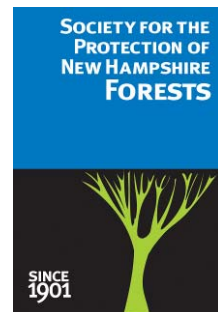


Methodology and Prioritization Analysis for Watershed Planning in the Ossipee Lake Watershed



Green Mountain Conservation Group
August 23, 2011



Introduction

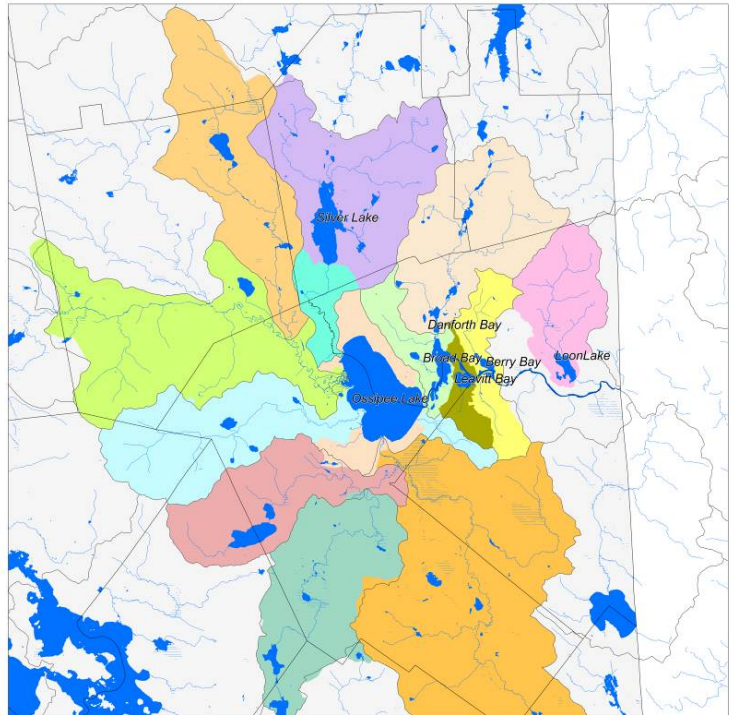
The Ossipee Watershed, in the eastern part of New Hampshire's Lakes Region, covers over 242,000 acres and contains the largest stratified drift aquifer in New Hampshire. This aquifer is the primary source of drinking water for this region and the Watershed has significant natural and recreational resources that drive the local economy. Early in 2011 the Green Mountain Conservation Group secured funding through the New Hampshire Department of Environmental Services (NHDES) and the Environmental Protection Agency to begin creating a plan for how to best evaluate this dynamic watershed and develop a Watershed Master Plan.

A consultant team including the firm Jeffrey H. Taylor and Associates, Plymouth State University, and the Society for the Protection of New Hampshire Forests was hired in May of 2011 to prepare this *Methodology and Prioritization Analysis for Watershed Planning in the Ossipee Lake Watershed*.

The results of this effort will be presented in this report, and provide a framework for how best to proceed with this watershed planning effort in the Ossipee Watershed.

This initial effort included reviewing existing water quality data collected by a variety of groups in the watershed, identification and analysis of the sub-watersheds, identification of missing data, and evaluation of the feasibility of phasing future watershed planning efforts. Mark Green of the Plymouth State University Center for the Environment took the lead on the review and analysis of water quality data in the watershed. The Geographic Information Systems (GIS) analysis performed by Dan Sundquist of the Forest Society then allowed the team to review the volumes of water quality data by sub-watershed and better understand the relationship between water quality data and the land uses in each watershed before drawing some conclusions for next steps.

This analysis has helped further clarify water quality issues in the Ossipee Watershed. The results identified missing parts of the watershed puzzle and data that, if collected, would be helpful in segregating natural from anthropogenic sources of phosphorus. This differentiation is critical to identifying, designing and costing any mitigation measures to reduce loading. Additionally, spatial analysis has identified the more problematic sub-watersheds in the system and determined that more detailed land use data is important to help better understand each sub-watershed's potential impact on total phosphorus loading. There are some interesting findings across the Watershed that deserve further investigation with all of the towns fully engaged. These include the correlations between phosphorus



levels and the presence of large wetland complexes and development activity, and chloride levels and road density.

Sub-Watershed Mapping

One of the first tasks completed during this effort was the mapping of the sub-watersheds. The goal in delineating actual sub-watershed catchment areas for water quality sampling stations in the Ossipee Watershed study area was to develop baseline data on the size and character of each sub-watershed for analysis and identification of potential drivers affecting water quality in the region and within each station sub-watershed. This section provides an overview of the methods used to delineate the sub-watersheds, and the next section discusses the mapping and GIS processing used to characterize each sub-watershed. A statistical summary of various characteristics for each sub-watershed can be found in the Appendix.

Method

Sub-watersheds for each stream-based water quality sampling station were delineated using GIS and the following method. GPS latitude/longitude data for each sampling station location were provided by the Green Mountain Conservation Group for the entire Ossipee Lake Watershed, including the bay areas east of the lake proper, and Silver Lake and Loon Lake. Data for Chocorua Lake were provided by UNH Cooperative Extension based on long term sampling work by that agency, published in 2003.

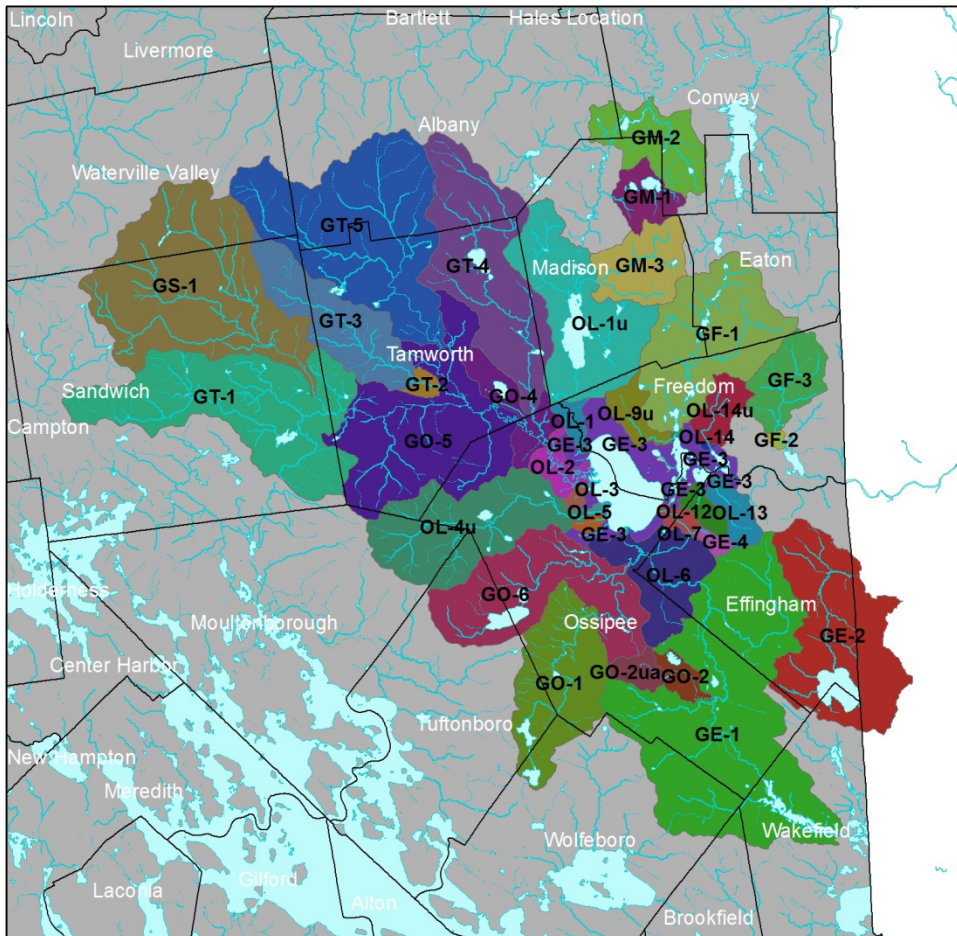
The structure of the sub-watersheds exists in work done previously by the USGS as part of the *SPARROW* mapping and water quality study published by the US Geological Survey (Moore et al., 2004). All stream sub-watersheds in New Hampshire were mapped as part of this project using a digital elevation model (DEM) derived from the original topographic contours shown on USGS quadrangle maps. The resolution of this DEM in the study area is 10-meters, or a grid of about 30 feet, which translates into high quality elevation data.

For each sampling station, the appropriate *SPARROW* sub-watersheds were selected and processed in the GIS to remove internal boundaries. In most cases, the *SPARROW* data do not correspond with the location of the “pour point”, or lowest point in the drainage to each sampling station, so additional work was required to shape the station sub-watersheds to match the topography immediate to the station itself. This was done by using topographic contours at a 20-foot interval which were derived from the DEM. Using on-screen digitizing, a watershed divide was established by following ridgelines or running perpendicular to the prevailing contour pattern with drainage leading directly to the sampling station point. The *SPARROW* sub-watersheds were then modified to remove downstream areas not appropriate to the sampling station drainage area.

As a final step, the individual sub-watersheds were merged into a master dataset of 37 sub-watersheds serving the greater Ossipee Lake sampling stations. In a few cases where sampling stations were located close to one another, as in a lake inlet site and an upstream site a short distance away, no sub-watershed was delineated for the inlet site as the intervening land area is so small as to be insignificant. The data for such sampling stations exist, however, and can be compared for water quality issues. One station was discontinued in 2003, and is not included in the mapping (GO-3). The sampling stations for Chocorua Lake have been mapped for reference in the GIS, but no characterization data have been developed for

those areas because they are part of larger sub-watersheds serving the Ossipee Lake sampling station network.

A separate dataset of so-called “deep water” sampling stations was digitized from GPS data, but no land-based watershed exists to map for these sites. The master GIS dataset of the 37 water quality sampling station sub-watersheds is shown below.



Sub-Watershed Character

The first step in generating baseline data on each sub-watershed area was to determine its size. This was done in the GIS for total area, and for land area only by subtracting out lakes, ponds, and rivers using the National Hydrography Dataset (NHD) data for New Hampshire. Water area was retained in the data summary however.

Next, the land area only derivative was intersected with a range of best-available data to assemble a profile of various physical features selected for correlation with the water quality data available for each sampling station. These features included:

- Stream miles & stream density per square mile (NHD data for perennial and intermittent streams)
- Steep slopes >25% (based on the same DEM used in delineating the catchments)
- Highly erodible soils (NRCS HEL rating)
- Hydric soils (NRCS data, as a proxy for wetlands)
- Organic soils (NRCS data for muck & peat soils)
- High quality stream watersheds (SPARROW classification for near pristine water quality)
- Stratified drift aquifer (USGS data as a proxy for excessively well drained soils)
- Road miles & road density per square mile (NHDOT data, including private roads)
- Land cover/use data for forest cover, developed land, agricultural land, and bare land (a proxy for disturbed land, gravel extraction); these data were extracted from the USGS National Land Cover Dataset (NLCD), current to 2006.

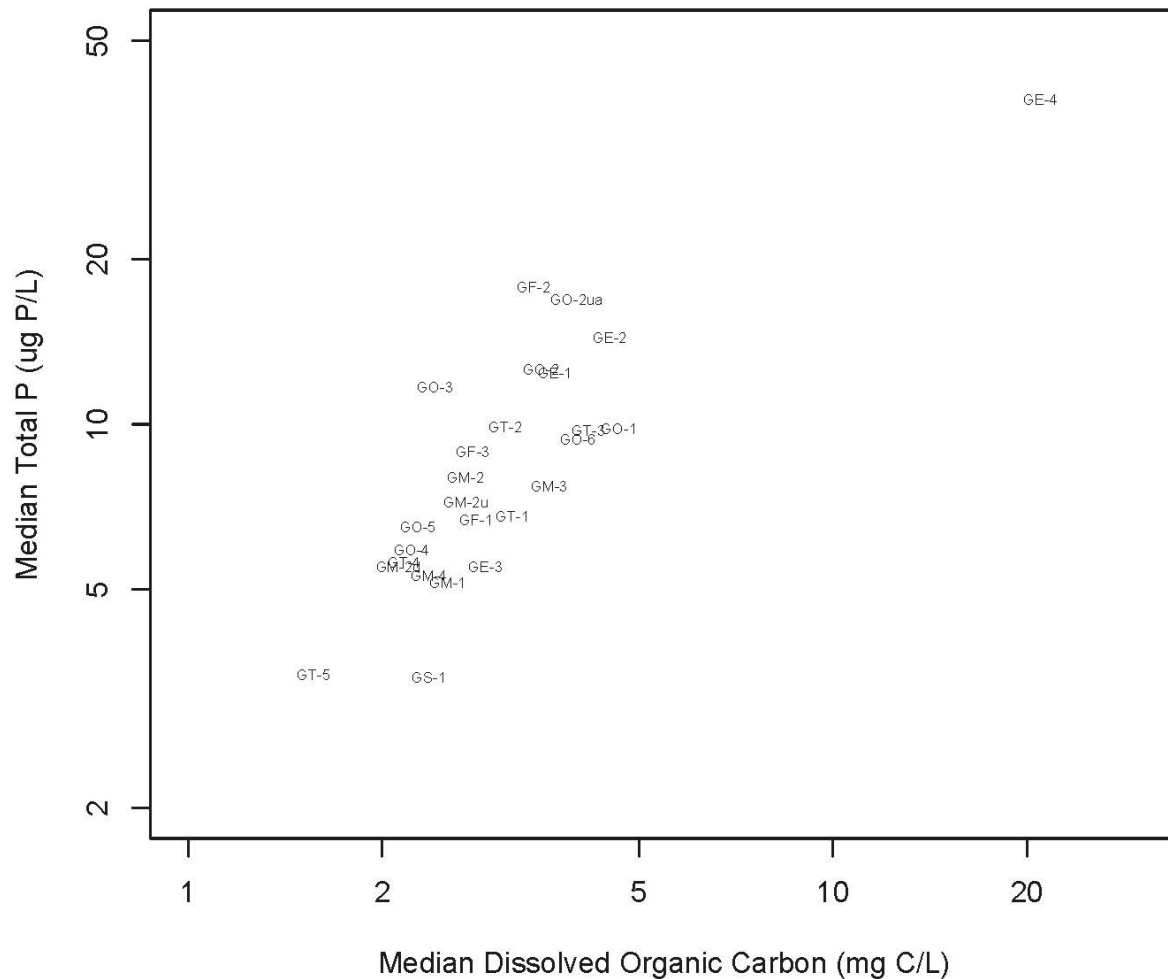
Mapping Related Recommendations

It is important to note that the land cover/use data are derived from satellite imagery, and thus are somewhat coarse in resolution (30-meter grid). The overall accuracy assessment for the NLCD is 85%, which is excellent in the field of remote sensing, but only provides a signal of actual on-the-ground conditions. The NLCD also does not include data for roads, highways or impervious surfaces which would help refine the understanding of land use and degree of development within a sub-watershed. These characterization data were developed on an exploratory basis to analyze for possible correlations with selected water quality data (phosphorus, dissolved oxygen, chlorides, etc.), and these needs to be explored further in future phases of this planning effort. **It is recommended that a land use data set be developed for the entire Ossipee Watershed to clearly represent existing development including structures, roadways, other impervious surfaces, and land use types.**

Water Quality Data Analysis

This analysis included a review of both lake data and stream data, which were examined to better understand the amount of phosphorus in the watershed (and its relationship with land cover) because of its potential to negatively affect water quality. The team calculated the median of every parameter monitored and then related each to phosphorus to look for relationships that may exist. Analysis of total phosphorus (TP) data with other water quality data provides insight into the sources of TP which is vital information if TP is to be managed efficiently and effectively.

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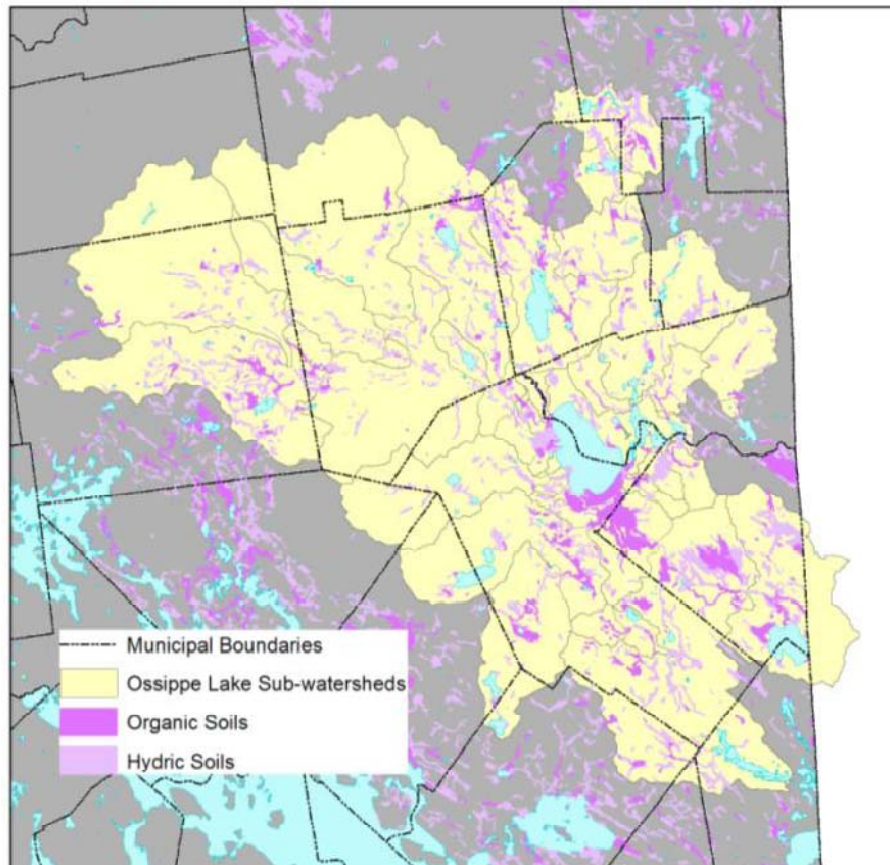


The stream/river data show that in general, the Ossipee basin inputs hover around a TP of 10 $\mu\text{g/L}$. This concentration level is higher than the 7.2 $\mu\text{g/L}$ standard for oligotrophic lakes in New Hampshire. Therefore, the lake has little assimilative capacity and the current stream concentrations cannot increase or the lake will further exceed State water quality standards. Analyses of historical phosphorus levels show areas of concern for the Ossipee Lake system. Based on initial calculations of each of the bays' median phosphorus levels from 2002-2010, two out of the five bays show phosphorus levels that are at or above the threshold for oligotrophic waterbodies. Both Berry Bay and Danforth Pond exhibit levels of phosphorus that indicate they are impaired (Berry Bay 8 $\mu\text{g/L}$; Danforth Pond 10 $\mu\text{g/L}$). The other three sites have median phosphorus levels that are close to the threshold for oligotrophic lakes (Broad Bay 7.9 $\mu\text{g/L}$; Leavitt Bay 7.3 $\mu\text{g/L}$; Ossipee Lake 7.7 $\mu\text{g/L}$), meaning, they are not far from being considered impaired waterbodies according to the state's criteria. NH DES reports that in 2010, Ossipee Lake had the highest mean annual phosphorus levels since monitoring began in 2002. The most recent analysis of data in the rivers and stream of this system show that the greatest frequency of occurrence across all stations/years is 10 $\mu\text{g/L}$ of phosphorus. Given that there are no substantial point sources it is clear that

identifying and remediating the most problematic sub-watersheds (or catchment areas) needs to be addressed.

There are also some higher concentration streams – in particular, the water quality monitoring stations GF-2, GO-2, GO-3, OL-12u, and OL-7 are somewhat higher. Reasons for higher streamwater TP concentrations are not clear, but trends in Appendix 1 shed some light on the issue. The positive relationships with dissolved organic carbon (DOC), dissolved organic nitrogen (DON), turbidity, and ammonium, combined with negative relationships with dissolved oxygen and sulfate all together indicate the importance of wetlands or highly organic parts of the landscape as sources of TP.

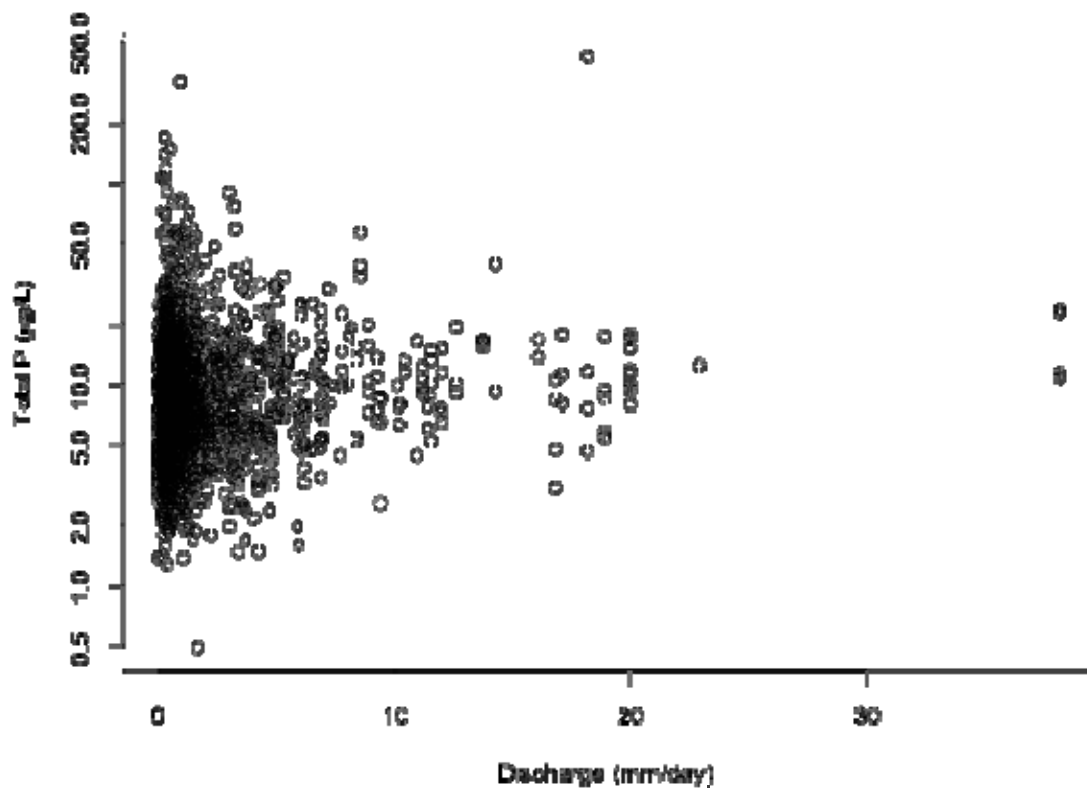
However, the positive correlation with calcium and magnesium may indicate a groundwater source – and the positive correlation with chloride may further indicate septic systems and roadways as a sources. The groundwater and septic ideas are highly speculative compared to the wetland idea. There is much greater evidence in the data of wetlands as contributors of TP. Only about 10% of the Ossipee Watershed land area is composed of hydric soils (best available wetlands data proxy), but 8 of the 37 sub-watersheds exceed 20% land with hydric soils. Certain sub-watersheds also have significant concentrations of organic soils within the hydric soils matrix, each with stream and river flowage directly connected to Ossipee Lake. The map below shows the extent and distribution of hydric and organic soils in the Watershed, as well as the concentration of both soil types southeast of Ossipee Lake and in the upper Bearcamp River valley to the west.



Further analysis of these data with landscape attributes for each contributing basin (from the GIS analysis) should help to form a better understanding of these patterns. By examining this data further, we should be able to identify both the natural and the manmade sources of TP, and can then examine the management implications of each. Because of the significant wetland complexes in the watershed, it will be important to determine if there has been a history of TP loading from these sources and how their contribution of TP compares to human activities in the basin.

When we move to calculating TP loading to the lake from streams, we have to consider the water discharge rate from the rivers to the lake. There is not a strong relationship between streamwater TP and discharge across the basin, just a general pattern of decreasing variability and slightly increasing concentrations. There are some clearer patterns in individual basins that may be useful for loading estimates (Appendix 2). However, many of the patterns are not amenable to fitting a predictive statistical model. Thus, simple loading estimates (using median TP concentrations) and/or more complicated probabilistic models should be explored.

The pattern of high TP at the lowest and highest discharge is interesting. This suggests that there is a TP source at low flow and maybe a different source at high flow. Tracing these sources in future phases of this study, particularly the high flow source, will be important to making accurate loading calculations.



The above figure shows TP concentrations for all stream and river samples at the daily discharge rate – from the USGS gage at Bearcamp Creek. In general this graphic shows that TP concentrations are much

more predictable as daily discharge increases and that there is not a trend of increasing or decreasing TP concentration with discharge. The high variability at low flows is due to heterogeneity in the landscape and as the watershed becomes more wet, the landscape expression in streamwater becomes more homogenous.

This is important information as annual TP loads to the lake are estimated. Because there is not a predictable pattern of TP concentration with daily discharge for any individual sub-watershed (see Appendix 2), annual TP loads can be estimated by using a mean TP concentration from the observations in any sub-watershed and daily discharge rates. The resulting simple estimates of TP load for each monitoring station is shown in Table 1. In general, the largest basins contribute the most TP to the lakes because larger basins contribute the most water. Some of the basins with the highest TP concentrations are not the largest contributors of TP to the lakes because they do not contribute much water to the lake. Thus, a positive finding is that the sub-watersheds with the highest TP concentrations contribute a relatively small fraction of the annual load of TP to Ossipee Lake.

Table 1 Total Phosphorus Loads by Sub-Watershed

Monitoring Station	Land Area (acres)	TP Load (lbs/year)	Monitoring Station	Land Area (acres)	TP Load (lbs/year)
OL-10	49.8	4.5	GF-2	196.8	22.7
OL-12	1,005.9	96.6	GF-3	3,843.5	219.6
OL-14	62.8	6.1	GM-1	2,075.8	77.7
OL-14u	1,812.5	152.2	GM-2	4,872.7	258.6
OL-1u	9,758.2	509.7	GM-3	4487	222.7
OL-2	1445	85.9	GO-1	9080.1	583.6
OL-3	281.4	19.4	GO-2	1,036.6	93.9
OL-4	185.9	6.7	GO-2ua	1,165.4	131.3
OL-4u	10,594.9	222.5	GO-4	2,796.4	115.7
OL-5	321.7	28.2	GO-5	15,646.5	667.2
OL-6	4,473.5	524.0	GO-6	11,102.7	701.5
OL-7	534.3	225.8	GS-1	19,834.8	451.8
OL-9u	1,559.5	156.4	GT-1	16,601.7	776.0
GE-1	27,751.8	2338.4	GT-2	509.6	33.3
GE-2	12,505.4	1285.2	GT-3	7,349	480.3

GE-4	447.2	37.8	GT-4	13,261.1	508.4
GF-1	11,557.5	548.0	GT-5	18,732.8	465.5

Water Quality Related Recommendations

The long-term TP concentration data from the lakes and bays is helpful in determining mean TP concentration for that water body. However, the gaps in that record prevent it from being used to determine the statistical certainty of long-term TP trends. Thus, a much longer record could provide important context for current the status of the lakes and understand if lake water TP is actually increasing or decreasing. **It is recommended that a sediment core from the different lakes and bays be taken so as to address this problem.** These sediment cores have been used in other systems to estimate lake dynamics (including TP concentrations) over hundreds of years.

It is also recommended that there be an increase in sampling of tributaries with high discharge rates. Much of the annual TP load is delivered during the most intense storms, and thus representing those high flows is important in making accurate estimates of TP loads. The sampling at high flows, and during storm events, could be accomplished by adapting the monitoring plan to target higher flows.

The watershed also would benefit from improved understanding of hydrologic connectivity in the basin. This would include detailed mapping of all streams and human drainage structures (culverts, road drainage structures, etc.) The exact location of many streams and human drainage structures is often not known, thus better information will provide new insight into how water moves in the watershed.

Determine the relative contribution of groundwater to surface waters. Monitoring of stable isotopes of water (Deuterium and oxygen-18) is recommended as an inexpensive way to trace water movement in the basin. Snow and summer rain in New Hampshire looks distinctly different with regards to their water isotopes. By monitoring groundwater wells for these isotopes, we can understand when groundwater is recharging, and depending on its signature, we can determine relative contributions of groundwater to the streams and lakes in the watershed. Such information paired with the water quality monitoring can help distinguish which water sources may be contributing different quality waters.

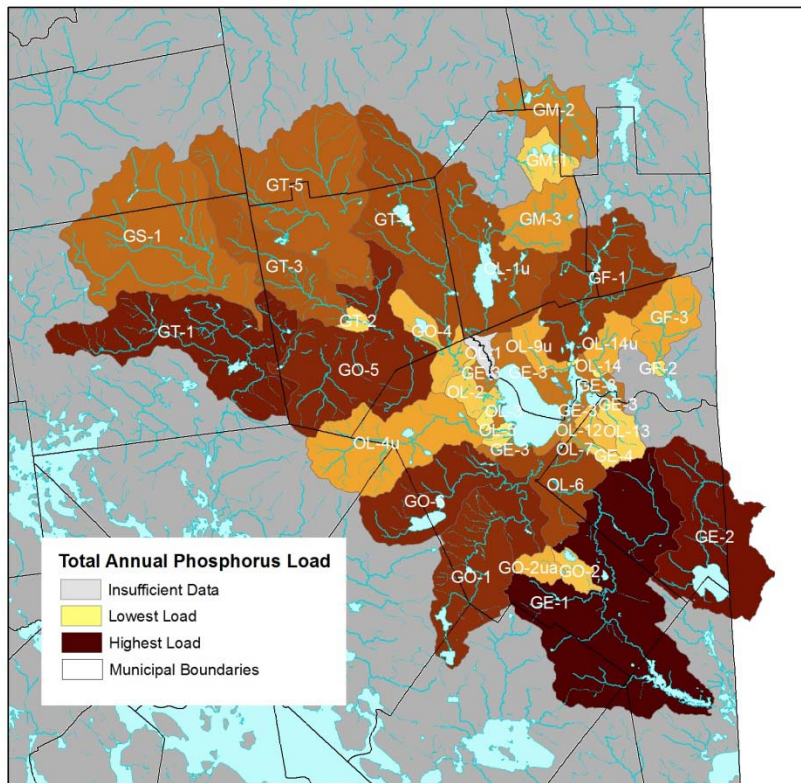
Finally, being able to distinguish anthropogenic sources of TP from natural sources will require analyzing different elements in routine water samples. A pilot study measuring carbon-13 isotopes in DOC and caffeine in water samples across different tributaries may provide natural tracers of wetland sources and septic sources of TP, respectively. The relative carbon-13 of wetland organic matter likely has a distinctly different signature than other sources in the watershed, making it a suitable tracer for organic matter (and any associated phosphorus) in the watershed. Caffeine is a demonstrated tracer of human waste in many watersheds, and would thus be an appropriate way to trace septic contributions of phosphorus in the Ossipee Watershed. Both tracers would not have to be monitored at the intensity of other water quality parameters, but may provide keen insight into sources of phosphorus to the lake.

Summary of Spatial Analysis of Selected Water Quality Parameters

This section of the report is a summary of selected water quality data for 37 sub-watersheds associated with historical and current water quality sampling stations in the greater Ossipee Watershed. The data include: total annual phosphorus loading, total phosphorus, turbidity, percent dissolved oxygen, and chloride. These parameters were selected as the most reliable signals of relative water quality.

In the following analysis, land use/cover character is highlighted for the two highest ranking sub-watersheds in four of the parameters (total phosphorus, turbidity, dissolved oxygen, and chloride). Descriptions of land use/cover are supported with aerial photography of the sub-watersheds; the date of the photography is 2008. The purpose of these brief highlights, and for going beyond just analyzing phosphorus, is to demonstrate the range of natural and human features which may affect water quality in the specific sub-watersheds and more generally across the region. The map legends identify the lowest and highest loads and the maps include a color gradient of continuous values from low to high for each parameter.

Total Annual Phosphorus Loading



Phosphorus (P) is an essential nutrient to all living organisms. When algae or plants in lakes are exposed to high P, they can grow excessively, resulting in water clarity impairment. Phosphorus in water comes in many forms, so the most common measurement of P includes a measure of all P together. That total phosphorus (TP) is often used as an indicator of lake productivity or eutrophic status. TP concentration in water is a useful indicator of water quality. However, P is also communicated as the total weight of P delivered to a lake annually – referred to as the TP load.

The map at the left displays by color gradient the total annual phosphorus loading calculations generated for 37 water quality sampling catchments. The two catchments with the highest loading are GE-1 and GE-2, located in the southeastern quarter of the map. Together, these catchments total ~42,000 acres in size.

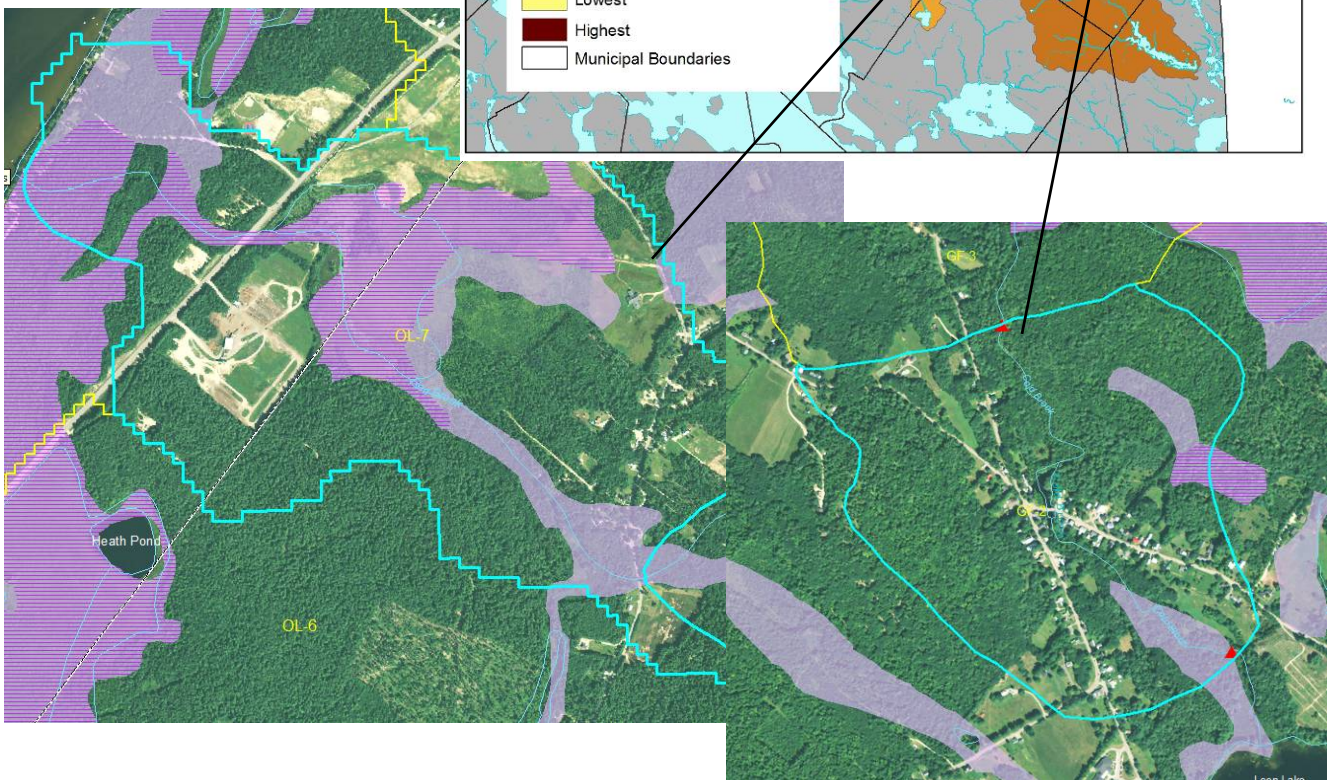
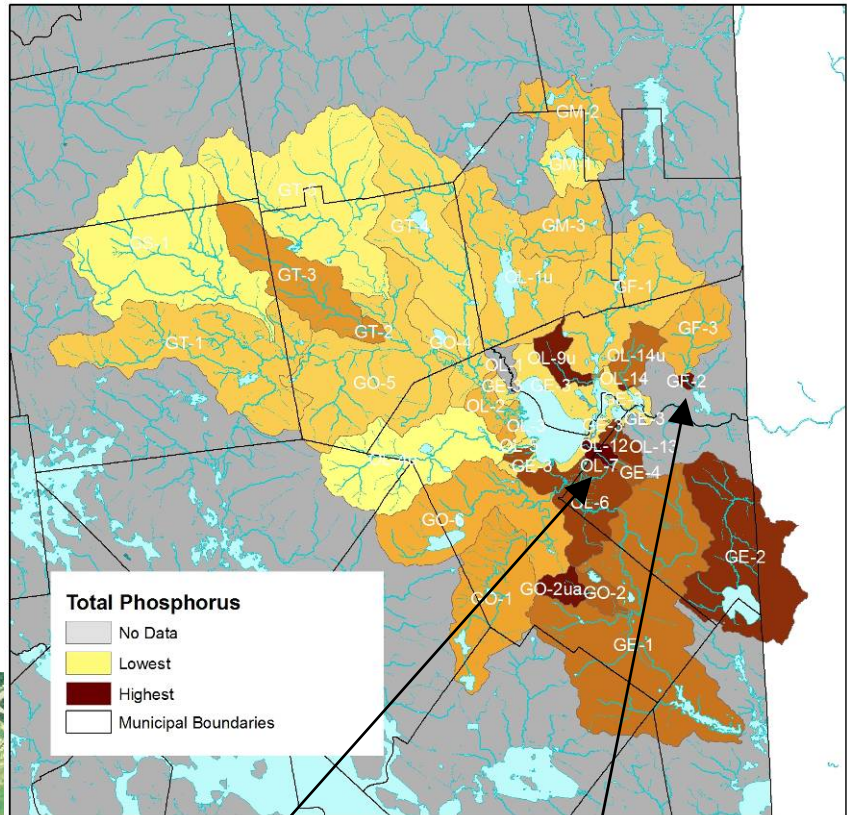
Third and fourth ranked catchments are GT-1 and GO-6, respectively, totaling ~28,500 acres. GT-1 is comprised of the upper reaches of the Bearcamp River, and GO-6 drains the Dan Hole Ponds to the Beech River, and then to the Pine River.

Total Phosphorus Concentration

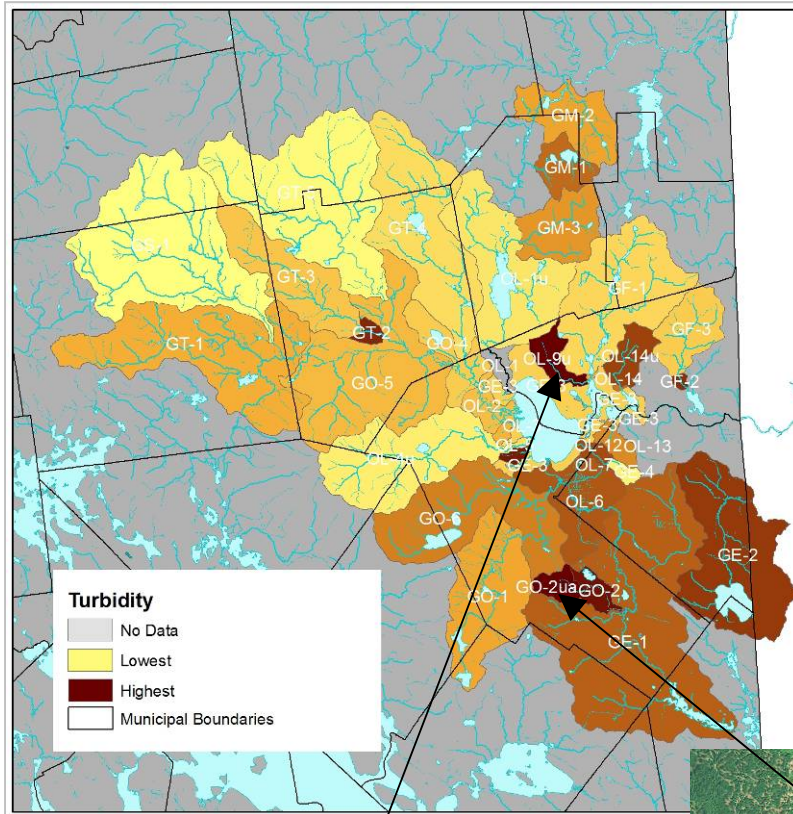
The two highest total phosphorus concentrations are in sub-watersheds OL-7 and GF-2. OL-7 is 58.4 ug/liter, while GF-2 is 17.2 ug/liter. The latter figure is more consistent with other sub-watersheds with relatively high concentrations, therefore, OL-7 may be an anomaly.

OL-7 includes a small area of low density residential development higher in the catchment, and what appears to be a lumber processing mill near Route 25. The core of the sub-watershed is wetland with a majority in organic soils. Old fields border the wetland to the north.

GF-2 consists mainly of a crossroads settlement (Freedom), with forest cover on a majority of the sub-watershed, and a small amount of wetland near the sampling station.

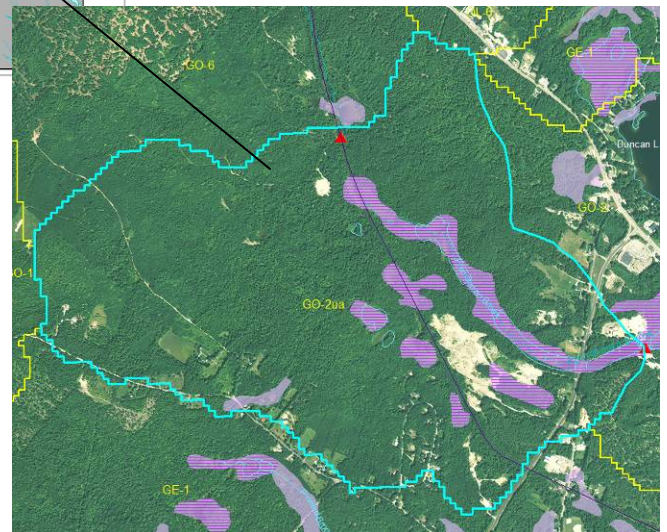
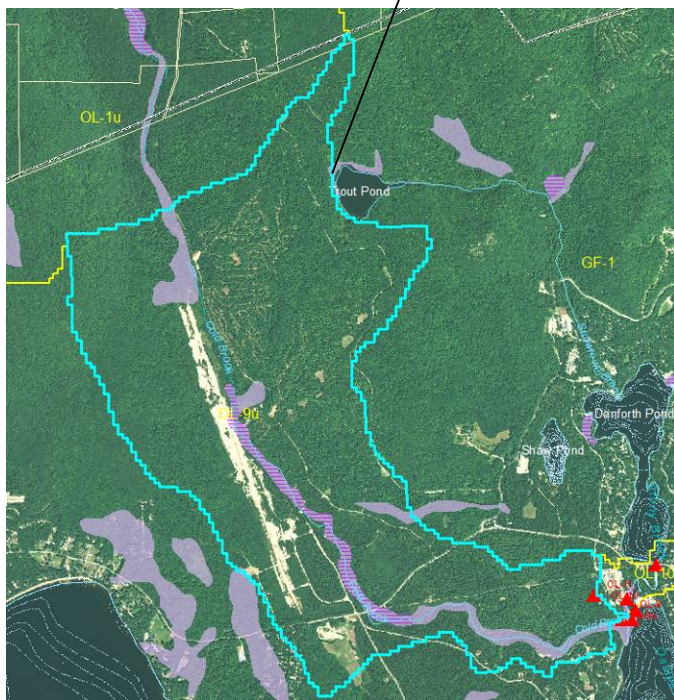


The clarity of water is quantified using instruments that measure light passage through a water sample, also referred to as turbidity. The more turbid a water sample, the less light can pass through the water. Anything that obscures light, like organic matter or sediment, can increase the turbidity of water. The two sub-watersheds with the highest Turbidity readings are OL-9ua and GO-2ua.



OL-9ua is drained by Cold Brook which includes a narrow band of wetlands along its length. There appear to be two sources of turbidity: a long, north/south excavation scar, and a moderately intensive timber harvest in the northern third of the catchment.

GO-2ua is predominately forested, and is drained by Frenchman Brook and wetlands near the intersection of Routes 16 and 25. Gravel extraction operations are apparent in the imagery.



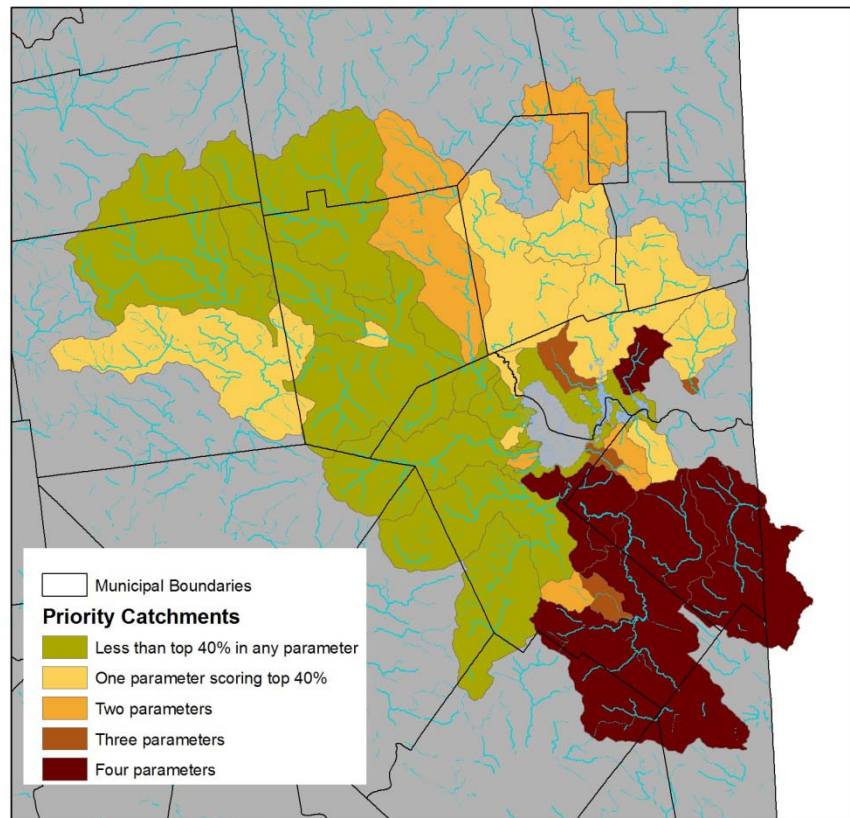
Route 25. There may be a hydrological connection between Duncan Lake and Frenchman Brook, given the subtle topography, but the chloride loading in this catchment seems more likely due to road salt and roadside development snow management.

Identifying Problematic Sub-Watersheds

In the Water Quality Data Analysis section of this report it was explained that TP data with other water quality data provides insight into the sources of TP which is vital information if TP is to be managed efficiently and effectively. With this in mind all of the sub-watersheds were evaluated using various GIS classification systems to identify problematic patterns based on selected water quality data, including total phosphorus, turbidity, dissolved oxygen, and chloride. Initially, a 5-step classification system used to extract the “top 20%” using a natural breaks statistical model in the GIS to group data. The results of this process appeared too narrow, with only a few scattered, smaller sub-watersheds identified as problematic. A second run using natural breaks was made with a 3-step classification to shift emphasis to the top 33% across the four parameters. This resulted in a broader array of sub-watersheds being prioritized, but still without a definite spatial continuity. Finally, a 10-step classification system was applied which allowed the top 40% of problematic sub-watersheds to be arrayed with better consolidation and continuity.

The co-occurrence map to the right shows several sub-watersheds that have at least one, and in three cases, two problematic water quality parameters using a top 40% assessment. The green area represents those sub-watersheds with net better water quality according to the four parameter approach.

As shown in the map, there are several sub-watersheds southeast of Ossipee Lake in Freedom and Ossipee that have all four parameters – total phosphorus, turbidity, dissolved oxygen and chloride – in the top 40% classification. There are other clusters north of the lake in Madison and



Tamworth, and the upper Bearcamp River, where one or two parameters are in the top 40%, and therefore are problematic. Note also the four small watersheds with three parameters working.

The table below provides a summary of the sub-watersheds with three or four parameters in the top 40%. Total annual phosphorus load is added to these selected data for reference and its overall importance in

the Ossipee Lake Watershed. As can be seen, sub-watersheds with a co-occurrence score of 4 show relatively consistent total phosphorus signals that are within the top 40%, but are typically lower than the data for the sub-watersheds with a score of 3. Generally, it is the mix of other problematic parameters that puts a sub-watershed into the most problematic category overall (score = 4). For example, OL-14u has a relatively low total phosphorus reading, but low dissolved oxygen and high chloride. However, if total phosphorus is given priority in the modeling, sampling station OL-7 should rise in rank as a priority sub-watershed for further study. Similarly, with the high total annual phosphorus load in stations GE-1 and GE-2 and top 40% total phosphorus ratings, further investigation of phosphorus sources is warranted.

Station	Acres	Total P	Turbidity	DO %	Chloride	Total Annual P Load	Score
OL-14	63	14.6	1.0	0.8	22.2	5.3	4
OL-14u	1,838	12.4	1.3	0.8	25.0	131.9	4
OL-6	5,646	13.9	1.2	0.8	11.5	454.2	4
GE-2	13,459	14.3	1.3	0.8	8.3	1,113.9	4
GE-1	28,471	12.3	1.1	0.9	12.9	2,026.7	4
OL-7	579	58.4	1.2	0.3	7.6	195.7	3
OL-9u	1,561	15.0	1.9	0.9	7.2	135.5	3
GO-2	1,120	12.6	1.7	1.0	32.0	81.3	3
GF-2	198	17.2	1.3	0.9	15.3	19.7	3

Planning Considerations and Prioritization Analysis for the Ossipee Watershed

Based on the data presented above there appears to be a need for a two pronged approach to address these sub-watersheds in future phases of the Ossipee Watershed Master Plan effort. The first aspect is to **work with the communities to ensure the rural sub-watersheds have the regulations that will be needed to continue to protect and manage them from water quality threats.** The second aspect will be to also **engage the communities and address the issues in the smaller more intense sub-watersheds through voluntary retrofits, regulatory and non-regulatory actions.** The intent of this approach is to learn and act collectively as a watershed. These issues cross town boundaries and there is still a need for further investigation watershed-wide. Ideally this will result in more effective outreach and education efforts based on GMCG’s collaborative history in the region, and the benefit of the Ossipee Watershed Coalition.

The process of analyzing the sub-watersheds and their water quality data has been very informative, and has identified areas where more data is needed. One example of this is phosphorus which is being contributed from both natural sources and human impact, but is difficult to determine which is having the larger impact and where. Turbidity and Chloride are also related to human activity, and all of the communities can benefit from these additional investigations and the lessons learned. Land uses are not static and each community has a role in guiding future land use activities for the good of the shared resources in the watershed. As a result, it appears that the focus of this watershed planning effort should be on understanding the sub-watersheds and moving forward as a region.

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The New Hampshire Department of Environmental Services has suggested that the size of the Ossipee Watershed makes it a good candidate for phasing, and even suggested some phasing breaks using five major sub-watersheds. After examining the water quality data, the sub-watershed characteristics, and GMCG's track record of working with the communities in the Ossipee Watershed we would like NHDES to consider a different phasing approach.

GMCG and the Ossipee Watershed Coalition that they helped create several years ago have developed strong relationships across the watershed, and have effectively tackled issues collectively. As a result it is recommended that future phases of this watershed master planning effort be conducted watershed-wide and evolve into an effort that will support local and regional initiatives to protect the water quality of the Ossipee Watershed by reducing sediment and nutrient loads and other threats. There is tremendous momentum for addressing these issues in the Watershed through GMCG's work and we want to be sure to take full advantage of that for the future phases of this effort.

The phasing that is recommended for this watershed master planning effort is as follows:

Prioritization Phase - *Methodology and Prioritization Analysis for Watershed Planning* - 2011

This phase is currently underway and scheduled to be complete on August 9, 2011.

Phase 1 – *Filling Critical Ossipee Watershed Data Gaps to Better Understand Phosphorus Dynamics* – (Current request for funding)

This phase would include additional data analysis to expand the knowledge of how each of the sub-watersheds contributes to Ossipee Watershed. This will include further investigation of the sources of phosphorus, and historical records of nutrients in the watershed. Additional resources should also be allocated to the creation of a detailed land use layer for GIS analysis and correlation to the sub-watersheds. This is particularly important given the pilot project finding of extensive organic soils in the region that might be impacting phosphorus loading into the lake systems. During phase one, GMCG will partner to collect the necessary science and will also expand community engagement activities to increase education and awareness about phosphorus loading to the Lake. GMCG will host meetings with consultants, municipal officials and other stakeholders to introduce information about what a watershed master plan is and why we need to work together to create and implement one. Participation from the Ossipee Watershed Coalition in this and future phases of this effort will be important. It should be noted that this approach is distinct from the development of other watershed plans, mainly because there is such a rich database of water quality data in the Ossipee Basin. Thus, identification of the phosphorus problem in the basin will also rely more on observations than watershed models particularly because of the numerous wetland systems.

Phase 2 – Watershed Master Plan Preparation and Delivery (Seeking DES funding in 2013/2014)

This phase will include additional demographic and planning analysis that might be necessary for the watershed master plan as identified in Phase 1. This phase will also include an assessment of how phosphorus loadings could be reduced to meet established phosphorus criteria. This approach will likely utilize empirical relationships established from Phase 1 combined with a simple lake assimilative capacity model. Based on that analysis, recommendations for management practices or mitigation strategies can be developed. A survey of area residents and other may also need to be completed during the first half of this phase to better inform the watershed master planning process. Once all of the studies and source materials have been assembled a summary document will be drafted and shared with residents through the Ossipee Watershed Coalition. It is very important during this phase that each community is represented and encouraged to help draft the management plan from their town's perspective if towns are to later adopt these documents into their own master plans.

Phase 3 – Adoption and Implementation (Seeking DES funding in 2014/2015)

The final phase of this project will be related to working with the local communities and others to adopt the watershed master plan and begin efforts to implement the regulatory and non-regulatory recommendations. This is a critical phase for protecting the water quality of the Ossipee Watershed. It takes the science and policy recommendations and results in real change in the watershed. GMCG will partner with Jeff Taylor and Associates to assess community need and then help develop innovative land use BMPs or regulations tailored to issues discovered in Phase 1 and 2. GMCG will coordinate this phase much as we did the Aquifer Protection Ordinance—hold monthly meetings for members of each of the six towns to work together to draft a watershed management plan that would specifically work in their town. While GMCG will help provide a template plan based on the previous two years of data collection, consultant guidance and community surveys, it will be up to each town planning board to edit it to work for that specific town. We have a track record of success by holding monthly meetings and offering workshop presentations at each town planning board. Following found information on phosphorus loading, GMCG will also lead community initiatives such as —septic socials, workshops on steep slopes, BMP workshops on lawn maintenance for lakeshore owners etc all as educational outreach as part of the Watershed Management Plan adoption phase.

Meeting the Environmental Protection Agencies Key Elements for Watershed Management Plans

The future phases of this effort will need to consider the nine key elements identified by the Environmental Protection Agency (EPA) for Watershed Management Plans. During this initial Methodology and Prioritization effort potential sources of P were identified, and a plan has been formulated for using watershed tracers and detailed mapping of land uses in future phases to determine the natural and anthropocentric sources of P. This may expose a very unique underlying limiting factor in this watershed. We need to know the natural, ambient base contributions to estimate the range of P loading that the region can tolerate. Once this is identified education and regulation recommendations can be formulated for the Watershed communities.

The detailed land use mapping proposed in Phase 1 will provide greatly improved inputs to the modeling and statistical correlation process tested in this pilot phase. Land uses will be digitized using aerial photography and a methodology similar to the CICEETS land cover mapping project completed for Strafford and Rockingham Counties in 1998. Mapping of critical culverts and other infrastructure in the sub-watersheds where there are turbidity signals in the WQ sampling will also be used to help identify and control physical problems in the Watershed. The use of caffeine testing in the sub-watersheds where we see dense residential developments is also likely to identify land use issues with septic systems.

In order to estimate the pollution reductions needed the Team is proposing to first figure out what the baseline is for this specific system by collecting sediment cores in Ossipee Lake. Phosphorus loading calculations will then be developed. The determination of how to achieve reductions is anticipated in Phase 2 because it will be necessary to first know where the P is coming from to propose reasonable reduction levels. Knowing where the P is coming from is critical before proposing sound solutions to reducing it.

The Ossipee Watershed is unique in many ways as it sits within the Saco Basin and contains a regionally significant sand and gravel aquifer which is connected hydrologically to the surface waters, including especially Ossipee Lake. This is the last and greatest potential municipal groundwater water supply source for future development to meet drinking water demands. The other unique aspect of this Watershed is the strong suggestion that we have natural inputs of P from the extensive wetlands mosaic.

In response to the remaining EPA Key Elements it is too soon to be able to address some of these points, but the proposed Phase 1 will assist with that. It is important to note that some match will be available from both the Forest Society and Plymouth State University in future phases of this project, and that further outreach and education activities have been targeted for the next three phases of this effort.

Public Meeting Presentations

On Monday, July 25, 2011 these report findings were presented to the full GMCG Board, and they voted to move forward to the next phase of the watershed master planning process. GMCG has had a very strong presence in the watershed and developed strong relationships with local boards, camps, and area residents. The Watershed Coalition, a group of area residents working with GMCG on environmental planning efforts in the watershed, is a good example of the relationships formed through this collaboration.

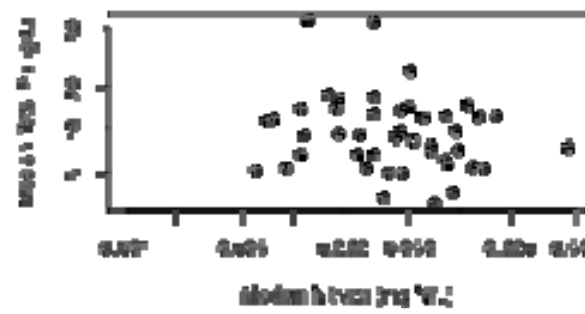
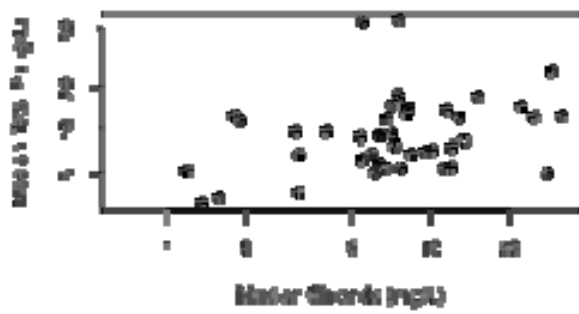
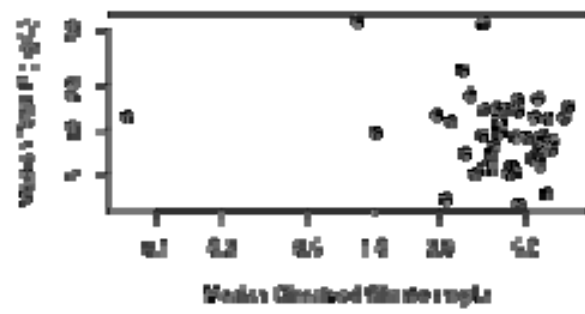
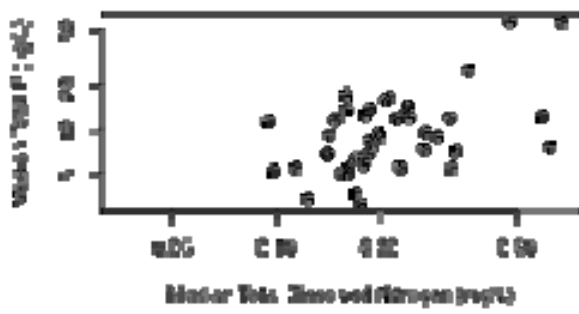
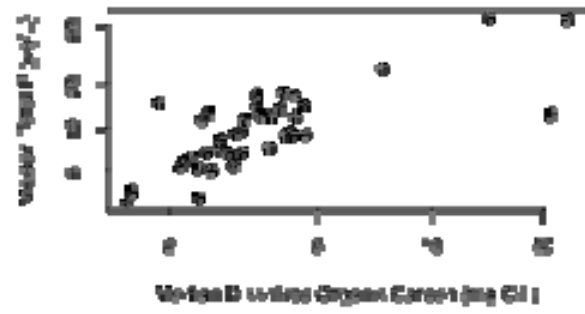
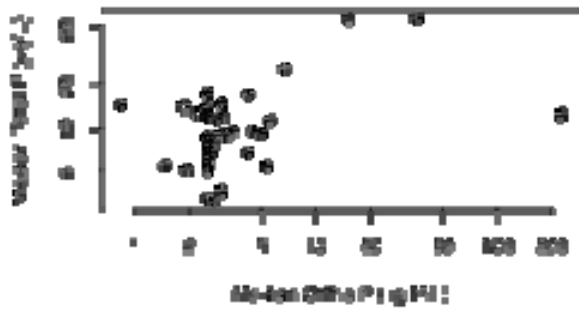
To continue this collaboration into the future this first phase of the watershed master planning process will be shared with the public as part of a State of the Lake event on August 9, 2011 at the Ossipee Town Hall. Having the residents of the Watershed engaged in this process and understanding the science will make the process stronger and more likely to be implemented successfully.

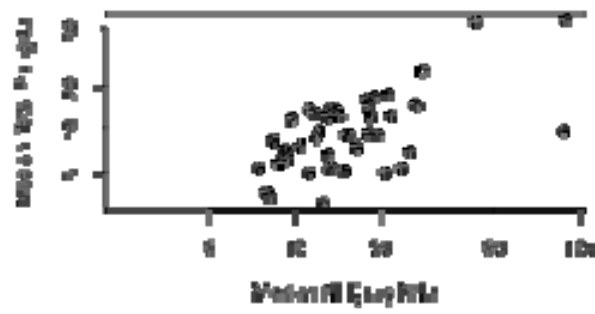
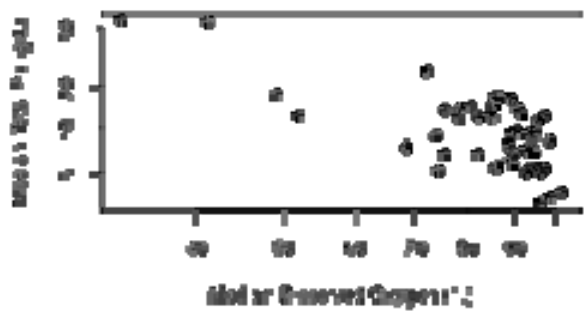
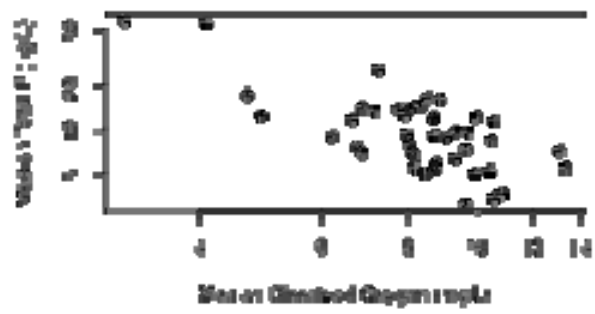
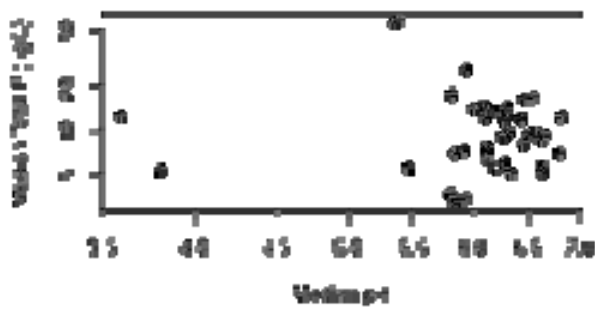
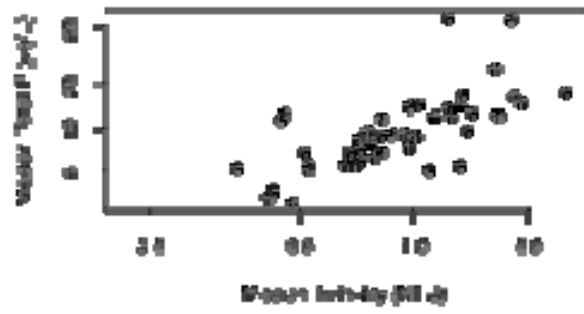
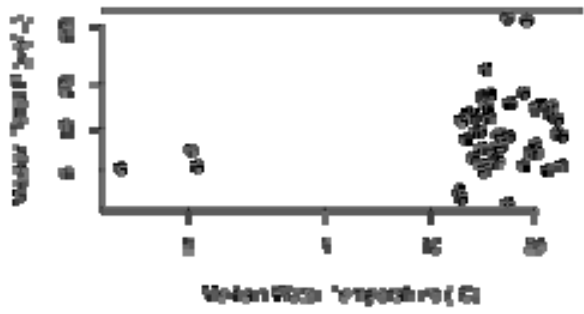
Conclusions and Recommendations

As an initial step in a watershed master planning process this *Methodology and Prioritization Analysis* has led to a deeper understanding of the issues in the Ossipee Watershed. It is clear that more investigation is needed into the sources of phosphorus in the watershed, and that more detailed land use data will help further an understanding of each sub-watershed. The specific recommendations mentioned in the report include:

- A land use data set will be developed using air photo-interpretation and GIS technology for the entire Ossipee Watershed to clearly represent existing development patterns, including structures, roadways and other impervious surfaces, and land use types such as agriculture and gravel extraction. Outcome: detailed GIS maps showing human development and land use in addition to existing data layers.
- Sediment cores from Ossipee Lake and its bays taken so as to provide a longer record of data that can be analyzed. Working with Plymouth State University we further propose to collect sediment core samples from the Pine River and Bearcamp River inlets as well as upper Danforth Bay that has shown Phosphorus loading which may be naturally occurring in part. Outcome: A historical baseline of phosphorus data and an analysis to show temporal trends to current date.
- The watershed also would benefit from improved understanding of hydrologic connectivity in the basin. Outcome: A detailed map of all streams and human drainage structures (culverts, road drainage structures, etc.) to be added to the GIS resource maps. Catchments and streams will also be mapped to show impact of steep slopes on their drainage systems and impact on nutrient loading to water bodies.
- Sampling of tributaries during high flows. Outcome: Improved ability to calculate phosphorus loads to the lakes.
- Monitoring of stable isotopes of water (Deuterium and oxygen-18) as an inexpensive way to trace water movement in the basin. Outcome: Ability to differentiate the relationship between surface and groundwater nutrient loadings and to determine upper versus lower catchment area impacts.
- Distinguishing anthropogenic sources of total phosphorus from natural sources will be accomplished by analyzing different elements, such as caffeine for wetlands sources, in routine water samples. Outcome: Better understanding of phosphorus sources to the lake, which will empower more efficient and effective mitigation strategies.
- Regional meetings held to engage the watershed communities and other stakeholders in discoveries and in the creation of the watershed master plan document. Identified stakeholders include but are not limited to: lake associations, municipal officials, homeowners, visitors, businesses, family camps on the lakes, NH Fish and Game and NH DREDS Outcome: Engagement of all stakeholders in the watershed management plan process and outcome.

It is a good time to further engage the citizens of the watershed in this process so that they can guide this effort from its initial studies through the crafting of a watershed master plan with regulatory and non-regulatory implementation actions.





Appendix 2. A comparison of the total phosphorus concentration with the daily discharge rate (estimated using the Bearcamp River USGS gage).

