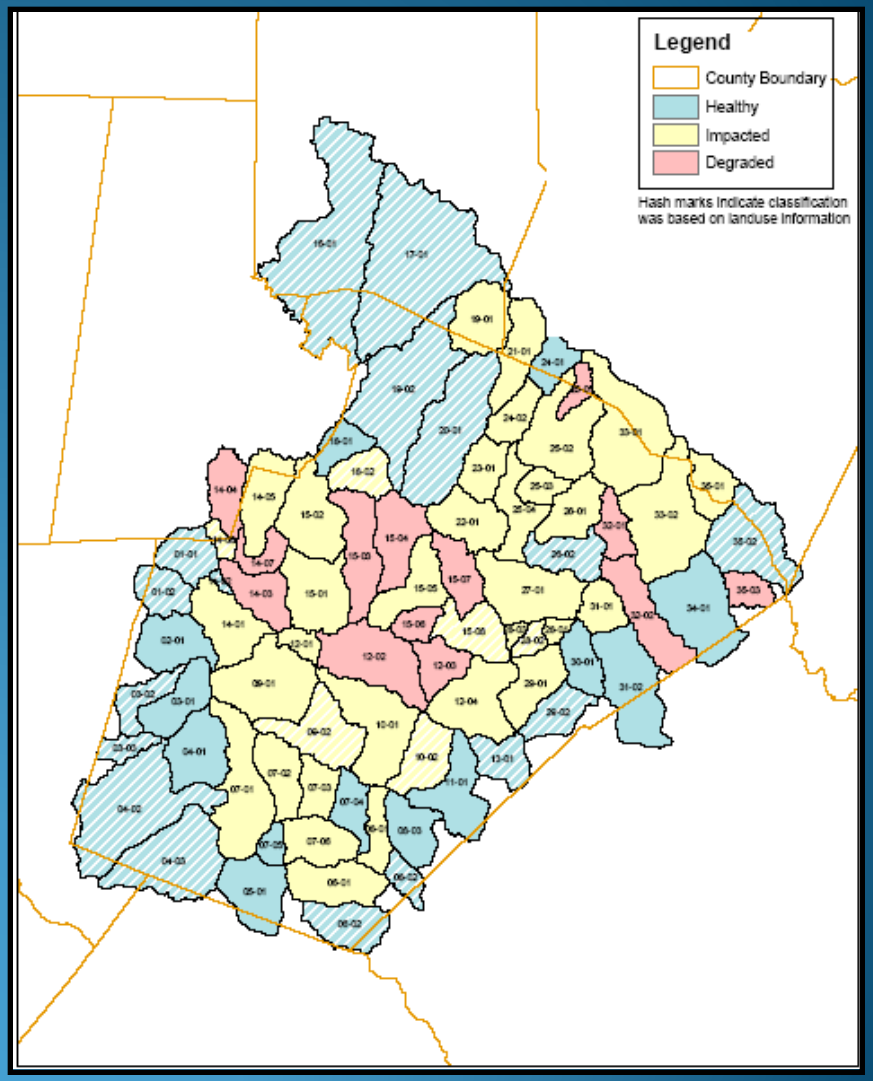
- Impairment due to poor biological communities
- Goal: comprehensive watershed management & restoration strategy
- Inventory of projects to improve water quality

Recreational Water Sampling Program

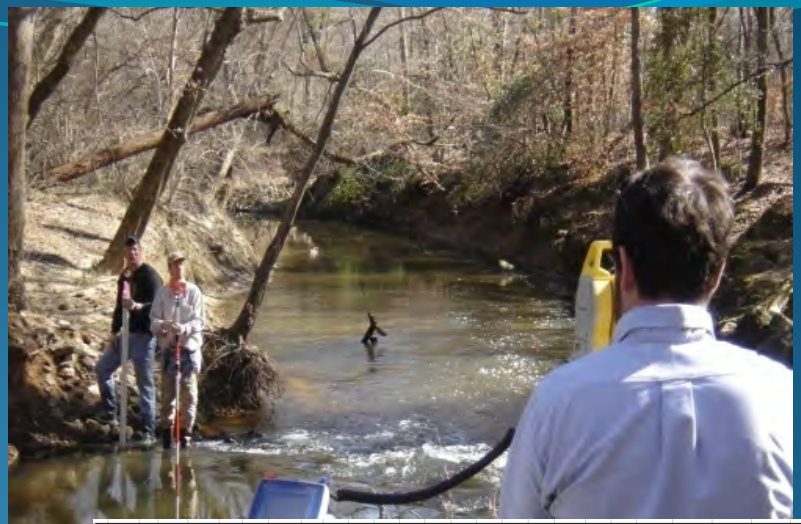
- Goal: Decrease the incidence of water-related illness
- E. coli and enterococci bacteria
- ~48 sites
- Public beaches and private camps, open-water used for boating in 3 county lakes

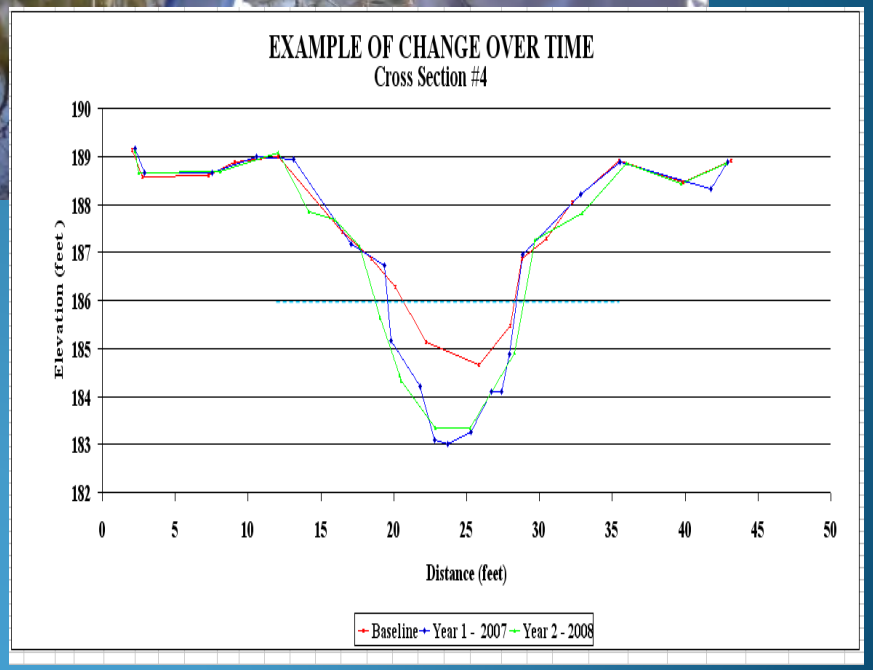
On the Horizon

- ID more sub-watersheds for monitoring
- Priority: impaired
- Develop discharge rating tables
- Begin monitoring active construction sites



- Survey of stream cross sections :bank erosion, sediment transport, & changes in stream morphology
- Share data for WQ Assessments 305(b), basin-wide planning
- Seek full laboratory certification





Any Questions?

Upper Neuse Water Quality Monitoring Plan

Potential Objectives

Table 1. Objectives for a water quality monitoring plan as grouped into headings.

Sources/Dynamics of Nutrient Loading

- What is entering the lake? Chlorophyll a, other tributaries N, P and Chlorophyll *a*
- Are loads to the lake declining? (N, P and chlorophyll a)
- What is entering the lake? (Chlorophyll a, other tributaries (N, P, Chl a)
- Where is the best location (stable) to monitor inputs to the lake?
- Sources Mapping
- Unknowns: Fertilizer, septic, sediment-attached P, atmospheric deposition
- What are the impervious cover characteristics of the watershed? (Where is IC and how is it distributed?)
- Understand (soils for) onsite wastewater attenuation rates
- What are the actual loads distributed from throughout the watershed? Can we better understand sources by having a watershed model that is calibrated to measured loads at multiple locations? At jurisdictional boundaries?
- What loads come from each jurisdiction?
- Characterize internal lake load
- What is approximate nutrient loading into Falls Lake watershed from groundwater?
- Nutrient loads from groundwater discharge
- Lake boundary conditions (are loads to the lake declining (N, P, Chl a))?
- Understand how loads from agriculture (equine) differ from others (flow, composition, urban/suburban)
- Where is the best location (stable N, P, Chlorophyll a) to monitor inputs to the lake?
- Nutrient loading by source type. Base, ongoing, and current as of date.
- Distinguishing sources of different types of Nitrogen (i.e. residential, fertilizer vs. onsite wastewater)
- Watershed characterization
- Characterize sources better
- Measured load from forests (slate vs. Triassic)
- Nutrient loading by source type, 2006 base and ongoing

Nutrient Mapping

- Characterize the distribution of loads
- Load distribution (at jurisdictional boundaries)
- What loads come from each jurisdiction?
- What are the actual loads distributed from throughout the watershed? Can we better understand sources by having a watershed model that is calibrated to measured loads at multiple locations? At jurisdictional boundaries?
- Know loads by jurisdiction & tributary
- Nutrient loading by jurisdiction and by subwatershed (2006 base and ongoing, current as of date certain)
- Better unit loading rates that may vary by geography and by land use
- Nutrient trading tool (USDA, lbs N, lbs P, reductions)

Lake Response Timeline

- Given high internal loading in the lake, how will the lake respond to changes in the load?
- Data and analysis that can be used to forecast or “backcast” conditions
- What contribution of P (maybe N) does re-suspension have on the total nutrient load to be managed in the lake?

ATTACHMENT C. UPPER NEUSE WATER QUALITY MONITORING OBJECTIVES

Lake Characterization

- Understand current condition of the lake
- Lake Boundary Conditions (are loads to the lake declining (N, P, Chl a)
- How much does water level fluctuation contribute to internal loading in the lake?
- Forest is the largest component of the watershed. What are the actual nutrient loads from forests in the Triassic basin?
- Understand loads from forest and atmospheric deposition
- Ask Corps of Engineers to do research evaluating lake operations on water quality
- Which streams do not have intact riparian buffers?
- Atmospheric deposition—coordinate with energy & air quality efforts with regard to nutrients
- Account for atmospheric deposition

Modeling Concerns

- Monitor Rainfall
- Given that the model used rain data from RDU, would local monitoring of rainfall improve hydrologic calibration?
- Determine if modeling is as accurate as possible given state of science.
- Propose a new model(s) to address any identified deficiencies. Make sure flexible enough to incorporate new learning
- Account for lake operations in model
- Fix short-comings of the existing model
- Capability to develop our own model
- Account for atmospheric deposition
- Gather new data for remodeling in 2018 (means we need to know which model will be used)
- What does good long-term lake & watershed management look like? (account for droughts, pool re-allocation, hurricanes)
- Better definition of how data will be used to modify NMS
- What are the least number of sites that would allow a remodel and use support assessment
- Data and analysis that can be used to forecast or “backcast” conditions
- New models needed
- Better unit loading rates that may vary by geography/use

Institutional Oversight

- Analyze process needs. Get Association
- Get Association together and let them determine accounting tools (instead of the Jordan Lake stakeholders)
- Define minimum data requirements
- One testing program accepted by all stakeholders and DWQ
- Know how DWQ is going to assess nutrient reductions for BMPs. Need to know requirements before assessing in projects (site specific before/after modeling?)

Regulatory Acceptance/QACC/QAPP

- One testing program accepted by all stakeholders and DWQ
- Negotiate MOA or program with DWQ for entire monitoring program
- Neutral & unbiased monitoring, management and oversight
- Data is accepted by DWQ
- Standardized methods, consistent and state approved.
- EPA & DWQ agreement on using correct & cost-effective study methods
- Implementable (fundable) plan that DWQ will accept

ATTACHMENT C. UPPER NEUSE WATER QUALITY MONITORING OBJECTIVES

Management Effectiveness

- Tell us whether management efforts are succeeding (a vigorous effort)
- Understand how management practices are affecting loads (individual and cumulative)
- Know by 2017 (at least) where we are vis-à-vis Stage I.
- Know the value of EACH individual management strategy (e.g., septic, ag). Do the BMPs work?
- Tell us whether management efforts are succeeding; track success of NMS by source (agriculture, existing development, etc)
- Determine if BMPS are effective
- Focused sub-basin monitoring designed to isolate impacts from individual sources and improvements after BMPs implemented (to use to calibrate for basin future modeling efforts)
- Monitor BMPs

Emerging Contaminates

- Consider pollutants other than just nutrients (i.e. those that pose health risks to users of water)
- Consider emerging pollutants (endocrine disruptors, personal care products, cyanotoxins)
- Need to know levels of endocrine-disrupting chemicals, pharmaceuticals, and personal care products. Will help determine/reflect sources of input to the lake and watershed

Use Support Analysis

- Evaluate how well the land (public) meets needs (recreation) in watershed
- Evaluate Past, Present and Future Uses of the Lake
- Determine if existing water quality standards support existing uses. Are they too restrictive, too loose, or missing?
- Evaluate how well the lake meets existing uses. Water supply, aquatic life propagation, recreation (boating, swimming, fishing)
- Evaluate the degree to which the lake has, is, or can support all its authorized uses.
- Supports UAA (Use Attainability Assessment) or change in use (water quality standard) for upper Falls Lake

Public Education and Outreach

- Designation of Actions/Behaviors that residents, volunteers, and non-profits can do that won't cost taxpayers money
- Expand/Improve/Increase public awareness and participation in annual big sweep events; track totals
- Subsidize or incentivize residential composting; track # participants

Drinking Water

- Understand relationship between TOC, nutrients, and Chlorophyll a

Wildlife Management

- Learn about fish populations and biota in upper and lower lake relative to chlorophyll a and turbidity (impairment)
- Map urban stream syndrome (deeply incised streams)

Data Consolidation

- Make sure our data can support decisions at a high level of certainty within regulatory time frame.
- Translate/compare data collected using different methods (if possible)
- Stable Funding (no gaps in data collection) (timing longitudinal)
- Understand current monitoring efforts
- Cost-effective, well-coordinated with other efforts
- Address data gaps
- Assess data being collected (current monitoring plans)
- Develop data standards for monitoring data and tools; convert current monitoring from various sources

into a more common format • Clear system of water quality benchmarks, relevant to decision-makers and public

Table 2. Questions for a water quality monitoring plan generated with heading names.

Sources and Dynamics of Nutrient Loading/Nutrient Mapping • Identify sources of nutrients within and outside our combined regulatory purview. • For nutrients within regulatory purview, identify sources of nutrients by use and by jurisdiction. • For modeling, accounting for transport/attenuation/uptake as they relate to streams, for different media (i.e. groundwater, types of streams). • How might different land uses inform efficient monitoring regimes? • Better understanding of poorly quantified nutrient sources (sources not regulated); can we trust nutrient trading tools?
Lake Response • What short-term changes in phytoplankton and chlorophyll-a community composition occur with measured load reductions from watershed? • How important is internal nutrient loading vs. allocthonous loading in the lake? • What are the major influences on watershed and lake hydrology? • What are influences of hydrology on nutrient expression in lake?
Lake Characterization • Where are the nutrient source loads originating from within the lake and watershed? • How does nitrogen get processed in lake? • What level of nutrients can the lake process? • Differentiate mass loads from different sources in watershed.
Modeling Concerns • What type/quantity of monitoring data to use? • What models are needed/appropriate? • Who develops the model? • What is the goal of the model? • Frequency of review and recalibration? • Who interprets data and model output? • What is appropriate time for sampling?
Institutional Oversight and Regulatory Acceptance • What are standards that would be acceptable to DWQ and local governments? • Who will develop the standards? • What organization will have oversight and will this be by consensus?
Management Effectiveness • Perform targeted evaluations of BMP assumptions. • Are there things we can do to evaluate model effectiveness? • Is management effectiveness a core goal of water quality monitoring process? • Can data on management effectiveness help feed data for compliance? • Question of degree to which evaluating the management effectiveness a core goal? • Different levels of evaluation. • Are loads to lake declining?

- Goals discussed at this table:
  - Understand relationship between TOC and chlorophyll-*a*.
  - Gather data on chlorophyll-*a* and other parameters such that model can be run to determine whether Stage II is appropriate.
  - Gather data for a use attainability analysis.
  - Targeted evaluations of established BMP assumptions.

Emerging Contaminants

- Are there measurable levels of emerging contaminants? At wastewater treatment plant effluent? In Falls Lake? In drinking water?
- If so, what are the concentrations compared to other research?

Drinking Water

- Is there a correlation between TOC, nutrients, and chlorophyll-*a*?

Use Support

- What type of monitoring should be performed to determine use support?
- Can existing data generate answers for use support questions?
- What are existing uses or classes and what type of land uses help determine use, land use focus on monitoring?

Public Outreach and Education

- Can monitoring generate increased participation in public outreach?
- Can monitoring determine effectiveness of public outreach involvement efforts?
- What are the priorities for public education?
- Do grassroots efforts such as residential composting produce reductions in nutrients? Is this too small a piece to measure?

Data Consolidation

- Is standardizing a test method a good way to achieve data consolidation?
- Is standardizing a test method a good way to achieve collection methods?
- Can permit regulations be modified to allow data consolidation?
- Can data consolidation be used to reduce duplication of effort and reduce overall cost?
- Can data consolidation be used to address existing data gaps?
- Can data consolidation help ensure the right data are being collected at an acceptable frequency?

UN WQ Monitoring Framework

Goal	Objectives	Questions to be answered:	Who Monitors	Research Questions
1) Regulatory Compliance/ In-lake issues	**<u>Monitor to determine if lake is in compliance.</u>** **From Objectives:** • Characterize internal lake load • Data and analysis that can be used to forecast or "backcast" conditions • Understand current condition of the lake • Lake Boundary Conditions (are loads to the lake declining (N, P, Chl a) • Forest is the largest component of the watershed. What are the actual nutrient loads from forests in the Triassic basin? • Understand loads from forest and atmospheric deposition • Atmospheric deposition—coordinate with energy & air quality efforts with regard to nutrients • Account for atmospheric deposition **<u>Are current regulations appropriate and/or achievable?</u>** **Should we remodel?** • What are the actual loads distributed from throughout the watershed? Can we better understand sources by having a watershed model that is calibrated to measured loads at multiple locations? At jurisdictional boundaries? • Monitor Rainfall • Given that the model used rain data from RDU, would local monitoring of rainfall improve hydrologic calibration? • Determine if modeling is as accurate as possible given state of science. • Propose a new model(s) to address any identified deficiencies. Make sure flexible enough to incorporate new learning • Account for lake operations in model • Fix short-comings of the existing model • Capability to develop our own model	• Is current lake monitoring sufficient? • Do we have the time, willingness, or expertise to answer these questions? • Whose responsibility is it? • Given high internal loading in the lake, how will the lake respond to changes in the load?	NCDWQ	• What contribution of P (maybe N) does re-suspension have on the total nutrient load to be managed in the lake? • How much does water level fluctuation contribute to internal loading in the lake? • Ask Corps of Engineers to do research evaluating lake operations on water quality • Understand relationship between TOC, nutrients, and Chlorophyll a

	• Account for atmospheric deposition
	• Gather new data for remodeling in 2018 (means we need to know which model will be used)
	• What does good long-term lake & watershed management look like? (account for droughts, pool re-allocation, hurricanes)
	• Better definition of how data will be used to modify NMS
	• What are the least number of sites that would allow a remodel and use support assessment
	• Data and analysis that can be used to forecast or "backcast" conditions
	• New models needed
	• Better unit loading rates that may vary by geography/use
	• How will the relook affect how/when/where we model?
	
	Perform Use Attainability Assessment or change water quality standard for upper Falls Lake
	• Evaluate how well the land (public) meets needs (recreation) in watershed
	• Evaluate Past, Present and Future Uses of the Lake
	• Determine if existing water quality standards support existing uses. Are they too restrictive, too loose, or missing?
	• Evaluate how well the lake meets existing uses. Water supply, aquatic life propagation, recreation (boating, swimming, fishing)
	• Evaluate the degree to which the lake has, is, or can support all its authorized uses.
	• Wildlife Management
	  • Learn about fish populations and biota in upper and lower lake relative to chlorophyll a and turbidity (impairment)
	  • Map urban stream syndrome (deeply incised streams)
	
	Who should lead the effort to challenge the regulatory environment?
	• Analyze process needs. Get Association
	• Get Association together and let them determine accounting tools			

UN WQ Monitoring Framework

	(instead of the Jordan Lake stakeholders)
	• Define minimum data requirements
	• One testing program accepted by all stakeholders and DWQ
	• Know how DWQ is going to assess nutrient reductions for BMPs. Need to know requirements before assessing in projects (site specific before/after modeling?)
	
	Should other issues be considered in the regulatory environment?
	• Emerging Contaminates:
	  • Consider pollutants other than just nutrients (i.e. those that pose health risks to users of water)
	  • Consider emerging pollutants (endocrine disruptors, personal care products, cyanotoxins)
	  • Need to know levels of endocrine-disrupting chemicals, pharmaceuticals, and personal care products. Will help determine/reflect sources of input to the lake and watershed			

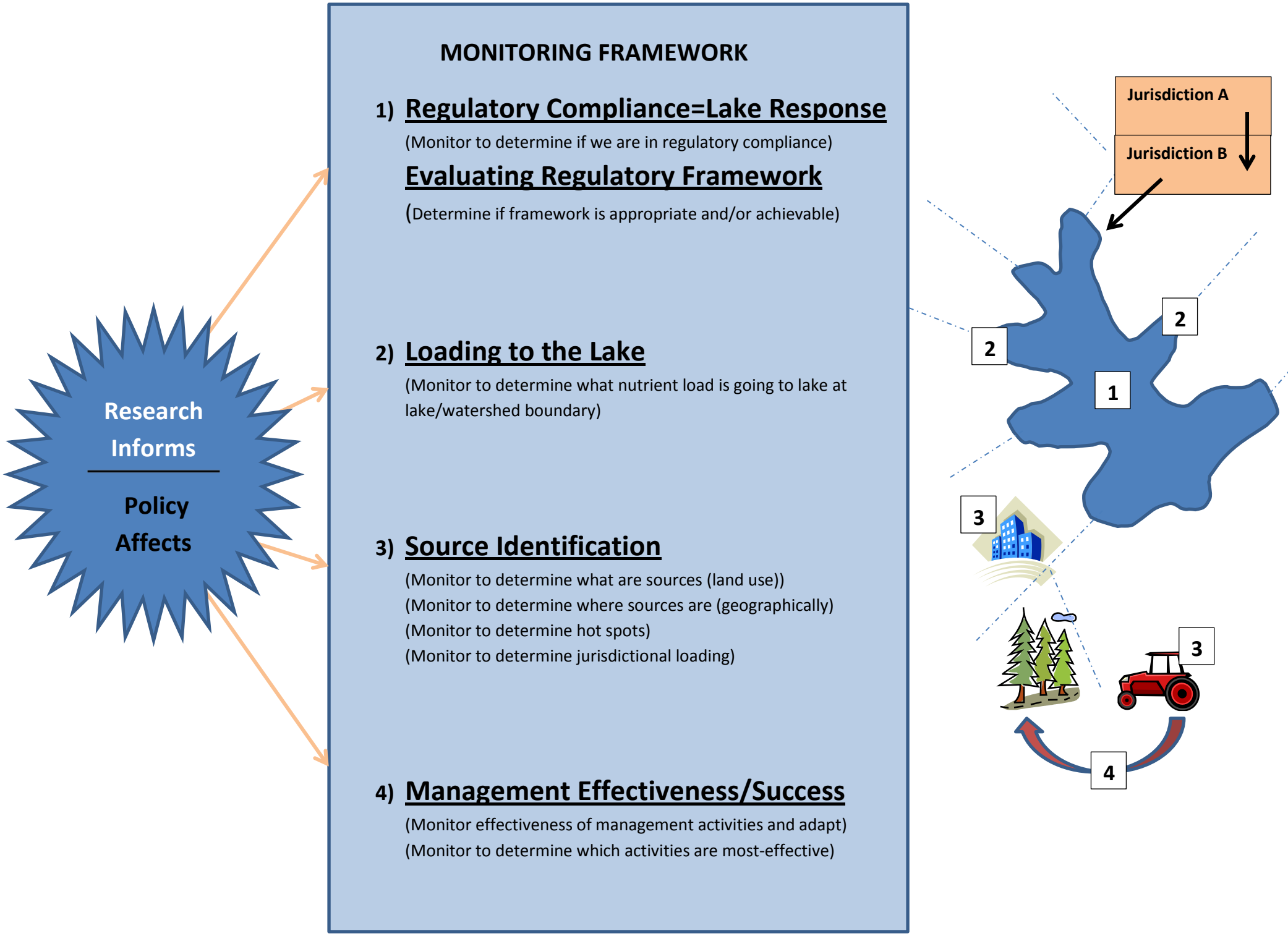
2) **Loading to the Lake**	**Monitor to determine what loading is going to the lake at the lake/watershed boundary.** • What is entering the lake? Chlorophyll a, other tributaries N, P and Chlorophyll *a* • Are loads to the lake declining? (N, P and chlorophyll a) (2) • Where is the best location (stable) to monitor inputs to the lake? (2) • Nutrient loads from groundwater discharge (2)?	• Do we need a model to do this? • How do we choose a model? • Can we design a monitoring network before we choose a model? • Is UNRB RFP going to do all this? • How do we handle land use/land cover data? Parameters; How many sites? Where? What frequency? What method?	Local Gov's Ag	• Better unit loading rates that may vary by geography and by land use

UN WQ Monitoring Framework

3) **Source Identification**	**Monitor to determine what sources are (land use).** **Monitor to determine where sources have highest nutrient loading.** **Monitor to determine hot spots.** **Jurisdictional loading.** **From Objectives:** • Sources Mapping • What loads come from each jurisdiction/tributary/subwatershed? (5) • Understand how loads from agriculture (equine) differ from others (flow, composition, urban/suburban) • Measured load from forests (slate vs. Triassic) • Nutrient loading by source type, 2006 base and ongoing • Characterize sources better • Unknowns: Fertilizer, septic, sediment-attached P, atmospheric deposition • Nutrient loading by source type. Base, ongoing, and current as of date. • Distinguishing sources of different types of Nitrogen (i.e. residential, fertilizer vs. onsite wastewater)	Parameters How many sites? Where? What frequency? What method?	Local Gov's Ag	• What are the impervious cover characteristics of the watershed? (Where is IC and how is it distributed?) • Understand (soils for) onsite wastewater attenuation rates
4) **Management Effectiveness and Success**	**Monitor effectiveness of management activities and adapt.** **Monitor to determine which activities are most-effective.** **From Objectives:** • Tell us whether management efforts are succeeding (a vigorous effort) • Understand how management practices are affecting loads (individual and cumulative) • Know by 2017 (at least) where we are vis-à-vis Stage I. • Tell us whether management efforts are succeeding; track success of NMS by source (agriculture, existing development, etc) • Determine if BMPS are effective • Focused sub-basin monitoring designed to isolate impacts from individual sources and improvements after BMPs implemented (to use to calibrate for basin future modeling efforts) • Monitor BMPs	Parameters How many sites? Where? What frequency? What method?	Local Gov's Ag	• Know the value of EACH individual management strategy (e.g., septic, ag). Do the BMPs work?

UN WQ Monitoring Framework

Homeless Things (Currently)…Where do these fit into our framework?

5) **Policy Related**	**Develop a DWQ-accepted QAPP** **Develop MOA for LG monitoring** • One testing program accepted by all stakeholders and DWQ • Negotiate MOA or program with DWQ for entire monitoring program • Neutral & unbiased monitoring, management and oversight • Data is accepted by DWQ • Standardized methods, consistent and state approved. • EPA & DWQ agreement on using correct & cost-effective study methods • Implementable (fundable) plan that DWQ will accept			
6) **Public Education and Outreach**	• Designation of Actions/Behaviors that residents, volunteers, and non-profits can do that won't cost taxpayers money • Expand/Improve/Increase public awareness and participation in annual big sweep events; track totals • Subsidize or incentivize residential composting; track # participants			
7) **Data Consolidation**	• Make sure our data can support decisions at a high level of certainty within regulatory time frame. • Translate/compare data collected using different methods (if possible) • Stable Funding (no gaps in data collection) (timing longitudinal) • Understand current monitoring efforts • Cost-effective, well-coordinated with other efforts			

ATTACHMENT D. UPPER NEUSE WATER QUALITY MONITORING FRAMEWORK