Water Resources Research Center
Annual Technical Report
FY 2005

Introduction

The New Hampshire Water Resources Research Center, located on the campus of the University of New Hampshire, is an institute which serves as a focal point for research and information on water issues in the state. The NH WRRC actually predates the Federal program. In the late 1950s Professor Gordon Byers (now retired) began a Water Center at UNH. This Center was incorporated into the Federal program in 1965 as one of the original 14 state institutes established under the Water Resource Research Act of 1964. The NH WRRC is currently directed by Dr. William McDowell with administrative and technical assistance from Shanna Fredyma, Jeff Merriam and Jody Potter. The NH WRRC is a stand alone organization, in that it is not directly affiliated with any other administrative unit at UNH. The NH WRRC has no dedicated laboratory, administrative or research space on campus and no formal library holdings. To overcome these potential limitations, our website (www.wrrc.unh.edu) is used heavily, and serves as a focal point for information dissemination and includes all NH WRRC publications and results from past research, as well as links to other sites of interest to NH citizens and researchers.

Research Program

Water Quality and the Landscape: Long-term monitoring of rapidly developing suburban watersheds

Basic Information

Title:	Water Quality and the Landscape: Long-term monitoring of rapidly developing suburban watersheds
Project Number:	2003NH21B
Start Date:	3/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	1
Research Category:	Not Applicable
Focus Category:	Non Point Pollution, Surface Water, Nutrients
Descriptors:	
Principal Investigators:	William H. McDowell

Publication

1. Buyofsky, L.A. 2006. Relationships between groundwater quality and landscape characteristics in the Lamprey River watershed. M.S. Dissertation, Department of Natural Resources, College of Life Science and Agriculture, University of New Hampshire, Durham, NH
2. Proto, Paul J. 2005, The Significance of High Flow Events in the Lamprey River Basin, New Hampshire, for Annual Elemental Export and Understanding Hydrologic Pathways. M.S. Dissertation, Department of Earth Sciences, College of Engineering and Physical Sciences, University of New Hampshire, Durham, NH, 176 pages.

Water Quality and the Landscape: Long-term monitoring of rapidly developing suburban watersheds

Statement of Critical Regional or State Water Problem

New Hampshire's surface waters are a very valuable resource, contributing to the state's economic base through recreation (fishing, boating, and swimming), tourism and real estate values. Many rivers and lakes also serve as local water supplies. New Hampshire currently leads all New England states in the rate of development and redevelopment (2000 Census). The long-term impacts of population growth and the associated changes in land use to New Hampshire's surface waters are uncertain. Of particular concern are the impacts of non-point source pollution to the state's surface waters (e.g. septic, urban run off, road salt application, deforestation and wetland conversion). Long-term datasets that include year-to-year variability in precipitation, weather patterns and other factors will allow adequate documentation of the cumulative effects of land use change and quantification of the effectiveness of watershed management programs.

Statement of Results or Benefits

The proposed project will provide detailed, high-quality, long-term datasets which will allow for a better understanding of the impacts of land use change and development on surface water quality. This could occur through the development, testing and refinement of predictive models, accurately assessing the impacts of watershed management practices, and potentially early warning of dramatic changes to surface water quality in the region resulting from rapid development.

Objectives of the Project

This project allows for the continued collection of long-term water quality data in New Hampshire. It will use UNH staff, students and volunteers from local communities to collect samples from the College Brook watershed (Durham, NH), the Lamprey River Watershed, the Oyster River watershed, and the Ossipee Watershed.

The College Brook watershed, which is dominated by the University of New Hampshire, receives a variety of non-point pollution from several different land uses. Suspended sediments, pH, conductivity, biological oxygen demand (BOD) and nutrient concentrations (Cl^-, SO_4^{-2}, Na^+, K^+, Mg^{+2}, Ca^{+2}, NO_3, NH_4, PO_4, DOC, TDN) will be measured to assess water quality. Samples from 7 sites will be collected monthly throughout the year. Sampling of College Brook began in 1991. Sample collection will be done by UNH staff and/or students, with analyses done by UNH staff at the Water Quality Analysis Lab (WQAL) of the WRRC.

The Lamprey River will be sampled weekly throughout the year and during major storm events. Samples will be measured for suspended sediments, pH, conductivity, and nutrient concentrations (Cl^-, SO_4^{-2}, Na^+, K^+, Mg^{+2}, Ca^{+2}, NO_3, NH_4, PO_4, DOC, TDN). Sampling and analyses will be done by UNH staff. Weekly sampling of the Lamprey River began in 1999.

Samples will also be collected monthly (when surface streams are present) at Moore Fields, a 42 acre agricultural property near the Oyster River. Moore Fields is owned by UNH and is used for soil science courses and research as well as growing feed for the university's livestock. Sampling began here when a land use change to soccer fields was proposed. This proposal has since been withdrawn. Samples will be collected and analyzed by UNH staff at the WQAL.

Streams within the Ossipee watershed of New Hampshire will be sampled by volunteers of the Green Mountain Conservation Group. Samples will be collected every 2 weeks from May to November. Water chemistry (Cl^-, SO_4^{-2}, Na^+, K^+, Mg^{+2}, Ca^{+2}, NO_3, NH_4, PO_4, DOC, TDN) will be measured by the WQAL at a per sample cost. WRRC staff will assist in data interpretation.

Principal Findings and Significance

College Brook

Samples have been collected from College Brook as planned during 2005-2006. However, data analysis was not complete at the time this report was due. Previous work on College Brook in the early 1990's (McDowell unpublished) shows that the UNH campus had a severe impact on water quality and was negatively affecting stream biota and the integrity of downstream ecosystems. By any yardstick, campus operations could not be considered sustainable. There was clear evidence that the UNH incinerator was causing excessive organic matter loading, resulting in high biochemical oxygen demand (BOD) and low dissolved oxygen in stream water. Other practices, such as washing of waste art materials (slip, poster paint, etc.) into street drains near the Service Building, were also impacting College Brook.

Comparisons between data collected in 1991 and 2000-present have indicated that overall water quality has improved in College Brook with the closing of the UNH incinerator and greater ecological awareness on campus. Recent water quality analysis (2000-2003) indicates that the drought of 2001 has a significant effect on water quality. It was the third driest year for the state of New Hampshire for 1895-2003 and water chemistry indicated that the health of the stream was at its lowest for some parameters (TDN, nitrate, ammonium, BOD, etc…). Construction on campus has also likely had an impact on stream quality and in 2001 construction occurred in close proximity to the stream in the watershed. Construction accidents (i.e. - water main break) caused large runoff discharges into College Brook and likely had effects on the stream, which further complicates the picture. Further analysis of the data and continued monitoring of College Brook is scheduled to continue. The College Brook web site can be viewed at http://www.wrrc.unh.edu/current_research/collegebrook/collegebrookhome.htm.

Weekly Lamprey Sampling and the Lamprey River Hydrologic Observatory

We have continued to sample the Lamprey River at the USGS gauging station in Durham, NH (referred to as "LR 73.3"), the North River at the USGS gauging station in Epping, NH (NR 26.9) and a small tributary to the Lamprey River in Lee, NH (WHB 1.03) for DOC, DON, NO_3-N, NH_4-N, PO_4-P, pH, DO, temperature and conductivity on

a weekly basis. In addition to these parameters, station LR 73.3 is also sampled for DIC, major cations (Na, Ca, Mg, K), major anions (Cl, SO_4), SiO_2, TSS, Particulate C and Particulate N. Our goal for this long-term water quality monitoring program is to document changes in water quality as the Lamprey watershed becomes increasingly more developed. We continue monitor stream flow at WHB 1.03 with an electronic distance meter and are now developing a rating curve for this site. We continue to collect precipitation at Thompson Farm (UNH property located in Durham, NH) and work with NOAA/AIRMAP in an attempt to link to precipitation chemistry to airmass chemistry.

Results of stream chemistry to date show an increase in peak NO_3-N concentration over time in the Lamprey and a link between population density and NO_3-N concentration and export. Dissolved organic matter (DOM) in the Lamprey watershed is related to wetland cover, but there are no clear trends in DOM over time nor is there a consistent relationship between DOM and stream discharge. Results of precipitation monitoring show that DOC and DON in precipitation are related to atmospheric black carbon. Several atmospheric volatile organic carbons (VOCs) appear to be strong predictors of DOC, TDN and NH_4.

Other projects in the Lamprey watershed include linking groundwater chemistry (by way of homeowner well analysis) to landscape characteristics and documenting changes in nitrogen concentrations in riparian zones. We found a positive relationship between average sub-basin NO_3-N concentration and sub-basin population density/urban land use and that average sub-basin groundwater NO_3-N is higher than NO_3-N in the stream water. Arsenic concentrations in individual wells vary in response to bedrock type and vary by sub-basin in response to the percentage of agriculture. There was one homeowner well that exceeded the current MCL for nitrate and 16 homeowner wells that exceeded the current Arsenic MCL. In riparian zones, there is a large reduction in NO_3-N (approximately 4.5 mg NO_3-N upslope to 0.2 mg/L NO_3-N near the stream) and an increase in NH_4-N (approximately 0.02 mg NH_4-N upslope to 0.2 mg/L NH_4-N near the stream) over a small distance (approximately 10 m).

Ossipee River watershed sampling

Collaboration with the Green Mountain Conservation Group and their sampling of the Ossipee River watershed has continued to be beneficial. Volunteers sampled streams within the watershed every 2 weeks from May to November, with approximately 340 samples collected from 14 sampling locations. Many presentations were made to planning boards, conservation commissions and other local government groups (see Publication, presentations and awards section below).

Presentations:

Buyofsky, L.A. 2006. Relationships between groundwater quality and landscape characteristics in the Lamprey River watershed. M.S. Thesis Defense, Department of Natural Resources, University of New Hampshire, March 2006.

McDowell, W.H. 2006. Biogeochemistry of suburban basins. University of Puerto Rico, February 2006.

McDowell, W.H., Daley, M.L. and Gettel, G. 2005. Nitrogen inputs, output, and retention in a coastal suburban basin. American Geophysical Union fall meeting, San Francisco, December 2005.

Buyofsky, L. 2005. The relationship between groundwater quality and land use in the Lamprey River watershed. Research to Practice: Science for Sustainable Water Resources Conference, Amherst, Massachusetts, October 2005.

McDowell, W.H. 2005. Biogeochemistry of suburban basins – putting people into the landscape. University of Colorado seminar series, November, 2005McDowell, W.H.. 2005. Biogechemsitry of suburban basins- putting people into the landscape. University of Vermont, Water in the Environment seminar series, April 2005

McDowell, W.H. 2005. Biogechemsitry of suburban basins- putting people into the landscape. Institute of Ecosystem Studies, Millbrook NY, March 2005

McDowell, W.H., M.L. Daley, T.E. O'Donnell, and L.A. Buyofsky. 2005. Biogeochemistry of a Suburban Basin. Emerging Issues Along Urban/Rural Interfaces: Linking Science and Society. Atlanta, GA. March 2005.

Information Transfer:

Buyofsky, L. "Drinking Water in Your Watershed." Oyster River Adventure Camp, July 2005

Buyofsky, L. "Groundwater Quality in the Lamprey River Watershed (homeowner version)", given 3 times: Northwood Conservation Commission, Northwood, NH; Henry Moore School, Candia NH, and UNH, April-May 2005

Buyofsky, L. "Groundwater Quality in the Lamprey River Watershed (broader high school version)" Souhegan High School, June 2005

Presentations related to the Green Mountain Conservation Group collaboration.
August 17th: "Water Quality in the Ossipee Watershed", Camp Calumet (20p.)

November 28th: Freedom WQM Presentation 7:00 Freedom Cons. Com, Selectmen, residents (15p.)

December 5th: Ossipee WQM Presentation 4:15 @ Ossipee Town Hall Ossipee Cons. Com, Selectmen, Planning Board, residents (25p.)

December 6th: Madison WQM Presentation 5:00 @ Madison Town Hall Madison Selectmen,, Cons. Com, Planning Board, residents (20p.)

December 12th: Sandwich WQM Presentation 7:30 @ Sandwich Town Hall Sandwich Selectmen, Cons. Com (10p.)

December 13th: Effingham WQM Presentation w/ Bob Craycraft 5:00pm @ Effingham Town Hall Effingham Selectmen, Planning Board, Cons. Com., residents (35p.)

December 15th : Tamworth WQM Presentation w/ Michelle Daley 4:00 @ Tamworth Town Hall Tamworth Cons. Com, Selectmen, Planning Board, residents (15p.)

January 1st: Annual Meeting w/ WQM Presentation (70 p.)

January 11th: Ossipee Conservation Commission WQM presentation 7:00-8:00pm (10 p.)

Approximately 20 programs with summer camps last year to teach about the program and collect data with campers.

Assessing Household Risk and Knowledge in Mitigating Nonpoint Source Pollution in Coastal Watersheds

Basic Information

Title:	Assessing Household Risk and Knowledge in Mitigating Nonpoint Source Pollution in Coastal Watersheds
Project Number:	2005NH36B
Start Date:	3/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	1
Research Category:	Social Sciences
Focus Category:	Water Quality, Models, Non Point Pollution
Descriptors:	None
Principal Investigators:	Robert Alex Robertson, Kristen B. Ward

Publication

"Assessing Homeowner Risk and Knowledge in Mitigating Nonpoint Source Pollution in Coastal Watersheds"

Mary Adamo Robertson and Robert A. Robertson, Ph.D.

Introduction

In recent years, the population within New England and other coastal areas in the United States has grown and is expected to continue in the future. Much of this growth occurred in rural and suburban areas north of Providence, RI and into southern New Hampshire and Maine (Robinson et al., 2004, pp4-5). The trend of increasing urbanization has lead to diminished surface and ground water quality in watersheds throughout the northeast and in other parts of the country. Subtle evidence of diminishing coastal water quality is observed through periodic episodes of eutrophication events such as "red tides" and other water quality warnings. For many individuals, the impacts of these episodes are limited and may only be experienced as a temporary nuisance, for example a beach closure or other marine-based restrictions, even though these events are symptomatic of larger ecological problems. We hypothesize that many individuals do not make the connection between household activities, such as consumptive water use, the application of fertilizers and pesticides on landscaped areas, other household activities and regional water quality. Moreover, in order to develop and administer public policies to mitigate the impacts of nonpoint source water pollution from household activities, it is essential to gain an understanding of residents' level of knowledge, attitudes and preferences with respect to consumptive water use, household activities and water quality.

Although residential water use, septic and wastewater treatment systems are considered to be a significant source of nonpoint source pollution, there is little in the literature that explores the linkages between household water use and water quality. Of interest, is the related literature on residential water demand which explores the relationship between residential water demand as a function of price and other socioeconomic variables. Much of this literature focuses on estimating the responsiveness of residential demand to a small change in price[1]; however, the literature reveals a wide range of estimates and thus there is no consensus as to which estimate is best. This is in part due to the fact that the estimated responsiveness of water demand to price is largely determined by the researcher's assumptions, model choice and data limitations. The general findings from this literature indicate that: water price is the primary instrument to control demand; the responsiveness of demand to a change in price is higher at lower household income levels because at lower income levels, the cost of water makes up a larger proportion of the overall household budget; and other variables such as housing characteristics, number of household members and education are significant in determining water demand (Arbues et al., 2003).

Rural households that supply their own water via a private well do not pay a regular utility bill which implies that they face a zero per-unit cost of water[2]. As such, water pricing policies are not applicable to motivate a change in behavior to increase water conservation and mitigate regional nonpoint source water pollution. Instead, homeowners may incur a lump sum investment cost to replace or upgrade their existing

[1] Generally referred to in the economics literature as the price elasticity of demand.

[2] Excluding the cost of electricity needed to pump the water from the ground.

well and/or septic system at some uncertain date. Because the cost to upgrade or replace these systems can be prohibitively expensive, homeowners have an incentive to take the appropriate measures to avert these costs by prolonging the life of their systems through preventative measures. In addition, septic systems which are properly maintained and in good working order are less likely to generate negative unintended impacts such as excessive nutrient contributions to local surface and ground water systems. Absent in the literature is research that examines the relationship between water use and environmental quality at the household level. It is important to explore these two topics jointly since household's water use and activities directly influence regional water quality even though each household's contribution may be small relative to the overall water quality problem; it is the resulting cumulative impact that warrants further attention at the household level.

Objectives

The objectives of this research are fourfold. First, we will develop and conduct a mail survey of household residents to assess their level of information with respect to their household water use and perceptions of regional water quality, identify their household practices and activities surrounding household water use and land management, collect demographic and economic data that will be used to characterize the households and identify their preferences and attitudes about potential water and environmental conservation initiatives. Second, using household survey data and ground water quality data obtained from University of New Hampshire Department of Natural Resources and the Water Resources Research Center, estimate a spatially distributed statistical model of ground water quality as a function of household, socioeconomic and environmental characteristics. Third, explore attitudes and preferences of household residents with respect to risk, defensive behavior and water quality. In particular, we are interested in examining whether the preferences for water quality and level of defensive behavior exhibited by households differ among those with private water systems (i.e. well and septic) versus those who receive public water and wastewater treatment services. Fourth, prepare a final report that analyzes and details the findings of the household survey and statistical analysis assessing homeowner risk and knowledge in mitigating nonpoint source pollution in coastal watersheds. Although not specifically mentioned in this proposal, we hope that the results of this research may be used in the future as part of a mathematical programming model to examine the impacts of changes in household behavior on water quality using mathematical programming simulations.

Preliminary Results and Progress to Date

Due to last minute personnel changes, the project has not been completed as of this report deadline. However, significant progress has been made to meet the objectives of the project. A list of 3000 residents within the 9 towns of the Lamprey River Watershed has been compiled, including a database of riparian abutters including, names, addresses and acreage. Following a review of the watershed study literature and interviews with local planners a mail survey was produced using a web based survey design. The survey has been pre-tested for clarity, content and respondent burden and is currently being reviewed by the UNH Office of Sponsored Research. The mail survey will be distributed August 1, 2006 to 3,000 residents in the nine watershed communities.

The Lamprey River Watershed Study: **A watershed is an area of land where all water from the area drains into a stream, river, lake or other water body.** The Lamprey River Watershed is only one of several watersheds that drain into the Great Bay. As water travels across lawns, farm fields, roads, and parking lots, it picks up pollutants, referred to as non-point source pollution. The way we use our land has a dramatic impact on the quality of our water in the watershed.

Confidentiality! Responses to the questions will not be associated with names or addresses. You have been chosen for this survey because the Lamprey River, or one of its tributaries, is in your town.

Thank you for participating in the survey. Its purpose is to help land use planners and water resource managers design programs and policies that reflect what residents are thinking about in their communities. The main focus is on issues related to water quality.

What is your main source of water at home, and do you filter or soften your water? Check all that apply:

_____A private well on my property
_____A shared well with two or more households/buildings in a subdivision
_____A public (town/city) water system
_____Purchase bottled water
_____Home water filtering system
_____Home water softening system

How is waste water disposed of at your home? Check all that apply:

_____A septic system, which is _____ years old, and cleaned every _____months.
_____A shared sewer system with two or more households/buildings in a subdivision
_____The public (town/city) sewer system

In general, have you thought about water pollution as a problem in these following locations?

Location:	**Yes, it is a problem in...**	**No, it is not a problem in...**	**I don't know if it is a problem in…**
The United States			
New England			
New Hampshire			
Your county			
The Great Bay			

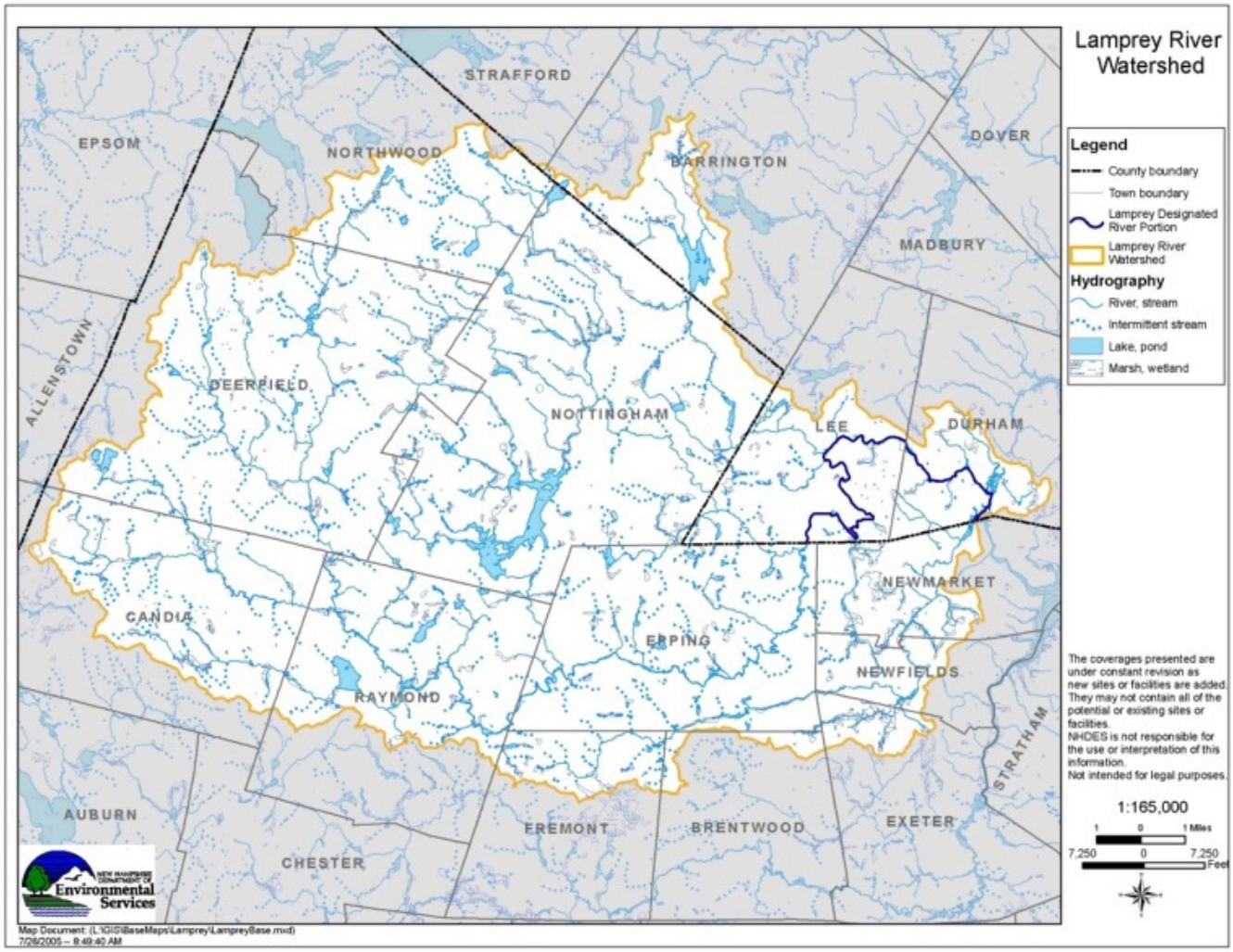
Your community			
Your household			

Lamprey River and Tributaries	**Not familiar**	**Familiar**	**Very familiar**
Lamprey River			
Little River			
North Branch River			
Bean River			
Picassic River			

Your drinking water			

How familiar are you with the location of the Lamprey River and its main tributaries?

Here is a map of the Lamprey River Watershed area. Please circle areas on the map where you feel like you know the area very well:


Lamprey River Watershed
STRAFFORD
EPSOM
NORTHWOOD
BARRINGTON
DOVER
MADBURY
ALLENSTOWN
DEERFIELD
NOTTINGHAM
LEE
DURHAM
NEWMARKET
CANDIA
EPPING
NEWFIELDS
RAYMOND
STRATHAM
AUBURN
FREMONT
BRENTWOOD
EXETER
CHESTER
Legend
County boundary
Town boundary
Lamprey Designated River Portion
Lamprey River Watershed
Hydrography
River, stream
Intermittent stream
Lake, pond
Marsh, wetland
The coverages presented are under constant revision as new sites or facilities are added. They may not contain all of the potential or existing sites or facilities.
NHDES is not responsible for the use or interpretation of this information.
Not intended for legal purposes.
1:165,000
1 0 1 Miles
7,250 0 7,250 Feet
Environmental Services
Map Document: (L:\GIS\BaseMaps\Lamprey\LampreyBase.mxd)
7/26/2005 -- 8:49:40 AM

These are problems that can exist in a community.

Community Problem	No, this is not a problem here	I Don't Know How I Feel About This	I am Somewhat Concerned	I am Concerned	I am Extremely Concerned
School at capacity					
High property taxes					
Loss of open lands to construction					
Lack of local jobs					
Availability of affordable housing					
Population growth					
Rising energy costs					
Lack of recreation opportunities					
Land pollution					
Traffic congestion					
Lack of sense of community					
Air pollution					
Lack of safe walking or biking paths					
Access to water for recreation					
Water pollution					
Garbage/refuse management					
Poor condition of roadways					
Town running out of water					
How the town/city looks					
Privacy at your home					
How your neighborhood looks					
Lack of public transportation					
Lack of businesses in town					
Lack of skilled community leaders					
Lack of long-range planning					
Lack of quality education					
Crime and vandalism in town					
Long commutes to work or shopping					

Is this a problem in your community? If so, how concerned are you?

Two major contributors to non-point source pollution are stormwater and septic system failure. **Stormwater** runs over land and paved areas (such as roads) and picks up pollutants (fertilizers, road salt, sand, automobile fluids, bacteria, and metals – to name a few!) Many storm drains discharge directly to surface waters without going to a waste water treatment facility. **Septic system failures** can also lead to pollutants seeping into waterways. These systems may go for years without notice that there is a problem. Improving these systems will cost money.

Who do you think should have the most, and who should have the least responsibility in paying for improvements to storm water management and septic systems in your town? <u>Please rank</u> the following from 1 to 5 to show who you think should have the <u>most cost responsibility (#1)</u> to who should have the least cost responsibility (#5), and those in-between (#2, #3, and #4).

	Rank (1-5) the Cost Share for Stormwater management	**Rank (1-5) the Cost Share for Septic system management**
Property owner	_____	_____
Town/City	_____	_____
County/Region	_____	_____
State	_____	_____
Federal	_____	_____

What would you be willing to do to improve water quality in your community? Check all that apply:

____Pay higher taxes
____Volunteer on a local board to help make these decisions
____Support local government to purchase land for conservation
____Support rules about regular septic system management
____Support controls for building permits in town
____Support infill development for density in some areas in order to preserve other areas
____Attend meetings with neighbors
____Host meetings with neighbors
____Attend planning board meetings
____Volunteer to do water quality sampling
____Support expenditures for the preparation of long-range planning
____Support expenditures to implement projects to protect water quality
____Join a local water conservation group
____Support controls on water usage
____Use rain water for watering lawns and plants
____Eliminate the use of fertilizers and pesticides

Various household and recreation activities are listed in these two tables. Please indicate how often you participate in these activities:

Household Activities	Never	Seldom	Often	Does Not Apply
Use salt on driveway or walks in the winter				
Apply lawn chemicals/fertilizer				
Apply garden pesticides				
Water your lawn				
Water your garden/flower beds				
Change car oil at home				
Use low phosphate detergents				
Wash your car at home				
Put dog poop in garbage bags or toilet				
Catch rain water to use around the house				
Use low-flow shower head				
Use low-flow toilets				
Check the septic system				
Remove trees and shrubs near the septic system				
Pump out septic tank				
Participated in household hazardous waste day				
Send in water samples for testing				
Compost kitchen scraps				
Recycle cans, glass, or paper				
Use environmentally- friendly household cleaning products				

Natural Resource Recreation Activities	Never	Seldom	Often	Does Not Apply
Sail, canoe, or kayak in New Hampshire				
Boat on the Lamprey River or its tributaries (North River, Little River, Bean River, Picassic River)				
Watch wildlife (bird or nature watch)				
Go shell fishing in New Hampshire				
Fish in local water bodies				
Take walks or bike rides in town				
Enjoy the outdoors				
Hike in the woods or mountains in the state				
Swim in a lake or river				
Swim in the Lamprey River or its tributaries				
Use a motor boat in New Hampshire				

How much do you think the following potential sources of pollution contribute to a water pollution problem in your watershed?

Possible Pollution Source	Does **Not** Contribute	Contributes **Slightly**	Contributes **Medium**	Contributes **Strongly**
Roads				
Litter				
Home lawns and gardens				
Dog poop				
Home septic systems				
Agriculture runoff				
Gas stations				
Illegal dumping				
Air conditioning				
Automobiles and trucks				
Construction activities				
Industry				
Burning fuel for heat				
Businesses				
Waste water treatment facilities				
Livestock waste				
Landfills/garbage				
Florescent light bulbs				
Prescription drugs				
Cigarette butts				

Are there certain pollutants that you are concerned about?

_____NO _____YES

List pollutants here and explain why you are concerned?

_____

_____

_____

Community Attachment

What gives you a sense of belonging to your community? Check all that apply?

_____Friends
_____People in the neighborhood
_____Living here
_____Place of worship
_____Owning property in the town
_____People at work
_____The schools
_____Activities in the town
_____Family
_____People that work for the town
_____The community volunteers
_____The landscape
_____Opportunities to get involved
_____Other:_____

If local officials asked everyone to conserve water or electricity because of some emergency, how likely is it that people in your community would cooperate?

Not Very Likely to Cooperate	Likely to Cooperate	Very Likely to Cooperate	Don't Know
_____	_____	_____	_____

Overall, how would you rate your community as a place to live?

Excellent _____ Good _____ Only Fair _____ Poor _____

Do you expect to be living in this town in 5 years?

Yes_____ No_____ Don't Know_____

Where would you prefer to be living? _____and why?

_____

Keeping in mind that a lawn can be work (mowing, etc.), and you pay higher property taxes with more land, which of the following would you prefer:

½ acre lot_____ 1 acre lot_____ 2 acre lot_____ Larger than 2 acre lot_____

Which of the following would you <u>prefer</u> to have in your town? Check all that apply:

_____Farmland _____Sidewalks _____Affordable housing _____Parks
_____Downtown businesses _____Public transportation _____My workplace

Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people?

_____People can be trusted
_____You can't be too careful
_____Depends
_____Don't know

Generally speaking, how much do you trust different groups of people?

Groups of People	Trust them a lot	Trust them some	Trust them only a little	Don't trust them at all	Does not apply	Don't know
People in your neighborhood						
People in your community						
People at work						
Local news media						
School administrators						
Government employees						
Local government officials						
Places of worship						
U. S. Government officials						
Corporate America						
State Government officials						

Overall, how much impact do you think people like you can have in making your community a better place to live?

____No impact at all. ___ A small impact. ___A moderate impact. ___A big impact

How many days in the past week did you <u>read a newspaper</u>? ____days per week.

How many hours a day do you spend <u>watching</u> television on an average weekday, that is Monday through Friday? _____hours per day.

How many hours do you spend using the <u>Internet or email in a typical week</u>, not counting the times you do so for work? _____hours per week.

How interested are you in politics and national affairs?

Very interested	Somewhat interested	Only slightly interested	Not at all interested	Don't know
_____	_____	_____	_____	_____

Are you currently registered to vote? _____Yes _____ No _____Don't Know

As you may know, around half the public does not vote in presidential elections. How about you – did you vote in the last presidential election, 2004, between George W. Bush and John Kerry?

_____I did vote _____No, I skipped that one _____I don't vote _____I don't know

How much of the time do you think you can trust the government to do what is right?

	Just about always	Most of the time	Only some of the time	Hardly ever	Don't know
Local government					
County/regional government					
State government					
National government					

Which of the following things have you done in the past twelve months?
Check all that apply:

Signed a petition
Attended a political meeting or rally
Worked on a community project
Participated in any demonstrations, protects, boycotts, or marches
Donated blood
Volunteered for a non-profit organization

Please check the activities that you participate in every week:

Attend religious services
Sports club or league
Outdoor activity club
A youth organization
A parents' association
A veteran's group
A neighborhood association
Clubs or organizations for senior citizens
A charity or service group
A labor union
A professional, trade, farm or business association
Ethnic or nationality group
Civil rights or peace group
Political group
A literary or art group
A hobby group
A self-help or support group
An group that meets through the Internet

Did any of the groups that you are involved with take any local action for social or political reform in the past 12 months? _____Yes _____ No _____Don't know

In the past twelve months, have you served as an officer or served on a committee of any local club or organization? _____Yes _____ No _____Don't know

Overall, how much impact do you think people like you can have in improving water quality?

____No impact at all. ___ A small impact. ___A moderate impact. ___A big impact

Communication and Social Events

Think about your neighborhood, or the 10 to 20 houses that are closest to you. About how often do you talk to or visit with these neighbors?

_____Just about everyday _____Several time a week
_____Several times a month _____Once a month
_____Several times a year _____Once a year or less
_____Never _____Don't know

In the past two years, have you worked with others to get people in your immediate neighborhood to work together to fix or improve something?

_____Yes _____No _____Don't know

Close friends are people that you feel at ease with, can talk to about private matters, or call on for help. How many close friends would you say you have?

_____No close friends _____One or two
_____Three to five _____Six to ten
_____More than 10 _____Don't know

Communication and Social Events:	Never	Once	Between 2 and 10 times	Once a month	Twice a month	Once a week	More than once a week	Don't know
Attend a celebration, parade, or local sports or art even in your community								
Taken part in artistic activities with others such as singing, dance, or acting with a group								
Played cards or board games with others								
Visited with relatives								
Attended a club meeting								
Had friends over to your home								
Socialized with coworkers outside of work								
Hung out with friends at a park, shopping mall, or								

public place

Recreated with friends or family in the outdoors	
Participated in on-line discussion over the Internet	
Attended a meeting about town or school issues	
Volunteered for a community function	

How many times in the past 12 months did you do the following?

Obstacles to Participation

Many obstacles keep people from becoming involved with their community. Thinking about your own life, are there obstacles or barriers that make it difficult for you to be as involved with your community as you would like, or not?

Obstacle?	**Very important obstacle**	**Somewhat important obstacle**	**Not an important obstacle**	**Don't know**
An inflexible or demanding work schedule				
Lack of childcare				
Lack of transportation				
Feeling unwelcome				
Concerns for your safety				
Lack of information				
Feeling that you can't make a difference				
Not knowing how to get involved				
Afraid that it will be more work				
Potential conflicts with people				
Feeling it would be a waste of time				

How likely is it that you will be involved in some community related activity in the next year?

____Very Likely ____Likely ____ Not Very Likely ____ Don't Know

A number of potential sources of information are listed below. Please indicate how much information on water-related or land use issues you have gotten from these sources:

Sources of Information:	I use this frequently.	I use this sometimes.	I don't use this at all.	This is not available to me.
Newspapers or magazines				
Attending meetings				
Government publications				
Neighbors				
Public officials				
Annual town meeting				
The community master plan				
Local public hearings				
UNH Cooperative Extension				
Through my work				
Environmental groups				
Retail stores				
Community newsletter				
Radio				
Television				
Internet sites				
Other:				

How would you prefer to get information on town related issues?

_____

About Your Health: This gives us some ideas about the overall health of the community.

How would you describe your overall state of health these days?
_____Excellent _____Very good _____Good _____Fair _____Poor

Do you go to the doctor for regular check-ups? _____Yes _____No

How often do you wear a seatbelt?
_____ All of the time _____ Most of the time _____ Some of the time
_____Never _____Does not apply

Do you participate in the following activities? Please check if you never do this, if you do this daily, OR put in the number of days in the week that you do participate in this activity:

I exercise at least 30 minutes… _____Never ____Daily OR _____Times a week

I eat out at a restaurant… _____Never ____Daily OR _____Times a week

I buy/eat organic food… _____Never ____Daily OR _____Times a week

I buy/eat fresh fruit and vegetables _____Never ____Daily OR _____Times a week

I drink bottled water… _____Never ____Daily OR _____Times a week

I drink tap water… _____Never ____Daily OR _____Times a week

I smoke cigarettes… _____Never ____Daily OR _____Times a week

I sleep very well… _____Never ____Daily OR _____Times a week

I drink alcohol beverages… _____Never ____Daily OR _____Times a week

I have dinner around a table
with family and friends... _____Never _____Daily OR_____Times a week

Please list as many as five things that you believe threaten your, or your family's, health:

1.

2.

3.

4.

5.

Please tell us a little more about you: This will help us better understand what the different groups of people within the community think about these issues.

Are you? Male _____ Female _____
What year were you born? _____

Do you rent, or own this place? Rent_____ Own_____
If you own: How much do you pay in property taxes annually $_____
If you own: What is the approximate property value $_____

How many years have you lived in this town? _____

Do you consider yourself politically as a _____Liberal _____Moderate-Liberal _____Moderate ___Moderate-Conservative _____Conservative?

Please check the box that comes closest to your total family income before taxes:
_____ Less than $20,000 _____ $20,000 - $40,000 _____$41,000 - $60,000
_____$61,000 to $80,000 _____$81,000 to $100,000
_____ between 101,000 and 300,000 _____ over $301,000

What is your highest level of education?
_____ High school _____Some college
_____Completed 2 year college _____Completed 4 year college
_____ Masters _____Ph.D. _____J.D. _____M.D.
_____Other:_____

What is your current employment status? _____Employed _____Unemployed
_____Retired _____Other:_____

How many hours a week do you work for pay?
_____ per week _____Does not apply

If you work outside the home: Do you ever telecommute - that is spend a whole day or more per week working at home instead of going to your main place of work?
_____No _____Yes _____ Does not apply

If YES: In a typical 5 day work week, how many days do you normally work at home?
____Less than once a week ____1 day ____2 days _____3 days _____4 days
____5 days

How many **miles** do you travel to work and home again each day? _____ a day.
How much **time** does this work commute take you? _____ a day.

Have you recreated on or near open water in your community or a neighboring town in the past year? _____Yes _____No

How many people live in this household? _____
How many are children under 18 years old? _____

Do you have access to the Internet in your home? _____Yes _____No

How many different telephone numbers does your household have, not counting those dedicated to a fax machine or computer? _____

Have you or any member of your family seen any of the following materials regarding the Lamprey River Watershed? Please check the appropriate box.	NO, I have not seen this.	I saw something similar to this.	YES, I have seen this.
A book, *The Story of Little Bear* by David Allan and Leslie Hamilton.			
Lamprey River Curriculum. Standard environmental curriculum for elementary schools with extensions to high school.			
A Video - *A River Story: The Lamprey Through History*, with an emphasis on the human history of the river. 20 minutes long.			
"The Lamprey River, A Special Place." A pamphlet that includes a map, river conservation information and policies, and introduces the Lamprey River Advisory Committee.			
"Living on the Lamprey." A pamphlet prepared especially for landowners along the river with information about the Lamprey's history, vegetation, and what landowners can do to conserve and protect the river.			
A presentation about the Lamprey River Watershed.			
The Lamprey river Wild and Scenic Management Plan			
The Lamprey River Watershed Guide			

The Importance of Streamside Buffers

Riverwatch: A Handbook for Water Quality Monitoring

The Lamprey River Resource Assessment

One last question!
There have been discussions in many towns about changing land use regulations to require buildings to be built closer together in order to reduce costs of materials for roads and utilities and to also preserve larger tracts of land for open space. **Do you see any other advantages to this type of development idea? Are you aware of any disadvantages to this type of development? Please write your comments here:**

Congratulations and thank you for completing the survey. For a summary report, please contact Mary Robertson at mary.robertson@unh.edu, or 312 James Hall, Durham, NH 03824. You will be contacted when the report has been completed.
Enjoy the rest of your summer!

The Role of Vegetated Buffers in Maintaining Salt Marsh Species Diversity

Basic Information

Title:	The Role of Vegetated Buffers in Maintaining Salt Marsh Species Diversity
Project Number:	2005NH39B
Start Date:	3/1/2005
End Date:	2/28/2006
Funding Source:	104B
Congressional District:	1
Research Category:	Water Quality
Focus Category:	Wetlands, Ecology, Nutrients
Descriptors:	None
Principal Investigators:	David Burdick, Joanne Glode

Publication

Water Resources Research Center Annual Progress Report
June, 2006

Project Title: Effects of vegetated buffers on the salt marsh plant community

Grant: 15024-2001 Water Resources Research, #115052
Recipient: Dr. David Burdick
MS Advisory Committee: Dr. David Burdick, Dept Natural Resources, UNH (Advisor)
Dr. Tom Lee, Dept Natural Resources, UNH
Dr. William McDowell, Dept Natural Resources, UNH
Douglas Bechtel, The Nature Conservancy

Problem statement

Replacement of natural vegetation with agriculture and residential land use within the watershed of an estuary is known to impact the integrity of the estuarine ecosystem. Vegetated buffer strips are recommended to reduce the impacts of these land uses on the estuary. However, specific responses within the salt marsh plant community to varying widths and types of vegetated buffers are unknown.

Knowledge of the effect of buffer width and type on the adjacent salt marsh plant community will inform best management practices for shoreline property owners and land managers, will help town planners with ecologically sound review of coastal development plans, and will help justify and strengthen guidelines for shoreline protection.

This project is designed as three independent investigations into the possible effects of natural buffers on 1) the salt marsh plant community; 2) the shallow groundwater chemistry, and; 3) the leaf tissue chemistry of a species of high salt marsh plant.

Methods

Plant community analysis

The buffer of natural vegetation between salt marshes around the Great Bay and residential and agricultural land uses was digitized from aerial photography using a geographic information system (GIS). Sites were identified with varying buffer width appropriate for further ground-based study. Appropriate sites were determined to be any contiguous marsh shoreline with at least 75m of edge in each of the following three buffer width categories: 0m; 1-20m; 21-100m. Plant communities of five sites were inventoried in the summer of 2005. At each site, a 50m transect was set up along the marsh/upland ecotone running parallel to the upland edge. A 1x1m quadrat was placed at every 10m interval along the transect. A percent cover was assigned for all plant species occurring within the quadrat, and soil pore water salinity measured.

Groundwater nitrogen analysis

Groundwater wells were installed at two farms on the shores of Great Bay. Sets of groundwater wells were placed at the upper and lower edges of 2-3 different buffer widths at each farm. Groundwater was collected from the wells monthly provided the water table was high enough. Upon arrival at each site, each well was bailed dry and allowed to recharge. From each well 60mL of filtered water was collected and frozen until future analysis by the Water Resource Research Laboratory at the University of New Hampshire for ammonium, nitrate, and total dissolved nitrogen.

Leaf tissue nitrogen analysis

Two sets of fertilized and control plots were set up on the salt marsh edge at each farm, one set where no buffer was present, and one set adjacent to a vegetated buffer. Plots were fertilized every two weeks with 60g/m2, 29-3-4 N:P:K, Scott's Turf Builder fertilizer between May and July, for a total of 6 applications. Two weeks following the final fertilizer application, the youngest fully expanded leaf of one stiff-leaved quack grass (*Agropyron pungens*) was collected from each fertilized and control plot and analyzed for N content.

Preliminary Results

Plant Community Analysis

Vegetation data was collected from the following five sites. An additional four sites will be surveyed in the summer of 2006. Data analysis for the plant community assessment will begin by December 2006.

Site	# transects	Date collected
White Marsh	*3*	*Sept 2005*
Bellamy	*3*	*Aug 2005*
Mill River	*3*	*Aug 2005*
Lubberland	*3*	*Aug 2005*
Wiggin Farm	*3*	*Sept 2005*
Stuart Farm N	*3*	
Stuart Farm S	*3*	
Pickering	*3*	
Chapmans Landing	*3*	

Groundwater Chemistry Effects

Groundwater wells were set up at both farms in May of 2005. Three buffer widths were selected at Wiggin Farm. Wells were set up in sets of three at the upper and lower edges of each buffer width, for a total of 18 wells at Wiggin Farm. Two buffer widths were selected at Stuart Farm, including one area where no buffer exists. A total of 9 wells were set up at Stuart Farm. An effort was made to collect groundwater from every well each month. However little rainfall in the late summer through fall of 2005 meant that

the water table dropped significantly, and often the wells were dry. Monthly well water collection began again in March of 2006 and is anticipated to continue until September of 2006.

Month / Year	*Site*	*# wells collected*	*Site*	*# wells collected*
June / 2005	*Wiggin*	*17*	*Stuart Farm*	*9*
July / 2005	*Wiggin*	*14*	*Stuart Farm*	*8*
August / 2005	*Wiggin*	*11*	*Stuart Farm*	*7*
November / 2005	*Wiggin*	*18*	*Stuart Farm*	*9*
March / 2006	*Wiggin*	*7*	*Stuart Farm*	*6*
April / 2006	*Wiggin*	*13*	*Stuart Farm*	*9*
May / 2006	*Wiggin*	*17*	*Stuart Farm*	*9*

Preliminary results suggest that there is a buffer effect on the concentration of groundwater nitrogen. Although only total dissolved nitrogen ($F = 4.95$; $p = 0.029$) and dissolved organic carbon ($F=6.36$; $p = 0.013$) concentrations were found to be significantly different between the upper and lower wells, all concentrations of the different nitrogen species were higher in the upper wells and lower in the lower wells, and data for NO3 ($F=3.79$; $p = 0.055$) and NH4($F = 3.59$; $p = 0.061$) were nearing significance. I anticipate an additional year of data collection will more solidly demonstrate a buffer effect on groundwater chemistry.

Leaf Tissue Effects

A split-plot ANOVA of the first year of data suggests there is no difference between the percent of nitrogen in leaf tissue from fertilized and control plots regardless of the presence or absence of a natural buffer ($F = 0.029$, $p=0.86$). It is unknown how fast the plants within the fertilized plots will respond to the fertilizer applications. Therefore, a second year of plot fertilization and data collection is more likely to detect any changes in the plant tissue chemistry.

Publications, presentations, and awards

- N/A

Number of students supported

- One Masters student (no stipend, but materials and analyses)
- One undergraduate student, partial support

-- END --

Information Transfer Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	2	0	0	0	2
Masters	4	0	0	0	4
Ph.D.	0	0	0	0	0
Post-Doc.	0	0	0	0	0
Total	6	0	0	0	6

Notable Awards and Achievements

One of the volunteer groups we work with as part of our 104B funded "Water Quality and the Landscape: Long-term monitoring of rapidly developing suburban watersheds" project received a prestigious from the Environmental Protection Agency. The Green Mountain Conservation Group received the EPA's Environmental Merit Award. Given out by EPA since 1970, the merit awards honor individuals and groups who have shown particular ingenuity and commitment in their efforts to preserve the region's environment. This year's competition drew approximately 50 nominations from across New England. These awards are among the highest honors EPA can bestow to recognize environmental accomplishments.

Publications from Prior Projects

1. 2001NH501B ("Effect of Surface Coatings and Ionic Strength on Bacterial Removal Rates in Porous Media.") - Dissertations - Strauss, Jessica, 2004, DETACHMENT OF ESCHERICIA COLI FROM SATURATED POROUS MEDIA IN LABORATORY COLUMNS. MS Dissertation, Department of Natural Resources, College of Life Science and Agriculture, University of New Hamphsire, Durham, NH, 108 pages.
2. 2001NH541B ("Developing Phosphorus Management Guidelines for Agriculture in the Connecticut River Watershed") - Articles in Refereed Scientific Journals - Buob, Thomas E. and Elizabeth A. Rochette, 2003, Status of Phosphorus in Soils of the Connecticut River Watershed in New Hampshire, Communications in Soil Science and Plant Analysis, 34: 1177 - 1192.
3. 2003NH21B ("Water Quality and the Landscape: Long-term monitoring of rapidly developing suburban watersheds") - Dissertations - O'Donnell, Tracey E, 2004, Suburbanization, water quality and property values in three northern forest watersheds, MS Dissertation, Department of Natural Resources, College of Life Sciences and Agriculture, University of New Hampshire, Durham, NH, 120 pages.
4. 2003NH21B ("Water Quality and the Landscape: Long-term monitoring of rapidly developing suburban watersheds") - Articles in Refereed Scientific Journals - Pellerin BA, WM Wollheim, CS Hopkinson, WH McDowell, MR Williams, CJ Vorosmarty, ML Daley, 2004, Role of wetlands and

developed land use on dissolved organic nitrogen concentrations and DON/TDN in northeastern US rivers and streams, LIMNOLOGY AND OCEANOGRAPHY 49 (4): 910-918.

5. 2001NH501B ("Effect of Surface Coatings and Ionic Strength on Bacterial Removal Rates in Porous Media") - Articles in Refereed Scientific Journals - Bolster CH, JM Bromley, SH Jones, 2005, Recovery of chlorine-exposed Escherichia coli in estuarine microcosms, ENVIRONMENTAL SCIENCE & TECHNOLOGY 39 (9): 3083-3089.
6. 2001NH761B ("Water Quality and the Landscape: Long-term monitoring of rapidly developing suburban watersheds") - Dissertations - Daley, Michelle, 2002, Export of Dissolved Organic Carbon, Dissolved Organic Nitrogen and Nitrate from the Lamprey River Watershed, New Hampshire: Examining Relationships with Watershed Characteristics, MS Dissertation, Department of Natural Resources, College of Life Science and Agriculture, University of New Hampshire, Durham, NH.