Ossipee Watershed Water Quality Report 2002-2008

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UNIVERSITY of NEW HAMPSHIRE
COOPERATIVE EXTENSION

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Executive Summary

Clean water is essential for New Hampshire communities. As demand for this resource increases, it is quickly becoming a more valuable resource requiring long-term study and protection on a watershed-wide, even global scale. There are many causes for concern including: an explosion in demand for water resources; a scarcity of new water sources; an increase in contamination threats; and a conflict between wellhead protection areas and development. The majority of residents and businesses in the fourteen-town Ossipee Watershed derive their drinking water from the Ossipee Aquifer, the largest stratified drift aquifer in New Hampshire. In addition, the Watershed's lakes, rivers and streams have many important ecological, economic and social values that contribute to the quality of life in this region. A 2007 report by the NH Lakes Association found that a perceived reduction in surface water clarity and purity could lead to lost sales of $25 million, lost income of $8.8 million, and 131 jobs lost in the Lakes Region alone. Milfoil infestation, which is now being experienced in the Ossipee Lake system, is just one example of how decreases in water quality can affect our communities.

This report provides surface-water quality information, analysis and recommendations for towns occupying most of the Ossipee Watershed, including Effingham, Freedom, Madison, Ossipee, Sandwich and Tamworth. Results are based on data collected from 2002 through 2008 by Green Mountain Conservation Group's Water Quality Monitoring Program, as well as the New Hampshire's Volunteer Lakes Assessment Program (since 1990 for some sites and 2002 for others). Twenty-four biological, chemical and physical parameters are now measured at up to 35 testing sites distributed among lakes and rivers around the watershed. Table 1 will help direct attention to the specific study site locations, described in detail in the report, within each town.

Table 1: Water Quality Study Sites within the Ossipee Watershed

Town	River Sites	Ossipee Lake Sites
Effingham	Pine River, Ossipee River, Red Brook, Phillips Brook, South River (Parsonsfield)	
Freedom	Danforth Bay Inlet and Outlet, Cold Brook (2 sites), West Branch River, Leavitt Brook, Square Brook	Broad Bay, Berry Bay, Lower Danforth Bay
Madison	Banfield Brook, Pequawket Brook, Forrest Brook (2 sites)	
Ossipee	Beech River (2 sites), Frenchman's Brook (2 sites), Bearcamp River (3 sites), Lovell River, Weetamoe Brook, Pine River, Red Brook	Ossipee Lake, Leavitt Bay
Sandwich	Cold river	
Tamworth	Bearcamp River, Chocorua River, Swift River	

Results from the past 7 years show the watershed's surface water quality is high.

- Levels of organic nutrients (phosphorus, nitrate & ammonium) are generally low.
- Levels of dissolved oxygen, conductivity, and turbidity are within a healthy range to support aquatic life.
- Monitoring of Ossipee Lake, Berry Bay, Broad Bay, Leavitt Bay and Danforth Pond (by New Hampshire's Voluntary Lake Assessment Program) showed concentrations of chlorophyll-a, transparency, total phosphorus, and conductivity that are low (good) to average for NH lakes.
- Macroinvertebrate community sampling showed that most of the 10 river sites sampled are in "good" to "excellent" condition.

However, some sites in the watershed have emerging problems that need attention.

- Square Brook, Ossipee Lake Road in Freedom; Phillips Brook, Route 25 in Effingham; Frenchman's Brook, Granite Road in Ossipee; and Banfield Brook, Route 113 in Madison all show elevated levels of sodium, chloride and conductivity, 3 to 4 times higher than the typical background levels for NH surface waters.
- Road salt application near these sites and throughout the watershed is the principal source. Road salt runoff enters streams via culverts and ditches and it may also infiltrate into groundwater supplies through roadside soils.
- Future monitoring in this watershed should incorporate groundwater to determine if, and to what extent, salt-related contamination is present beneath the surface.
- Future monitoring should also examine if road salt application or other contaminants are negatively impacting local biotic communities.
- Towns should consider adopting road salt alternatives as they are developed and make use of pervious surfaces and skid-resistant pavement alternatives when possible.

More than 1,000 streams, rivers and lakes in the greater Saco River Watershed (which includes the Ossipee Watershed) in New Hampshire and Maine are now listed as impaired. Most of these impairments arise not from a designated source or pipe but rather from nonpoint source pollution that enters surface and groundwater. Examples of nonpoint source pollutants are stormwater runoff and snowmelt that pick up pollutants such as silt, fertilizers, pesticides and animal waste, septic system effluent and road salt. Communities can address water quality issues like these by adopting NHDES, Lake Association and UNH recommended Best Management Practices (BMPs) and Low Impact Development (LID) techniques as parts of their local land-use planning and development regulations. In addition, and if they have not already done so, towns should incorporate into their local planning and regulatory structures the provisions and procedures of the State's wetlands, shoreland protection laws and aquifer protection ordinance guidelines. These laws and guidelines have been carefully crafted to permit activities along and adjacent to surface water features but in ways fully sensitive to, and protective of, nearby surface and groundwater resources.

The Green Mountain Conservation Group and its staff will be glad to assist with this cooperative approach in any ways that it can and offers a comprehensive list of recommendations at the end of this report, including those below, for municipal officials and property owners in the Ossipee Watershed:

- ***Continue Water Research.*** The most important step for future protection of the surface and groundwater sources is to continue with the monitoring program. We also recommend the inclusion of annual groundwater monitoring to understand drinking water issues. Only through regular, long-term data can we understand our ecosystems and recognize how and why they change. This is essential to help us make informed decisions about their future use and protection.

- ***Emphasize Coordinated Local Planning.*** Prevent pollution by good planning at the local level (watershed associations, local government), utilizing low impact development techniques and best management practices in the watershed, and develop and pass local watershed ordinances. Encourage town officials to promote sustainable development and to develop and adopt watershed district ordinances/aquifer overlay districts and Low Impact Development and Best Management Practices guidelines. Town officials are encouraged to coordinate planning and policy making with all the other towns that comprise the watershed.
- ***Minimize Nonpoint Source Pollution.*** Minimize nonpoint source inputs in the landscape by adopting erosion and sediment control ordinances, maintaining septic systems, limiting fertilizer and road salt usage and adopting Best Management Practices (BMPs)
- ***Identify and Monitor Potential Contamination Sources.*** Identify and evaluate specific potential sources of contamination to surface waters and the aquifer and ensure BMPs are being followed and spill containment and emergency procedures are in place.
- ***Protect Shorelines.*** Protect riparian corridors, shorelines, and wetlands from incompatible development that could degrade water quality. Stabilize stream banks, lake shorelines, disturbed soils, especially dirt roads located next to rivers, tributaries and the lake system. Incorporate CSPA standards into municipal ordinances so that enforcement can be done locally. Visit: http://www.des.state.nh.us/CSPA/ for more details on the Comprehensive Shoreland Protection Act and 2008 updates.
- ***Promote Best Management Practices.*** Promote the use of Best Management Practices (BMPs*)to prevent non point source pollution. Visit:
    - BMPs for Groundwater Protection: http://www.des.state.nh.us/factsheets/ws/ws-22-4.htm;
    - BMPs for Surface Water Protection: http://www.des.state.nh.us/wmb/was/manual/;
    - UNH Stormwater Research Center w/ LIDs & BMPs: http://www.unh.edu/erg/cstev/;
    - LRPC Aquifer Protection BMPs/Guide for Developers: http://www.lakesrpc.org/services_resources_aquifer.asp.

  *BMPs include limiting or using alternatives to road salt/road salting strategies, the use of vegetative buffers, covering salt/sand piles, preventing snow dumping directly in surface waters, and proper treatment of runoff.
- ***Promote Low Impact Development Techniques***. Encourage the use of Low Impact Development in the Watershed. LID can include such things as permeable pavement which reduces the need for salting in the winter and increases infiltration and groundwater recharge. Also support policies and ordinances that protect against inappropriate development on steep slopes and protect water resources.
- ***Educate the Public.*** Continue to educate watershed residents about the quality and value of the watershed's resources, the sources of pollutants in our watershed and the positive and negative ecological, recreational and economical impacts their utilization can have on our lakes, ponds, rivers & streams.

Section 1: Program Background

A. What is Water Quality? The essence of water quality is easy to illustrate when comparing a murky, green, warm lake and a cool, clear lake with abundant wildlife. The first lake has no fish, is not ideal for recreation, and property values around it are low. The second lake has ample fish and other wildlife, is more suitable for recreation, and property values around it are high. The difference between the two lakes is *water quality.* A widely agreed upon definition of water quality is more difficult to find since it is a complex topic, with differing definitions, criteria, and state and federal standards guiding what is acceptable from one place to the next. One definition that has been used is the following:

Water quality is the ability of a water body to support all appropriate beneficial uses.

Beneficial uses refer to the ways water is used by humans and wildlife, such as for drinking water and fish habitat. If water supports a beneficial use, water quality is said to be 'good' or 'unimpaired'. If water does not support a beneficial use, water quality is said to be 'poor' or 'impaired'. Good water quality implies that harmful substances (pollutants) are absent from the water, and needed substances (oxygen, nutrients) are present.

NH surface waters are classified according to their uses. "Class B Waters" are the second highest quality, considered acceptable for fishing, swimming and other recreational purposes and, after adequate treatment, for use as water supplies. The state then sets water quality criteria for different biological, chemical and physical attributes that this class of water must meet in order to support these uses. Surface water quality in the Ossipee Watershed is measured against standards set for Class B Waters, pursuant to RSA 485-A:8, I-III. Field testing and sampling are used to measure the biological, chemical and physical characteristics of water, gather information about trends and identify changes over time. Many pollutants are invisible, so measuring and monitoring as many parameters as possible helps to paint a more complete picture of water health. With regular testing, changes in water quality can be detected before the pond, lake or stream is seriously impacted. Water quality information also empowers communities to make informed planning and resource-protection decisions.

The GMCG's Water Quality Monitoring programs are designed to be long term studies to track water quality across the Ossipee Watershed. Only after many years of data collection will trends emerge. Data collected through these programs is used by the DES in the Environmental Monitoring Database and examined biennially as part of the Environmental Protection Agency's surface waters assessment, as mandated by the Clean Water Act. UNH also uses this water quality data for their research on New Hampshire watersheds. These organizations do not even begin statistical analysis until after ten consecutive years of data has been collected. Statistical analysis is an important, more objective way to determine if there has been a significant change in water quality. Currently, data are evaluated based on preliminary trends over the last seven years to speculate about overall increases or decreases in water quality. Sites are also compared to one another within the watershed, and assessed in light of acceptable surface water quality standards for the state or the state mean value for measured parameters. Minimally impaired reference sites serve as a standard by which data from other sites are compared to determine the level of impairment. Where no surface water quality standards exist, water quality in the Ossipee Watershed is compared with that of other watersheds in the state.

Water quality data provides an understanding of how land use and underlying geological controls affect the water in our lakes, rives and streams. Because we do not always have sufficient historical data or long term background information to review, it is difficult to determine if current land use practices are negatively affecting water quality. Compiling water quality data will allow us to determine the effectiveness or harmfulness of specific land use practices in maintaining good water quality. These determinations can further guide us in making informed decisions to protect the watershed's natural resources.

B. Program History: Clean water is essential for New Hampshire communities. As demand for this resource increases, it becomes even more valuable, requiring long-term study and protection on a watershed-wide, even global scale. In recent years, water has become one of the most important political issues in New Hampshire. There are many causes for concern including: a scarcity of new water sources; an increase in contamination sources, an over lap of wellhead protection areas (the land area from which water may feed a public water supply well) with development, and an explosion of demand for water resources. Since New Hampshire has not enacted a statewide protection program or legislation to proactively protect surface waters or groundwater, it is incumbent upon communities to protect their own water resources from potential contamination or misuse.

The Ossipee Watershed is home to the state's largest stratified drift aquifer, a critically important statewide resource for existing and future drinking water supplies. The majority of residents and businesses in this fourteen-town watershed derive their drinking water from the Ossipee Aquifer. Water flowing through this region is also a source of drinking water for Maine communities located downstream. The Watershed's lakes, rivers and streams have many important ecological, economic and social values that contribute to the quality of life in the region. With the population of Carroll County expected to increase by 50% by 2020, (Office of Energy and Planning, Forest Society), it is becoming even more imperative to plan ahead for the protection of these resources into the future. Green Mountain Conservation Group (GMCG)[1] is committed to assisting watershed communities as they plan for this growth.

In 2000, GMCG responded to growing concerns about Ossipee Lake by hosting a forum that featured a panel discussion by state experts and representatives of the New Hampshire Audubon Society and The Nature Conservancy. One of the conclusions drawn from the forum was that resolution of lake issues was being hampered by the lack of an organization representing the interests of a majority of the lake's stakeholders. To assist in that role, GMCG worked with the University of New Hampshire Cooperative Extension and the Society for the Protection of the New Hampshire Forests to produce a series of Natural Resource Inventory (NRI) maps of each town in the Ossipee Watershed. The NRI maps included information on hydrology, soils, town conservation land, unfragmented land, public water supplies, known and potential contamination sites as well as co-occurrences of important resources. Copies of these maps were provided to each town in the watershed and are displayed at the town halls for public use. The Water Quality Monitoring (WQM) program grew out of the NRI mapping project as a way to further study natural resources and as a way to work with the broader community to plan for growth while protecting the environment. Since water does not recognize political boundaries, GMCG began working collaboratively on the WQM program with Saco River Corridor Commission (SRCC), an organization located in Maine.

[1] The Green Mountain Conservation Group (GMCG) is a community-based, charitable organization dedicated to the protection of natural resources in the Ossipee Watershed towns of Effingham, Freedom, Madison, Ossipee, Sandwich and Tamworth. Founded in 1997, GMCG's mission is to coordinate and carry out environmental education, research, natural resource advocacy and voluntary land protection. The guiding principle is to present objective information in a neutral format with the belief that informed citizens will make good judgments about their area's natural resources.

The Saco River Corridor Commission began its WQM program in 2001 and monitors 27 sites in twenty towns along the Saco River. GMCG modeled its Water Quality Program after that of the SRCC. In 2002, the Green Mountain Conservation Group began testing surface waters in the Ossipee Watershed to collect baseline data and establish a volunteer-based, long-term monitoring program to track water quality as land uses change in the region. In 2004, GMCG and SRCC created a cross-border Quality Assurance Protection Plan (QAPP) which was approved by the Environmental Protection Agency to ensure that field sampling, lab analysis and volunteer training follow standard protocols for the data to be acceptable for surface water assessments.

The past seven years of water testing has improved the understanding of this area's surface water quality. Baseline data for many of the area's rivers, streams, and major lakes has also been established. At seven sites, testing has also been extended from the summer months to year-round sampling to provide a better understanding of year-round conditions. Volunteer support has increased from an initial fifteen residents to now over fifty individuals who regularly test local streams, rivers and lakes each year. In addition, hundreds of summer campers and school children have also participated in lake and river sampling with the assistance of locally hired interns. Other local students are hired each summer through the New Hampshire Lake Association's Lake Host program to monitor boats and provide education about aquatic invasive species of plants such as variable milfoil.

GMCG is thankful for the continued support that local towns, citizens and organizations have provided for this program. In the past five years, this support and collaboration has enabled GMCG to successfully:

- Collect water quality data for 19 river (7 sites year round), 11 tributary and 5 deep water locations
- Conduct a study of recreational use of the lake and monthly deep water testing for the lake system
- Discover a variable milfoil infestation in Phillips Brook
- Inspect 3,992 boats and provided milfoil education for 7 years on Lake Ossipee
- Produce annual reports and present test results to town officials for each watershed town
- Establish a biomonitoring program at 10 locations
- Acquire the necessary equipment to maintain testing for field-measured parameters for the life of the equipment
- Acquire equipment to conduct groundwater testing in the near future
- Bracket sites with apparent water quality impairments

Initiate a Source Water Protection Project for the Ossipee Watershed, including a survey and mapping of potential contamination sources (PCSs) for the Watershed and Best Management Practices surveys of these PCSs.

C. Study Area

1. The Saco River Basin

The Ossipee Watershed is part of the Saco River Basin (Figure 1), a 1,700m^2 area that includes 63 municipalities in New Hampshire and Maine. The Saco River originates in the White Mountains of New Hampshire at Saco Lake. It is joined in Cornish by the Ossipee River, ends at Saco Bay in Maine where it drains into the Atlantic Ocean. The Saco River serves as a water supply for the citizens and businesses of Saco, Biddeford, Old Orchard Beach and part of Scarborough. It is also used to supplement local supplies in the Kennebunk-Kennebunkport-Wells Water District. The river itself has seen a dramatic increase in recreation and shoreline development in recent years and much of the land bordering its surface waters is privately owned.

Figure 1: The Saco River Basin Water from the White Mountains in New Hampshire and empties into the Atlantic Ocean in Maine.

2. The Ossipee Watershed

The Ossipee Watershed is a subwatershed of the Saco River Basin and includes an area of about 379 square miles located in Carroll and Grafton Counties, New Hampshire. It contains 82 lakes and ponds that cover about 9,400 acres in thirteen towns. At its widest point the watershed extends approximately 29 miles east and west and 23 miles north and south. Water from the Ossipee Watershed flows into the Saco River, continues throughout Maine and finally empties into the Atlantic Ocean at Saco Beach. The watershed's drainage area encompasses 14 towns in New Hampshire and is bound by the mountains of the Sandwich Range to the northwest, the Ossipee Mountains to the south and the sandy pine barren lands of the Ossipee-Freedom-Effingham plains to the east (Figure 2). Elevations range from 375 feet at the Maine-New Hampshire border in Effingham to 4,060 feet on Mount Passaconway in Waterville.

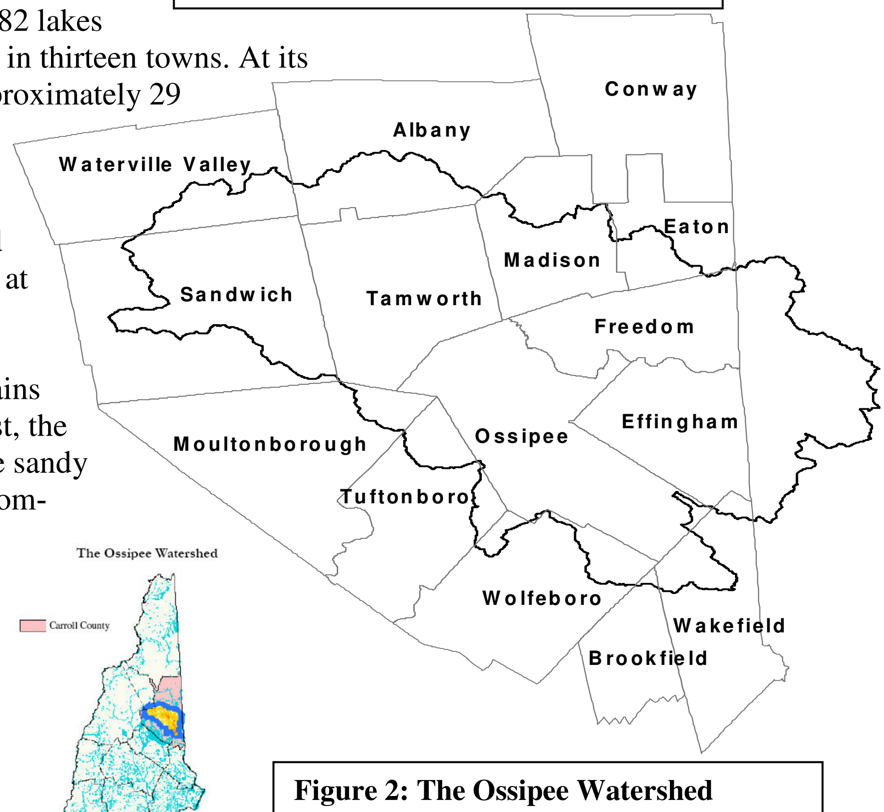


Figure 2: The Ossipee Watershed includes an area of about 379 square miles, encompassing 14 towns in New Hampshire and Maine.

3. The Ossipee Aquifer

The Ossipee Watershed contains New Hampshire's largest and deepest stratified-drift aquifer. This type of aquifer is unique because it recharges more rapidly than any other due to its porous sand and gravel soils, which were deposited by water from melting glaciers. In many areas of the Ossipee Aquifer, water can travel more than 2,000 ft^2 per day (Figure 3). As a result of this quick recharge, these aquifers also allow pollution to be carried more rapidly into the underground water supply. Recharge areas consisting of more permeable soils absorb precipitation and allow it to percolate down to the water table and flow into the aquifer. These areas usually include the land surface directly above the aquifer and the porous, permeable areas adjacent to the aquifer.

In New Hampshire, stratified drift aquifers cover only 15% of the state. These same areas unfortunately also include 54% of known potential contamination sources (such as gas stations, automobile repair facilities, dry cleaning shops, junkyards, and manufacturing sites) (Susca, 2006). Water quality professionals recommend the protection of stratified drift aquifers because of their sensitivity to contamination and their importance to community water supplies. The New Hampshire Department of Environmental Services has identified 69 towns with groundwater protection ordinances, most prohibiting certain land uses and underground storage tanks, and some are based on the model ordinance drafted by the NH DES.

In the Ossipee Watershed, there are approximately 27,000 acres of high yield aquifer with about 20%, or roughly 5,557 acres currently protected (lying beneath conservation lands), according to a recent report by the Forest Society (reference?) (Figures 4 & 5). Water quality professionals recommend a multiple level approach to address the challenge of source water protection, including: land conservation, zoning and land use controls, inventories and inspections of potential contamination sources, municipal and regional actions and management plans. In a recent study, the Trust for Public Lands and the American Water Works Association demonstrated the economic benefits of conserving land to protect drinking water quality, and showed that the more forest cover in a watershed, the lower the water treatment costs. The study of 27 surface water supplies found that for every 10% increase in forest cover, treatment and chemical costs decreased approximately 20% (Forest Notes, 2006). Addressing source water protection not only makes good economic sense, it also provides the potential for developing new wells in the aquifer in the future.

Groundwater and surface water in the Ossipee Watershed are connected, and thus the quantity and quality of each are also connected. Ground water is recharged through rain and snowmelt, and groundwater discharges into streams, wetlands, lakes and ponds. In New Hampshire, groundwater provides an estimated 40% of the total flow in New Hampshire's rivers, which in turn feed the state's lakes, reservoirs, and estuaries. During times of drought, some surface waters in the Ossipee Watershed exhibit higher levels of silica (indicative of soil weathering processes) since they are being replenished by groundwater rather than rainwater. If too much groundwater is removed from the aquifer, there will not be enough groundwater to maintain minimum stream flows needed to support aquatic life, especially during summertime low flows. Where wells are located near rivers and streams, surface water can also be drawn into a well via induced recharge. The protection and wise use of the aquifer, therefore, is dependent upon the protection and wise use of the land and waters located above it.

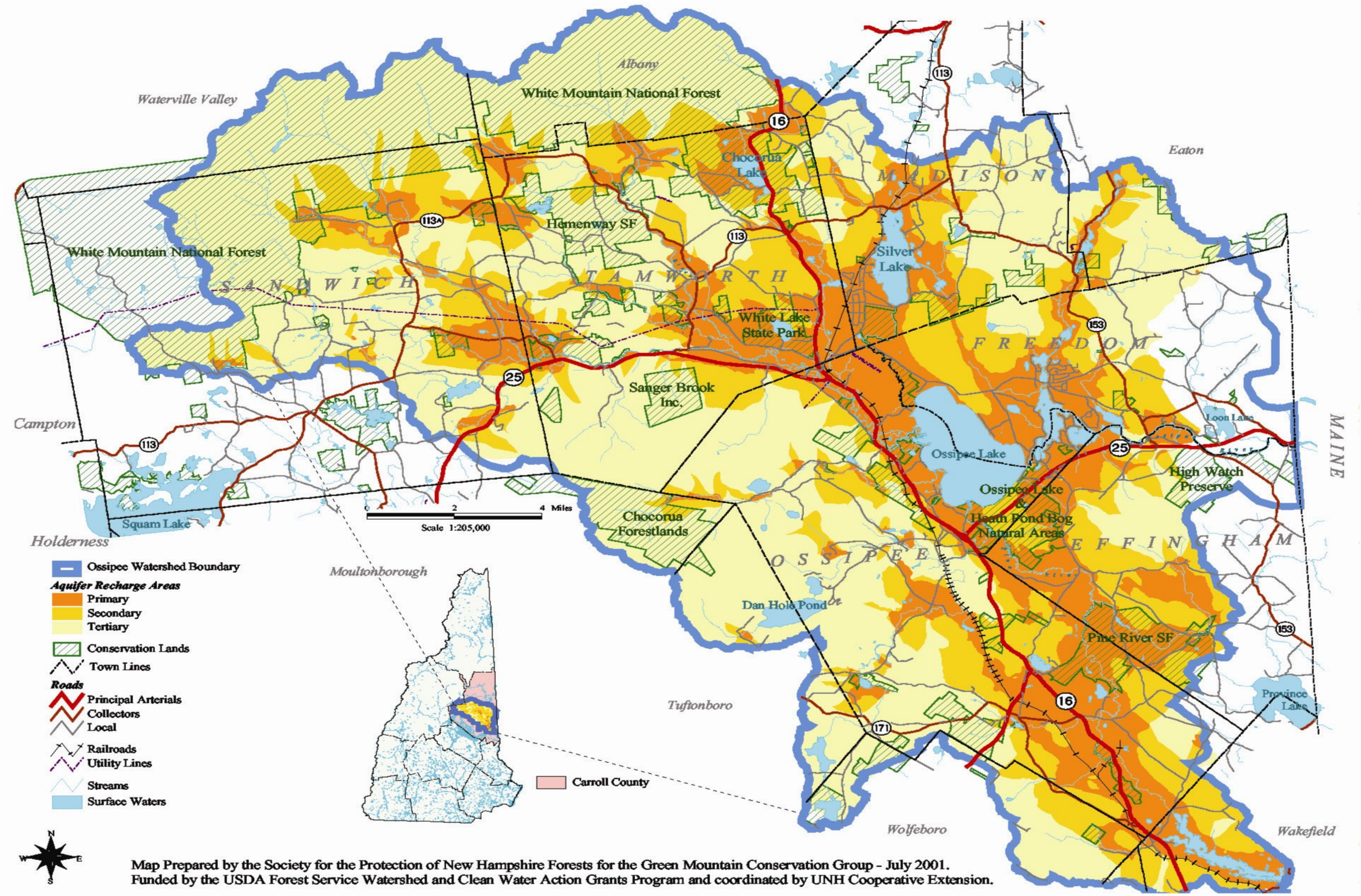


Figure 3: Ossipee Watershed & Aquifer Recharge Areas The Ossipee Watershed is home to the largest stratified drift aquifer in New Hampshire, a critically important statewide resource for existing and future drinking water supplies. Darker shades of orange represent primary recharge areas where water moves quickly from surface to groundwater, sometimes up to 2,000ft^2 per day. These areas are particularly vulnerable to contamination. (Map courtesy of the Society for the Protection of New Hampshire Forests).

Figure 4: Protected High Yield Aquifer in Six Major Overlying Ossipee Watershed Towns

	High Yield	Protected High	% Protected High
Effingham	3,756.5	1,132.1	30.1%
Freedom	3,082.1	379.9	12.3%
Madison	3,544.1	564.0	15.9%
Ossipee	10,154.3	2,428.4	23.9%
Sandwich	1,303.1	24.2	1.9%
Tamworth	5,162.3	1,029.1	19.9%

Figure 5: Protected High Yield Aquifer & Wellhead Protection Areas

	Wellhead Protection Area (acres)	Area WHPA Protected (acres)	% Protected WHPA	Coincident High Yld Aquifer & WHPA	Protected Coincident Aquifer & WHPA	% Protected Aquifer & WHPA
Effingham	4,503.3	1,091.2	24.2%	2,609.0	893.2	34.2%
Freedom	2,552.3	24.6	1.0%	582.0	1.7	.3%
Madison	1,984	31.2	1.6%	658.2	2.0	.3%
Ossipee	5,104.5	1,543.1	30.2%	1,350.6	543.4	40.2%
Sandwich	218.6	4.9	2.3%	0	0	0
Tamworth	1,838.3	163.6	8.9%	567.9	75.8	13.4%
Carroll County	38,799.8	4,997.1	12.90%	9,024.9	2,031.6	22.5%
New Hampshire	317,592.3	34,076.3	10.7%	33,270.8	5,140.7	15.5%

Figures 4 & 5: Tables created from the Forest Society's *NH's Changing Landscape* base data through 2004. Conservation and Public lands data provided by GRANIT (October 2004 release) and updated by SPNHF. Includes all stratified drift aquifer with maximum transmissivity rates greater than or equal 2,000 square feet per day. Data produced by USGS and distributed by NH Department of Environmental Services. *Wellhead Protection Areas: Wellhead protection areas are delineated by NH Department of Environmental Services. Protected WHPA: Area of wellhead protection areas within protected conservation lands. Coincident Aquifer and WHPA: Areas where wellhead protection areas fall over high-yield aquifers - areas where there is potential for high-capacity wells.

4. Ossipee Lake System

Ossipee Lake (Figure 6) is the center of the Ossipee Watershed. Comprised of over 4,000 acres of water, the lake consists of a main body of water known as Ossipee Lake and five large connecting bodies of water: Berry Bay, Broad Bay, Leavitt Bay, Danforth Pond and Huckins Pond. As one of New Hampshire's largest lakes, it is a major economic contributor to Freedom, Ossipee and surrounding towns. A primary destination for vacationers, boaters and outdoor enthusiasts, its appeal has placed it under developmental pressure and environmental stress.

Figure 6: Ossipee Lake is a popular destination for tourists and residents. Photo courtesy Jamie Cole.

In 1995 the Environmental Protection Agency listed Ossipee Lake as one of the top five areas in New Hampshire to protect. However, there is still a need for public education about the importance of the lake and its environmental assets since the lake does not have a management or stewardship plan.

According to a 2003 NHLA report, recreational use of New Hampshire's freshwaters generates up to $1.2 billion annually while waterfront property owners contribute upwards of $247 million in property taxes each year to the state. Lakes, including shoreline areas and associated wetlands are also some of the most productive and diverse ecological systems, serving as critical feeding, spawning and brood rearing habitat for many wildlife species.

Figure 7: Recreation, development, nonpoint source pollution, and exotic invasive species are among the greatest threats to the lake's future health. In the photo above, hundreds recreate in the area known as Long Sands/Ossipee Lake Natural Area.

Particularly vulnerable are Ossipee Lake's unique ecological assets, including two globally rare pondshore communities, pine barrens, a kettlehole quaking bog and the largest stratified drift aquifer in New Hampshire.

Recreation and development pressure, water quality degradation from non point source pollution, and invasive aquatic species are some of the greatest threats facing this lake system (Figure 7). GMCG has been conducting educational programs and water quality monitoring with volunteers, hundreds of summer campers and staff, and other visitors on the lake since 2003. The New Hampshire Department of Environmental Services, New Hampshire Department of Economic Development, New Hampshire Heritage Inventory, Ossipee Lake Alliance (OLA,) local conservation commissions and other associations have also made efforts to educate the public about protecting the unique features of this lake. In 2008, NH Department of Resources and Economic Development put together a management plan for the Ossipee Lake Natural Area, a unique, undeveloped area of shoreline on Ossipee Lake. The plan will be implemented and managed by a 17 member Working Group made up of local representatives and associations. The Working Group will help monitor the plan and advice the state on public communication, education and water safety issues through a balance of recreation and preservation. For a draft of Management Plan, go to: http://www.nhdfl.org/library/pdf/Ossipee%20Lake%20Natural%20Area/DraftOLNAManagementPlan-18Jun08.pdf .

The NH DES, GMCG and OLA gather data for the lake every year to track water quality and address any issues that may harm the lake. Deep spot samples are collected at five stations: Ossipee Lake, Broad Bay, Berry Bay, Leavitt Bay and Lower Danforth Pond. Ossipee Lake, Berry Bay and Lower Danforth have been monitored since 2003, Broad and Leavitt Bays since 1990.

*For the full 2008 report, and past VLAP reports, visit: http://www.gmcg.org/water-quality-data.php.

***Note:** There are many other lakes and ponds within the Ossipee Watershed that are not discussed in this report. For links and information about other major lakes and ponds, including those with lake associations and existing water quality monitoring programs, see the Ossipee Watershed Natural Resource Guide: http://www.gmcg.org/administration/pdf/07%20Water%20Resources%20Chapter%20Lakes%20&%20Ponds.pdf.

Section 2: Water Quality Monitoring

A. Lake Water Quality

Background: The Ossipee Lake System has been tested since 1990 by the NH Lakes Lay Monitoring Program and the NH Department of Environmental Services Volunteer Lakes Assessment Program, with assistance from local camps and volunteers (Figure 8), the Green Mountain Conservation Group, and Ossipee Lake Alliance. These programs have continued to add data to the historical data base to determine year to year conditions of the lakes and to identify any short or long-term changes in water quality. While the Broad and Leavitt Bays have been monitored since 1990, Ossipee Lake, Berry Bay and Danforth Pond have only been monitored since 2003.

One of the major concerns for any lake is cultural eutrophication, or the increase in biological productivity of the lake, including the amount of algal and plant growth, due to the addition of nutrients from human activities. Another concern is changes to pH of the lake waters, New Hampshire receives large amounts of acid precipitation and most lakes have low acid neutralizing capacity due to their underlying geology. Lake testing, like river testing, must be conducted frequently over a substantial amount of time to determine if any change in water quality is occurring. Evaluation and interpretation of this long-term data base can indicate if the lake's water quality has worsened, improved, or remained stable. With sufficient data, predictions can also be made about the future, inform management decisions and identify problem areas so that water quality impairments can be remedied before they become more costly or serious. Well-informed management of a lake system also makes good economic sense. **Studies have shown that even a one foot loss in transparency can lead to a decrease in lakeshore property value of as much as $2,000 (Craycraft, 2006). Can also refer to NH Lakes economic impacts studies**

Sites & Site Maps: A total of five deep spot locations on the Lake Ossipee system are monitored were monitored between 2002 and 2008 (Figure 9, page 18).

Lake Monitoring Testing Schedule Deep water sites were tested four times during the summer months between the hours of 10:00 a.m. and 2:00 p.m. in accordance with the VLAP protocol. (see Appendix D for sampling schedules).

Lake Monitoring Parameters: Deep spots in each of the five main waterbodies are tested for biological, chemical and physical water quality parameters. Parameters include: chlorophyll-a, transparency, total phosphorus, chloride, conductivity, pH, dissolved oxygen, turbidity, acid neutralizing capacity, nitrogen, bacteria and phytoplankton.

Results: Yearly sampling of the Ossipee Lake System thus far has shown good water quality when compared with other waterbodies in the state. For the most part, sites have demonstrated high transparency, high dissolved oxygen levels, low concentrations of chlorophyll-a, nutrients, *E.coli*, cyanobacteria and low conductivity levels. The following is a summary of lake monitoring results to date based on the 2008 Volunteer Lake Assessment Program from NH DES.

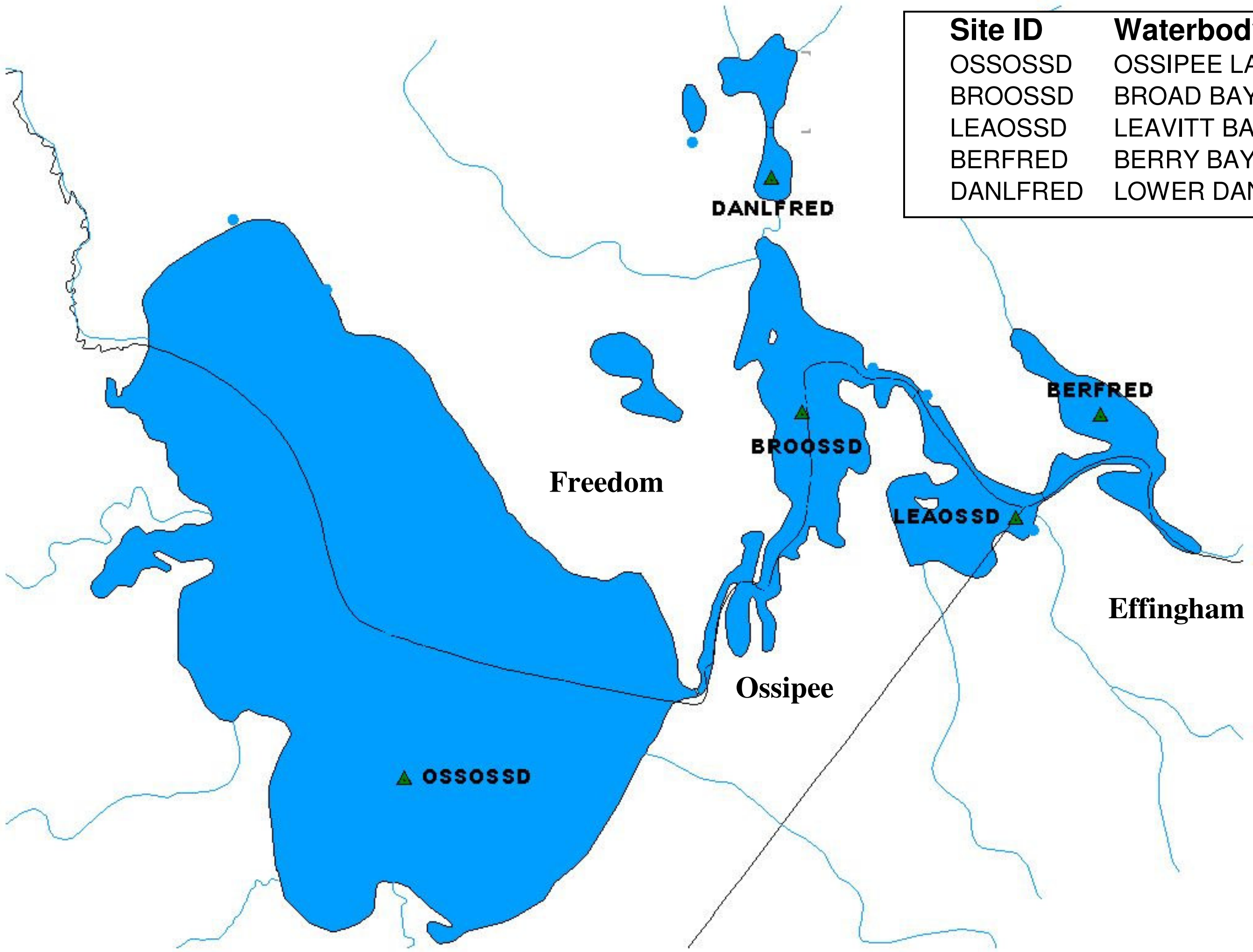
- Average yearly concentration of all parameters (chlorophyll-a, transparency, total phosphorus, and conductivity) remain in a low (good) to average range for New Hampshire lakes.
- **Ossipee Lake** deep spot shows a stable chlorophyll-a trend, decreasing (worsening) transparency trend, slight increase in epilimnetic total phosphorus, stable hypolimnetic total phosphorus, and a slight decrease in epilimnetic conductivity levels.

- **Berry Bay** deep spot shows a stable chlorophyll-a trend, variable transparency trend, slight increase in epilimnetic total phosphorus, stable hypolimnetic total phosphorus, and a slight decrease in epilimnetic conductivity levels.
- **Broad Bay** deep spot has greater than 10 years of data and therefore statistical trend analyses were performed. Analyses showed a variable chlorophyll-a trend, a significantly decreasing (worsening) transparency by approximately 3.0%, and variable epilimnetic and hypolimnetic total phosphorus trends. The epilimnetic conductivity appears to be increasing slightly, however statistical analyses were not conducted.
- **Leavitt Bay** deep spot has greater than 10 years of data and therefore statistical trend analyses were performed. Analyses showed an increasing (although not statistically significant) chlorophyll-a trend, a significantly decreasing (worsening) transparency by approximately 2.3%, and variable epilimnetic and hypolimnetic total phosphorus trends. The epilimnetic conductivity appears to be increasing slightly, however statistical analyses were not conducted. In 2006, the cyanobacterium *Anabaena* was one of the most-dominant species in the Leavitt and Broad Bay plankton samples on the July 18th sampling event. NH DES notes that "this species, if present in large amounts, can be toxic to livestock, wildlife, pets and humans. Cyanobacteria can reach nuisance levels when phosphorus loading from the watershed to surface waters is increased and favorable environmental conditions occur, such as a period of sunny, warm weather. The presence of cyanobacteria serves as a reminder of the lake's delicate balance."
- **Lower Danforth Pond** deep spot shows a variable chlorophyll-a trend, a variable transparency trend, variable epilimnetic and hypolimnetic total phosphorus trends, and a slight decrease in epilimnetic conductivity levels. Monitoring results show that Lower Danforth Pond has different water quality characteristics than the rest of the lake basins, with higher chlorophyll-a and total phosphorus levels each year than levels found at other sites. Total phosphorous concentrations at Lower Danforth Pond have been greater than the state mean, and the NH DES suggests that the process of internal phosphorous loading is occurring in the hypolimnion, or deepest layer, of Lower Danforth Pond.

Another parameter that it is important to note is pH. The state median for the epilimnion (upper layer) of lakes and ponds in New Hampshire is 6.6, and the Ossipee Lake system is also slightly acidic, becoming more acidic in the hypolimnion (lower layer) at each of the five deep spots. This increase in acidity near the lake bottom is likely due to the decomposing organic matter. According to the DES's analysis of this system's acid neutralizing capacity, or the ability to resist changes in pH by neutralizing the acidic input to the lake, surface water at each deep spot is moderately vulnerable to acidic inputs. NH DES states that due to the underlying bedrock geology (and with the Ossipee Lake system, mostly sandy glacial outwash material), acid deposition from snowmelt, rainfall and atmospheric particulates, "there is not much that can be feasibly done to effectively increase lake pH."

Figure 8: Area camp staff and campers help each year with data collection on the lake.

Other Resources:
VLAP parameters: http://des.nh.gov/organization/divisions/water/wmb/vlap/documents/parameters.pdf
VLAP manual: http://des.nh.gov/organization/commissioner/pip/publications/wd/documents/wd-07-35.pdf
Shoreline Protection Act 2008: http://www.gencourt.state.nh.us/rsa/html/nhtoc/nhtoc-l-483-b.htm



Site ID	Waterbody	Town	Dep
OSSOSSD	OSSIPEE LAKE-DEEP SPOT	OSSIPEE	51
BROOSSD	BROAD BAY-DEEP SPOT	FREEDOM	73
LEAOSSD	LEAVITT BAY-DEEP SPOT	OSSIPEE	42
BERFRED	BERRY BAY-DEEP SPOT	FREEDOM	32
DANLFRED	LOWER DANFORTH POND-DEEP SPOT	FREEDOM	30

Figure 9: Volunteers for Lake Assessment Program (VLAP) test sites. At these sites, DES and GMCG staff and volunteers collected water samples at various depths to assess biological, chemical and physical health of the lake basin

B. Milfoil & Ossipee Lake: Exotic aquatic plants have become a problem across the country and are believed to have been introduced into New Hampshire's lakes and ponds by the mid-1960s. The best known invasive plant is variable milfoil, which is the most wide-spread exotic plant in the state. According to the Department of Environmental Services, variable milfoil spread from Lake Winnipesaukee to 38 other waterbodies, primarily through human activity. Exotic plants can be invasive since their growth is not kept in check by native fauna because they do not have an established relationship with these species. They can grow out of control and become a nuisance to human recreational uses for waterbodies, and they also replace native plants and habitat, disrupt the food chain, stunt fish growth, and degrade wildlife habitat. To date, there is no practical or ecological means of eradicating these plants, and once a waterbody has an infestation it requires continuous, often expensive management and control practices. Prevention of new infestations and early detection therefore becomes the most important form of defense against the spread of milfoil and other invasives that are problematic in this state, such as fanwort, water chestnut, Eurasian milfoil, purple loosestrife and common reed.

GMCG has hired local students since 2002 in conjunction with the New Hampshire Lake Association's Lake Host Program to prevent the introduction and spread of exotic aquatic plants (such as variable milfoil) in Ossipee Lake. To date, Lake Hosts have inspected over 3,000 boats at the Pine River boat launch and provided information to many more boaters about the lake's milfoil infestations and how they can prevent the spread of exotic plants.

Variable milfoil infestations were first discovered in the Ossipee Lake system in the 1980s. The map below highlights locations of known milfoil infestations: Phillips Brook, Leavitt Bay, Portsmouth Cove, Ossipee River and Danforth Pond (Figure 10). Hand pulling, benthic barriers and herbicide treatments undertaken with the assistance of the DES, Ossipee Lake Alliance, local businesses that depend upon the lake and towns have been used since 1995 (Figures 11&12), with marginal success at limiting growth. In 2006 New England Milfoil and Ossipee Lake Alliance reported that approximately 25% of the milfoil in Phillips Brook and 5% of the plants in the area where it enters Leavitt Bay came back after hand pulling efforts the previous year.

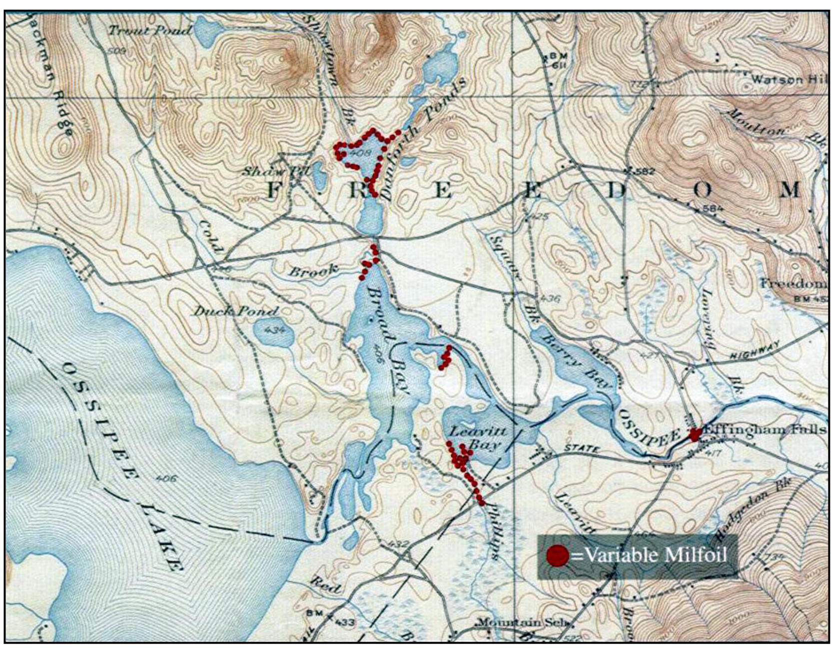


Figure 10: Ossipee Lake has confirmed infestations of the invasive aquatic plant variable milfoil as shown in this map. Milfoil treatment with herbicides and hand-harvesting has cost the state, towns of Ossipee and Freedom and local businesses tens of thousands of dollars. (Map created by Ossipee Lake Alliance).

All infested waterbodies must have management plans in place before further management practices (particularly herbicides) are approved. In 2008, Ossipee Lake Alliance and the Friends of Danforth Pond, along with NH DES, put together a Long-Term Variable Milfoil Management Plan for Danforth Pond. Freedom Selectmen have approved a plan to treat Danforth Pond's growing milfoil infestation with 2,4-D, an aquatic pesticide said to prohibit invasive weeds for three to five years. The plan can be found at: http://ossipeelake.org/news/2008/09/03/state-favors-herbicide-treatment-for-danforth-pond-milfoil/. On March 26, 2009 the Freedom Select Board voted to delay the chemical treatment of milfoil in Danforth Bay until spring 2010. Voters had appropriated $2,800 at Town Meeting for the treatment, with the remainder of the total $14,300 cost pledged from private sources. Continued diligence in the form of educating boaters and lakefront homeowners and keeping infestations from spreading will be essential to preventing new infestations from occurring in the lake system or spreading at other sites.

Contractor	**Management Type:**	**Cost:**	**Chemical Application/Treatment Date**	**Treatment Area (acres)**	**Effectiveness of treatment**
Lycott Environmental Research	Chemical:	$4,730.00 (Total)	June 1995	6.1 Acres	
Aquatic control technology	Chemical:	$5,890.00 (total/DES)	Completion date: September 30th 1996	6.1 Acres	

Figure 11: Lake Ossipee – Leavitt Bay/Phillips Brook, Ossipee treatment history for milfoil infestations, courtesy NH DES.

Contractor	**Management Type:**	**Cost:**	**Chemical Application/Treatment Date**	**Treatment Area (acres)**	**Effective-ness of treatment**
Cliff Cabral	Hand pulling	$10,000.00 (total) $5,000.00 (DES 50%)	Summer 2005	4 acres	

Figure 12: Lake Ossipee - Broad Bay, Freedom treatment history for milfoil infestations, courtesy NH DES.

*Please note: additional hand-pulling treatments have been carried out multiple times at Danforth Pond through funding from the Danforth Bay Camping Resort, private donations and the town of Freedom. Estimates are that more than $90,000 has been spent to date on milfoil management in Danforth Pond alone.

Other Resources:

Ossipee Watershed Natural Resource Guide (milfoil & milfoil management programs in the Ossipee Watershed):http://www.gmcg.org/administration/pdf/07%20Water%20Resources%20Chapter%20Lakes%20&%20Ponds.pdf.
NH DES contact for exotic invasives: Amy P. Smagula, (603) 271-2248 asmagula@des.state.nh.us; http://des.nh.gov/organization/divisions/water/wmb/exoticspecies/index.htm
2008 milfoil & milfoil prevention statistics for NH's lakes, NH Lakes website: www.nhlakes.org/
Ossipee Lake Weed Watchers Program: June D'Andrea: (603)539-1643 jmdandrea@ossipeelake.org

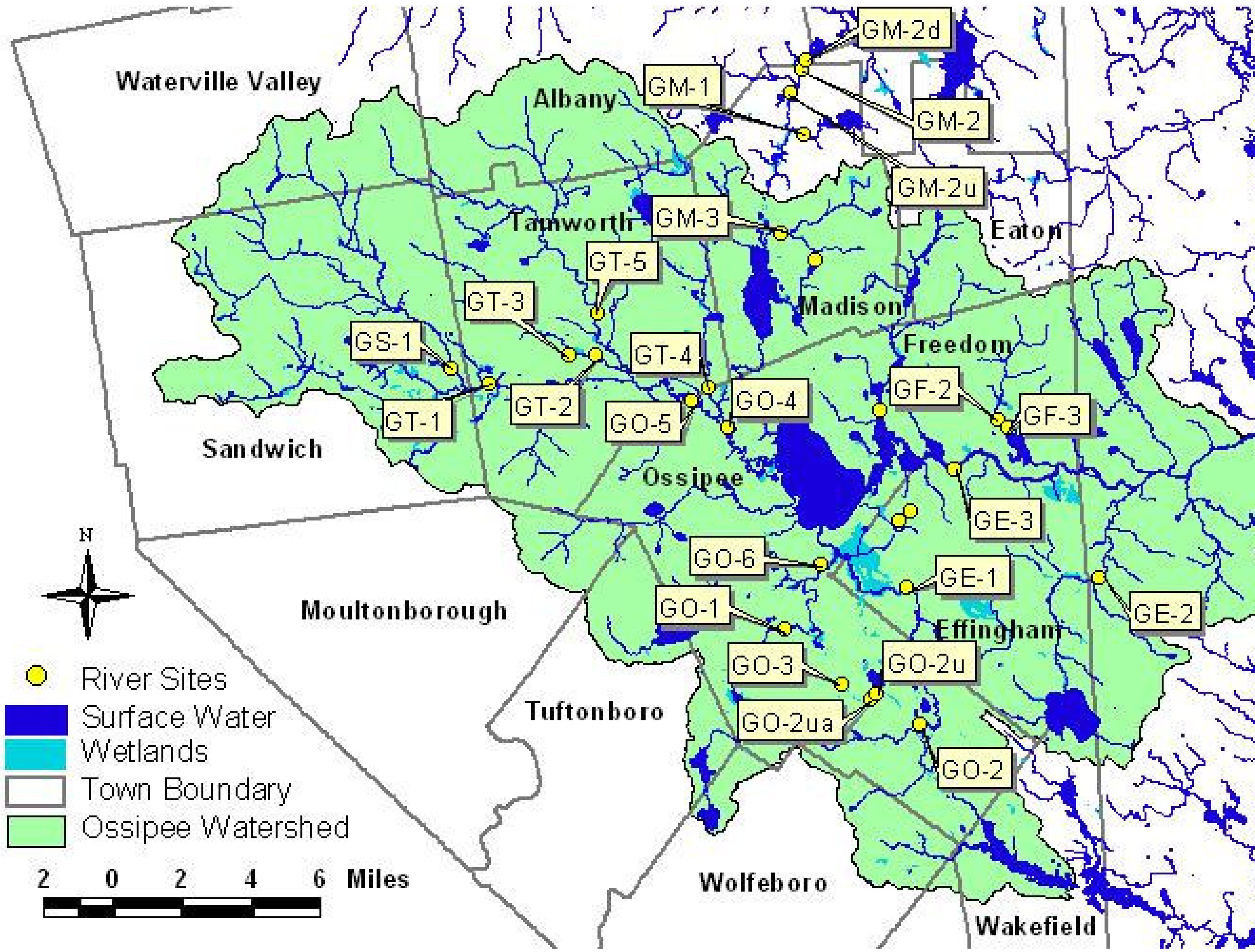
C. River Water Quality

Background: In 2002, the Green Mountain Conservation Group began testing surface waters of the Ossipee Watershed to collect baseline data and establish a long-term monitoring program to track water quality as land use changes in the region. The program is called Regional Interstate Volunteers for the Ecosystems and Rivers of Saco (RIVERS), and is managed in conjunction with the University of New Hampshire and the Saco River Corridor Commission (SRCC) in Maine. Since 2002, the Water Quality Monitoring program for rivers and streams has expanded to include the testing of 19 river sites in New Hampshire through the RIVERS program, eleven tributary sites through the Ossipee Lake and Tributaries (OLT) program, and in 2006, eleven rivers and streams through the Volunteer Biological Assessment Program (VBAP). Currently, a total of nineteen physical and chemical parameters are measured at rivers testing sites, in addition to biological assessments at eleven sites. The program has also been extended from the summer months to include year-round sampling at seven sites, as well as increased from fifteen to thirty volunteers, in addition to hundreds of summer campers and school children each year.

The SRCC now has 33 river sites that are monitored in the lower part of the Saco River Basin for a total of six parameters, including pH, dissolved oxygen, turbidity, total phosphorus, total Kjeldhal nitrogen, and Escherichia coli. For more information on their program and results, visit: http://www.srcc-maine.org. In October of 2008, representatives from SRCC, GMCG, the Ossipee Watershed Coalition and UNH held a meeting to discuss future goals, research and partnerships for this collaborative effort to understand the water quality of the Saco River Basin. Among the outcomes from that meeting included additional recommendations for site review and modified monitoring of sites for the GMCG program (Appendix G) and potential partnerships and studies for the future (see "Recommendations" section). For past year's reports, please see the following: http://www.gmcg.org/water-quality-data.php.

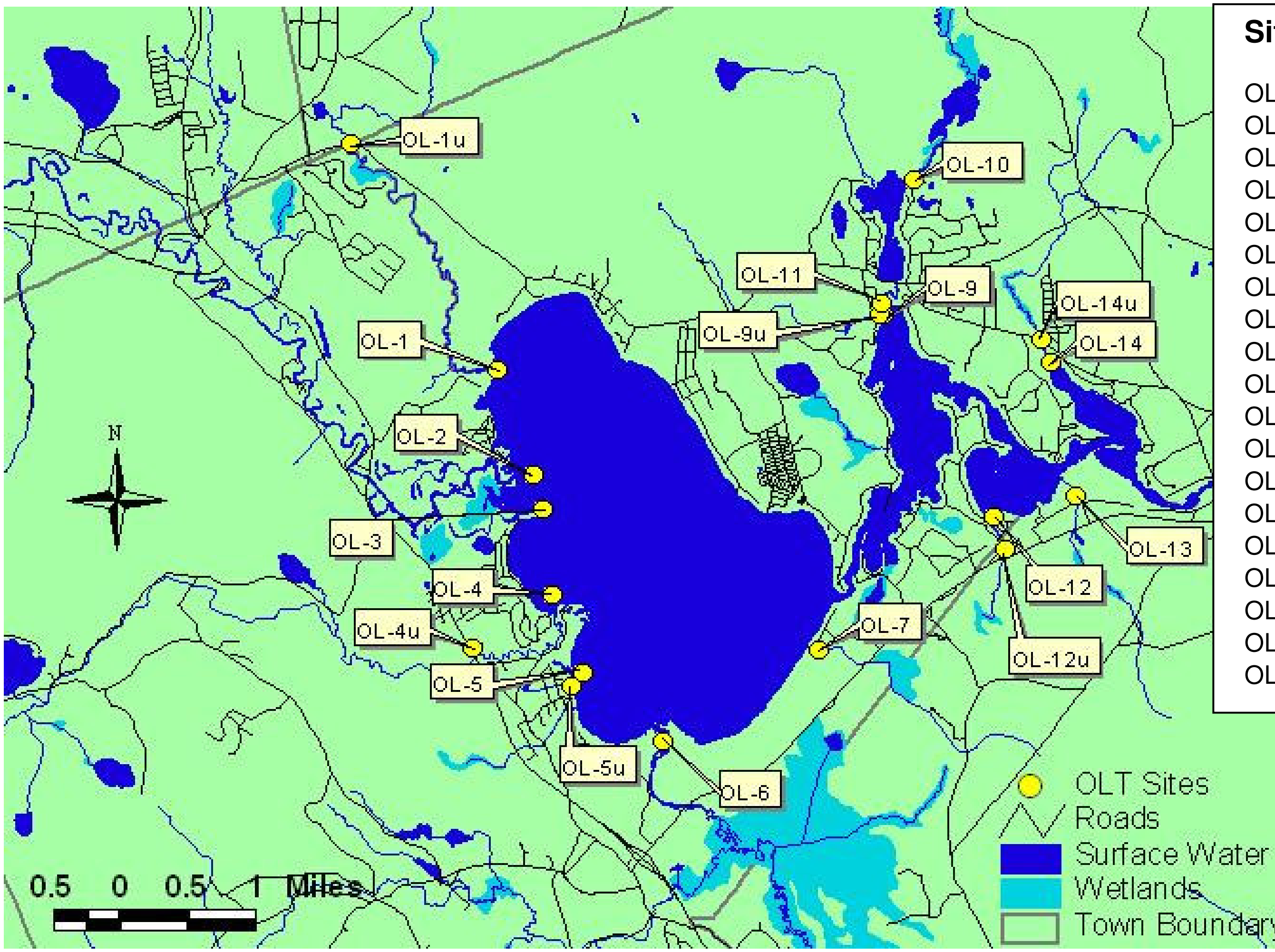
Sites & Site Maps: A total of nineteen river and stream sites, eleven tributaries of Lake Ossipee and its bays were monitored between 2002 and 2008 (Figures 13-14). These sites were selected in 2002 and during subsequent years of the monitoring program, with the assistance of town officials and water quality experts from the University of New Hampshire. Eleven sites were also sampled for macroinvertebrates from 2006 to 2008 (Figure 15). Sites were chosen based on considerations such as size, accessibility, and surrounding land use. For example, sites are located downstream from gravel pits, designated drinking water zones, transfer stations, landfills, or next to major roads or developments. Other sites were chosen to track the quality of water entering and leaving Ossipee Lake, or because of concerns over malfunctioning septic systems, erosion, timber-cutting, mill sites, junkyards, old tanneries, or to bracket potential sources of contamination for further investigation. See individual site sheets (Appendix B) for detailed descriptions of sites.

In 2005, some tributary sites were relocated to sites farther upstream based on feedback from UNH water quality experts. Previous data indicated lake water influence at some sites where samples were taken too close to the lake. To obtain true river data, certain sites were moved upstream and are designated as new sites with the letter "u" following the site name, for example, the Phillips Brook site in Effingham OL-12 was moved upstream to OL-12u.



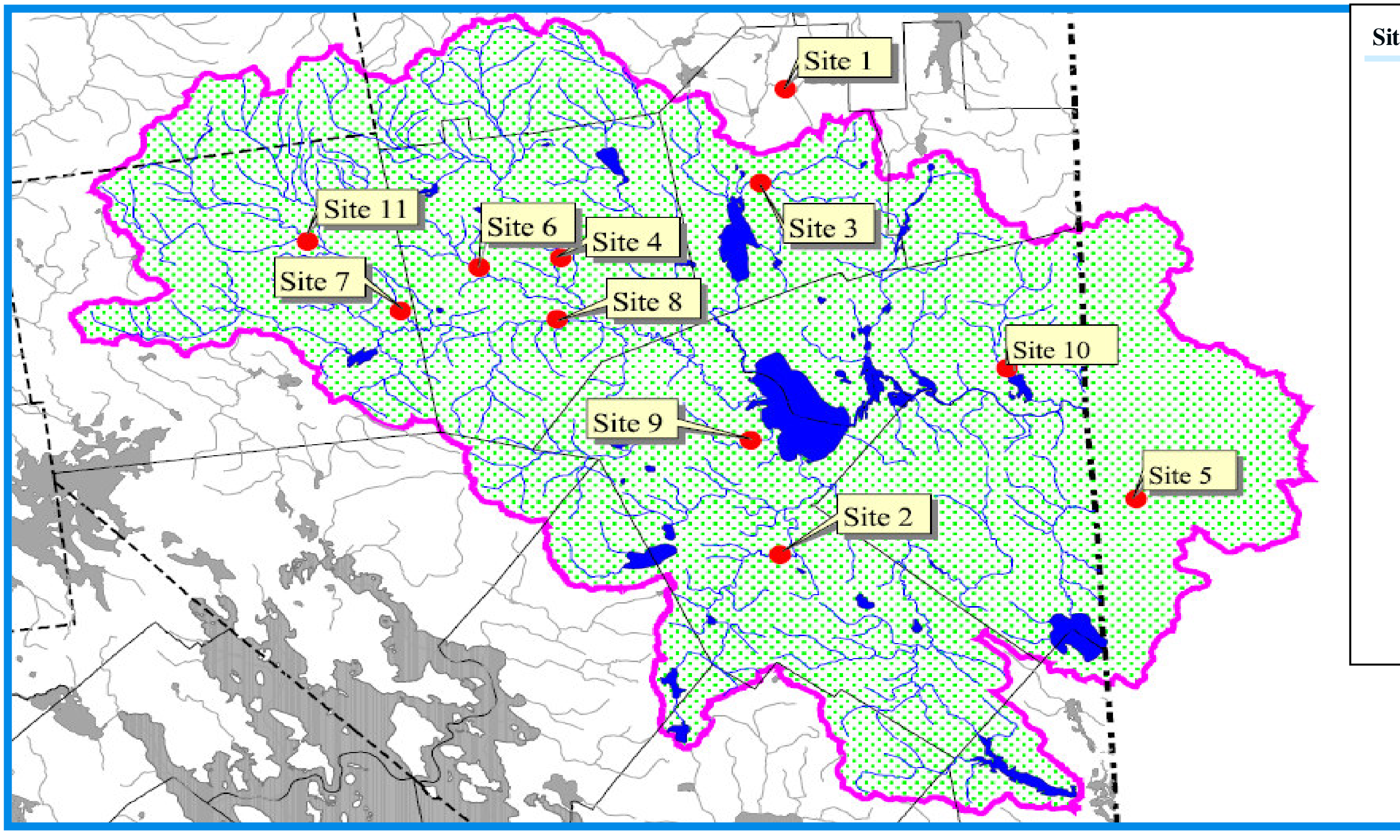
Site ID	Waterbody	Town
GE-1	Pine River	Effingham
GE-2	South River	Effingham
GE-3	Ossipee River	Effingham
GF-1	Danforth outlet	Freedom
GF-2	Cold Brook	Freedom
GF-3	Cold Brook	Freedom
GM-1	Banfield Brook	Madison
GM-2	Pequawket Brook	Madison
GM-3	Forrest Brook	Madison
GT-1	Bearcamp River	Tamworth
GT-2	Mill Brook	Tamworth
GT-3	Mill Brook	Tamworth
GT-4	Chocorua River	Tamworth
GO-1	Beech River	Ossipee
GO-2	Frenchmans Brook	Ossipee
GO-3	Frenchmans Brook	Ossipee
GO-4	Bearcamp River	Ossipee
GO-5	Bearcamp River	Ossipee
GS-1	Cold River	Sandwich
GE-4	Red Brook	Effingham
GT-5	Swift River	Tamworth
GO-6	Beech River	Ossipee
GO-2ua	Frenchmans Brook	Ossipee
GO-2u	Frenchmans Brook	Ossipee
GM-2d	Pequawket Brook	Albany
GM-2u	Pequawket Brook	Madison

Figure 13: Ossipee Watershed Regional Interstate Volunteers for the Ecosystems and River of the Saco (RIVERS) Program test sites. At these sites, GMCG staff and volunteers collected water samples and conducted field measurements to assess the chemical and physical health of waterbodies. *Map by Michelle Daley, UNH, 2007.*



Site ID	Waterbody	Town
OL-1	West Branch	Ossipee
OL-1u	West Branch upstream	Ossipee
OL-2	Bearcamp River	Ossipee
OL-3	Patch Pond	Ossipee
OL-4	Lovell River	Ossipee
OL-4u	Lovell River upstream	Ossipee
OL-5	Weetamoe Inlet	Ossipee
OL-5u	Weetamoe Brook upstream	Ossipee
OL-6	Pine River	Ossipee
OL-7	Red Brook	Ossipee
OL-9	Cold Brook	Freedom
OL-9u	Cold Brook upstream	Freedom
OL-10	Danforth Inlet	Freedom
OL-11	Danforth Brook/Huckins	Freedom
OL-12	Phillips Brook	Effingham
OL-12u	Phillips Brook upstream	Effingham
OL-13	Leavitt/Camp Marist	Effingham
OL-14	Square Brook	Freedom
OL-14u	Square Brook upstream	Freedom

Figure 14: Ossipee Lake Tributaries (OLT) program test sites. At these sites, GMCG staff and volunteers collected water samples and conducted field measurements to assess the chemical and physical health of waterbodies. *Map by Michelle Daley, UNH, 2007.*



Site number	Stream name, town
1	Banfield Brook, Madison
2	Beech River, Ossipee
3	Forrest Brook, Madison
4	Swift River, Tamworth
5	South River, Parsonsfield
6	Mill Brook, Tamworth
7	Cold River, Sandwich
8	Bearcamp River, Tamwor
9	Lovell River, Ossipee
10	Cold Brook, Freedom
11	Pond Brook, Sandwich

Figure 15: Volunteers for Biomonitoring Assessment Program (VBAP) test sites. At these sites, DES and GMCG staff and volunteers collected, identified, and tallied macroinvertebrate samples to assess the biological health of various waterbodies. *Map by Dawn Keppler, NH DES, 2006.*

River Monitoring Testing Schedule: Sampling at most river and stream sites occurred fourteen times each season, from mid-April through mid-October. Some river sites were sampled less frequently due to limited resources, water flow, or to bracket specific waterbodies. Seven river sites were selected for year-round sampling and are tested monthly to provide a better understanding of year-round watershed health, including the spring snow melt period. Eleven tributary sites were sampled four times in July and August. The above sites were sampled between 6:00 and 9:00 a.m. to capture dissolved oxygen measurements when they are typically at their lowest value (prior to major photosynthesis activity) and comply with the Quality Assurance Project Plan.

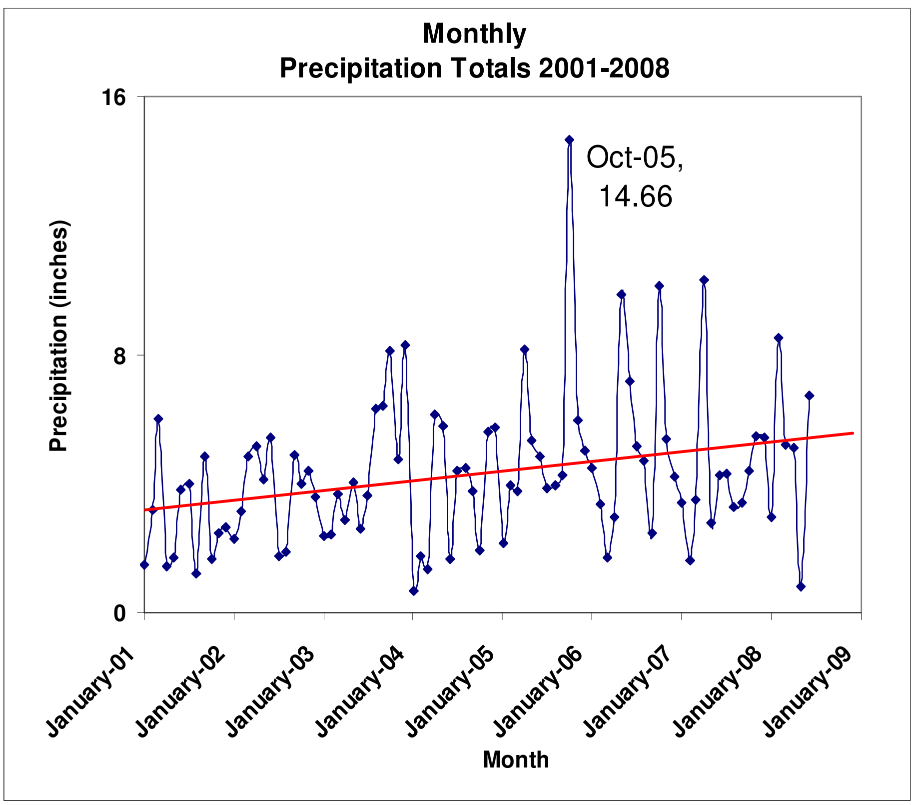
River Monitoring Parameters: A total of nineteen parameters are monitored for RIVERS and OLT sites. Five parameters are tested in the field, including pH, temperature, dissolved oxygen, conductivity and turbidity. Volunteers record values on a data sheet (Appendix D). For instructions on how to use field parameter equipment, refer to Appendix B in the 2003 Ossipee Watershed Water Quality Report. Fourteen additional chemical parameters were also measured, including total phosphorus, sodium, chloride, calcium, magnesium, total dissolved nitrogen, nitrate, sulfate, potassium, phosphate, dissolved organic carbon, silica, dissolved organic nitrogen, and ammonium. Volunteers and GMCG staff collected two water samples in 250 ml bottles at each site. GMCG staff acidified one sample with one milliliter of concentrated sulfuric acid then froze it. GMCG staff filtered the other sample using a 47 mm diameter 0.7 micron mesh Whatman filter, stored it in a 60 ml bottle and froze the sample. These samples were then sent to the University of New Hampshire to analyze for the parameters listed in Appendix C. While all sites were analyzed for the fourteen additional chemical parameters in 2005, due to limited funding for lab work in 2006 and 2008, seven sites were selected across the watershed for monthly year-round lab analysis, and other sites' chemical monitoring was amended to reflect available funding. All sites, however, continued to be monitored for total phosphorous and field parameters. Conductivity measurements were not taken at every sampling event due to equipment limitations.

Section 3: River Monitoring Results

A. RIVERS & Ossipee Lake Tributaries Results

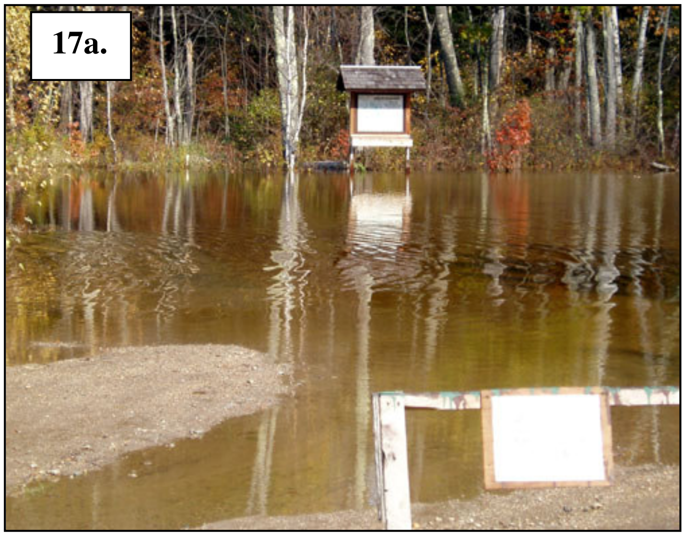
Precipitation

Precipitation totals ranged from 34.38 inches in 2001 to 65.92 inches in 2005, as measured by the USGS monitoring station located on the Bearcamp River in Tamworth. Month-to-month variation was considerable in some cases, as in October 2005 when record rainfall amounts were documented in many areas of the northeast (Figure 16). In May of 2006 New Hampshire received record amounts of rainfall once again, which NH DES has stated resulted "in excessive soil erosion, increased nutrient loading to surface waters throughout the state." (DES, VLAP Report 2006). In general, rainfall can play a large role in surface water quality, affecting the physical and chemical composition by influencing temperature, pH, and nutrient and sediment runoff. For example, during dry periods pollutants accumulate in the uplands and are ultimately flushed into the receiving waters during storm events. The Ossipee Watershed's rivers and streams were often flooded, causing significant damage and erosion to dirt roads over the past few years (Figures 17-19).



YEAR	TOTAL PRECIPITATION (inches)	
2001	34.38	
2002	45.50	
2003	55.40	
2004	43.14	
2005	65.92	
2006	61.62	
2007	52.09	
2008	29.31	(through June, 2008)

Figure 16: Total annual precipitation and monthly variation are shown in the graph and table above, taken from the Tamworth USGS monitoring station on the Bearcamp River. Total rainfall appears to be increasing over time, with many records set in recent years. In October of 2005, a record 14.66 inches of rain was recorded. October of 2006 was also the second wettest October on record for the area. In 2008, total annual precipitation records (rain and snowfall) were also broken in Concord (Mary D. (Lemcke) Stampone, State Climatologist).



Figures 17a, b, c: Heavy rains and flooding in the fall of 2005 contributed to a) turbulent waters at Effingham Falls on the Ossipee River (right). b) Many trees were uprooted and shorelines scoured as floodwaters overflowed river banks, such as the Pine River (left – photo of Pine River boat launch). c) Heavy rainfall in 2007 and 2008 contributed to dirt road erosion and sedimentation of nearby waterways, as was the case with this road in Freedom near Cold Brook (below).

Temperature

Background: Water temperature is influenced by a number of variables, including air temperature, sunlight, shading, water source, and the width, depth, and circulation of the waterbody. Human activities that can affect temperature include: industrial discharge of water used as coolant (thermal pollution), the cutting of trees which once shaded the water, dams or other impoundments, and soil erosion, which causes more turbid water that absorbs more heat from the sun. The metabolic rates of organisms increase with increasing water temperature which in turn increases the need for oxygen. More plants grow in warmer waters causing more plant death and more oxygen is used as bacteria decompose them. Since gases dissolve more easily in cooler water, water temperature also plays a large role in the amount of dissolved oxygen found in waterbodies. Organisms such as trout and mayfly nymphs thrive in cooler, more oxygen-rich waters (13ºC and below) while bass and most plant life prefer warmer waters (20ºC and above). The middle temperature range supports salmon, trout, water beetles, and limited plant life.

Class B NH Surface Water Quality Standard: Temperature in Class B waters (waters that are clean enough to safely swim and fish) shall be in accordance with RSA 485-A:8, II which states in part "any stream temperature increase associated with the discharge of treated sewage, waste or cooling water, water diversions, or releases shall not be such as to appreciably interfere with the uses assigned to this class."

Results: Temperatures vary across the RIVERS sites and OLT sites. The highest surface water temperatures continue to be observed at Danforth Brook (GF-1/OL-11) and the Ossipee River (GE-3), both lake outlets. Other tributary sites have exhibited warmer temperatures, such as Huckins Pond Outflow (OL-10), Bearcamp River (OL-2) and West Branch River (OL-1); however, the influx of warmer lake water is most likely a factor at these sites (Figure 18). In 2005, most of the testing sites for tributaries were moved upstream to prevent lake water from affecting tributary samples. Most of the new upstream sites exhibited cooler temperatures than downstream sites in previous years. Site OL-10 continued to exhibit warmer temperatures through 2007, and a new testing location farther upstream will likely provide data that represents the tributary's conditions.

Since 2002, mean monthly water temperatures have been variable from year to year, yet follow a seasonal pattern as exemplified in Figure 20. Over time, statistical tests will determine whether or not any significant change in temperature is occurring at sites, independent of natural seasonal fluctuations. Former state climatologist David Brown commented that temperature data for New England provides evidence supporting the theory of global climate change, and surface water temperature data for the Ossipee Watershed may also be important as far as this topic is concerned. (Carbon Coalition, 2007).

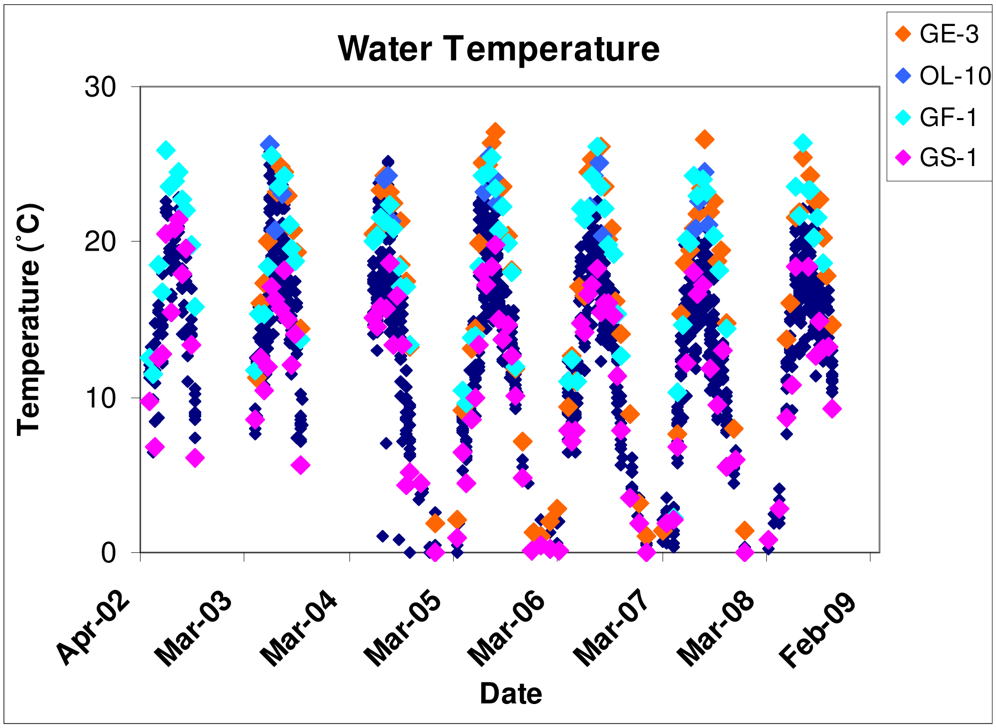


Figure 18: Water temperatures fluctuate seasonally. Year-round testing is providing a better understanding of conditions at sites, especially during the winter and spring when snow melt and storm water run-off can impact water quality. Some sites in the watershed, particularly lake outlets such as at Danforth Brook (GF-1/OL-11) and the Ossipee River (GE-3), have exhibited the warmest temperatures in the watershed, while sites like the Cold River (GS-1) have exhibited the coldest conditions in the watershed. **Note: There are 7 sites tested year-round. Other sites are tested April through October, such as GF-1.*

PGpppp5.5.Turbidity

Background: Turbidity is a measurement of the amount of suspended material in the water, such as clay, silt, algae, sediment, and decaying plant material. Turbidity is measured in nephelometeric turbidity units (NTU), the measure of light refraction through a vial of water. The more suspended material in the water, the more light is refracted and the higher the turbidity reading. In general, the murkier the water, the higher the turbidity.

Sources of increased turbidity include soil erosion, waste discharge, stormwater runoff, and excessive algal growth. Rain events often contribute to surface water turbidity by flushing sediment, organic matter and other materials from the surrounding landscape. These suspended materials can clog fish gills, reducing resistance to disease in fish, lowering growth rates, and affecting egg and larval development. As the particles settle, they can blanket the stream bottom, especially in slower waters, and smother fish eggs and benthic macroinvertebrates. Higher turbidity increases water temperatures because suspended particles absorb more heat. This, in turn, reduces the concentration of dissolved oxygen (DO) because warm water holds less DO than cold. Higher turbidity also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of life-supporting dissolved oxygen.

Class B NH Surface Water Quality Standard: Shall not exceed naturally occurring conditions by more than 10 NTUs.

Results: Most sites in the Ossipee Watershed exhibited low turbidity levels that were within a healthy range and state standards (Figure 19)(why this number when last figure was Fig. 17??), with the average for all sites being 1.18 NTUs. The one exception when turbidity levels fluctuated more than 10 NTUs occurred in 2005 when a spike in turbidity was observed at Phillips Brook (OL-12u), shown in Figure 20. This spike in turbidity was linked to sediment runoff witnessed from road work activities just upstream of the testing site. In this situation, best management practices were being used by the road crew, but were not completely effective at preventing sedimentation in the brook. Many chemical pollutants and nutrients are commonly attached to silt particles, and in this case, an associated phosphorous spike was also observed (Figures 21a. & 21b.).

Mean turbidity levels for the majority of RIVERS sites were below 2 NTUs, with the average for all sites at 1.18 NTUs. Frenchmans Brook (GO-2) had the highest mean turbidity of 1.92 NTUs for RIVERS sites, and a bracketing site upstream (GO-2ua) on the same waterbody had a mean turbidity of 2.25 NTUs. Although not as many data points were collected at GO-2ua compared with other sites, visual observations during a rainfall event pointed to runoff from a nearby sand parking lot as possible causes for higher turbidity readings. Three tributary sites had mean turbidity levels above 2 NTUs: Cold Brook (OL-9u) 2.01 NTUs; Phillips Brook (OL-12u) 12.66 NTUs; and Weetamoe Brook (OL-5u) 2.45 NTUs. The high mean turbidity for OL-12u includes the spike measured in 2005. Sites with the lowest mean turbidity levels included Cold River (GS-1) .50 NTUs; Swift River (GT-5) .55 NTUs; and Lovell River (OL-4u) .35 NTUs. Overall, higher turbidity levels were experienced since 2002 at most sites, most likely due to more frequent heavy rain events and more erosion.

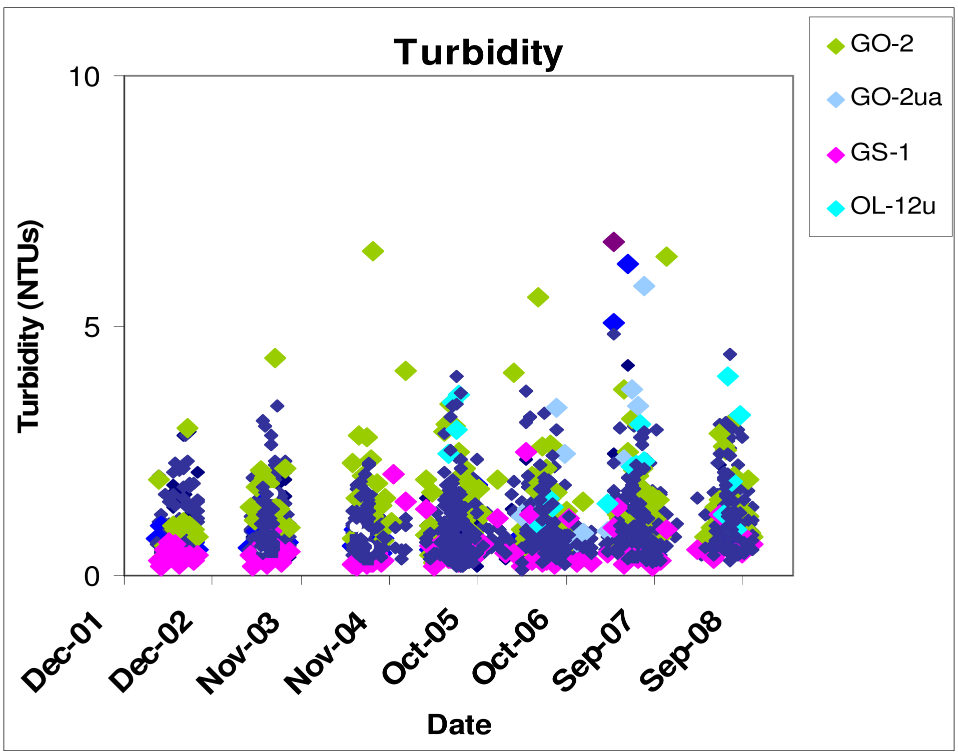


Figure 19: Turbidity levels recorded for RIVERS and OLT sites from 2002-2008. Sites shown in the legend have exhibited higher turbidity levels than other sites in the watershed. Most sites fall below 2 NTUs and have not fluctuated more than 10 NTUs, the state surface water quality standard.

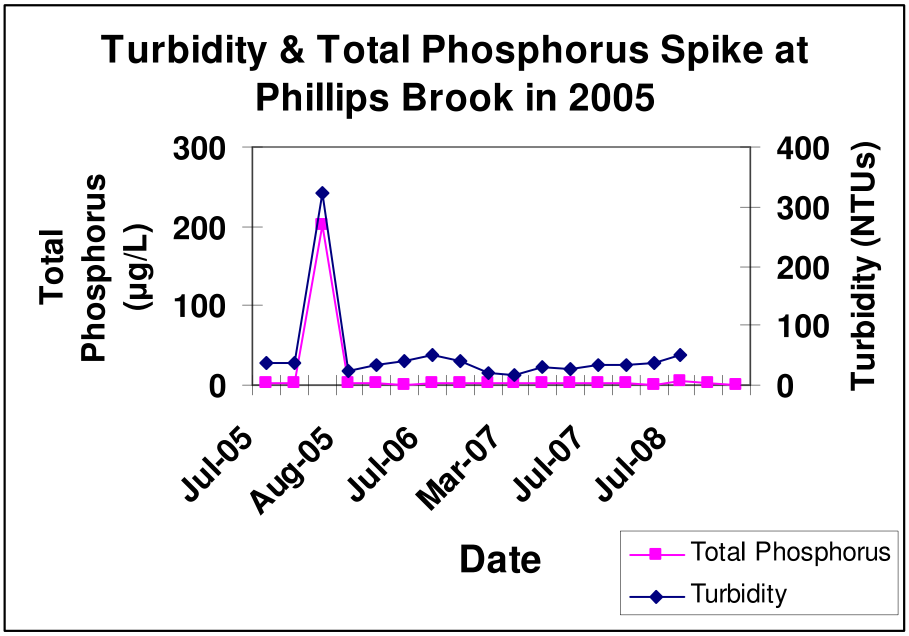
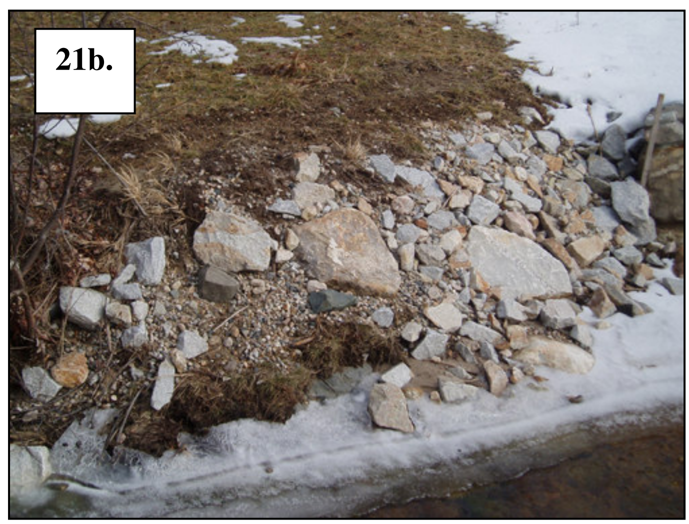


Figure 20: In 2005, Phillips Brook (OL-12u) experienced a spike in turbidity and total phosphorus due to sediment runoff from road work. This graph demonstrates how one incident can significantly impact water quality as well as the potential of the nutrient phosphorous to bind with sediment particles.



Figures 21a. & 21b: Best management practices were used in 2005 when road work was being done on Route 25. Although riprap and other screens were in place, there was some sedimentation observed in Phillips Brook. (Photos taken in winter, 2005).

Conductivity

Background: Conductivity is the numerical expression of water's ability to carry an electrical current. Water contains ions or charged particles, such as chloride, nitrate, sulfate, phosphate, sodium, magnesium, calcium, iron and aluminum. These ions can be from natural sources, such as bedrock, or introduced by human activity. "Specific conductivity" compares conductivity levels at 25°C since conductivity is influenced by temperature. High conductivity levels can be a sign of pollution from road salting, septic systems, wastewater treatment plants and urban or agricultural runoff.

Class B NH Surface Water Quality Standard: While there is no numeric standard for surface waters in the state because levels vary naturally according to local geology, values exceeding 100 $\mu S/cm^2$ generally indicate human disturbance. According to the DES, New Hampshire's surface waters traditionally have low conductivity values, but levels are increasing at a statistically significant rate largely due to the influence of road salting.

Results: In the Ossipee Watershed, water sampling has shown a close relationship between chloride and conductivity levels, indicating that chloride, accounts for 82% of the variation in conductivity levels at testing sites (Figure 22). This relationship will allow conductivity measurements to serve as a surrogate for chloride in future monitoring efforts, saving time and money by eliminating the need for lab analysis of chloride.

The majority of RIVERS and OLT sites monitored for conductivity between 2005 and 2008 had levels below 100 $\mu S/cm^2$ (Figure 23), with the mean for all sites at 67 $\mu S/cm^2$. However, some sites have consistently exhibited levels above 100 $\mu S/cm^2$. Four sites within the watershed have mean specific conductivity levels above 100 $\mu S/cm^2$, including: Banfield Brook (GM-1) at 120 $\mu S/cm^2$, Frenchmans Brook (GO-2) at 146 $\mu S/cm^2$, Phillips Brook (OL-12u) at 222 $\mu S/cm^2$, and Square Brook (OL-14u) at 121 $\mu S/cm^2$. These sites are located downstream from major roads, and have elevated sodium and chloride levels when compared with other sites, which is likely the cause of higher mean conductivity levels. Sites with the lowest mean conductivity values include Cold River (GS-1) at 23 $\mu S/cm^2$ and Lovell River (OL-4u) at 22 $\mu S/cm^2$.

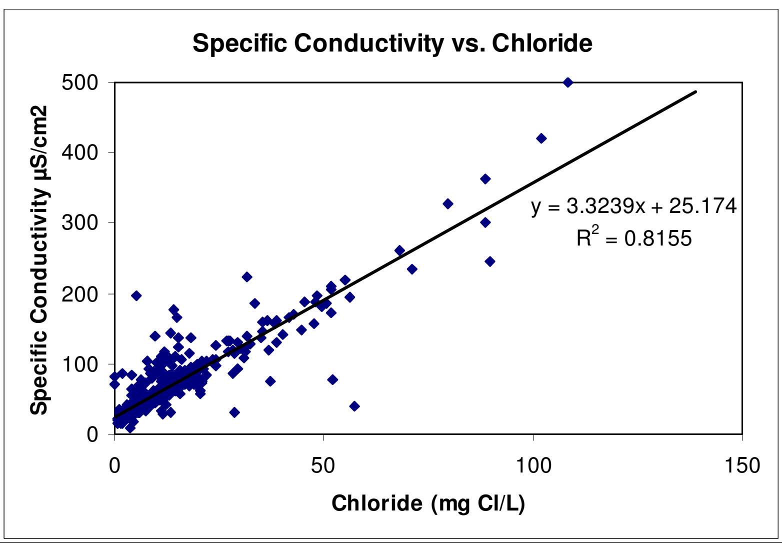


Figure 22: Variations in chloride levels account for variations in conductivity levels (road salt) 82% of the time at the Ossipee Watershed sites. This means that conductivity readings taken in the field can be used as a surrogate for chloride analysis in the lab if funding is not available to perform lab testing for all sites.

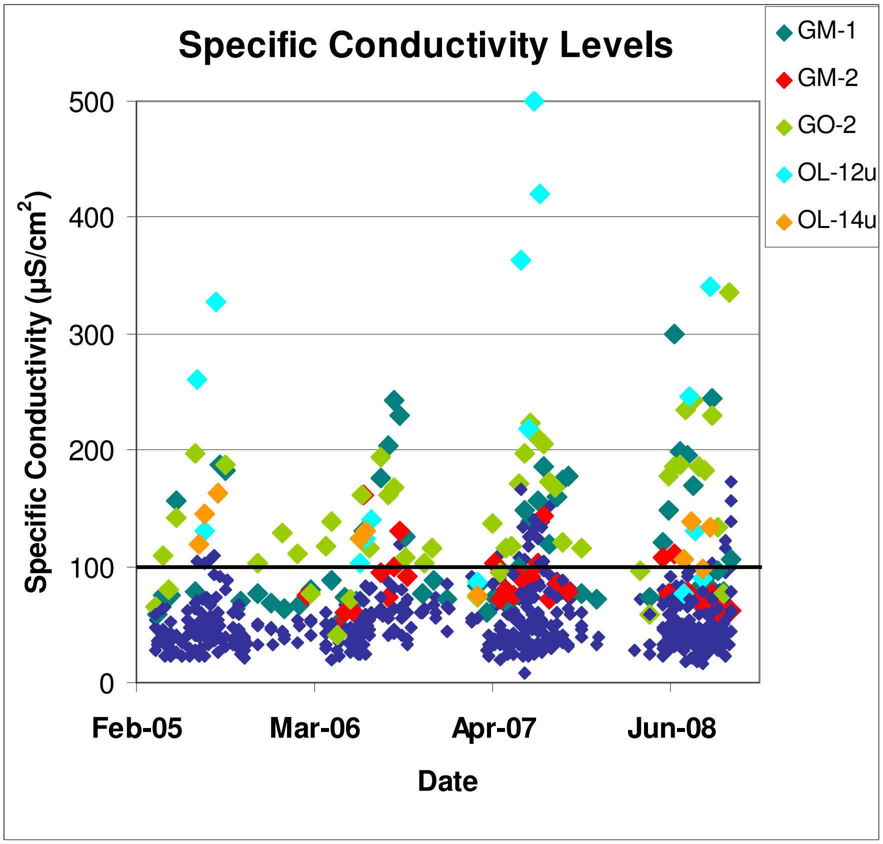


Figure 23: Conductivity levels greater than 100 µS/cm^2 have been observed at some sites within the watershed since conductivity testing began in 2005. Levels above 100 µS/cm^2 typically indicate human disturbance. Sites GM-1, GM-2, GO-2, OL-12u, OL-14u regularly have levels above 100 µS/cm^2.

Dissolved Oxygen

Background: Dissolved Oxygen (DO) is commonly expressed as a concentration in terms of milligrams per liter (mg/L) or as a percent saturation. Percent saturation is the amount of oxygen dissolved in water divided by the maximum amount of oxygen that water can hold at a given temperature. In some instances, water can become saturated with more than 100 percent dissolved oxygen. Oxygen is dissolved into the water from the atmosphere, from turbulent water and as a product of photosynthesis of aquatic plants. It is consumed by organisms in the water and is essential to the basic metabolic processes of most plants and animals and also to bacteria decomposing dead plants and animals. Dissolved oxygen levels rise throughout the day as a result of photosynthesis, reaching a peak in late afternoon. Overnight, as photosynthesis stops and organisms continue to use oxygen, levels fall, reaching a low point just before dawn. The amount of DO that water can hold is dependent upon temperature and atmospheric pressure as gases dissolve more easily in cooler water under higher pressure. Water flow, depth, and the amount of organic matter can also influence DO in water. Depletions in dissolved oxygen can cause major shifts in the kinds of aquatic organisms in water bodies (Figure 24).

How much oxygen do fish need?

Mg/L DO

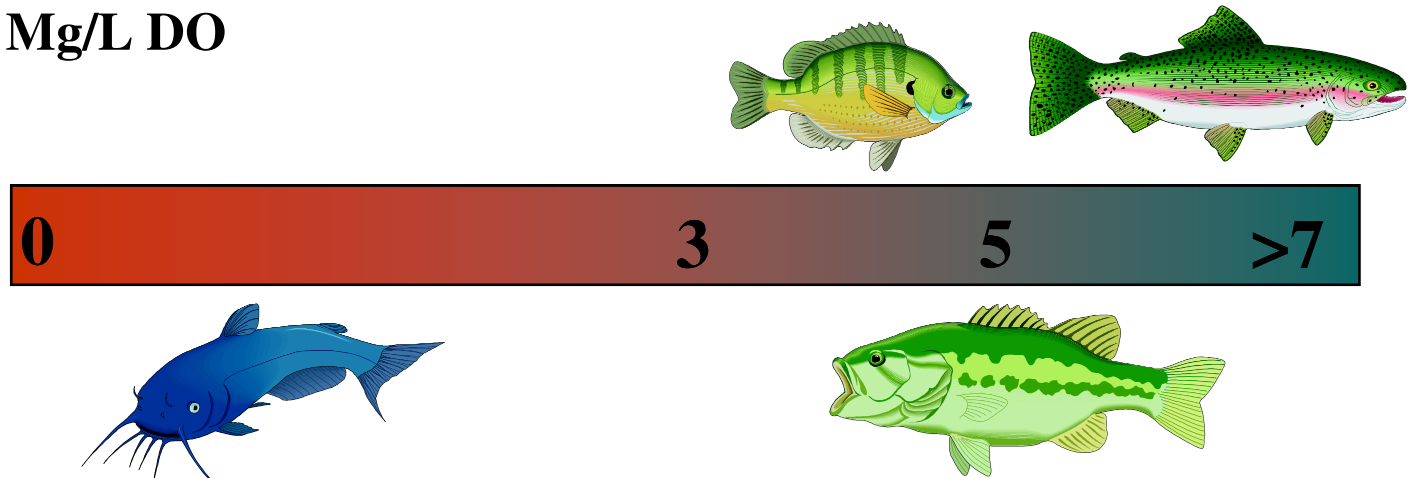


Figure 24: Different organisms have different tolerances for dissolved oxygen levels. For fish, trout and pike require more, catfish & carp require less. The aquatic insects that they depend upon for food also have different tolerances; mayflies, stoneflies, caddisflies and beetles cannot tolerate low oxygen levels, while sewage worms, midges and fly larvae are tolerant of low levels.

Class B NH Surface Water Quality Standard: 5 mg/L at any place or time or 75% minimum daily average, unless naturally occurring. When dissolved oxygen falls below 5 mg/L or a 75% minimum daily average, inputs of nutrients, wastes, or other organic material may be occurring. Levels are also considered critical for aquatic organisms when they fall below 5 mg/L.

Results: The majority of RIVERS and OLT sites demonstrated dissolved oxygen concentrations above 5 mg/L and 75% saturation (Figures 25 and 26), with the mean for all sites at 9.08 mg/L and 87.6%. Mean dissolved oxygen levels were highest at the Swift River (GT-5) at 11.06 mg/L and 101.9% and lowest at Red Brook (OL-7) at 2.21 mg/L and 24.12%. Sites with mean values that fell below either 5 mg/L or 75% saturation included: Pequawket Brook (GM-2) 67.58%, Red Brook (GE-4) 4.74 mg/L and 42.88%, Weetamoe Brook (OL-5u/5ua) 4.93 mg/L and 53.3% and 3.67 mg/L and 39.23%, and Phillips Brook (OL-12u) 66.17% (Figures 29 & 30, 31 & 32). Natural conditions may be driving down oxygen levels at sites such as GE-2, OL-12u, OL-7 and GM-2, all located below wetlands. In these instances, oxygen is likely being depleted by natural processes. Lower flow rates and associated build up of organic matter, whether natural or human-induced, could also be driving down oxygen levels at sites GF-2, OL-5u, OL-5ua and GE-4. Dams and culverts causing restrictions to water flow and resulting in stagnation could be the cause of low oxygen levels in a few cases. Human inputs of other organic matter could also be occurring at these sites, depleting oxygen levels.

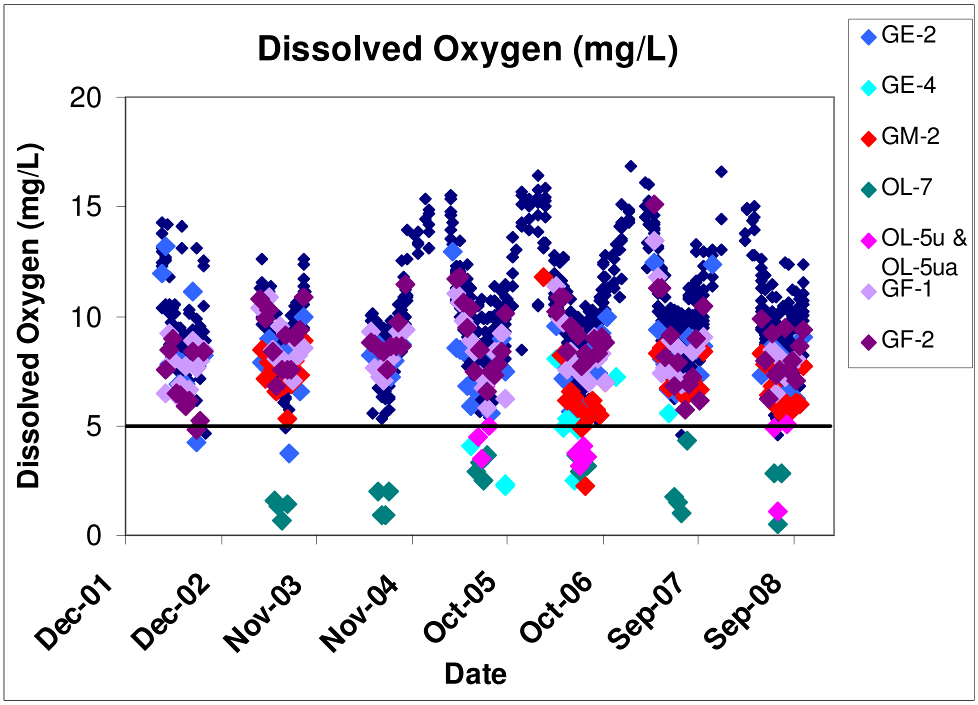


Figure 25: Dissolved oxygen levels recorded for RIVERS and OLT sites from 2002-2008. Sites shown in the legend exhibited levels lower than 5 mg/L, due to natural and/or human processes.

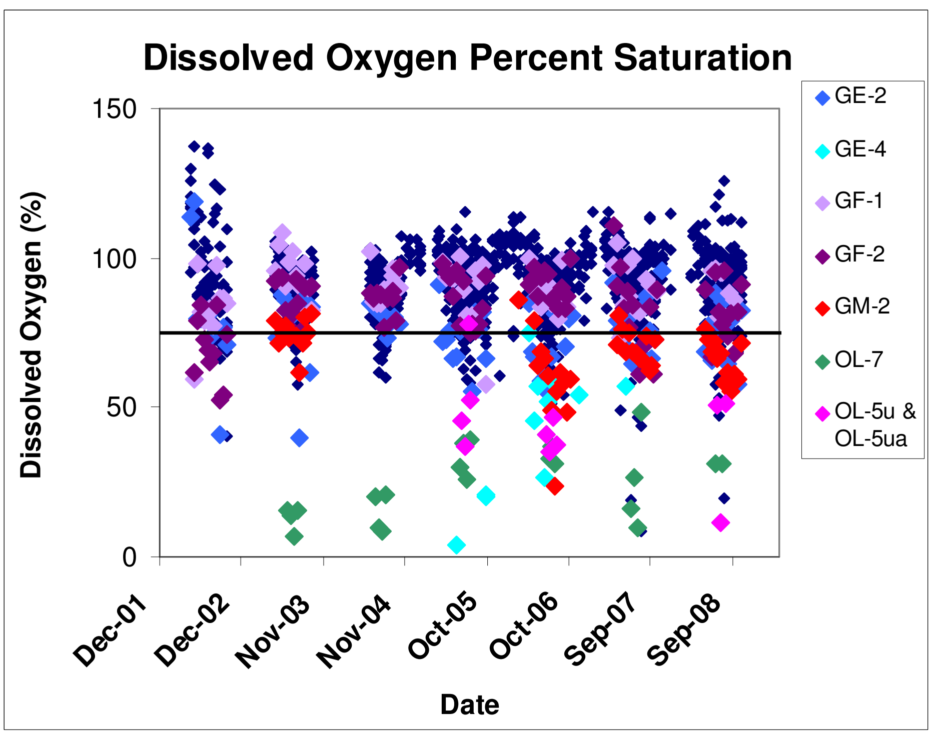


Figure 26: Dissolved oxygen levels recorded for RIVERS and OLT sites from 2002-2008. Sites shown in the legend exhibited levels lower than 75% saturation, due to natural and/or human processes.

pH

Background: pH is a measure of the acidity of water in terms of hydrogen ions. Water contains both hydrogen and hydroxyl ions. At a pH of 7.0 (neutral), the concentration of both is equal. When the pH is less than 7.0 (acidic), there are more hydrogen ions than hydroxyl ions. When the pH is greater than 7.0 (alkaline or basic), there are more hydroxyl ions than hydrogen ions. Everything that rivers come in contact with affects their pH, including soils, organic acids (decaying leaves or other matter), and human-induced acids from acid rain. pH affects many chemical and biological processes in the water, and different organisms flourish within different ranges of pH. The majority of aquatic animals prefer a range of 6.5– 8.0. The ability of aquatic organisms to complete a life cycle greatly diminishes as pH falls below 5.0 or exceeds 9.0. Levels below 5.5 can severely limit growth and reproduction in fish, as is the case with brook trout in some streams in New England. Low pH can also allow toxic elements and compounds such as heavy metals to become mobile and "available" for uptake by aquatic plants and animals. This can cause deformities in fish and produce conditions that are toxic to aquatic life. Low pH levels can be due to naturally occurring conditions, such as the influence of tannic and humic acids from decaying plants in wetlands. Humans can also influence pH in water bodies; wastewater discharge and atmospheric deposition of nitric and sulfuric acids in acid rain can also decrease pH levels. Surface waters in New Hampshire are particularly vulnerable to acid rain because their contact with granite confers little buffering capacity (as opposed to limestone-base water bodies). Since the Ossipee Watershed is downwind of industrial and urban areas (both in the State and in the Midwest) with automobile and coal power plant emissions, air quality and its effects on the pH of waterways is a major concern.

Class B NH Surface Water Quality Standard: pH must be between 6.5 and 8.0, unless naturally occurring. Reducing the minimum pH criteria to 6.0 may be considered as lower pH values (between 6.0 and 8.0) are often observed in streams in New Hampshire given the acidified rain (average pH of rain in New England is 4.3) and low buffering capacity due to the underlying geology. Until the statute and regulations are changed, however, compliance for pH must be based on this range.

Results: The majority of RIVERS and OLT sites had pH levels below the state standard and are therefore considered impaired, with the average for all sites at 6.22 (Figure 27). Mean pH levels varied from 3.75 at pilot site Red Brook (GE-4) to 6.76 at Danforth Pond outlet (GF-1). pH levels appear to have decreased at most sites since 2005, possibly due to higher rainfall experienced during these years. Mean pH levels are lower than 5.5 (the level that is critical for growth and reproduction in fish) at GE-4 (3.75) and downstream on the same brook at OL-7 (5.11). The presence of humic acids from upstream wetlands could account for the lower pH observed at site OL-7, but further investigation at site GE-4 is warranted since this site is not located below a known wetland. In this case, lower pH levels could be due to organic matter, restrictions to water flow, stagnation, or other inputs. UNH water quality experts have stated that pH levels at GE-4 are lower than what would normally be found under natural conditions.

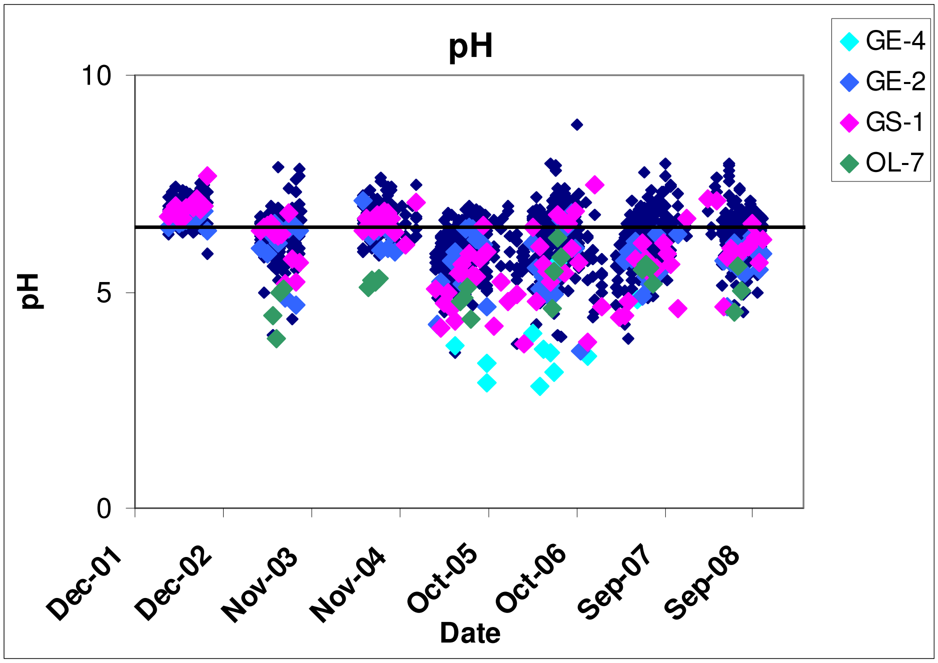


Figure 27: pH levels recorded for RIVERS and OLT sites from 2002 through 2006. Sites shown in the legend exhibited pH levels lower than 6.5, due to natural and/or human processes. Higher rainfall amounts in 2005 and 2006 may have contributed to lower pH readings than in the past since the average pH of rain in New England is 4.3.

Total Phosphorus

Background: Phosphorous is an essential nutrient for growth, and is the main limiting nutrient to plant growth in freshwater systems. Total phosphorus includes all dissolved phosphorus as well as the phosphorus contained in or adhered to suspended particles such as sediment and plankton. In nature, it is usually present in low concentrations. Phosphorus is primarily associated with human activities within the watershed and is therefore important to monitor and control. Total phosphorus will accumulate in slow moving stream reaches and in impoundments (i.e. upstream of a dam, in lakes and in wetlands) where phosphorus that is attached to particulates settles out of the water column. When a region becomes rich in phosphorus, it can result in localized algal blooms and related water quality problems, including cultural eutrophication. Sources of phosphorous include: human waste, animal waste, industrial waste, soil erosion, fertilizers, disturbance of land and vegetation i.e.: draining or filling wetlands Phosphorus tends to "stick" to sediment, and in instances of shoreline disturbance or heavy rain events causing erosion, phosphorus attached to soil particles can be washed into waterways. Figure 28 illustrates the relationship between suspended particles measured as turbidity, and total phosphorus.

Class B NH Surface Water Quality Standard: "Class B waters shall contain no phosphorus or nitrogen in such concentrations that would impair any existing or designated uses, unless naturally occurring". Due to the high degree of natural variability in total phosphorous and the difficulty in pinpointing an exact source, there is no numeric standard. However, DES does pay attention to readings above .05mg/L or 50 µg/L.

Results: As in past reports turbidity and total phosphorus have been closely related at Ossipee Watershed sites. Analysis of the data shows that variations in turbidity account for 61% (R^2=0.61) of the variations in total phosphorus concentrations at most sites (Figure 28), the exceptions being Red Brook (OL-7) and Weetamoe Brook (OL-5ua) The majority of RIVERS and OLT sites demonstrated total phosphorus concentrations below 50 µg/L, with the mean level for all sites at 11.97 µg/L (Figure 29). Mean concentrations ranged from 3.12 µg/L at Lovell River (OL-4u) to 77.99 µg/L at Red Brook (OL-7). Sites with mean levels above 50 µg/L included: Red Brook (GE-4) 56.10 µg/L; Red Brook (OL-7) 77.99 µg/L; Phillips Brook (OL-12u) 52.18 µg/L; and Weetamoe Brook (OL-5ua) 72.22 µg/L.

Site OL-7 is part of a large wetland complex. Elevated total phosphorus levels may be attributed to this wetland system. In other instances, singular spikes in total phosphorus drove up mean total phosphorus levels at sites GE-4 and OL-12u. At site OL-12u, this spike was associated with sediment runoff observed the day of sampling (Figure 30). At site GE-4 this spike could be attributed to water stagnation and associated nutrient accumulation that has been observed at the site. The GE-4 mean value is also based on three samples, and could be attributed to sample contamination or lab error for one of the samples taken in 2006. Similarly, site OL-5ua has exhibited low flow and water stagnation which could be responsible for higher levels of total phosphorus.

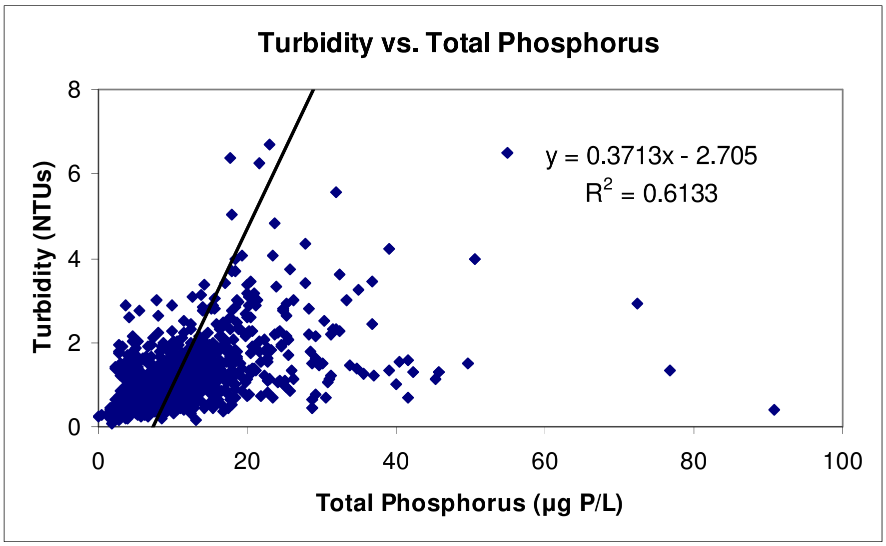


Figure 28: A comparison of total phosphorous and turbidity for sites in the Ossipee Watershed shows that total phosphorus and turbidity have been closely related. Analysis of the data shows that variations in total phosphorus concentrations account for variations in turbidity levels 61% (R^2=0.6133) of the time at most sites the exceptions being Red Brook (OL-7) and Weetamoe Brook (OL-5ua).

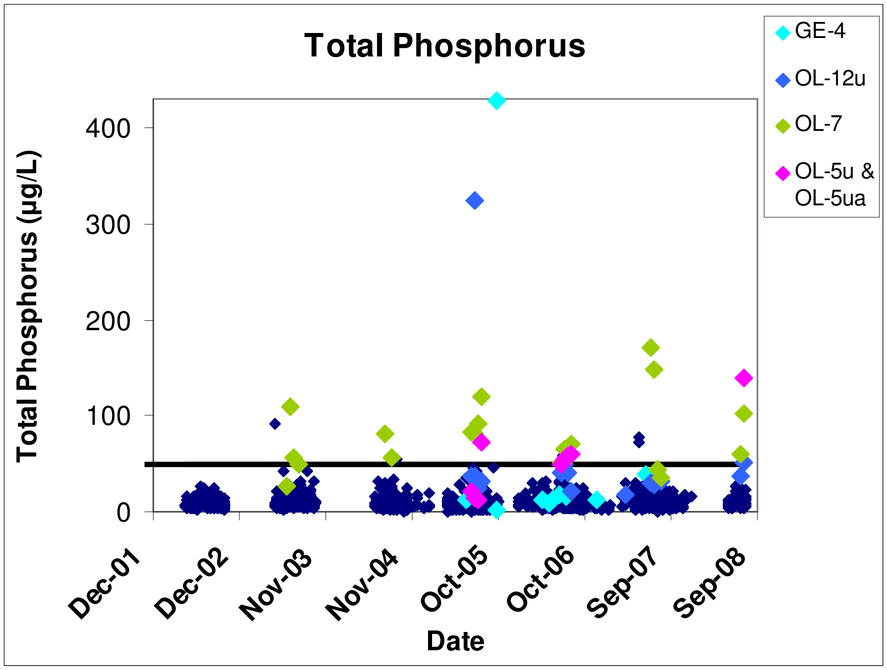


Figure 29: Total phosphorus concentrations recorded for RIVERS and OLT sites from 2002 through 2008. Sites shown in legend exhibited total phosphorus levels higher than 50µg/L, due to natural and/or human processes.

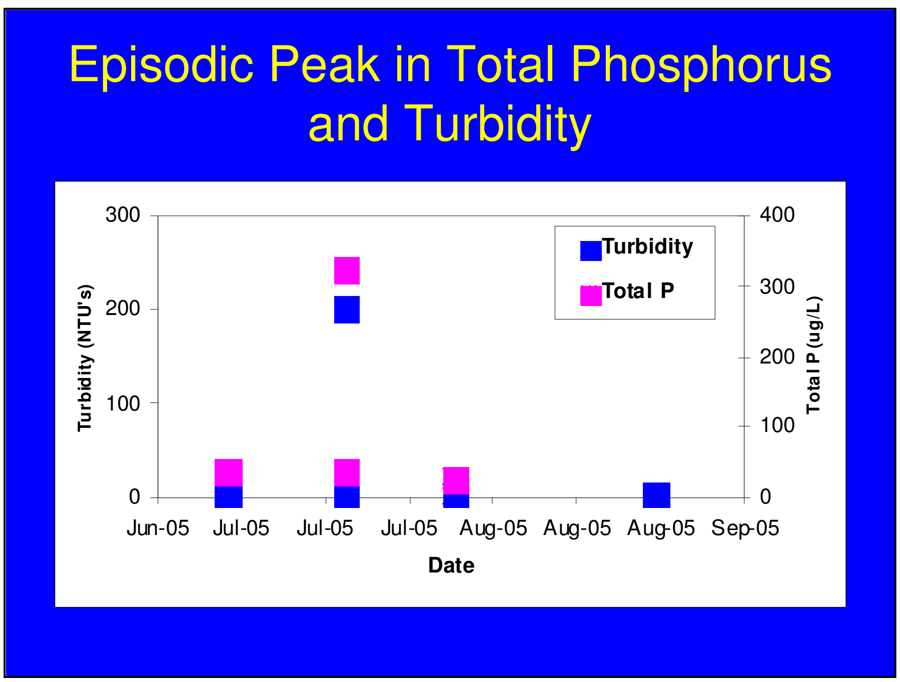


Figure 30: One episode in 2005 was recorded when total phosphorous and turbidity levels spiked at Phillips Brook (OL-12u). Water was visibly murky from shore disturbance upstream at a road construction site. In this instance, total phosphorous levels reached 324.2 µg/L. Levels at this particular site usually average 35.2 µg/L. *(Graph courtesy Michelle Daley, UNH)*

Phosphate

Background: Phosphate or orthophosphate (PO_4) is a component of total phosphorus and is the most biologically available form of phosphorous. Since it is a component of total phosphorous, it is impossible for phosphate to exceed total phosphorus. Phosphate is typically very low in natural systems, therefore a small amount of phosphate can have a large impact, triggering problematic algal blooms, plant growth, decreased oxygen levels, decreased recreation, and an overall domino effect on a water system that can lead to eutrophication. This can lead to anoxia, or deficiency of oxygen, in fish and other aquatic organisms. Sources of phosphate include: sewage, agricultural inputs, excess fertilizing and stormwater runoff. Synthetic phosphates are also often used in laundry detergent as a water softener.

Class B NH Surface Water Quality Standard: As with total phosphorous, there is no numeric surface water quality standard for phosphate due to the high degree of natural variability and difficulty in pinpointing the exact source. However, natural levels are usually low, and under 50 µg PO_4-P/L. In the Lamprey Watershed of southern New Hampshire, typical streams average 0-20 µg PO_4-P/L.

Results: The majority of RIVERS and OLT sites had phosphate concentrations below 20 µg PO_4-P/L, with the average for all sites at 5 µg PO_4-P/L. Mean phosphate levels ranged from 0 µg/L at West Branch River (OL-1) to 151 µg PO_4-P/L at Red Brook (GE-4) (Figure 31). Red Brook (OL-7) 50 µg PO_4-P/L, Square Brook (OL-14u) 26 µg PO_4-P/L and pilot site (GE-4) 151 µg PO_4-P/L had mean values above 20 µg/L. A phosphate-rich environment at OL-7 could be explained by the wetland that OL-7 drains. The upstream site on the same waterbody, pilot site Red Brook (GE-4) had a mean value of 151 µg PO_4-P/L, however, this is based on three samples, and could be attributed to sample contamination or lab error for one of the samples taken in 2005 where phosphate was higher than total phosphorus. A few sites appear to have elevated phosphate levels in 2005 and 2007. This could be a result of higher precipitation amounts experienced in the watershed during those year's and excess stormwater runoff. By examining the regression line and the total phosphorus and phosphate data in Figure 32, there seems to be some phosphate levels that exceed total phosphorus, which could be lab error.

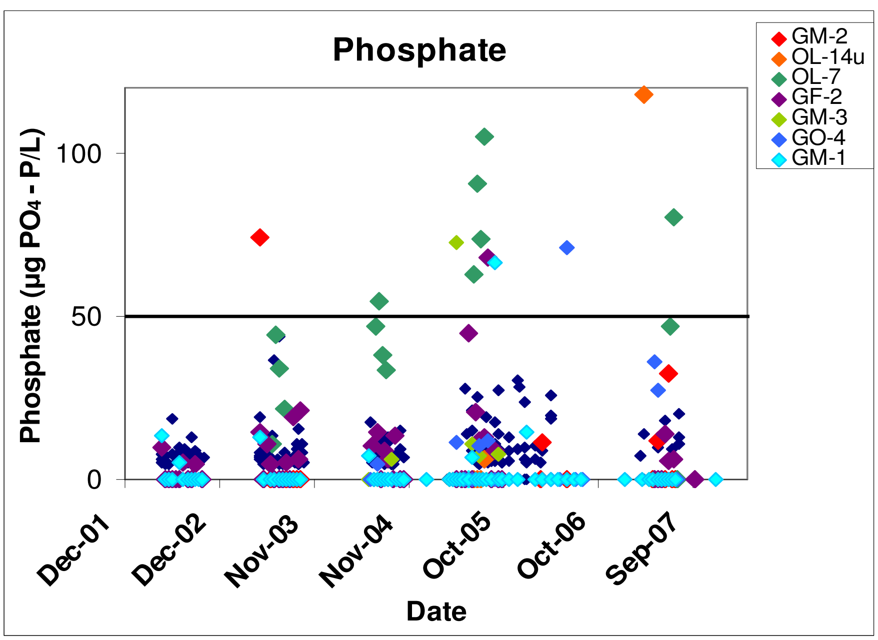


Figure 31: Phosphate levels for all sites over time. Sites shown in the legend exhibited phosphate levels higher than 50µg/L, due to natural and/or human

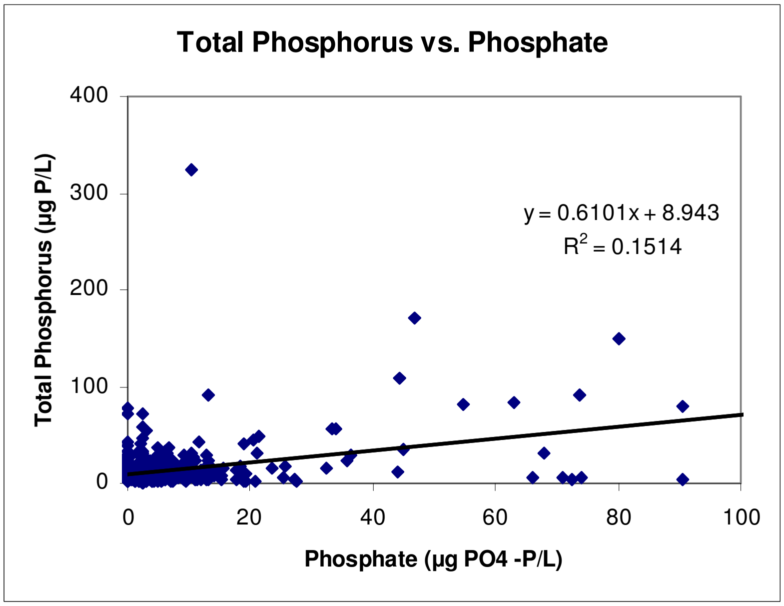


Figure 32: Comparison of phosphate and total phosphorus measurements for all sites 2002-2008. 15% of the variability of total phosphorus can be accounted for by variability in phosphate concentrations.

Dissolved Organic Carbon (DOC):

Background: Dissolved Organic Carbon (DOC) occurs naturally as a result of decomposition processes of organic matter, such as plants. DOC is a broad classification for organic molecules of varied origin and composition within aquatic systems. When water gets in touch with high organic soils such as those found in wetlands and forests, a certain amount of these components can be drained into rivers and lakes as DOC.

DOC and Dissolved Organic Nitrogen (DON) are both part of Dissolved Organic Matter (DOM). The ratio of DOC to DON determines the quality of DOM, since DON estimates the proportion of total dissolved organics (DOC) comprised of N-rich (i.e., high quality) protein. A lower DOC to DON ratio generally indicates higher quality DOM, or matter that is more digestible for organisms. DON and DOC are often positively related to each other as they are chemically bound together (when DOC increases so does DON).

Although most DOC is natural in origin, occasionally, high levels of organic carbon indicate anthropogenic influences such as storm water run off and sewage inputs. Chlorination of high DOC water causes the formation of trihalomethanes, which have been linked to cancer, reproductive problems and other heath issues. DOC is also extremely important in the transport of metals in aquatic systems. Metals form extremely strong complexes with DOC, enhancing metal solubility while also reducing metal bioavailability.

Class B NH Surface Water Quality Standard: There is no state standard for DOC, however, in the absence of extensive wetlands, baseflow concentrations of DOC in undisturbed watersheds generally range from approximately 1 to 20 mg C/L. DOC will also vary seasonally, typically higher with leaf matter in the fall, and may be higher than 20 mg/L with significant wetlands.

Results: Most RIVERS and OLT sites demonstrated DOC concentrations below 20 mg/L from 2002-2008, with the average for all sites at 3.61 mg/L (Figure 33). Mean DOC levels ranged from 1.49 mg/L at Lovell River (OL-4u) to 19.3 mg/L at Weetamoe Brook (OL-5ua). Only pilot site Red Brook (GE-4) had a mean value above 20 mg/L at 21.79 mg/L based on three samples, and downstream on the same brook were the third highest mean DOC levels for the watershed of 15.43 mg/L at OL-7. High DOC values are to be expected at OL-7 because of the wetland system that it drains. Other sites that exhibited higher concentrations of DOC include: Phillips Brook (OL-12), Phillips Brook (OL-12u); and South River (GE-2), however, levels were still below 20 mg/L at these sites. Most likely, these levels were due to wetlands upstream of the sampling sites, except at sites GE-4 and OL-5ua where restrictions to water flow and low flow periods may have caused elevated DOC levels (Figure 34a. & 34b.).

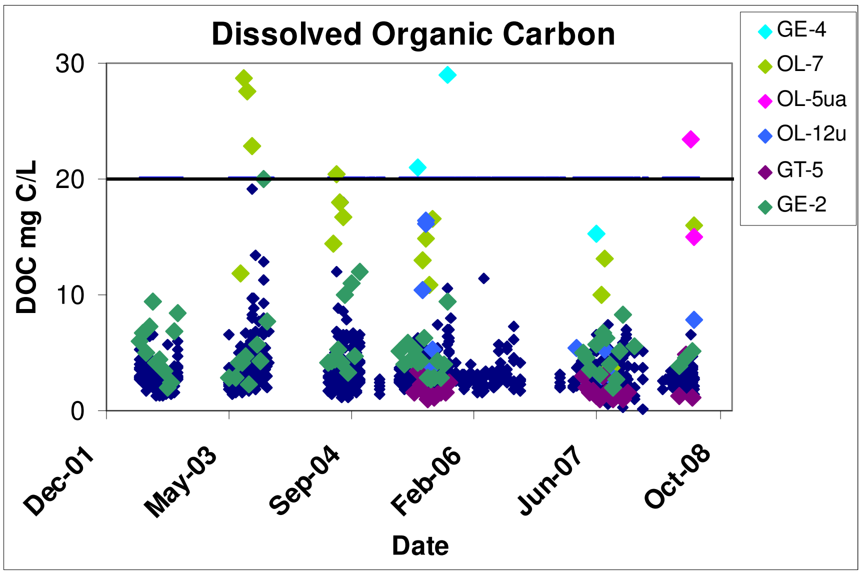


Figure 33: Dissolved organic carbon levels have been variable for Ossipee Watershed sites in the past five years. Sites shown the legend exhibited DOC levels higher than 20mg/L, due to natural and/or human processes. Site GT-5 (Swift River) has exhibited some of the lowest DOC levels, with the mean being 1.79 mg/L.

34a.

Figures 34a. & 34b.: Restrictions to flow from high-placed culverts (37a.) and stagnant waters (37b.) could be contributing to higher DOC levels at sites such as GE-4 and OL-5ua.

34b.

Nitrogen

Background: Nitrogen makes up about 80% of the earth's atmosphere and is found in all plant and animal tissues. It is considered a limiting nutrient in stream water. Nitrogen is categorized as either organic or inorganic. We refer to organic nitrogen as Dissolved Organic Nitrogen (DON) and inorganic nitrogen as Dissolved Inorganic Nitrogen (DIN). DIN is the sum of two forms of inorganic nitrogen, ammonium and nitrate. Combined DON and DIN make up Total Dissolved Nitrogen (TDN). Both DIN and DON can be important nutrients for plants and microbes, but DIN is the preferred form of nitrogen to fuel growth. Excess nitrogen loading, particularly DIN loading, in streams can act as a fertilizer to algae and other aquatic plants, resulting in unwanted algal blooms and excessive growth. In most undisturbed ecosystems, DON will be higher than DIN and in disturbed streams, DIN (nitrate and ammonium) will be higher than DON. DIN enters bodies of water from storm water runoff, septic systems, animal waste, agricultural runoff, excess fertilizing of lawns and discharges from car exhausts. DON is generated by natural processes occurring in wetlands and forest soils.

Ammonium is a form of DIN that is a toxic waste product of metabolic processes in animals. Ammonium ions (NH_4^+) are the preferred form of nitrogen for plant and microbial uptake since it is more energy efficient to use than nitrate. However, ammonium is typically very low in undisturbed streams, since in the presence of oxygen, it is rapidly nitrified by bacteria, turning into nitrate. High levels usually indicate some type of pollution resulting in limited oxygen present..

Nitrate is an inorganic form of nitrogen that occurs naturally from the nitrification of ammonium. Nitrification occurs in an oxygen rich environment, such as in stream water, where microbes convert ammonium to nitrite (NO_2^-) which is then quickly converted to nitrate (NO_3^-). The conversion of nitrite to nitrate is so fast that nitrite is usually undetectable in stream water. Particulate nitrate is not abundant in nature as nitrate is very soluble. Nitrate is widely used as an indicator of water quality. In freshwater systems, nitrate can reach high levels that can potentially cause the death of fish and other aquatic organisms since nitrification causes acidification and oxygen depletion. Elevated levels of nitrate can also lead to eutrophication and induce algal blooms, leading to water anoxia. Nitrate contamination of drinking water can cause Methemoglobenemia, a serious illness in infants where respiration in inhibited and increases the risk of gastric cancer at levels above 4 mg NO_3-N/L (Ward et al. 1996).

Class B NH Surface Water Quality Standard: No quantitative standard exists, however, nitrogen should not occur in any concentration that would impair designated uses, unless naturally occurring. The EPA limit for nitrate in drinking water is 10 mg NO_3-N/L, however, some studies have suggested that concentrations above 4 mg NO_3-N/L can cause neurological damages (Michelle Daley, 2005). Typical nitrate levels in undisturbed streams are usually 0-.5 mg NO_3-N/L, 0.5 to 2 mg NO_3-N/L suggest some level of disturbance and nitrate levels greater than 2 mg NO_3-N/L clearly indicate disturbance. In the Lamprey Watershed (southeastern NH), streams averaged 0-1 mg NO_3-N/L, depending on development. Ammonium levels in streams are also usually low as well, typically less than 200 µg NH_4-N/L, and in the Lamprey Watershed levels average between 0-100 µg NH_4-N /L.

Results: DON is greater than DIN (nitrate and ammonium) at most sites, and DON comprised more than 63% of the mean at all sites (Figure 35). Sites GM-2, GT-2, GT-4, GT-5, GO-2u, GO-5, OL-1u, OL-9u, OL-12u and OL-14u are sites where mean DIN was greater than or equal to DON. These sites have DIN concentrations which range indicate impairing inputs from human activities. Of the sites where DIN dominated TDN, site GM-2 Pequawket Brook had the highest percentage of TDN as nitrate(73%, .37 mg NO_3-N/L) and OL-7 Red Brook had the highest percentage of TDN as ammonium (38%, 139.14 ug NH_4-N/L).

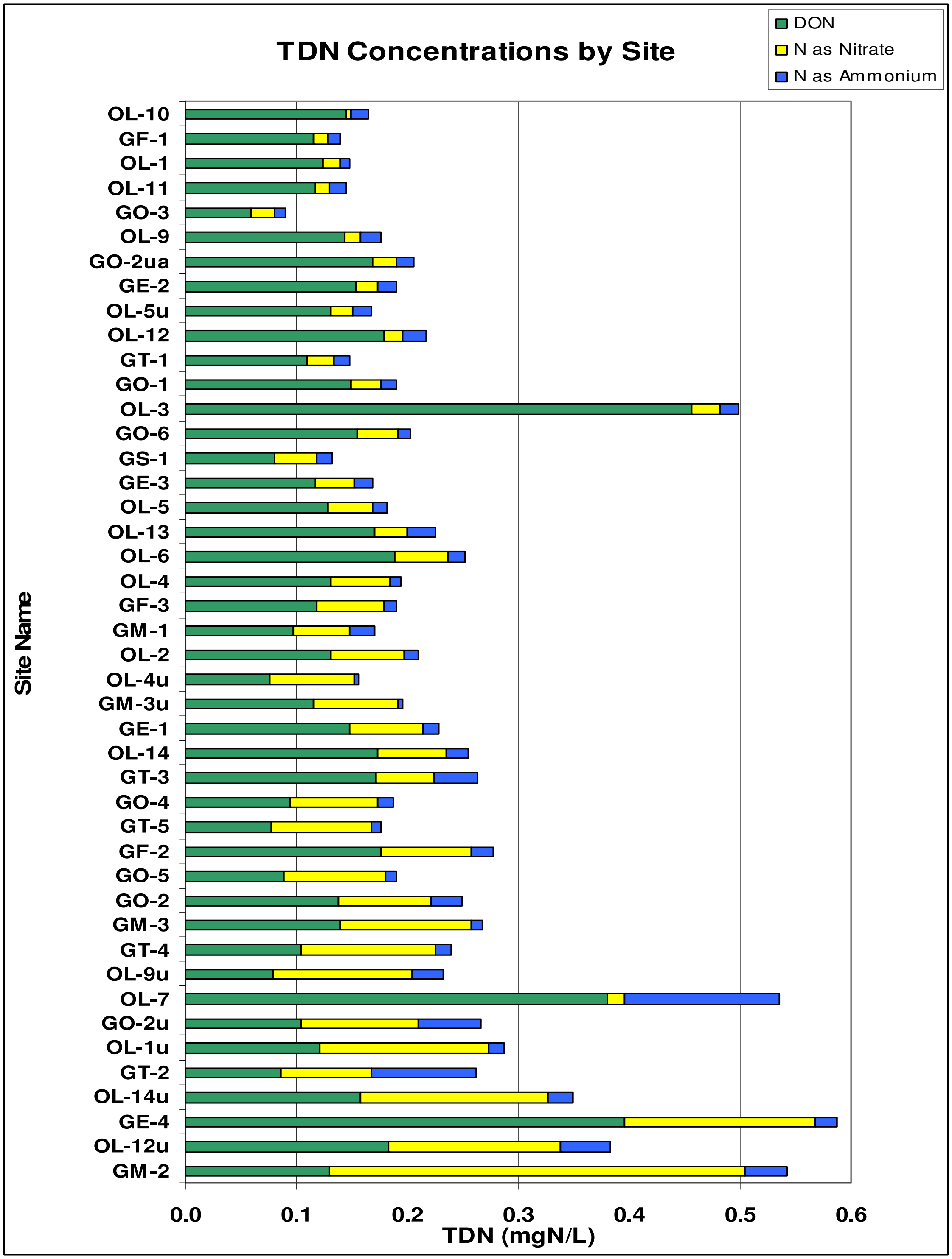


Figure 35: RIVERS and OLT sites mean total dissolved nitrogen comparison for 2002-2008. Bars show range of TDN levels for each site. Colored bars show fractions of DON, nitrate and ammonium. Since organic nitrogen typically dominates in unimpaired systems, where DIN dominates DON, or yellow and blue bars are greater than green bars there may be an impairing input. Mean DON dominates at most sites, however, sites GM-2, GT-2, GT-4, GT-5, GO-5, GO-2u, OL-1u, OL-9u, OL-12u and OL-14u have higher mean DIN concentrations. GM-2 in particular showed signs of impairment with the highest DIN concentration.

Sites shown in Figure 36 have higher DON levels, most of which are located nearby wetlands which could account for higher levels.

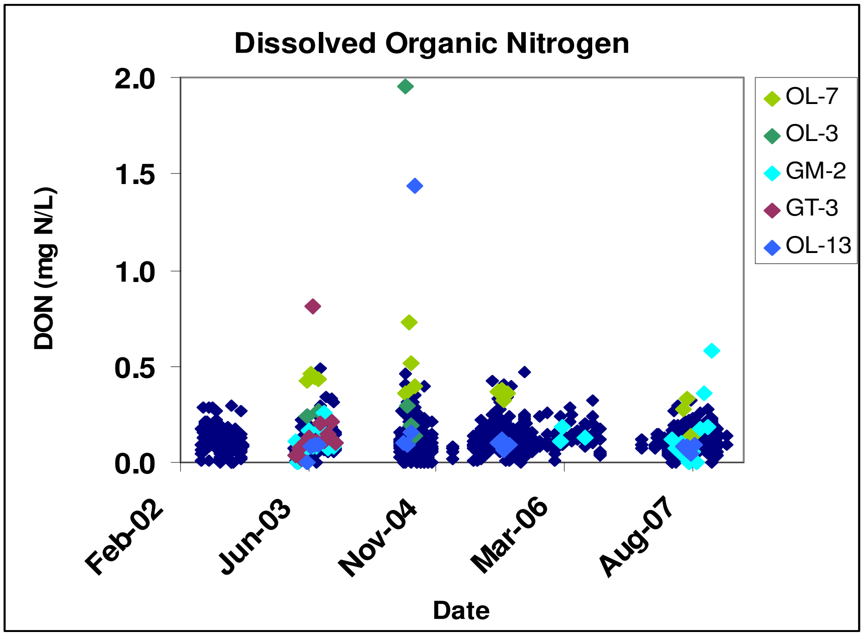


Figure 36: Dissolved Organic Nitrogen (DON) is generated by natural processes occurring in wetlands and forest soils. In most undisturbed ecosystems, DON will be higher than DIN and in disturbed streams, DIN (nitrate and ammonium) will be higher than DON. Sites shown in the legend have higher DON levels.

Mean nitrate concentrations ranged from 0 mg NO_3-N/L at Danforth Pond inlet (OL-10) to .37 mg NO_3-N/L at Pequawket Brook (GM-2). Nitrate concentrations have typically been below .5 mg NO_3-N/L since testing began, with the average for all sites being .07 mg NO_3-N/L (Figure 37). Site GM-2 is up to 1 mg N/L, which is on the high end of what is showing up in more developed southeastern New Hampshire. These levels also appear to be increasing over time.

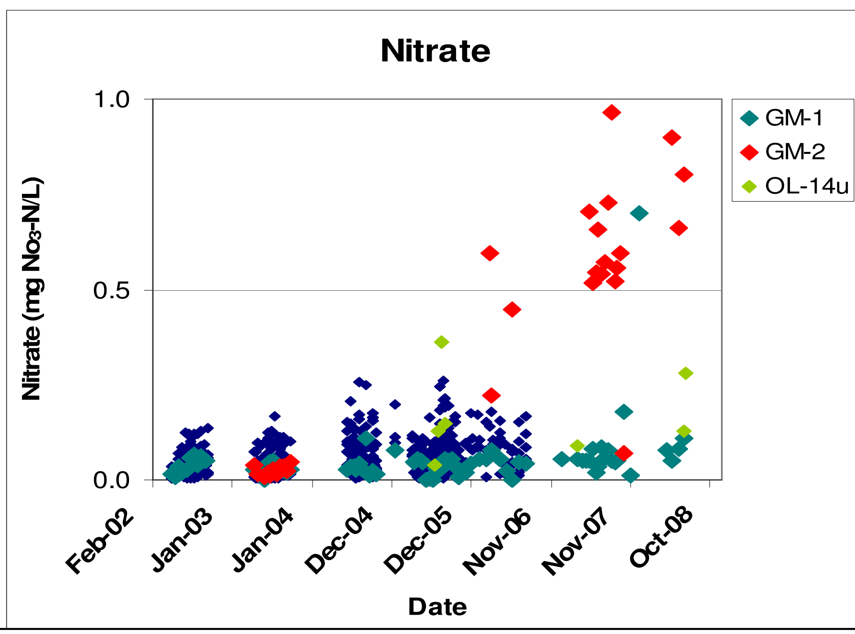


Figure 37: Sites exhibiting higher nitrate levels in the Watershed include those shown in the legend: GM-2, GM-1 and OL-14u. Site GM-2 is up to 1 mg N/L, which is on the high end of what is showing up in more developed southeastern New Hampshire. These levels also appear to be increasing over

Testing along the Bearcamp River at various sites showed higher nitrate concentrations at downstream sites, although levels were relatively low (Figure 38), and an increase in nitrate levels over time. Pine River sites also have low, but increasing nitrate concentrations (Figure 39). Bracketing of Route 113 and a local gas station at Forrest Brook (GM-3 & GM-3u) has shown only slightly higher nitrate levels downstream of the road and the gas station (Figure 40). Future testing will determine if there is a statistically significant increase in nitrate levels over time.

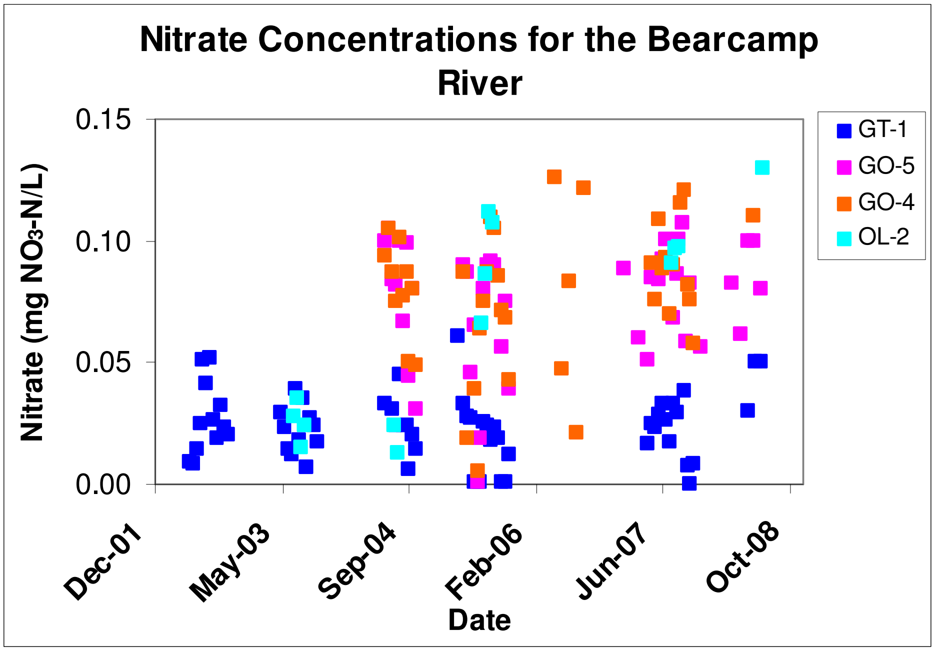


Figure 38: Nitrate concentrations on the Bearcamp River sites. Sites are listed from most upstream site (GT-1) to most downstream site (OL-2). Nitrate levels were higher downstream from site GT-1 at sites GO-5, GO-4 and OL-2. Nitrate levels at site OL-2, at the mouth of the Bearcamp River as it enters Ossipee Lake, increased from 2003 to 2008. Similarly, levels at GO-4 and GO-5 increased from 2004 to 2008. Future testing will show if this is an ongoing trend.

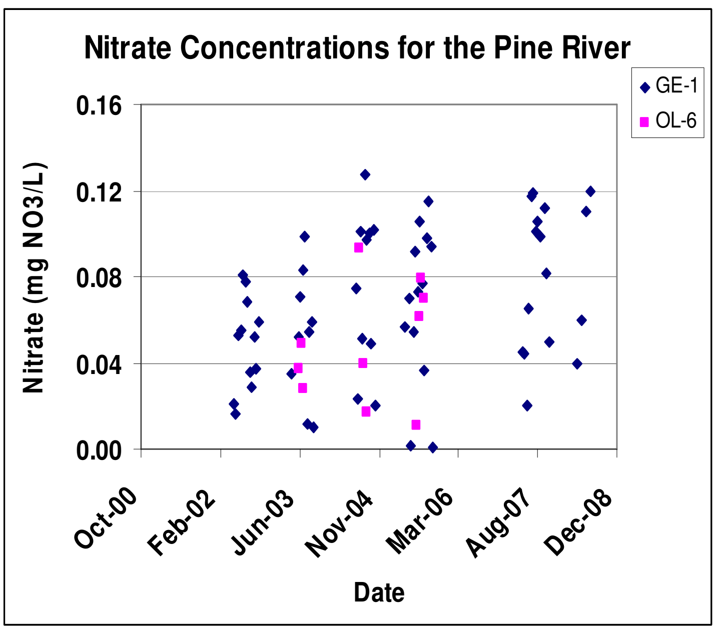


Figure 39: Nitrate concentrations for the Pine River were lower downstream from site GE-1 at site OL-6. Nitrate levels at site OL-6, at the mouth of the Pine River as it enters Ossipee Lake, increased from 2003 to 2006. Similarly, levels at GE-1 increased from 2002 to 2008. Future testing will show if this is an ongoing trend.

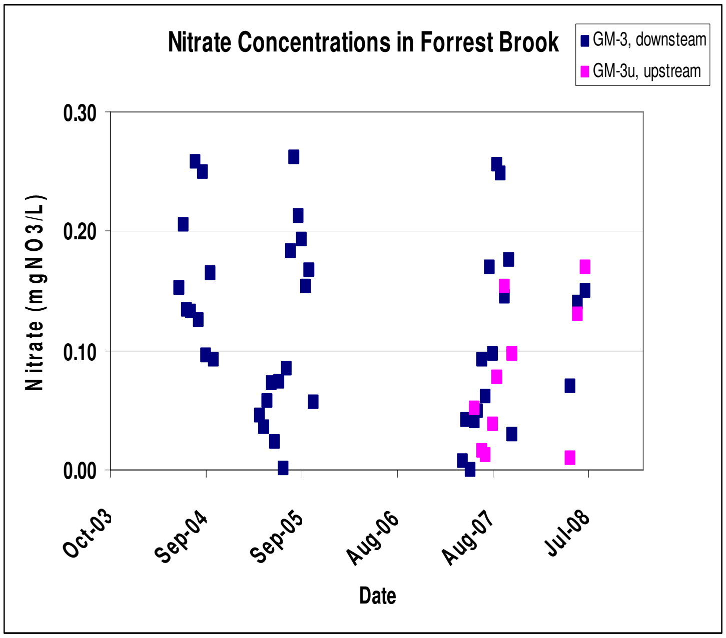


Figure 40: Forrest Brook GM-3 has exhibited some of the highest nitrate concentrations of all sites in the past. Site GM-3u was chosen to bracket the brook and determine where nitrate could be entering the system. Nitrate concentrations appeared to be only slightly lower upstream at site GM-3u than at site GM-3 from samples taken in 2007 and 2008.

Mean ammonium levels ranged from 4 µg NH_4-N/L at Lovell River (OL-4u) to 139 µg NH_4-N/L at Red Brook (OL-7). Ammonium concentrations have typically been below 200 µg NH_4-N/L since testing began, with the average for all sites at 20 µg NH_4-N/L (Figure 41). Red Brook (OL-7) has exhibited some higher ammonium levels, possibly from nearby wetland/wildlife influences.

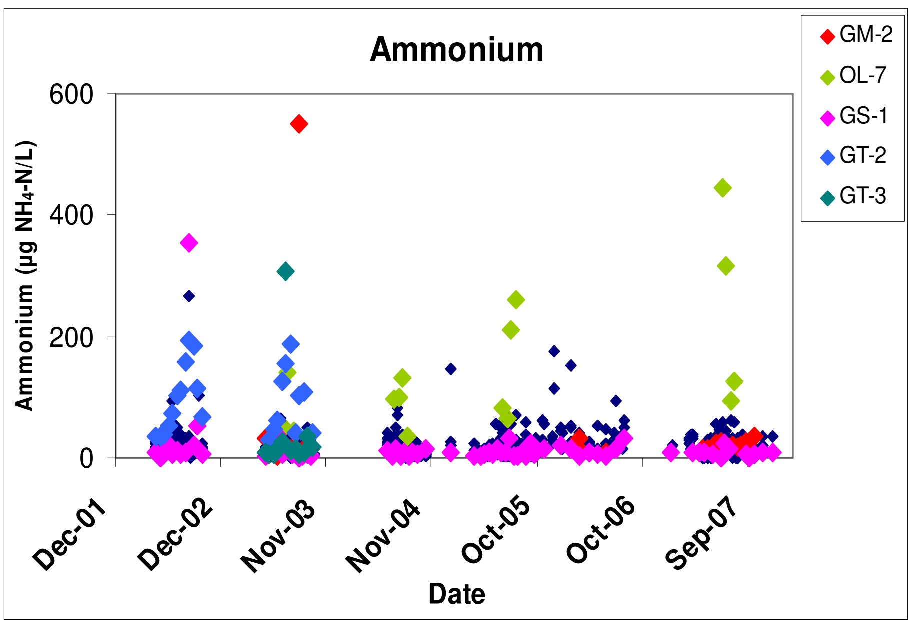


Figure 41: Ammonium concentrations have been very low at sites tested in the Ossipee Watershed sites since 2002. Sites exhibiting higher ammonium levels in the Watershed are shown in the legend.

Dissolved Organic Matter:

Background: Dissolved organic carbon and dissolved organic nitrogen are both forms of dissolved organic matter (DOM) which is found naturally in the environment. The quantity of carbon and nitrogen found in DOM is indicated by DOC and DON concentrations. The ratio between these two elements is used to determine the quality of the DOM, or how digestible it is. A lower C:N ratio generally indicates higher quality DOM – suggesting a comparatively higher portion of N-rich protein in the detrital material.

Class B NH Surface Water Quality Standard: There is no numeric standard due to the high degree of natural variability.

Results: DOC has been less than 10 mg C/L 97% of the time at Ossipee Watershed sites (Figure 42). Sites OL-7, OL-5ua, GE-4, OL-12u, and GE-2 have shown levels higher than 10 mg C/L, and these sites are either downstream of wetlands or have some issues with flow/water stagnation. Wetands are typically the largest sources of DOM. Based on the regression line in Figure 43, dissolved organic carbon (DOC) explains 50% (R^2=0.50) of the variation in dissolved organic nitrogen (DON) for all sites.

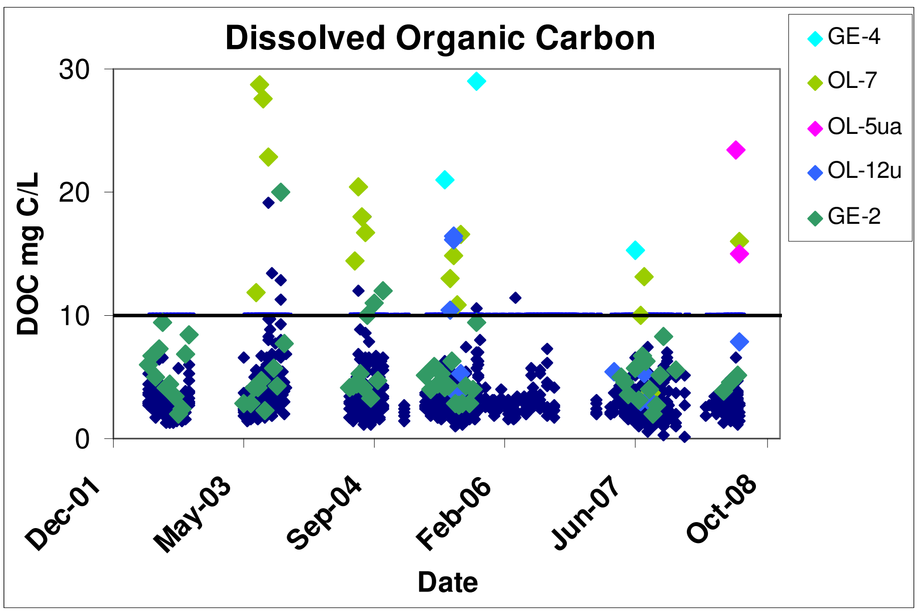


Figure 42: DOC is less than 10 mg C/L 97% of the time at Ossipee Watershed sites since 2002. Sites shown in the legend have had levels higher than 10 mg C/L

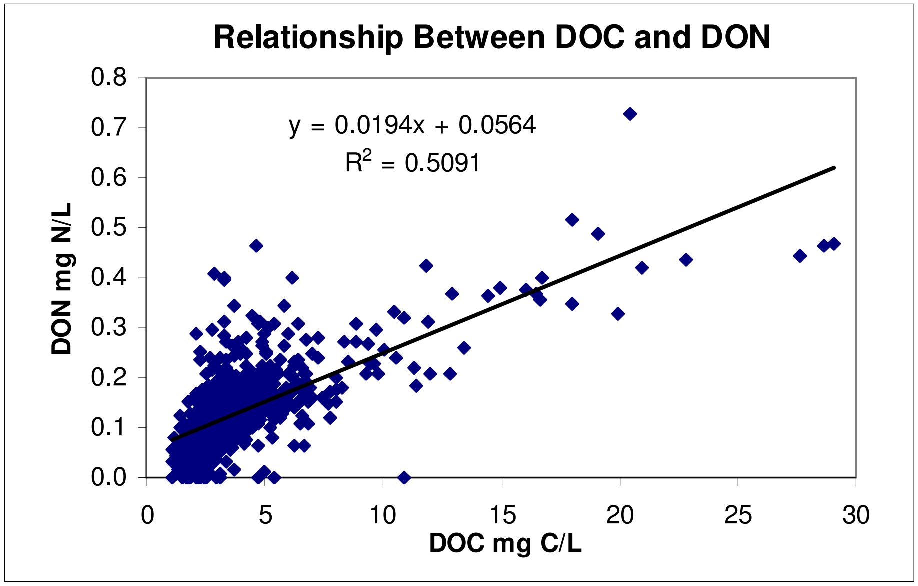


Figure 43: The relationship between DON and DOC for all sites in the Watershed. This regression line shows that variations in dissolved organic carbon accounts for 50% of the variation in dissolved organic nitrogen.

Sodium:

Background: Sodium (Na) is a component of many minerals and is an essential element for animal life. It is present in great quantities in the earth's oceans as sodium chloride. Natural levels of sodium can vary depending on geology. For example, on the seacoast sodium is higher due to marine clays and sediments in the landscape. Human activities can greatly influence the concentrations of sodium found in surface waters. Runoff from salt used on roads, water softeners and crop irrigation can have noticeable effects on sodium levels.

Class B NH Surface Water Quality Standard: While there is no state standard set for surface waters, the drinking water limit for sodium 250 mg/L. The EPA now requires public water supplies to report Na concentrations greater than 20 mg/L since sodium is linked to hypertension (high blood pressure) which affects 24% of the U.S. population (Burt et al. 1995). Typical background levels in New Hampshire surface waters are less than 20 mg/L and were less than 10 mg/L prior to 1900.

Results: Most RIVERS and OLT sites had mean sodium concentrations below 20 mg/L, with the average for all sites at 8.45 mg/L. Exceptions included: Frenchmans Brook (GO-2) 23.6 mg/L and Phillips Brook (OL-12u) 44.5 mg/L. Other sites with levels of sodium that rose above 20 mg/L at times were: GM-1, GM-2, GO-1 and OL-14u (Figure 44). Sites GO-2 and OL-12u at times have shown sodium levels two to four times higher than typical background levels.

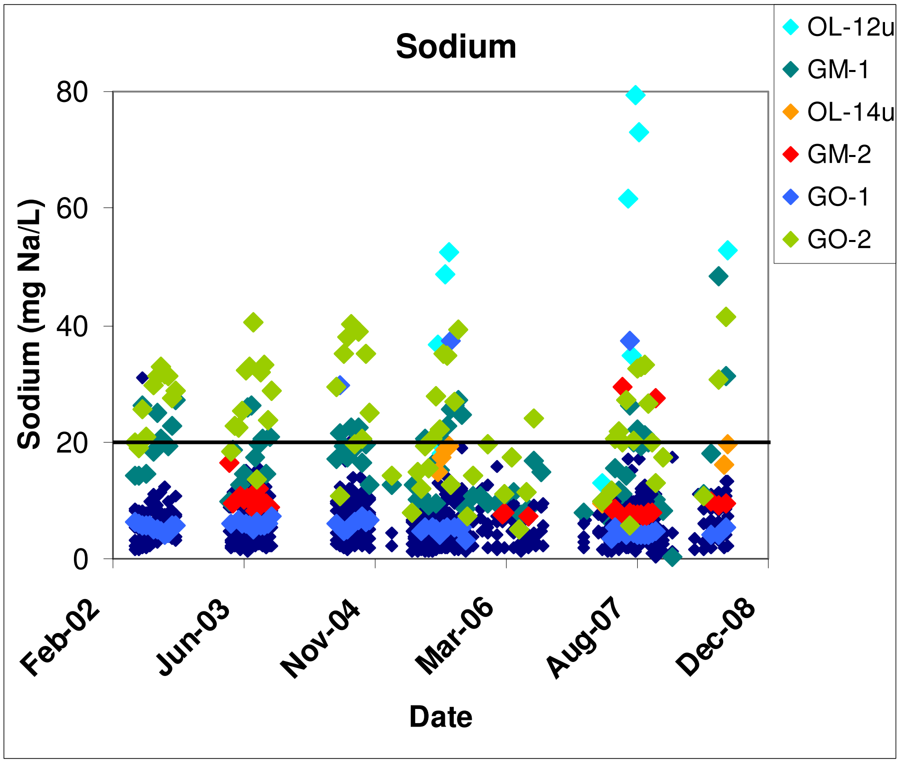


Figure 44: Sodium concentrations at most sites tested in the Ossipee Watershed have been below 20 mg/L, the typical background level of most surface waters in New Hampshire. Sites exhibiting higher sodium levels in the Watershed are shown in the legend.

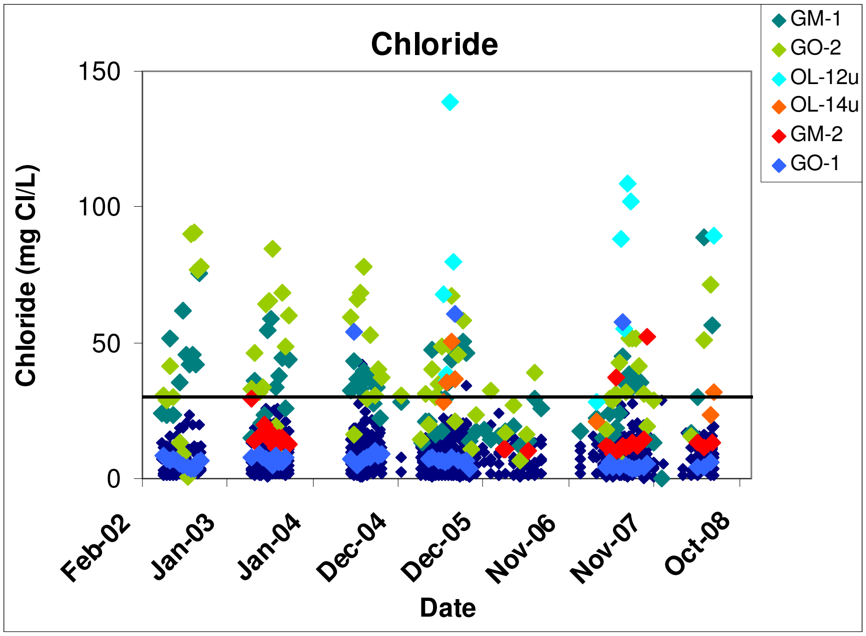
Chloride

Background: Chloride (Cl) is present naturally in some water bodies, but typically concentrations are low. Natural levels vary depending on geology. For example, on the seacoast, chloride levels can be higher due to marine clays and sediment in the landscape. Elevated levels occur primarily from road salt runoff and sometimes from domestic water softeners or farming. Excessive chloride can have a negative impact on vegetation (as has been observed with Interstate 93 in New Hampshire) and higher concentrations can be toxic to aquatic species.

Class B NH Surface Water Quality Standard: The chloride acute toxicity limit (level which sudden and severe impacts occur) is 860 mg/L and the chronic toxicity limit (level which negatively impacts aquatic health) is 230 mg/L for NH surface waters. The drinking water limit for chloride is 250mg/L. Typical background levels in New Hampshire surface waters are less than 30 mg/L.

Results: Most RIVERS and OLT sites had mean chloride concentrations below 30 mg/L, with the average for all sites at 12.85 mg/L. Exceptions included: Frenchmans Brook (GO-2) at 39.07 mg/L, Banfield Brook (GM-1) at 31.56 mg/L, Phillips Brook (OL-12u) at 75.74 mg/L and Square Brook (OL-14u) at 32.35 mg/L (Figure 45). Mean chloride levels ranged from 1.40 mg/L at Lovell River (OL-4u) to 75.74 mg/L at Phillips Brook (OL-12u). Sites GO-2, GM-1 and OL-12u at times have shown chloride levels two to five times higher than typical background levels. The higher levels of sodium and chloride at these sites could be attributed to being closer to major routes such as Route 113, 25 and Ossipee Lake Road where salt application occurs. The NH WRRC showed that average chloride concentrations at each site were tightly related to the respective watershed road density or % road pavement at each site (Figure 46).

Sodium and chloride were also strongly related to each other at the Ossipee Watershed sites, where chloride concentrations account for 93% (R^2= 0.93) of sodium concentrations (Figure 47). Bracketing of Route 16 at Frenchmans Brook (GO-2) showed that chloride concentrations were lower at upstream locations from the highway (Figure 51). Additional lab data can help pinpoint the source of chloride inputs to the brook.



Figures 45: Chloride concentrations at most sites tested in the Ossipee Watershed have been below 30 mg/L, the typical background level of most surface waters in New Hampshire. Sites exhibiting higher chloride levels in the Watershed are shown in the legend.

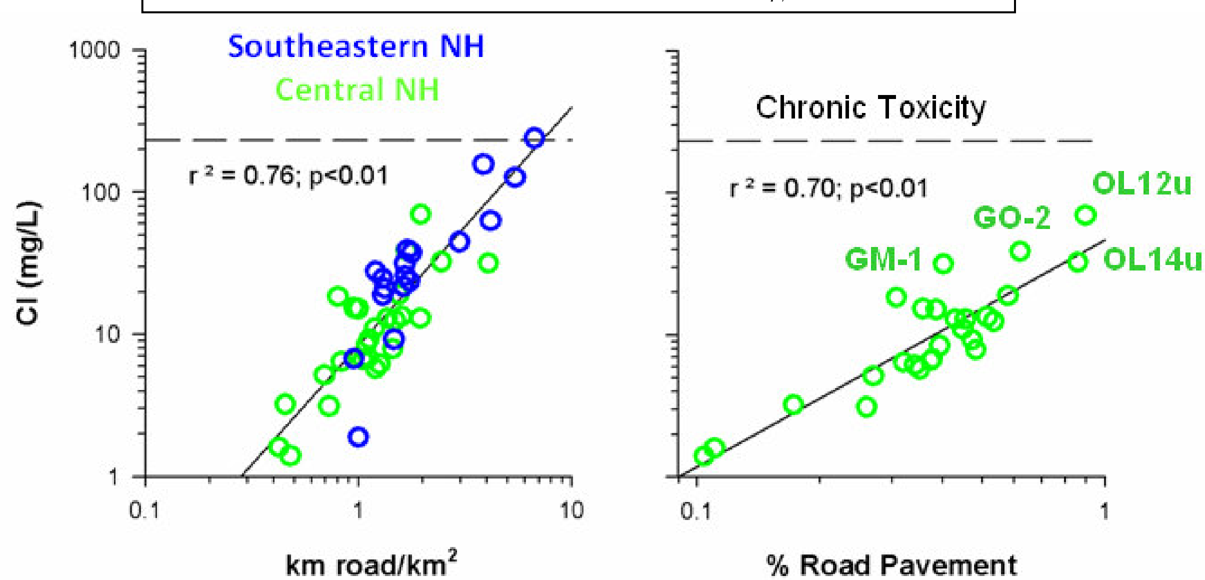


Figure 46: Average chloride concentrations among streams in southeastern and central NH vs. watershed road density and watershed % road pavement. These tight relationships indicate that road salting practices are elevating stream water chloride levels and the chronic toxicity limit has been reached in southeastern NH streams.

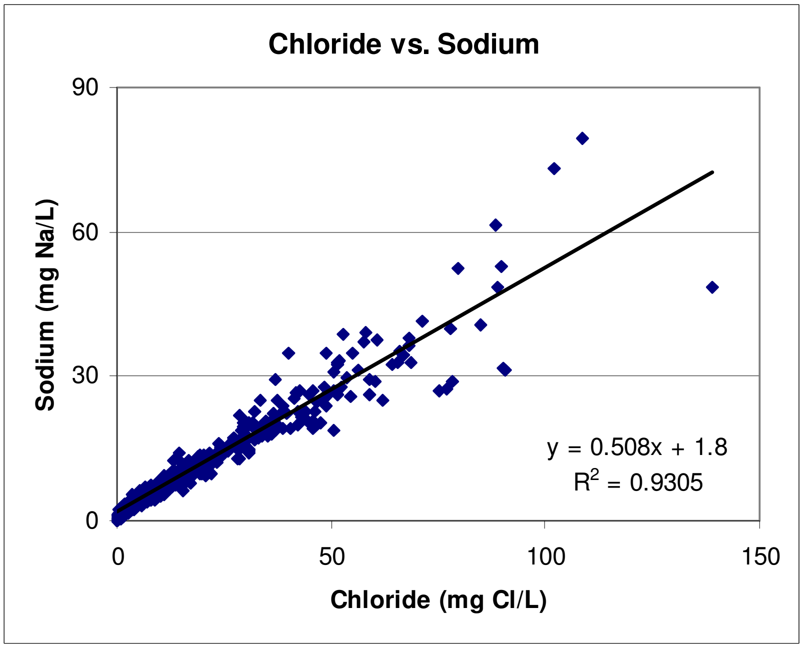


Figure 47: Sodium and chloride were also strongly related to each other at the Ossipee Watershed sites, where chloride concentrations account for 93% (R^2= 0.93) of sodium concentrations.

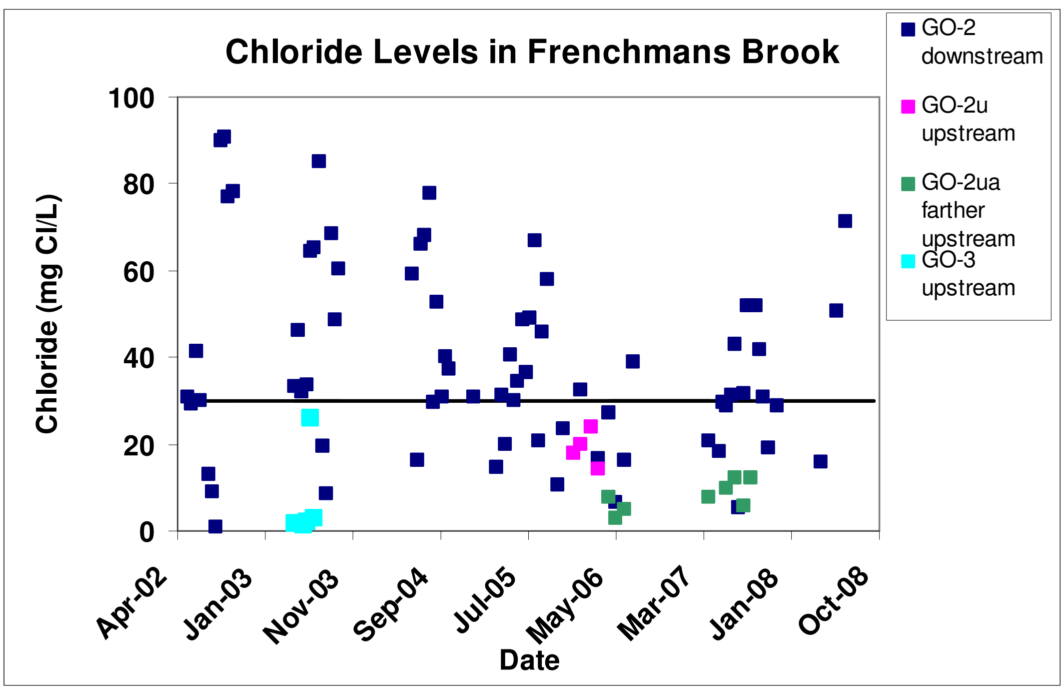


Figure 48: Monitoring at different locations on Frenchmans Brook over the years has shown that chloride concentrations were lower at upstream locations, above major roadways and development, and higher downstream.

Sulfate

Background: Sulfate (SO_4) is a component of sulfuric acid and occurs naturally from weathering. Sulfate plays a significant role both in the chemical industry and in biological systems, and sulfate is highly soluble in water. Sulfate is a byproduct of fossil fuel and biomass combustion, increasing the acidity of the atmosphere and resulting in acid rain. Acid rain is primarily caused by emissions of sulfur dioxide (SO_2) and nitrous oxide (N_2O) from electric utilities burning fossil fuels, especially coal. These chemicals are converted to sulfuric acid and nitric acid in the atmosphere and can be carried by the winds for many miles from where the original emissions took place. About one-third of the total sulfur compounds deposited over the eastern United States originates from sources in the Midwest more than 300 miles away. Sulfuric acid is used in lead storage batteries and in the manufacture of nitric acid; copper sulfate is a common algicide. Health concerns regarding sulfate in drinking water have been raised because of reports that diarrhea may be associated with the ingestion of water containing high levels of sulfate.

Class B NH Surface Water Quality Standard: Sulfate is a substance that occurs naturally in drinking water. Sulfate in drinking water currently has a secondary maximum contaminant level (SMCL) of 250 mg/L based on aesthetic effects such as taste and odor. This regulation is not a federally enforceable standard, but is provided as a guideline for states and public water systems. EPA estimates that about 3% of the public drinking water systems in the country may have sulfate levels of 250 mg/L or greater. Sulfate in surface waters can be highly varied, due to acid deposition, geology and weathering. In the Lamprey Watershed (southeast NH), streams average from 1-4 mg/L.

Results: Most of the RIVERS and OLT sites had very low mean sulfate concentrations, typically below 2 mg SO_4-S/L, the average for all sites being 1.24 mg SO_4-S/L. Mean sulfate levels for the watershed ranged from .20 mg SO_4-S/L at Weetamoe Brook (OL-5ua) to 3.64 mg SO_4-S/L at Cold Brook (GF-3). Other sites with mean sulfate concentrations above 2 mg/L included: GT-3 Mill Brook (2.15 mg SO_4-S/L) and GO-2u Frenchmans Brook (2.94 mg SO_4-S/L), however, GT-3 was only sampled through 2003 and GO-2u is a bracketing site that is not sampled regularly. Cold Brook (GF-3) had a mean sulfate concentration of 3.64 mg SO_4-S/L, mainly due to two elevated readings in 2005 and 2006 (Figure 49). It is unknown why sulfate levels spiked at GF-3 in 2005 and 2006.

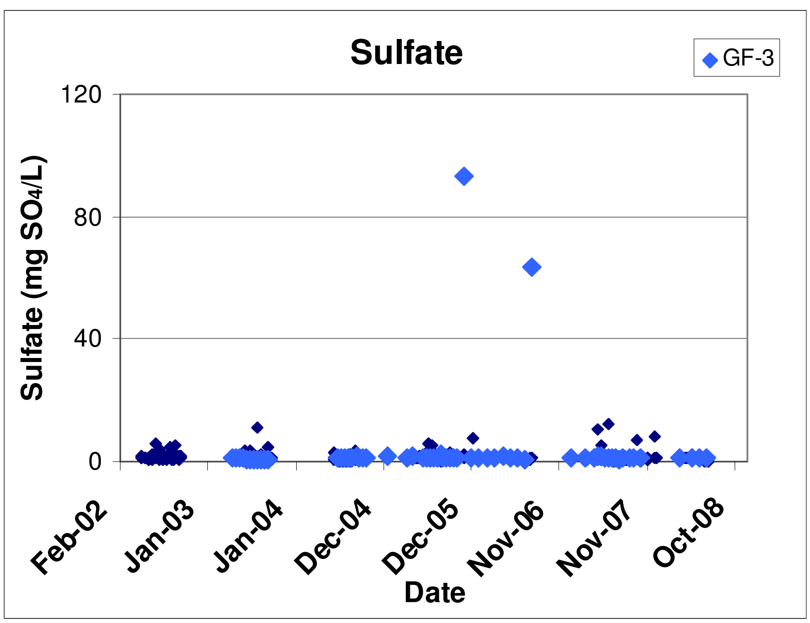


Figure 49: Sulfate concentrations at most sites tested in the Ossipee Watershed have been very low, although site GF-3 has shown some elevated readings in 2005 and 2006, for unknown reasons.

Silica

Background: Silica (SiO_2) is the most abundant mineral found in the crust of the earth. It forms an important constituent of practically all rock-forming minerals and is found in nature in several forms, including quartz. It is the most common component of sand, mostly because quartz is a hard mineral that resists erosion. Most of the dissolved silica observed in natural water results originally from the chemical breakdown of silicate minerals in the weathering process. Many forms of life contain silica structures including microorganisms such as diatoms, plants such as horsetail, and animals such as sponges and radiolaria. Silica is important for diatom growth, and diatoms often account for much of the phytoplankton's productivity. Silica is also present in the cell walls of various plants to strengthen structural integrity. Silica can be used as a ground water tracer since ground water has higher concentrations of silica, since silica in sunlit waters is rapidly taken up by diatoms. Silica sand is also used in plaster, glass, and in the Ossipee Watershed, is mined for gravel and concrete manufacture.

Class B NH Surface Water Quality Standard: There is no state standard for silica in surface waters. Silica levels in surface water vary, depending on local geology and weathering processes.

Results: Silica concentrations for all sites averaged 4.48 mg SiO_2/L, and mean silica levels ranged from .24 mg SiO_2/L at Red Brook (GE-4) to 9.45 mg SiO_2/L at Phillips Brook (OL-12u) (Figure 50). Other sites with higher mean silica concentrations included: Pine River (GE-1) 6.08 mg SiO_2/L; Lovell River (OL-4) with 6.37 mg SiO_2/L; Leavitt Brook (OL-13) with 8.09 mg SiO_2/L and West Branch River (OL-1u) with 7.49 mg SiO_2/L. These sites may get more of their flow from groundwater sources. Silica levels appear to have increased for most sites in 2007, possibly from a larger relative groundwater influence that year.

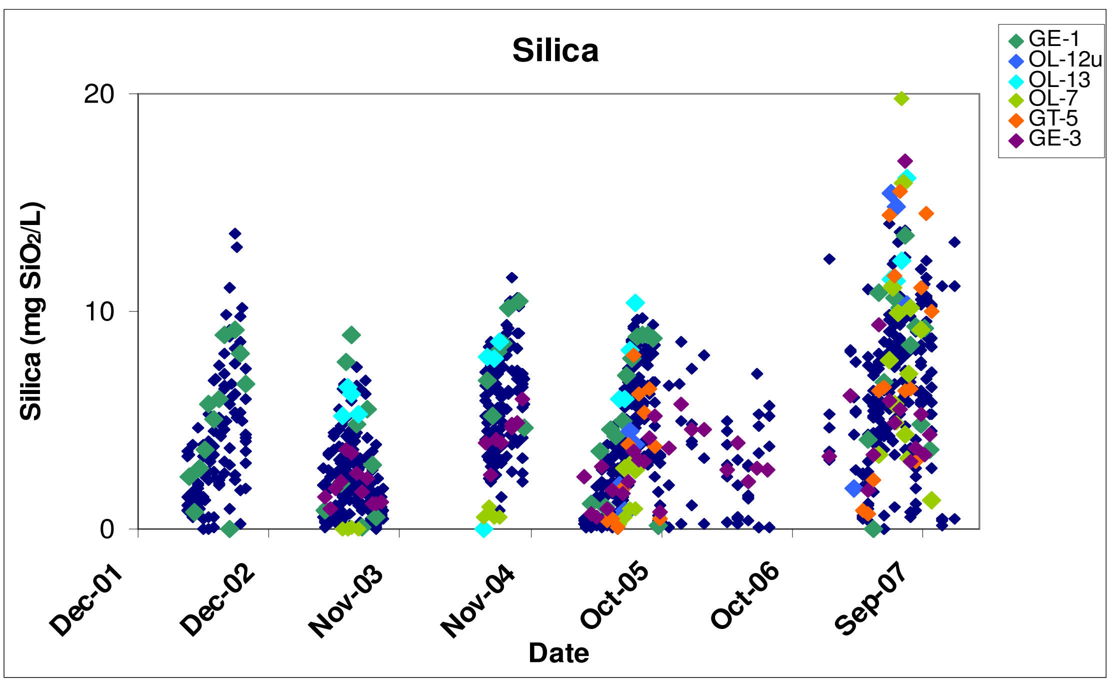


Figure 50: Sites exhibiting higher silica levels in the Watershed are shown in the legend. Silica levels appear to have increased for most sites in 2007, possibly from a larger relative groundwater influence that year.

Potassium

Background: Potassium (K) is one of the most abundant elements in the earth's crust. It is essential in both plant and human nutrition. Potassium occurs naturally in water as a result of the chemical breakdown of minerals in the weathering process, or through plant decomposition. Potassium is also found with nitrogen and phosphorus in chemical fertilizers. Elevated levels in surface waters can be the result of industrial pollution, over-fertilization of crops, and failing septic systems. As with the other nutrients nitrogen and phosphorous, too much potassium results in nutrient loading, and can lead to an excessive amount of phytoplankton and algal blooms, speeding up the natural process of eutrophication.

Class B NH Surface Water Quality Standard: There is no state standard for potassium in surface waters. Potassium levels in surface water vary, depending on local geology and weathering processes. In the Lamprey Watershed, streams average from 0-2.5 mg/L.

Results: Potassium levels at most sites was typically below 2.5 mg/L, with the average for all sites at .71 mg/L (Figure 51). Mean potassium concentrations ranged from .35 mg/L at Lovell River (OL-4u) to 1.36 mg/L at Frenchmans Brook (GO-2). Frenchmans Brook has maintained higher potassium levels than other sites since testing began. Cold Brook (GF-3) and Pequawket Brook (GM-2) experienced spikes in potassium in 2005 and 2006, as did Bearcamp River (GO-4) in 2007. The reason for potassium spikes at these sites is unknown.

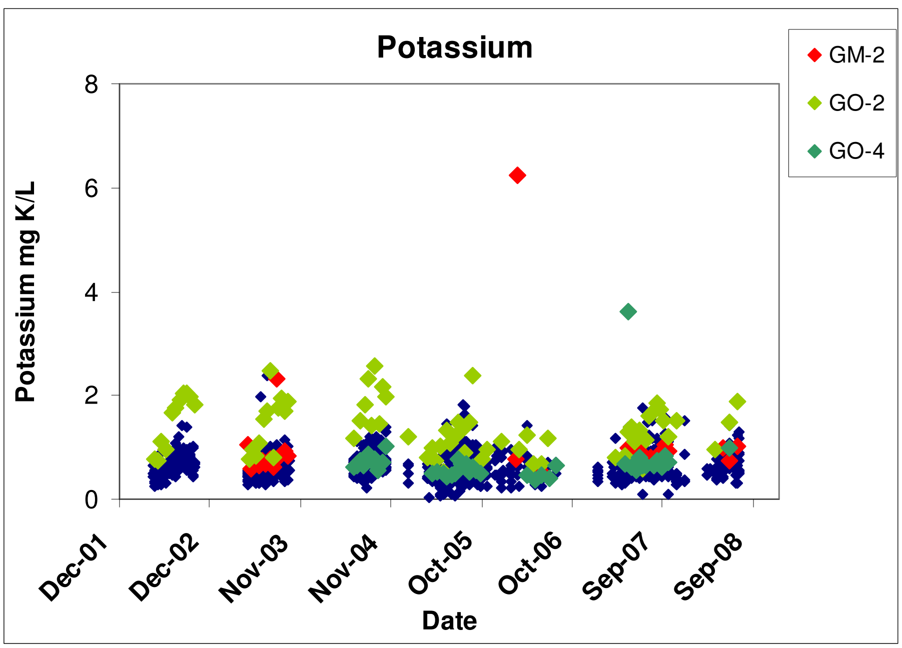


Figure 51: RIVERS and OLT sites potassium concentrations from 2002-2008. Sites exhibiting higher potassium levels in the Watershed are shown in the legend.

Calcium

Background: Calcium (Ca) is the most abundant of the alkaline-earth metals in the Earth's crust and makes up many common rock minerals. It is an essential element to plants and animals down to the cellular level, and is a major component of the solutes found in most natural water. Calcium is generally the predominant cation in river water. Calcium is used in conjunction with magnesium to determine water "hardness.

Class B NH Surface Water Quality Standard: There is no state standard for calcium in surface waters. Calcium levels in surface water vary, depending on local geology and weathering processes. In the Lamprey Watershed, streams average from 2-20 mg/L.

Results: Calcium levels at most sites was typically below 9 mg/L, with the average for all sites at 3.88 mg/L (Figure 52)**.** Mean calcium concentrations ranged from 2.05 mg/L at Red Brook (GE-4) to 6.67 mg/L at Square Brook (OL-14u). Frenchmans Brook (GO-2) 5.56 mg/L, Pequawket Brook (GM-2) 5.14, Leavitt Brook (OL-13) 6.15 mg/L and Phillips Brook (OL-12u) 6.52, have exhibited higher levels than other sites.

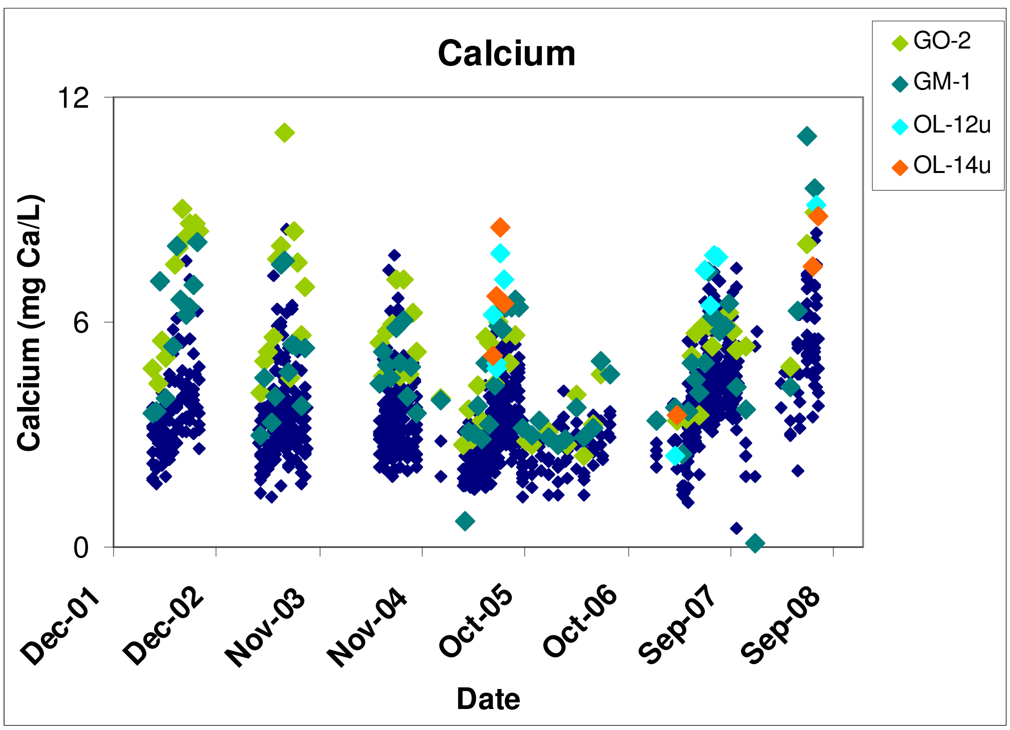


Figure 52: RIVERS and OLT sites calcium concentrations from 2002-2008. Sites exhibiting higher calcium levels in the Watershed are shown in the legend.

Magnesium

Background: Magnesium (Mg) is a common element, constituting about 2% of the Earth's crust. The magnesium ion is essential to all living cells and is an essential part of plant and animal nutrition. Magnesium is used in conjunction with calcium to determine water "hardness".

Class B NH Surface Water Quality Standard: There is no state standard for magnesium in surface waters. Magnesium levels in surface water vary, depending on local geology and weathering processes. In the Lamprey Watershed, streams average from 0-8 mg/L.

Results: Magnesium levels averaged .59 mg/L for all sites. Mean magnesium concentrations ranged from .25 mg/L at Lovell River (OL-4u) to 1.13 mg/L at Square Brook (OL-14u) (Figure 53). Phillips Brook (OL-12u) is the only other site that had a mean level >1.00 mg/L, at 1.08 mg/L.

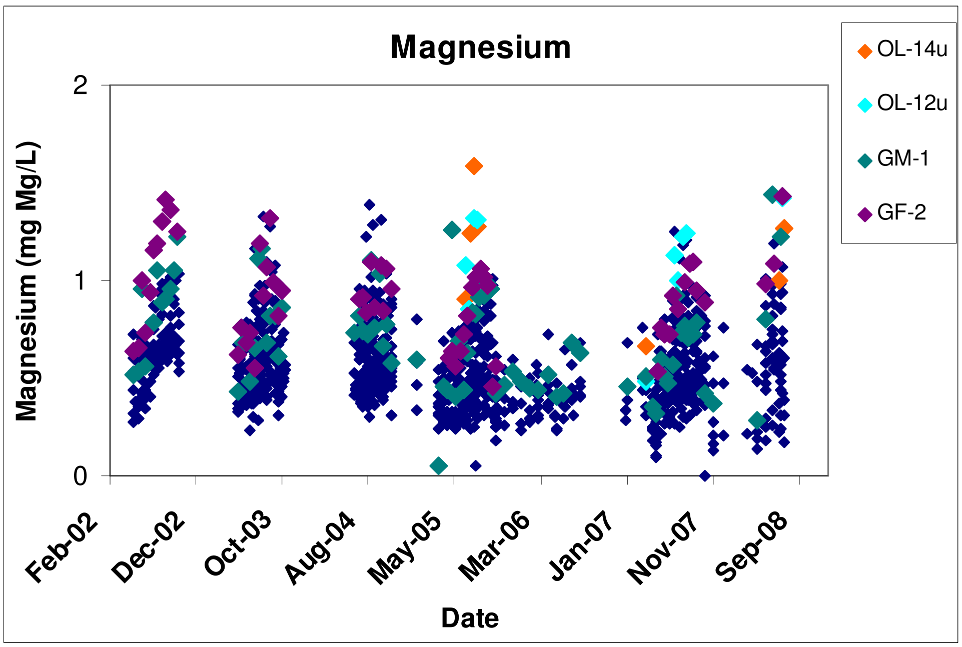


Figure 53: RIVERS and OLT sites magnesium concentrations from 2002-2008. Sites exhibiting higher magnesium levels in the Watershed are shown in the legend.

B. Volunteer Biological Assessment Program (VBAP) Results

Background: The Department of Environmental Services worked with GMCG and local volunteers in 2006 to establish a Volunteer Biological Assessment Program (VBAP) for the Ossipee Watershed. VBAP assesses the biological health and integrity of aquatic ecosystems throughout the state. The results of these assessments are used to establish reference locations for "least disturbed" conditions in the state, identifying areas that are biologically impaired, and for prioritizing those areas needing management, restoration, or preservation efforts.

Macroinvertebrate sampling is the method used for biomonitoring in the Ossipee Watershed. Macroinvertebrates are organisms that lack a backbone, yet are visible to the naked eye, and spend at least a part of their life cycle in the water. They are an extremely important part of river ecosystems, serving as the base of the food webs upon which many wildlife species depend. Most are insects, but they also include such organisms as clams, snails, mussels, worms, spiders, and crayfish. Beyond their supporting role in food webs, macroinvertebrates provide an indication of water quality. They possess a range of tolerances to pollutants—stoneflies and mayflies, for example, are pollution intolerant, while species such as worms, midges, and fly larvae are pollution tolerant, and capable of withstanding stresses better than more sensitive species.

Macroinvertebrates can quickly tell us things about a river's water quality that chemical testing would otherwise cost tens of thousands of dollars to reveal. Since they are easily disturbed by human activities like farming and urban development, the presence or absence of species can indicate high water quality or a deeply troubled ecosystem, even if the water may look healthy on the surface. Maine and Vermont have recognized the value and cost effectiveness of this type of research and currently use macroinvertebrate sampling to assess water quality in their states' surface waters. Macroinvertebrate sampling not only expands understanding of river and stream health, but it can also be used as a way to test for other sources of pollution that can be harmful to aquatic organisms and human health, such as pesticides, herbicides, heavy metals and volatile organic chemicals.

A biotic score is calculated for each site sampled. By counting the types of macroinvertebrates found and assigning each a numeric value based on their tolerance, a rough "biotic index" can be calculated and compared to those of other sites. While the biotic index provides a method for relative comparisons of the sites sampled, the tolerance values and narrative categories are still under development and must be calibrated to a set of reference sites before statewide application is possible.

NH Standards: Env-Ws 1703.08 Benthic Deposits: Class B waters shall contain no benthic deposits that have a detrimental impact on the benthic community, unless naturally occurring; Env-Ws 1703.19 Biological and Aquatic Community Integrity: The surface waters shall support and maintain a balanced, integrated, and adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of similar natural habitats of a region.

Results: Most sites tested from 2006-2008 had scores of good water quality or better. In fact, in thirty separate sampling events over those three years, 27 samples had scores of good water quality or better. In 2006, two sites, the Swift River in Tamworth and the Lovell River in Ossipee, had scores indicative of fairly poor quality streams as they were dominated by black fly larvae which are more tolerant to pollution and have a higher biotic index, driving up their scores. The index appeared to react to macroinvertebrate community composition, but was less effective when a single organism dominated the sample (e.g. black fly larvae). Water chemistry data do not indicate any water quality concerns at these sites thus far.

In 2007, according to David Neils, NH DES Biomonitoring Program Manager, the majority of sites (9) sampled appeared to be in "excellent" condition. Six of the nine streams that were sampled fell into the 'excellent' category. None of the sites were placed in the "fairly poor" category. Most of the communities were dominated by relatively intolerant macroinvertebrate groups, such as mayflies, stoneflies, and caddisflies. In 2007, taxonomic groups considered to be tolerant of pollution made up 10 percent or less of the samples for all sites. None of the sites sampled in 2007 had lower narrative categories ratings than in 2006" (April, 2008).

In 2008, Banfield Brook in Madison was the only site to have a score of "fairly poor", with the rest of sites scoring "good" to "excellent" (Figure 54). This site has also shown some water quality concerns with field testing and lab analysis of water samples, particularly with elevated conductivity, sodium and chloride levels, which corroborate these biological sampling results. Continued testing will determine how the biological compositions reflect stream health. For a more in depth look at the results, and to see the full reports from 2006, 2007 and 2008, visit: http://www.gmcg.org/water-quality-data.php. Many local students and volunteers assisted GMCG and NH DES staff to gather the data and produce the reports (Figure 55a. & 55b.).

Site Number	Stream name, town	Biotic score	VBAP narrative category
1	Banfield Brook, Madison	5.49	Fairly Poor
2	Beech River, Ossipee	3.59	Good
3	Forrest Brook, Madison	4.12	Good
4	Swift River, Tamworth	2.89	Excellent
5	South River, Parsonsfield	4.09	Good
6	Mill Brook, Tamworth	3.72	Good
7	Cold River, Sandwich	3.34	Excellent
8	Bearcamp River, Tamworth	3.54	Good
9	Lovell River, Ossipee	3.85	Good
10	Cold Brook, Freedom	3.22	Excellent

Figure 54: Biotic scores and VBAP narrative categories of macroinvertebrate samples collected at 10 sites in the Ossipee Watershed in fall 2008. Most sites were in the "good" to "excellent" category, with Banfield Brook in Madison being the only site to have "fairly poor" conditions.


55a.


55b.

Figures 55a. & 55b.: Volunteers from around the Watershed were trained by the GMCG and NH DES to collect, identify and sort macroinvertebrate samples. More than 100 people, including students from five local schools, assisted with sampling at a total of eleven sites across the watershed.

Section 4: Discussion, Recommendations & References

A. Discussion

Results from the past seven years have shown the quality of surface waters across the Ossipee Watershed to be high. The majority of sites demonstrated low nutrient levels with total phosphorus concentrations below 50 µg/L and nitrate and ammonium levels below 1mg N/L. Physical parameters were within a healthy range to support aquatic life with dissolved oxygen concentrations above 5 mg/L and saturation above 75% , conductivity levels below 100 µS/cm^2 and low turbidity levels. Lake monitoring data collected through the Volunteer Lake Assessment Program (VLAP, since 1990 for some sites, 2002 for others) for Ossipee Lake, Berry Bay, Broad Bay, Leavitt Bay and Danforth Pond showed that average yearly concentrations of all parameters (chlorophyll-a, transparency, total phosphorus, and conductivity) remained in a low (good) to average range for New Hampshire lakes. Annual macroinvertebrate sampling since 2006 through the Volunteer Biological Assessment Program (VBAP) indicated that the majority of the ten river sites sampled were in "excellent" condition, based on coarse identification of macroinvertebrate communities down to the order level. Most of the communities in rivers and streams were dominated by relatively pollution-intolerant macroinvertebrate groups (indicating good water quality), such as mayflies, stoneflies, and caddisflies. Taxonomic groups tolerant of pollution (indicating poor water quality) comprised 8 to 24 percent of the invertebrate population among all sites from 2006 to 2008.

However, in the greater Saco River Watershed (which includes the Ossipee sub-watershed) there are now over 1,000 impaired waters listed (Surface Water Quality Assessments [305(b) and 303(d)] for Maine and New Hampshire) caused by pathogens, bacteria, low dissolved oxygen, aquatic life impairment, sedimentation, pH, ammonium, chloride, and mercury. Many of these impairments are nonpoint source issues, meaning, they do not come from a designated source or pipe but rather pollution enters surface and groundwater as stormwater runoff and snowmelt move across the landscape picking up pollutants such as fertilizers, pesticides, animal waste and road salt. While local communities may not be able to address large-scale processes such as atmospheric deposition of mercury and acid rain, they can address water quality issues that arise from pollutants such as road sand and salt, sediment introduced during storm events due to inadequate road and site development management practices, and faulty septic systems. Data and observations from the Green Mountain Conservation Group's Water Quality Monitoring Program point to the need for implementing Best Management Practices (BMPs) and Low Impact Development (LID) techniques.

Although the majority of sites showed healthy physical, nutrient and biological conditions, some sites had elevated sodium, chloride and conductivity levels, at times three to four times higher than the typical background levels for New Hampshire surface waters. Road salt application is the dominant source of these elevated levels as these concentrations are strongly related to watershed road density or watershed percent road pavement among streams and tributaries in the Ossipee watershed (Daley, et. al. 2009). Road salt applied in the winter can enter streams directly through culverts and roadside ditches or accumulate in roadside soils, enter the groundwater and make its way to surface waters. Square Brook, on Ossipee Lake Road in Freedom, Phillips Brook on Route 25 in Effingham, Frenchman's Brook on Granite Road in Ossipee and Banfield Brook on Route 113 in Madison are all sites that exhibit elevated sodium and chloride concentrations and are closely monitored with sites located to bracket potential sources of impairing inputs. Future monitoring should incorporate groundwater sampling to determine if stream water sodium and chloride concentrations elevated from road salting are also found in the groundwater. Biological monitoring at Banfield Brook has also shown “fairly poor” conditions for two out of the three years of macroinvertebrate sampling, corroborating field and chemical evidence that the site is being impacted by human activities.

In 2008, statistical analyses performed on some lake data by Department of Environmental Services (DES) showed decreasing transparency trends in Leavitt and Broad bays over the past eighteen years, and slightly increasing epilimnetic conductivity levels. According to DES, New Hampshire’s surface waters traditionally have low conductivity values, but levels are increasing at a statistically significant rate due to the influence of road salting. In the Ossipee Watershed, river and tributary monitoring data showed that conductivity levels are closely associated with chloride levels (road salt) 95% of the time. It is most probable that the elevated conductivity levels found in these bays are a result of long-term road salting practices. Other potential sources of elevated conductivity and sodium chloride are water softener systems, snow dumping practices or improper storage of salt piles. Data clearly show that the Ossipee Watershed is showing impacts from road salt on surface water quality, and UNH water quality professionals have stated that “in some places, (salt) concentrations are higher than those found in the seacoast region of the state where ocean water plays a larger role,” (RIVERS Report, 2004). Sodium chloride ($NaCl$) is a concern due to its toxicity to aquatic organisms, adverse effects on human health, and the damage it causes to roadside plants (Daley et al., 2008). Now is the time to plan ahead and address water quality issues before conditions worsen. Once water quality is impaired, it is difficult if not impossible, and often very expensive, to find solutions or reverse conditions. It is recognized that maintaining safe driving conditions is important for public safety; however, towns are urged to only apply deicers on an as needed basis remembering that more is not necessarily better. Towns should consider adopting road salt alternatives as they are developed, particularly in sensitive areas, and make use of pervious pavement wherever possible. Pervious pavement requires less deicer to keep road surfaces clear of ice and has better skid resistance than traditional pavement.

Sampling results also indicate that water clarity may be diminishing and this has broad ramifications to Lake Ossipee and those who use it. For example, a 2007 report by the NH Lakes Association found that a perceived reduction in surface water clarity and purity could lead to lost sales of $25 million, lost income of $8.8 million, and 131 jobs lost in the Lakes Region alone. Reductions in water clarity can be caused by excessive sand and silts being washed into the streams and lakes due to improper sediment control or increased phytoplankton growth due to increased nutrients. Either way, water quality monitoring is important to track these potential changes. The use of local volunteers in this program provides a very cost effective method to accomplish monitoring, and it raises citizen awareness. If changes continue and/or are significantly higher than historical values, more effort may have to be put into methods to control runoff and nutrient input and other nonpoint source inputs. Utilization of Best management Practices, controlling PCS sources, putting better control ordinances in place and insuring septic systems are in good working order are ways to manage these problems. Careful management is the key.

A combined approach of continued surface and ground water quality research, strategic planning amongst Ossipee Watershed towns, protection of important aquifer recharge areas, and addressing potential contamination sources are all necessary to safeguard rivers, lakes, streams and drinking water supplies for the future. Together, we can ensure the protection of the region’s water resources, and most importantly, continue tracking the long-term health of the watershed.

B. Recommendations

WQM Program Recommendations:
In 2004, Green Mountain Conservation Group held its second Water Quality Monitoring Program Steering Committee meeting with stakeholders including: New Hampshire Department of Environmental Services, Maine Department of Environmental Protection, Saco River Corridor Commission, US Environmental Protection Agency Region 1, Chocorua Lakes Association, Maine Chapter of The Nature Conservancy, University of New Hampshire Natural Resources Department, University of New Hampshire Cooperative Extension, The Community School, the Eaton Conservation Commission, and the Water Quality Monitoring volunteers in both Maine and New Hampshire.

Many of the committee's recommendations from this meeting have been carried out, including:

☑ winter testing at 7 RIVERS sites
☑ additional storm event sampling
☑ since 2005, deep water sampling (VLAP) is conducted 3-4 times on the lake each summer
☑ some OLT sites were relocated upstream in 2005
☑ since 2005, monitoring begins earlier and ends later to gather snow melt and fall data
☑ the RIVERS and OLT monitoring data has been evaluated and compared
☑ sites recommended by town representatives have been added to the program
☑ GMCG purchased another multiparameter meter to measure conductivity levels at all sites and ensure compatibility of data
☑ a macroinvertebrate sampling program (VBAP) was added to the program in 2006

Other recommendations from this meeting that are guiding the program include:

- Continue monitoring in the Ossipee Watershed to create a long term database.
- Place staff and rain gauges at each site to better monitor precipitation and water level.
- Work with The Community School and Rose de Mars (WQM volunteer and hydrogeologist) to create GIS maps of several of the sites and their smaller watersheds.
- Work with Maine Department of Environmental Protection, New Hampshire Department of Environmental Services, Saco River Corridor Commission, the University of New Hampshire, and Ned Hatfield (WQM volunteer) to consider guiding volunteers in streamside assessment to gather qualitative data.
- Consider adding groundwater sampling to the program. (2008-2010)
- Work with towns to expand watershed-wide, water/aquifer protection program to encompass the entire Saco Watershed from the White Mountains to the Atlantic Ocean.

Since 2004, UNH and DES water quality professionals, GMCG and town representatives from the watershed community have made some additional recommendations both for the water quality monitoring program. These are listed below, as well as when they will be addressed:

- Update the Quality Assurance Project Plan (QAPP). (2009)
- Conduct additional spring testing at tributary sites and sites of concern. (2009)
- Locate an upstream site from OL-10 to prevent lake water influencing samples. (2009)
- Locate a site with more reliable flow than OL-5ua on Weetamoe Brook. (2009. Need help from the community – alternative access point most likely located on private land.)
- Seek a volunteer with water craft to sample OL-3 once again. (2009. Need a volunteer.)

- Continue bracketing sites of concern to pinpoint locations of impairing inputs. (2009)
- Research long-term sources of funding for the program, including interns. (GMCG continues to work on this, and is open to suggestions from the community.)
- Carry out a conductivity study around the lake shoreline to locate sources of conductivity inputs to the lake. (GMCG did a pilot project to start this in 2006; motor boat needed and volunteer assistance.)
- Continue monitoring recreational use of the lake - follow-up to the Ossipee Lake Protection Program conducted in 2003. (No plans yet; work with OLA in the future on another study.)
- Continue milfoil and exotic plant education around the lake to prevent new infestations and the spread of existing infestations. (2009 and beyond: GMCG plans to continue working with NH Lakes to hire Lake Hosts each summer for the Pine River boat launch.)
- Increase volunteer participation to cover existing sites and bracketing sites as they are needed. (New volunteers are needed each year to assist with data collection, and in 2009, groundwater monitoring volunteers will be needed to help sample wells.)
- Continue collecting data and perform statistical analysis in the coming years. (2012)

Recommendations for future water monitoring for the Ossipee Lake system:
Water quality professionals' recommendations for the lake monitoring program include:

- sample the five deep spots at least once per month during the summer months
- conduct base-flow vs. storm event sampling along inlets with elevated conductivity levels to help pinpoint sources of increasing conductivity in the lake
- investigate the source of phosphorous loading in Lower Danforth Pond
- track water quality trends to enable the identification of potential sources of pollutants from the watershed that may affect surface water quality. (Note: water quality trend analysis is not feasible with only a few data points. It will take at least 10 years of data to develop a set of water quality baseline data.)

A presentation in August of 2008 of lake monitoring results to area stakeholders from Ossipee and Freedom also raised some recommendations for lake water quality research from the audience, including:

- Add sampling sites of the lake system near Cassie Cove/Spindle Point to investigate impacts of large number of boaters/people recreating here as possible contributor to Broad/Leavitt Bay trends.
- Investigate salt imported into watershed for salting activities – how much is being used, where and by who?
- Can GMCG, NH DES & Freedom work on a strategy for investigating increased plant growth/milfoil in Danforth Pond? How can the town proceed with a plan to find a solution to this growing problem?

Recommendations for lakefront property owners:

- Keep septic systems properly maintained to avoid adding excess nutrients and harmful chemicals to local waterbodies. Septic system surveys should be conducted since towns have indicated concern about antiquated or faulty septic systems so these do not impact lake and surface water quality. Anonymous survey sheet example: http://des.nh.gov/organization/divisions/water/wmb/vlap/documents/septic_system_survey.pdf
- Minimize the clearing of vegetation and leave buffer strips above and below clearings to intercept sediments and dissolved chemicals before they can enter water sources
- Use native or low maintenance shrubs minimizing the need for fertilizer, water and other

amendments.

- Keep grass cut high to minimize erosion, reduce runoff velocity, and reduce watering needs.
- Get soil tested before applying any fertilizers or amendments so excess that cannot be taken up by plants is not washed into surface waters.
- Reduce nutrient loading to the lake by eliminating fertilizer use on lawns and keeping the lake shoreline natural, or use low or no phosphorous slow release nitrogen blends.
- Dispose of waste materials properly to prevent contamination of surface waters.
- Limit impervious surfaces on property to enhance infiltration, minimize erosion and flooding.
- Divert any water flow into vegetated areas to help filter pollutants and slow down flow.
- Use drains, swales and waterbars to minimize erosion and sedimentation into surface waters.
- Store and apply dangerous materials with care to prevent contamination.
- Do not add sand, dredge or fill shoreline areas as this can negatively impact others' shorelines by adding sediment, changing water flow, velocity and shoreline ecosystems.
- Where new beaches are desired, waterfront property owners should look into perched beaches to protect the lake from sand deposition, the leading cause of lake quality degradation.
  http://des.nh.gov/organization/divisions/water/wmb/vlap/2006/documents/appendix_d.pdf
- Document any algal blooms that may be observed in September in October, collecting a sample for the DES lab if one should occur.
  http://des.nh.gov/organization/commissioner/lsu/index.htm

Recommendations for Communities in the Ossipee Watershed:

•***Continue Water Research.*** The most important step for future protection of the rivers is to continue with the monitoring program. There is a great need for regular, long-term data to help us understand our ecosystems and how and why they change to make informed decisions about their future use and protection.

• ***Local Planning is Key.*** Prevent pollution by good planning at the local level (watershed associations, local government), utilizing low impact development techniques and best management practices in the watershed, and develop and pass local watershed ordinances. Encourage town officials to develop and adopt erosion and sediment control ordinances, watershed district ordinances/aquifer overlay districts, LID and BMP guidelines across the watershed.

•***Minimize Nonpoint Source Pollution.*** Minimize non-point source inputs in the landscape by maintaining septic systems, limiting fertilizer usage and promoting sustainable development. Don't bathe yourself or pets in rivers or lakes, keep land clearing to a minimum, plant native vegetation along the shoreline, don't feed ducks/geese, pick up pet wastes, and don't use powerful outboard motors in shallow areas. Apply road salt on an as needed basis, not under a more is better regime and seek suitable alternatives to conventional road salt. Use pervious pavement which requires less road salt application than traditional dense mixed asphalt. Implement best management practices for salt storage, road maintenance, and snow dumping to prevent impacts of road salt on surface waters. In some cases, reduced sodium chloride application may be suitable to some sections of highway (low speed, flat, no hills/curves). DOT will consider conducting reduced sodium chloride programs in communities which request consideration and on roads that meet specific requirements of the program. http://www.nh.gov/dot/bureaus/highwaymaintenance/documents/WinterMaintSnowandIcePolicy.pdf.

A more in depth discussion of road salt is below.

•***Identify and Monitor Potential Contamination Sources.*** Identify and evaluate potential sources of contamination to surface waters and the aquifer and ensure BMPs are being followed and spill containment and emergency procedures are in place.

•***Protect Shorelines.*** Protect riparian corridors, shorelines, and wetlands from incompatible development that could degrade water quality. Stabilize stream banks, lake shorelines, disturbed soils, especially dirt roads located next to rivers, tributaries and the lake system. Visit: http://www.des.state.nh.us/CSPA/ for more details on the Comprehensive Shoreland Protection Act and 2008 updates.

•***Promote Best Management Practices.*** Promote the use of Best Management Practices to prevent non point source pollution from entering surface and groundwater in runoff. (Visit: BMPs for Groundwater Protection: http://www.des.state.nh.us/factsheets/ws/ws-22-4.htm; BMPs for Surface Water Protection: http://www.des.state.nh.us/wmb/was/manual/; UNH Stormwater Research Center w/ LIDs & BMPs: http://www.unh.edu/erg/cstev/; LRPC Aquifer Protection BMPs/Guide for Developers: http://www.lakesrpc.org/services_resources_aquifer.asp.) BMPs can include limiting or using alternatives to road salt/road salting strategies, the use of vegetative buffers, coving salt/sand piles, preventing snow dumping directly in surface waters, and proper treatment of runoff before it enters surface and groundwater.

•***Promote Low Impact Development Techniques***. Encourage the use of Low Impact Development in the Watershed. LID can include such things as permeable pavement which reduces the need for salting in the winter and increases infiltration and groundwater recharge.

•***Educate the Public.*** Continue to educate watershed residents about the sources of pollutants in a watershed and the ecological, recreational and economical impacts they can have on our lakes, ponds, rivers & streams.

•***Promote Solutions for Regional Water Quality Issues.*** Learn about what can be done to prevent and reduce acid rain in New England.
http://des.nh.gov/organization/divisions/air/tsb/tps/acidrain/index.htm.
Learn about mercury reduction through pollution prevention techniques, rules and regulations, upcoming legislation, and the state's Mercury Task Force.
http://des.nh.gov/organization/commissioner/p2au/pps/ms/mrpptp/index.htm.

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Appendix A: Site Condition Summaries

The Maine and New Hampshire Surface Water Quality Assessments [305(b) and 303(d)] have been completed for 2008. In the NH report, surface waters in New Hampshire have been divided into over 5,200 individual segments or assessment units (AUs). The vast majority of AUs are listed as impaired due to mercury or pH levels* (3,747). The impairments in the Ossipee Watershed are due to atmospheric deposition and for the most part a result of local activities. The report lists 43 sites within the boundaries of the Ossipee Watershed as being impaired for low pH and dissolved oxygen levels, high bacteria levels in some cases, and one site based on benthic macroinvertebrate bioassessments. In the lower parts of the Saco River Watershed where the Saco River Corridor Commission has been sampling since 2001, there are only two segments listed under the Department of Environmental Protection's impaired waters list. Thatcher Brook is listed for bacteria contamination, and the main stem of the Saco River as it enters the estuary is listed for toxicity, bacteria and copper. Below are links to these reports and lists of impaired waterbodies.

- Maine 2008 Report (147 pages); 2008 Appendices, including 303d list (102 pages)

- New Hampshire 2008 Report (196 pages); 2008 Appendices, Watershed Report Cards, etc. & 2008 303d list (130 pages)

Below Figure 56 is a brief synopsis of water quality conditions for each site monitored by GMCG in the Ossipee Watershed based on the data from the RIVERS, OLT and VBAP monitoring programs. In cases where sites are listed as impaired in the 303(d) report the listing and reason for listing are also mentioned.

*Note: Many sites in the Ossipee Watershed are listed as "impaired" in the 303(d) report due to low pH levels that could harm aquatic life. According to the state water quality standards, pH must be between 6.5 and 8.0, unless naturally occurring. Reducing the minimum pH criteria to 6.0 may be considered as lower pH values (between 6.0 and 8.0) are often observed in streams in New Hampshire given the acidified rain (average pH of rain in New England is 4.3) and low buffering capacity due to the underlying geology. Until the statute and regulations are changed, however, compliance for pH must be based on this range.

RIVERS Sites:

GE-1 Pine River, Elm Street, Effingham (monitored 2002-2008)

Mean levels for all parameters were within the acceptable range for surface waters according to state standards. Dissolved Organic Nitrogen dominates Dissolved Inorganic Nitrogen at this site, and total phosphorus, sodium and chloride levels remained below natural background levels for New Hampshire surface waters. Silica levels at this site were one of the highest of all sites tested, indicating that the Pine River receives more groundwater flow than other sites or some other inputs of silica. In fact, the stratified drift aquifer is at its closest point to the surface near this site. Silica levels also increased slightly over the sampling period, and turbidity levels remained stable. Conductivity levels slightly decreased over the sampling period, but were elevated in 2007 above natural background levels. Dissolved organic carbon has been slightly elevated at this site in the past, possibly due nearby wetlands, although levels remain within the typical range for surface waters and decreased over the sampling period.

GE-2 South River, Plantation Road, Parsonsfield, ME (monitored 2002-2008)
Mean levels for all parameters except for pH and dissolved oxygen were within the acceptable range for surface waters according to state standards. Dissolved Organic Nitrogen dominates Dissolved Inorganic Nitrogen at this site, and total phosphorus, sodium and chloride levels remained below natural background levels for New Hampshire surface waters. Dissolved organic carbon concentrations remained elevated but decreased slightly over the sampling period, and this site had some of the highest mean concentration of DOC of all sites tested. Extensive wetlands above this site are responsible for the elevated DOC concentrations, lower dissolved oxygen and lower pH. Silica levels remained slightly elevated and increased slightly over the sampling period. Conductivity levels slightly increased over the sampling period and were elevated on two occasions above natural background levels in the summer and fall of 2007 and 2008. pH and turbidity levels decreased over the sampling period, as did dissolved oxygen. In 2006, 2007 and 2008, the macroinvertebrate composition at the South River was indicative of a river in 'good' condition.

GE-3 Ossipee River, Effingham Falls (monitored 2003-2008)
Mean levels for all parameters were within the acceptable range for surface waters according to state standards. Dissolved Organic Nitrogen dominates Dissolved Inorganic Nitrogen at this site, and total phosphorus, sodium and chloride levels remained below natural background levels for New Hampshire surface waters. The Ossipee River continued to exhibit some of the highest temperatures in the watershed, most likely due to its location below the dam where warmer lake water flows out of Berry Bay. Conductivity levels remained below natural background levels for state surface waters, and appear to be stable over the sampling period, while turbidity levels slightly increased.

GE-4 Red Brook, Green Mountain Road, Effingham (pilot site 2005-2006)
Data for this site is based on a handful of samples, as the stream is intermittent and not a regular testing site. Based on those data, Dissolved Organic Nitrogen dominates Dissolved Inorganic Nitrogen, conductivity, sodium and chloride levels remained below natural background levels for New Hampshire surface waters. Total phosphorus levels were elevated on one occasion, and could be attributed to lab error. Dissolved oxygen levels measured at this site were regularly below state standards, and the pH at this site was the lowest of all sites - well below naturally occurring levels. The site also exhibited the highest dissolved organic carbon levels and one of the highest total dissolved nitrogen levels in the watershed, although as mentioned above, DON dominated DIN. Poorer water quality is most likely due to restrictions to flow and the resulting stagnation of water upstream of a narrow and highly-placed culvert. Continued sampling and further investigation is recommended for this site, as well as adjustments to the culvert that is inhibiting the natural flow.

GF-1 Danforth Brook, Ossipee Lake Road, Freedom (monitored 2002-2008)
Mean levels for all parameters were within the acceptable range for surface waters according to state standards. Dissolved Organic Nitrogen dominates Dissolved Inorganic Nitrogen at this site, and total phosphorus, sodium and chloride levels remained below natural background levels for New Hampshire surface waters. Danforth Brook continues to exhibit some of the highest temperatures in the watershed, most likely because it is the outlet where warmer lake water flows out of Lower Danforth Pond. Dissolved oxygen only rarely fell below state standards, and pH levels were slightly acidic and decreased over the sampling period. Conductivity levels remained stable over the sampling period, while turbidity levels slightly increased.

GF-2 Cold Brook, Maple Street, Freedom (monitored 2002-2008)
Mean levels for all parameters except for pH and dissolved oxygen were within the acceptable range for surface waters according to state standards. As with most sites in the Ossipee Watershed, water at this site was slightly acidic. Dissolved Organic Nitrogen dominates Dissolved Inorganic Nitrogen at this site, sodium and chloride levels remained below natural background levels for New Hampshire surface waters. Total phosphorus and phosphate levels remained stable over the sampling period, and on one occasion in 2007 total phosphorus levels rose above natural background levels. Total phosphorus levels are slightly elevated and higher than the sampling site downstream (GF-3), most likely due to the stagnation of water and build up of materials behind the dam. Nitrate levels and conductivity levels at this site increased slightly over the sampling period, as did turbidity. This site consistently exhibited some of the highest magnesium levels in the watershed, increasing slightly over the sampling period, and silica levels have been higher at this site, indicating groundwater input.

GF-3 Cold Brook, Loon Lake inlet, Freedom (monitored 2003-2008)
Mean levels for all parameters except for pH were within the acceptable range for surface waters according to state standards. Dissolved Organic Nitrogen dominates Dissolved Inorganic Nitrogen at this site, sodium and chloride levels remained below natural background levels for New Hampshire surface waters. This site had the highest mean sulfate level among testing sites, with two spikes in 2005 and 2006. Total phosphorous was elevated above natural background levels on one occasion in 2006, but was typically below background levels and stable overall. Similar to the site GF-2 upstream, silica levels have been higher at this site, indicating groundwater input. Also similar to GF-2, this site has some of the highest magnesium levels in the watershed. Conductivity levels at this site slightly increased over the sampling period, as did turbidity levels. In 2006, 2007 and 2008 sampling showed macroinvertebrate composition in Cold Brook that was indicative of streams with 'excellent' water quality.

GM-1 Banfield Brook, Route 113, Madison (monitored 2002-2008)
Mean levels for all parameters except for pH were within the acceptable range for surface waters according to state standards. Sodium, chloride and calcium levels at this site were among the highest in the watershed, frequently above typical background levels for NH surface waters and indicate influence from road salting activities, although chloride levels remained stable and sodium levels slightly decreased over the sampling period. Conductivity levels at this site were also among the highest in the watershed and were often above typical surface water levels found under natural conditions, and slightly increased over the sampling period. Magnesium levels were slightly elevated when compared to other sites in the watershed and a spike occurred in 2007, although these levels were relatively low overall and remained stable over the sampling period. Although Dissolved Organic Nitrogen dominates Dissolved Inorganic Nitrogen at this site, nitrate levels slightly increased over the sampling period and were elevated when compared with other sites in the Watershed. Higher levels of silica at this site indicate groundwater input, and along with higher nitrate levels, suggest that the aquifer could contain elevated levels of DIN. In 2006 and 2007 the macroinvertebrate community composition at a location just upstream of the site was indicative of a stream in 'good' condition. However, in 2008 sampling showed 'fairly poor' water quality conditions and this shift in the macroinvertebrate community could be caused by the high sodium and chloride levels and the increasing nitrate.

GM-2 Pequawket Brook, Rt. 113, Madison (monitored 2003, 2006-2008)
Mean levels for all parameters except for pH and dissolved oxygen were within the acceptable range for surface waters according to state standards. This site exhibited the highest nitrate levels recorded in the watershed, and levels increased over the sampling period. The anthropogenic sources of nitrate at this site should be investigated. As with most sites in the Ossipee Watershed, water at this site was slightly acidic, and this site in particular had one of the lowest mean pH levels in the watershed. Dissolved oxygen levels measured at this site were regularly below state standards, and these levels decreased over the sampling period. Conductivity levels were slightly elevated, but generally fell below levels that would indicate human disturbance, and slightly decreased over the sampling period. Sodium and chloride levels remained stable over the sampling period but were elevated above natural background levels on a few occasions in 2007, and turbidity levels slightly increased. Surges in phosphate observed in the past were not observed 2006-2008, and levels decreased slightly over the sampling period. Dissolved organic carbon was slightly elevated when compared with other sites, however, levels decreased over the sampling period. Dissolved Inorganic Nitrogen dominated TDN at this site, indicating impairment. Higher levels of silica at this site indicate groundwater input, and along with higher nitrate levels, suggest that the aquifer could contain elevated levels of DIN.

GM-3 Forrest Brook, Rt. 113, Madison (monitored 2004-2008)
Mean levels for all parameters except for pH were within the acceptable range for surface waters according to state standards. Sodium and chloride levels remained below natural background levels for New Hampshire surface waters. Phosphate levels were elevated in 2005, and this site continued to have some of the highest levels of nitrate in the watershed, though overall levels were relatively low when compared with sites GM-1 and GM-2 in Madison. Dissolved Inorganic Nitrogen was approximately equal to the Dissolved Organic Nitrogen indicating possible impairing inputs. Higher levels of silica at this site indicate groundwater input, and along with higher nitrate levels, suggest that the aquifer could contain elevated levels of DIN. In 2006, 2007 and 2008 sampling just upstream showed that the macroinvertebrate community is indicative of ‘good’ quality streams.

GM-3u Forrest Brook upstream site, East Madison Road, Madison (monitored 2007-2008)
Mean levels for all parameters except for pH were within the acceptable range for surface waters according to state standards. Dissolved Organic Nitrogen slightly dominates Dissolved Inorganic Nitrogen at this site, and total phosphorus, sodium and chloride levels remained below natural background levels for New Hampshire surface waters. Since Forrest Brook GM-3 site had exhibited some of the highest nitrate concentrations of all sites in the past, GM-3u was chosen to bracket the brook and determine where nitrate could be entering the system. Nitrate concentrations appeared to be only slightly lower upstream at site GM-3u than at site GM-3 based on samples taken in 2007 and 2008. On a few occasions, nitrate levels at GM-3u were slightly higher than downstream site GM-3. Again, higher levels of silica at this site indicate groundwater input as with other sites in Madison.

GO-1 Beech River, Tuftonboro Road, Ossipee (monitored 2002-2008)
Mean levels for all parameters except for pH were within the acceptable range for surface waters according to state standards. As with most sites in the Ossipee Watershed, water at this site was slightly acidic. Dissolved oxygen levels have at times fallen below state standards. Dissolved Organic Nitrogen dominates Dissolved Inorganic Nitrogen at this site, and total phosphorus, sodium and chloride levels remained mostly below natural background levels for New Hampshire surface waters. On a few occasions in the summer months, sodium and chloride

levels at this site were higher than typical background levels of NH surface waters. Conductivity levels remain below natural background levels and appear to have remained stable over the sampling period, and turbidity levels slightly decreased. This site continues to show one of the highest silica levels in the watershed, indicating groundwater input. Macroinvertebrate sampling results from 2006 through 2008 suggest the Beech River contains a macroinvertebrate community indicative of a stream in good to excellent condition.

GO-2 Frenchman Brook, White Pond Road, Ossipee (monitored 2002-2008)
Although pH and dissolved oxygen levels were acceptable according to state standards, this site had elevated levels of salt, nutrients and other parameters that indicate impairment. Dissolved Organic Nitrogen slightly dominates Dissolved Inorganic Nitrogen at this site, and total phosphorus levels remained mostly below natural background levels for New Hampshire surface waters (on one occasion in 2004 total phosophorus levels were elevated). Mean sodium, chloride, potassium and calcium concentrations at this site were the highest among all sites, frequently above typical background levels for NH surface waters and indicating potential influence from road salting activities, although the levels of these salts appears to have decreased in the past few years. Turbidity levels were also consistently the highest at this site and increased slightly over the sampling period. Conductivity levels were also consistently among the highest in the watershed, sometimes two to three times higher than natural background levels, indicating adverse impacts from road salting. Field testing of conductivity, sodium, and chloride levels along the length of the brook below Route 16 and above Route 16 have indicated that runoff from the highway and impervious surfaces nearby Route 16 that drain into the brook are the source of impairing inputs to this waterbody. It is recommended that reduced salting, alternatives to road salt, and/or other best management practices be explored by the town and businesses to lessen the impacts to this brook before chronic toxicity limits are reached as is the case in southeastern NH streams.

GO-3 Frenchman Brook, Polly's Crossing, Ossipee. (monitored 2003)
This site did not experience the elevated nutrient levels as the downstream GO-2 site saw in 2002 and 2003. This site was discontinued due to intermittent flow and dry conditions during the summer months.

GO-4 Bearcamp River, UNH property, Newman Drew Rd., Ossipee (monitored 2004-2008)
Mean levels for all parameters except for pH were within the acceptable range for surface waters according to state standards. Total phosphorus, conductivity, sodium and chloride levels remained below natural background levels for New Hampshire surface waters, although conductivity levels appear to have increased slightly over the sampling period, as did turbidity levels. Mean dissolved inorganic nitrogen approached the level of dissolved organic nitrogen at this site, indicating some impairing inputs. Nitrate concentrations at this site and a site farther downstream (OL-2) were also slightly higher than nitrate levels observed at upstream sites (GT-1, GO-5), however, nitrate levels overall were relatively low (below .15 mg NO_3-N/L). Higher silica levels at this site indicated a significant amount of groundwater input.

GO-5 Bearcamp River, Whittier Bridge, Ossipee (monitored 2004-2008)
Mean levels for all parameters except for pH were within the acceptable range for surface waters according to state standards. Total phosphorus, conductivity, sodium and chloride levels remained below natural background levels for New Hampshire surface waters, although total phosphorus levels were elevated on one occasion in 2007. Conductivity levels appear to have remained stable over the sampling period, while turbidity levels slightly increased. Dissolved

Inorganic nitrogen dominated Dissolved Organic Nitrogen, indicating some impairing inputs. Nitrate concentrations at this site and sites farther downstream (OL-2 & GO-4) were also slightly higher than nitrate levels observed at the upstream sites (GT-1), however, nitrate levels overall were relatively low (below .15 mg NO_3-N/L). This site has experienced high levels of silica, indicating a significant amount of groundwater input.

GO-6 Beech River, Route 16, Ossipee (pilot site 2005-2006)
Random testing at this pilot site through 2006 was conducted at this site based on a request from town officials who thought potential impairing inputs from an old mill and tannery could be affecting the stream. Mean levels for all parameters except for pH were within the acceptable range for surface waters according to state standards.

GS-1 Cold River, Route 113, Sandwich (monitored 2002-2008)
Mean levels for all parameters except for pH were within the acceptable range for surface waters according to state standards. Total phosphorus, conductivity, sodium and chloride levels remained well below natural background levels for New Hampshire surface waters, and Dissolved Organic Nitrogen slightly dominates Dissolved Inorganic Nitrogen at this site. Aside from one slightly elevated phosphate reading in 2005, this site continued to demonstrate the lowest temperatures, nutrient concentrations and salts in the watershed. GS-1 serves as a minimally impacted reference site for the rest of the Ossipee Watershed. In 2006, 2007 and 2008 sampling just upstream from the site showed the macroinvertebrate community was indicative of a stream with 'excellent' water quality.

Pond Brook, Sandwich (sampled in 2006)
In 2006, the macroinvertebrate community in Pond Brook was indicative of streams with 'excellent' water quality.

GT-1 Bearcamp River, Route 113, Tamworth (monitored 2002-2008)
Mean levels for all parameters except for pH were within the acceptable range for surface waters according to state standards. Total phosphorus, conductivity, sodium and chloride levels remained well below natural background levels for New Hampshire surface waters. There was only one occasion in 2005 when chloride levels rose above natural background levels. As with most sites in the Ossipee Watershed, water at this site was slightly acidic, and this particular site's pH was almost always below state standards. Dissolved oxygen levels occasionally dipped below state standards, but the mean was within an acceptable range. The tea stain in the water and the low dissolved oxygen and pH could be a factor of the several wetlands that the Bearcamp winds through before passing by GT-1; however, if this is the case, the DOC and DON concentrations are surprisingly low as well. Dissolved Organic Nitrogen dominates Dissolved Inorganic Nitrogen at this site. Nitrate concentrations at this site were lower than nitrate levels observed at the downstream sites (GO-5, GO-4, and OL-2), and nitrate levels overall were relatively low (below .15 mg NO_3-N/L).The macroinvertebrate community in the Bearcamp River at a site downstream from GT-1 in 2006 and 2008 was indicative of a stream with 'good' water quality in 2006 and 2008.

GT-2 Mill Brook, Earle Remick Natural Area, Tamworth (monitored 2002-2003)
DIN dominated TDN at this site in 2003, while the site upstream GT-3 did not, indicating that the source of impairment occurs between GT-2 and GT-3. In 2002 and 2003, this site experienced the highest mean concentration of ammonium measured thus far for sites in the

watershed. *This site was discontinued because NH DES has monitoring wells nearby to monitor the capped landfill for nutrients and other chemicals.*

GT-3 Mill Brook, Durrell Road, Tamworth (monitored 2003)
This site is listed as "impaired" due to lower pH levels that could harm aquatic life. This site had elevated levels of DOC, indicating the presence of more organic matter and decomposition at the site. Water color was tea-stained, and unlike downstream site GT-2, this site did not experience the same DIN domination or low pH. *This site was discontinued because NH DES has monitoring wells nearby to monitor the capped landfill for nutrients and other chemicals.*

Mill Brook, Bunker Hill Road, Tamworth (monitored 2006-2008)
From 2006 to 2008, the macroinvertebrate community at Mill Brook was indicative of a stream with ‘good’ to ‘excellent’ water quality. The site tested was located upstream from GT-2 and GT-3.

GT-4 Chocorua River, RT. 41, Tamworth (monitored 2004-2008)
Mean levels for all parameters except for pH were within the acceptable range for surface waters according to state standards. Total phosphorus, conductivity, sodium and chloride levels remained below natural background levels for New Hampshire surface waters, although conductivity and turbidity levels appear to be increasing slightly over time and conductivity was elevated above natural background levels on one occasion in 2008. DIN concentrations dominated DON, and this site continued to have one of the higher mean nitrate concentrations measured across the watershed, although levels were relatively low overall (<.32 mg NO_3-N/L).

GT-5 Swift River, Tamworth Village, Tamworth (monitored 2005-2008)
Mean levels for all parameters except for pH were within the acceptable range for surface waters according to state standards. Total phosphorus, conductivity, sodium and chloride levels remained below natural background levels for New Hampshire surface waters. Conductivity levels appear to be stable while turbidity levels increased slightly over the sampling period. DIN dominated DON concentrations at this site, although TDN levels were low overall. This site had the lowest mean DOC concentrations in the watershed.
In 2006 the macroinvertebrate community was indicative of a stream with ‘fairly poor’ water quality. However, the data may reflect a bias towards the selection of black fly larvae, driving up the biotic score. Sampling in 2007 and 2008 showed ‘good’ and ‘excellent’ water quality, respectively, based on the communities found.

OLT Sites:

OL-1 West Branch River (monitored 2003-2004)
In 2003 and 2004, with low turbidity and nutrients and high dissolved oxygen and neutral pH, this site exhibited good water quality, although it is listed as "impaired" due to lower pH levels that could harm aquatic life.

OL-1u West Branch River, Ossipee Lake Road, Ossipee (monitored 2005-2008)
Mean levels for all parameters except for pH were within the acceptable range for surface waters according to state standards. Total phosphorus, conductivity, sodium and chloride levels remained below natural background levels for New Hampshire surface waters, although chloride levels have approached minimum background levels on a number of occasions. Conductivity and turbidity levels appear to have increased slightly over the sampling period. DIN

concentrations dominated DON, and mean nitrate levels were one of the highest of all sites, although below .34 mg NO_3-N/L Dissolved oxygen levels also fell below state standards occasionally.

OL-2 Bearcamp River (monitored 2003-2008)
Mean levels for all parameters except for pH were within the acceptable range for surface waters according to state standards. Low turbidity, nutrient and salt levels and high dissolved oxygen have been observed at this site. Dissolved Organic Nitrogen dominates Dissolved Inorganic Nitrogen at this site. Total phosphorus, conductivity, sodium and chloride levels remained below natural background levels for New Hampshire surface waters. Conductivity levels appear to have remained stable while turbidity levels appear to have increased slightly over the sampling period. This site exhibited higher temperatures than other sites, most likely due to the influence of warmer lake waters.

OL-3 Patch Pond Point River (monitored 2003-2004)
This site experienced elevated levels of calcium in 2003 and 2004 which were higher than calcium levels at most other sites in the watershed. This may be from a natural source and future sampling will determine if this is an ongoing occurrence. This site was discontinued in 2005 & 2006 for lack of an upstream access point. This site could be sampled in the future from a small watercraft.

OL-4 Lovell River, outlet to lake (monitored 2003-2004)
This site exhibited good water quality in both 2003 and 2004. This site was moved upstream in 2005 to OL-4u to eliminate the influence of lake water.

OL-4u Lovell River, Route 16, Ossipee (monitored 2005-2008)
Mean levels for all parameters except for pH were within the acceptable range for surface waters according to state standards. This site had some of the lowest concentrations of sodium, chloride, calcium, potassium and magnesium of all sites. Likewise, conductivity levels were low over the sampling period. Dissolved oxygen is typically high, and pH tends to be low. While total phosphorus levels were some of the lowest in the watershed and total dissolved nitrogen levels were also low, DIN is almost equal to DON, with nitrate concentrations accounting for the majority of DIN. Biomonitoring in 2006 suggested the macroinvertebrate community composition was indicative of a site with ‘fairly poor’ water quality. However, the data may reflect a bias towards the selection of more visible black fly larvae. Sampling in 2007 and 2008 showed ‘excellent’ and ‘good’ water quality conditions, respectively.

OL-5 Weetamoe Brook, outlet to lake (monitored 2003-2004)
This site exhibited good water quality in 2003 and 2004 with low turbidity and nutrients and high dissolved oxygen and neutral pH readings. At the recommendation of UNH water quality experts, in 2005 this site was moved upstream to OL-5u to ensure lake water would not influence samples and data.

OL-5u Weetamoe Brook, Weetamoe Road, Ossipee (monitored 2005)
Total phosphorus, conductivity, sodium and chloride levels remained below natural background levels for New Hampshire surface waters, except on one occasion in 2007 when total phosophorus levels were higher than natural background levels. This site exhibited one of the highest mean turbidity levels in the watershed, most likely due to lower flow and water stagnation. This site also had one of the lowest mean dissolved oxygen levels, with

concentrations consistently below state standards, and some of the lowest pH readings in the watershed. Total phosphorus concentrations were at times elevated when compared with other sites in the watershed. The site was discontinued in 2005 in an effort to find more reliable flow upstream at site OL-5ua.

OL-5ua Weetamoe Brook, Weetamoe Road, Ossipee (monitored 2006-2008)
Conductivity, sodium and chloride levels remained below natural background levels for New Hampshire surface waters. This site exhibited similarly high mean turbidity levels to the downstream site OL-5u, again, most likely due to lower flow and water stagnation. This site also had one of the lowest mean dissolved oxygen levels, with concentrations consistently below state standards, and some of the lowest pH readings in the watershed. Total phosphorus concentrations were often elevated when compared with other sites in the watershed, and rose above natural background levels on multiple occasions. Efforts will continue on this brook to find a suitable monitoring site with reliable flow to determine whether or not water quality at this site is due to natural conditions, or to determine if causes to low flows are natural or anthropogenic, such as a high-placed culvert.

OL-6 Pine River (monitored 2003-2006)
Mean levels for all parameters except for pH were within the acceptable range for surface waters according to state standards. Conductivity, sodium and chloride levels remained below natural background levels for New Hampshire surface waters. Dissolved oxygen levels dipped below state standards occasionally. Nutrient and salt levels were similar to upstream site GE-1, with mean silica levels also higher than most other sites, indicating groundwater input.

OL-7 Red Brook (monitored 2003-2008)
OL-7 continued to exhibit many traits of a wetland system: low dissolved oxygen and pH and high nitrogen, phosphate, total phosphorus, and dissolved organic carbon. Indeed, this site drains a large shrub-dominated wetland. While the site has some of the highest mean levels of nutrients, it has the lowest mean silica and sulfate levels in the watershed. Dissolved Organic Nitrogen dominated Dissolved Inorganic Nitrogen at this site, with this site showing some of the highest levels of ammonium in the watershed. Preliminary analysis of data from 2003 to 2008 shows an increasing trend in phosphate and a variable trend in dissolved organic carbon. A site upstream of this wetland would determine the quality of the water as it comes into the wetland. A comparison of the water quality upstream and downstream of the wetlands could determine the functionality of this area. GE-4 was initially selected as the upstream bracketing site, however, this site's restricted flow does not allow for regular testing. This stream enters the lake just to the east of OLNA. The sense (from what I hear) is that currents typically move down to the Ossipee River from there (through the bays), so not sure that water has much of an influence on OLNA beach area.

OL-9 Cold Brook, outlet to lake (monitored 2003-2004)
This site exhibited high levels of both total phosphorus and phosphate in 2003. However, in 2004, total phosphorus and phosphate were low relative to other OLT sites. In addition, this site showed good water quality with low turbidity and nutrients and high dissolved oxygen. This site was moved upstream in 2005 to eliminate the influence of lake water.

OL-9u Cold Brook, Alvino Road, Freedom (monitored 2005-2008)
Mean levels for all parameters except for pH were within the acceptable range for surface waters according to state standards. Conductivity, sodium and chloride levels remained below natural

background levels for New Hampshire surface waters. Turbidity and conductivity levels slightly decreased over the sampling period. Dissolved Inorganic Nitrogen dominated Dissolved Organic Nitrogen, however, nitrogen levels were relatively low, with nitrate being the primary component and levels falling below .17 mg NO_3-N/L.

OL-10 Huckins Pond Outflow (monitored 2003-2007)
Mean levels for all parameters except for pH were within the acceptable range for surface waters according to state standards. This site continued to show higher temperatures when compared with other watershed sites, most likely due to lake water influence. Overall, the site exhibited low turbidity, conductivity, nutrients and salts. In the future, moving this site upstream will yield data more representative of the tributary's water quality since it appears that lake waters are influencing samples.

OL-11 Danforth Brook, outlet of Lower Danforth Pond (monitored 2003-2004; same site as GF-1)
This site is listed as "impaired" due to lower pH levels that could harm aquatic life. Turbidity and nutrients were low, dissolved oxygen was high, and the pH was neutral. This site was discontinued as a tributary site since it was already being monitored as RIVERS site GF-1.

OL-12 Phillips Brook, outlet to Leavitt Bay (monitored 2003-2004)
This site is listed as "impaired" due to lower pH levels that could harm aquatic life. A new infestation of variable milfoil was found at this site in 2003. Since the milfoil was discovered it has been treated with herbicides and mats; however, the milfoil still exists in the brook. In 2004, this site showed elevated levels of dissolved organic carbon, sodium and chloride relative to other OLT sites. This site was moved upstream to be sampled by the road when the campers could not sample. This could explain the difference in sodium and chloride as the water is more influenced by road salt application. This site was moved permanently upstream in 2005 to OL-12u.

OL-12u Phillips Brook, Remle Road, Effingham (monitored 2005-2008)
This site exhibited signs of impairment based on data from the sampling period. Monitoring through 2008 showed some of the highest conductivity readings and turbidity readings in the watershed, with conductivity levels variable over the sampling period. This site also had the highest mean sodium and chloride levels observed for the watershed due to road salting of Route 25 and other small roads in the watershed. Dissolved Inorganic Nitrogen dominated Dissolved Organic Nitrogen, however, nitrogen levels were relatively low, with nitrate being the primary component and levels falling below .33 mg NO_3-N/L. Mean dissolved oxygen and pH levels were below state standards. Calcium, magnesium and potassium levels were slightly elevated as well. One particular incident with road work just upstream on Route 25 in 2005 led to a spike in turbidity and total phosphorus. Continued monitoring and spring testing at this site may help determine if these conditions persist, but the recommendation is to look into reduced salting and/or road salt alternatives near this site.

OL-13 Leavitt Brook, Camp Marist property, Effingham (monitored 2003-2008)
Mean levels for all parameters except for pH were within the acceptable range for surface waters according to state standards. Conductivity, total phosphorus, sodium and chloride levels remained below natural background levels for New Hampshire surface waters, although in 2005 conductivity levels were slightly above natural background levels on a few occasions. While conductivity levels appeared to decrease slightly over the sampling period, turbidity levels

increased. Dissolved Organic Nitrogen dominated Dissolved Inorganic Nitrogen at this site. This site consistently showed elevated levels of silica, indicating that this site is groundwater fed.

OL-14 Square Brook, outlet at Broad Bay, Freedom (monitored 2003-2004)

In 2003, with low turbidity and nutrients and high dissolved oxygen and pH, this site exhibited good water quality, although it is listed as "impaired" due to lower pH levels that could harm aquatic life. In 2004, this site exhibited high turbidity, dissolved inorganic nitrogen, sodium, chloride, potassium, calcium, and magnesium, indicating impairment. This site also exhibited high levels of silica suggesting that it is groundwater fed. The difference between the two years may be explained by a change in sampling location further upstream from the lake and closer to Ossipee Lake Road. This site was moved permanently upstream in 2005 to site OL-14u.

OL-14u Square Brook, Ossipee Lake Road, Freedom (monitored 2005-2008)

As with other sites in the watershed, mean pH levels were below state standards. Monitoring through 2008 showed consistently elevated conductivity readings, indicating impact from human activities. Magnesium, calcium, potassium, sodium and chloride were all slightly elevated at this site when compared with other sites in the watershed. Chloride was regularly above typical background levels for NH's surface waters in 2005 and again in 2008. Total Dissolved Nitrogen was also elevated, with Dissolved Inorganic Nitrogen dominating TDN at a higher percentage than most sites, however, nitrogen levels were relatively low, with nitrate being the primary component and levels falling below .36 mg NO_3-N/L.

B. Road Salt Management in the Ossipee Watershed

Salinization of surface and ground water from sodium chloride, or road salt, is becoming one of the most significant nonpoint source pollution issues in the state of New Hampshire. Surface water chloride has increased by as much as 760% in the Merrimack River watershed over the 20th century, (Daley et. al, 2008). Chloride loading in water courses elsewhere in the state has led to TMDL (total maximum daily load) studies and the development of salt management plans to reduce salt usage and snow dumping (Figure 58) where water bodies are already impaired, such as the 2007-2008 NH DOT Route 93 project.

Figure 58: A brook in the Ossipee Watershed where snow is plowed and dumped, (along with salt, sand and other roadway debris), directly into the surface water. *Photo from winter, 2005.*

The University of New Hampshire Natural Resources Department specialists are also conducting studies on chloride, sodium and conductivity data for seacoast streams because they see "VERY strong relationships in the seacoast between chloride in the stream and percent imperviousness of the watershed," (Michele Daley, UNH Natural Resources Department, personal communication 2008). A recent study which included Ossipee watershed streams reveled that even though the Ossipee Watershed is divorced from major interstate highways (i.e. I 93, I 95) there is still a strong relationship between stream water sodium and chloride and watershed road density or percent of the watershed paved for roads. A recent road salt study from Derry, Londonderry, Salem and Belham, N.H. found that 90% of salt imported to the watershed was for roadway and parking lot deicing (DES, DOT, EPA 2002-2006). Brooks in this watershed were experiencing more than one hundred times the historic background level of chloride and chronic water quality violations (Trowbridge, 2008). Currently, no such studies have quantified the amount of salt imported into the Ossipee Watershed even though there is a clear impact of road salt on steams and salt use is increasing without any management plan. The New Hampshire Department of Transportation typically spreads 180,000 tons of salt on the roads it maintains; in the winter of 2007-2008, it used 250,000 tons (Conway Daily Sun, 2008).

One of the top recommendations of a recent study of the Ossipee Watershed's natural resources highlighted protection of water resources from road salting and storage as one of the top priorities for this region (see http://www.gmcg.org/gmcg.php?id=160 for details). Towns need to have a better sense of how much road salt is being added to the watershed each year, and what the threshold is for salt in our surface and ground waters. Proactive research and planning can help determine how much salt is too much to prevent the problems that road salt is having elsewhere in New Hampshire. A strategic plan for Ossipee Watershed towns and state and town road agents should be developed to lessen the impact that road salt is having on surface waters now and in the future.

Below are findings from the UNH Stormwater Center's (UNHSC) studies on porous asphalt. The use of porous asphalt pavement in the Ossipee Watershed could drastically reduce the need for road salt in winter conditions, thereby reducing loading to nearby surface and groundwater. "The answer is to use less salt in the first place. Our research indicates that by using pervious pavement, like porous asphalt or concrete, we can reduce the amount of salt needed for winter maintenance drastically, maybe by as much as 70 percent," says Robert Roseen, UNHSC Director. "Porous asphalt allows snowmelt and rain to drain through the surface and filter through the layers of gravel and sand below," explains Thomas Ballestero, center co-director and UNH associate professor of civil engineering. "So, not only does it appear to need less salt, this infiltration process removes pollutants like sediment, heavy metals, and petroleum products. The lot also does a phenomenal job of reducing the volume of runoff."

Porous asphalt is suitable for many sites, such as parking lots and low use roadways, and it is ideal for proposed developments with large areas of impervious surface. However, the use of porous asphalt should be evaluated on a site-by-site basis as there are site-specific considerations and maintenance to consider.

The 2008 Porous Asphalt Study by Jeff Gunderson (http://stormh2o.com/september-2008/pervious-asphalt-concrete.aspx), highlights some of the findings mentioned above:

Design & Durability:

- The principal cause of parking lot pavement breakdown in northern climates is freeze-thaw cycling. Parking lots in these regions typically have a lifespan of about 15 years.
- An open-graded, well-drained porous pavement system incorporating significant depth will have a longer life cycle from reduced freeze-thaw susceptibility and greater load-bearing capacity than conventional parking lot pavements.

Run-off:

- Throughout the research period, the study found that surface runoff did not occur from the parking lot, even though the Northeast region experienced an increase in extreme storm events. "We witnessed two 100-year storm events during the monitoring period and have never seen surface runoff, only runoff through the subdrainage system as designed," said Dr. Robert Roseen, director of the UNHSC.

Water Quality:

- The UNHSC also monitored the quality of water draining at the base of the pervious asphalt system. Temperature, conductivity, dissolved oxygen, pH, and turbidity were monitored every five minutes in addition to automated sampler collections during storms. Water samples were sent to a certified lab for analysis of water quality. Results showed exceptional water-quality performance for the porous asphalt with no seasonal variation.
- "The porous asphalt design is distinctive in its use of a medium-grained sand for a reservoir base and filter course," says Roseen. "This refinement enhances its effectiveness in treating water quality."

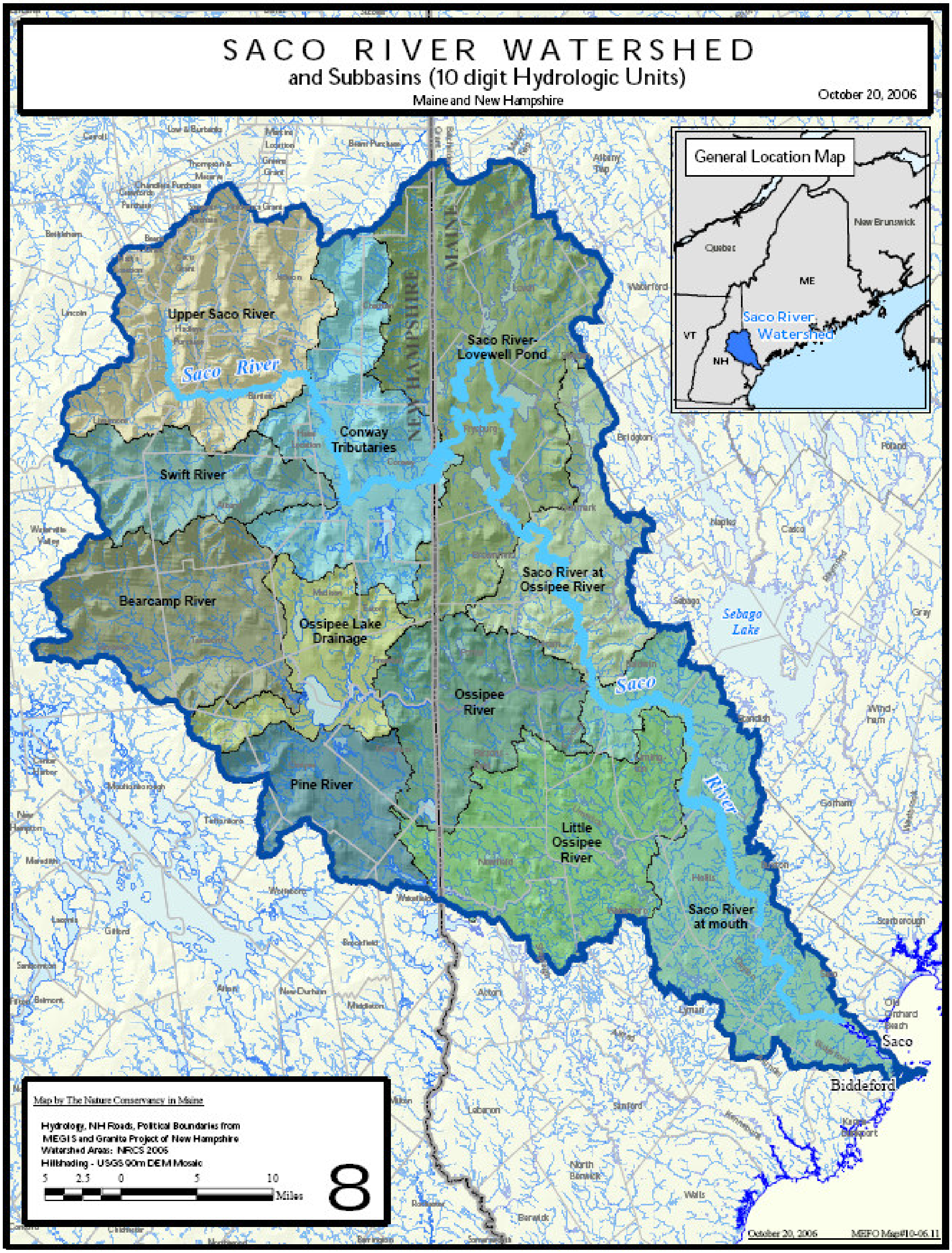
Winter Maintenance:

- Research findings showed that salt application for porous asphalt could be reduced by 75%, based on snow and ice cover. "With only 25% of the salt, the snow and ice cover on the porous asphalt was the same as on the dense-mix asphalt parking lot," says Roseen. "And even with no salt, porous asphalt has higher frictional resistance than dense-mix asphalt with 100% of the normal salt application," he says. "Therefore, a sizable reduction in salt application rate is possible for porous asphalt without compromising braking distance or increasing the chance of slipping and falling."
- "During the summertime, runoff can get very hot, sometimes as high as 120 degrees," says Roseen. "When you have stormwater at that temperature flowing into a groundwater-fed stream that is at 65 degrees, severe impacts can occur in the aquatic ecosystem. Pervious pavements can significantly cool runoff."

Other Resources:

UNH Stormwater Center 2007 Annual Report:
http://www.unh.edu/erg/cstev/2007_stormwater_annual_report.pdf
UNH Research Says, "Hold the Salt" http://unh.edu/news/campusjournal/2008/Feb/20salt.cfm
NH DOT Route 93 Water Quality Study Documents:
http://www.rebuildingi93.com/content/environmental/waterquality/documents/
NH DOT Winter Maintenance Snow Removal and Ice Control Policy:
http://www.nh.gov/dot/bureaus/highwaymaintenance/documents/WinterMaintSnowandIcePolicy.pdf

Appendix C: Saco River Watershed Sub basins *(The Nature Conservancy, 2006)*



Appendix D: Parameters Tested for RIVERS & Ossipee Lake Tributary Programs

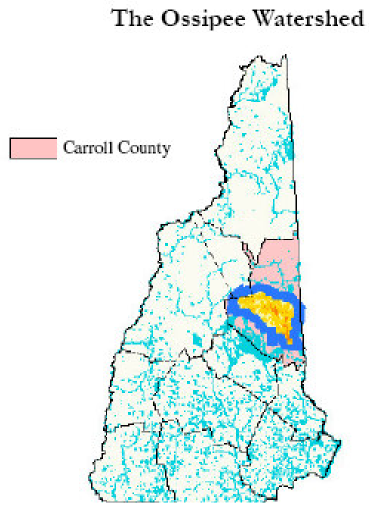
Table 1. Field parameters tested for RIVERS and OLT programs.

Parameter	Units	Instrument Used	Range	Accuracy
pH	pH units	YSI 60 YSI 556	0 to 14 0 to 14	±0.1 unit within 10°C of calibration ±0.2 unit within 20°C ±0.2 unit
Dissolved Oxygen	mg/l, %	YSI 550A YSI 556	0-200 % 0-50 mg/L 0-500%	±2% ±0.3 mg/L ±2% ±2%
Turbidity	NTU	HACH Model 2100P Portable Turbidimeter	0-1000 NTU	± 2% of reading
Temperature	˚C	HACH Non-mercury thermometer YSI 60 YSI 556	-5 to 45˚C	± 0.3˚C ± 0.1˚C ± 0.15˚C
Conductivity	µS/cm	YSI 556 (20 m cable)	0-200 mS/cm or 0-200,000 µS/cm	±1.0% of reading or ±.001 mS/cm; whichever is greater

Table 2. Lab parameters tested for RIVERS and OLT programs.

Parameter	Units	Instrument Used	Description	Sample Preservative
Total Phosphorus (TP)	µg/L	Milton-Roy 1001+ Spectrophotometer	Std Methods Ascorbic Acid method. 10cm pathlength cuvette	1 ml concentrated sulfuric acid and frozen
Dissolved Organic Carbon (DOC)	mg C/L	Shimadzu TOC-V	High Temperature Catalytic Oxidation (HTCO)	Filtered and Frozen
Total Dissolved Nitrogen (TDN)	mg N/L	Shimadzu TOC-V	HTCO with chemiluminescent N detection	
Nitrate (NO_3^-)	mg N/L	Smartchem Automated Colorimetry	Automated Cd-Cu reduction	
Ammonium (NH_4^-)	mg N/L		Automated Phenate	
Dissolved Organic Nitrogen (DON)	mg N/L		DON= TDN-(NO_3^-+ NH_4^-)	
Phosphate (PO_4^{3-})	µg P/L	Smartchem Automated Colorimetry	Automated Ascorbic Acid	
Silica (SiO_2)	mg SiO_2/L		Automated Molybdate Reactive Method	
Anions (Cl^-, SO_4^{2-})	mg/L	Ion Chromatograph	Anions via ion chromatography with suppressed conductivity	
Cations (Na^+, K^+, Ca^{2+}, Mg^{2+})	mg/L		Cations via ion chromatography and conductivity	

Field Data Sheet



PART I – SITE AND SAMPLER ID

Site Code Number__________Sample Collection Date________

Site Location______________ Time Begin/Finish____________

Field Samplers Names________________________________

Signature of Sampler________________________________

PART II – WEATHER CONDITIONS

Current Weather: □ Clear □ Partly Cloudy □ Mostly Cloudy □Fog □Haze □Sunny □Drizzle □Steady Rain □Downpour □Snow
(*check all that apply*)
Rainfall in previous 24 hours:□None□Light□Heavy _______inches
Source of rainfall information: ________________________________ (*i.e. rain gauge, regional weather report, etc.*)

PART III – SITE OBSERVATIONS (*check all that apply*)
Water Appearance:□Clear □Milky □Turbid □Foamy □Oily □Light/Dark Brown □Greenish □Other (*explain*)_
Water Odor:□None □Fishy □Chlorine □Rotten Eggs □Other(*explain*)_
Wildlife Observations:____
Floatable Observations (*i.e. leaves, foam, or debris*): ____
Bottom Observations (*i.e. color, bottom type, silt, rocky, algae, sand etc.*)____
Local Observations (erosion, flooding, road work, littering or other disturbances)________________________________

PART IV – EQUIPMENT INFORMATION
YSI 556 Meter # 1 _______Turbidity Meter Used________
YSI 556 Meter # 2_______
pH meter used___________
DO meter used___________
*Calibration completed by WQM staff and/or volunteers (see log).

PART V – FIELD MEASUREMENTS

Depth that measurements were taken________________________inches *(Indicate the depth of the **probe** in the water when taking the measurement).*

	Temperature	Specific (25˚C) Conductivity	Conductivity	Dissolved Oxygen	pH	Turbidity
Reading #1				% sat.		NTU
Reading #2				% sat.		NTU
HACH Thermometer Reading						

Averages (to be computed by staff)	° C	µS/cm	µS/cm	% sat	mg/L		NTU

PART VI – SAMPLE COLLECTIONS

Time DOC,TDN, NH4, PO4, cations, anions sample collected	a.m.	Time Total Phosphorus sample collected	a.m.

REPLICATE SAMPLE COLLECTED?YESNO

Time DOC,TDN, NH4, PO4, cations, anions **replicate sample** collected	a.m.	Time Total Phosphorus **replicate sample** collected	a.m.

Rivers Sites **Test Sites Codes / Locations***Tributary Sites*

GE-1Pine River, Elm St., Effingham OL-1u West Branch River, Ossipee Lake Road, Freedom
GE-2South River, Plantation Rd., Parsonsfield OL-4u Lovell River Rt. 16, Ossipee
GE-3Ossipee River, Rt. 153, Effingham Falls OL-5ua Weetamoe Brook, Ossipee
GE-4 Red Brook, Green Mountain Rd, Effingham (pilot site) OL-7 Red Brook, Long Sands, Ossipee
GF-1Danforth Pond outlet, Ossipee Lake Rd., Freedom OL-9u Cold Brook, Ossipee Lake Marina, Freedom
GF-2 Cold Brook, Maple St., Freedom OL-10 Shawtown Brook, Danforth Camping Resort, Freedom
GF-3Cold Brook, inlet to Loon Lake, Cemetery Rd., Freedom OL-12u Phillips Brook, Effingham
GM-1Banfield Brook, Rt. 113, Eidelweiss, Madison OL-13 Leavitt Brook, Effingham
GM-2Pequawket Brook, Rt. 113, Madison OL-14u Square Brook, Ossipee Lake Road, Freedom GM-3Forrest Brook, Rt. 113, Silver Lake Hardware, Tamworth
GM-3uForrest Brook (bracketing site upstream) East Madison Rd, Madison
GO-1Beech River, Tuftonboro Rd., Ossipee
GO-2 Frenchman Brook, White Pond Rd., Ossipee
GO-2ua Frenchman Brook (bracketing site upstream) Pike Concrete Facility, Ossipee
GO-4Bearcamp River, UNH property accessed via Witt's End Camp Ground, West Ossipee

Appendix F: Examples of Water Testing Schedules 2005-2006

2005 RIVERS Water Quality Sampling Schedule

	Monday***	Tuesday**	Wednesday**	Thursday**
Key: ***** indicates a 3 pt calibration needs to be completed to pH meter, in addition to DO calibration** **** indicates a 2 pt calibration needs to be done to pH meter, in addition to DO calibration**	GE1 Volunteer	GM1 Volunteers	GT1 Volunteer	GF1 Volunteer
	GO1 Volunteers	GM3 Volunteers	GO4 Volunteers	GF2 Volunteer
	GO2 Volunteers	GT4 Volunteers	GS1 Volunteer	GF3 Volunteers
		GE2 Volunteer	GO5 Volunteer	GE3, GE 4, GO 6 GMCG Staff
			GT-5 Volunteer	

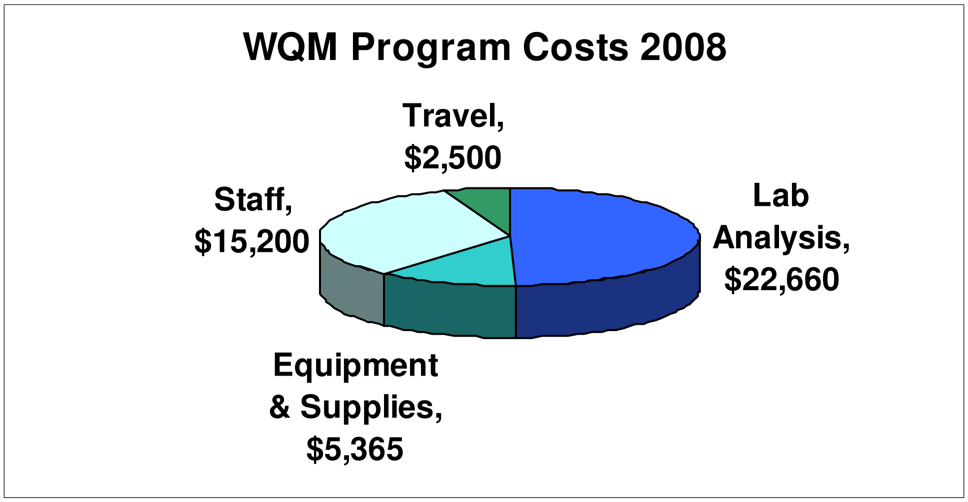
2005 OLT Schedule

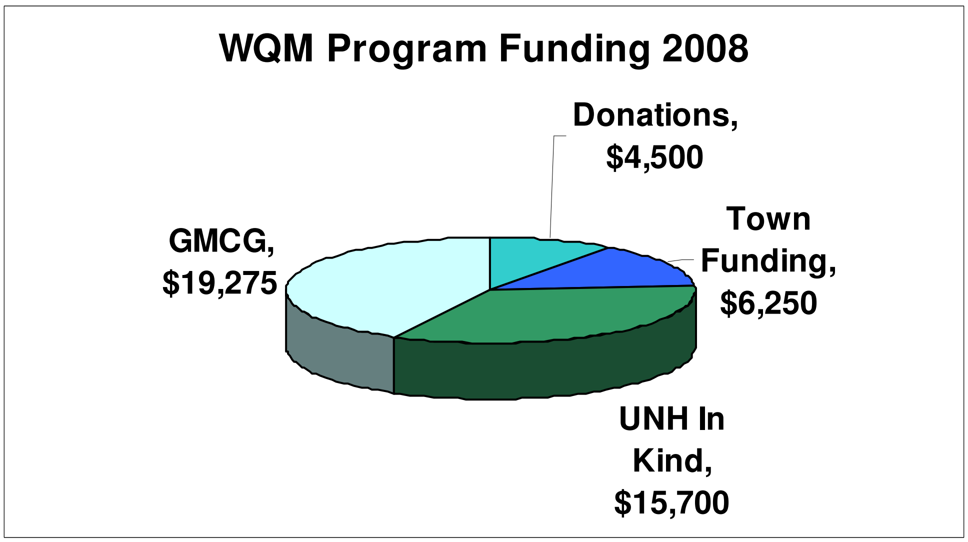
	Monday***	Tuesday**	Wednesday**	Thursday**	Friday**	Saturday**
Key: ***** indicates a 3 pt** **calibration needs to be completed to pH meter, in addition to DO calibration** **** indicates a 2 pt calibration needs to be done to pH meter, in addition to DO calibration**	OL-2 Camp Calumet 7:30 AM Campers/Staff Volunteers	OL-12u Volunteers	DW-1 Camp Cody 12:30pm Campers/Staff Volunteers	DW-2 Camp Huckins 12:00pm Campers/Staff Volunteers	DW-5 Danforth Bay Campground Staff Volunteers	DW-4 Volunteers
	OL-6 Camp Calumet	DW-3 Camp Robin Hood 1:00pm Campers/Staff Volunteers	OL-1u, OL-14u GMCG Staff	OL-4u GMCG staff	OL-10u GMCG staff	
	OL-9u Volunteers	OL-7u GMCG staff	OL-3u GMCG Staff	OL-5u GMCG staff		
		OL-13u GMCG staff				

2006 OLT & VLAP Schedule

	Monday***	Tuesday**	Wednesday**	Thursday**	Friday**
Key: ***** indicates a 3 pt calibration needs to be completed to pH meter, in addition to DO calibration** **** indicates a 2 pt calibration needs to be done to pH meter, in addition to DO calibration**	OL-13u GMCG OL-7 Volunteer 8:00 am	OL-2 OL-6 Camp Calumet 7:30 am Campers/Staff Volunteers	OL-1u OL-14u GMCG	Ol-5u OL-4u OL-10u Volunteer	
	OL-12u Volunteer 8:00 am		OL-9u Volunteers		
				DW-5 Danforth 10:00am Staff Volunteers	**** Samples to DES lab by 4:00 pm Wednesdays & Thursdays
			DW-2 Camp Huckins 11:45 am Campers/Staff Volunteers	DW-4 Robin Hood 11:30 am Campers/Staff Volunteers	
			DW-1 Camp Cody 1:00 pm Campers/Staff Volunteers	DW-3 Robin Hood 1:00 pm Campers/Staff Volunteers	

Appendix G: Program Funding





The Ossipee Watershed Water Quality Monitoring program is made possible by in kind donations of lab analysis from the University of New Hampshire, town support, GMCG membership support and donations from charitable organizations. Volunteers are a crucial part of the program, contributing approximately 450 hours each year, or $8,500 in labor, to the program.

Appendix H: Pollutants & Impacts Chart

Stormwater Pollutant	Examples of Sources	Related Impacts
Nutrients: Nitrogen, Phosphorus	Animal waste, fertilizers, septic systems	Algal growth, reduced clarity, other problems associated with eutrophication (oxygen deficit, release of nutrients and metals from sediments)
Sediments: Suspended and Deposited	Construction sites, other disturbed and/or non-vegetated lands, eroding banks, road sanding	Increased turbidity, reduced clarity, lower dissolved oxygen, deposition of sediments, smothering of aquatic habitat including spawning sites, sediment and benthic toxicity
Organic Materials	Leaves, grass clippings	Oxygen deficit in receiving water body, fish kill
Pathogens: Bacteria, Viruses	Animal waste, failing septic systems	Human health risks via drinking water supplies, contaminated swimming beaches
Hydrocarbons: Oil and grease, PAH (Napthalenes, Pyrenes)	Industrial processes; automobile wear, emissions & fluid leaks; waste oil	Toxicity of water column and sediment, bioaccumulation in aquatic species and through food chain
Metals: Lead, Copper, Cadmium, Zinc, Mercury, Chromium, Aluminum, others	Industrial processes, normal wear of auto brake linings and tires, automobile emissions & fluid leaks, metal roofs	Toxicity of water column and sediment, bioaccumulation in aquatic species and through the food chain, fish kill
Pesticides: PCBs, Synthetic Chemicals	Pesticides (herbicides, insecticides, fungicides, rodenticides, etc.), industrial processes	Toxicity of water column and sediment, bioaccumulation in aquatic species and through the food chain, fish kill
Chloride	Road salting and uncovered salt storage	Toxicity of water column and sediment
Trash and Debris	Litter washed through storm drain networks	Degradation of the beauty of surface waters, threat to wildlife

Appendix I: Resources & Links

Forestry

Hubbard Brook Experimental Forest: www.hubbardbrook.org
National Forest Service: www.fs.fed.us/
Project Learning Tree: www.nhplt.org
Society for the Protection of the NH Forests: www.forestsociety.org

Land Conservation

Conservation Law Foundation: www.clf.org
NH Conservation Real Estate: www.NHConservationRE.com
The Nature Conservancy: www.nature.org/wherewework/northamerica/states/newhampshire/
Upper Saco Valley Land Trust: www.usvlt.org

Planning/Mapping

Environmental System and Research Institute: www.esri.com
GRANIT: Geographically Referenced Analysis Information Transfer System: www.granit.sr.unh.edu
Lakes Region Planning Commission: www.lakesrpc.org
NH Department of Resources and Economic Development: www.dred.state.nh.us
North Country Council: www.nccouncil.org
Plan-link: www.nh.gov/oep/programs/MRPA/PlanLink.htm

Water

DES Environmental Monitoring Database: http://des.nh.gov/OneStop.htm
DES Surface Water Quality Assessments [305(b)&303(d)]: www.des.state.nh.us/wmb/swqa/303d
http://www.des.state.nh.us/wmb/swqa/303dList.html
Hubbard Brook Mercury Report: http://www.hubbardbrookfoundation.org/article/view/13188/1/2076/
NASA Global Change Master Directory: www.gcmd.gsfc.nasa.gov
NH Lakes: www.nhlakes.org
NH Rivers Council: www.nhrivers.org
Ossipee Lake Alliance: www.ossipeelake.org
River Network: www.rivernetwork.org
Saco River Corridor Commission: www.srcc-maine.org
Water Quality Standards: http://des.nh.gov/wqs/;
www.epa.gov/waterscience/standards/wqslibrary/nh/nh_1_chapter1700.pdf

Wildlife

Fish and Wildlife Service: www.fws.gov
Loon Preservation Committee: www.loon.org
National Wildlife Federation: www.nwf.org
NH Audubon: www.nhaudubon.org
NH Coverts: http://extension.unh.edu/Wildlife/NHCovrts.htm
New Hampshire Fish & Game: www.wildlife.state.nh.us
N.H. Wildlife Action Plan: www.wildlife.state.nh.us/Wildlife/wildlife_plan.htm
Project Wild: www.projectwild.org/index.htm
Squam Lakes Natural Science Center: www.nhnature.org

Local/ State

Greater Ossipee Area Chamber of Commerce: www.ossipeevalley.org
Town of Ossipee: www.ossipee.org
Town of Madison: www.madison-nh.org
Maine Department of Environmental Protection: www.state.me.us/dep/
NH Department of Environmental Services: www.des.state.nh.us/
NH Rivers Council: www.epa.gov/cgi-bin/epaprintonly.cgi
SPACE: Statewide Program of Action to Conserve our Environment: www.nhspace.org
Trout Unlimited: www.tu.org/
University of NH Cooperative Extension: www.ceinfo.unh.edu

Regional/National

Environmental Protection Agency: www.epa.gov/region1

New England Interstate Water Pollution Control Commission: http://www.neiwpcc.org/
American Rivers: www.americanrivers.org/
National Park Service: www.nps.gov
River Watch Network: www.rivernetwork.org

Reports:
Society for the Protection of New Hampshire Forests: *New Hampshire's Changing Landscape, 2005:* http://www.spnhf.org/research/papers/nhcl2005es.pdf
New Hampshire Lake Association: Phase II Report on the Economic Value of NH's Surface Waters

APPENDIX J: Site Descriptions & Raw Data (see separate PDF sheets for each site with data 2002-2007; below see data from 2008)

Site	River Site	Town	Date	Temp	Turbidity	pH	Oxygen mg/L	Oxygen (%)	Sp. Cond. µS/cm2	Cond. µS/cm2	Total P ug P/L	DOC mg C/L	TDN mg N/L	mg Cl/L	mg NO3-N/L	mg SO4-S/L	mg Na/L	mg K/L	mg Mg/L	mg Ca/L
GE-1	Pine River 1	Effingham	4/14/2008	2.21	0.69	7.09	12.77	94.4	33	19		3.38	0.20	7.45	0.04	0.88	5.85	0.50	0.22	3.39
GE-1	Pine River 1	Effingham	5/12/2008	12.20	0.96		9.38	87.6			11.7	3.56	0.23	10.93	0.06	0.99	8.69	0.54	0.58	5.29
GE-1	Pine River 1	Effingham	5/26/2008	13.13	1.21	6.16	9.35	89.0	77	60	11.2									
GE-1	Pine River 1	Effingham	6/9/2008	18.62	1.16	7.9	7.76	83.2	76	67	15.2	3.16	0.3	16.04	0.11	0.84	11.54	1.07	0.97	7.25
GE-1	Pine River 1	Effingham	6/23/2008	16.60	2.08	6.53	8.37	85.9	75	64	18.2									
GE-1	Pine River 1	Effingham	7/7/2008	17.85	1.73	5.64	7.80	81.9	81	70	15.5	3.26	0.32	15.55	0.12	1.91	11.59	0.74	0.86	7.01
GE-1	Pine River 1	Effingham	7/21/2008	17.01	1.53	6.35	7.71	79.8	77	65	22.8									
GE-1	Pine River 1	Effingham	8/4/2008	17.99	3.19	5.59	7.73	81.6	47	41										
GE-1	Pine River 1	Effingham	8/18/2008	17.47	1.70	5.89	7.62	79.6	66	57										
GE-1	Pine River 1	Effingham	9/1/2008	15.03	1.78	6.22	7.68	76.3	83	67										
GE-1	Pine River 1	Effingham	9/15/2008	16.41	1.12	6.3	8.07	83.0	60	50										
GE-1	Pine River 1	Effingham	9/29/2008	15.80	1.09		6.79	68.5	46	38										
GE-1	Pine River 1	Effingham	10/13/2008	10.35	1.03	6.46	9.79	87.6	67	48										
GE-2	South River	Effingham/Parsonsfield	5/15/2008	12.41	1.66	5.72	7.30	68.4	45	35	12.7	3.87	0.15	7.13	0	0.78	5.46	0.51	0.47	4.63
GE-2	South River	Effingham/Parsonsfield	5/30/2008	12.76	2.24	4.64	8.19	77.4	48	36										
GE-2	South River	Effingham/Parsonsfield	6/12/2008	17.90	3.02	5.67	6.23	65.7	53	45	26.2	4.59	0.22	8.09	0.03	0.72	6.28	0.91	0.88	6.26
GE-2	South River	Effingham/Parsonsfield	6/26/2008	16.31	1.92	6.13	8.67	88.5	47	39	20.9									
GE-2	South River	Effingham/Parsonsfield	7/10/2008	20.61	1.63	5.8	6.67	74.3	47	43	22.8	5.13	0.26	6.93	0.02	0.64	5.68	0.88	0.94	6.66
GE-2	South River	Effingham/Parsonsfield	7/24/2008	16.93	1.82	5.45	8.28	85.6	43	37										
GE-2	South River	Effingham/Parsonsfield	8/7/2008	16.96	1.13	5.43	6.38	65.9	38	32										
GE-2	South River	Effingham/Parsonsfield	8/21/2008	15.42	1.46	6.12	6.45	64.8	48	39										
GE-2	South River	Effingham/Parsonsfield	9/4/2008	16.22	1.76	6.27	7.75	78.9	52	43										
GE-2	South River	Effingham/Parsonsfield	9/18/2008	13.78	1.29	5.92	6.20	59.9	48	37										
GE-2	South River	Effingham/Parsonsfield	10/2/2008	13.82	1.15	5.49	5.99	57.9	95	75										
GE-2	South River	Effingham/Parsonsfield	10/16/2008	11.32	1.10	5.86	9.04	82.7	100	74										
GE-3	Ossipee River	Effingham	5/12/2008	13.70	0.71		10.34	99.7			4.9	2.64	0.14	4.87	0.05	0.88	4.76	0.70	1.01	2.02
GE-3	Ossipee River	Effingham	5/26/2008	16.00	0.80	6.2	9.98	101.1	39	32	7.5									
GE-3	Ossipee River	Effingham	6/9/2008	21.59	1.22	7.55	8.80	99.9	37	40	6.8	2.81	0.16	5.9	0.03	0.9	4.9	0.78	0.67	5.36
GE-3	Ossipee River	Effingham	6/23/2008	21.97	0.71	6.73	7.70	88.2	45	42	7									
GE-3	Ossipee River	Effingham	7/7/2008	25.40	0.77	6.51	7.72	94.3	42	42	7	2.56	0.18	6.45	0.01	1.14	5.21	0.49	0.48	5.01
GE-3	Ossipee River	Effingham	8/4/2008	24.22	0.90	6.65	7.56	90.2	42	41										
GE-3	Ossipee River	Effingham	8/18/2008	22.56	0.85	6.63	7.77	88.3	37	35										
GE-3	Ossipee River	Effingham	9/1/2008	22.68	0.90	7.09	7.38	85.5	38	37										

GE-3	Ossipee River	Effingham	9/15/2008	20.27	1.15	6.39	8.25	91.2	37	34										
GE-3	Ossipee River	Effingham	9/29/2008	17.87	0.85		8.87	93.5	37	32										
GE-3	Ossipee River	Effingham	10/13/2008	14.70	0.68	6.34	9.49	93.5	33	26										
GF-1	Danforth Pond Outlet	Freedom	6/11/2008	23.52	0.82	6.76	8.14	96.0	56	55		1.75	0.17	8.24	0.02	1.03	6.43	0.79	0.55	5.63
GF-1	Danforth Pond Outlet	Freedom	6/25/2008	21.72	0.68	7.01	8.47	96.5	51	49	8.4									
GF-1	Danforth Pond Outlet	Freedom	7/9/2008	26.42	0.90	6.78	6.48	80.3	52	53	14.5	3.26	0.18	6.99	0	1.06	5.99	0.54	0.61	5.32
GF-1	Danforth Pond Outlet	Freedom	7/23/2008	23.27	1.38	6.64	8.07	95.1	45	44										
GF-1	Danforth Pond Outlet	Freedom	7/30/2008	23.27	1.38	6.64	8.07	95.1	45	44										
GF-1	Danforth Pond Outlet	Freedom	8/13/2008	20.23	0.80	6.46	7.19	80.3	40	36										
GF-1	Danforth Pond Outlet	Freedom	8/13/2008	20.23	0.80	6.46	7.19	80.3	40	36										
GF-1	Danforth Pond Outlet	Freedom	8/28/2008	21.60	0.53	6.93	7.75	88.1	45	42										
GF-1	Danforth Pond Outlet	Freedom	9/17/2008	18.60	0.77	6.78	8.02	85.7	47	42										
GF-2	Cold Brook A1	Freedom	5/15/2008	11.04	1.15	6.42	9.88	89.5	71	51	10.9	2.33	0.13	13.36	0	1.19	9.83	0.96	0.98	6.25
GF-2	Cold Brook A1	Freedom	5/30/2008	12.64	1.61	6.54	7.95	74.9	80	61										
GF-2	Cold Brook A1	Freedom	6/12/2008	18.75	1.39	6.56	6.22	66.8	79	69	20.7	4.5	0.2	13.77	0.02	0.9	10.07	0.91	1.09	7.14
GF-2	Cold Brook A1	Freedom	6/26/2008	16.81	1.15	6.73	9.23	95.3	83	70	13.2									
GF-2	Cold Brook A1	Freedom	7/10/2008	20.97	2.68	6.57	7.28	81.8	92	85	19.8	3.89	0.23	15.75	0.06	0.8	10.74	0.98	1.43	8.37
GF-2	Cold Brook A1	Freedom	7/24/2008	16.80	4.43	6.89	7.57	77.9	70	59										
GF-2	Cold Brook A1	Freedom	8/7/2008	15.83	1.39	6.22	9.50	95.9	41	34										
GF-2	Cold Brook A1	Freedom	8/21/2008	14.35	2.23	6.9	7.55	74.0	77	62										
GF-2	Cold Brook A1	Freedom	9/4/2008	16.41	2.77	6.64	7.96	81.4	94	79										
GF-2	Cold Brook A1	Freedom	9/18/2008	13.72	1.41	6.84	7.08	68.4	79	62										
GF-2	Cold Brook A1	Freedom	10/2/2008	12.76	1.28	6.53	8.65	81.9	116	89										
GF-2	Cold Brook A1	Freedom	10/16/2008	11.07	1.35	6.7	9.34	91.3	172	126										
GF-3	Cold Brook A2	Freedom	3/26/2008	2.41	0.40	6.48	14.86	108.8	71	40		2.65	0.17	16.69	0.06	1.23	11.16	0.60	0.53	4.64
GF-3	Cold Brook A2	Freedom	5/15/2008	11.13	0.62	6.5	12.24	111.4	79	58	7.1	3.08	0.13	15.4	0.03	1.19	10.98	0.86	0.98	6.19
GF-3	Cold Brook A2	Freedom	5/30/2008	12.00	0.54	6.43	9.84	92.9	92	70										
GF-3	Cold Brook A2	Freedom	6/12/2008	17.82	1.14	6.62	8.22	86.6	83	72	17.4	4.34	0.22	15.45	0.05	0.93	11.06	0.99	1.19	7.31

GF-3	Cold Brook A2	Freedom	6/26/2008	16.56	0.95	6.75	11.44	117.3	80	67	11.9									
GF-3	Cold Brook A2	Freedom	7/10/2008	20.58	1.79	6.56	10.89	121.0	95	86	21.6	3.02	0.26	18.87	0.1	0.91	13.3	0.74	1.07	7.5
GF-3	Cold Brook A2	Freedom	7/24/2008	16.14	2.54	6.5	8.70	88.4	38	32										
GF-3	Cold Brook A2	Freedom	8/7/2008	15.81	1.39	5.98	12.47	125.8	46	38										
GF-3	Cold Brook A2	Freedom	8/21/2008	14.90	1.15	6.75	10.21	99.2	79	63										
GF-3	Cold Brook A2	Freedom	9/4/2008	15.75	0.86	6.94	11.18	112.8	102	84										
GF-3	Cold Brook A2	Freedom	9/18/2008	13.45	0.96	6.78	9.57	91.8	79	62										
GF-3	Cold Brook A2	Freedom	10/2/2008	12.82	1.13	6.49	10.48	99.1	122	94										
GF-3	Cold Brook A2	Freedom	10/16/2008	10.96	0.70	6.52	12.36	112.1	157	115										
GM-1	Banfield Brook	Madison	4/17/2008	2.83	0.68	7.63	14.99	110.9	73	42		2.29	0.21	16.94	0.08	1.00	11.22	0.62	0.28	4.26
GM-1	Banfield Brook	Madison	5/13/2008	11.90	0.76	6.64	10.72	99.3	121	91		2.86	0.15	30.09	0.05	1.00	18.05	0.94	0.80	6.31
GM-1	Banfield Brook	Madison	5/27/2008	14.89	0.84	6.2	9.70	96.0	148	119										
GM-1	Banfield Brook	Madison	6/10/2008	15.12		7.23	10.16	101.0	300	244	7.8	2.08	0.24	88.7	0.08	1.02	48.38	1.42	1.44	10.97
GM-1	Banfield Brook	Madison	6/24/2008	13.21	1.61	6.48	10.21	97.4	199	154	5.2									
GM-1	Banfield Brook	Madison	7/8/2008	18.37	2.03	6.79	8.39	89.3	195	171	4.7	1.75	0.23	56.21	0.11	0.91	31.16	1.25	1.22	9.55
GM-1	Banfield Brook	Madison	7/22/2008	18.04	2.76	6.72	8.57	90.7	169	139	5.6									
GM-1	Banfield Brook	Madison	8/5/2008	22.11	1.10		8.06	92.3	82	78										
GM-1	Banfield Brook	Madison	8/19/2008	20.78	2.90	6.62	8.45	94.4	84	77										
GM-1	Banfield Brook	Madison	9/2/2008	13.86		7.04	9.27	90.2	245	193										
GM-1	Banfield Brook	Madison	9/16/2008	16.76	1.77	6.09	9.45	97.1	96	80										
GM-1	Banfield Brook	Madison	9/30/2008	16.82	0.85	5.87	9.46	97.6	79	67										
GM-1	Banfield Brook	Madison	10/14/2008	12.33	0.87	6.11	10.58	98.9	106	81										
GM-2	Pequawket Brook 2	Madison	5/13/2008	11.08	0.82	6.43	8.34	76.4	108	79		2.6	0.99	13.17	0.9	1.29	9.78	1	0.44	6.18
GM-2	Pequawket Brook 2	Madison	5/27/2008	15.00	1.02	6.1	7.78	72.8	77	62										
GM-2	Pequawket Brook 2	Madison	6/10/2008	18.84	1.06	6.23	6.36	68.4	111	98	7.8	1.97	0.78	11.15	0.66	1.16	9.11	0.74	0.6	6.88
GM-2	Pequawket Brook 2	Madison	6/24/2008	15.21	1.31	6.13	6.79	72.2	72	59	12.3									
GM-2	Pequawket Brook 2	Madison	7/8/2008	20.78	0.90	6.53	5.92	66.1	78	72	11.2	2.4	0.83	12.99	0.8	1.01	9.45	1.03	0.93	8.17
GM-2	Pequawket Brook 2	Madison	7/22/2008	19.01	1.47	6.5	6.32	67.8	74	66	8.8									
GM-2	Pequawket Brook 2	Madison	8/5/2008	18.24	1.07		5.48	58.1	69	59										

GM-2	Pequawket Brook 2	Madison	8/19/2008	17.37		6.02	5.97	61.9	71	61										
GM-2	Pequawket Brook 2	Madison	9/2/2008	16.54	1.06	6.4	5.63	55.3	76	64										
GM-2	Pequawket Brook 2	Madison	9/16/2008	15.70	1.12	6.24	6.06	60.9	67	55										
GM-2	Pequawket Brook 2	Madison	9/30/2008	15.63	1.12	6.09	5.95	59.7	56	47										
GM-2	Pequawket Brook 2	Madison	10/14/2008	12.05	0.85	6.15	7.73	71.8	62	47										
GM-3	Forrest Brook	Madison	5/13/2008	9.18	0.54	6.35	11.27	98.0	48	34		2.89	0.15	8.33	0.07	0.89	6.58	0.78	0.66	5.42
GM-3	Forrest Brook	Madison	5/27/2008	13.11	0.66	6.22	9.73	92.6	59	46										
GM-3	Forrest Brook	Madison	6/10/2008	17.27	1.52	6.29	9.45	93.5	64	54	12.6	3.51	0.29	10.48	0.14	0.71	8.16	1.05	0.82	6.52
GM-3	Forrest Brook	Madison	6/24/2008	15.09	1.11	5.88	9.42	93.6	37	31	11.8									
GM-3	Forrest Brook	Madison	7/8/2008	17.51	0.97	6.63	8.09	84.5	65	56	11.9	3.61	0.34	11.1	0.15	0.75	9.01	0.76	0.6	6.1
GM-3	Forrest Brook	Madison	7/22/2008	17.52	1.04	6.6	8.24	86.2	47	40	13.2									
GM-3	Forrest Brook	Madison	8/5/2008	17.91	0.87		8.61	90.7	42	36										
GM-3	Forrest Brook	Madison	8/19/2008	17.15		5.7	9.02	93.7	42	36										
GM-3	Forrest Brook	Madison	9/2/2008	14.89	1.25	6.58	8.58	84.9	73	59										
GM-3	Forrest Brook	Madison	9/16/2008	14.13		5.91	9.79	95.3	46	36										
GM-3	Forrest Brook	Madison	9/30/2008	14.51	1.19	5.4	9.70	95.3	39	31										
GM-3	Forrest Brook	Madison	10/14/2008	11.16	0.79	6.05	10.19	92.3	45	33										
GM-3u	Forrest Brook 1	Madison	5/13/2008	8.98	0.54	6.34	11.60	101.1	27	19		2.99	0.11	3.08	0.01	0.84	3.11	0.64	0.58	4.6
GM-3u	Forrest Brook 1	Madison	5/27/2008	13.01	0.39															
GM-3u	Forrest Brook 1	Madison	6/10/2008	17.85	0.83	5.94	9.57	101.8	30	26	10.2	3.89	0.26	3.42	0.13	0.64	3.84	0.74	0.69	5.45
GM-3u	Forrest Brook 1	Madison	6/24/2008	15.11	1.16	5.43	10.04	99.8	22	18	13.5									
GM-3u	Forrest Brook 1	Madison	7/8/2008	18.22	0.58	6.61	8.45	89.2	28	24	9.5	3.76	0.32	11.39	0.17	0.73	8.69	0.97	0.85	6.93
GM-3u	Forrest Brook 1	Madison	7/22/2008	17.87	0.76	6.46	8.88	93.6	25	22	11.9									
GM-3u	Forrest Brook 1	Madison	8/5/2008	18.32	0.88		9.08	19.6	22	19										
GM-3u	Forrest Brook 1	Madison	8/19/2008	17.46		5.38	9.42	98.4	22	19										
GM-3u	Forrest Brook 1	Madison	9/2/2008	14.69	0.58	6.55	8.57	82.3	34	27										
GM-3u	Forrest Brook 1	Madison	9/16/2008	14.25		5.88	10.25	100.0	23	18										
GM-3u	Forrest Brook 1	Madison	9/30/2008	14.67	0.89	5	10.23	100.8	21	17										
GM-3u	Forrest Brook 1	Madison	10/14/2008	11.15	1.10	6.33	10.71	97.3	23	17										
GO-1	Beech River 1	Ossipee	5/12/2008	12.00	0.58						6.2	3.15	0.18	4.11	0	0.81	3.97	0.42	0.25	4.1
GO-1	Beech River 1	Ossipee	5/26/2008	12.91	0.59		9.76	92.7	34	26	8.9									
GO-1	Beech River 1	Ossipee	6/9/2008	19.58	0.65	6.42	7.71	83.9	37	34	11.5	3.64	0.2	3.92	0.04	0.6	4.26	0.73	0.75	6.27

GO-1	Beech River 1	Ossipee	6/23/2008	18.04	1.29	7.04	8.57	89.3	39	34	16.8									
GO-1	Beech River 1	Ossipee	7/7/2008	20.19	0.97	7.11	7.48	82.5	43	39	12	4.66	0.29	5.75	0.04	0.46	5.37	0.31	0.52	5.55
GO-1	Beech River 1	Ossipee	7/21/2008	18.29	1.57	7.36	8.18	86.9	41	36	14.9									
GO-1	Beech River	Ossipee	8/4/2008	19.13	0.91		7.67	83.0	38	34										
GO-1	Beech River	Ossipee	9/1/2008	15.07	0.69	6.39	8.39	83.2	41	33										
GO-1	Beech River	Ossipee	9/15/2008	17.76	0.65	6.29	8.43	88.1	36	31										
GO-1	Beech River	Ossipee	9/29/2008	15.68	1.71	6.33	9.48	95.5	33	27										
GO-1	Beech River	Ossipee	10/13/2008	11.49	0.56	6.7	10.04	92.1	77	57										
GO-2	Frenchman Brook 4	Ossipee	3/26/2008	1.84		6.32	14.90	107.3	96	53										
GO-2	Frenchman Brook 4	Ossipee	4/14/2008	1.88	0.77	7.41	14.36	103.5	58	32		3.01	0.21	15.61	0.07	1.08	10.64	0.95	0.67	4.80
GO-2	Frenchman Brook 4	Ossipee	5/12/2008	11.00	0.97						9.6									
GO-2	Frenchman Brook 4	Ossipee	5/26/2008	13.05	1.37		10.31	98.0	178	137	11.8									
GO-2	Frenchman Brook 4	Ossipee	6/9/2008	19.82	2.85	6.72	8.42	92.3	186	168	18.3	2.88	0.29	50.79	0.18	0.86	30.72	1.49	0.93	8.08
GO-2	Frenchman Brook 4	Ossipee	6/23/2008	16.89	2.59	7.12	9.38	96.9	187	158	20									
GO-2	Frenchman Brook 4	Ossipee	7/7/2008	19.06	2.50	6.78	8.22	88.9	235	208	11.6	2.63	0.32	71.16	0.14	0.92	41.48	1.89	0.98	8.94
GO-2	Frenchman Brook 4	Ossipee	7/21/2008	17.90	3.03	7.39	8.66	91.4	242	209	15.7									
GO-2	Frenchman Brook 4	Ossipee	8/4/2008	17.56	2.00		8.75	91.6	186	161										
GO-2	Frenchman Brook 4	Ossipee	8/18/2008	17.68	1.45	6.77	8.38	88.1	182	157										
GO-2	Frenchman Brook 4	Ossipee	9/1/2008	15.11	1.26	6.83	10.30	103.0	230	186										
GO-2	Frenchman Brook 4	Ossipee	9/15/2008	17.54	1.27	6.72	8.70	90.9	134	130										
GO-2	Frenchman Brook 4	Ossipee	9/29/2008	14.76	1.91	6.3	9.84	97.0	77	62										
GO-2	Frenchman Brook 4	Ossipee	10/13/2008	11.01	0.85	6.72	10.67	97.0	335	246										
GO-4	Bearcamp River 3	Ossipee	5/27/2008	13.95	0.71	6.8	8.97	87.0	50	39										

GO-4	Bearcamp River 3	Ossipee	6/10/2008	19.00	0.90	7.69	8.42	90.8	51	45	7	1.67	0.16	7.69	0.11	0.99	6.29	0.98	0.72	6.16
GO-4	Bearcamp River 3	Ossipee	6/24/2008	15.54	1.42	6.53	9.46	94.9	36	30	14.4									
GO-4	Bearcamp River 3	Ossipee	8/5/2008	17.98	1.49	4.54	8.49	89.7	27	23										
GO-4	Bearcamp River 3	Ossipee	8/19/2008	17.06	0.98	5.64	9.47	98.4	38	32										
GO-4	Bearcamp River 3	Ossipee	9/3/2008	16.06		6.35	9.86	99.8	51	43										
GO-5	Bearcamp River 2	Ossipee	3/13/2008	0.24	1.56	6.86	13.74	94.6	28	14		2.50	0.19	3.85	0.08	1.06	3.44	0.45	0.21	3.70
GO-5	Bearcamp River 2	Ossipee	4/17/2008	3.35	1.22	7.32	13.92	104.3	25	15		2.37	0.15	3.14	0.06	0.99	2.90	0.39	0.19	3.03
GO-5	Bearcamp River 2	Ossipee	5/13/2008	9.25	0.64	5.13	9.50	82.6	33	23		2.65	0.16	5.86	0.1	1.02	4.68	0.86	0.64	5.46
GO-5	Bearcamp River 2	Ossipee	5/27/2008	12.46	0.98	6.65	9.09	85.4	41	31										
GO-5	Bearcamp River 2	Ossipee	6/10/2008	17.62	0.84	7.78	8.31	86.9	43	37	7	1.7	0.18	5.45	0.1	1.06	4.86	0.73	0.34	4.98
GO-5	Bearcamp River 2	Ossipee	6/24/2008	15.04	1.95	6.66	9.42	93.4	31	25	24.6									
GO-5	Bearcamp River 2	Ossipee	7/8/2008	18.72	0.94	5.85	8.10	86.5	43	37	7.1	1.79	0.19	5.37	0.08	0.98	5.05	0.54	0.44	5.23
GO-5	Bearcamp River 2	Ossipee	7/22/2008	17.40	1.08	6.12	8.59	89.8	35	30	12.7									
GO-5	Bearcamp River 2	Ossipee	8/5/2008	17.50	1.12	4.92	8.82	92.4	21	18										
GO-5	Bearcamp River 2	Ossipee	8/19/2008	16.46	0.97	5.95	8.98	91.8	33	28										
GO-5	Bearcamp River 2	Ossipee	9/2/2008	15.06	0.81	6.55	8.85	93.1	61	37										
GO-5	Bearcamp River 2	Ossipee	9/16/2008	14.91	1.50	6.31	8.50	85.0	32	26										
GO-5	Bearcamp River 2	Ossipee	9/30/2008	14.62	1.12	5.64	10.03	98.7	24	19										
GO-5	Bearcamp River 2	Ossipee	10/14/2008	11.06	0.81	6.41	9.41	85.6	79	58										
GS-1	Cold River	Sandwich	3/13/2008	0.77	0.50	7.14	13.41	93.7	21	11		1.90	0.13	1.30	0.04	1.05	1.53	0.58	0.55	4.35
GS-1	Cold River	Sandwich	4/17/2008	2.84	0.49	7.1	14.50	107.2	18	10		1.98	0.14	1.40	0.04	1.06	1.63	0.37	0.14	2.97
GS-1	Cold River	Sandwich	5/14/2008	8.67	0.32	4.67	11.86	101.8	17	15	2.7	3.38	0.24	4.51	0.04	2.31	4.24	0.87	0.87	3.43

GS-1	Cold River	Sandwich	5/28/2008	10.81	0.42	5.78	11.17	100.9	21	15	3.6									
GS-1	Cold River	Sandwich	6/11/2008	18.35	1.20	6	9.03	96.1	23	20		3.49	0.23	3.01	0.05	1.56	3.99	0.6	0.54	4.66
GS-1	Cold River	Sandwich	7/23/2008	18.35	1.03	5.93	8.79	93.7	21	19										
GS-1	Cold River	Sandwich	8/20/2008	12.63	0.51	6.04	10.62	99.9	18	14										
GS-1	Cold River	Sandwich	9/3/2008	14.87	0.46	6.56	9.50	94.6	27	21										
GS-1	Cold River	Sandwich	9/17/2008	13.12	0.77	6.26	9.92	94.1	19	14										
GS-1	Cold River	Sandwich	10/1/2008	13.20	0.70	5.66	9.51	90.6	16	12										
GS-1	Cold River	Sandwich	10/15/2008	9.27	0.61	6.21	11.04	96.1	45	32										
GT-1	Bearcamp River 1	Tamworth	5/14/2008	10.60	0.78	5.84	10.18	91.6	23	17		1.94	0.15	1.19	0.03	1.07	1.75	0.4	0.29	3.18
GT-1	Bearcamp River 1	Tamworth	5/28/2008	12.87	0.76	6.58	8.70	82.5	28	21	6.6									
GT-1	Bearcamp River 1	Tamworth	6/11/2008	20.82	2.23	6.16	6.52	73.0	33	30		3.36	0.18	2.87	0.05	1.02	3.14	0.91	0.68	5.64
GT-1	Bearcamp River 1	Tamworth	6/25/2008	16.15	0.99	5.95	8.20	88.3	31	26	11.8									
GT-1	Bearcamp River 1	Tamworth	7/9/2008	22.09	1.44	6.13	5.27	60.2	32	31	12	3.11	0.28	5.35	0.05	1.9	5.45	0.65	0.57	4.31
GT-1	Bearcamp River 1	Tamworth	7/23/2008	20.03	1.17	6.11	6.43	70.1	33	30										
GT-1	Bearcamp River 1	Tamworth	8/6/2008	16.90	1.74	5.48	8.33	85.9	20	17										
GT-1	Bearcamp River 1	Tamworth	8/20/2008	14.75	0.76	5.98	7.42	73.3	25	20										
GT-1	Bearcamp River 1	Tamworth	9/3/2008	17.46	1.34	6.44	7.60	79.7	33	29										
GT-1	Bearcamp River 1	Tamworth	9/17/2008	14.97	0.76	6.31	7.45	73.9	28	22										
GT-1	Bearcamp River 1	Tamworth	10/1/2008	14.66	0.85	5.47	7.64	75.3	23	18										
GT-1	Bearcamp River 1	Tamworth	10/15/2008	10.53	0.89	6.15	8.25	74.1	60	43										
GT-4	Chocorua River	Tamworth	4/17/2008	4.11	0.57	7.63	12.76	97.7	58	34		2.37	0.19	11.54	0.09	0.89	8.49	0.78	0.48	4.61
GT-4	Chocorua River	Tamworth	5/13/2008	12.34	0.53	5.62	8.31	77.7	66	50		1.94	0.22	13.15	0.11	0.94	9.68	0.94	0.52	5.47
GT-4	Chocorua River	Tamworth	5/27/2008	15.49	0.90	6.81	8.77	87.4	70	57										
GT-4	Chocorua River	Tamworth	6/10/2008	20.60	0.86	7.96	7.44	82.7	74	68		1.48	0.25	15.44	0.17	1.08	11.07	0.79	0.26	5.18
GT-4	Chocorua River	Tamworth	6/24/2008	17.76	0.92	6.57	8.35	87.9	68	58	8.8									
GT-4	Chocorua River	Tamworth	7/8/2008	20.92	0.94	6.05	7.57	84.8	72	66	6.1	2.04	0.28	14.55	0.15	1.2	10.72	0.83	0.24	5.06
GT-4	Chocorua River	Tamworth	7/22/2008	20.25	0.78	6.27	7.66	84.7	70	64	7									
GT-4	Chocorua River	Tamworth	8/5/2008	20.83	0.87	6.12	6.86	77.7	58	54										

GT-4	Chocorua River	Tamworth	8/19/2008	20.30		5.62	7.89	87.1	58	52										
GT-4	Chocorua River	Tamworth	9/2/2008	17.30	0.46	6.42	8.80	91.8	72	61										
GT-4	Chocorua River	Tamworth	9/16/2008	16.15	0.66	6.27	8.51	86.5	63	53										
GT-4	Chocorua River	Tamworth	9/30/2008	16.27		6.17	8.17	83.4	51	42										
GT-4	Chocorua River	Tamworth	10/14/2008	13.04	0.69	6.29	9.23	87.7	139	107										
GT-5	Swift River	Tamworth	5/14/2008	7.65	0.40	5.65	12.59	105.4	29	19		1.28	0.22	4.96	0.13	1.26	4.71	0.82	0.18	3.88
GT-5	Swift River	Tamworth	5/28/2008	9.19		5.86	11.86	103.2	31	21	3.7									
GT-5	Swift River	Tamworth	6/11/2008	15.57	2.44	5.36	10.10	101.4	31	25		4.89	0.2	3.24	0.06	0.89	3.66	0.92	0.59	5.09
GT-5	Swift River	Tamworth	6/25/2008	12.81	0.52	5.91	10.91	103.1	30	23	9.4									
GT-5	Swift River	Tamworth	7/9/2008	16.60	0.47	5.73	9.73	99.7	33	28	4.7	1.08	0.17	3.46	0.09	1	4	0.54	0.31	4.49
GT-5	Swift River	Tamworth	7/23/2008	15.64	0.60	6.19	10.16	102.3	33	27										
GT-5	Swift River	Tamworth	8/6/2008	14.03	1.29	4.99	10.42	101.2	27	21										
GT-5	Swift River	Tamworth	8/20/2008	11.41	0.42	5.93	12.34	112.7	25	19										
GT-5	Swift River	Tamworth	9/3/2008	13.33	0.47	6.43	9.95	95.2	30	24										
GT-5	Swift River	Tamworth	9/17/2008	12.33	0.44	6.28	11.08	103.7	29	22										
GT-5	Swift River	Tamworth	10/1/2008	12.49	0.60	5.65	10.82	101.6	55	19										
GT-5	Swift River	Tamworth	10/15/2008	9.40	0.53	6.22	11.57	101.1	62	43										
OL-12u	Phillips Brook 1	Effingham	6/30/2008	17.73	1.21	4.7	5.48	57.7	77	67	37.1									
OL-12u	Phillips Brook 1	Effingham	7/14/2008	18.48	3.97	5.98	4.97	53.0	246	254	50.5	7.84	0.43	89.61	0.08	0.77	52.81	1.29	1.42	9.12
OL-12u	Phillips Brook 1	Effingham	7/28/2008	18.56	1.89	5.41	8.62	91.5	130	114										
OL-12u	Phillips Brook 1	Effingham	8/13/2008	17.22	0.91	5.22	9.21	95.7	90	77										
OL-12u	Phillips Brook 1	Effingham	8/28/2008	14.26	3.20	6.16	6.35	62.1	341	271										
OL-13	Leavitt Brook	Effingham	7/14/2008	19.74	1.26	6.54	7.49	81.9	72	64	12.5	2.91	0.19	18.94	0.02	0.62	13.4	0.5	0.74	7.55
OL-13	Leavitt Brook	Effingham	8/11/2008	17.14	0.79	6.08	9.33	97.7	78	66										
OL-14u	Square Brook 1	Freedom	7/2/2008	17.58	3.05	5.9	8.34	87.3	107	92	20.9	6.62	0.52	23.54	0.13	1.1	16.07	0.87	1	7.47
OL-14u	Square Brook 1	Freedom	7/16/2008	13.71	2.42	5.69	8.19	79.0	139	109	12.4	2.7	0.43	31.63	0.28	1.31	19.64	0.9	1.27	8.85
OL-14u	Square Brook 1	Freedom	8/13/2008	15.24	1.09	6.2	7.89	78.7	98	80										
OL-14u	Square Brook 1	Freedom	8/13/2008	15.24	1.09	6.2	7.89	78.7	98	80										
OL-14u	Square Brook 1	Freedom	8/28/2008	13.06	1.25	6.39	8.37	79.4	134	104										
OL-1u	Westbranch River 1	Freedom	7/2/2008	21.96	0.61	5.78	7.24	82.2	35	32	6.9	2.35	0.13	5.14	0.03	0.79	4.5	0.82	0.63	5.06
OL-1u	Westbranch River 1	Freedom	7/16/2008	17.10	0.50	5.8	4.54	47.2	34	29	4.8	2.11	0.19	5.73	0.03	0.91	5.26	0.86	0.6	5.57

OL-1u	Westbranch River 1	Freedom	7/30/2008	19.31	0.48	5.48	6.90	74.9	34	30										
OL-1u	Westbranch River 1	Freedom	8/13/2008	20.02	0.51	5.86	7.67	84.4	33	30										
OL-1u	Westbranch River 1	Freedom	8/13/2008	20.02	0.51	5.86	7.67	84.4	33	30										
OL-2	Bearcamp River 4	Ossipee	7/1/2008	18.70	1.82	5.59	8.15	87.6	35	30	13.2									
OL-2	Bearcamp River 4	Ossipee	7/15/2008	18.44	0.99	6.42	7.82	83.3	53	47	9.6	2.69	0.22	8.71	0.13	1.02	7.14	1.02	0.69	6.47
OL-2	Bearcamp River 4	Ossipee	7/29/2008	19.94	0.93	6	10.29	112.5	39	36										
OL-4u	Lovell River 1	Ossipee	7/3/2008	14.75	0.59	6.32	8.70	85.8	19	15	3.1	1.68	0.19	1.15	0.07	0.91	1.93	0.32	0.22	3.47
OL-4u	Lovell River 1	Ossipee	7/17/2008	16.94	0.29	6.13	6.84	72.6	21	18	3.6	1.38	0.22	1.33	0.12	0.87	2.37	0.54	0.17	4.13
OL-4u	Lovell River 1	Ossipee	7/31/2008	16.66	0.46	6.5	8.40	86.6	19	16										
OL-4u	Lovell River 1	Ossipee	8/14/2008	14.48	0.49	5.68	9.65	93.9	16	13										
OL-5ua	Weetamoe Brook 1	Ossipee	7/3/2008	17.00	1.64	5.15	4.91	50.9	39	33		23.5	0.53	5.48	0.03	0.25	6.32	0.65	0.57	5.19
OL-5ua	Weetamoe Brook 1	Ossipee	7/17/2008	18.19	2.41	5.73	1.12	11.8	36	32	139.1	15.1	0.8	3.49	0	0.14	5.33	0.73	0.31	3.77
OL-5ua	Weetamoe Brook 1	Ossipee	8/14/2008	15.80	1.11	5.35	5.09	51.4	45	37										
OL-7	Red Brook 3	Ossipee	6/30/2008	19.97	1.97	4.54	2.84	31.3	29	26	60.2									
OL-7	Red Brook 3	Ossipee	7/14/2008	13.24	1.18	5.58	0.53	5.1	97	74	102.8	16	0.84	13.84	0.05	0.16	9.28	1.16	0.42	4.27
OL-7	Red Brook 3	Ossipee	7/28/2008	19.49	1.27	5.01	2.82	31.0	36	33										
OL-7	Red Brook 3	Ossipee	8/11/2008																	
OL-9u	Cold Brook B1	Freedom	7/2/2008	17.03	1.60	5.64	8.58	88.6	42	36	16.3	3.45	0.25	5.87	0.08	0.63	5.82	0.45	0.37	4.66
OL-9u	Cold Brook B1	Freedom	7/16/2008	15.64	2.04	5.88	8.75	88.0	49	41	13.9	1.83	0.29	7.85	0.11	0.74	7.33	0.56	0.39	4.76
OL-9u	Cold Brook B1	Freedom	7/30/2008	16.04	2.97	5.86	9.04	92.2	43	36										
OL-9u	Cold Brook B1	Freedom	8/13/2008	14.24	1.22	5.71	9.31	90.7	35	28										
OL-9u	Cold Brook B1	Freedom	8/13/2008	14.24	1.22	5.79	9.31	90.7	35	28										