Interim Update to the North Carolina General Assembly

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UNC Nutrient Management Study

Submitted by NC Policy Collaboratory

December, 2016

Introduction

During the 2016 legislative short session the North Carolina General Assembly approved Session Law 2016-94, which included several sections related to the "Development of New Comprehensive Nutrient Management Regulatory Framework."

One of these sections, 14.13.(c) directs UNC-Chapel Hill to conduct a multi-year study and analysis of nutrient management strategies and compilation of existing water quality data specifically in the context of Jordan Lake and Falls Lake. (*The full text of the legislative language from 14.13 (c) can be found in Appendix I)*

The legislation provides $500,000 annually over six years beginning in FY 2016 - 2017 and ending in FY 2021 - 2022. The legislation requires a final report on the results of the study and recommendations for action for Jordan Lake no later than December 31, 2018 and for Falls Lake, no later than December 31, 2021. The legislation also calls for interim updates every year beginning with an interim update on Jordan Lake by December 31, 2016.

The legislation details a couple of specific components that are to be included in the study:

- review data collected by the Department of Environmental Quality and by other stakeholders from water sampling in areas subject to the Falls Lake or Jordan Lake Water Supply Nutrient Strategies and compare trends in water quality to the implementation of the various elements of each of the Strategies and;

- examine the costs and benefits of basinwide nutrient strategies in other states and the impact (or lack of impact) those strategies have had on water quality.

Based on the legislative language above, what follows in this document is an outline of how the UNC Study will be conducted during the first six months of 2017. This initial work will form the foundation for further research and analysis and the delivery of the final report on Jordan Lake in December, 2018. It is the expectation that the final report on Jordan Lake will contain specific findings and actionable recommendations for consideration by the General Assembly, the Environmental Management Commission and the Department of Environmental Quality.

This document satisfies the legislature's requirement for an Interim Update on the UNC Jordan Lake Study (UNC Study) before December 31, 2016.

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Study Overview

As directed by the legislation, UNC-Chapel Hill's Chief Sustainability Officer, Brad Ives, designated the recently formed North Carolina Policy Collaboratory (Collaboratory) as the entity to oversee the UNC Study. The Collaboratory worked with faculty and staff to identify experts in the nutrient management field to form the UNC Study research team *(see Appendix II for a full listing of the UNC Study research team)*.

These faculty experts have expanded their current research or developed new research proposals to support the UNC Study. This research team has a broad and diverse expertise that can bring a specialized focus in several distinct areas to help address the scientific and policy questions related to nutrient management.

The research team will conduct a comprehensive study to understand the underlying processes and propose management options to control the sources, transport, and fate of nutrients and sediment from the watersheds contributing to water quality problems, including excessive algal growth and potentially toxic cyanobacterial blooms, in Jordan Lake. Specific components of that research are outlined in more detail later in this report.

This type of comprehensive study requires an understanding of the links between watershed economic and ecological conditions, the biological, chemical, and physical functioning, and nutrient sensitivity of Jordan Lake. Furthermore, a process based understanding of the linked watershed-lake system is required to efficiently develop and test innovative management practices, based on sound scientific theory and evidence, that will ensure long-term sustainability of these reservoirs for their basic purposes of safe drinking water, aquatic habitat, recreational activities, and flood control.

The study will also include a robust engagement effort with key stakeholders and interested parties throughout the Jordan Lake watershed that will help inform the research actions outlined in the study. In addition, efforts will be made to integrate the research from this study with undergraduate education classes and programs.

It is our full expectation that the UNC Study will meet the charge detailed in the legislation and also advance the understanding of the science that is critical to the regulatory and management decisions to improve and protect the water quality in Jordan Lake.

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Study Principles

- **Utilize Science-Based Results to Guide Findings**

The UNC Study will identify those topics in which further research can assist in addressing existing data gaps, trends in water quality, and financial consequences of management decisions.

- **Build Upon Previous Work to Advance the Discussion**

The efforts to address water quality in Jordan Lake have taken place over a number of decades. It is imperative that the UNC Study build on that foundational work and not duplicate previous and existing efforts.

- **Integrate Existing Initiatives**

The research team recognizes that the UNC Study is one project of many that are currently underway in relation to how North Carolina develops and implements nutrient management strategies. As such, the UNC Study will incorporate new findings of these related projects when appropriate.

- **Leverage Current Research**

The research and work undertaken as part of the UNC Study will utilize ongoing research partnerships and expand the scope of current research projects to identify outcomes and results in the most timely and cost-effective manner.

- **Operate in a Transparent Manner**

Results and conclusions from the UNC Study and the background information and data that formed the basis of those conclusions will be publicly available.

- **Engagement with Stakeholders**

A key component of the UNC Study will be to incorporate the guidance and perspectives of a diverse array of citizens and stakeholders throughout the watershed that will help inform not only the UNC Study but future management and policy decisions for the Jordan Lake watershed.

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Study Components

The UNC Study will utilize the expertise and leverage the work of a number of researchers at UNC-Chapel Hill and other institutions. The research and analysis carried out during the study will advance the science and synthesize information that will help guide future policy decisions.

The UNC Study will initiate and connect a number of distinct research projects to provide a better understanding of the Jordan Lake watershed and help answer these fundamental questions:

- What are the sources of nutrients in the watershed and how significant is the problem of nutrient eutrophication for Jordan Lake?
- What are the most current nutrient mitigation measures and how cost-effective are these options?

The following outlines how the UNC Study will attempt to answer these questions and details the projects that will be undertaken in the first six months of the course of the study. It is the expectation that some of the research from the UNC Study on Jordan Lake will also inform the basis for the Falls Lake study that UNC has also been directed by the legislature to complete.

It is important to note that the UNC Study team reserves the right to adapt and modify the study plan based on initial results as well as guidance and input received during the stakeholder engagement phase.

Water Quality Monitoring and Nutrient Loading

Restoration of urban and agricultural land to support water quality goals and reduce nutrient loads can curtail the use of productive land, requires substantial up front capital costs as well as maintenance. Therefore, evaluating where in the landscape nutrient loading is the highest, what the sources are, and where they are most easily reduced is critical to efficient targeting of funds and effort to most efficiently reach water quality goals.

At present, we have a broad understanding of the general patterns of nutrient loading from different land uses, but not at a level sufficient to target stormwater control and nutrient reduction practices to maximize benefits while minimizing costs. Available data on stream nutrient loads are largely derived from infrequent (e.g., monthly or quarterly) sampling in a small number of larger streams by federal, state, or local agencies. These sparse samples are extrapolated to all streams and rivers in order to estimate sources for the total loads entering reservoirs, which often results in large uncertainty.

Optimizing the allocation of resources towards the most achievable nutrient reduction goals requires a denser (more streams, more frequently) sampling to both target resources, and to demonstrate that restoration efforts produce desired results. Some balance between upland, small stream and large stream and in-lake controls, needs to be planned to gain these efficiencies. This planning requires strategic up front and continuing sampling to improve targeting and reduce costs.

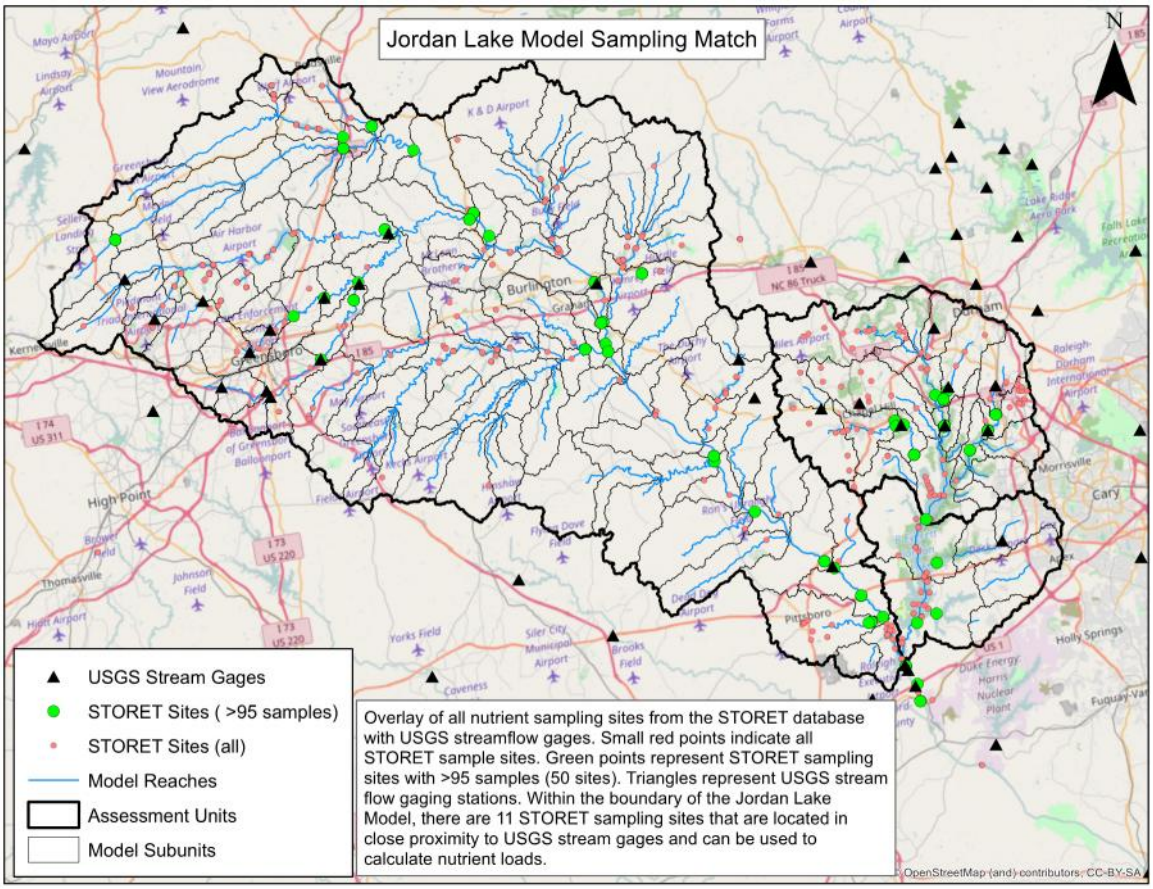
In general, the cost of sampling and improving our ability to target nutrient reductions and verify results is a small fraction of the total restoration costs, representing a cost effective, strategic investment. The measurements from government agencies can be supplemented by a set of studies by regional

universities that often emphasize smaller streams better reflecting local sources of nutrient loads. We will first consolidate all available nutrient sampling information to determine where the highest value samples can be collected to maximize efficiency in nutrient load control strategies. We will then identify gaps in existing sampling efforts so that we can better identify and target where the most cost effective nutrient control methods can be deployed.

Major questions requiring new data include:

- Where in the Jordan Lake watershed are nutrients coming from? And what details of land use, terrain, soils, and infrastructure best explain nutrient sources?
- When and under what flow conditions are the most nutrients being delivered to streams?
- What are the optimal best management practices to reduce nutrient loads?

Existing stream chemistry monitoring data is available for much larger watersheds, often in sites that lack discharge measurements. This makes it difficult to directly relate nutrient sources to landscape attributes such as land use, soils, terrain, and wastewater infrastructure. The below map shows state and federal monitoring stations. This will be supplemented with local and university data to first catalog and calculate water quality loads. Then additional monitoring will be conducted in order to improve estimates of nutrient loading that is land use specific and considers storm events in different seasons.



The new water quality monitoring in the Jordan Lake watershed outlined above will provide a more accurate picture of the current nutrient loading from different land uses. In addition to gaining a better understanding of the source of nutrients in the watershed through increased sampling, the UNC study will further evaluate the impact of sediments and integrate recent research findings from an agricultural land use study in the watershed.

Researchers will analyze sediment concentrations in the Haw and New Hope Rivers to determine sediment input into Jordan Lake. Samples will be collected daily and also hourly in five selected flood events. The data collected will be integrated with the watershed loading model.

One recent multi-disciplinary study was just completed that focused specifically on the Jordan Lake watershed. Among the results were determinations made related to source and loading of nutrients relative to urban and agricultural lands. The results of this research will be described and integrated with other nutrient source research being conducted in the UNC study.

Evaluate Controls on Algal Blooms

Biological Assessments

Research will be conducted to determine which nutrients are controlling algal growth. Through the deployment of seasonal biological assessments (bioassays) vital information will assist in determining the nutrient reductions necessary to maintain Jordan Lake below the bloom thresholds. Multi-year applications of these bioassays will enable determinations of thresholds under hydrologically-variable conditions, such as drought and flood years. Results will inform models linking nutrient inputs to phytoplankton growth potential and prescribe watershed nutrient reductions needed to control blooms and maintain acceptable chlorophyll *a* levels.

Similar bioassays were used to determine nutrient reductions needed in the lower Neuse River and estuary to determine nutrient reductions to meet state acceptable chlorophyll *a* levels; a critical step in the development of a Total Maximum Daily Load (TMDL) for the Neuse River Estuary. Currently, the technology is being used to determine toxic bloom thresholds in Lake Taihu, China's 3rd largest lake which serves as a drinking water supply for more than 10 million people.

In-Lake Monitoring

Researchers will deploy several instruments to measure exchange times within the lake, water quality variables, and meteorological parameters.

Acoustic velocity meters will be deployed to determine flow patterns and exchange along the length of the lake and particularly between the lower portion of the lake, that receives inflow from the Haw River, and the larger portion of the lake, that receives inflow from the Upper and Lower New Hope watersheds.

Two Autonomous Vertical Profilers (AVPs) will also be deployed to continuously monitor and report the characteristics of the water column over time. The profiler lowers a water quality instrument from the surface to the bottom while recording data such as depth, temperature, salinity, dissolved oxygen, chlorophyll concentration and turbidity. At the same time, the AVP also collects meteorological data (wind velocity, air temperature, solar radiation) above the water's surface. These data will be available over the internet in near real time.

Altogether this data will provide a clearer picture of how key aspects of the water in Jordan Lake is behaving over time.

These results will add to new water quality data sets being conducted under this study, and in particular, the results of gathering these measurements on the lake will greatly inform the work evaluating controls on algal growth and potentially toxic cyanobacterial blooms.

Analyze the Effectiveness of Nutrient Mitigation Measures

Bioretention

One of the most popular nutrient mitigation measures in North Carolina is the stormwater practice of bioretention. Bioretention as defined by the state Department of Environmental Quality is "the use of plants and soils for removal of pollutants from stormwater runoff via adsorption, filtration, sedimentation, volatilization, ion exchange, and biological decomposition." Given the importance of this practice research will be conducted to provide a first look to see whether these biologically-based treatment practices improve with age. Changes in performance (for better or worse) with time can then be used in basin-wide assessments of this important stormwater practice.

Agricultural Best Management Practices

Over the last decade researchers from NC State University have conducted a number of agricultural studies in the Jordan Lake watershed. The results of these studies will be integrated into the findings and recommendations of the UNC study and, when appropriate, help guide further research questions undertaken as part of the UNC study.

One such study included survey practices, such as collecting field scale information relative to cropping systems, nutrient applications, conservation practices, soil test phosphorous, livestock, and other detailed information by visiting each field site and talking to landowners. Consequently, information gathered from these detailed surveys provides a basis for the types of agricultural practices and additional conservation measures that could be used to reduce nutrient losses.

One recent multi-disciplinary study was just completed that focused specifically on the Jordan Lake watershed. Among the results were determinations made related to source and loading of nutrients relative to urban and agricultural lands, determined effectiveness of specific conservation practices, and economic analysis of water quality trading.

Identify Financing Options for Nutrient Mitigation Measures

State, regional, and local policies have a major impact on the costs associated with achieving nutrient control and mitigation targets and benefits. Policies control how costs are allocated and aggregated among different groups. This research will study the costs and benefits associated with nutrient strategies as forecasted, designed, and implemented in other regions of the country facing similar nutrient issues. Approaches from other states will be compared with North Carolina practices and policies.

More specifically, the research will study the modeled and forecasted costs of different aspects of basinwide nutrient strategies and how policies aggregate costs among groups of nutrient producers. In addition, the work will identify potential innovative financing strategies by studying:

- sources of revenues used to fund initiatives;
- capital and financing tools; and
- alternative service delivery methods involving public-private partnerships.

Review of Nutrient Mitigation Strategies in Other States

One of the primary directives of the legislation mandating the UNC Study is a review of nutrient strategies in other states. This section outlines the plans to conduct a review of nutrient management strategies in order to meet the legislative directive. As with other parts of the UNC Study a key aspect of this component of the study is to build on and leverage earlier work related to this topic.

In addition to the review of the financial policies and costs and benefits associated with nutrient strategies outlined above this research will take a wide-ranging evaluation of nutrient strategies currently underway across the region and country.

<u>NC Nutrient Management Forum</u>

In 2012 at the direction of the state's Department of Environment and Natural Resources (subsequently renamed to the Department of Environmental Quality) and the Environmental Management Commission state agency staff organized the North Carolina Forum on Nutrient Over-Enrichment. The Forum brought together a number of policy and technical experts with backgrounds in nutrient management. These experts included many participants from across the country with a vast array of experience related to nutrients and water quality on the state, regional, and national level.

The Forum included discussions on a wide range of nutrient management topics, including regulatory approaches, economic considerations, technical innovations, and the value of clean water to the public.

One result of this convening is that North Carolina officials have developed connections with colleagues around the country working in this field. As such, the UNC Study will leverage these connections and work with participants of the Forum to summarize and update the takeaways and recommendations from the Forum.

Review of the Chesapeake Bay Program

In 2014 the Chesapeake Bay Watershed Agreement (Agreement) was signed. Numerous federal partners and six states committed to the Agreement representing a comprehensive watershed management approach. The Agreement calls for collaboration across the Bay's watershed and establishes goals and outcomes for the restoration of the Bay. The Agreement outlines ten high level goals, which will be explored.

After the adoption of the Agreement stakeholders spent over a year developing management strategies to implement the goals noted above. These strategies detail an implementation plan and how monitoring and tracking will take place.

The UNC Study will evaluate these management strategies and look for comparable approaches that could be utilized in North Carolina. Members of the UNC Study team have experience working in the Chesapeake watershed and have provided guidance and input into that restoration program.

Gulf of Mexico Action Plan

In 2008 the Gulf of Mexico Hypoxia Action Plan (Plan) was developed as a national strategy to reduce and control hypoxia (low oxygen) in the Gulf of Mexico and improve water quality in the Mississippi River basin. A major component of the Plan is for the dozen states along the Mississippi River to develop strategies to reduce nutrient loading to the Gulf.

These Midwestern states, when developing their state plans, have generally been following the framework established by EPA in 2011 for the development of nutrient management strategies. This framework recommended eight elements for managing nitrogen and phosphorous pollution.

National Success Stories

Part of the task in evaluating nutrient management strategies implemented in other states is to begin to catalogue where those efforts have been successful. A cursory review indicates that examples of large watersheds that have recovered from nutrient pollution are rare. Nevertheless, there are a number of examples of where waterbodies have improved due to the implementation of agricultural and forestry best management practices, stormwater projects, and other nutrient controls.

It is important to note that what constitutes "success" when considering improvement of water quality in large watersheds is a relative term. Efforts to improve water quality impairment from nutrients are subject to a number of factors such as, population growth, climate variability, and land use changes. Furthermore, lag time in water quality response, which in some cases can last for decades, is a factor that should be accounted for in determining the success of the implementation of nutrient strategies.

The U.S. Environmental Protection Agency (EPA) has been tracking success stories throughout the country for a number of years (https://www.epa.gov/polluted-runoff-nonpoint-source-pollution/nonpoint-source-success-stories).

The EPA has compiled hundreds of examples where waters impaired by nonpoint sources-impaired have seen water quality improvements based on best management practices and other nutrient mitigation strategies. The UNC Study will review these examples and look for lessons learned from other regions of the country that may be applicable for North Carolina. In addition, the UNC Study will engage with

EPA's Office of Water to identify the latest developments in nutrient strategies underway across the country.

Outreach to Watershed Stakeholders

One piece of the UNC Study will be to conduct engagement and outreach to local governments and a range of stakeholders in the Jordan Lake watershed. UNC's Environmental Resource Program will conduct several meetings to gain insight into the knowledge, attitudes, and beliefs of key interest groups and the public throughout the watershed. These meetings may take the form of listening sessions or focus groups and will provide an updated snapshot of how stakeholders view the significance of water quality problems in the watershed and how best to approach identifying solutions.

In addition, the UNC study will include a pilot project for community engagement for stormwater management. This pilot project would focus on engagement techniques that would identify community concerns about environmental quality, increase awareness of stormwater management tools like green infrastructure, and enable the community to participate more fully in the decision-making around the use of best management practices within their community.

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A Look Ahead to 2017-2018

The above components form the framework of the UNC Study and what is planned for the first half of calendar year 2017. The focus of that work is a review of existing data and initiating additional water quality monitoring that can address current gaps in information. In addition, as outlined above the UNC Study will begin engaging with communities in the watershed and begin gathering information from across the country on successful nutrient mitigation strategies.

The second year of the UNC Study plans to build on the first year of research results and also, significantly, integrate an educational component of making Jordan Lake a showcase for research.

Develop Jordan Lake as an Educational Field Site

An integral part of the UNC Study will be to establish the Jordan Lake Observatory (JLO) as a nexus of experiential learning at Carolina. The rigors of undergraduate education often limits the possibilities of learning experiences outside the traditional classroom setting. The Carolina campus is located only a few miles from Jordan Lake and is within the Jordan Lake watershed. This proximity and connectivity with the university makes this location ideal as a living laboratory for university students.

An established observatory would foster experiential learning in a variety of ways. Each semester, hundreds of students seek independent study opportunities, working with faculty and graduate student mentors, to gain field and laboratory experience. The JLO infrastructure would provide many opportunities for students to pursue their independent study. Maymester and summer school classes could be structured around the JLO and also support field experiences for classroom courses during the spring and fall semesters. The JLO would provide a more proximate and inexpensive alternative to Institute for the Environment field sites at the coast, in the mountains and in the Galapagos Islands.

The JLO would also greatly benefit graduate students at Carolina. It would be an important resource for graduate student training and a valuable setting to test experimental approaches and designs. The opportunity to mentor undergraduate researchers would help graduate students develop and hone their own teaching skills, providing them with valuable experience.

In collaboration with researchers who are focusing on Jordan Lake, the observatory would utilize already established transects throughout the lake for water and sediment sampling and would use real-time streaming of data from at least two monitoring stations continuously measuring physical, chemical and biological parameters in the lake. In addition, undergraduate researchers would have the opportunity to participate in ongoing monitoring of the rivers and streams entering Jordan Lake as part of the overall nutrient and sediment budget monitoring of the lake.

The addition of a permanent environmental observatory near campus, which is utilized by a wide spectrum of faculty and students, will be a strong addition to Carolina's commitment to serving the state.

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Appendix I

Legislative Text of Session Law 2016-94, Section 14.13. (c)

Of the funds appropriated to the Board of Governors of The University of North Carolina, the sum of five hundred thousand dollars ($500,000) for each of the fiscal years from 2016 - 2017 through 2021 - 2022 is allocated to the Chief Sustainability Officer at the University of North Carolina at Chapel Hill to designate an entity to oversee a continuing study and analysis of nutrient management strategies (including in situ strategies) and compilation of existing water quality data specifically in the context of Jordan Lake and Falls Lake.

As part of this study, the entity shall

(i) review data collected by the Department of Environmental Quality and by other stakeholders from water sampling in areas subject to the Falls Lake or Jordan Lake Water Supply Nutrient Strategies and compare trends in water quality to the implementation of the various elements of each of the Strategies and;

(ii) Examine the costs and benefits of basin wide nutrient strategies in other states and the impact (or lack of impact) those strategies have had on water quality.

The entity shall report to the Environmental Review Commission, the Environmental Management Commission, and the Department of Environmental Quality as set forth below:

(1) With respect to Jordan Lake, the final results of its study and recommendations for further action (including any statutory or regulatory changes necessary to implement the recommendations) no later than December 31, 2018, with interim updates no later than December 31, 2016, and December 31, 2017.

(2) With respect to Falls Lake, the final results of its study and recommendations for further action (including any statutory or regulatory changes necessary to implement the recommendations) no later than December 31, 2021, with interim updates no later than December 31, 2019, and December 31, 2020. No indirect or facilities and administrative costs shall be charged by the University against the funds allocated by this section. The Department of Environmental Quality shall provide all necessary data and staff assistance as requested by the entity for the duration of the study required by this subsection. The Department shall also designate from existing positions an employee to serve as liaison between the Department and the entity to facilitate communication and handle data requests for the duration of the project.

Appendix II

Roster of UNC Study Team Members

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