RIVERNET: Continuous Monitoring of Water Quality in the Neuse River Basin

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The nation's rivers, lakes, streams, ground waters, and estuaries are priceless public assets. Fish kills and harmful alga blooms are conspicuous end-members of water quality degradation. We face serious challenges as we enter the 21st century if we are to protect and sustain our nation's environmental quality and water resources. These challenges include the links between water quality and public health, the effects of extreme natural events such as hurricanes, and the impact of rapidly growing urban centers and agri-business operations on ground water resources. To protect our nation's water, public policy must evolve quickly to meet the continually changing landscape of society's demands on our water resources.

Figure 1. Monitoring stations are attached to bridge pilings and the data transmitted by cell phones. These stations will collect data during extreme events, such as hurricanes, when some areas are inaccessible.

To meet this challenge, a system of automated real-time monitoring stations that continuously collect, archive and disseminate water quality data are now being installed on the coastal plain of North Carolina (Figure 1). This system of automated real-time monitoring stations was mandated by Legislative House Bill 168 for waters that are impaired based on the criteria of the State's basin-wide water quality management plans. The house bill also mandates that the North Carolina Water Quality Workgroup develop a water quality monitoring system that effectively uses the combined resources of North Carolina State University and State agencies.

Long term monitoring needs to be completed in the watersheds where nutrients enter the aquatic systems and where regulations will be enacted to improve water quality. Rapid advances in monitoring technology and information management systems with web based data dissemination makes a project such as RiverNet not only possible, but important to the prudent management of our national water resources in the future (see Figure 3). 10 water quality parameters and up to three nutrient concentrations are measured in situ at each station every five to sixty minutes. The data is automatically
sent back to the university data archiving center via cell phones where the data is organized, calibrated for measurement accuracy, and disseminated to the various user groups and stakeholders via the RiverNet web site (http://rivernet.ncsu.edu). In this way, immediate access to water quality data is provided to state and national agencies, the research community, education co-operative groups, citizen environmental groups, and public policy makers.

Development of the RiverNet Water Quality Monitoring Plan

The North Carolina Water Quality Workgroup (NCWQW) discussed the RiverNet Water Quality Monitoring Plan between March to December 2000. Written plans were distributed during the March and May meetings. The final plan was given to the Chairman in December, and distributed to the entire workgroup in January 2001.

Objectives: To provide better assessment of nutrient loading in the impaired waters of eastern North Carolina.
- Assessment of dissolved and particulate nutrient loading variability on different time scales.
- Assessment of dissolved and particulate nutrient loading variability during different discharge states.
- Assessment of variability of nutrient loading in areas of different Land Use (LCLU) areas.
- To provide better water quality data during crisis management and extreme storm events.
- To provide better estimates of the spatial and temporal nutrient fluxes that contribute to the impairment of water quality

Station Location

Stations are located along highways and state roadways, because the RiverNet stations are attached to existing bridges. The station locations were determined by criteria suggested by DENR-DWQ and the USGS, in addition to the criteria defined by the NCWQW. The Neuse River basin will be the primary focus of the initial RiverNet Program in accordance with these criteria and because of the importance of water quality problems in the Neuse River estuary. The stations are currently operating are at Fort Barnwell on the Neuse mainstem, at Seven Springs (Neuse mainstem below Goldsboro), and at Grifton on Contentnea Creek (Figure 2).

Figure 2. RiverNet Monitoring Station Locations on the NC Coastal Plain, three stations are operational at Fort Barnwell, at Seven Springs below Goldsboro, and at Grifton. The entire network will be operational in Spring 2001.

Station Design and Installation
The RiverNet stations use *in situ* NAS-2E nutrient analyzers from WS Oceans and the YSI 6920 Sonde as *instream* monitors. The instruments were initially put in a perforated metal pipe that was banded to the bridge piling to protect the instruments during hurricane flooding events (Figure 3a). The data logger, cell phone transceiver, and battery were placed in a watertight compartment on the top of the pipe. During the summer of 2000 in low flow conditions, the water level in the pipe fell below the intake level of the NAS. Cages were constructed that allowed the NAS to lay horizontally and make measurements during low water conditions (Figure 3a). These cages are chained to the bridge pilings and can be placed in different locations around the bridges when channels migrate during low flow conditions. Shallow water levels are more of a problem in the middle and upper portions of the basins where the river channels are not deep. The upper and middle portion of the basins will have the sonde in a pipe below water level (Figure 3b). Water for the ISCO and NAS analyzer at these stations will be pumped up to the top of the bridge by a peristaltic pump. This design will also allow RiverNet stations to be placed in smaller creeks that are assigned a high priority by DENR and the US Geological Survey.

![Figure 3](image)

**Figure 3.** Original RiverNet Station Design for the lower Basin (Left). The monitors are placed in a pipe banded to the bridge piling in high water, and placed in a cage chained to the bridge in low water. This type of design works well in the lower basin, where the river channels are deep. The above water design (right) will be used for the middle and upper portions of the river basins where river channels are shallow during the summer low flow conditions. This design will also allow stations to be placed in smaller creeks where access is difficult.

**RiverNet: Results**

The initial results during the Summer of 2000 from the lower basin monitoring stations show significant variability in the concentration of dissolved nitrogen in the Neuse and Contentnea watersheds during low flow conditions (Figure 4). Measurements taken at the RiverNet Stations are calibrated against water samples taken in the ISCO samplers or by personnel visiting the site. Particulate and dissolved nutrient concentrations are measured on these discrete samples with a La Chat QuickChem 8000 ion analyzer according to EPA protocols. The red points in the nutrient plots are the river water nitrate concentrations from these samples plotted against the *in situ* nitrate measurements made by the nutrient analyzers in the river. The agreement between these two types of nutrient measurements are acceptable. During higher discharge periods, nitrate concentrations also exhibit significant variability (Figure 5). The variability is also different from one site to the next during high discharge. The site at Grifton on Contentnea Creek shows more variability than the Fort Barnwell site on the Neuse River mainstem. During the winter period, Contentnea Creek show large dilution events that decrease nutrient concentrations. These results demonstrate the importance of having long term high resolution water quality monitoring records to understand nutrient loading variability and for accurate calculations of nutrient fluxes to the Neuse River estuary.
Figure 4. Nitrate concentration in the Neuse River above at the Seven Springs site above Kinston NC during the summer low flow conditions. The rapid concentration changes during this period are not associated with discharge variation. These data demonstrate that estimates of nutrient flux calculated from weekly or daily measurements can contain significant error, since these concentrations change on an hourly basis.

Figure 5. Nitrate concentration in the Neuse River at Fort Barnwell and in Contentnea Creek at Grifton during the fall when river discharge is higher. The rapid concentration changes during this period are associated with discharge variation, the agreement between the calibrated (red) and insitu measurements (green) are good.
CONCLUSIONS:

This continuous monitoring system will give researchers and water quality regulators a new understand of the processes effecting water quality. For example, how important are spills and accidental discharges to overall water quality conditions versus the long term, chronic point and non-point loading? What is the fine scale temporal and spatial variation of nutrient loading with different types of land use? How well can we estimate total maximum daily loads (TMDLs) of nitrogen and phosphorus? It will also give citizen environmental groups and educators such as high school science teachers access to water quality conditions in their area of the river or water shed. In combination with university extension and educational outreach groups, this data can be used to raise public awareness water quality issues. But most important, data will be available to policy makers in real time to answer questions about water quality problems. By installing a network of stations, spatial and temporal variability in nutrient loading and water quality can be assessed over the entire river basin. Operating this monitoring network over a period of time will assist in documenting the effect of new regulations enacted to improve water quality in North Carolina, and assist in the US EPA basin-wide model that is requested under the reauthorization of the Clean Water Act.

By wisely using state and national resources and by emphasizing results focused on the systematic application of research-based knowledge, we can expedite the timely resolution of our water quality problems and protect our invaluable water resources. By combining research efforts with educational outreach programs we can improve the public’s understanding of water resource issues and the essential social, economic, and environmental value of local water resources for all persons and sectors of society.