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# Water Quality Change: Effects of Development on Nutrient Loading in Selected Watersheds

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## **2008 WRRC Report for project dates March 1, 2008 to February 28, 2009:**

### **Title- Water Quality Change:-Effects of Development on Nutrient Loading in Selected Watersheds**

**PI:** Jeffrey Schloss, Extension Professor in Biological Science (UNH Center for Freshwater Biology) and Water Resources Specialist, UNH Cooperative Extension.

#### **Statement of regional or State water problem-**

The waters of New Hampshire represent a valuable water resource contributing to the state's economic base through recreation, tourism, and real estate revenues. Some lakes and rivers serve as current or potential water supplies. For most residents (as indicated by boating and fishing registrations and shoreline re-development) our waters help to insure a high quality of life. As documented in the 2000 Census, New Hampshire currently leads all of the New England states in the rate of new development and redevelopment. The long-term consequences of the resulting pressure and demands on the state's precious water resources remain unknown. Of particular concern is the response of our waters to increasing non-point source pollutant loadings due to watershed development and land use activities.

Of all the in-depth watershed nutrient budget measurements and modeling efforts that have been attempted in NH none have primarily focused on change detection due to development as they were either baseline studies on relatively pristine lakes or focused on specific problems such as internal nutrient loading from past sewage outfalls, or septic systems in the water table of a seepage lake. In addition nitrogen species were only monitored for less than a handful of studies and the measurement technologies at the time were not sensitive enough to provide much usable data. The opportunity to add nitrogen monitoring and support GIS land change analysis to co-occurring externally funded phosphorus watershed nutrient budget studies on two lakes that had previous budgets done in the past provides a true cost-effective project that directly addresses Statewide concerns.

Alone, these watershed nutrient budgets represent only short-term examinations of non-point source pollution nutrient loadings to the lake. A longer-term monitoring program conducted through differing weather years at both shallow and deep sites is required to best estimate the lake response to the loadings due to development over time.

#### **Nature, scope and objectives of the project and task status .-**

This project funding has allowed for the continued collection of long-term water quality data over a substantial spatial and temporal scale. Both project components utilized a combination of students and volunteer citizen water quality monitors to collect samples (and preserve them for analysis) from a wide range of lake and stream watersheds throughout the state which are part of the NH Lakes Lay Monitoring Program (LLMP), a 30 year long-term sampling effort.

The Mendums Pond Watershed Study component for this year was the completion and calculation of a water nutrient budget for a local lake that UNH has a recreational center on. Comparisons to a previous study completed a decade ago allowed for the examination of any changes that occurred in subwatersheds with increased development compared to subwatersheds that experienced little developmental change. Emphasis on LLMP efforts has been to maintain and expand tributary monitoring for participating lakes to allow for long-term change detection through a number of years with differing weather regimes.

As other funding sources were already available for most water quality analysis costs and related expenses, funding from this project provided support for nitrogen species and anion/cation analyses (seepage samples), student lab and field technicians and for supervision, data management and data analysis by the project director.

NOTE: We have envisioned this effort as providing the foundation to further assess the impacts of land use and the effectiveness of watershed management strategies using long-term data sets in future years.

To summarize, objectives of this study included:

1. To add nitrogen analysis for the groundwater seepage component of an already funded project developing a water and total phosphorus budget for a lake watershed that has experienced land cover change since a previous study was undertaken over a decade ago.

*Status: Project was completed and final project report to the state funding agency was submitted in February 2009. Master's thesis focusing on the seepage component of the project is near completion (May 2009 target).*

2- The continued collection and analysis of long-term water quality data in selected watersheds.

*Status: 14 new monitors trained directly, 15 indirectly; 50+ monitors re-trained and tested, eight additional shallow lake sites added to Bow Lake. Over 940 deep lake site trips by volunteers; 80 deep lake site trips by CFB field team (students and faculty), Over 600 shallow lake and tributary site trips made by volunteers; 54 tributary sample trips made by CFB team.*

3- The dissemination of the results of the analysis to cooperating agencies, water managers, educators and the public on a local, statewide and regional basis.

*Status: Data for both the Mendum's Pond Nutrient Water Budget as well as the Newfound Lake Study have been transferred to the NH Department of Environmental Services (NH DES) data exchange warehouse that also uploads to the US EPA Storet II system. Also, NH LLMP phosphorus data from participating NH lakes was used in the determination of statewide nutrient criteria by the NH DES. Results from a previous WRRRC funded project on GIS based nutrient loading coefficients for NH watersheds have also been the basis for TMDL studies addressing impaired waters in NH.*

*Reports:*

35 Individual Reports produced for each lake and or watershed association participating;

“Mendum's Pond Watershed Study Final Report” submitted to the NH DES and the Al Wood Road Association (February 2009)

*Peer reviewed reports:*

“Quality Assurance Project Plan for the Acton Wakefield Watershed Alliance”(February 2009)

*Public Presentations:*

“Protecting NH Lakes Thirty Years of Collaborative Monitoring: and Participatory Research” invited plenary NH Lakes Congress, NH lakes Association (June 2008)

“Mendums Pond Watershed Study Update” (grad student presentation) Barrington Selecman's meeting (May 2008)

“Mendums Pond Watershed Study: Final Report” presented at a joint public meeting of the Barrington and Nottingham Planning Boards and Conservation Commissions. (February 2009).

*Class Presentations:*

*Introduction to Water Resources Management (Natural Resources)- “NH Lakes: Issues and Concerns”*

*Lake Biology (Zoology/Plant Biology)- “The NH Lakes Lay Monitoring Program”*

*Watershed Ecology (Natural Resources)- “Lake Ecology”, “Lake Water Quality Sampling” and “Following the Flow: Nonpoint Source Pollution in NH Watersheds”*

*Multidisciplinary Lakes Management (Zoology/Plant Biology)- “Analysis of a long term datasets”*

*Academia /Professional Societies:*

4- To offer undergraduate and graduate students the opportunity to gain hands-on experience in water quality sampling, laboratory analysis, data management and interpretation.

*Status: See table below- 7 undergraduate and 2 graduate students were directly involved*

5- To further document the changing water quality in a variety of watersheds throughout the state in the face of land use changes and best management efforts.

*Status:* See significant findings section below for Mendum's Pond Study results

6- To determine next steps for further analysis of long-term data sets and GIS spatial data on land cover.

*Status:* We can now further refined our dataset on nutrient loading coefficients for various landcover combinations that are currently being used by state and regional agencies as well as consulting firms who are conducting TMDL development projects. Our future efforts will be to try to use GIS spatial analysis to account for variations in coefficients among subwatersheds with similar landcover characteristics.

#### Methods, procedures and facilities used:-

An EPA approved QAPP (Schloss 2006) for the watershed water/nutrient budget was followed that included volunteer sample collection and gage readings and student technicians sampling and conducting stream flow measurements using a Doppler water velocity meter (SonTek/YSI).

Lake and stream monitoring through the LLMP generally involved a minimum of monthly sampling starting at spring runoff through to lake stratification and weekly to bi-weekly sampling through to fall mixis. Water clarity, chlorophyll a, acid neutralizing capacity, dissolved organic color, dissolved oxygen and nutrients (total N, total P and nitrate) were the default suite of parameters measured for lakes while nutrients, turbidity, dissolved organic color and flow were the parameters of choice for the lake tributary work. On occasion, student field teams traveled to join the volunteer monitors to perform quality assurance checks and do more in-depth analysis and lake profiling.

As stated above the primary scope of this project is to maintain the long-term data collection effort but in addition, land cover changes to study subwatersheds were documented on our established GIS data base and any new management practices or conservation efforts were also documented

This project was coordinated from the University of New Hampshire College of Life Sciences and Agriculture, which supplied the office and laboratory space. The Center for Freshwater Biology Analytical Water Quality Laboratory has a Quality Assurance Project Plan for surface water analysis on file with the US Environmental Protection Agency Region 1 Office (EPA New England). Besides nutrient analysis (Total Phosphorus, Total Nitrogen, Nitrate), other water quality capabilities used included chlorophyll a, dissolved oxygen, dissolved CO<sub>2</sub>, acid neutralizing capacity, specific conductivity, pH, ORP, turbidity, water clarity, iron and E.coli. The lab also provided field sampling, field water quality instruments, automated data loggers, water velocity measurement equipment. and real-time differential GPS units for watershed surveying and ground truth sampling.

The Water Resource Center Laboratory, which follows standard methods, performed ion chromatography for a variety of anions and cations.

UNH Cooperative Extension provided vehicles for travel for PI's, students and interns at a cost (mileage) basis. A dedicated GIS PC Windows XP workstation running ArcGIS and ArcView Software, ArcView Extensions: Spatial Analyst, 3-D Analyst, Image Analysis and ArcPress. was used for watershed delineations and spatial landcover analyses.

The project utilized an extensive GIS database for the study subwatersheds created through previous WRRF funding to the PI. Updated and additional GIS data was made available through the UNH Complex Systems Research Center, which manages the NH GRANIT statewide GIS data depository. The extensive data directory contains statewide GIS data layers (usually at 1:24,000 scale) including hydrology, geology, soils, National Wetlands Inventory, land-use, land cover, and digital elevation models. Also available are Landsat Thematic Mapper, SPOT Panchromatic and digital orthophoto imagery.

Students impacted for 2008-2009 (supported by and/or worked on aspects of project):

<u>Field of Study</u>	<u>Undergraduate</u>	<u>Masters</u>	<u>Ph.D.</u>	<u>Total</u>
Marine and Freshwater Biology (Plant Biology or Zoology)	3			3
Pre-Med	1			1
Environmental Conservation	2			2
Water Resources (Natural Resources or Hydrology Dept.s)	1	1	1	3
<b>TOTAL:</b>	<b>7</b>	<b>1</b>	<b>1</b>	<b>9</b>

Major Findings:

- 1) Importance of wetland complexes for attenuating phosphorus and runoff flows: One of the major tributaries at Mendums Pond (Perkins Brook) which had low development and little change over time and many connected wetland complexes showed little change in terms of storm event flow and nutrient loading. Most excessive runoff and higher areal nutrient loads occurred in the more developed subwatersheds.
- 2) Improvements in water quality can occur through mitigation and best management practices: two drainage areas which were flagged for relative high runoff and loading concerns (Bridge Brooks) in the original Mendum's Pond Study, and where erosion and parking lot runoff problems were addressed, had major improvements in nutrient loading and were less "flashy" in terms of storm flows.
- 3) Even relatively small sized developments can have significant impacts if they are designed or implemented poorly. A relatively small subdivision development (Gerrior Drive) with under-designed stormwater controls in one of the Mendums Pond subwatersheds had a significant impact on increased runoff and nutrient loading due to its location at the headwaters of the subwatershed's stream (Wood Road Brook).
- 4) Seepage flows in the shallow lake areas of Mendum's Pond were significantly correlated with monthly precipitation.
- 5) Of the nutrients, anions and cations assayed in the groundwater seepage component of the project, only chloride concentration was significantly higher near developed areas compared to undeveloped areas. Surprisingly, nitrogen species were in highest concentrations in the seepages closest to steep and undeveloped sites.