Newfound Lake Watershed Assessment (2013)

Prepared by

University of New Hampshire Center for Freshwater Biology and University of New Hampshire Cooperative Extension

A project of the Newfound Lake Region Association

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University of New Hampshire, US Department of Agricultural Cooperative State Research Education and Extension Service, NH Counties cooperating.

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ACKNOWLEDGEMENTS

The Newfound Lakes Region Association (NLRA), in conjunction with the University of New Hampshire Center for Freshwater Biology (CFB) and Cooperative Extension Water Resource Program, undertook a two year sampling effort on Newfound Lake and select tributary inlets with the primary goals of better characterizing the current condition of Newfound Lake, identifying potential problem areas around the lake and providing recommendations to minimize future water quality impacts. This report builds upon the findings of a Newfound Lake Tributary Assessment (Craycraft and Schloss, 2008) that characterized the water and phosphorus load into Newfound Lake as well as the findings of a follow-up Newfound Lake Watershed Assessments (Craycraft and Schloss, 2009, 2012) that provided additional insight into the condition of Newfound Lake and its tributary inlets. The success of this project was the culmination of the assistance and guidance of numerous volunteers highlighted in Table 1. The NLRA, under the guidance of Boyd Smith (executive director) and Nikki Wooster-Goodwin (program director), undertook the formidable task of coordinating this multi-site sampling effort, assuring that samples and data were transferred to University of New Hampshire staff members on a timely basis and helping coordinate the use of the NLRA pontoon boat during CFB field team visits. We also acknowledge Dan Sundquist of the Society for the Protection of New Hampshire Forests who delineated the stream watersheds that are part of this study.

Jillian McCarthy, New Hampshire Department of Environmental Services (DES) Quality Assurance Coordinator, Vincint Perelli, New Hampshire DES Quality Assurance Manager, and Charles Porfert, Environmental Protection Agency (EPA) New England Quality Assurance Officer, provided technical support and reviewed the Quality Assurance Project Plan (QAPP) that outlined the standard operating procedures used in this study. Steve Landry, New Hampshire DES Merrimack Watershed Supervisor, provided guidance and assistance with the development and implementation of the Newfound Watershed Master Plan (WMP) initiative that will utilize the water quality data contained in this report in a watershed wide planning effort.

Table 1: Newfound Lake and Headwater Tributary Volunteer Monitors (2012 and 2013).

Stephanie Bednay	Dick Beyer	Linda Beyer	Orin Bliss
Katie Callahan	Finn Callahan	Bruce Callahan	Herb D'Arcy
Rosemary D'Arcy	Nancy Dineen	Gavin Divelbiss	Lyn Egsgard
Steve Gunn	Jeff Hillier	Ron Olson	Ali Plankey
Anne Purrington	Laurie Randall	Ted Randall	Val Scarboroough
Jack Scarborough	Bob Twombly	Ken Weidman	

Laboratory space was provided by the University of New Hampshire College of Life Sciences and Agriculture while administrative support was provided by University of New

Hampshire Cooperative Extension. Members of the University of New Hampshire CFB laboratory and field team, who assisted in the collection and analysis of water quality samples include: Robert Craycraft, Amy Arsenault, Casey Chalmers, Hannah Johnson and Jessica Waller.

EXECUTIVE SUMMARY

Purpose and Objectives

The Newfound Lake watershed is located in the Towns of Alexandria, Bristol, Bridgewater, Danbury, Dorchester, Groton, Hebron, Plymouth and Orange. With continued development pressures facing local decision-makers in the nine towns, the need exists for scientifically-based information that will provide support for proactive natural resource based planning within the Newfound Lake watershed.

The 2013 Newfound Lake watershed assessment builds upon historical Newfound water quality monitoring efforts that included a Newfound Lake water/phosphorus budget (Craycraft and Schloss, 2008) and Newfound Lake Watershed Assessments (Craycraft and Schloss, 2009, 2012). This intensive water quality monitoring project is a component of the larger watershed master planning initiative that relies on expertise in land-use and watershed planning, survey design and interpretation, education and outreach. The collective expertise of the professionals involved in this project will help educate local municipal officials and will foster informed land-use planning decisions that will benefit future generations.

Scope

The 2013 Newfound Lake Watershed Assessment monitoring effort expands upon Newfound Lake base-line data that provides insight into the identification of potential problem areas within the Newfound Lake watershed. This effort is designed to generate data that will provide local decision makers and the public with a better understanding of the potential impacts of development, population growth, and land use change on the Newfound Lake and its drainage basin (watershed). The focus of this two-year monitoring effort includes:

- Conduct in-lake water quality sampling at historical deep sampling locations that will add to the long-term database, will facilitate continued trend detection and will continue to assess Newfound Lake's trophic status.
- Conduct tributary sampling at pre-existing and expanded headwater sampling sites to document water quality variations among sampling locations and to screen for problem areas within the Newfound Lake watershed.

Lake Aging (Eutrophication) Overview

A common concern among New Hampshire lakefront property owners is a perceived increase in the density and abundance of aquatic plants in the shallows, increases in the amount of microscopic plant "algae" growth (detected as greener water), and water transparency decreases collectively known as eutrophication. Eutrophication is a natural process that takes place on a geological time frame of thousands of years, during which lakes progress from clear pristine lakes to green, nutrient enriched lakes. Much like the fertilizers applied to our lawns, nutrients that enter our lakes stimulate plant growth and culminate in greener (and in turn, less clear) waters. Some lakes age at a faster rate than others due to naturally occurring attributes: watershed area relative to lake area, slope of the land surrounding the lake, soil type, mean lake depth, etc. Since our New Hampshire lakes were created during the last ice-age, which ended about 12,000 years ago, we should have a natural continuum of lakes ranging from pristine to nutrient enriched.

Deep Sampling Site Water Quality Assessment

The overall condition of Newfound Lake remained excellent and was characteristic of a relatively young, oligotrophic lake, although there was a clear difference between the Mayhew sampling station and the remaining Newfound Lake sampling sites.

The Mayhew site, the only site located south of Mayhew Island, was characterized by the lowest dissolved oxygen concentrations among the seven sampling locations (Appendix F). The lack of dissolved oxygen in the deeper, cold waters, of the Mayhew site likely restricted the cold water fishery to other areas of Newfound Lake during the summer and fall months. Likewise, the water clarity was shallower (Figure 7), the amount of algal (microscopic plant) growth was higher (Figure 6) and the total phosphorus (nutrient) concentrations were higher (Appendix B) at the Mayhew Site. The Mayhew site is located in the most developed segment of Newfound Lake and might be reflecting localized nutrient inputs associated with a more intense level of residential development (Craycraft and Schloss, 2009). As indicated above, the overall Newfound Lake water quality is excellent but the Mayhew sampling site is exhibiting the early symptoms of nutrient enrichment that are not evident at the other Newfound Lake sampling sites.

Headwater Stream Assessment

The overall Newfound headwater tributary water quality was excellent although sampling during higher flow periods and following heavy periods of rainfall reaffirms the threat of phosphorus and sediment loading from upland sources (Craycraft and Schloss, 2012). Turbidity measurements were slightly elevated in Brock Brook on June 13, 2013, relative to other sampling locations within the Fowler River subwatershed. Historical water quality sampling conducted on August 30, 2011 and October 3, 2011 also documented elevated turbidity measurements in Brock Brook and suggest this stream may be more susceptible to increased sediment loading during periods of elevated streamflow (Craycraft and Schloss, 2012).

Long-Term Water Quality Trends

A review of twenty eight years of water quality sampling in Pasquaney Bay indicates a long-term trend of decreasing water clarity since 1986 (Figure 16). The amount of algal (microscopic plant) growth exhibits a trend of increasing concentrations in both Pasquaney Bay and south of Mayhew Island since 1986 (Figures 17 and 18). Thus, while the overall water quality remained excellent in Newfound Lake, there are signs that the water quality has been degraded over time (even at the deep centrally located reference stations) and may be influenced by land use changes within the Newfound Lake watershed.

Conclusions and Recommendations

One may consider the saying, "a lake is a reflection of its watershed," which ties lake and stream quality to watershed wide land use patterns. A watershed-wide effort is essential to the preservation of the exceptional Newfound Lake and tributary water quality that is characteristic of the region. Short-term and localized water quality variations, identified through the extensive Newfound Lake and tributary sampling and discussed previously, are a reminder that threats exist within the watershed. If these threats are ignored, they will ultimately have an adverse impact on the Newfound Lake and stream quality.

Many Newfound Lake tributary inlets are characterized by extensive bank-undercutting associated with the erosive force of stream flow. Elevated turbidity and total phosphorus concentrations documented during intense storm events reflect the displacement of sediments from the stream bank and upland sources. On a more positive note, extensive streamside (riparian) forests extend along most of the tributary inlets and help stabilize the stream banks, prevent excessive erosion and in turn protect water quality and critical fishery habitat. Healthy riparian buffers can also serve as travel corridors for upland wildlife species. Streamside vegetative buffer requirements that fall under the jurisdiction of the Shoreland Water Quality Protection Act (SWQPA) are currently limited to the lower reaches of the Cockermouth and Fowler Rivers (DES, 2013).

Residents within the Newfound Lake watershed should be educated on measures that can be undertaken to control soil erosion and that will reduce the amount of fertile, nutrient enriched, soils that erode into the lake. The NH DES recently published a guide, New Hampshire Homeowner's Guide to Stormwater Management: Do-It-Yourself Stormwater Solutions for Your Home (McCarthy, 2011), that provides stormwater management advice to homeowners aimed at minimizing the amount of pollutant laden runoff into surface waters and wetlands. Considering the amount of forestland within the watershed and the potential for sediment and nutrient runoff associated with poorly managed forestry operations, residents who are managing their woodlots for timber production should be knowledgeable in timber harvest laws and may also consider reviewing the recommendations outlined in the document, Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices for New Hampshire, second edition (Bennett, 2010). This document provides various forestry management options and includes sections that pertain to water quality protection.

Those involved with future land-use planning efforts should consider minimizing the percentage of impervious surfaces, such as roads and out-buildings, that tend to concentrate and accelerate overland water flow and thus increase the potential for erosion. Much of the Newfound Lake watershed is steep sloped and is particularly susceptible to water quality problems due to rapid runoff. Increases in impervious cover and removal of natural forest canopy, associated with home site development, can alter natural hydrology and can increase the discharge velocities of streams and the erosion potential of overland water flow. Rainwater that runs over the impervious surface and associated developed areas can also pick up pollutants such as pet waste and lawn fertilizers that may enter water courses and adversely impact water quality. Impervious surfaces also reduce groundwater recharge and can result in atypically low in-stream water levels during summer low-flow (summer base flow) periods. The lack of in-stream flow can have adverse impacts on the local fishery and may also coincide with atypically low or dry dug wells for local residents.

Municipalities might want to consider creating, reviewing or amending their storm water management regulations that provide temporary and permanent storm water management requirements. Strong stormwater management requirements can simultaneously protect water quality and reduce highway maintenance costs associated with inadequately engineered storm water management measures. Municipalities might further consider incorporating low impact development (LID) principals into their subdivision, site plan and zoning ordinances that will help retain natural hydrology and that will protect water quality. Recent publications by the DES, New Hampshire Stormwater Manual Volume 2: Post-Construction Best Management Practices Selection and Design (DES, 2008) and Innovative Land Use Planning Handbook (DES, 2008) discuss LID principles and provide model ordinances and regulations that can assist communities in their environmental planning efforts.

The Newfound Lake Watershed Master Plan is a good source of land use planning suggestions for those seeking further land use planning suggestions, http://www.newfoundlake.org/index.php/protect-the-lake-watershed/publications.

The Watershed Master Plan was developed with a mind towards balancing the protection of natural resources, fostering the retention of rural character, promoting economic vitality and meeting the needs of changing demographics and increasing population.

NEWFOUND LAKE AND ITS WATERSHED

Introduction

The Newfound Lake Watershed, the geographic area in which all water drains into Newfound Lake, is closely tied to water quality and quantity in Newfound Lake. Stated another way, a lake is a reflection of its watershed; what occurs in the watershed can have significant impacts on whether the water quality improves, degrades or remains the same. As population growth occurs in our region and the resulting pressures from development and recreational use ensue, there is growing concern over the potential for degradation of lake water quality. The resulting symptoms of these impacts can include algal blooms, establishment of nuisance aquatic weeds, shoreline scums, declining fishery (as well as a decline in the lake's overall ecological integrity) and increased sedimentation. Of primary concern are the impacts of increased nutrient loading caused by human activities in the watershed that result in accelerated plant growth (submerged and emergent vascular plants and algae) within the lake. Nutrients can come from many sources and include surface runoff resulting from precipitation upon the natural and developed areas of the lake's watershed (drainage basin). Additional nutrients are transported into the lake through stream inflow, groundwater, septic system effluent that leaches into groundwater and even from precipitation and dry fallout (dust particles). Activities within the watershed, such as the construction of residential subdivisions, result in removing or damaging vegetation, duff layers (leaf litter) and soils that, when left in an undisturbed and natural state, trap nutrients before they reach wetlands, streams, lakes and ponds. Roads, driveways and drainage ways increase channelized flow that tends to transport more runoff and nutrient laden materials through the watershed. Improper and unneeded fertilizer applications for agriculture and homeowner landscaping can also add to the nutrient load that reaches the lake.

Of the two nutrients most important to the growth of aquatic plants, nitrogen and phosphorus, it is generally observed that phosphorus is the more limiting to plant growth in lakes, and therefore the more important to monitor and control. Phosphorus is generally present in lower concentrations than nitrogen, and its sources arise primarily through human activity in a watershed. The total phosphorus discussed in this report includes dissolved phosphorus as well as phosphorus contained in or adhered to suspended particles such as sediment and plankton.

As little as 10 parts per billion of phosphorus in a lake can cause an algal bloom. Using a full Olympic swimming pool as an example, it would take 10 drops of water added to the approximately 130,000 gallons of water to equal 10 parts per billion. Extensive blooms will block sunlight and can depress oxygen levels in the water due to the death and subsequent microbial decomposition of plant and algal matter. Reduced oxygen concentrations can be detrimental to fish, plants and wildlife of the lake and can also result in the degradation of aesthetic quality due to events such as fish kills and accumulations of decaying material (muck) along the lake bottom. When the oxygen, dissolved in the water over the sediments, becomes reduced below two milligrams per liter, phosphorus, the majority of which usually binds to the lake sediments and remains unreactive, can be released. Thus, it is important to obtain an understanding of the sources and amounts of phosphorus supplied to a lake from its watershed in order to control its input to the surface waters. The best method to achieve this is to conduct field sampling and derive a water and phosphorus budget, which has been reported in a previous report (Craycraft and Schloss, 2008). The information summarized in this report builds upon the Newfound Lake water and phosphorus budget and a follow up Newfound Lake Watershed Assessments (Craycraft and Schloss, 2009, 2012) that characterized the water quality conditions within Newfound Lake and the surrounding tributary inlets. The 2012 and 2013 water quality results summarized in this report continue to emphasize the collection of total phosphorus measurements while supporting measurements, highlighted and discussed in Table 2, were also collected to better assess current lake and tributary conditions.

The comprehensive water quality sampling approach outlined in this report is a component of a larger Watershed Master Planning project that will facilitate natural resource management at the watershed scale. Educational outreach efforts that evolve as part of this effort will involve numerous entities that include the NLRA, Jeffrey Taylor and Associates, Plymouth State University, NH DES, the University of New Hampshire and UNH Cooperative Extension, the Society for the Protection of New Hampshire Forests, the watershed community, concerned citizens, and local decision-makers.

Table 2: Primary sampling parameters and sampling rationale

Sampling Parameters	Rationale
Total Phosphorus	Phosphorus (P) tends to be the limiting nutrient in lakes. Total phosphorus is the sum of phosphorus in all its forms (dissolved or particulate) and can be used to determine a lake's trophic (nutrient enrichment) state. Quantifying the phosphorus load is of paramount importance in lake management and is highly correlated to the amount of microscopic plant growth that can be measured as chlorophyll *a*.
Soluble Reactive Phosphorus	Soluble reactive phosphorus (SRP) is a dissolved fraction of the total phosphorus and the SRP is readily available for algal growth. Soluble reactive phosphorus is formed naturally through the decomposition of organic matter but can also be associated with fertilizer applications and septic system effluent.
Turbidity	Turbidity reflects the amount of particulate matter suspended in the water column and can also help determine the areas within the Newfound watershed where sediment erosion is the greatest concern. Turbidity can also be used as a surrogate for "total phosphorus" loading into Newfound Lake since phosphorus tends to attach to sediment particles and is also part of organic debris that enter Newfound Lake.
Temperature	Temperature is correlated to what types of aquatic organisms can survive in the lake and the streams. Temperature variations can also reflect differences in the amount of (shoreside) riparian cover in the Newfound Lake sub-watersheds. Temperature may also be correlated with the amount of impervious surface (surfaces that do not allow water infiltration such as roofs, roads, etc).
Light	Sunlight is a necessary component to the photosynthetic activity of both aquatic and terrestrial plants. The amount of light penetration can influence the amount of aquatic vascular plant and algal growth. Much like terrestrial plants, many aquatic species require high light levels to successfully grow, reproduce and flourish.
Specific Conductivity	Specific Conductivity is the capacity of water to carry an electrical current. It provides insight into local geological variations among the sampling stations, as well as insight into regions where road salt runoff, nutrient runoff, etc. might be impacting the water quality. Specific conductivity is highly correlated with sodium and chloride concentrations and thus is a good surrogate measurement of road salt runoff.

Sampling Parameters	Rationale
Total Alkalinity	Alkalinity is a measure of the water's capacity to neutralize acids. The alkalinity is generally low in New Hampshire Lakes and provides insight into the susceptibility of Newfound Lake to acid precipitation.
pH	pH is an indicator of the acidity of the lake and streamwater. pH influences nutrient availability from the sediments and impacts the fitness and distribution of aquatic organisms.
Dissolved Oxygen	Dissolved oxygen concentrations are essential for a healthy fishery and are also associated with the eutrophication (lake aging) process. During the summer months, deep north temperate lakes stratify into three distinct zones; an upper warm water zone (epilimnion), a zone of rapid temperature decrease (thermocline/metalimnion) and a deep cold water zone (hypolimnion). During the summer months, the zones are partitioned and oxygen is not readily replenished to the bottom waters. Oxygen deprived (anoxic) conditions, near the lake bottom, are commonly associated with more nutrient enriched lake that may also be experiencing internal nutrient loading, a process by which nutrients are "released" from the sediments into the water column.
Carbon Dioxide	Carbon Dioxide is a by-product of microbial decomposition and can build-up in the deeper areas of Newfound Lake during the summer stratification period. When dissolved in the water, carbon dioxide is in equilibrium with carbonic acid, which can naturally impact the lake acidity (pH) during the course of the day as well as among the thermal layers in the water column.
Secchi Disk Transparency	Water transparency integrates the impacts of sediments, microscopic plant "algal" cells, colored water and detrital (decomposing) debris that are flushed into the lake. The Secchi Disk transparency measurements provide water transparency data that can be compared among sampling locations and among years to assess the spatial and temporal variation.
Chlorophyll *a*	Chlorophyll a serves as a good estimator of microscopic plant "algal" biomass. Generally speaking, the greener the water, the more microscopic plant/chlorophyll *a* in the water column. The collection and analysis of chlorophyll samples are relatively simple and provide insight into the trophic condition of Newfound Lake.

Sampling Parameters	Rationale
True Color	True color is a measure of the natural color of the water after particulate debris has been filtered out. For instance, wetland systems tend to be darkly stained and when these waters enter the lake, they can also result in more tea stained waters. True color can have a significant impact on the water clarity, particularly in localized areas of the Newfound Lake watershed where considerable wetland drainage exists. True color measurements provide insight into the causes of water transparency variations as well as insight into the seasonal variations in the amount of wetland drainage into Newfound Lake.
Sodium and Chloride	Sodium and Chloride are constituents of road salt and can become elevated in more developed watersheds where increased salt applications occur. Sodium and chloride are closely correlated with Specific Conductivity measurements and this study will examine those relationships within the Newfound Lake watershed.

BACKGROUND DATA

Newfound Lake Watershed

The Newfound Lake watershed encompasses all or part of the towns of Alexandria, Bristol, Bridgewater, Danbury, Dorchester, Groton, Hebron, Plymouth and Orange. Newfound Lake is located south of Plymouth and east of Mount Cardigan at a mean elevation of 179 meters (586 feet) above sea level. The Newfound River, which drains the lake, flows southerly through the Town of Bristol to the Pemigewasset River that forms the Merrimack River at its confluence with the Winnipesaukee River in Franklin (Table 3). In the 1930s, Newfound Lake was artificially raised by a dam that is currently operated by the New Hampshire DES Dam Bureau. Newfound Lake is considered the deepest lake in New Hampshire with a maximum recorded depth of 55.5 meters (182 feet) and ranks fifth among the largest New Hampshire Lakes. The watershed is predominantly forested and includes two larger wetland complexes that drain into two of the larger streams: Georges Brook to the north and Bog Brook to the west. The watershed, delineated to the Newfound Lake Dam (outlet) at the Newfound River, totals 56,825 acres (Table 3 and Figure 1).

Table 3. Newfound Lake Summary Data

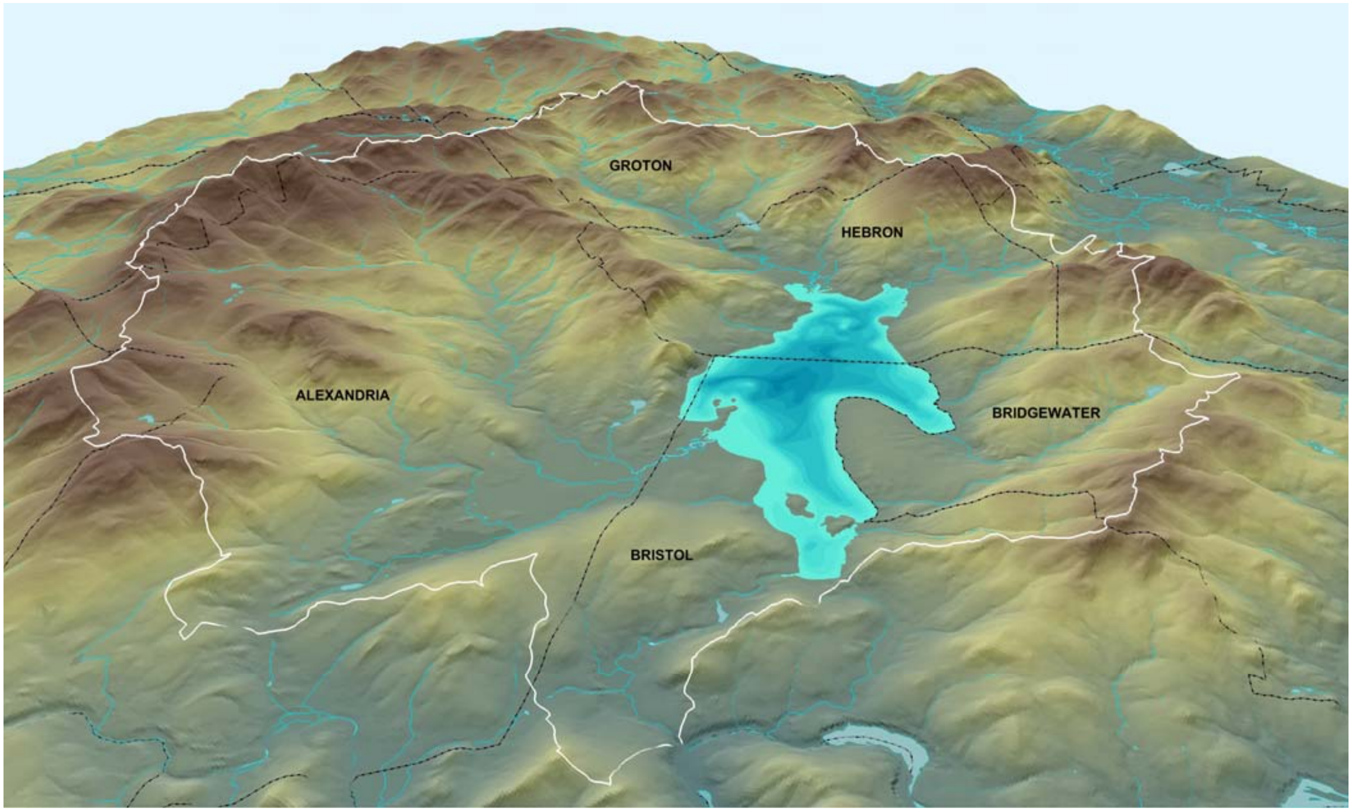
Latitude	43°39'46"
Longitude	71°46'31"
Lake Elevation	586 feet
Lake Area	4,451 acres
Maximum Depth	182 feet
Watershed Area	56,825 acres
Lake type	Natural with Dam
River Basin	Merrimack

Newfound Lake surface area and Watershed area were derived from 7.5 minute US Geological Survey mapping data that was digitized into a Geological Information System.

Geology and Topography

The bedrock geology of the Newfound Lake watershed, as typical of most New Hampshire watersheds, is predominantly granite and metamorphic rocks. Its topography is highly variable, with some of the flatter land located adjacent to the main stems of the Cockermouth and Fowler Rivers (Figure 1), and the Bog Brook tributary that is fed by a large meandering wetland complex. There is also flatter land around the perimeter of Newfound Lake, although steep sloped regions are interspersed and include "the Ledges" located northwest of Wellington State Park. Viewing the surrounding landscape, one sees hills and mountains in the distance that delineate the headwaters of Newfound Lake and the watershed divide with Mount Cardigan forming the highest land elevation of 3,155 feet along the westerly watershed boundary. The bedrock geology and thin soils that do not retain much water, coupled with relatively steep slopes, cause the tributaries to experience rapid runoff during storm and snowmelt events. During these short-duration and high intensity runoff periods, rainfall and/or melt-waters tend to rapidly flow off the landscape and concentrate to form well-defined stream channels. The channels of many Newfound Lake tributary inlets are characterized by cobble and boulders as is expected in steep-sloped watersheds where finer materials are flushed downstream due to the erosive force of the water.

Figure 1. Shaded Relief map of the Newfound Lake Watershed



Source: Society for the Protection of NH Forests

Newfound Lake Bathymetry

The Newfound Lake bathymetry refers to the depth contours characteristic of the lake, much like the topographic contours of the Newfound Lake watershed. The deepest point of the lake is located east of “the Ledges” well away from the shoreline while a second deep basin, over 120 feet deep, is located in the more northerly section of Newfound Lake (Figure 1). Some of the larger areas of continuous shallow water are located in Hebron Marsh and near the outflows of the two largest tributary inlets: the Cockermouth and Fowler Rivers. A shallow and relatively sandy strip runs from the Fowler River south to Mayhew Island on the southwest side of the lake. While shallower than the other deep basins, a third basin of approximately 60 feet is located south of Mayhew Island. The Newfound bathymetry, coupled with coves and bays, partitions the lake in such a way that local watershed influences (i.e. differences in the amount of development or forest-cover) may influence water quality differently among sampling locations.

UNDERSTANDING LAKE AGING (EUTROPHICATION)

A common concern among New Hampshire lakefront property owners is a perceived increase in the density and abundance of aquatic plants in the shallows, increases in the amount of microscopic plant “algae” growth (detected as greener water), and water transparency decreases; what is known as **eutrophication**. Eutrophication is a natural process by which all lakes age and progress from clear pristine lakes to green, nutrient enriched lakes on a geological time frame of thousands of years. Much like the fertilizers applied to our lawns, nutrients that enter our lakes stimulate plant growth and culminate in greener (and in turn less clear) waters. Some lakes age at a faster rate than others due to naturally occurring attributes: watershed area relative to lake area, slope of the land surrounding the lake, soil type, mean lake depth, etc. Since our New Hampshire lakes were created during the last ice-age, which ended about 12,000 years ago, we should have a natural continuum of lakes ranging from extremely pristine to very enriched.

Classification criteria are often used to categorize lakes into what are known as **trophic states**, in other words, levels of lake plant and algae productivity or “greenness” (Refer to Table 4 below for a summary eutrophication parameters used to assess water quality through the CFB).

Table 4: Eutrophication Parameters and Trophic Categorization

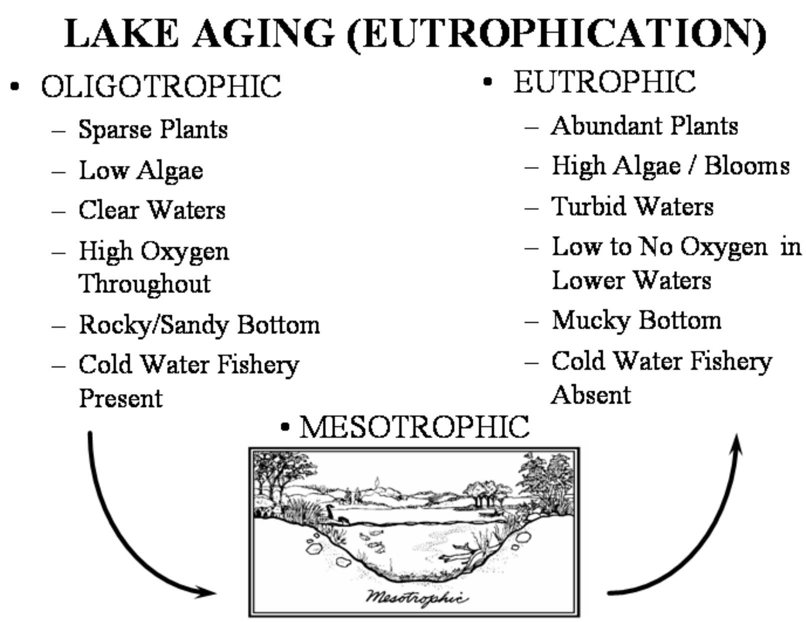
Parameter	Oligotrophic “pristine”	Mesotrophic “transitional”	Eutrophic “enriched”
Chlorophyll a (*ug*/l) *	<3.0	3.0-7.0	>7.0
Water Transparency (meters) *	>4.0	2.5-4.0	<2.5
Total Phosphorus (*ug*/l) *	<15.0	15.0-25.0	>25.0
Dissolved Oxygen (saturation) #	high to moderate	moderate to low	low to zero
Macroscopic Plant (Weed) Abundance	low	moderate	high

*** Denotes classification criteria employed by Forsberg and Ryding (1980).**
 # Denotes dissolved oxygen concentrations near the lake bottom.

Oligotrophic lakes are considered “unproductive” pristine systems and are characterized by high water clarities, low nutrient concentrations, low algae concentrations, minimal levels of aquatic plant “weed” growth, and high dissolved oxygen concentrations near the lake bottom. **Eutrophic** lakes are considered “highly productive” enriched systems characterized by low water transparencies, high nutrient concentrations, high algae concentrations, large stands of aquatic plants and very low dissolved oxygen concentrations near the lake bottom. **Mesotrophic** lakes have qualities between those of oligotrophic and eutrophic lakes and are characterized by moderate water transparencies, moderate nutrient concentrations, moderate algae growth, moderate aquatic plant “weed” growth and decreasing dissolved oxygen concentrations near the lake bottom (Figure 2).

Is a pristine, oligotrophic, lake “better than” an enriched, eutrophic, lake? Not necessarily! As indicated above, lakes will naturally exhibit varying degrees of productivity. Some lakes will naturally be more susceptible to eutrophication than others due to their

Figure 2



natural attributes and in turn have aged more rapidly. This is not necessarily a bad thing as our best bass fishing lakes tend to be more mesotrophic to eutrophic than oligotrophic; an ultra-oligotrophic lake (extremely pristine) will not support a very healthy cold water fishery. However, human related activities can augment the aging process (what is known as cultural eutrophication) and result in a transition from a pristine system to an enriched system in tens of years rather than the natural transitional period that should take thousands of years. Cultural eutrophication is particularly a concern for northern New England lakes where large tracts of once forested and agricultural lands are being developed.

The DES has formalized aquatic life use nutrient criteria to determine whether lakes are impaired based upon the ability to support aquatic life. The DES criteria for an oligotrophic lake are < 8.0 micrograms per liter (*u*g/l) for total phosphorus and < 3.3 *u*g/l for chlorophyll *a*. Data collected through the Newfound Lake Watershed Assessment (2007 & 2008) and collected by the Newfound Lake volunteer monitors and CFB (1986-2013), indicate Newfound Lake is best classified as an Oligotrophic Lake based upon the draft DES aquatic life use nutrient criteria.

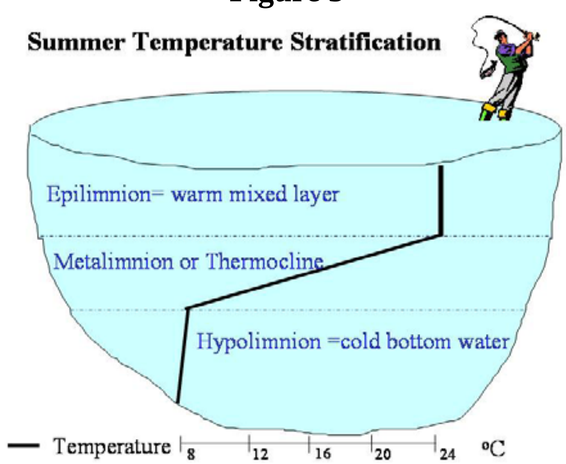
DISCUSSION OF LAKE AND STREAM MONITORING MEASUREMENTS

The section below details the important concepts involved for the various testing procedures used in the **New Hampshire Lakes Lay Monitoring Program**. Certain tests or sampling performed at the time of the optional **Center for Freshwater Biology** field trip are indicated by an asterisk (*).

Thermal Stratification in the Deep Water Sites

Lakes in New Hampshire display distinct patterns of temperature stratification, that develop as the summer months progress, where a layer of warmer water (the **epilimnion**) overlies a deeper layer of cold water (**hypolimnion**). The layer that separates the two regions characterized by a sharp drop in temperature with depth is called the **thermocline** or **metalimnion** (Figure 3). Some shallow lakes may be continually mixed by wind action and will never stratify. Other lakes may only contain a developed epilimnion and metalimnion.

Figure 3



Water Transparency

Secchi Disk depth is a measure of the water transparency. The deeper the depth of Secchi Disk disappearance, the more transparent the lake water; light penetrates deeper if there is little dissolved and/or particulate matter (which includes both living and non-living particles) to absorb and scatter it.

In the shallow areas of many lakes, the Secchi Disk will hit bottom before it is able to disappear from view (what is referred to as a "Bottom Out" condition). Thus, Secchi Disk measurements are generally taken over the deepest sites of a lake. Transparency values greater than 4 meters are typical of clear, unproductive lakes while transparency values less than 2.5 meters are generally an indication of highly productive lakes. Water transparency values between 2.5 meters and 4 meters are generally considered indicative of moderately productive lakes.

Chlorophyll *a*

The chlorophyll *a* concentration is a measurement of the standing crop of phytoplankton and is often used to classify lakes into categories of productivity called trophic states. **Eutrophic** lakes are highly productive with large concentrations of algae and aquatic plants due to nutrient enrichment. Characteristics include accumulated organic matter in the lake basin and lower dissolved oxygen in the bottom waters. Summer chlorophyll *a* concentrations average above 7 mg m^3 (7 milligrams per cubic meter; 7 parts per billion). **Oligotrophic** lakes have low productivity and low nutrient levels and average summer chlorophyll *a* concentrations that are generally less than 3 mg m^3. These lakes generally have cleaner bottoms and high dissolved oxygen levels throughout. **Mesotrophic** lakes are intermediate in productivity with concentrations of chlorophyll *a* generally between 3 mg m^3 and 7 mg m^3. Testing is sometimes done to check for **metalimnetic algal populations**, algae that layer out at the thermocline and generally go undetected if only epilimnetic (point or integrated) sampling is undertaken. Chlorophyll concentrations of a water sample collected in the thermocline is compared to the integrated epilimnetic sample. Greater chlorophyll levels of the point sample, in conjunction with microscopic examination of the samples (see Phytoplankton section below), confirm the presence of such a population of algae. These populations should be monitored as they may be an early indication of increased nutrient loading into the lake.

Turbidity

Turbidity is a measure of suspended material in the water column such as sediments and planktonic organisms. The greater the turbidity of a given water body the lower the Secchi Disk transparency and the greater the amount of particulate matter present. Turbidity is measured as nephelometric turbidity units (NTU), a standardized method among researchers. Turbidity levels are generally low in New Hampshire reflecting the pristine condition of the majority of our lakes and ponds. Increasing turbidity values can be an indication of increasing lake productivity or can reflect improper land use practices within the watershed, which destabilize the surrounding landscape and allow sediment runoff into the lake.

While Secchi Disk measurements will integrate the clarity of the water column from the surface waters down to the depth of disappearance, turbidity measurements are collected at discrete depths from the surface down to the lake bottom. Such discrete sampling can identify layering algal populations (previously discussed) that are undetectable when measuring Secchi Disk transparency alone.

Dissolved Color

The dissolved color of lakes is generally due to dissolved organic matter from **humic substances**, which are naturally-occurring polyphenolic compounds leached from decayed vegetation. Highly colored or "stained" lakes have a "tea" color. Such substances generally do not threaten water quality except as they diminish sunlight penetration into deep waters.

Increases in dissolved watercolor can be an indication of increased development within the watershed as many land clearing activities (construction, deforestation, and the resulting increased run-off) add additional organic material to lakes. Natural fluctuations of dissolved color occur when storm events increase drainage from wetlands areas within the watershed. As suspended sediment is a difficult and expensive test to undertake, both dissolved color and chlorophyll information are important when interpreting the Secchi Disk transparency

Dissolved color is measured on a comparative scale that uses standard chloroplatinate dyes and is designated as a color unit or ptu. Lakes with color below 10 ptu are very clear, 10 to 20 ptu are slightly colored, 20 to 40 ptu are lightly tea colored, 40 to 80 ptu are tea colored and greater than 80 ptu indicates highly colored waters. Generally the majority of New Hampshire lakes have color between 20 to 30 ptu.

Total Phosphorus (TP)

Of the two "nutrients" most important to the growth of aquatic plants, nitrogen and phosphorus, it is generally observed that phosphorus is the more limiting to plant growth, and therefore the more important to monitor and control. Phosphorus is generally present in lower concentrations, and its sources arise primarily through human related activity in a watershed. Nitrogen can be fixed from the atmosphere by many bloom-forming blue-green bacteria, and thus it is difficult to control. The total phosphorus includes all dissolved phosphorus as well as phosphorus contained in or adhered to suspended particulates such as sediment and plankton. As little as 10 parts per billion of phosphorus in a lake can cause an algal bloom.

Generally, in the more pristine lakes, phosphorus values are higher after spring melt when the lake receives the majority of runoff from its surrounding watershed. The nutrient is used by the algae and plants, which in turn die and sink to the lake bottom causing surface water phosphorus concentrations to decrease as the summer progresses. Lakes with nutrient loading from human activities and sources (agriculture, logging, sediment erosion, septic systems, etc.) will show greater concentrations of nutrients as the summer progresses or after major storm events.

Soluble Reactive Phosphorus (SRP) *

Soluble reactive phosphorus is a fraction of the (total) phosphorus that consists largely of orthophosphate, the form of phosphorus that is directly taken up by algae and that stimulates growth. Soluble reactive phosphorus is obtained by filtering a water sample through a fine mesh filter, generally a 0.45 micron membrane filter, which effectively removes the particulate matter from the sample. Thus, soluble reactive phosphorus concentrations are less than, or equal to, the measured total phosphorus concentrations for a water sample.

Soluble reactive phosphorus typically occurs in trace concentrations while applications of fertilizers as well as septic system effluent can be associated with elevated concentrations. Knowledge of both the total phosphorus and the soluble reactive phosphorus is important to understanding the sources of phosphorus into a lake and to understanding the lake's response to the phosphorus loading. For instance, a lake experiencing soluble reactive phosphorus runoff from a fertilized field may exhibit immediate water quality decline (i.e. increased algal growth) while lakes experiencing elevated total phosphorus concentrations associated with sediment washout may not exhibit clear symptoms of increased nutrient loading for years.

Streamflow *

Streamflow, when collected in conjunction with stream cross-section information, is a measure of the volume of water traversing a given stream stretch over a period of time and is often expressed as cubic meters per second. Knowledge of the streamflow is important when determining the amount of nutrients and other pollutants that enter a lake. Knowledge of the streamflow in conjunction with nutrient concentrations, for instance, will provide the information necessary to calculate phosphorus loading values and will in turn be useful in discerning the more impacted areas within a watershed.

pH *

The pH is a way of expressing the acidic level of lake water and is generally measured with an electrical probe sensitive to hydrogen ion activity. The pH scale has a range of 1 (very acidic) to 14 (very "basic" or alkaline) and is logarithmic (i.e.: changes in 1 pH unit reflect a ten times difference in hydrogen ion concentration). Most aquatic organisms tolerate a limited range of pH and most fish species require a pH of 5.5 or higher for successful growth and reproduction.

Alkalinity

Alkalinity is a measure of the buffering capacity of the lake water. The higher the alkalinity value, the more acid that can be neutralized. Typically lakes in New Hampshire have low alkalinities due to the absence of carbonates and other natural buffering minerals in the bedrock and soils of lake watersheds.

Decreasing alkalinity over a period of a few years can have serious effects on the lake ecosystem. In a study on an experimental acidified lake in Canada by Schindler, gradual lowering of the pH from 6.8 to 5.0 in an 8-year period resulted in the disappearance of some aquatic species, an increase in nuisance species of algae and a decline in the condition and reproduction rate of fish. During the first year of Schindler's study the pH remained unchanged while the alkalinity declined to 20 percent of the pre-treatment value. The decline in alkalinity was sufficient to trigger the disappearance of zooplankton species, which in turn caused a decline in the "condition" of fish species that fed on the zooplankton.

The analysis of alkalinity employed by the **CFB** includes use of a dilute titrant allowing an order of magnitude greater sensitivity and precision than the standard method. Two endpoints are recorded during each analysis. The first endpoint (gray color of dye; pH endpoint of 5.1) approximates low level alkalinity values, while the second endpoint (pink dye color; pH endpoint of 4.6) approximates the alkalinity values recorded historically, such as NH Fish and Game data, with the methyl-orange endpoint method.

The average alkalinity of lakes throughout New Hampshire is low, approximately 6.5 mg per liter (calcium carbonate alkalinity). When alkalinity falls below 2 mg per liter the pH of waters can greatly fluctuate. Alkalinity levels are most critical in the spring when acid loadings from snowmelt and run-off are high, and many aquatic species are in their early, and most susceptible, stages of their life cycle.

Specific Conductivity *

The specific conductance of a water sample indicates concentrations of dissolved salts. Leaking septic systems and deicing salt runoff from highways can cause high conductivity values. Fertilizers and other pollutants can also increase the conductivity of the water. Conductivity is measured in **micromhos** (the opposite of the measurement of resistance **ohms**) per centimeter, more commonly referred to as micro-Siemans (*u*S). Specific conductivity implies the measurements are standardized to the equivalent room temperature reading as conductivity will increase with increasing temperature.

Sodium and Chloride *

Low levels of sodium and chloride are found naturally in some freshwater and groundwater systems while high sodium and chloride concentrations are characteristic of the open ocean and are elevated in estuarine systems as well. Elevated sodium and chloride concentrations in freshwater or groundwater systems, that exceed the natural baseline concentrations, are commonly associated with the application of road salt. Sodium and particularly chloride are highly mobile and, relatively speaking, move into the surface and groundwater relatively unimpeded. Sodium and chloride concentrations can become elevated during periods of heavy snow pack melt when the salts are flushed into surface waters and have also been observed in elevated concentrations during the summer months when low flow conditions concentrate the sodium and chloride.

Road salt runoff is known to adversely impact roadside vegetation as is oftentimes evidenced by bleached (discolored) leaves and needles and in more extreme instances dead trees and shrubs. The United States Environmental Protection Agency (EPA) has set the standard for protection of aquatic life, both plants and animals, at 230 milligrams per liter (mg/l). The EPA has also established a secondary maximum contaminant level of 250 mg/l for both sodium and chloride, predominantly for taste, while the sodium advisory limit for persons with hypertention is 20 mg/l

Dissolved Oxygen and Free Carbon Dioxide *

Oxygen is an essential component for the survival of aquatic life. Submergent plants and algae take in carbon dioxide and create oxygen through **photosynthesis** by day. **Respiration** by both animals and plants uses up oxygen continually and creates **carbon dioxide**. Dissolved oxygen profiles determine the extent of declining oxygen concentrations in the lower waters. High carbon dioxide values are indicative of low oxygen conditions and accumulating organic matter. For both gases, as the temperature of the water decreases, more gas can be dissolved in the water.

The typical pattern of clear, unproductive lakes is a slight decline in hypolimnetic oxygen as the summer progresses. Oxygen in the lower waters is important for maintaining a fit, reproducing, cold water fishery. Trout and salmon generally require oxygen concentrations above 5 mg per liter (parts per million) in the cool deep waters. On the other hand, carp and catfish can survive very low oxygen conditions. Oxygen above the lake bottom is important in limiting the release of nutrients from the sediments and minimizing the collection of undecomposed organic matter.

Bacteria, fungi and other **decomposers** in the bottom waters break down organic matter originating from the watershed or generated by the lake. This process uses up oxygen and produces carbon dioxide. In lakes where organic matter accumulation is high, oxygen depletion can occur. In highly stratified eutrophic lakes the entire hypolimnion can remain unoxygenated or **anaerobic** until fall mixing occurs.

The oxygen peaks occurring at surface and mid-lake depths during the day are quite common in many lakes. These characteristic **heterograde oxygen curves** are the result of the large amounts of oxygen, the by-product of photosynthesis, collecting in regions of high algal concentrations. If the peak occurs in the thermocline of the lake, metalimnetic algal populations (discussed above) may be present.

Indicator Bacteria *

Certain disease causing organisms such as pathogenic bacteria, viruses and parasites, can be spread through contact with polluted waters. Faulty septic systems, sewer leaks, combined sewer overflows and the illegal dumping of wastes from boats can contribute fecal material containing these pathogens. Typical water testing for pathogens involves the use of detecting coliform bacteria. These bacteria are not usually considered harmful themselves but they are relatively easy to detect and can be screened for quickly. Thus, they make good surrogates for the more difficult to detect pathogens.

Total coliform includes all coliform bacteria that arise from the gut of animals or from vegetative materials. **Fecal coliform** are those specific organisms that inhabit the gut of warm blooded animals. Another indicator organism **Fecal streptococcus** (sometimes referred to as **enterococcus**) also can be monitored. The ratio of fecal coliform to fecal strep may be useful in suggesting the type of animal source responsible for the contamination. In 1991, the State of

New Hampshire changed the indicator organism of preference to *E. coli*, which is a specific type of fecal coliform bacteria thought to be a better indicator of human contamination. The new state standard requires Class A “bathing waters” to be under 88 organisms (referred to as colony forming units; cfu) per 100 milliliters of lake water.

Ducks and geese are often a common cause of high coliform concentrations at specific lake sites. While waterfowl are important components to the natural and aesthetic qualities of lakes that we all enjoy, it is poor management practice to encourage these birds by feeding them. The lake and surrounding area provides enough healthy and natural food for the birds and feeding them stale bread or crackers does nothing more than import additional nutrients into the lake and allows for increased plant growth. As birds also are a host to the parasite that causes "swimmers itch", waterfowl roosting areas offer a greater chance for infestation to occur. Thus, while leaving offerings for our feathered friends is enticing, the results can prove to be detrimental to the lake system and to human health.

NEWFOUND LAKE WATER QUALITY MONITORING: 2012 & 2013

The WMP project is part of a pro-active effort dedicated to assisting local decision makers in their long-term planning efforts. The in-lake and tributary monitoring components of this project provide the watershed communities with quantitative baseline data that have identified potential problems and areas of concern that can be mitigated through a combination of education/outreach efforts with a long-term land use planning initiative directed at controlling pollutant runoff into Newfound Lake. The primary pollutant of concern is phosphorus (the lake stressor variable) in the context of how it will impact lake productivity as measured by chlorophyll concentration (lake reaction variable), while supplemental turbidity and total suspended solids data provide additional insight into the degree of sediment runoff into Newfound Lake. Specific conductivity data were also collected and serve as a surrogate for the amount of road salt runoff (i.e. sodium and chloride) into the tributary inlets. All data collected through this project will assist in the implementation of the Watershed Management Plan.

The water quality monitoring effort is designed to complete two independent, but interrelated objectives that provide a better understanding of the impacts of development, population growth, and land use change on the Newfound Lake watershed. Water quality monitoring results are discussed by task in the following section:

- Conduct In-lake water quality sampling to assist in trend detection and water quality assessment.
- Expand stream sampling into the Newfound Lake watershed headwaters to better characterize the condition of the feeder streams and to screen for potential problem areas within the watershed.

Extensive details of the project's sampling design and methods can be found in the Quality Assurance Project Plan: Newfound Lake Watershed Assessment (Schloss, J.A and R. Craycraft, 2007) and the Newfound Watershed Assistance Quality Assurance Project Plan Amendment (Craycraft, R and J. Schloss, March 2010).

In-Lake (Reference) Sampling Sites

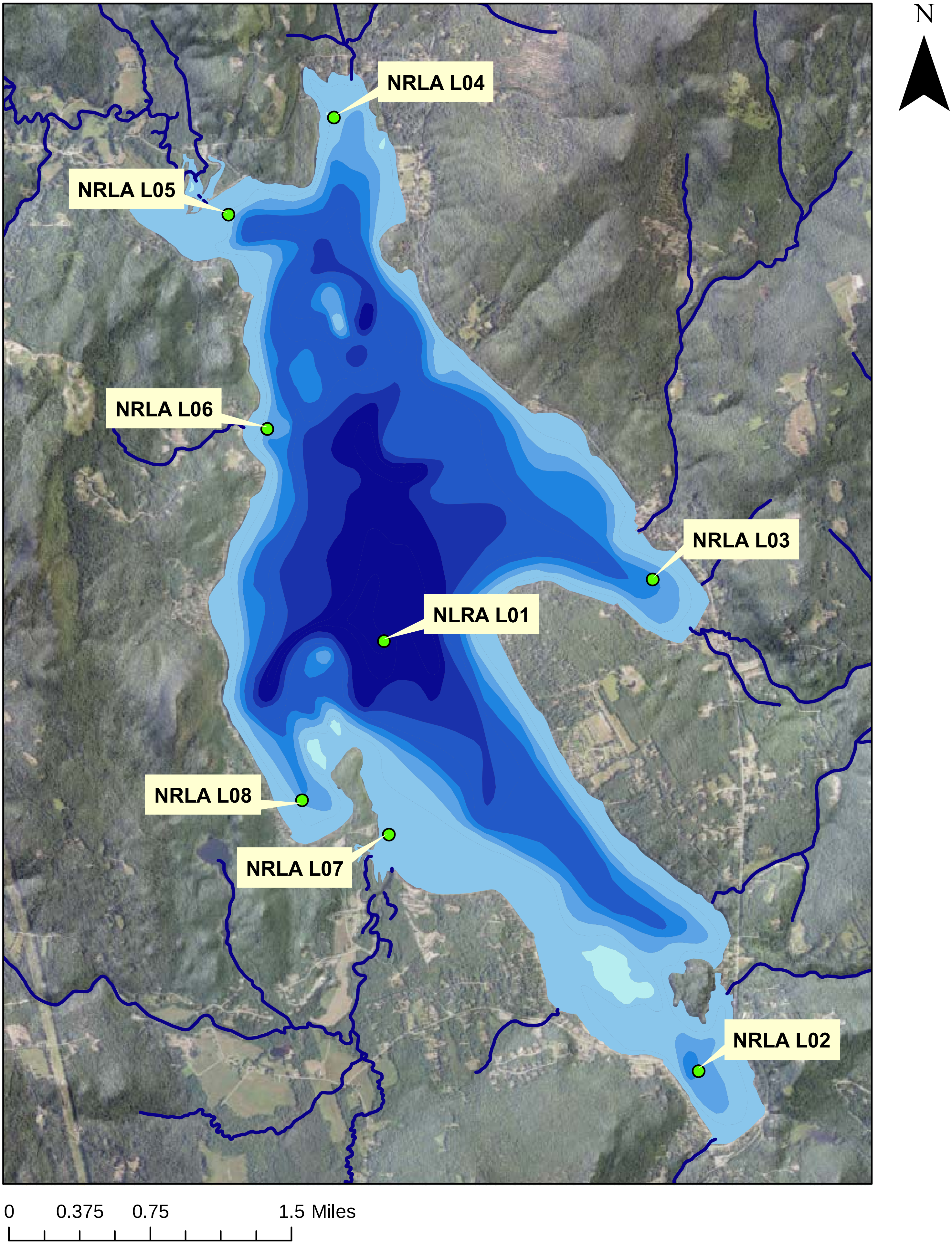
<u>Choice Of Deep In-Lake Sampling Stations</u>

The seven in-lake sampling locations included in this study have been included in past sampling efforts for Newfound Lake undertaken by the CFB and the NH LLMP (LLMP). Historical data have been documented in the annual volunteer monitoring reports provided since 1986 (LLMP, 1986-2006) and in the Newfound Lake Water Quality Assessments (Craycraft and Schloss, 2009, 2012). The seven sampling sites are positioned at deeper points around Newfound Lake and reflect localized water quality variations found among the more centrally located sampling stations in both the open waters and more confined basins (Table 5 and Figure 4). The monitoring of the seven in-lake sampling locations also provides insight into the differences and similarities among the sites that could be important when considering future remedial actions for the lake as well as the susceptibility of the seven Newfound Lake sampling stations to water quality degradation. Furthermore, during the period of thermal stratification, sampling locations such as L01 Deep and L02 Mayhew can effectively function as two "independent lakes" where the chemical, physical and biological characteristics vary between sampling locations.

Table 5. Newfound Lake Study Sites

Lake Sites	Site ID	Location: Latitude Longitude	Sampling Site Description / Rationale
Deep	NLRA L01	43°39'24.7" 71°46'24.5"	Near the deepest point in Newfound Lake, reflects the overall condition of Newfound Lake
Mayhew	NLRA L02	43°37'26.0" 71°44'24.4"	Southern Lake basin with heavy first-tier lakeshore development that might impact water quality.
Pasquaney Bay	NLRA L03	43°39'41.8" 71°44'42.1"	Sampling station located in Pasquaney Bay where watershed runoff might impact local water quality.
Loon Island	NLRA L04	43°41'49.3" 71°46'43.8"	Sampling station located in the northeasterly bay. Water quality will reflect sub-watershed inputs.
Cockermouth	NLRA L05	43°41'22.5" 71°47'24.0"	Sampling station located in the northwesterly bay that is "fed" by the Cockermouth River. Water quality will reflect the Cockermouth River drainage and other local watershed inputs.
Beachwood	NLRA L06	43°40'23.3" 71°47'09.1"	Sampling station located along the westerly shoreline.
Follansbee Cove	NLRA L08	43°38'40.7" 71°46'55.6"	Sampling location located in a westerly basin located near Wellington state park. Water quality reflects the sub-watershed inputs.

Figure 4. Newfound Lake Sites



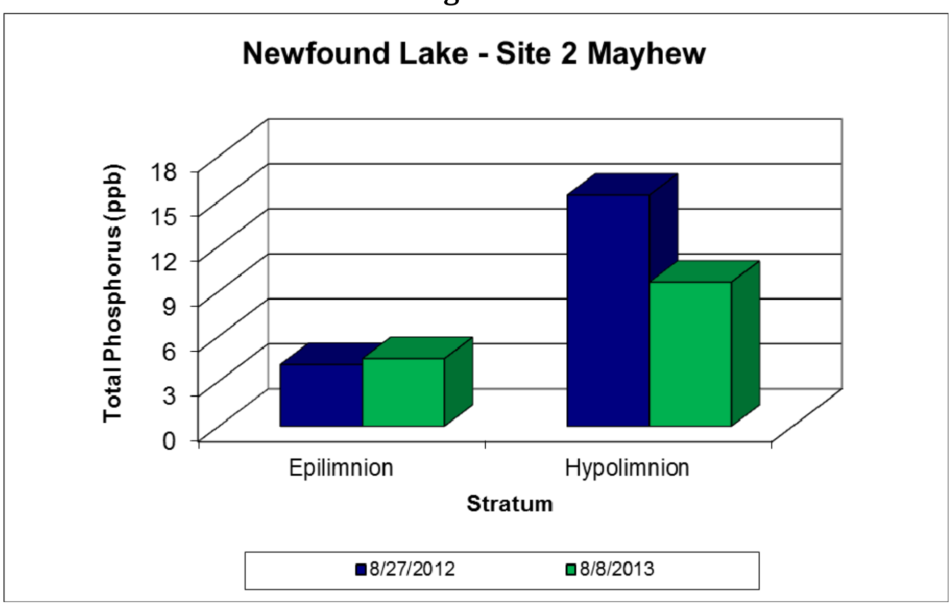
In-Lake Sampling Results

The Newfound Lake water quality data were variable among sampling locations as well as among sampling dates. The following section summarizes the 2012 and 2013 water quality data that were collected by the UNH CFB field team, while 2011 data are also highlighted when appropriate. The summary also reviews supplemental volunteer monitor Secchi Disk transparency data, which provide a better assessment of the seasonality of water transparency measurements and the impact of an extreme weather event. This section includes a brief discussion of the water quality monitoring results for each analytical water quality parameter followed by a summary of the water quality results.

Total Phosphorus

Total phosphorus concentrations were low to moderate at all sampling sites. The composite epilimnetic total phosphorus concentrations ranged from 3.3 to 6.5 parts per billion (ppb) during the summers of 2012 and 2013 (Appendix B). Deep water (hypolimnetic) phosphorus samples were generally low and ranged from 2.9 to 15.4 ppb during the summers of 2012 and 2013 (Appendix B). The hypolimnetic total phosphorus concentrations documented at Site L02 Mayhew were significantly higher than the corresponding surface water (composite) sample on August 27, 2012 and August 8, 2013 (Figure 5). All of the epilimnetic total phosphorus concentrations remained below 8 ppb that is considered the DES aquatic life threshold for an oligotrophic lake (Appendix B).

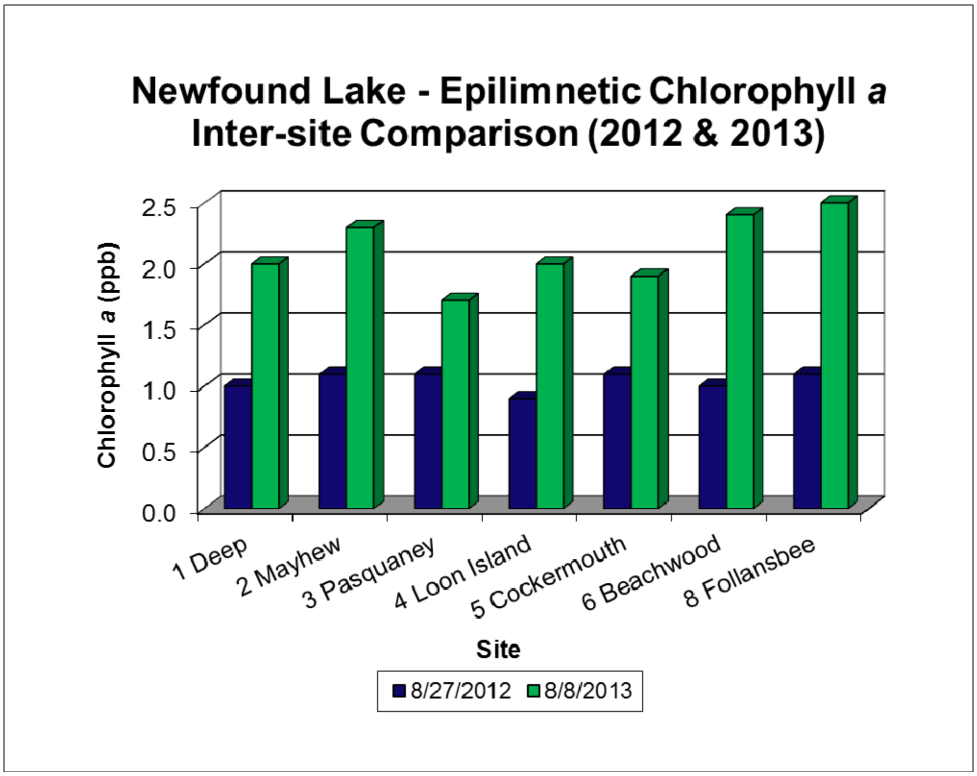
Figure 5.



Chlorophyll *a*

Chlorophyll *a* concentrations were variable between the 2012 and 2013 sampling dates and ranged from 0.9 to 2.5 parts per billion (ppb). The chlorophyll *a* concentrations remained below 3.3 ppb on both the August 27, 2012 and August 8, 2013 sampling dates (Figure 6). The chlorophyll *a* concentrations of 3.3 ppb is considered the DES aquatic life threshold for an oligotrophic lake. The August 27, 2012 chlorophyll *a* concentrations were consistently lower than the August 8, 2013 chlorophyll *a* concentrations among the seven sampling locations (Figure 6).

Figure 6.



Secchi Disk Transparency

The paired Secchi Disk transparency readings measured by the UNH CFB ranged from 21.7 feet (6.6 meters) to 31.2 feet (9.5 meters) and varied between sampling dates (Figure 7). The shallowest water transparency measurements were documented at Site L02 Mayhew on both sampling dates (Figure 7). *Note: Site 4 Loon Island was not included in the Secchi Disk transparency inter-comparison due to the shallowness of the site and the Secchi Disk resting on the lake bottom before disappearing from view.*

A review of 2011 Secchi Disk transparency data reveals a large contrast in Secchi Disk transparency measurements recorded before and after the August 28 tropical storm event, Irene (Figure 8). Secchi Disk transparency data collected on August 26, prior to Tropical Storm Irene, ranged from 7.4 to 8.3 meters while the measurements collected on August 31 ranged from 1.6 to 2.3 meters. Continued Secchi Disk transparency measurements collected in September and October documented a gradual increase in Secchi Disk transparency over time.

Figure 7.

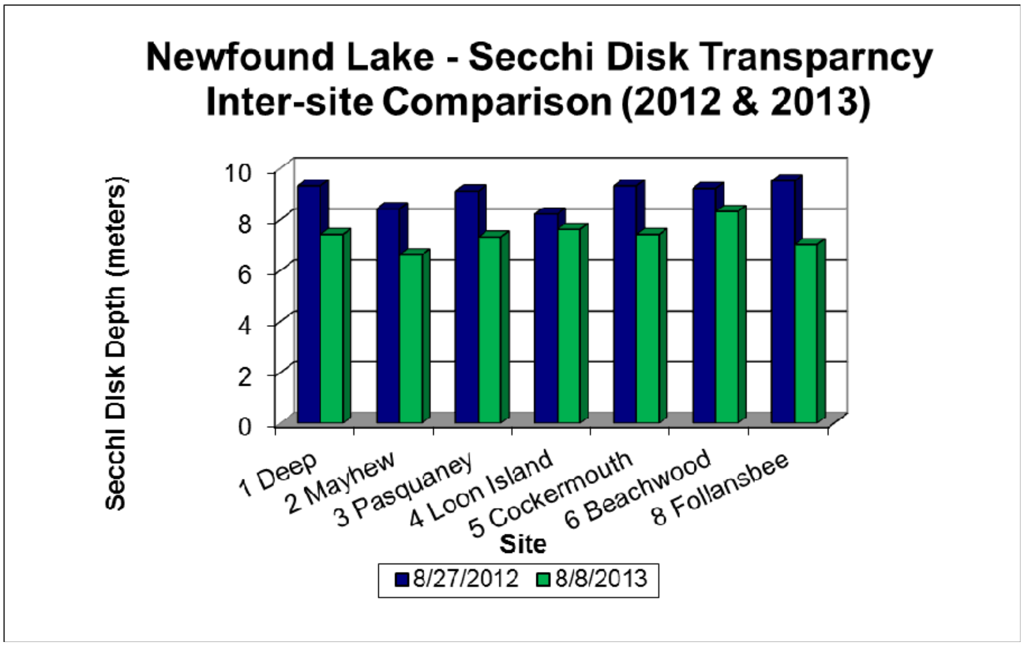
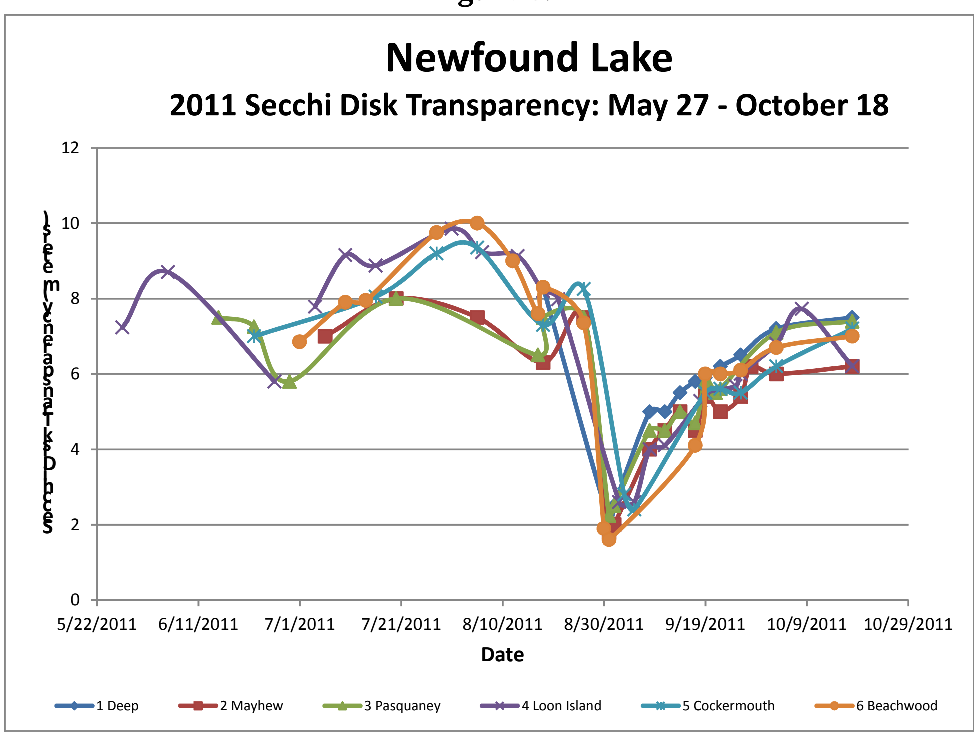


Figure 8.



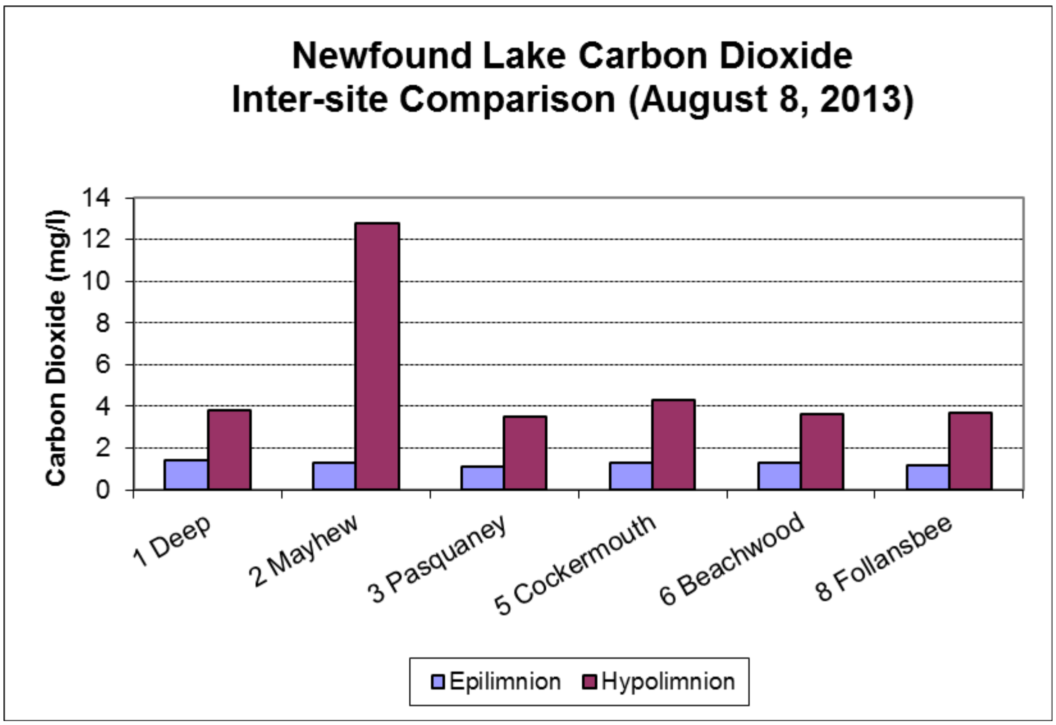
Dissolved Oxygen

Dissolved oxygen concentrations generally remained above 5 milligrams per liter (mg/l), which is commonly considered the minimum oxygen concentration required for successful growth and reproduction of a coldwater fishery (Appendix F). The single exception was documented at Site L02 Mayhew where the bottom water (hypolimnetic) oxygen concentrations were near or below 5 mg/l by August 8, 2013 (Appendix C).

Carbon Dioxide

Carbon dioxide concentrations were consistently low in the surface waters and increased with depth as one would expect (Figure 9). Higher carbon dioxide concentrations near the lake bottom are commonly associated with the decomposition of organic matter by microbes and the corresponding respiration (production of the carbon dioxide by-product). The highest carbon dioxide concentration was documented near the lake bottom of Site 2 Mayhew on the August 8, 2013 sampling date (Figure 9).

Figure 9.



Total Alkalinity

Total alkalinity measurements ranged from 4.0 to 4.5 milligrams per liter (mg/l) among the seven sampling locations on August 27, 2012 and August 8, 2013. While low, the Newfound Lake alkalinity remained capable of neutralizing acid inputs and avoiding large pH (acidity) swings that can be toxic to aquatic organisms.

pH

The August 8, 2013 pH measurements varied from 7.0 to 7.1 in the surface waters (epilimnion) and generally exhibited a decrease in pH with depth (Appendix F). The most acidic water was documented near the lake bottom, in the hypolimnion, where a pH minimum of 5.9 units was measured at Site 2 Mayhew (Appendix F). Carbonic acid, a natural acid that forms when carbon dioxide is dissolved in lake water, is common among New Hampshire lakes.

Specific Conductivity

Specific conductivity measurements were low and ranged from 33.0 to 37.0 micro-Siemans per centimeter (*u*S/cm) among the seven sampling stations on August 8, 2013 (Appendix F). The highest specific conductivity measurement of 37.0 *u*S/cm was documented near the lake bottom of Site L02 Mayhew on August 8, 2013. The elevated specific conductivity corresponded to low dissolved oxygen concentrations near the lake bottom (Appendix F).

Water Quality Summary

The water quality remained high at all Newfound Lake sampling Stations in 2012 and 2013 and the data were characteristic of a high quality water body. A comparison among the seven Newfound Lake sampling stations indicates that the southerly sampling station, Site L02 Mayhew, is characterized by lower water transparency, higher total phosphorus concentrations as well as declining late season dissolved oxygen concentrations in the deep, hypolimnetic and metalimnetic, waters. The data indicate that the southern sampling station is more nutrient enriched than the sampling stations to the north and may reflect the influence of a higher level of watershed development in the southern segment of Newfound Lake. While the L02 Mayhew sampling station was clearly the most nutrient enriched among the deep sampling locations, the water quality conditions were characteristic of an oligotrophic lake that is approaching more nutrient enriched, mesotrophic, status. Continued water quality monitoring of the Newfound Lake deep sites is recommended to track both short-term (e.g. Tropical Storm Irene) and longer-term trends. Future sampling should include:

- Continued weekly to bi-weekly epilimnetic chlorophyll *a* and dissolved color sampling at the seven historical sampling stations. Secchi Disk transparency measurements should also be collected during each site visit.
- Implementation of bi-weekly epilimnetic total phosphorus sampling at each of the seven historical sampling stations.
- Implementation of hypolimnetic total phosphorus sampling at Site L02 Mayhew during the months of July, August and September.
- Continued collection of late season (mid-August/September) dissolved oxygen and metalimnetic chlorophyll *a* samples at each of the historical sampling sites.

Headwater Stream Study

Choice of Headwater Stream Sampling Locations

Thirty-five stream sampling sites were selected for the headwater stream sampling component of this study (Table 6 and Appendix G). In-stream water quality will vary depending upon natural factors (i.e. topography, vegetative cover, etc) as well as anthropogenic factors. The tributary monitoring sites were selected to include historical sampling locations that are part of a longer-term database, as well as new and expanded sampling of headwater stream reaches to further characterize the water quality in small-scale Newfound Lake sub-watersheds. The headwater tributary sampling focused on the collection of total phosphorus, to track variations among watersheds, while accessory measurements were also collected to better characterize the condition of the respective sampling locations. The accessory measurements included temperature, dissolved oxygen, specific conductivity, turbidity and pH measurements that provide additional insight into the conditions of the Newfound Lake watershed.

The following summary reviews the water quality data that were collected by both the UNH CFB and the volunteer monitors during the 2012 and 2013 sampling seasons, which spanned January 1, 2012 to October 20, 2013. Total phosphorus, temperature and specific conductivity data were collected by both the volunteers and the CFB field team, while the remaining accessory parameters were only collected by the UNH CFB field team. Thus, the accessory parameters were not necessarily measured on all sampling dates.

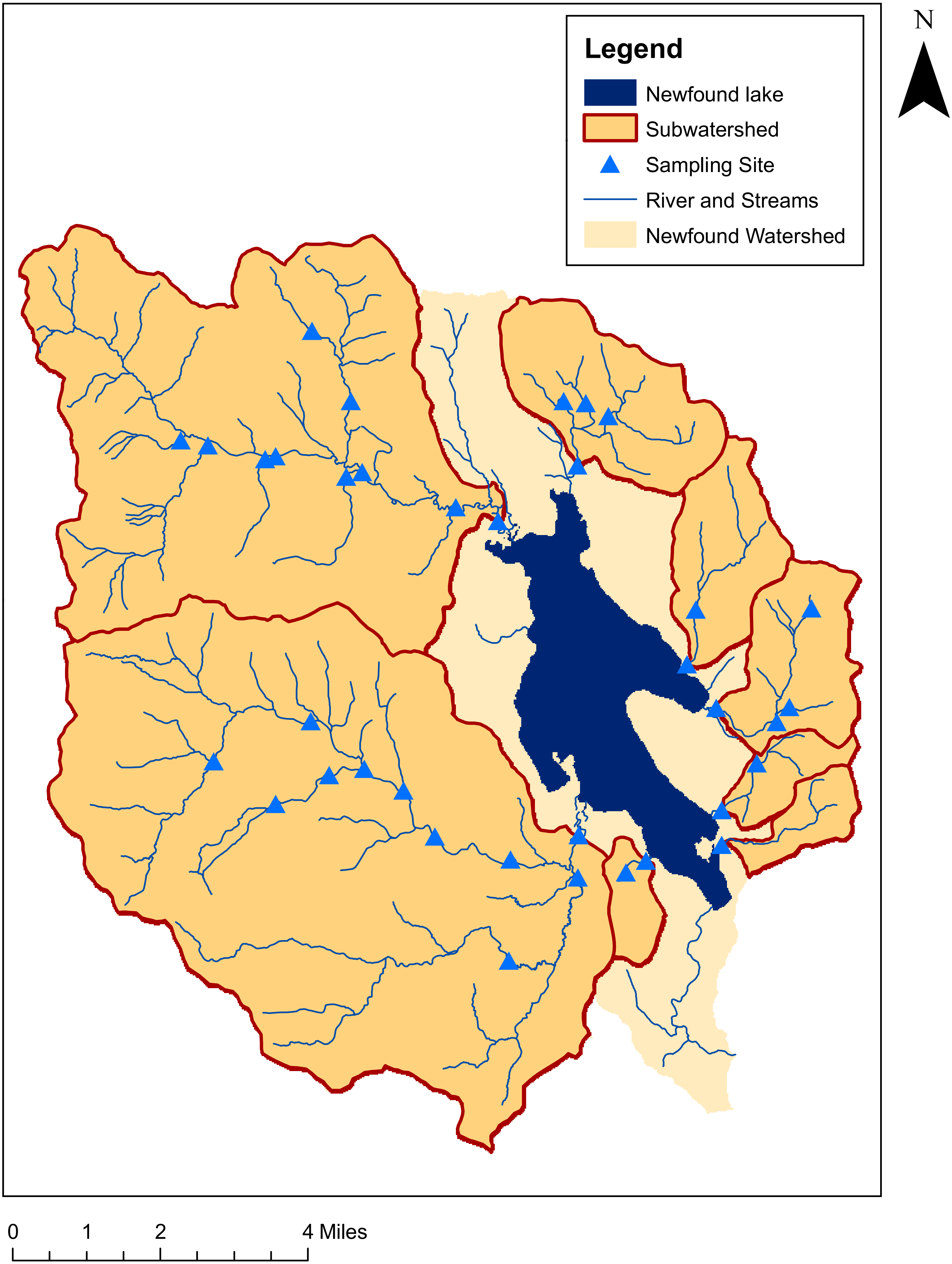
Table 6. Newfound Lake Headwater Streams.

Subwatershed	Tributary Name	Site ID	Location: Latitude Longitude (dd:mm:ss.s)	Sampling Location	Sampled in 2011
Black Brook	Black Brook	BB H23	43°37'40.2" 71°45'22.7"	Intersection of Black Brook and Westh Shore Road near Browns Beach Road.	Yes
Black Brook	Black Brook	BB U10	43°37'32.0" 71°45'42.1"	Intersection of Black Brook and Upper Birch Drive.	Yes
Cockermouth River	Cockermouth River	CR H11	43°41'39.9" 71°47'47.2"	Intersection of the Cockermouth River and North Shore Road.	Yes
Cockermouth River	Cockermouth River	CR H12	43°41'49.4" 71°48'28.8"	Intersection of the Cockermouth River and Braley Road.	Yes
Cockermouth River	Cockermouth River	CR H14	43°42'14.1" 71°49'59.8"	Intersection of the Cockermouth River and North Groton Road.	Yes
Cockermouth River	Hardy Brook	CR U10	43°42'10.9" 71°50'15.6"	Intersection of Sculptured Rock Road and Hardy Brook near Hayward Lane.	Yes
Cockermouth River	Cockermouth River	CR U20	43°42'25.2" 71°51'24.2"	Cockermouth River off Sculptured Rock Road and adjacent to the Sculptured Rock Geologic Site Parking area.	Yes
Cockermouth River	Unnamed Brook	CR U25	43°42'24.8" 71°51'36.0"	Intersection of Unnamed Brook and Sculptured Rock Road.	Yes
Cockermouth River	Atwell Brook	CR U30	43°42'32.7" 71°52'30.2"	Intersection of Atwell Brook and Sculptured Rock Road near Orange Road.	Yes
Cockermouth River	Unnamed Brook	CR U40	43°42'36.4" 71°52'56.9"	Intersection of unnamed brook and Sculptured Rock Road approximately 150 feet before the blacktop transitions to gravel.	Yes
Cockermouth River	Unnamed Brook	CR U70	43°43'04.4" 71°50'11.0"	Intersection of Unnamed Brook and North Grotton Road near Rogers Road.	Yes
Cockermouth River	Unnamed Brook	CR U80	43°43'54.0" 71°50'49.3"	Intersection of Unnamed Brook and North Grotton Road south of Orchard Hill Lane	Yes
Dick Brown Brook	Dick Brown Brook	DBB H03	43°39'28.4" 71°44'14.7"	Intersection of Dick Brown Brook and Route 3A near Whittemore Point Road North	Yes
Dick Brown Brook	Unnamed Brook	DBB U05	43°39'28.9" 71°43'03.0"	Intersection of Unnamed Brook and Dick Brown Road.	Yes
Dick Brown Brook	Dick Brown Brook	DBB U10	43°39'18.3" 71°43'15.5"	Intersection of Dick Brown Brook and John Smith Hill Road approximately 400 feet north of Dick Brown Road	Yes
Dick Brown Brook	Dick Brown Brook	DBB U20	43°40'38.7" 71°42'42.1"	Intersection of Dick Brown Brook and Brock Hill Road Brock Hill Road Immediately downstream of Dick Brown Pond	Yes
Fowler River	Fowler River	FR H20	43°37'58.1" 71°46'28.1"	Intersection of the Fowler River and West Shore Road	Yes
Fowler River	Bog Brook	FR H21	43°37'28.5" 71°46'29.0"	Intersection of Bog Brook and Fowler River Road	Yes
Fowler River	Fowler River	FR H22	43°37'41.0" 71°47'34.4"	Intersection of the Fowler River and Fowler River Road	Yes

Table 6 (Continued). Newfound Lake Headwater Streams

Subwatershed	Tributary Name	Site ID	Location: Latitude Longitude	Sampling Location	Sampled In 2011
Fowler River	Fowler River	FR U05	43°37’56.6” 71°48’48.5”	Intersection of the Fowler River and Cole Hill Road.	No
Fowler River	Unnamed Brook	FR U10	43°38’29.4” 71°49’19.1”	Intersection of Unnamed Brook and Fowler River Road about 0.3 mi South East of Robie Road.	Yes
Fowler River	Clark Brook	FR U20	43°38’44.9” 71°49’57.4”	Intersection of Clark Brook and Fowler River Road about 500 feet west of Healey Road.	Yes
Fowler River	Clark Brook	FR U25	43°39’18.6” 71°50’49.7”	Intersection of Clark Brook and Welton Falls Road.	Yes
Fowler River	Brock Brook	FR U30	43°38’40.3” 71°50’31.6”	Intersection of Brock Brook and Brook Road near Copatch Road, arched culvert.	Yes
Fowler River	Brock Brook	FR U40	43°38’19.8” 71°51’23.7”	Intersection of Brock Brook and Shem Valley Road near Knowles Hill Road East.	Yes
Fowler River	Tributary Confluence	FR U50	43°38’50.0” 71°52’23.8”	Intersection of tributary confluence and Shem Valley Road near the AMC hut.	Yes
Fowler River	Patten Brook	FR U60	43°36’29.8” 71°47’36.0”	Intersection of Patten Brook and Bog Road.	Yes
Georges Brook	Georges Brook	GB H10	43°42’19.0” 71°46’30.0”	Intersection of Georges Brook and Cooper Road near Sarah Lane.	Yes
Georges Brook	Georges Brook	GB U10	43°42’54.1” 71°46’00.0”	Intersection of Georges Brook and Georges Road about 0.3 miles west of Route 3A.	Yes
Georges Brook	Cilley Brook	GB U20	43°43’03.1” 71°46’21.8”	Intersection of Cilley Brook and Georges Road near Cilley Brook Lane.	Yes
Georges Brook	Fretts Brook	GB U30	43°43’04.5” 71°46’43.5”	Intersection of Fretts Brook and Georges Road about 0.9 miles west of Route 3A.	Yes
Hemlock Brook	Hemlock Brook	HB H01	43°37’51.4” 71°44’09.3”	Intersection of Hemlock Brook and Route 3A.	Yes
Tilton Brook	Tilton Brook	TB H02	43°38’15.8” 71°44’09.1”	Intersection of Tilton Brook and Route 3A near Whittemore Point Road South.	Yes
Whittemore Brook	Whittemore Brook	WTB H04	43°39’58.8” 71°43’35.2”	Intersection of Whittemore Brook and Route 3A near Brook Road	Yes
Whittemore Brook	Whittemore Brook	WTB U10	43°40’37.6” 71°44’34.5”	Intersection of Whittemore Brook and High Meadow Road	Yes
Wise Brook	Wise Brook	WB U10	43°42’02.9” 71°47’56.9”	Intersection of Wise Brook and Braley Road	

Figure 10. Newfound Lake Subwatersheds



Headwater Stream Sampling Results

Rainfall

Rainfall totals were reviewed from the National Climatic Data Center climatological sampling station, Alexandria 4, located within the Newfound Lake watershed (latitude: 43:38, longitude: 71:48, elevation: 1160.1 feet). Rainfall quantities can be correlated to periods of heavy runoff and concurrent periods of heavy sediment erosion, and are thus important to the interpretation of water quality data. The UNH CFB conducted tributary sampling on two dates in 2013. The June 13, 2013 sampling date followed a three day period of rainfall and included stream flows that were elevated above base flow while the September 24, 2013 sampling data was characteristic of base flow conditions associated with dry weather sampling (Table 7). Daily rainfall totals, collected at 7:00 AM each day, are reported for the two CFB sampling dates, while a further description of the streamflow characteristics are provided in the accompanying comments section to provide an assessment of the general conditions at the time of sampling.

Table 7. Alexandria 4 Climatological Sampling Station daily rainfall totals

Sampling Date *	Rainfall (Inches)	Comments
6/13/13	0.00	Rain over the past four days: 1.38 inches on June 10, 0.78 inches on June 11 and 0.70 inches on June 12. The streamflow was elevated above baseflow due to recent rainfall events.
9/24/13	0.00	0.64 inches of rainfall on September 22. This sampling date is characteristic of baseflow conditions.

Total Phosphorus

Total phosphorus concentrations were variable among sampling dates and among sampling locations. Total phosphorus concentrations were typically low in 2012 and 2013 and ranged from <2.0 to 174.4 ppb (Appendix H and I). The two highest total phosphorus concentrations, collected in Bog Brook (FR H-21) on July 12, 2012 (174.4 ppb) and August 20, 2012 (85.0 ppb), contained particulate debris (Appendix A and I).

Turbidity

Turbidity measurements were generally low and were typically below one nephlometric turbidity unit (NTU); the turbidity measurements ranged from less than 0.2 to 1.4 NTU (Appendix H). The turbidity patterns were variable among subwatersheds and do not exhibit a clear pattern of turbidity between the two sampling dates. The Fowler River subwatershed sampling locations along Brock Brook, Sites FR U30 and FR U40, were characterized by elevated turbidity levels on the June 13, 2013 sampling date, relative to other Fowler River subwatershed sampling locations. Elevated turbidity levels were previously documented at the Brock Brook sampling locations on August 30 and October 3, 2011, following intense and or sustained periods of rainfall, and suggest this stream may be more susceptible to siltation than most streams that have been sampled as part of the water quality monitoring effort (Craycraft and Schloss, 2012).

<u>Discharge</u>

Stream discharge, visually estimated by Bob Craycraft during CFB field team visits, were low on both the June 13, 2013 and September 24, 2013 sampling dates (Appendix A). The discharge volumes were characteristic of base flow conditions on September 24 while the June 13 discharge estimates were elevated and responded to 2.86 inches of rainfall over the antecedent four days. *Note: discharge values were recorded to characterize general variations in discharge between sampling dates and among sites and should not be misinterpreted as quantitative data that is intended for nutrient loading calculations.*

<u>Specific Conductivity</u>

The specific conductivity measurements ranged from 12.3 micro-Siemans per centimeter (*u*S/cm) to 155.1 *u*S/cm during the study period (Appendix H). Previous water quality sampling in the Newfound Lake watershed (Craycraft and Schloss, 2009) documented a strong correlation between the road salt constituents, sodium and chloride, and specific conductivity (Figures 11 and 12).

Figure 11

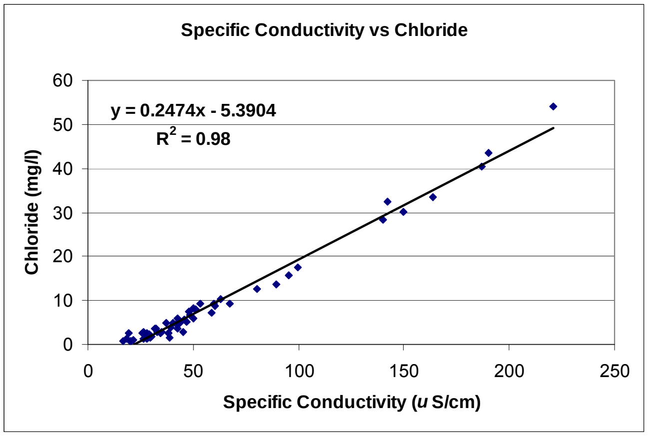
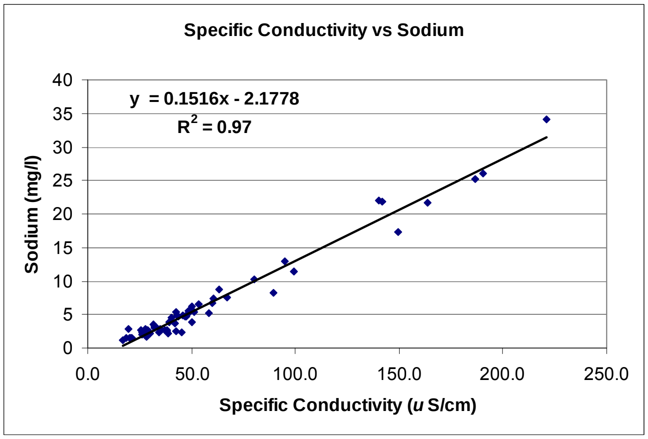


Figure 12



Temperature

The Temperature results were related to the seasons with a general pattern of the highest temperature readings during the summer months and lower readings documented earlier and later in the season (Appendix H and I). The temperature readings observed during this study ranged from 0.1^{o} to 24.2^{o} Celsius.

Dissolved Oxygen

Dissolved Oxygen concentrations ranged from 7.5 to 11.3 milligrams per liter when measured on June 13 and September 24, 2013 (Appendix H). Dissolved oxygen was also assessed as percent saturation with a range of 71.9% to 103.2% saturation (Appendix H).

pH

The pH levels ranged from 5.7 to 6.7 during the study period and were variable among sampling locations (Appendix H). The pH measurements varied between the June 13 and September 24, 2013 sampling dates but did not exhibit a consistent pattern of higher/lower readings among sampling locations (Appendix H).

Water Quality Summary

The 2012 and 2013 tributary water quality was high which is consistent with past findings that indicate high quality conditions within the Newfound Lake watershed. Tributary sampling conducted over the past two years was generally undertaken during dry periods or, at times, hours to days after the most recent rainfall event. Historical water quality monitoring has documented significantly poorer water during rainfall events (Craycraft and Schloss, 2012). Continued water quality monitoring of the Newfound Lake tributary inlets is recommended to continue to track both short-term (e.g. Tropical Storm Irene) and longer-term trends. Future sampling should include:

- Collection of tributary data during storm events to capture the impacts of increased overland water flow that have historically coincided with increased sediment and phosphorus loading.
- Collection of both turbidity and total phosphorus samples during each sampling event.
- Collection of digital photographs that provide a visual representation of the stream conditions and a visual record of potential pollutant sources (e.g. gravel road washout, recent land clearing activities, grazing livestock, etc) where future corrective efforts should be directed.
- Collection of water samples in March/April that correspond to high flow periods associated with rapid snowpack melt.

DETERMINING WATER QUALITY CHANGES AND TRENDS

Box and Whisker Plots

<u>Quick Overview</u>

A trend analysis for the L02 Mayhew and L03 Pasquaney sampling sites is included in this section using *box-and-whisker* plots that provide a visual representation of how the data are spread out and how much variation exists on an annual basis. The *box-and-whisker* plots also provide a summary of how your data have varied among years and a trendline has been inserted into the graphs to visualize the long-term water quality trend.

These plots illustrate how the data group together for a given year. The line in the “box” represents the sample median, the extent of the “box” represents a statistical range for comparison to another year, the “whiskers” show the boundaries of what could be considered the representative range of all the samples, and any points above or below the whiskers show atypical readings or “outliers” that represent an extreme condition or difference from that year’s data range. An algae bloom event may cause this type of outlier to occur in the chlorophyll data (high point) or Secchi disk clarity (low point).

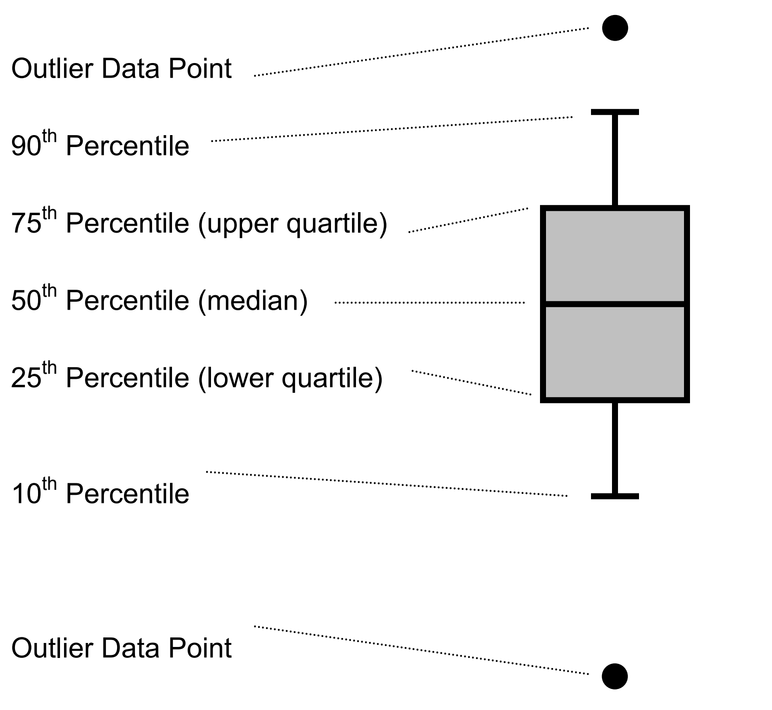
We recommend that each **NH LLMP** participating group plan on collecting weekly or biweekly measurements throughout the sampling season to ensure that enough data are available for this type of statistical analysis. We suggest that at least 8 data collections per year occur and generally set 10 measurements per year as a sampling effort goal per site.

<u>The Details</u>

In the sections below we further describe the use of the box and whisker plot for those that are interested on how they are determined and how they are interpreted:

The **box-and-whisker plot** is good at showing the **extreme values** and the range of middle values of your data (Figure 13). The box depicts the middle values of a variable, while the **whiskers** stretch to demonstrate the values between which 80% of the data points will fall. The filled circles then reflect the “outlier” data points that fall outside of the whiskers and reflect values that are atypically high or atypically low relative to the other data measured for a given year.

Figure 13. Sample Box and Whisker Plot



The box-and-whisker plots can be summarized as a graphic that displays the following important features of the data when they are arranged in order from least to greatest:

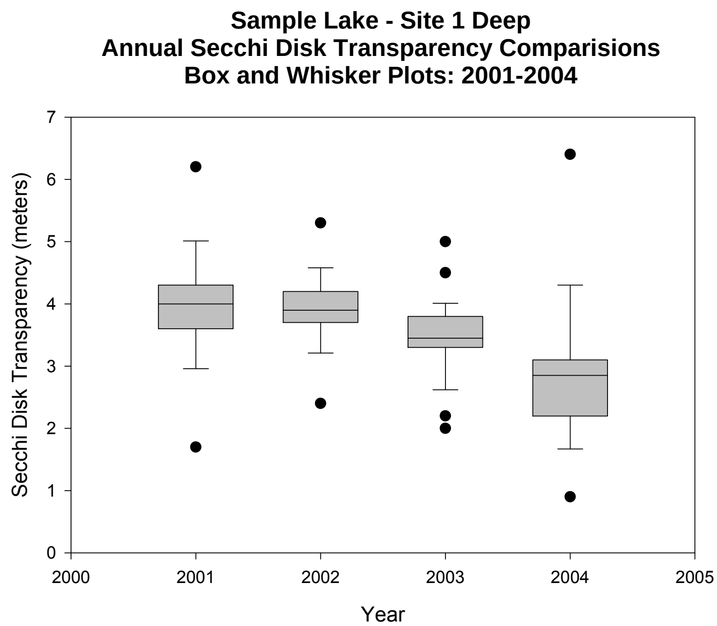
- Median (50th percentile) – the middle of the data
- Lower Quartile (25th percentile) – the point below which 25% of the data points are located.
- Upper Quartile (75th percentile) – the point below which 75% of the data points are located.
- 90th Percentile – the point below which 90% of the data points are located.
- 10th Percentile – the point below which 10% of the data points are located.
- Outlier Data points – data points that represent the upper 10% or the lowest 10% of the data collected for a specific year.

Note: A minimum number of data points is required to compute each feature documented above. At least three points are required to compute the Lower and the Upper Quartiles, five points are needed to compute the 10th percentile, and six points are needed to compute the 90th percentile. In the event that insufficient data points have been collected features will not be graphed due to the inability to reliably calculate the respective attribute.

Sample Box-and-Whisker Plot Interpretation

A sample *box-and-whisker* plot depicted in Figure 14 provides an opportunity to assess the usefulness of this type of plot at interpreting water quality monitoring data. The imaginary data depicted in Figure 14 reflect the annual water transparency measurements between the years 2001 and 2004. As you can glean from Figure 14, the distribution of the water clarity measurements has shifted to less clear conditions between 2001 and 2004. The median values, as well as the upper and lower quartiles (what is represented by the gray shaded box) have gradually shifted to less clear conditions over the four year span. The data points that lie between the upper and lower quartiles reflect 50% of the data collected for a given year and can provide insight into whether or not the water quality data are varying significantly between or among years. In extreme cases, when the gray shaded regions do not overlap between successive years or among years, one can quickly determine that the data distribution is significantly different for those years where the middle data (gray shading) does not overlap. Such differences can reflect long-term trends or can be a reflection of extreme climatic conditions for a given year such as atypically wet or atypically dry conditions that can have a profound impact on water quality.

Figure 14.



Note: The number of outlier data points is dependant on the size of the dataset.

Additional evaluation of the data can include a review of the 10th and the 90th percentiles (the whiskers) that provide additional insight into the distribution of the data. In this case, the trends exhibited by the 10th and the 90th percentiles are following the pattern of decreasing Secchi Disk Transparency as is exhibited by boxes (gray shaded regions). Outlier data points that fall outside of the “whiskers” can also be insightful. Such extreme values can be an early indicator of coming trends or can be an early warning sign of potential water quality problems. For instance, when Secchi Disk transparency measurements occasionally become significantly reduced (i.e. shallower water) such phenomenon can be an indication of short-term water quality problems such as excessive sediment or an algal bloom. If such problems are not contended with, but are instead left unattended, the longer-term impact could result in an increase in the magnitude and frequency of the water transparency reductions that, in turn, would result in a decreasing trend as evidenced by a shift of the “Boxes” to shallower water transparencies. There might also be occasions when the Secchi Disk transparency outliers reflect atypically clear water clarity. Such outliers can be a sign that conditions are improving or, as is often the case, the water quality is responding to short-term climatic variations that can have a profound impact on the water quality data. For instance, the outlier data point of 6.4 meters that was documented in 2004 (Figure 14) is counter intuitive to the long term trend of decreasing water quality. Plausible explanations for such an anomaly could be due to short term overgrazing of algae by zooplankton (typical for moderate to highly productive lakes), an abrupt shift in climate that might have favored clearer water (cloudy days or cooler water) or perhaps there was some sort of human intervention, such as a fish stocking or lake treatment that would have resulted in clearer water claries.

Newfound Lake Long-term Trends

Newfound Lake Data

Water quality data have been collected annually at the L02 Mayhew and the L03 Pasquaney sampling sites since 1986 during which samples have been collected as early as May 22 and as late as October 21. The majority of the data have been collected between June 1 and September 15, among years, and the following trend analysis is based upon the June 1 – September 15 sampling period to ensure the results reflect variations among years rather than variations introduced by the timing of data collection. For instance, measurements collected in the spring and fall oftentimes differ appreciably from the summer samples. If the samples are not consistently collected during the same time period among years, the results might reflect the impact of seasonal water quality fluctuations that can mask the actual long-term trends. Samples have not been consistently collected prior to June or after September 15 in Newfound Lake. The long-term trend graphs are based on both volunteer monitor and CFB data collected between 1986 and 2013.

Newfound Secchi Disk Trends

The 28 year long-term Secchi Disk trend indicates a slight decrease in water transparency data collected at L02 Mayhew which is largely driven by the atypically low Secchi Disk transparencies documented during the 2011 sampling season (Figure 15). On the other hand, the Secchi Disk transparency documented at L03 Pasquaney Bay (Figure 16) has more rapidly decreased over the past 28 years. The Pasquaney Bay sampling site is located in a relatively isolated segment of Newfound Lake and may reflect localized land-use alterations along the shoreline or extending further into the watershed. Both the Mayhew and Pasquaney Bay sampling sites are characterized by significant water transparency fluctuations between years and within a single year (Figure 15 and 16). Such water transparency variations can be an indication of annual variations in rainfall that tend to have an impact on water quality. Many lakes experience less water clarity during heavy rainfall years relative to years with below average rainfall. Water transparency reductions during heavy rainfall years would tend to be exacerbated when land clearing and construction activities within the watershed do not follow proper erosion control practices and when development occurs on environmentally sensitive areas such as on steep slopes, immediately adjacent to Newfound Lake or adjacent to stream inlets.

Figure 15.

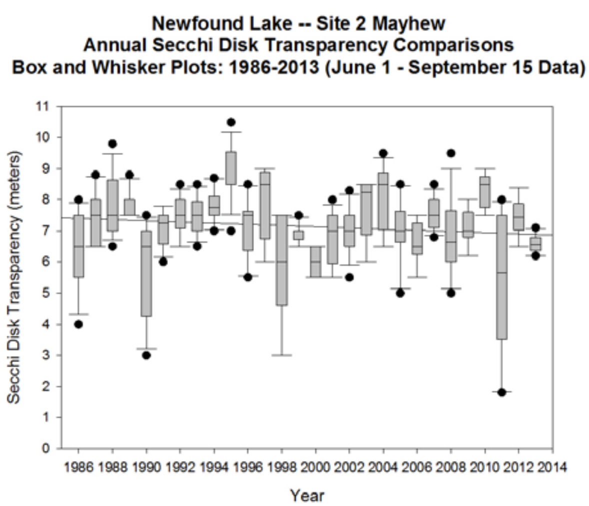
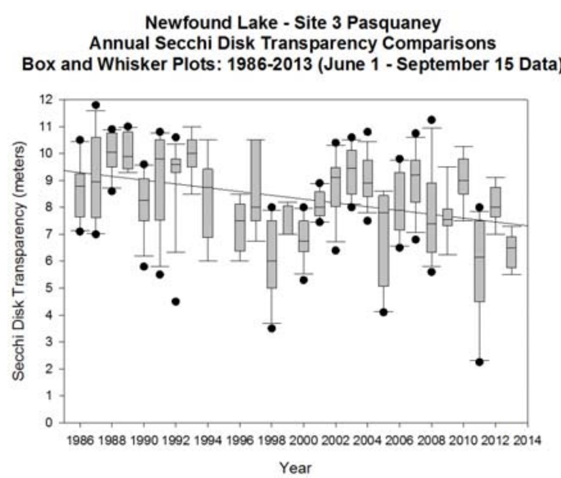


Figure 16.



<u>Newfound Lake Chlorophyll *a* Trends</u>

Sites L02 Mayhew and L03 Pasquaney both exhibit a gradual trend of increasing chlorophyll *a* concentrations over the 28 year period (Figures 17 and 18). Similar to the annual Secchi Disk transparency graphs, the chlorophyll *a* graphs indicate a large degree of annual variation that may reflect fluctuations in rainfall among years, as well as, the influence of land use alterations that have the potential to increase the sediment and nutrient runoff into Newfound Lake.

Figure 17

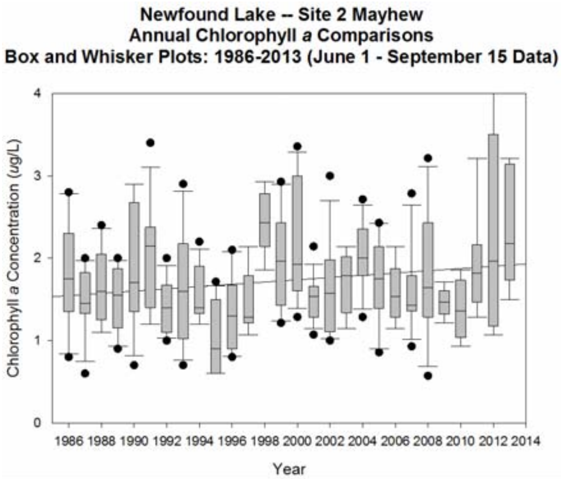
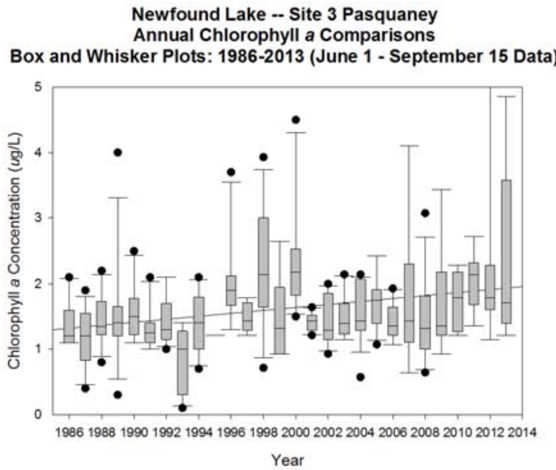


Figure 18



CONCLUSIONS AND RECOMMENDATIONS

Everyone in the watershed has a stake in Newfound Lake. Some enjoy the lake and tributaries directly by participating in recreational opportunities including swimming, boating and fishing, while others benefit indirectly through increased revenues associated with tourism and an expanded tax base associated with waterfront property. This report highlights threats to the lake as well as action that can be taken by municipal officials and members of the public who are stewards of the lake and the surrounding uplands.

The overall condition of Newfound Lake, measured at open water deep sampling sites, is excellent and the lake is characterized by some of the clearer water in New Hampshire. However, upon closer examination, one will observe a gradient of clearer water north of Mayhew Island and less clear and more nutrient enriched water south of Mayhew Island. Such variations in water quality can be naturally occurring but can also be a reflection of human activities. In the case of Newfound Lake, the poorest (relatively speaking) water quality was documented in the more developed region located south of Mayhew Island.

<u>Total Phosphorus</u>

Total phosphorus (nutrient) concentrations were generally low in Newfound Lake and within the Newfound Headwater tributaries but included periodic spikes along some stream reaches. The highest tributary total phosphorus concentrations have typically been documented during periods of elevated streamflow (Craycraft and Schloss, 2009, 2012); data suggest the majority of the total phosphorus entering the lake is delivered in a particulate form. Thus, protecting the lake and its headwater tributaries should include measures that avoid, and when appropriate mitigate, erosion through the stabilization of the upland soils.

Some General Considerations Include:

Steep Slopes create increased runoff water velocities, which cause increased sediment (and concurrent phosphorus) mobilization. Shoreline areas, such as the area near Follansbee Cove, are characterized by steep sloped terrain, while the Newfound Lake watershed is comprised of an extensive network of feeder streams that are largely characterized by relatively steep-sloped sub-watersheds highly susceptible to perturbation. Future land use management efforts should be directed towards maximizing riparian (shoreline) vegetation, which will reduce the water velocity and will both physically (i.e. filter) and chemically (i.e. plant uptake) remove nutrients. Slopes of 15% and greater compose 56.2% of the Newfound Lake watershed and characterize the headwaters of most tributary inlets (Craycraft and Schloss, 2008). Steep sloped regions should be carefully managed to preserve vegetation and prevent soil erosion.

Riparian (shoreside) Buffers provide many natural functions that include the protection of water quality and the preservation and enhancement of in-stream and in-lake fishery and wildlife habitat. The New Hampshire Shoreland Water Quality Protection Act (SWQPA) regulates land clearing, development and fertilization activities within a 250 foot jurisdictional area adjacent to Newfound Lake and Spectacle Pond, as well as, specified segments of the Cockermouth and Fowler Rivers. The SWQPA should be consulted prior to removing any shoreside vegetation within 250 feet of the aforementioned water bodies. However, most of the steep sloped regions are not regulated by the SWQPA and thus it falls upon local municipalities and landowners to minimize unintended environmental impacts in steep-sloped terrain.

When construction is undertaken, riparian cover should be maintained and diverted stormwater runoff should be directed towards vegetated regions where water will infiltrate the ground and minimize water quality impacts. Foresight should also be given to ensure that any implemented Best Management Practices (BMPs) are properly designed for the site-specific conditions and that a long-term maintenance plan, that includes regular inspections and corrective actions (when necessary), is followed.

Impervious Surfaces such as roads, driveways, houses and out-buildings tend to concentrate, and accelerate overland waterflow, and thus increase the potential for sediment and phosphorus loading. Roads, homes and other structures cover the soil with impenetrable materials that reduce the natural infiltration and purification of water. Instead, the water often flows directly to the lake and tributaries as channelized and/or sheet runoff, which can carry with it a significant phosphorus and sediment load. Homeowners should consider implementing erosion control measures including check dams, plunge pools, water bars and vegetated buffers that will attenuate stormwater runoff from impervious surfaces. Any existing pipes and culverts that bring concentrated flow directly to the shore should be daylighted and the water diverted or infiltrated. An inspection and long-term maintenance plan is a critical component of ensuring the long-term effectiveness of all erosion control measures. Again, the SWQPA contains regulations that are in effect within 250 feet of the shorelines of Newfound Lake and the lower reaches of the Cockermouth and the Fowler Rivers.

Town officials should consider adopting a strategy to minimize water quality impacts associated with road construction. As the population grows, the road network will likely be improved. Improvements to existing roads and construction of new roads require implementation of proper erosion control measures to minimize the adverse impacts to surface water and to minimize the expenses associated with long-term road maintenance. Drainage systems that were adequate for rough and semi-pervious gravel roads will not be able to handle the increased velocities and water volumes of paved roads; many more water turnouts and diversions will be required when roads are paved. The size of culverts may need to be increased to carry heavier storm flows. Road runoff should never go directly into the lake or any tributary but instead should be directed to a vegetated area that can reduce the velocity and increase infiltration.

Wetland Complexes are found within the Newfound watershed and include extensive wetland complexes in the Georges Brook and in the Bog Brook sub-watersheds. Wetland systems play a large role in mitigating flow and shunting nutrients but can also be highly susceptible to perturbation. Care needs to be taken when roads and driveways are improved so they do not interrupt these networks nor create excessive water loadings or sedimentation into these systems that can greatly reduce the wetland functionality as well as destroy critical wildlife habitat.

Septic System effluent is laden with phosphorus and is thought to constitute a significant portion of the phosphorus reaching many of our New Hampshire lakes. Aging septic systems, along with the conversion of homes from seasonal to year round use (which increases the annual load), often exacerbate the problems. While the scope of this study did not measure the impacts of septic systems bordering the lake shore and the tributaries, direct measurements of groundwater seepage in Mendums Pond (Schloss et al., 2009) identified septic systems as one of the major phosphorus sources that occur during the dry summer months. For the Newfound watershed, any marginal systems will continue to pose a threat due to the well to excessively-drained soils around the lake and the close proximity of lakeshore homes to the lake. Septic systems have been shown to contribute a significant phosphorus load to Flint Pond (Hollis) where a combination of sandy soils, aging septic systems and conversions from seasonal to year round use existed. Even a well functioning septic system can contribute a significant phosphorus load to the lake (Conner and Bowser, 1997). Thus, residents within the Newfound Lake watershed might consider installing low volume fixtures to limit the water used and thus reduce the phosphorus load. Local building codes could be amended to incorporate water-conserving appliances and fixtures. The NLRA might consider working with interested Towns to facilitate a timely septic tank inspection and pumping schedule that will facilitate a bulk-rate discount for watershed residents.

Stream Bank Undercutting and Destabilization (Watershed-wide Erosion Concerns) The Newfound watershed, as previously discussed, is characterized by steep slopes that accelerate water flow and in extreme cases scour substrate materials such as cobble and boulders during high flow periods. Evidence of extensive bank undercutting (Figure 19) and collapsing stream banks (Figure 20) has been observed in numerous tributaries within the Newfound Lake watershed. The bank undercutting and erosion are reminders of erosive force of the water that enters Newfound Lake through its channelized network of tributaries. On the other hand, Figures 19 and 20, illustrate the stabilizing capacity of the riparian vegetation and associated root systems that are prevalent along most stream channels. Some might consider the root systems as natural “re-bar” that effectively stabilizes the shoreline and minimizes erosion into our New Hampshire streams and lakes. As previously discussed, the majority of the Newfound Lake watershed is forested and includes extensive riparian vegetation along the tributary network. Future conservation efforts should foster the retention of riparian vegetation and, when possible, the reestablishment of riparian vegetation in regions where it has been removed. Riparian cover not only minimizes the phosphorus and sediment loading into surface waters but it also enhances fishery habitat and provides travel corridors for wildlife species.

Figure 19. Atwell Brook (Site CR U-30)
bank undercutting (Photographed August 30, 2011)

Figure 20. Hardy Brook (Site CR U-10)
Collapsing stream bank (Photographed March 31, 2011)

The following pages contain some more generic recommendations for maintaining healthy lakes that can be copied and distributed to watershed residents to let them know what can be done to protect their valued water resources.

10 Recommendations for Healthy Lakeshore and Streamside Living

1. Encourage shoreside vegetation and protect wetlands - Shoreside vegetation (also known as **riparian vegetation**) and wetlands provide a protective buffer that "traps" pollutants before reaching the lake. These buffers remove materials both chemically (through biological uptake) and physically (settling materials out). As riparian buffers are removed and wetlands lost, pollutant materials are more likely to enter the lake and in turn, favor declining water quality. Tall shoreline vegetation will also discourage geese invasions and shade the water reducing the possibility of aquatic weed recruitment including the dreaded invasive milfoil.

2. Limit fertilizer applications - Fertilizers entering the lake can stimulate aquatic plant and algal growth and in extreme cases result in noxious algal blooms. Increases in algal growth tend to diminish water transparency and in extreme cases culminate in surface "scums" that can wash up on the shoreline and can also produce unpleasant smells as the material decomposes. Excessive nutrient concentrations also favor algal forms known to produce toxins which irritate the skin and under extreme conditions, are dangerous when ingested. Use low maintenance grasses such as fescues that require less nutrients and water to grow. Do not apply any fertilizers until you have had your soils tested. Oftentimes a simple pH adjustment will do more good and release nutrients already in the soils. After a lawn is established a single application of fertilizer in the late fall is generally more than adequate to maintain a healthy growth from year to year.

3. Prevent organic matter loading - Excessive organic matter (leaves, grass clippings, etc.) are a major source of nutrients in the aquatic environment. As the vegetative matter decomposes, nutrients are "freed up" and can become available for aquatic plant and algal growth. In general, we are not concerned with this material entering the lake naturally (leaf senescence in the fall) but rather excessive loading of this material as occurs when residents dump or rake leaf litter and grass clippings into the lake. This material not only provides large nutrient reserves which can stimulate aquatic plant and algal growth but also makes great habitat for leaches and other potentially undesirable organisms in swimming areas.

4. Limit the loss of vegetative cover and the creation of impervious surfaces - A forested watershed offers the best protection against pollutant runoff. Trees and tall vegetation intercept heavy rains that can erode soils and surface materials. The roots of these plants keep the soils in place, process nutrients and absorb moisture so the soils do not wash out. Impervious surfaces (paved roads, parking lots, building roofs, etc.) reduce the water's capacity to infiltrate into the ground, and in turn, go through nature's water purification system, our soils. As water seeps into the soil, pollutants are removed from the runoff through absorption onto soil particles. Biological processes detoxify substances and/or immobilize substances. Surface water runoff over impervious surfaces also increases water velocities which favor the transport of a greater load of suspended and dissolved pollutants into your lake.

5. Follow the Flow - Try to landscape and re-develop with consideration of how water flows on and off your property. Divert runoff from driveways, roofs and gutters to a level

vegetated area or a rain garden so the water can be slowed, filtered and hopefully absorbed as recharge.

6. Discourage the feeding of ducks and geese - Ducks and geese that are locally fed tend to concentrate in higher densities around the known food source and can result in localized water quality problems. Waterfowl quickly process food into nutrients that can stimulate microscopic plant ("algal") growth. Ducks and geese are also host to the parasite responsible for swimmers itch. While not a serious health threat, swimmers itch is very uncomfortable especially for young children.

7. Maintain septic systems - Faulty septic systems are a big concern as they can be a primary source of water pollution around our lakes in the summer. Septic systems are loaded with nutrients and can also be a health threat when not functioning properly. Inspect your system on a timely basis and pump out the septic tank every three to five years depending on tank capacity and household water use. Since the septic system is such an expensive investment often costing a minimum of $10,000 for a complete overhaul, it is advantageous to assure proper care is taken to prolong the system's life. Additionally, following proper maintenance practices will reduce water quality degradation.

8. Take care when using and storing pesticides, toxic substances and fuels as it only takes a small amount to pollute lake, stream and ground water. Store, handle and use with attention paid to the label instructions.

9. Stabilize access areas and beaches - Perched beaches (cribbed areas) that keep sand and rocks in-place are preferred if you have to have that type of access. Do not create or enhance beach areas with sand because sand contains phosphorus, smothers aquatic habitat, fills in the lake as it gets transported away by currents and wind and encourages invasive plants and algal blooms.

10. Review the updated New Hampshire Shoreland Water Quality Protection Act (SWQPA) if you have shoreland property. The SWQPA sets legal regulations aimed at protecting water quality. If you have any questions regarding the act or need further information contact the SWQPA Coordinator at (603) 271-3503.

Note: Consult materials such as those listed below, for further guidance on assessing and implementing corrective actions that can maintain or improve the quality of surface and subsurface (septic) runoff that may otherwise impact water quality.

- Pipeline: Summer 2008. Vol. 19, No. 1. Septic Systems and Source Water Protection: Homeowners can help improved community water quality. http://www.nesc.wvu.edu/pdf/WW/publications/pipline/PL_SU08.pdf
- Landscaping at the Water's Edge: an Ecological Approach. $20.00/ea University of New Hampshire Cooperative Extension Publications Center, Nesmith Hall, 131 Main Street, Durham NH 03824. http://extension.unh.edu/resources/ to order a hard copy. http://extension.unh.edu/resources/files/Resource004159_Rep5940.pdf - to obtain a digital copy of the entire manual.

- Good Forestry in the Granite State: Recommended Voluntary Practices for New Hampshire (second edition). University of New Hampshire Cooperative Extension, Durham, N.H. http://extension.unh.edu/goodforestry/index.htm
- Integrated Landscaping: Following Nature's Lead. $20.00/ea University of New Hampshire Cooperative Extension Publications Center, Nesmith Hall, 131 Main Street, Durham NH 03824. http://extension.unh.edu/resources/
- The Best Plants for New Hampshire Gardens and Landscapes - How to Choose Annuals, Perennials, Small Trees & Shrubs to Thrive in Your Garden. University of New Hampshire Cooperative Extension Publications Center, Nesmith Hall, 131 Main Street, Durham NH 03824. http://extension.unh.edu/resources/
- New Hampshire Homeowner's Guide to Stormwater Management: Do-It-Yourself Stormwater Solutions for Your Home. March 2011. New Hampshire Department of Environmental Services. 29 Hazen Drive. Concord NH 03301. http://des.nh.gov/organization/commissioner/pip/publications/wd/documents/wd-11-11.pdf

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APPENDIX A

Tabular listing of the 2012 and 2013 Newfound Lake and Newfound Headwater Tributary water quality monitoring data.

2012 and 2013 Newfound Lake Data Listing (Center for Freshwater Biology Data)

Lake	Site	Date	Start Time (24:00 hrs)	End Time (24:00 hrs)	Depth (meters)	Carbon Dioxide (mg/L)	Alkalinity gray end pt. @ pH 5.1 (mg/L)	Alkalinity pink end pt. @ pH 4.6 (mg/L)	Total Phosphorus (ug/L)	Turbidity (NTU)	Chlorophyll *a* (*u* g/L)	Dissolved Color (CPU)	Secchi Disk Transparency (meters)
Newfound	1 Deep	8/27/2012	10:05	10:54	28.5	3.5	3.7	4.2	3.3	------	------	------	------
Newfound	1 Deep	8/27/2012	10:05	10:54	0-6.0	------	4.0	4.5	3.3	0.3	1.0	7.5	9.3
Newfound	1 Deep	8/8/2013	10:10	10:52	0.5	1.4	4.3	4.7	------	0.5	3.0	10.8	------
Newfound	1 Deep	8/8/2013	10:10	10:52	3.5	1.2	4.3	4.8	------	0.4	------	------	------
Newfound	1 Deep	8/8/2013	10:10	10:52	7.5	1.6	4.0	4.5	4.6	0.6	3.1	9.9	------
Newfound	1 Deep	8/8/2013	10:10	10:52	30.0	3.8	4.1	4.3	2.9	0.4	------	------	------
Newfound	1 Deep	8/8/2013	10:10	10:52	0-6.5	------	4.3	4.6	3.8	0.7	2.0	11.7	7.4
Newfound	2 Mayhew	8/27/2012	11:43	12:22	0.5	1.3	4.2	4.9	------	------	0.6	6.5	------
Newfound	2 Mayhew	8/27/2012	11:43	12:22	9.0	7.8	4.4	5.1	10.2	------	4.1	10.2	------
Newfound	2 Mayhew	8/27/2012	11:43	12:22	17.5	12.9	6.8	7.5	15.4	------	------	------	------
Newfound	2 Mayhew	8/27/2012	11:43	12:22	0-5.5	------	4.2	4.6	4.1	0.3	1.1	9.3	8.4
Newfound	2 Mayhew	8/8/2013	12:06	12:30	0.5	1.3	4.3	4.5	------	0.4	2.1	12.6	------
Newfound	2 Mayhew	8/8/2013	12:06	12:30	2.5	1.2	4.2	4.5	------	0.4	------	------	------
Newfound	2 Mayhew	8/8/2013	12:06	12:30	6.0	1.9	4.2	4.5	5.3	0.5	9.7	11.7	------
Newfound	2 Mayhew	8/8/2013	12:06	12:30	17.0	12.8	4.6	5.1	9.6	1.6	------	------	------
Newfound	2 Mayhew	8/8/2013	12:06	12:30	0-5.0	------	4.2	4.5	4.5	0.4	2.3	16.2	6.6
Newfound	3 Pasquaney	8/27/2012	11:00	11:22	13.0	3.2	3.7	4.2	6.4	------	------	------	------
Newfound	3 Pasquaney	8/27/2012	11:00	11:22	0-6.0	------	4.1	4.7	4.1	0.3	1.1	7.5	9.1
Newfound	3 Pasquaney	8/8/2013	12:40	13:10	0.5	1.1	4.3	4.5	------	0.5	1.6	10.8	------
Newfound	3 Pasquaney	8/8/2013	12:40	13:10	2.5	1.2	4.3	4.6	------	0.5	------	------	------
Newfound	3 Pasquaney	8/8/2013	12:40	13:10	7.0	1.5	4.2	4.5	4.3	0.4	2.9	10.8	------
Newfound	3 Pasquaney	8/8/2013	12:40	13:10	14.5	3.5	3.9	4.2	4.7	0.4	------	------	------
Newfound	3 Pasquaney	8/8/2013	12:40	13:10	0-6.0	------	4.3	4.5	4.4	0.5	1.7	10.8	7.3
Newfound	4 Loon Island	8/27/2012	14:15	14:35	8.5	1.0	4.1	4.6	5.1	------	------	------	------
Newfound	4 Loon Island	8/27/2012	14:15	14:35	0-7.0	------	4.1	4.7	4.0	0.3	0.9	8.4	8.2
Newfound	4 Loon Island	8/8/2013	13:57	14:26	0.5	1.4	4.3	4.6	------	0.5	2.1	11.7	------
Newfound	4 Loon Island	8/8/2013	13:57	14:26	8.5	2.6	4.1	4.4	4.8	0.6	2.7	10.8	------
Newfound	4 Loon Island	8/8/2013	13:57	14:26	0-6.0	------	4.3	4.6	6.5	0.4	2.0	11.7	7.6
Newfound	5 Cockermouth	8/27/2012	9:23	9:55	19.0	3.7	3.5	4.1	4.8	------	------	------	------
Newfound	5 Cockermouth	8/27/2012	9:23	9:55	0-6.0	------	4.2	4.8	4.2	0.3	1.1	9.3	9.3
Newfound	5 Cockermouth	8/8/2013	9:20	9:56	0.5	1.3	4.8	5.2	------	0.3	1.9	11.7	------
Newfound	5 Cockermouth	8/8/2013	9:20	9:56	4.0	1.4	4.8	5.2	------	0.4	------	------	------
Newfound	5 Cockermouth	8/8/2013	9:20	9:56	9.0	2.4	4.2	4.5	3.9	0.7	2.8	10.8	------
Newfound	5 Cockermouth	8/8/2013	9:20	9:56	25.0	4.3	4.1	4.4	4.6	0.5	------	------	------
Newfound	5 Cockermouth	8/8/2013	9:20	9:56	0-7.5	------	4.4	4.8	4.0	0.5	1.9	11.7	7.4
Newfound	6 Beachwood	8/27/2012	13:35	14:02	14.5	3.0	4.6	5.2	3.7	------	------	------	------
Newfound	6 Beachwood	8/27/2012	13:35	14:02	0-7.0	------	4.1	4.6	5.1	0.4	1.0	8.4	9.2
Newfound	6 Beachwood	8/8/2013	13:17	13:45	0.5	1.3	4.3	4.6	------	0.4	1.9	9.9	------
Newfound	6 Beachwood	8/8/2013	13:17	13:45	3.5	1.2	4.3	4.6	------	0.4	------	------	------
Newfound	6 Beachwood	8/8/2013	13:17	13:45	7.5	1.5	4.4	4.7	4.5	0.5	4.2	12.6	------
Newfound	6 Beachwood	8/8/2013	13:17	13:45	15.5	3.6	4.5	4.8	3.8	0.4	------	------	------

2012 and 2013 Newfound Lake Data Listing (Center for Freshwater Biology Data)

Lake	Site	Date	Start Time (24:00 hrs)	End Time (24:00 hrs)	Depth (meters)	Carbon Dioxide (mg/L)	Alkalinity gray end pt. @ pH 5.1 (mg/L)	Alkalinity pink end pt. @ pH 4.6 (mg/L)	Total Phosphorus (ug/L)	Turbidity (NTU)	Chlorophyll *a* (*u* g/L)	Dissolved Color (CPU)	Secchi Disk Transparency (meters)
Newfound	6 Beachwood	8/8/2013	13:17	13:45	0-6.5	------	4.5	4.8	4.2	0.4	2.4	10.8	8.3
Newfound	7 Boat Ramp	8/8/2013	11:45	11:45	0.5	------	4.2	4.8	4.2	0.4	1.6	12.6	------
Newfound	8 Fallansbee	8/27/2012	12:56	13:25	14.5	3.6	4.8	5.3	------	------	------	------	------
Newfound	8 Follansbee	8/27/2012	12:56	13:25	0-7.5	------	4.1	4.6	4.3	0.4	1.1	13.0	9.5
Newfound	8 Follansbee	8/8/2013	10:58	11:30	0.5	1.2	4.2	4.5	------	0.5	3.7	11.7	------
Newfound	8 Follansbee	8/8/2013	10:58	11:30	3.5	1.1	4.3	4.6	------	0.7	------	------	------
Newfound	8 Follansbee	8/8/2013	10:58	11:30	8.5	1.6	4.1	4.4	4.5	0.6	2.4	10.8	------
Newfound	8 Follansbee	8/8/2013	10:58	11:30	15.0	3.7	3.9	4.2	4.2	0.5	------	------	------
Newfound	8 Follansbee	8/8/2013	10:58	11:30	0-6.5	------	4.2	4.5	4.0	0.6	2.5	11.7	7.0

2012 and 2013 Newfound Lake Data Listing (Volunteer Data)

Lake	Site	Date	Secchi Disk Transparency (meters)	Epilimnetic Composite Chlorophyll *a* (*u* g/L)	Epilimnetic Composite Dissolved Color (CPU)	Epilimnetic Composite Total Phosphorus (*u* g/L)	Epilimnetic Composite Alkalinity gray end pt. @ pH 5.1 (mg/L)	Epilimnetic Composite Alkalinity pink end pt. @ pH 4.6 (mg/L)
Newfound	1 Deep	8/30/2013	8.7	-----	-----	-----	-----	-----
Newfound	1 Deep	9/3/2013	7.4	-----	-----	-----	-----	-----
Newfound	1 Deep	9/15/2013	8.3	-----	-----	-----	-----	-----
Newfound	1 Deep	9/26/2013	9.0	-----	-----	-----	-----	-----
Newfound	2 Mayhew	5/28/2012	7.1	1.5	15.6	5.5	-----	-----
Newfound	2 Mayhew	6/16/2012	6.5	2.5	15.6	8.8	-----	-----
Newfound	2 Mayhew	7/16/2012	7.5	2.9	12.6	8.3	-----	-----
Newfound	2 Mayhew	7/26/2012	7.2	5.4	11.3	6.1	-----	-----
Newfound	2 Mayhew	8/5/2012	7.4	1.2	11.2	-----	-----	-----
Newfound	2 Mayhew	8/20/2012	7.7	1.4	10.2	-----	-----	-----
Newfound	2 Mayhew	9/18/2012	8.2	1.4	10.1	-----	-----	-----
Newfound	2 Mayhew	10/2/2012	7.6	1.9	10.1	-----	-----	-----
Newfound	2 Mayhew	5/18/2013	6.5	2.4	14.4	-----	-----	-----
Newfound	2 Mayhew	6/6/2013	7.1	1.8	13.5	-----	-----	-----
Newfound	2 Mayhew	6/16/2013	6.8	1.7	-----	-----	-----	-----
Newfound	2 Mayhew	7/3/2013	6.6	2.1	17.5	-----	-----	-----
Newfound	2 Mayhew	7/29/2013	6.5	3.1	22.1	-----	-----	-----
Newfound	2 Mayhew	8/15/2013	6.3	1.5	18.5	6.4	-----	-----
Newfound	2 Mayhew	8/30/2013	6.8	3.2	15.7	7.2	-----	-----
Newfound	2 Mayhew	9/3/2013	6.2	-----	-----	-----	-----	-----
Newfound	2 Mayhew	9/7/2013	6.4	3.1	13.0	-----	-----	-----
Newfound	2 Mayhew	9/15/2013	6.4	-----	-----	-----	-----	-----
Newfound	2 Mayhew	9/17/2013	5.8	2.0	15.1	4.9	-----	-----
Newfound	3 Pasquaney	5/30/2012	9.5	1.1	19.9	-----	-----	-----
Newfound	3 Pasquaney	6/15/2012	9.0	1.6	17.4	-----	-----	-----
Newfound	3 Pasquaney	6/28/2012	8.0	2.0	18.3	-----	-----	-----
Newfound	3 Pasquaney	7/11/2012	7.8	1.8	13.9	-----	-----	-----
Newfound	3 Pasquaney	7/20/2012	8.2	2.0	13.1	-----	-----	-----

2012 and 2013 Newfound Lake Data Listing (Volunteer Data)

Lake	Site	Date	Secchi Disk Transparency (meters)	Epilimnetic Composite Chlorophyll *a* (*u* g/L)	Epilimnetic Composite Dissolved Color (CPU)	Epilimnetic Composite Total Phosphorus (*u* g/L)	Epilimnetic Composite Alkalinity gray end pt. @ pH 5.1 (mg/L)	Epilimnetic Composite Alkalinity pink end pt. @ pH 4.6 (mg/L)
Newfound	3 Pasquaney	7/30/2012	8.0	2.6	12.2	-----	-----	-----
Newfound	3 Pasquaney	8/13/2012	7.0	6.2	11.1	-----	-----	-----
Newfound	3 Pasquaney	8/21/2012	8.5	1.8	10.2	-----	-----	-----
Newfound	3 Pasquaney	8/31/2012	7.5	1.6	10.1	-----	-----	-----
Newfound	3 Pasquaney	9/17/2012	7.3	3.0	11.1	-----	-----	-----
Newfound	3 Pasquaney	7/24/2013	6.0	1.6	19.3	-----	-----	-----
Newfound	3 Pasquaney	8/1/2013	6.5	4.9	18.4	-----	-----	-----
Newfound	3 Pasquaney	8/29/2013	6.5	1.2	28.7	-----	-----	-----
Newfound	3 Pasquaney	9/7/2013	5.5	2.3	15.7	-----	-----	-----
Newfound	4 Loon Island	5/13/2012	7.7	1.4	12.4	-----	-----	-----
Newfound	4 Loon Island	5/20/2012	8.2	1.1	16.5	-----	-----	-----
Newfound	4 Loon Island	5/27/2012	8.9	0.4	14.7	4.5	-----	-----
Newfound	4 Loon Island	6/10/2012	6.0	1.8	19.0	7.1	-----	-----
Newfound	4 Loon Island	6/12/2012	8.2	1.8	16.5	6.0	-----	-----
Newfound	4 Loon Island	6/24/2012	-----	2.5	14.8	8.2	-----	-----
Newfound	4 Loon Island	7/2/2012	8.5	2.6	13.9	6.1	-----	-----
Newfound	4 Loon Island	7/14/2012	8.4	1.1	13.5	-----	-----	-----
Newfound	4 Loon Island	7/22/2012	8.6	1.4	13.1	4.9	-----	-----
Newfound	4 Loon Island	7/28/2012	8.9	2.1	11.2	4.6	-----	-----
Newfound	4 Loon Island	8/5/2012	9.2	1.3	9.3	3.6	-----	-----
Newfound	4 Loon Island	8/12/2012	8.9	1.6	10.2	4.1	-----	-----
Newfound	4 Loon Island	8/19/2012	8.7	1.4	11.9	4.6	-----	-----
Newfound	4 Loon Island	8/26/2012	9.1	1.1	9.1	3.7	-----	-----
Newfound	4 Loon Island	8/31/2012	8.7	1.6	-----	4.0	-----	-----
Newfound	4 Loon Island	6/1/2013	10.5	1.2	11.7	6.0	-----	-----
Newfound	4 Loon Island	6/15/2013	10.5	2.0	13.5	4.5	-----	-----
Newfound	4 Loon Island	6/23/2013	8.4	2.3	9.0	4.0	-----	-----
Newfound	4 Loon Island	7/6/2013	7.8	1.4	-----	4.2	-----	-----

2012 and 2013 Newfound Lake Data Listing (Volunteer Data)

Lake	Site	Date	Secchi Disk Transparency (meters)	Epilimnetic Composite Chlorophyll *a* (*u* g/L)	Epilimnetic Composite Dissolved Color (CPU)	Epilimnetic Composite Total Phosphorus (*u* g/L)	Epilimnetic Composite Alkalinity gray end pt. @ pH 5.1 (mg/L)	Epilimnetic Composite Alkalinity pink end pt. @ pH 4.6 (mg/L)
Newfound	4 Loon Island	7/14/2013	7.1	1.3	17.1	4.9	-----	-----
Newfound	4 Loon Island	7/21/2013	7.9	1.3	16.2	-----	-----	-----
Newfound	4 Loon Island	7/28/2013	7.0	1.5	16.2	5.7	-----	-----
Newfound	4 Loon Island	8/4/2013	7.6	1.6	16.0	4.2	-----	-----
Newfound	4 Loon Island	8/10/2013	7.1	1.9	15.1	7.0	-----	-----
Newfound	4 Loon Island	8/16/2013	8.6	1.8	13.2	4.3	-----	-----
Newfound	4 Loon Island	8/24/2013	8.0	6.5	13.2	3.0	-----	-----
Newfound	4 Loon Island	8/30/2013	8.0	1.5	13.2	3.0	-----	-----
Newfound	4 Loon Island	9/7/2013	6.5	2.6	16.0	5.0	-----	-----
Newfound	4 Loon Island	9/15/2013	8.8	1.7	15.1	3.4	-----	-----
Newfound	4 Loon Island	9/29/2013	9.4	2.6	14.7	4.5	-----	-----
Newfound	5 Cockermouth	6/24/2012	6.8	2.0	16.6	-----	3.4	4.1
Newfound	5 Cockermouth	7/13/2012	8.3	1.6	12.9	-----	3.9	4.8
Newfound	5 Cockermouth	7/22/2012	8.1	0.8	12.0	-----	3.5	4.5
Newfound	5 Cockermouth	8/2/2012	9.3	1.6	12.9	-----	3.6	4.3
Newfound	5 Cockermouth	8/13/2012	8.6	1.4	12.0	-----	3.5	4.2
Newfound	5 Cockermouth	8/23/2012	8.9	1.4	10.1	-----	3.6	4.4
Newfound	5 Cockermouth	9/7/2012	10.3	1.8	10.1	-----	3.6	4.3
Newfound	5 Cockermouth	7/7/2013	7.0	1.0	18.9	-----	3.7	4.4
Newfound	5 Cockermouth	7/21/2013	7.4	0.9	17.0	-----	3.7	4.3
Newfound	5 Cockermouth	8/1/2013	7.0	0.7	17.0	-----	3.7	4.5
Newfound	5 Cockermouth	8/12/2013	7.5	1.1	15.1	-----	3.9	4.8
Newfound	5 Cockermouth	8/25/2013	8.9	1.1	16.0	-----	3.8	4.4
Newfound	5 Cockermouth	9/7/2013	6.9	1.5	16.0	-----	3.6	4.1
Newfound	6 Beachwood	7/4/2012	8.6	1.6	14.6	-----	2.8	3.5
Newfound	6 Beachwood	7/13/2012	9.1	1.4	13.7	-----	3.3	3.9
Newfound	6 Beachwood	7/21/2012	8.7	1.4	12.8	-----	3.1	3.7
Newfound	6 Beachwood	7/27/2012	8.3	2.4	12.8	-----	3.2	4.3

2012 and 2013 Newfound Lake Data Listing (Volunteer Data)

Lake	Site	Date	Secchi Disk Transparency (meters)	Epilimnetic Composite Chlorophyll *a* (*u* g/L)	Epilimnetic Composite Dissolved Color (CPU)	Epilimnetic Composite Total Phosphorus (*u* g/L)	Epilimnetic Composite Alkalinity gray end pt. @ pH 5.1 (mg/L)	Epilimnetic Composite Alkalinity pink end pt. @ pH 4.6 (mg/L)
Newfound	6 Beachwood	8/3/2012	8.3	1.5	11.9	-----	3.2	3.9
Newfound	6 Beachwood	8/9/2012	8.8	1.3	10.9	-----	3.2	3.9
Newfound	6 Beachwood	8/15/2012	8.3	1.6	11.9	-----	3.4	4.3
Newfound	6 Beachwood	8/22/2012	8.4	1.4	11.9	-----	3.1	4.3
Newfound	6 Beachwood	8/28/2012	8.5	1.6	10.9	-----	3.5	4.5
Newfound	6 Beachwood	7/3/2013	8.2	1.7	11.1	-----	3.2	3.8
Newfound	6 Beachwood	7/11/2013	8.4	1.9	14.5	-----	3.4	4.1
Newfound	6 Beachwood	7/18/2013	8.4	1.0	14.8	-----	3.6	3.9
Newfound	6 Beachwood	7/26/2013	7.9	1.6	14.8	-----	3.2	3.8
Newfound	6 Beachwood	8/3/2013	8.1	1.7		-----	3.5	4.8
Newfound	6 Beachwood	8/10/2013	7.8	2.0	13.0	-----	3.5	4.2
Newfound	6 Beachwood	8/16/2013	8.1	2.2	13.0	-----	3.4	4.3
Newfound	6 Beachwood	8/21/2013	8.4	1.5	12.0	-----	3.5	4.1
Newfound	6 Beachwood	8/30/2013	8.7	1.6		-----	3.4	4.2
Newfound	6 Beachwood	9/4/2013	8.0	2.2	13.0	-----	3.5	4.3
Newfound	7 Fowler	5/27/2012	-----	0.9	15.7	-----	-----	-----
Newfound	7 Fowler	6/24/2012	-----	2.2		-----	-----	-----
Newfound	7 Fowler	7/15/2012	-----	1.1	13.8	-----	-----	-----
Newfound	7 Fowler	8/9/2012	-----	0.9	10.1	-----	-----	-----
Newfound	7 Fowler	9/2/2012	-----	1.2	10.1	-----	-----	-----
Newfound	7 Fowler	7/5/2013	-----	1.4	27.6	-----	-----	-----
Newfound	7 Fowler	7/28/2013	-----	0.7	17.5	-----	-----	-----
Newfound	7 Fowler	8/25/2013	-----	1.4	13.8	-----	-----	-----
Newfound	7 Fowler	9/15/2013	-----	1.5	15.7	-----	-----	-----
Newfound	8 Follansbee	7/31/2012	-----	-----	-----	-----	-----	-----
Newfound	8 Follansbee	8/3/2012	7.9	1.5	12.1	3.9	-----	-----
Newfound	8 Follansbee	8/7/2012	9.4	1.1	-----	-----	-----	-----
Newfound	8 Follansbee	8/15/2013	6.9	-----	-----	-----	-----	-----

2012 and 2013 Newfound Lake Data Listing (Volunteer Data)

Lake	Site	Date	Secchi Disk Transparency (meters)	Epilimnetic Composite Chlorophyll *a* (*u* g/L)	Epilimnetic Composite Dissolved Color (CPU)	Epilimnetic Composite Total Phosphorus (*u* g/L)	Epilimnetic Composite Alkalinity gray end pt. @ pH 5.1 (mg/L)	Epilimnetic Composite Alkalinity pink end pt. @ pH 4.6 (mg/L)
Newfound	8 Follansbee	8/17/2013	7.3	3.4	12.2	3.8	-----	-----
Newfound	8 Follansbee	8/30/2013	8.9	1.5	9.4		-----	-----
Newfound	8 Follansbee	9/3/2013	7.0	-----	-----	-----	-----	-----
Newfound	8 Follansbee	9/7/2013	7.3	2.1	15.9	-----	-----	-----
Newfound	8 Follansbee	9/15/2013	8.0	-----	-----	-----	-----	-----
Newfound	8 Follansbee	9/17/2013	7.5	2.1	13.2	4.3	-----	-----
Newfound	8 Follansbee	9/26/2013	9.0	-----	-----	-----	-----	-----

2013 Newfound Watershed Tributary Data Listing (Center for Freshwater Biology)

Site ID	Date	Subwatershed	Tributary Name	Time (24:00)	Temperature (^{o}C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	Specific Conductivity (*u* S/cm)	pH (standard units)	Turbidity (NTU)	Total Phosphorus (*u* g/L)	Visual Discharge Estimate (m^3/sec)
BB H23	6/13/2013	Black Brook	Black Brook	8:51	11.9	9.9	92.0	90.5	6.5	0.4	11.1	0.0500
BB H23	9/24/2013	Black Brook	Black Brook	9:06	10.2	8.9	79.3	155.1	6.5	1.1	9.3	0.0100
BB U10	6/13/2013	Black Brook	Black Brook	9:13	12.0	10.1	93.3	56.1	6.5	0.1	11.6	0.0300
BB U10	9/24/2013	Black Brook	Black Brook	9:27	9.9	9.8	87.0	94.1	6.4	0.4	9.8	0.0050
CR H11	6/13/2013	Cockermouth River	Cockermouth River	14:50	12.4	10.3	96.3	26.7	6.5	0.4	4.8	------
CR H11	9/24/2013	Cockermouth River	Cockermouth River	14:45	12.8	9.6	90.7	44.6	6.1	0.3	4.1	------
CR H12	6/13/2013	Cockermouth River	Cockermouth River	12:33	12.2	10.5	98.4	26.9	6.3	0.2	5.1	10.0000
CR H12	9/24/2013	Cockermouth River	Cockermouth River	14:31	12.5	9.6	90.4	44.2	6.1	0.3	4.0	1.0000
CR H14	6/13/2013	Cockermouth River	Cockermouth River	12:50	12.1	10.5	98.1	24.5	6.4	0.3	6.0	6.0000
CR H14	9/24/2013	Cockermouth River	Cockermouth River	14:19	12.7	9.9	93.3	35.7	6.3	0.1	2.7	------
CR U10	6/13/2013	Cockermouth River	Hardy Brook	13:32	12.0	10.7	99.0	14.6	6.5	0.2	4.9	0.1000
CR U10	9/24/2013	Cockermouth River	Hardy Brook	13:51	11.9	10.3	95.7	19.9	6.4	0.2	3.8	0.0250
CR U20	6/13/2013	Cockermouth River	Cockermouth River	13:45	11.8	11.0	101.1	18.9	6.6	0.1	3.5	4.0000
CR U20	9/24/2013	Cockermouth River	Cockermouth River	13:02	11.5	10.8	99.5	25.6	6.4	0.2	3.0	1.0000
CR U25	6/13/2013	Cockermouth River	Unnamed Brook	14:03	11.8	10.7	99.1	19.8	6.7	0.2	4.5	0.1000
CR U25	9/24/2013	Cockermouth River	Unnamed Brook	13:20	9.9	11.0	96.8	27.4	6.5	0.2	2.8	0.0250
CR U30	6/13/2013	Cockermouth River	Atwell Brook	14:15	11.4	10.9	99.9	15.1	6.7	0.6	5.6	0.3000
CR U30	9/24/2013	Cockermouth River	Atwell Brook	13:28	10.4	10.9	97.3	19.4	6.5	0.1	3.5	0.1000
CR U40	6/13/2013	Cockermouth River	Unnamed Brook	14:25	11.5	10.8	99.3	19.8	6.7	0.2	4.5	0.0750
CR U40	9/24/2013	Cockermouth River	Unnamed Brook	13:36	11.1	10.5	95.5	25.8	6.5	0.1	1.8	0.0200
CR U70	6/13/2013	Cockermouth River	Unnamed Brook	13:04	11.8	10.7	99.0	39.9	6.5	0.3	5.2	0.2000
CR U70	9/24/2013	Cockermouth River	Unnamed Brook	14:00	11.7	10.6	97.6	56.0	6.5	0.1	3.9	0.0500
CR U80	6/13/2013	Cockermouth River	Unnamed Brook	13:20	12.0	10.6	97.9	70.2	6.6	0.2	6.4	0.0500
CR U80	9/24/2013	Cockermouth River	Unnamed Brook	14:04	10.6	10.8	96.5	93.7	6.6	0.3	3.3	0.0250
DBB H03	6/13/2013	Dick Brown Brook	Dick Brown Brook	16:18	12.9	10.2	97.0	42.2	6.6	0.4	11.4	------
DBB H03	9/24/2013	Dick Brown Brook	Dick Brown Brook	16:13	11.4	10.2	93.5	59.9	6.3	0.4	5.9	0.1000
DBB U05	9/24/2013	Dick Brown Brook	Unnamed Brook	16:40	10.0	10.8	96.1	28.9	6.5	0.3	2.7	0.0030
DBB U10	6/13/2013	Dick Brown Brook	Dick Brown Brook	16:30	13.1	9.8	93.5	30.3	6.7	0.5	8.0	0.3000
DBB U10	9/24/2013	Dick Brown Brook	Dick Brown Brook	16:35	11.3	10.2	93.0	38.7	6.5	0.6	5.0	0.0750
DBB U20	6/13/2013	Dick Brown Brook	Dick Brown Brook	16:45	16.6	8.8	90.7	21.9	6.6	0.3	10.0	0.1000
DBB U20	9/24/2013	Dick Brown Brook	Dick Brown Brook	16:49	15.5	8.0	80.6	26.5	6.4	0.5	10.1	0.0200
FR H20	6/13/2013	Fowler River	Fowler River	12:06	13.0	9.1	86.6	24.3	6.0	0.3	8.2	------
FR H20	9/24/2013	Fowler River	Fowler River	12:05	11.6	8.7	80.2	37.2	5.9	0.6	8.7	------
FR H21	6/13/2013	Fowler River	Bog Brook	9:32	13.7	7.5	71.9	28.0	5.9	0.5	10.2	4.0000
FR H21	9/24/2013	Fowler River	Bog Brook	9:41	11.8	8.3	76.4	50.5	6.2	0.7	10.0	1.0000
FR H22	6/13/2013	Fowler River	Fowler River	9:44	11.3	11.3	103.2	17.0	6.1	0.5	5.1	5.0000
FR H22	9/24/2013	Fowler River	Fowler River	9:50	9.9	10.4	91.7	23.8	6.2	0.5	5.0	3.0000
FR U05	6/13/2013	Fowler River	Fowler River	9:57	11.3	11.2	102.6	16.5	6.1	0.3	4.2	4.0000
FR U05	9/24/2013	Fowler River	Fowler River	10:01	10.1	10.4	91.9	22.9	6.1	0.4	5.0	2.0000
FR U10	6/13/2013	Fowler River	Unnamed Brook	10:17	11.2	10.8	98.6	14.8	6.2	0.1	4.0	0.1250
FR U10	9/24/2013	Fowler River	Unnamed Brook	10:37	9.8	9.9	87.4	18.2	5.8	0.3	3.7	0.0250
FR U20	6/13/2013	Fowler River	Clark Brook	10:25	11.2	10.8	98.5	12.3	5.8	0.2	4.4	2.0000
FR U20	9/24/2013	Fowler River	Clark Brook	10:42	9.8	10.2	90.2	16.5	5.9	0.3	5.8	1.0000
FR U25	6/13/2013	Fowler River	Clark Brook	10:40	11.0	11.2	101.5	12.7	5.7	0.2	4.6	2.5000
FR U25	9/24/2013	Fowler River	Clark Brook	10:54	9.5	10.5	91.5	14.7	5.9	0.5	5.8	0.4000
FR U30	6/13/2013	Fowler River	Brock Brook	10:55	11.5	10.9	99.6	21.1	6.3	0.9	8.5	0.2000

2013 Newfound Watershed Tributary Data Listing (Center for Freshwater Biology)

Site ID	Date	Subwatershed	Tributary Name	Time (24:00)	Temperature (^oC)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	Specific Conductivity (*u* S/cm)	pH (standard units)	Turbidity (NTU)	Total Phosphorus (*u* g/L)	Visual Discharge Estimate (m^3/sec)
FR U30	9/24/2013	Fowler River	Brock Brook	11:03	9.7	10.3	90.8	29.4	6.3	0.7	7.6	0.1000
FR U40	6/13/2013	Fowler River	Brock Brook	11:08	11.3	10.9	100.1	14.8	6.3	1.4	10.6	0.2750
FR U40	9/24/2013	Fowler River	Brock Brook	11:14	9.3	10.3	89.3	20.7	6.1	0.8	10.6	0.0300
FR U50	6/13/2013	Fowler River	Tributary Confluence	11:25	11.3	11.0	100.1	14.8	6.3	0.1	4.0	0.4000
FR U50	9/24/2013	Fowler River	Tributary Confluence	11:30	9.2	10.3	89.2	14.6	5.9	0.4	3.9	0.1000
FR U60	6/13/2013	Fowler River	Patten Brook	11:53	11.7	11.1	102.1	21.1	6.4	0.1	4.4	2.5000
FR U60	9/24/2013	Fowler River	Patten Brook	11:54	11.0	9.9	89.6	46.0	6.2	0.2	3.7	0.3500
GB H10	6/13/2013	Georges Brook	Georges Brook	15:02	15.4	9.4	94.1	38.0	6.5	0.5	8.0	0.6000
GB H10	9/24/2013	Georges Brook	Georges Brook	15:00	12.9	10.1	95.4	53.0	6.4	0.9	10.7	0.0350
GB U10	6/13/2013	Georges Brook	Georges Brook	15:39	13.2	9.8	93.1	47.4	6.5	0.5	8.5	0.1000
GB U10	9/24/2013	Georges Brook	Georges Brook	15:30	12.7	9.1	85.5	74.2	6.2	0.9	9.3	0.0150
GB U20	6/13/2013	Georges Brook	Cilley Brook	15:29	12.0	10.4	97.0	15.2	6.3	0.2	3.6	0.0500
GB U20	9/24/2013	Georges Brook	Cilley Brook	13:24	11.1	10.5	95.4	23.2	6.0	0.1	3.3	0.0075
GB U30	6/13/2013	Georges Brook	Fretts Brook	15:19	11.8	10.6	97.5	15.4	6.1	0.1	3.9	0.0250
GB U30	9/24/2013	Georges Brook	Fretts Brook	15:09	11.2	10.2	93.3	21.2	5.9	0.1	4.6	0.0050
WTB H04	6/13/2013	Whittemore Brook	Whittemore Brook	16:06	12.1	10.7	99.4	21.6	6.6	0.3	40.0	0.2000
WTB H04	9/24/2013	Whittemore Brook	Whittemore Brook	16:04	11.3	10.7	97.5	30.3	6.4	0.1	3.8	0.0750
WTB U10	6/13/2013	Whittemore Brook	Whittemore Brook	15:55	12.2	10.7	100.1	18.7	6.6	0.4	6.1	0.1250
WTB U10	9/24/2013	Whittemore Brook	Whittemore Brook	15:54	11.0	10.6	96.5	26.0	6.3	0.3	4.9	0.0500

2012 and 1013 Newfound Watershed Tributary Data Listing (Volunteer Data)

Subwatershed	Site ID	Sampling Date	Recent Rainfall	Rain Intensity	Temperature (°C)	Specidic Conductivity (uS/cm)	Total Phosphorus (ug/L)	Comments
Cockermouth River	CR-H11	04-May-13	------	------	13.5	40.5	5.1	minnows
Cockermouth River	CR-H11	18-May-13	Past 24 hrs	Short Duration	13.9	44.8	------	0.45 inches of total percipitation
Cockermouth River	CR-H11	23-Jun-13	Current	Drizzle	16.7	50.6	5.4	minnows, 3 motor boats/tied to bank (unoccupied boats)
Cockermouth River	CR-H11	13-Jul-13	Past 24 hrs	Short Duration	18.0	37.1	4.5	toadlets on bank, small minnows (black- maybe bass?); heavy storm in the past 48 hours
Cockermouth River	CR-H11	21-Aug-13	Past Week	Long Duration	20.5	64.4	9.1	volume (depth) much lower; 0.75 inches of precipitation on August 14
Cockermouth River	CR-H11	29-Sep-13	------	------	14.3	58.7	7.2	volume (depth) much lower; boat moored at sampling spot (tied in front of launch site)
Cockermouth River	CR-H11	20-Oct-13	Past 24 hrs	Short Duration	11.9	50.0	6.8	mink and gray fox tracks
Cockermouth River	CR-H12	04-May-13	None	------	14.4	41.2	3.3	No Precipitation all week; 2 female mergansers, tracks of minks, raccoon, otter under bridge
Cockermouth River	CR-H12	18-May-13	Past 24-48 hrs	Short Duration	14.0	46.4	------	Tracks of multiple mammal species under bridge
Cockermouth River	CR-H12	23-Jun-13	Current	Drizzle	15.7	50.5	5.0	0.12 inches of rain over the past week; minnows, leech, tracks in sand, large piece of metal
Cockermouth River	CR-H12	13-Jul-13	Past 24 hrs	Short Duration	18.7	37.4	4.4	1.5 inches of precipitation past week; 2 inch minnows, dragonflies, many tracks; Sandbar downstream from bridge; heavy storm 7/11/2013
Cockermouth River	CR-H12	21-Aug-13	Past Week	Long Duration	20.2	63.9	4.2	0.75 inches of precipitation on August 14; Few mammal Tracks; sand bars downstream and upstream of bridge
Cockermouth River	CR-H12	29-Sep-13	------	------	14.4	56.4	4.1	usual variety of tracks under bridge; sand bars downstream and upstream from bridge
Cockermouth River	CR-H12	20-Oct-13	Past 24 hrs	Short Duration	11.2	47.2	4.3	Tracks of mink and housecat; sand bars up and downstream from bridge
Cockermouth River	CR-H14	04-May-13	------	------	15.1	40.2	3.2	Male Mallard, sandpiper
Cockermouth River	CR-H14	18-May-13	Past 24-48 hrs	Short Duration	14.2	42.9	------	Orange traffic cone submerged under the bridge. Brook Trout observed
Cockermouth River	CR-H14	23-Jun-13	Past 24 hrs	Short Duration	15.7	42.7	3.7	Merganser flew by upstream under bridge
Cockermouth River	CR-H14	13-Jul-13	Past 24 hrs	Short Duration	18.4	33.6	4.7	small narrow sand bar under bridge still above surface, top of piling now submerged
Cockermouth River	CR-H14	21-Aug-13	Past Week	Long Duration	19.3	50.5	2.0	small sand bar under bridge, more growth here, channel volume depth low; 0.75 inches of precipitation on August 14
Cockermouth River	CR-H14	29-Sep-13	------	------	15.0	43.3	3.0	
Cockermouth River	CR-H14	20-Oct-13	Past 24 hrs	Short Duration	11.7	41.3	3.4	
Cockermouth River	CR-U10	04-May-13	------	------	12.9	17.8	3.0	Sampled the deep pool at the culvert outlet
Cockermouth River	CR-U10	18-May-13	Past 24-48 hrs	Short Duration	12.2	20.1	------	Sampled in deep pool at the culvert outlet
Cockermouth River	CR-U10	23-Jun-13	Past 24 hrs	Short Duration	16.5	20.7	5.8	pool at outlet to culvert 90% covered
Cockermouth River	CR-U10	13-Jul-13	Past 24 hrs	Short Duration	18.1	17.4	6.1	pool full but downstream channel low
Cockermouth River	CR-U10	21-Aug-13	Past Week	Long Duration	17.6	23.6	3.1	No water flowing through culvert - sampled in pool, no water upstream side of road, except maybe water flowing under the rocks
Cockermouth River	CR-U10	29-Sep-13	------	------	14.5	23.2	4.8	there is now water flowing through the culvert (none last month - August), sampled in pool at culvert outlet
Cockermouth River	CR-U10	20-Oct-13	Past 24 hrs	Short Duration	10.5	24.5	6.7	Sampled in pool at culvert outlet, pool full, stream braided downstream of pool
Cockermouth River	CR-U20	04-May-13	------	------	14.8	25.7	3.7	Light foot traffic from road down to river.
Cockermouth River	CR-U20	18-May-13	Past 24 hrs	Short Duration	13.4	22.7	------	light foot traffic from road down to river
Cockermouth River	CR-U20	23-Jun-13	Past 24 hrs	Short Duration	16.4	28.6	5.3	
Cockermouth River	CR-U20	13-Jul-13	Past 24 hrs	Short Duration	18.3	23.9	5.1	slight erosion from foot paths
Cockermouth River	CR-U20	21-Aug-13	Past Week	Long Duration	19.7	38.4	3.3	slight erosion from foot paths, 2 minnows, water striders, 0.75 inches of precipitation on August 14
Cockermouth River	CR-U20	29-Sep-13	------	------	14.7	32.0	5.0	
Cockermouth River	CR-U20	20-Oct-13	Past 24 hrs	Short Duration	10.4	28.6	4.9	
Cockermouth River	CR-U25	04-May-13	------	------	11.2	22.0	3.0	Sampled pool at the culvert outlet
Cockermouth River	CR-U25	18-May-13	Past Week	Short Duration	10.4	25.1	------	Sampled at the deep pool at the culvert outlet
Cockermouth River	CR-U25	23-Jun-13	Past 24 hrs	Short Duration	15.6	26.5	5.4	0.12 inches of precipitation over the past week
Cockermouth River	CR-U25	13-Jul-13	Past 24 hrs	Short Duration	17.5	23.5	6.8	Over 1.5 Inches of precipitation over the past week
Cockermouth River	CR-U25	21-Aug-13	Past Week	Long Duration	17.0	31.9	4.6	sampled downstream of road/culvert (in pool at outlet); 0.75 inches of precipitation on August 14
Cockermouth River	CR-U25	29-Sep-13	------	------	12.8	31.6	3.7	sampled upstream end of culvert
Cockermouth River	CR-U25	20-Oct-13	Past 24 hrs	Short Duration	9.2	33.1	4.3	
Cockermouth River	CR-U70	04-May-13	------	------	14.4	52.8	3.5	Access Downstream Of Bridge
Cockermouth River	CR-U70	18-May-13	Past 24-48 hrs	Short Duration	12.2	63.3	------	Water striders amd black flies
Cockermouth River	CR-U70	23-Jun-13	Past Week	Short Duration	15.1	63.4	5.8	water striders
Cockermouth River	CR-U70	13-Jul-13	Past 24 hrs	Short Duration	17.5	47.3	6.0	evident that water has been much higherthe past week or two and has now receded; Over 1.5 inches of precipitation over the past week
Cockermouth River	CR-U70	21-Aug-13	Past Week	Long Duration	18.8	89.7	4.2	mink tracks; 0.75 inches of precipication on August 14
Cockermouth River	CR-U70	29-Sep-13	------	------	14.3	76.4	6.5	
Cockermouth River	CR-U70	20-Oct-13	Past 24 hrs	Short Duration	10.6	65.8	5.2	
Cockermouth River	CR-U80	04-May-13	------	------	14.2	101.7	3.1	Water Striders present, Otter tracks seen. Minor Erosion
Cockermouth River	CR-U80	18-May-13	Past 24-48 hrs	Short Duration	11.5	114.8	------	
Cockermouth River	CR-U80	23-Jun-13	Past 24 hrs	Short Duration	15.3	107.7	5.4	water striders
Cockermouth River	CR-U80	13-Jul-13	Past 24 hrs	Short Duration	17.4	94.1	6.5	
Cockermouth River	CR-U80	21-Aug-13	Past Week	Long Duration	17.8	120.2	5.1	
Cockermouth River	CR-U80	29-Sep-13	------	------	13.7	120.1	4.6	Water flowing around large rocks
Cockermouth River	CR-U80	20-Oct-13	Past 24 hrs	Short Duration	10.0	107.9	6.5	Observed a big bull moose
Dick Brown Brook	DBB-H03	23-May-12	Past 24 hrs	Drizzle	14.5	37.7	6.7	On and off drizzle for the past week with 2 inches of rain
Dick Brown Brook	DBB-H03	11-Jul-12	Current	Drizzle	17.0	93.3	10.5	
Dick Brown Brook	DBB-H03	20-Aug-12	Past Week	Heavy Storm	18.5	69.8	11.4	7 inches of rain over the last week
Dick Brown Brook	DBB-H03	24-May-13	Current	Drizzle	12.6	32.7	15.3	
Dick Brown Brook	DBB-H03	27-Jun-13	Past 24 hrs	Short Duration	16.9	56.4	8.2	

2012 and 1013 Newfound Watershed Tributary Data Listing (Volunteer Data)

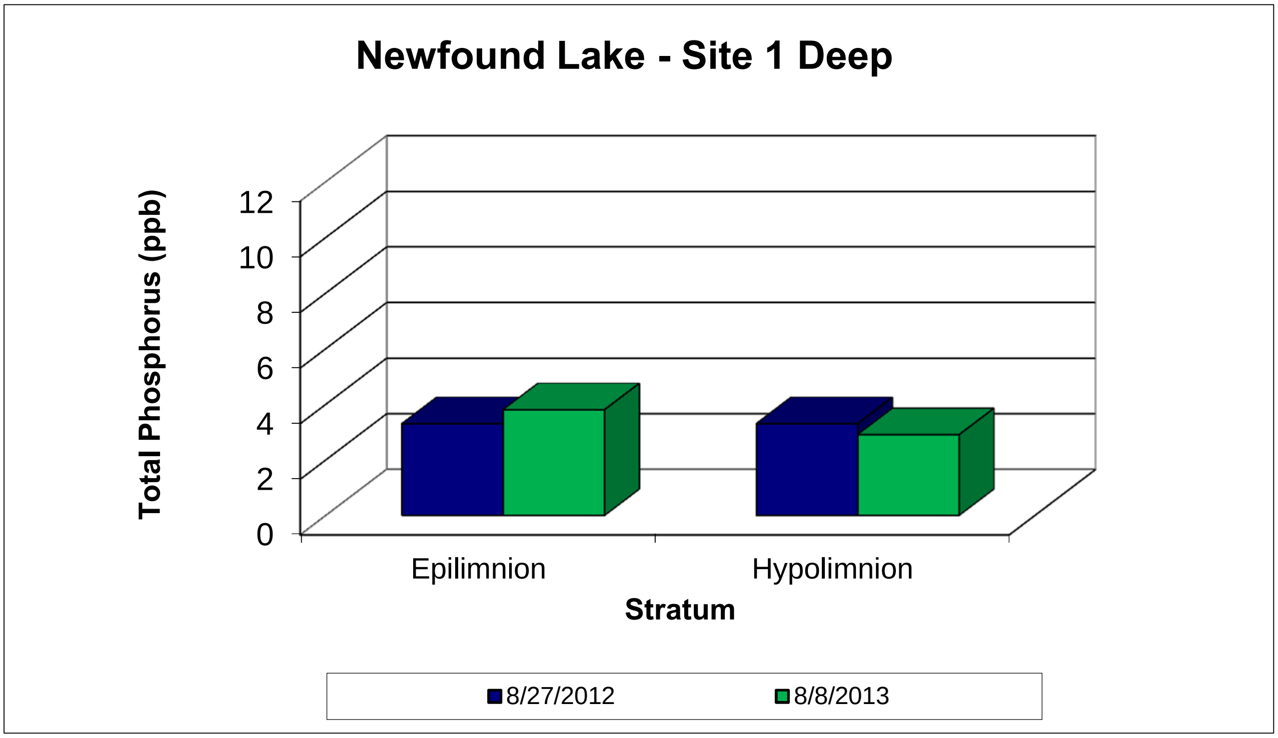
Subwatershed	Site ID	Sampling Date	Recent Rainfall	Rain Intensity	Temperature (°C)	Specidic Conductivity (uS/cm)	Total Phosphorus (ug/L)	Comments
Dick Brown Brook	DBB-H03	01-Aug-13	Past 24-48 hrs	Long Duration	16.5	47.5	6.9	
Dick Brown Brook	DBB-H03	30-Aug-13	Past 24-48 hrs	Heavy Storm	19.0	57.2	8.1	
Dick Brown Brook	DBB-U10	23-May-12	Past 24 hrs	Drizzle	14.1	26.0	8.5	On and off drizzle for the past week with 2 inches of rain
Dick Brown Brook	DBB-U10	11-Jul-12	Current	Drizzle	15.7	51.6	3.7	
Dick Brown Brook	DBB-U10	20-Aug-12	Past Week	Heavy Storm	14.3	38.2	4.1	7 inches of rain over the last week
Dick Brown Brook	DBB-U10	24-May-13	Current	Short Duration	12.4	21.2	9.4	
Dick Brown Brook	DBB-U10	27-Jun-13	Past 24 hrs	Short Duration	16.8	39.3	9.5	
Dick Brown Brook	DBB-U10	01-Aug-13	Past 24-48 hrs	Long Duration	16.4	31.1	9.3	
Dick Brown Brook	DBB-U10	30-Aug-13	Past 24-48 hrs	Heavy Storm	17.9	37.8	7.7	
Dick Brown Brook	DBB-U20	23-May-12	Past 24 hrs	Drizzle	20.5	22.1	10.8	On and off drizzle for the past week with 2 inches of rain
Dick Brown Brook	DBB-U20	11-Jul-12	Current	Drizzle	18.4	53.3	31.7	
Dick Brown Brook	DBB-U20	20-Aug-12	Past Week	Heavy Storm	21.5	31.7	14.3	7 inches of rain over the last week
Dick Brown Brook	DBB-U20	24-May-13	Current	Short Duration	16.4	19.8	9.7	
Dick Brown Brook	DBB-U20	27-Jun-13	Past 24 hrs	Short Duration	23.5	25.2	15.7	
Dick Brown Brook	DBB-U20	01-Aug-13	Past 24-48 hrs	Long Duration	21.8	24.9	12.9	
Dick Brown Brook	DBB-U20	30-Aug-13	Past 24-48 hrs	Heavy Storm	24.2	28.6	11.5	
Fowler River	FR-H20	23-May-12	Past 24 hrs	Drizzle	16.1	29.7	15.0	On and off drizzle for the past week with 2 inches of rain
Fowler River	FR-H20	11-Jul-12	Current	Drizzle	21.5	58.0	22.8	
Fowler River	FR-H20	20-Aug-12	Past Week	Heavy Storm	19.6	52.3	15.0	Could not see river bottom. 7 inches of rain over the last week
Fowler River	FR-H20	24-May-13	Past 24 hrs	Short Duration	13.7	22.5	10.9	
Fowler River	FR-H20	27-Jun-13	Past 24 hrs	Short Duration	18.2	27.8	13.7	
Fowler River	FR-H20	01-Aug-13	Past 24-48 hrs	Long Duration	19.1	36.8	12.3	
Fowler River	FR-H20	30-Aug-13	Past 24-48 hrs	Heavy Storm	21.3	50.7	12.4	Approximately 1 Inch of precipitation
Fowler River	FR-H21	23-May-12	Past 24 hrs	Drizzle	18.1	38.9	12.2	On and off drizzle for the past week with 2 inches of rain
Fowler River	FR-H21	11-Jul-12	Current	Drizzle	18.9	73.0	174.4	Particulates in phosphorus sample bottle
Fowler River	FR-H21	20-Aug-12	Past Week	Heavy Storm	18.6	52.7	85.0	Particulates in the Phosphorus Sample, 7 inches of rain over the last week
Fowler River	FR-H21	24-May-13	Past 24 hrs	Short Duration	15.1	35.6	12.9	
Fowler River	FR-H21	27-Jun-13	Past 24 hrs	Short Duration	19.0	32.9	13.2	
Fowler River	FR-H21	01-Aug-13	Past 24-48 hrs	Long Duration	19.6	45.6	13.5	
Fowler River	FR-H21	30-Aug-13	Past 24-48 hrs	Heavy Storm	20.3	24.5	14.1	Approximately 1 inch of precipitation
Fowler River	FR-H22	23-May-12	Past 24 hrs	Drizzle	14.9	20.0	11.9	On and off drizzle for the past week with 2 inches of rain
Fowler River	FR-H22	11-Jul-12	Current	Drizzle	18.7	32.4	3.8	
Fowler River	FR-H22	20-Aug-12	Past Week	Heavy Storm	19.1	35.0	4.7	7 inches of rain over the last week
Fowler River	FR-H22	24-May-13	Past 24 hrs	Short Duration	13.1	15.1	5.7	Heavy Storm Past 48 hours
Fowler River	FR-H22	27-Jun-13	Current	Drizzle	17.0	18.1	6.2	Heavy Storm past week
Fowler River	FR-H22	01-Aug-13	Past 24-48 hrs	Long Duration	16.7	23.0	5.4	Heavy storm over the past week
Fowler River	FR-H22	30-Aug-13	Past 24-48 hrs	Heavy Storm	21.7	27.4	7.5	Approximately 1 Inch of precipiation
Georges Brook	GB-H10	08-Jan-12	Current	Drizzle	0.1	20.0	6.0	Stream was 75% iced in, Short term snow showers in the past week,
Georges Brook	GB-H10	01-Apr-12	Past Week	Drizzle	5.0	40.9	8.4	Light snow earlier in the week
Georges Brook	GB-H10	31-May-12	Past 24-48 hrs	Heavy Storm	17.2	43.7	16.0	Pine needles, not leaves, in the stream
Georges Brook	GB-H10	29-Jun-12	Past 24 hrs	Short Duration	20.7	52.4	15.5	Bugs on Surface, Heavy rain past week
Georges Brook	GB-H10	31-Jul-12	Past 24 hrs	Heavy Storm	21.1	57.5	11.4	Heavy storms over the past week.
Georges Brook	GB-U10	08-Jan-12	Current	Drizzle	5.5	24.3	7.7	Stream 60% covered in ice
Georges Brook	GB-U10	01-Apr-12	Past Week	Drizzle	4.7	49.2	5.7	Water Bugs, Light snow earlier in the week
Georges Brook	GB-U10	31-May-12	Past 24-48 hrs	Heavy Storm	14.5	48.4	13.7	
Georges Brook	GB-U10	29-Jun-12	Past 24 hrs	Short Duration	19.5	67.9	18.8	Bugs on surface, Long duration showers 24-48 hours, heavy storm past week
Georges Brook	GB-U10	31-Jul-12	Past 24 hrs	Heavy Storm	18.3	71.1	11.8	Heavy storms over the past week.
Georges Brook	GB-U20	08-Jan-12	Current	Drizzle	0.9	9.1	------	Snow shower earlier in the week.
Georges Brook	GB-U20	01-Apr-12	Past Week	Drizzle	4.9	17.7	3.5	Light snow earlier in the week.
Georges Brook	GB-U20	31-May-12	Past 24-48 hrs	Heavy Storm	13.5	17.2	5.4	
Georges Brook	GB-U20	29-Jun-12	Past 24 hrs	Short Duration	17.6	25.0	3.1	Bugs on surface, Long duration showers 24-48 hours, heavy storm past week
Georges Brook	GB-U20	31-Jul-12	Past 24 hrs	Heavy Storm	18.1	30.4	4.2	Heavy storms over the past week.
Georges Brook	GB-U30	08-Jan-12	Current	Drizzle	1.3	9.3	3.3	Stream 50% covered in ice, Snow earlier in the week
Georges Brook	GB-U30	01-Apr-12	Past Week	Drizzle	4.3	17.2	3.9	Light snow earlier in the week
Georges Brook	GB-U30	31-May-12	Past 24-48 hrs	Heavy Storm	13.2	17.6	6.4	
Georges Brook	GB-U30	29-Jun-12	Past 24 hrs	Short Duration	15.2	24.2	7.8	Long duration showers 24-48 hours, heavy storm past week
Georges Brook	GB-U30	31-Jul-12	Past 24 hrs	Heavy Storm	16.4	26.7	12.0	Heavy storms over the past week.
Wise Brook	WB-U10	04-May-13	------	------	12.6	17.7	------	
Wise Brook	WB-U10	18-May-13	Past 24 hrs	Short Duration	12.1	18.6	------	0.45 inches of total precipitation over the past week
Wise Brook	WB-U10	23-Jun-13	Past 24 hrs	Short Duration	14.0	19.5	------	
Wise Brook	WB-U10	13-Jul-13	Past 24-48 hrs	Heavy Storm	16.8	17.7	4.1	New drainage ditch dug across field into Wise Brook 20+/- feet upstream of the Braley Road culvert

2012 and 1013 Newfound Watershed Tributary Data Listing (Volunteer Data)

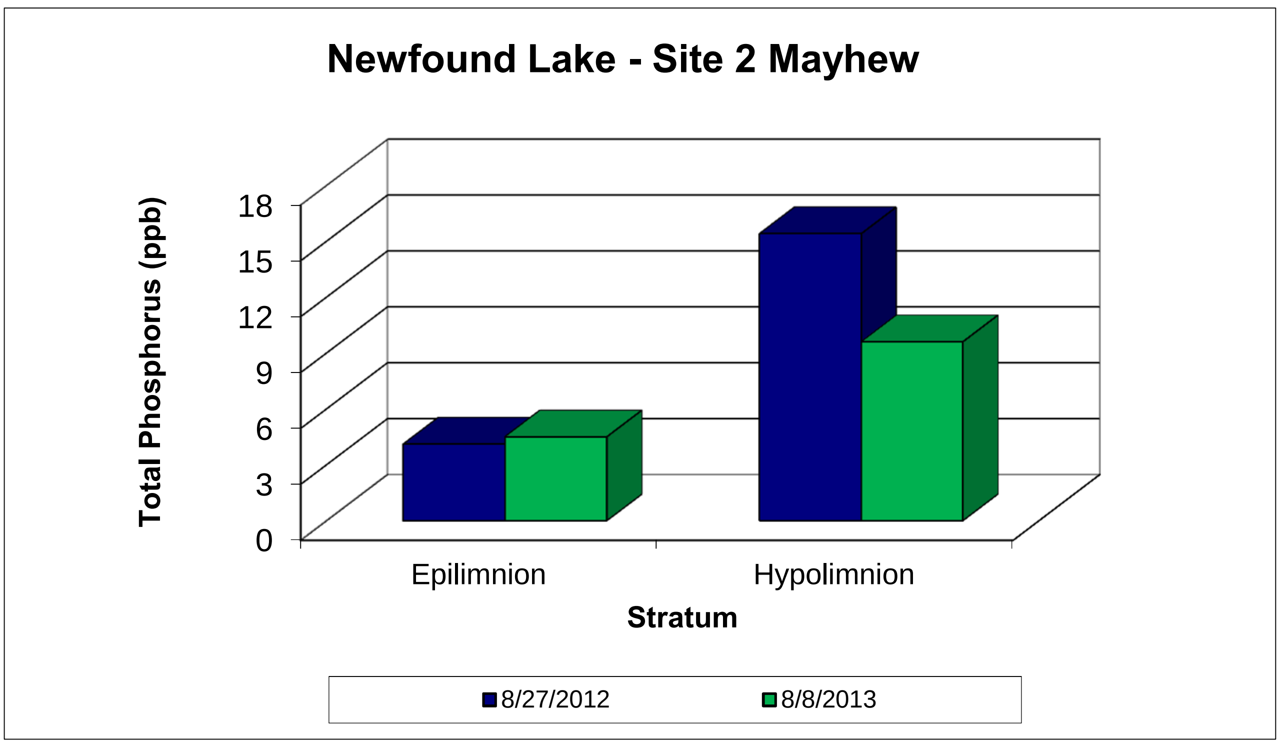
Subwatershed	Site ID	Sampling Date	Recent Rainfall	Rain Intensity	Temperature (°C)	Specidic Conductivity (uS/cm)	Total Phosphorus (ug/L)	Comments
Wise Brook	WB-U10	21-Aug-13	Past Week	Long Duration	18.0	21.3	2.1	considerable growth/tufts upstream of culvert, less abundant (but present now) downstream, slight sulfur smell -- might be from the mud
Wise Brook	WB-U10	29-Sep-13	------	------	15.1	21.8	2.6	Fields recently hayed/mowed @ Hazelton Farm (either side Wise Brook). Mink Tracks
Wise Brook	WB-U10	20-Oct-13	Past 24 hrs	Short Duration	12.0	21.4	------	Great blue herron tracks, large branches stuck against upstream end of culverts, green algae "cloud" upstream of culvers.

APPENDIX B

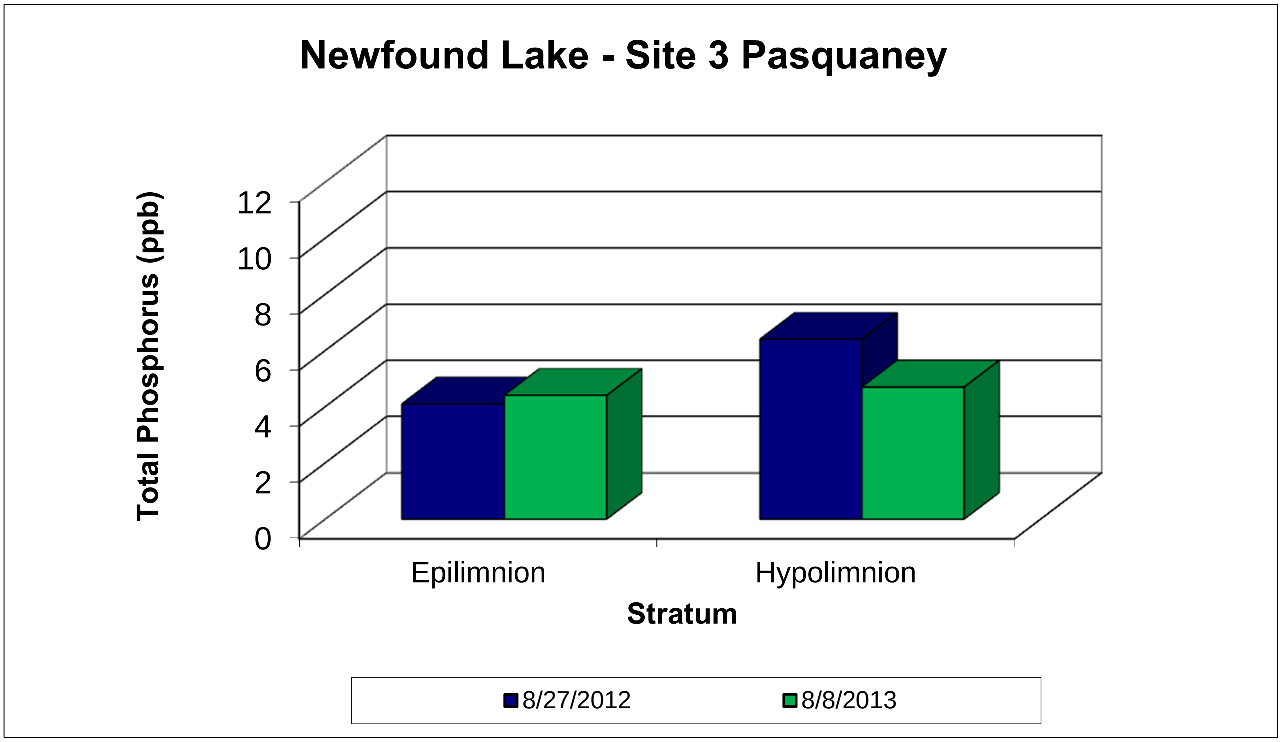
Comparison of the August 27, 2012 and the August 8, 2013 Newfound Lake total phosphorus concentrations documented in the surface waters and one-half meter off the lake bottom. The data are displayed as vertical bars that represent the total phosphorus concentrations to the nearest tenth (0.1) part per billion (ppb).

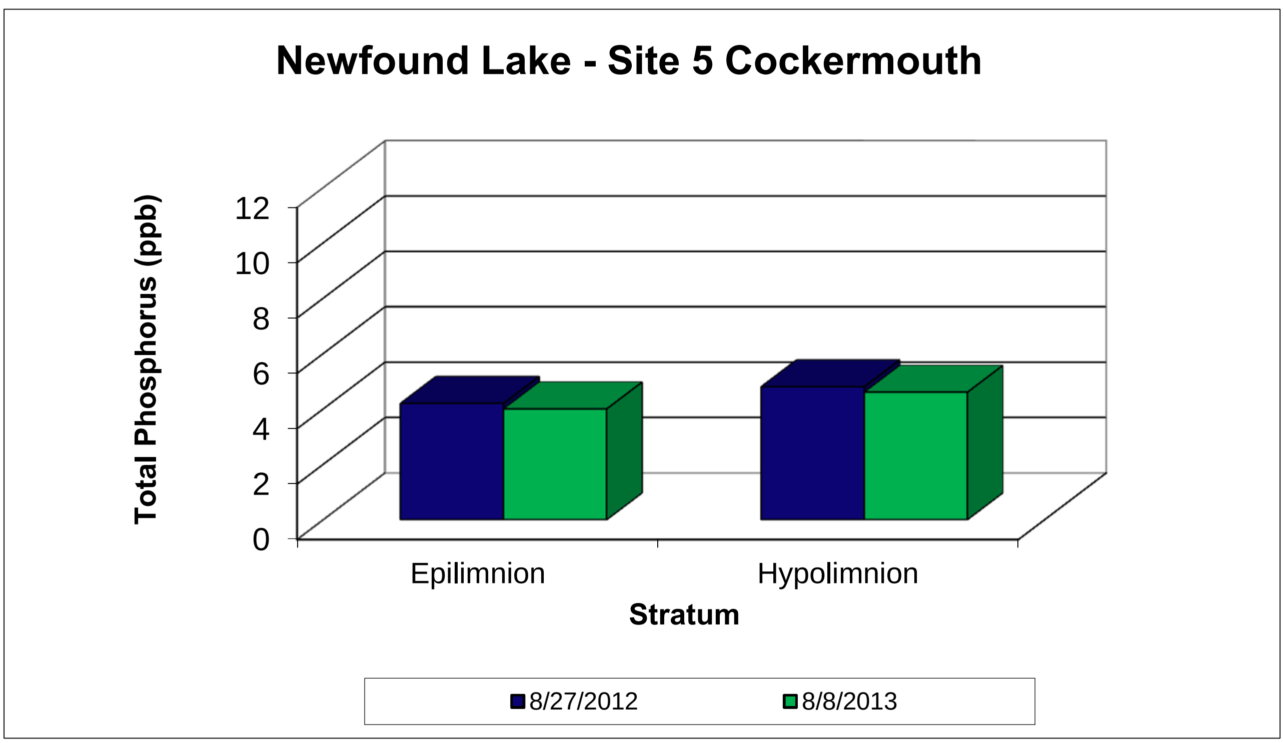


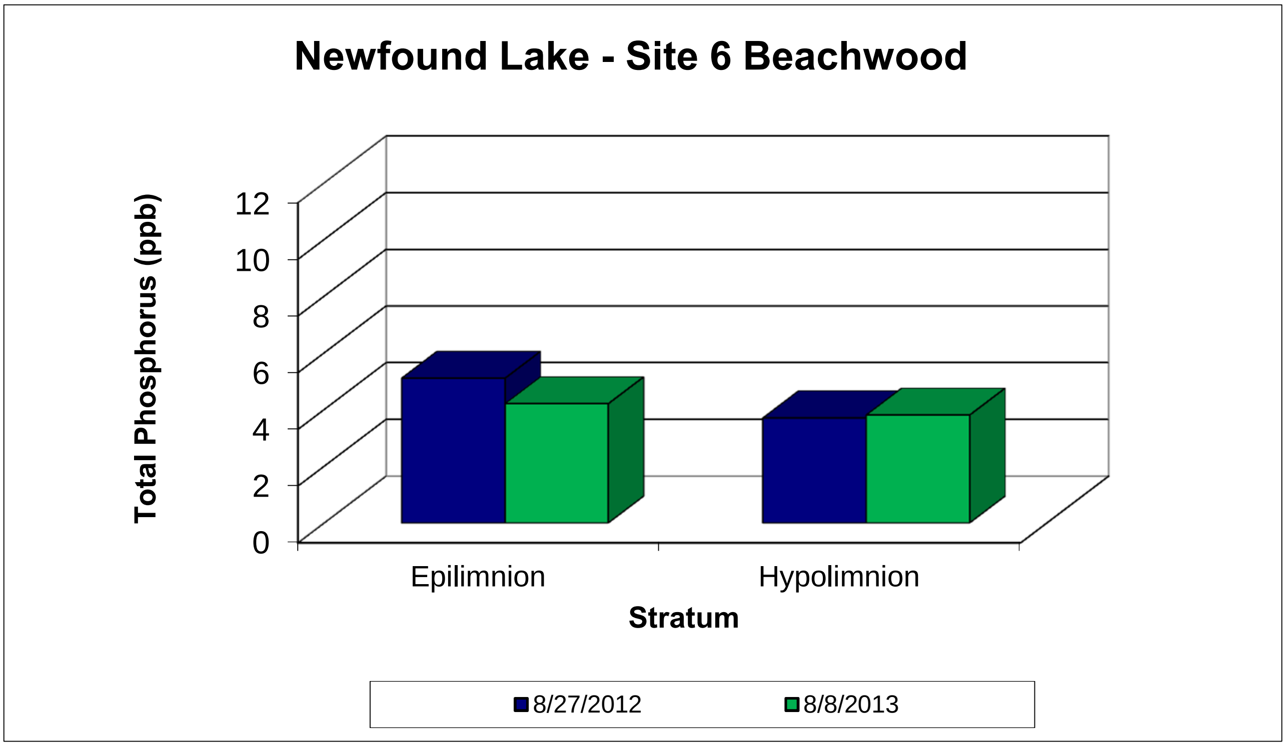
Newfound Lake - Site 1 Deep
Total Phosphorus (ppb)
12
10
8
6
4
2
0
Epilimnion
Hypolimnion
Stratum
8/27/2012
8/8/2013

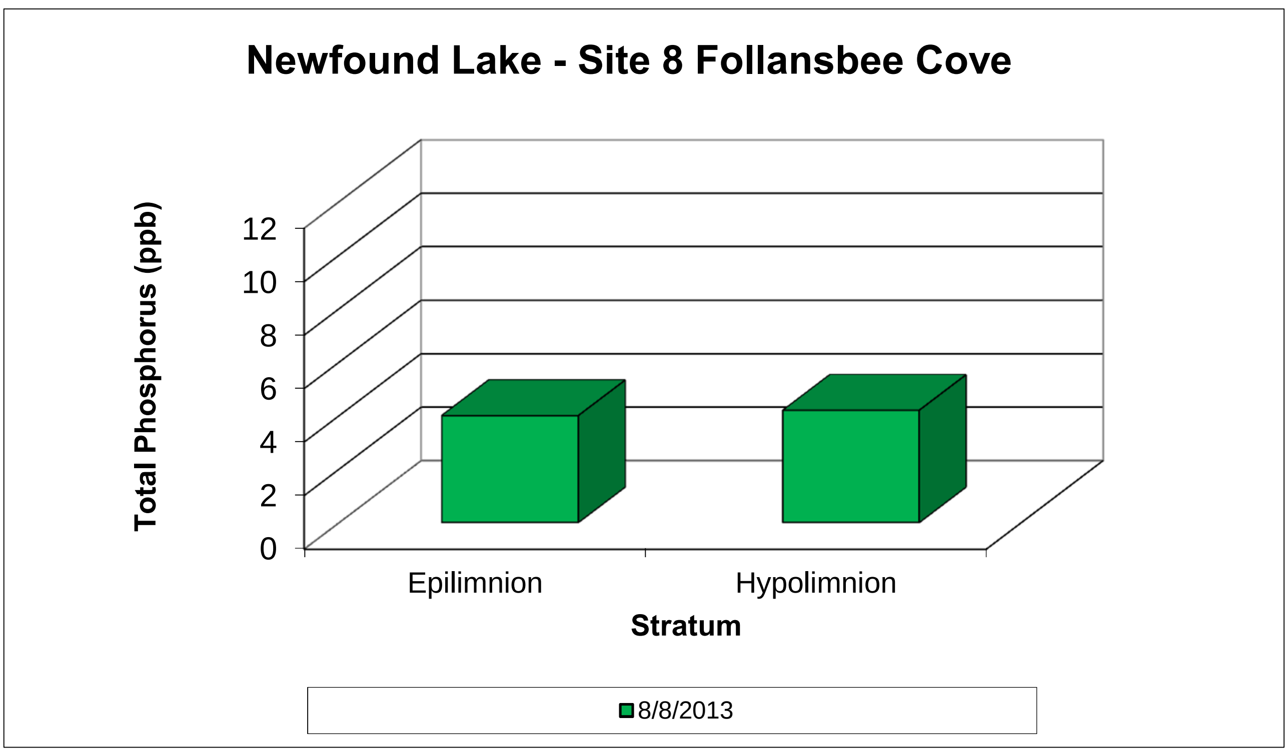


Newfound Lake - Site 2 Mayhew
Total Phosphorus (ppb)
18
15
12
9
6
3
0
Epilimnion
Hypolimnion
Stratum
8/27/2012
8/8/2013


Newfound Lake - Site 3 Pasquaney
Total Phosphorus (ppb)
12
10
8
6
4
2
0
Epilimnion
Hypolimnion
Stratum
8/27/2012
8/8/2013


Newfound Lake - Site 5 Cockermouth
Total Phosphorus (ppb)
12
10
8
6
4
2
0
Epilimnion
Hypolimnion
Stratum
8/27/2012
8/8/2013


Newfound Lake - Site 6 Beachwood
Total Phosphorus (ppb)
0
2
4
6
8
10
12
Epilimnion
Hypolimnion
Stratum
8/27/2012
8/8/2013

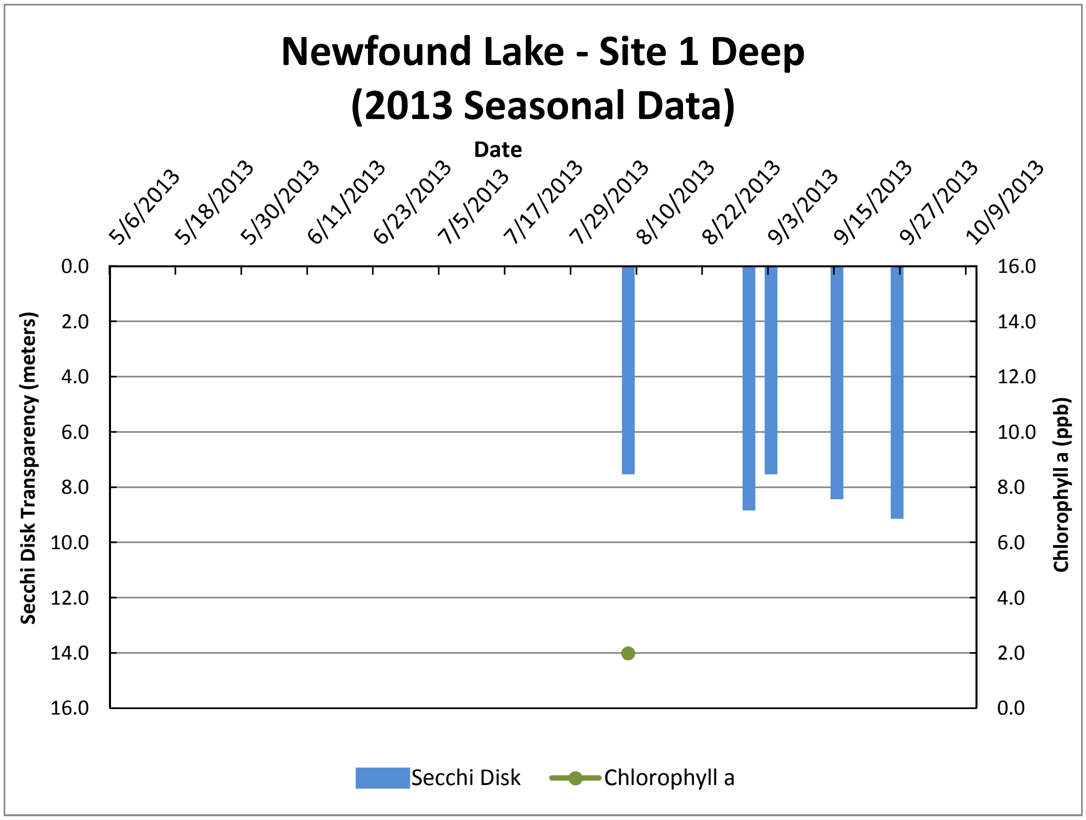

Newfound Lake - Site 8 Follansbee Cove
Total Phosphorus (ppb)
0
2
4
6
8
10
12
Epilimnion
Hypolimnion
Stratum
8/8/2013

APPENDIX C

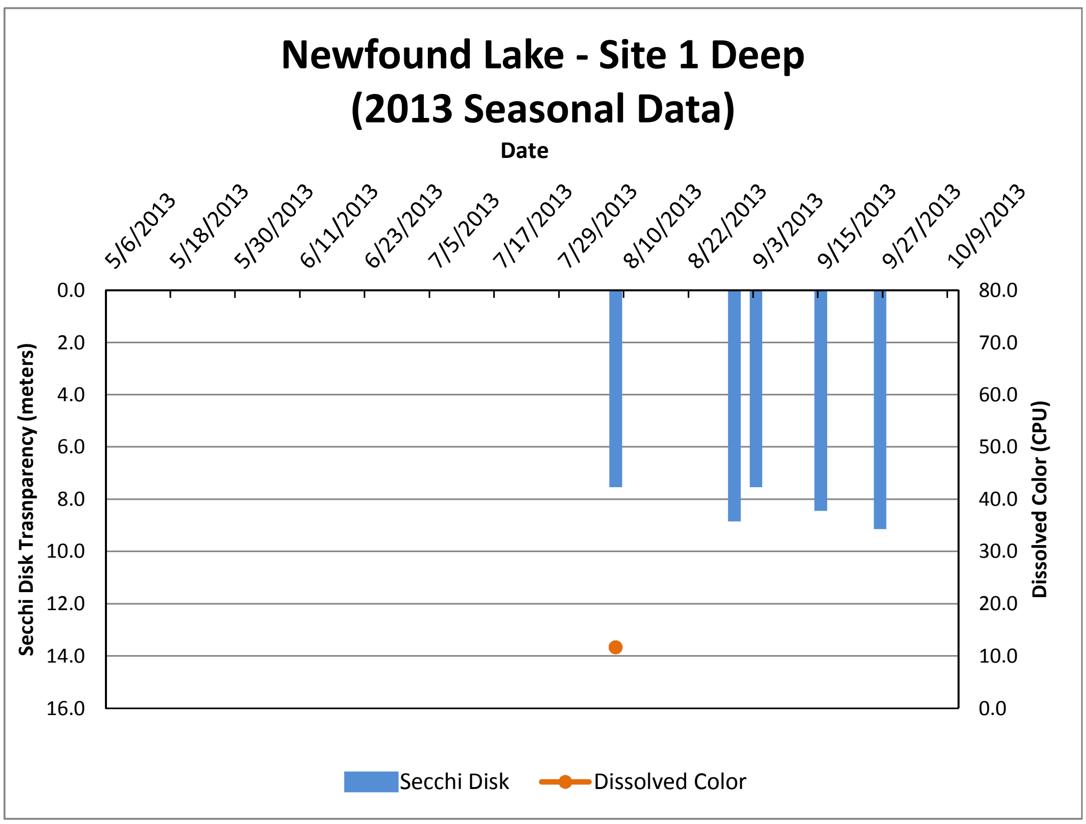
Newfound Lake, 2013. Seasonal Secchi Disk (water transparency) and chlorophyll *a* measurements. The Secchi Disk transparency data are reported to the nearest 0.1 meters while the chlorophyll *a* data are reported to the nearest 0.1 parts per billion (ppb).

Newfound Lake, 2013. Seasonal Secchi Disk (water transparency) and dissolved color measurements. The Secchi Disk transparency data are reported to the nearest 0.1 meters while the dissolved color data are reported to the nearest 0.1 chloroplatinate unit (CPU).

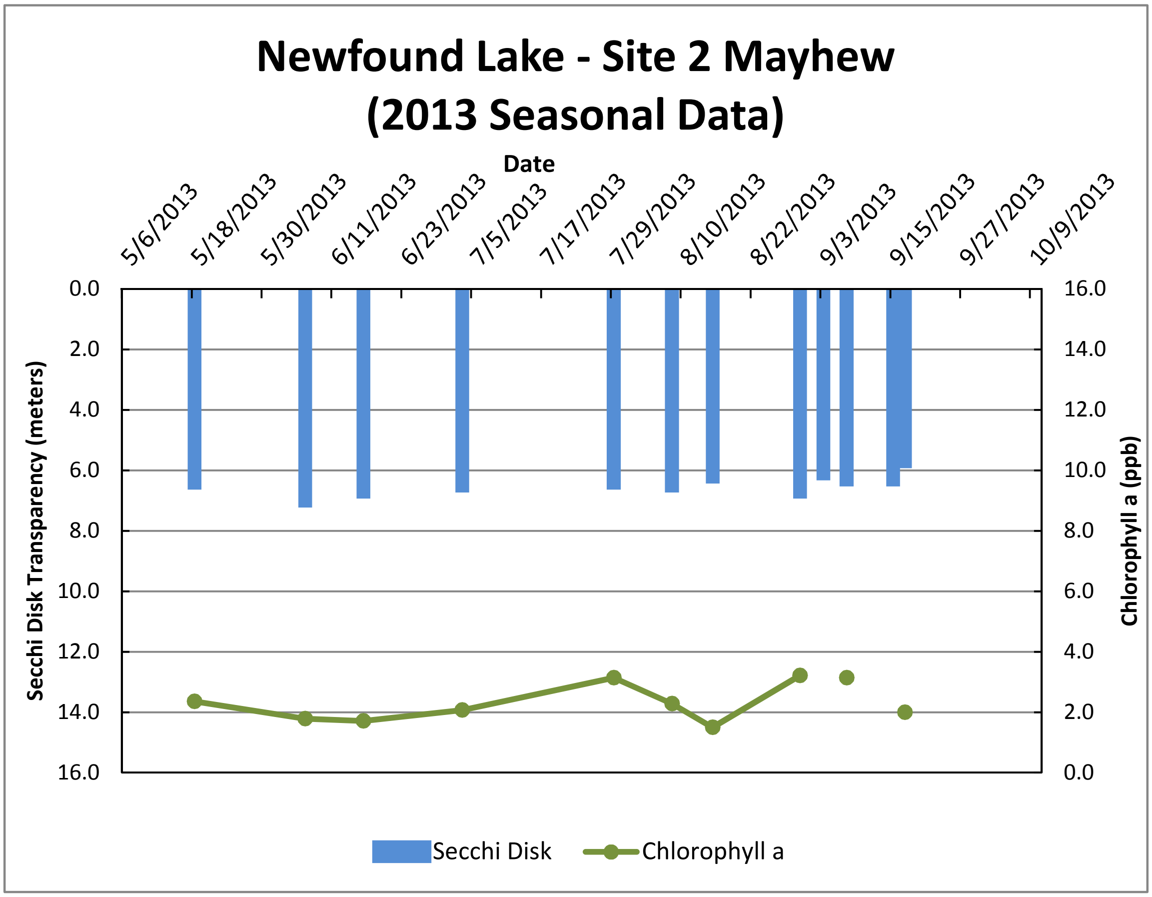
Note: the overlay of the Secchi Disk data with chlorophyll *a* and dissolved color data is intended to provide a visual depiction of the impacts of chlorophyll *a* and dissolved color on water transparency measurements (e.g. higher chlorophyll a and dissolved color concentrations often correspond to shallower water transparencies).



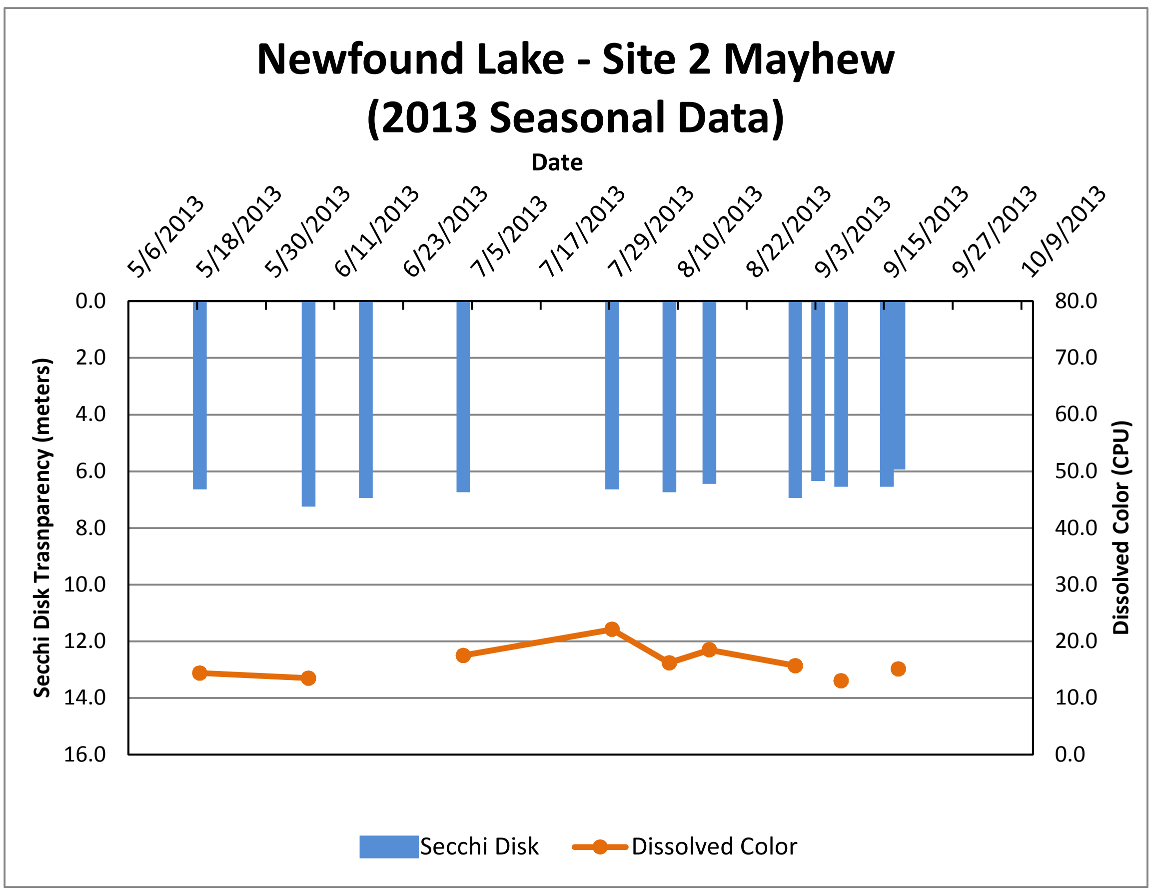
Newfound Lake - Site 1 Deep
(2013 Seasonal Data)
Date
5/6/2013
5/18/2013
5/30/2013
6/11/2013
6/23/2013
7/5/2013
7/17/2013
7/29/2013
8/10/2013
8/22/2013
9/3/2013
9/15/2013
9/27/2013
10/9/2013
Secchi Disk Transparency (meters)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
Chlorophyll a (ppb)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Secchi Disk
Chlorophyll a



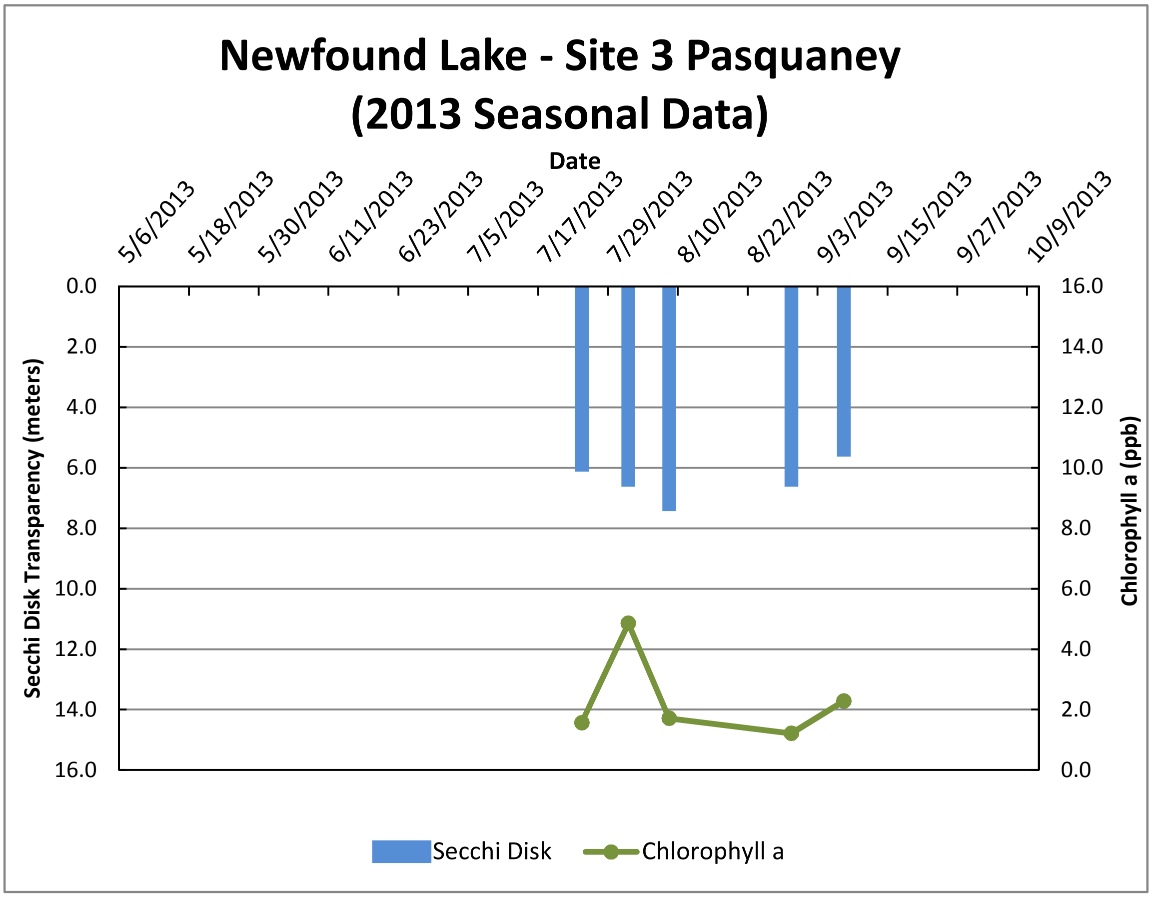
Newfound Lake - Site 1 Deep
(2013 Seasonal Data)
Date
5/6/2013
5/18/2013
5/30/2013
6/11/2013
6/23/2013
7/5/2013
7/17/2013
7/29/2013
8/10/2013
8/22/2013
9/3/2013
9/15/2013
9/27/2013
10/9/2013
Secchi Disk Trasnparency (meters)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
Dissolved Color (CPU)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Secchi Disk
Dissolved Color

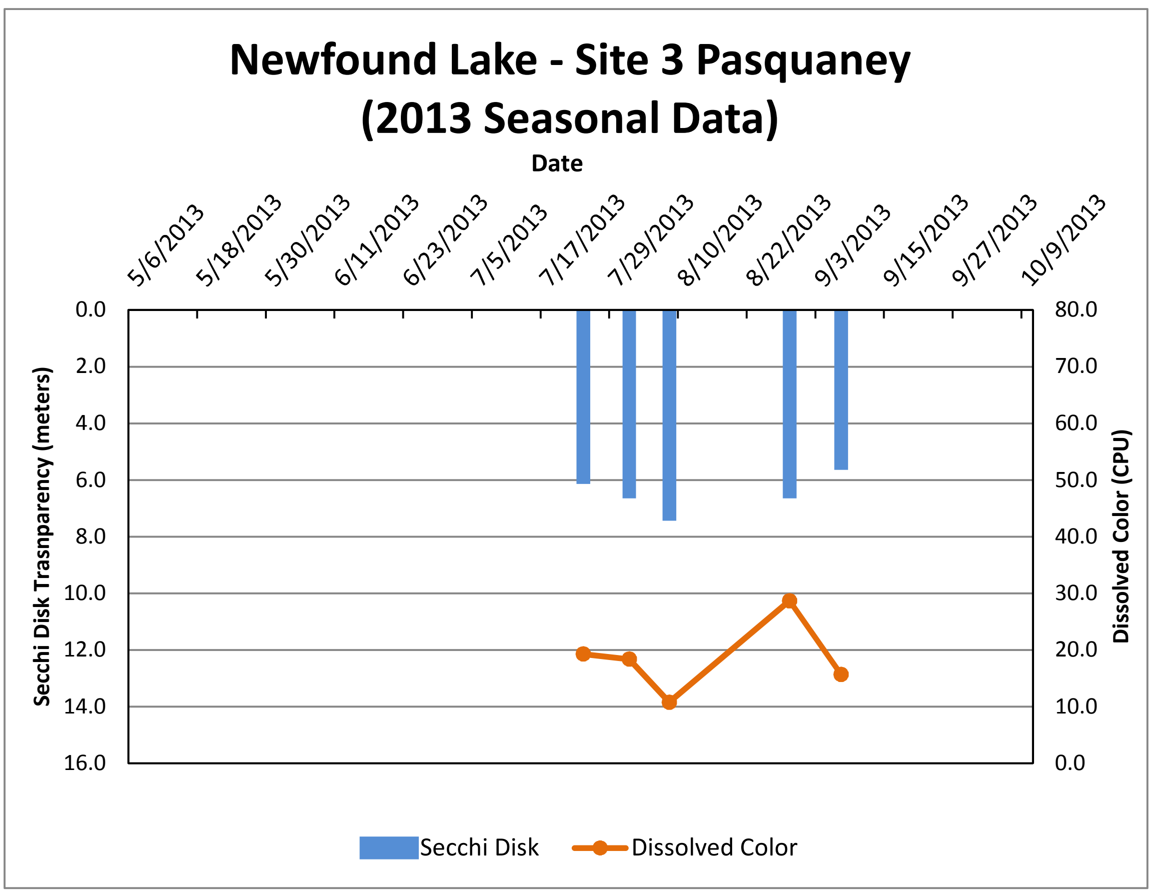


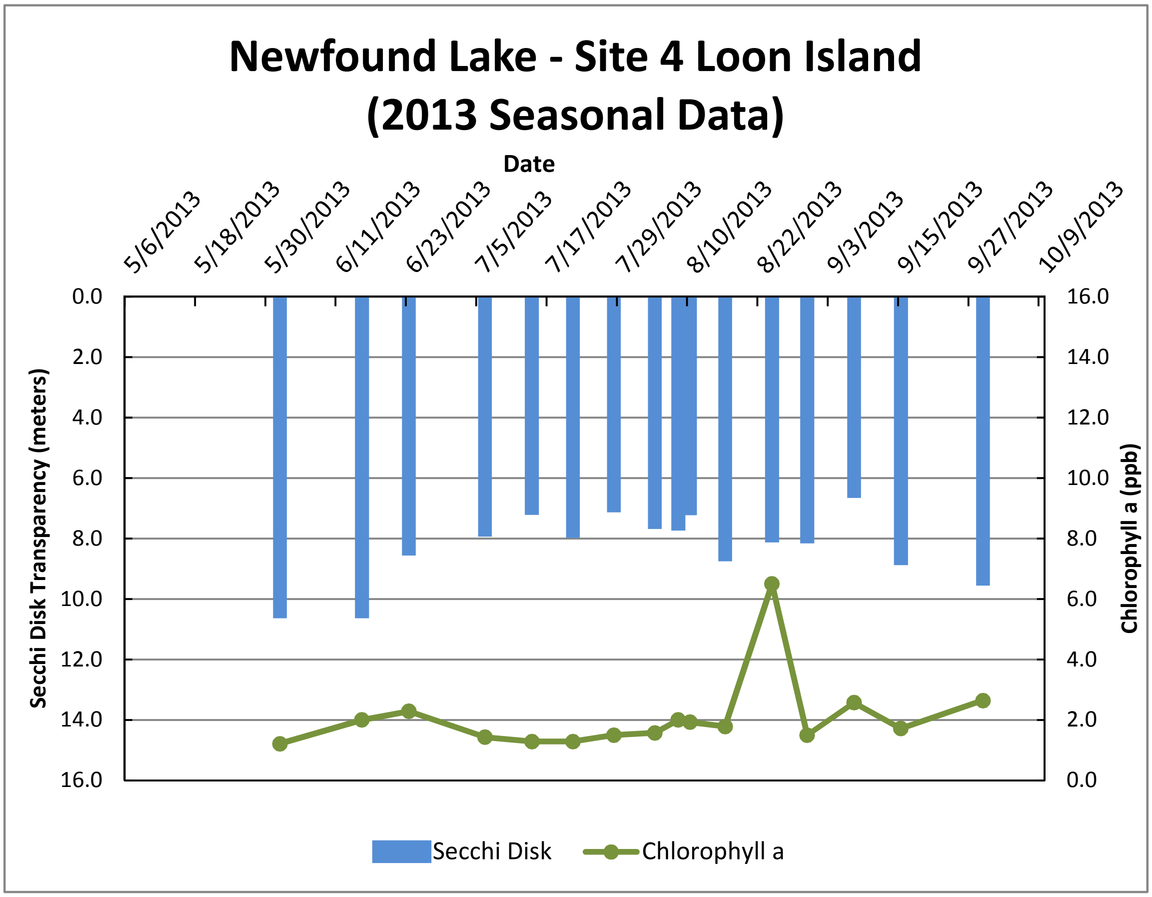
Newfound Lake - Site 2 Mayhew
(2013 Seasonal Data)
Date
5/6/2013
5/18/2013
5/30/2013
6/11/2013
6/23/2013
7/5/2013
7/17/2013
7/29/2013
8/10/2013
8/22/2013
9/3/2013
9/15/2013
9/27/2013
10/9/2013
Secchi Disk Transparency (meters)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
Chlorophyll a (ppb)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Secchi Disk
Chlorophyll a

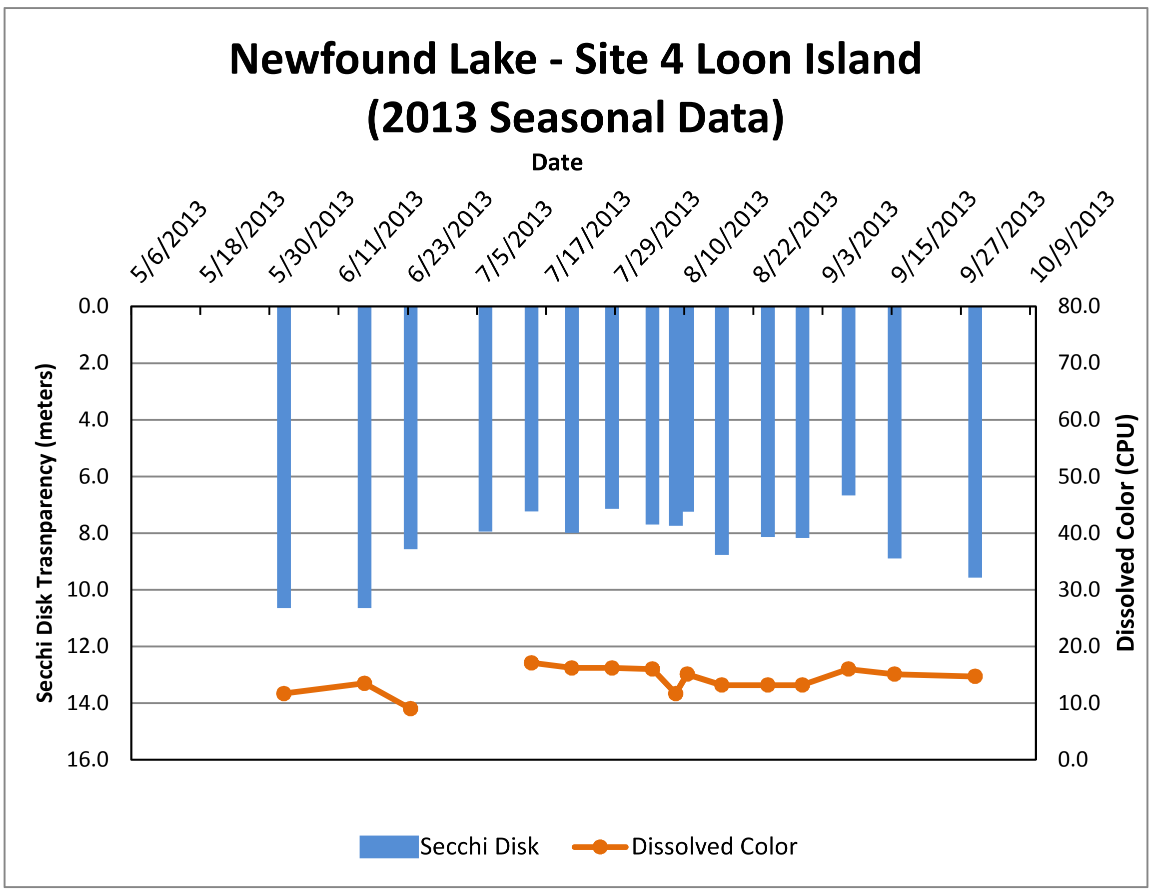


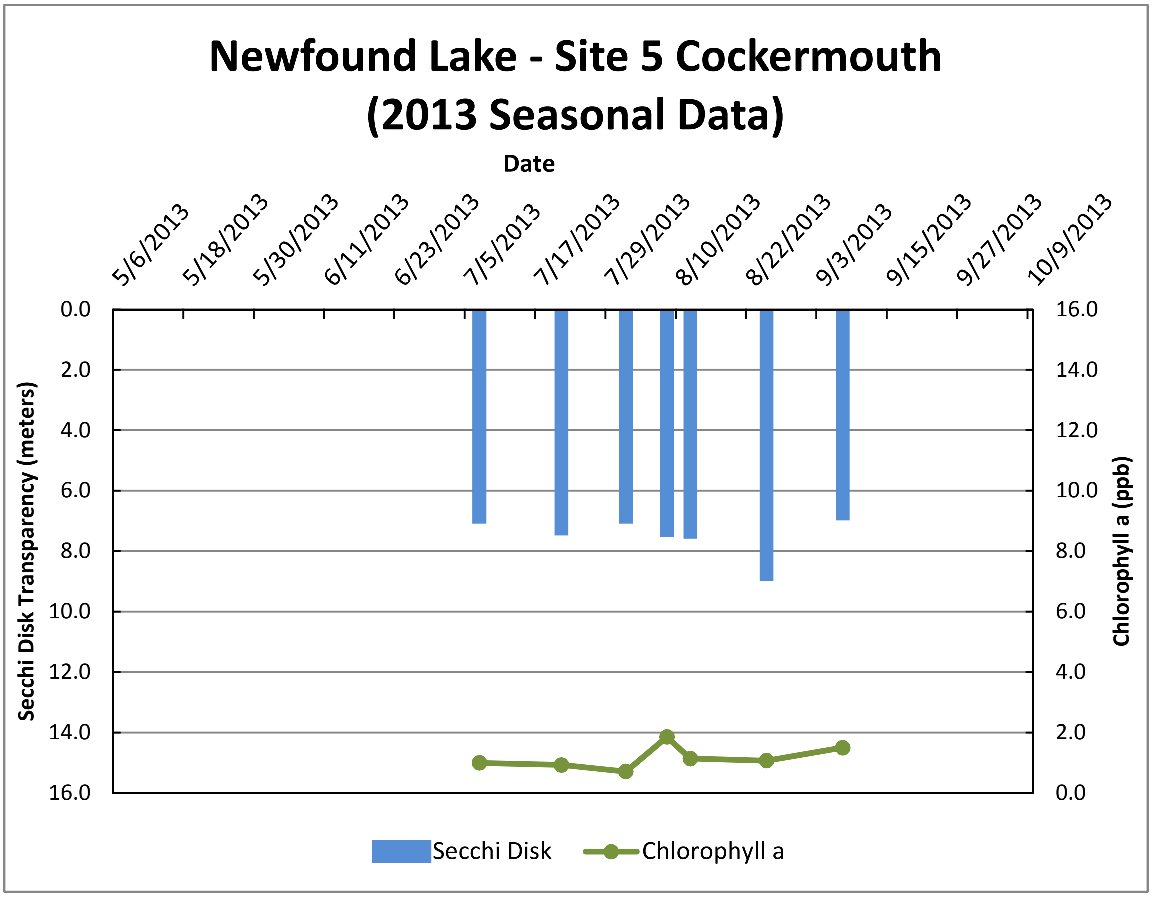
Newfound Lake - Site 2 Mayhew
(2013 Seasonal Data)
Date
5/6/2013
5/18/2013
5/30/2013
6/11/2013
6/23/2013
7/5/2013
7/17/2013
7/29/2013
8/10/2013
8/22/2013
9/3/2013
9/15/2013
9/27/2013
10/9/2013
Secchi Disk Trasnparency (meters)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
Dissolved Color (CPU)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Secchi Disk
Dissolved Color

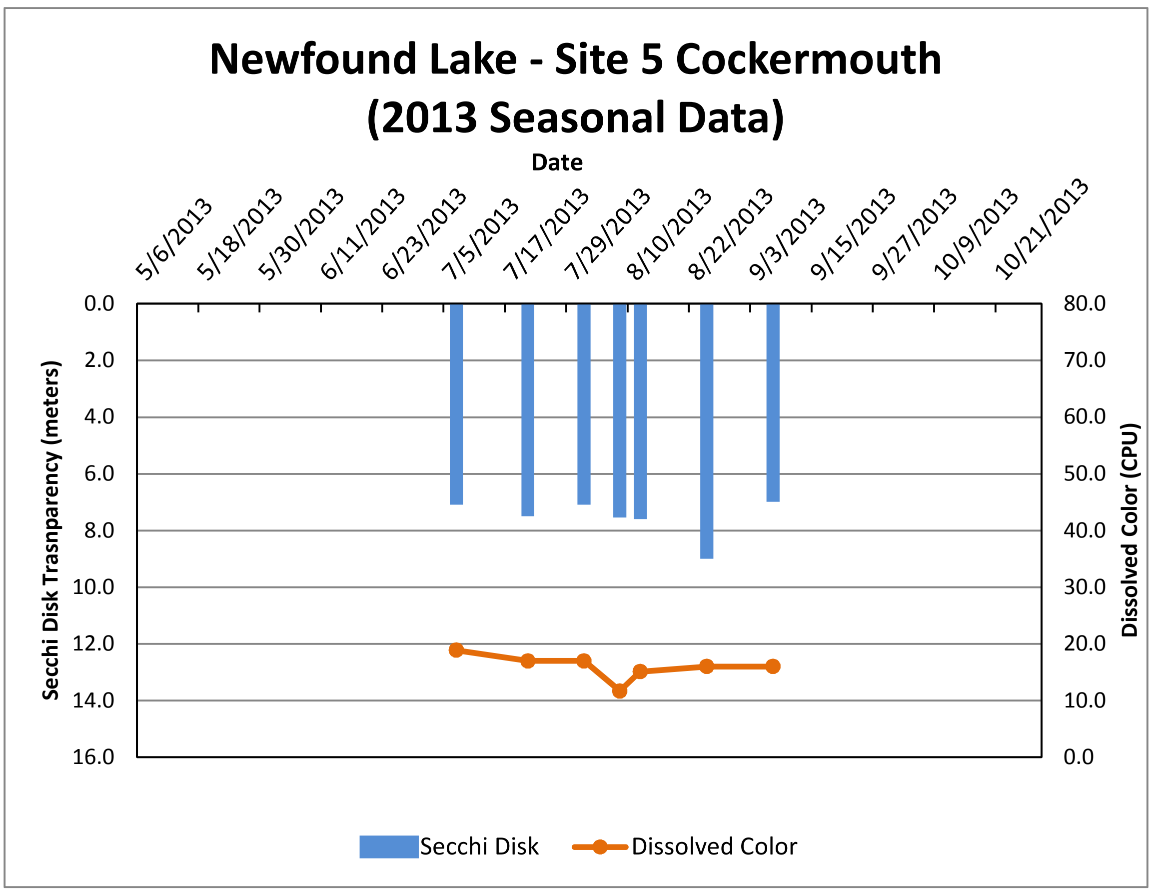

Newfound Lake - Site 3 Pasquaney
(2013 Seasonal Data)
Date
5/6/2013
5/18/2013
5/30/2013
6/11/2013
6/23/2013
7/5/2013
7/17/2013
7/29/2013
8/10/2013
8/22/2013
9/3/2013
9/15/2013
9/27/2013
10/9/2013
Secchi Disk Transparency (meters)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
Chlorophyll a (ppb)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Secchi Disk
Chlorophyll a

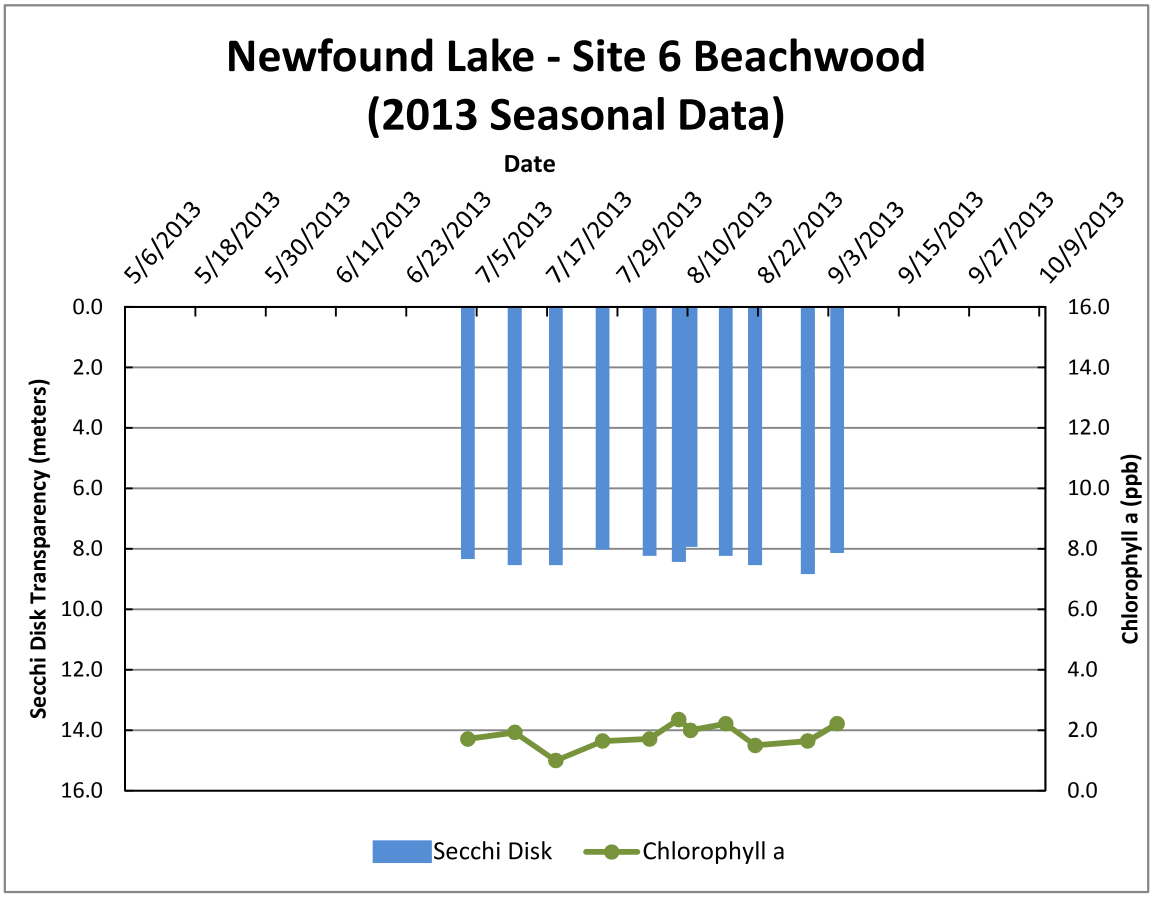

Newfound Lake - Site 3 Pasquaney
(2013 Seasonal Data)
Date
5/6/2013
5/18/2013
5/30/2013
6/11/2013
6/23/2013
7/5/2013
7/17/2013
7/29/2013
8/10/2013
8/22/2013
9/3/2013
9/15/2013
9/27/2013
10/9/2013
Secchi Disk Trasnparency (meters)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
Dissolved Color (CPU)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Secchi Disk
Dissolved Color

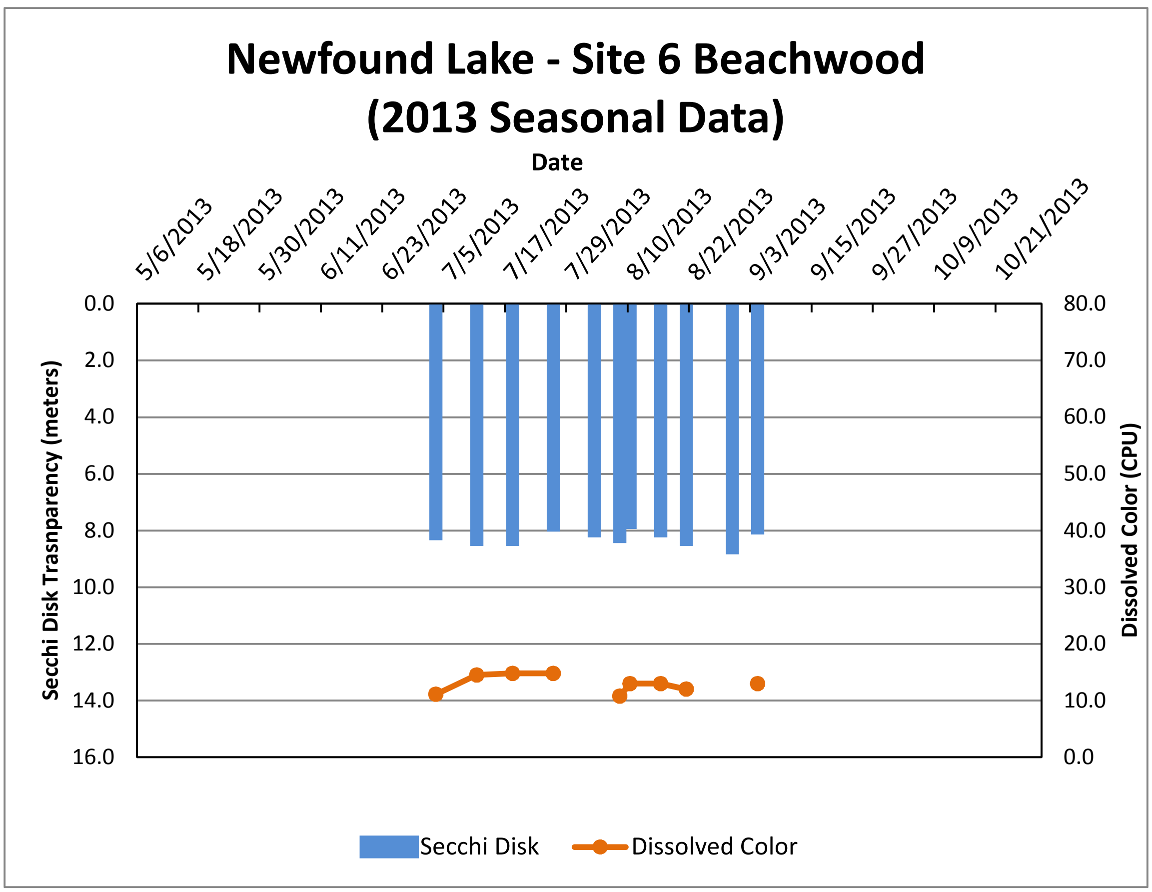

Newfound Lake - Site 4 Loon Island
(2013 Seasonal Data)
Date
5/6/2013
5/18/2013
5/30/2013
6/11/2013
6/23/2013
7/5/2013
7/17/2013
7/29/2013
8/10/2013
8/22/2013
9/3/2013
9/15/2013
9/27/2013
10/9/2013
Secchi Disk Transparency (meters)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
Chlorophyll a (ppb)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Secchi Disk
Chlorophyll a

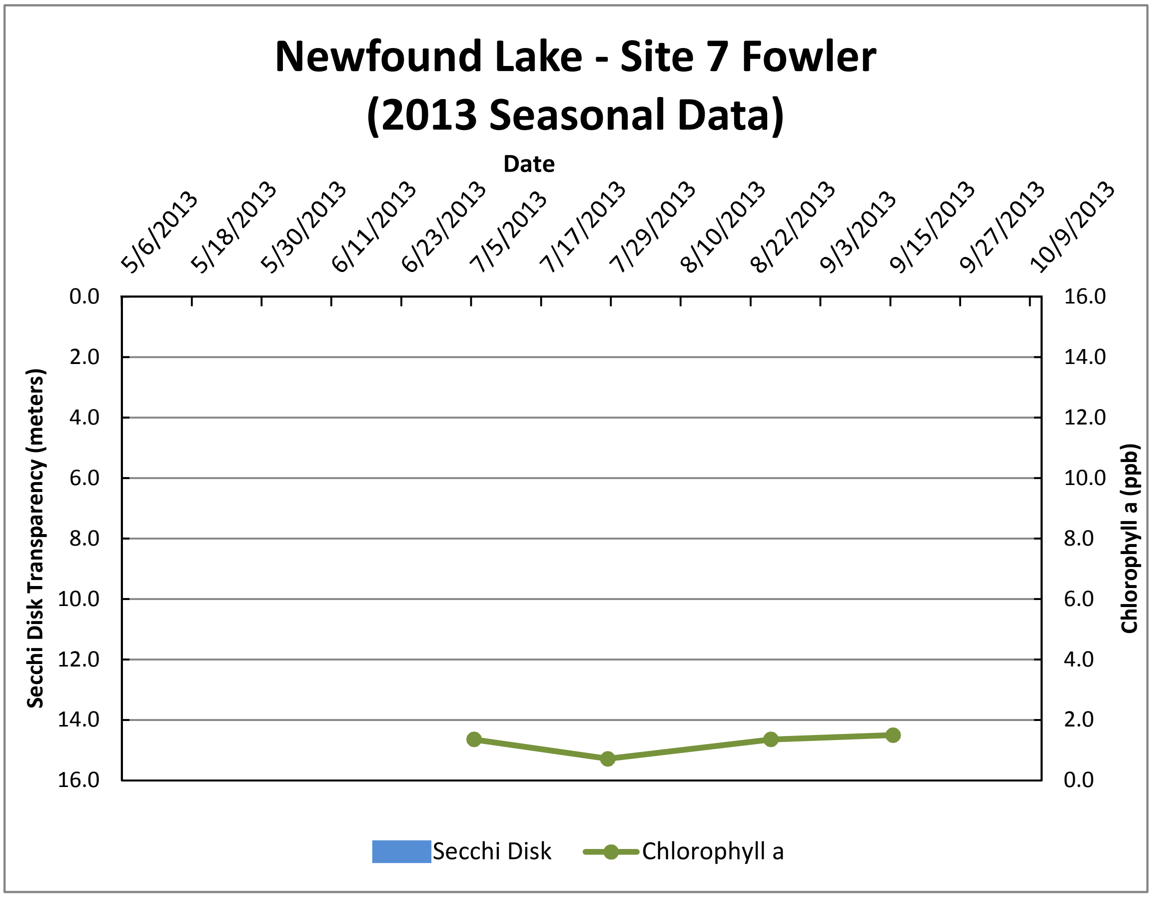

Newfound Lake - Site 4 Loon Island
(2013 Seasonal Data)
Date
5/6/2013
5/18/2013
5/30/2013
6/11/2013
6/23/2013
7/5/2013
7/17/2013
7/29/2013
8/10/2013
8/22/2013
9/3/2013
9/15/2013
9/27/2013
10/9/2013
Secchi Disk Trasnparency (meters)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
Dissolved Color (CPU)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Secchi Disk
Dissolved Color


Newfound Lake - Site 5 Cockermouth
(2013 Seasonal Data)
Date
5/6/2013
5/18/2013
5/30/2013
6/11/2013
6/23/2013
7/5/2013
7/17/2013
7/29/2013
8/10/2013
8/22/2013
9/3/2013
9/15/2013
9/27/2013
10/9/2013
Secchi Disk Transparency (meters)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
Chlorophyll a (ppb)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Secchi Disk
Chlorophyll a

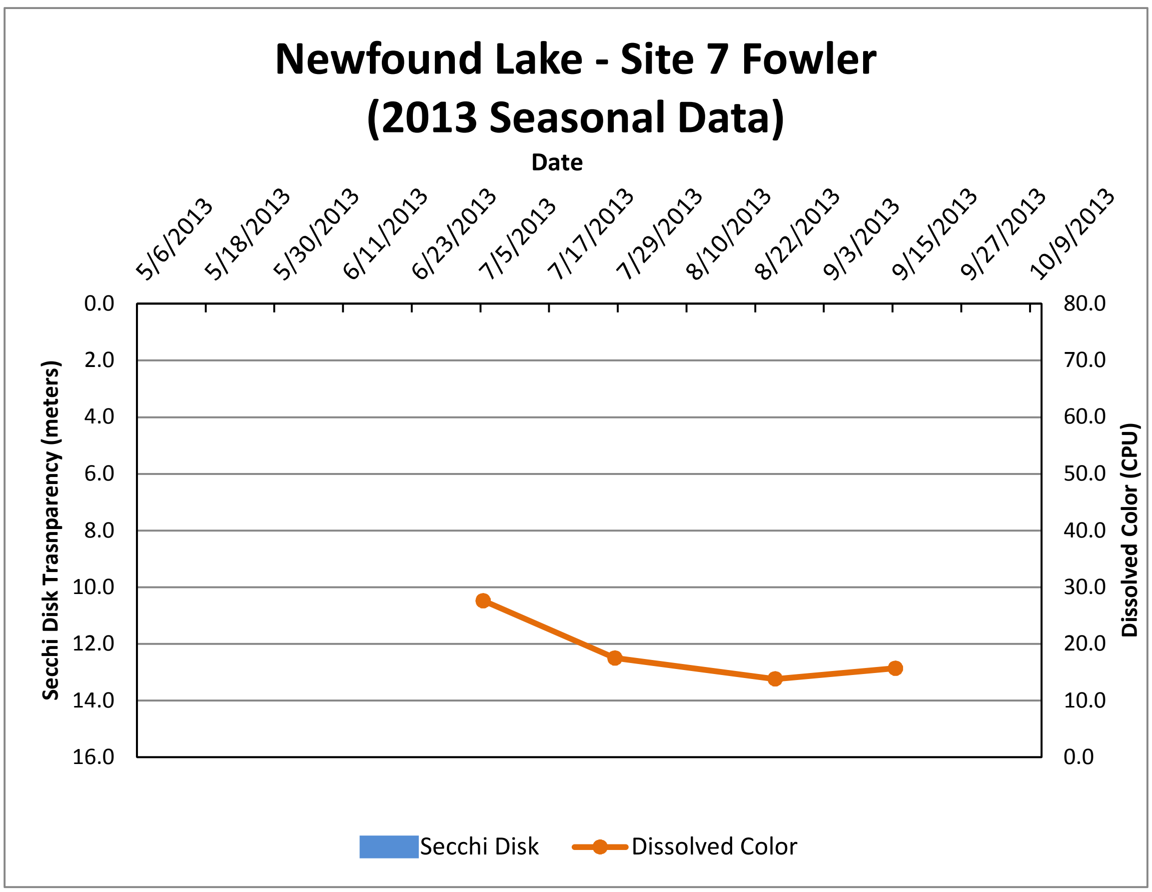

Newfound Lake - Site 5 Cockermouth
(2013 Seasonal Data)
Date
5/6/2013
5/18/2013
5/30/2013
6/11/2013
6/23/2013
7/5/2013
7/17/2013
7/29/2013
8/10/2013
8/22/2013
9/3/2013
9/15/2013
9/27/2013
10/9/2013
10/21/2013
Secchi Disk Trasnparency (meters)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
Dissolved Color (CPU)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Secchi Disk
Dissolved Color


Newfound Lake - Site 6 Beachwood
(2013 Seasonal Data)
Date
5/6/2013
5/18/2013
5/30/2013
6/11/2013
6/23/2013
7/5/2013
7/17/2013
7/29/2013
8/10/2013
8/22/2013
9/3/2013
9/15/2013
9/27/2013
10/9/2013
Secchi Disk Transparency (meters)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
Chlorophyll a (ppb)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Secchi Disk
Chlorophyll a

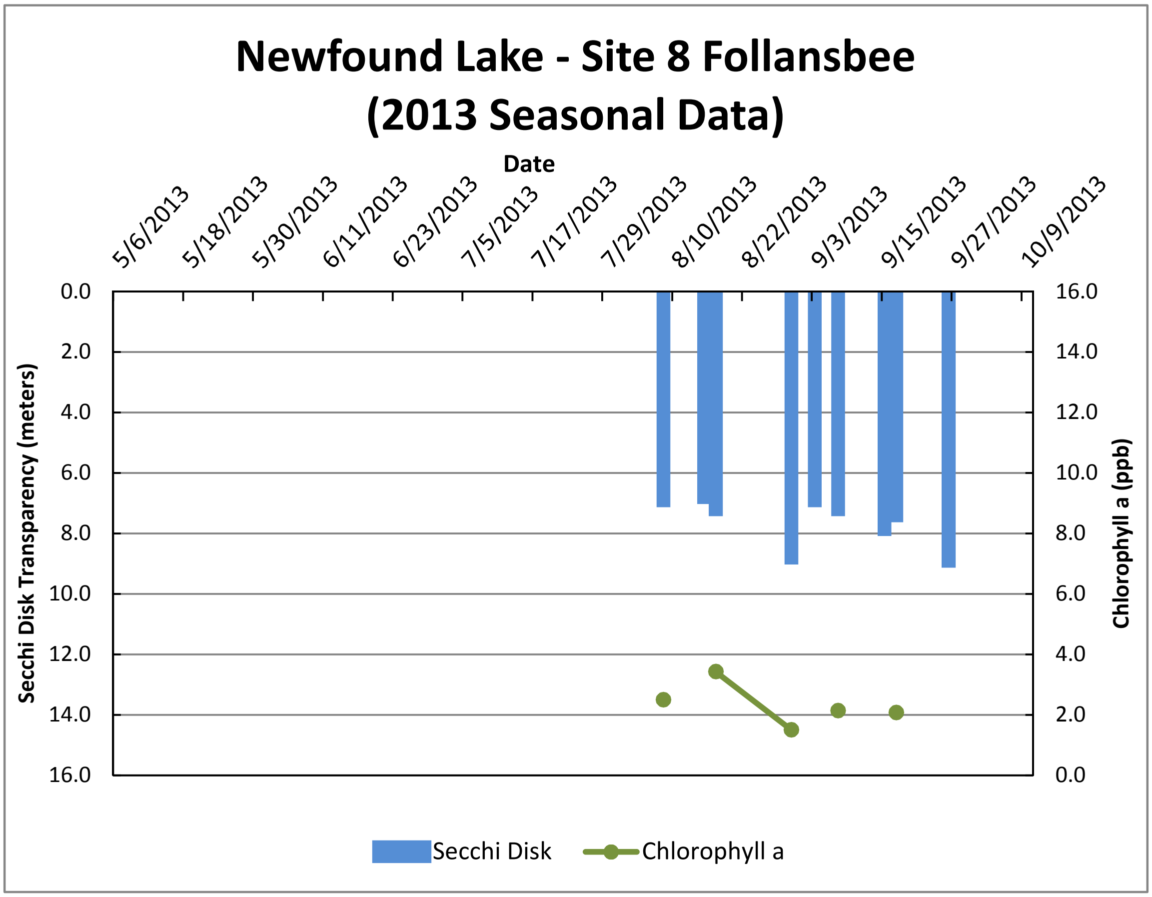

Newfound Lake - Site 6 Beachwood
(2013 Seasonal Data)
Date
5/6/2013
5/18/2013
5/30/2013
6/11/2013
6/23/2013
7/5/2013
7/17/2013
7/29/2013
8/10/2013
8/22/2013
9/3/2013
9/15/2013
9/27/2013
10/9/2013
10/21/2013
Secchi Disk Trasnparency (meters)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
Dissolved Color (CPU)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Secchi Disk
Dissolved Color

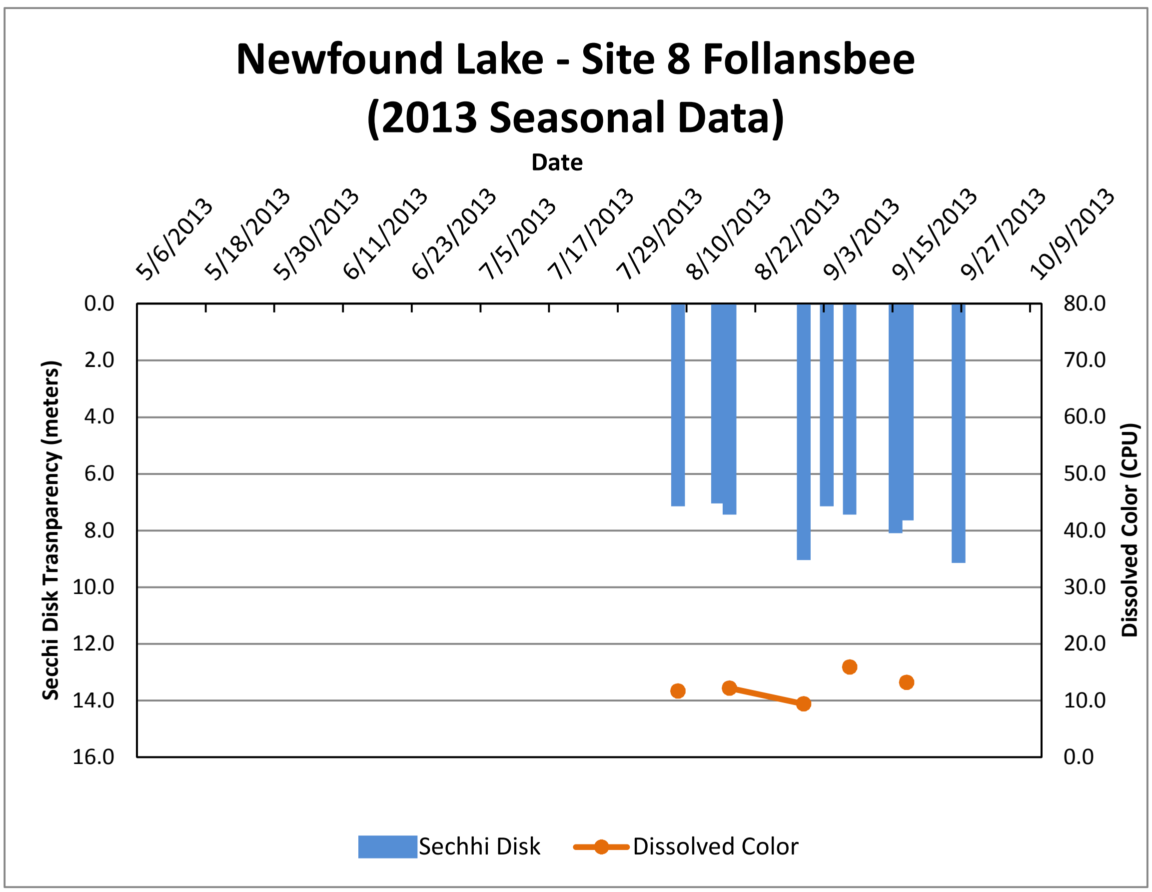


Newfound Lake - Site 7 Fowler
(2013 Seasonal Data)
Date
5/6/2013
5/18/2013
5/30/2013
6/11/2013
6/23/2013
7/5/2013
7/17/2013
7/29/2013
8/10/2013
8/22/2013
9/3/2013
9/15/2013
9/27/2013
10/9/2013
Secchi Disk Transparency (meters)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
Chlorophyll a (ppb)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Secchi Disk
Chlorophyll a



Newfound Lake - Site 7 Fowler
(2013 Seasonal Data)
Date
5/6/2013
5/18/2013
5/30/2013
6/11/2013
6/23/2013
7/5/2013
7/17/2013
7/29/2013
8/10/2013
8/22/2013
9/3/2013
9/15/2013
9/27/2013
10/9/2013
Secchi Disk Trasnparency (meters)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
Dissolved Color (CPU)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Secchi Disk
Dissolved Color


Newfound Lake - Site 8 Follansbee
(2013 Seasonal Data)
Date
5/6/2013
5/18/2013
5/30/2013
6/11/2013
6/23/2013
7/5/2013
7/17/2013
7/29/2013
8/10/2013
8/22/2013
9/3/2013
9/15/2013
9/27/2013
10/9/2013
Secchi Disk Transparency (meters)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
Chlorophyll a (ppb)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Secchi Disk
Chlorophyll a

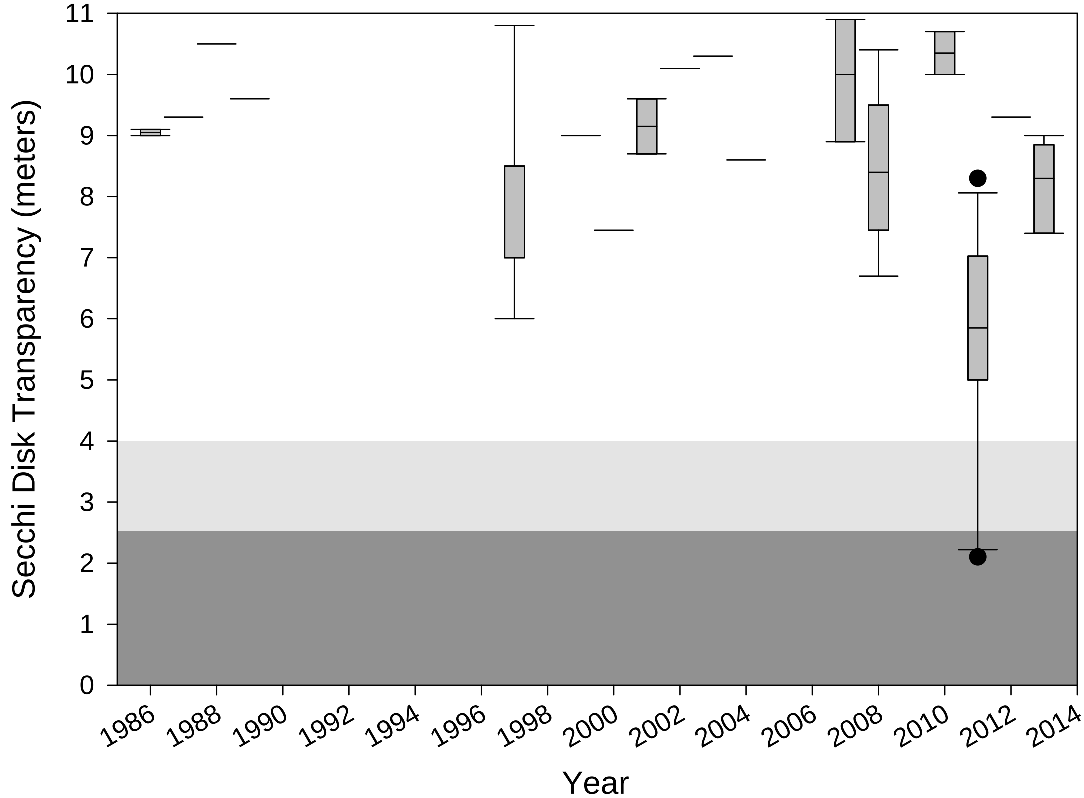

Newfound Lake - Site 8 Follansbee
(2013 Seasonal Data)
Date
5/6/2013
5/18/2013
5/30/2013
6/11/2013
6/23/2013
7/5/2013
7/17/2013
7/29/2013
8/10/2013
8/22/2013
9/3/2013
9/15/2013
9/27/2013
10/9/2013
Secchi Disk Trasnparency (meters)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
Dissolved Color (CPU)
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Sechhi Disk
Dissolved Color

APPENDIX D

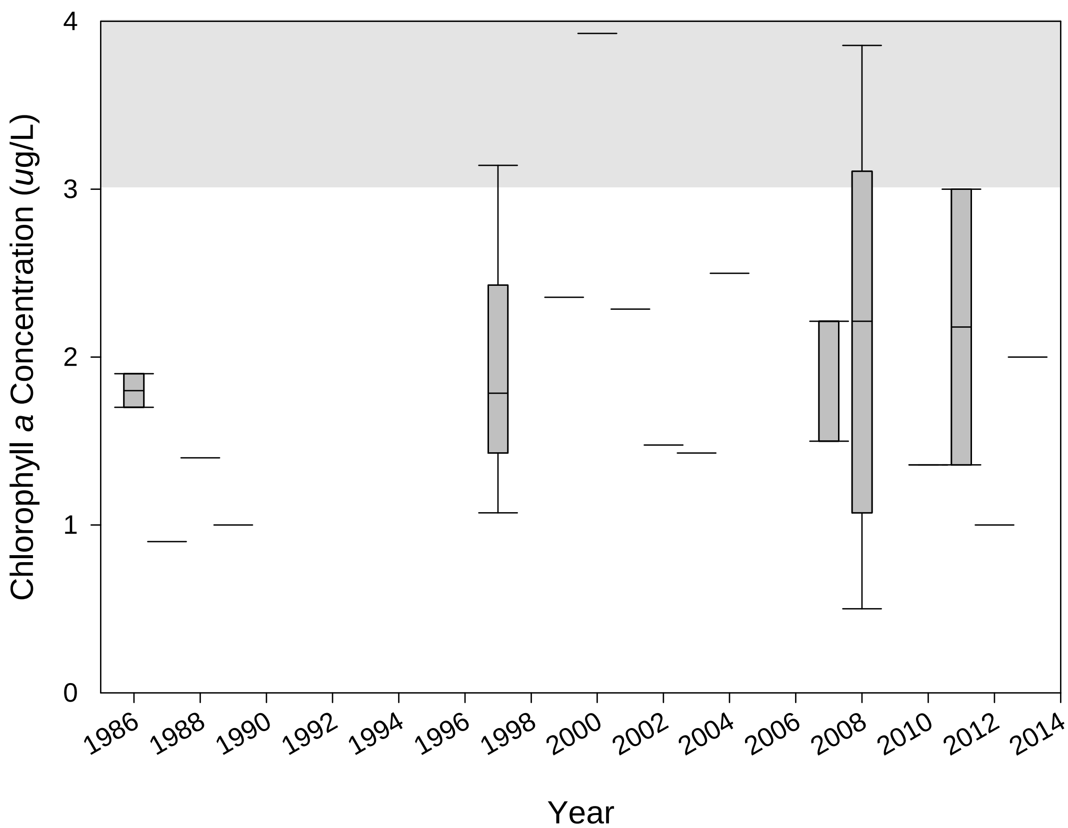
Comparison of the annual Newfound Lake Secchi Disk transparency data that are presented as box and whisker plots. The line in the “box” represents the sample median, the extent of the “box” represents a statistical range for comparison to another year, the “whiskers” show the boundaries of what could be considered the representative range of all the samples, and any points above or below the whiskers show atypical readings or “outliers” that represent an extreme condition or difference from that year’s data range. The gray shaded areas on the graph denote the ranges characteristic of unproductive (non-shaded), moderately productive (light gray shading), and highly productive (dark gray shading) lakes.

Comparison of the annual Newfound Lake chlorophyll *a* data that are presented as box and whisker plots. The line in the “box” represents the sample median, the extent of the “box” represents a statistical range for comparison to another year, the “whiskers” show the boundaries of what could be considered the representative range of all the samples, and any points above or below the whiskers show atypical readings or “outliers” that represent an extreme condition or difference from that year’s data range. The gray shaded areas on the graph denote the ranges characteristic of unproductive (non-shaded), moderately productive (light gray shading), and highly productive (dark gray shading) lakes.

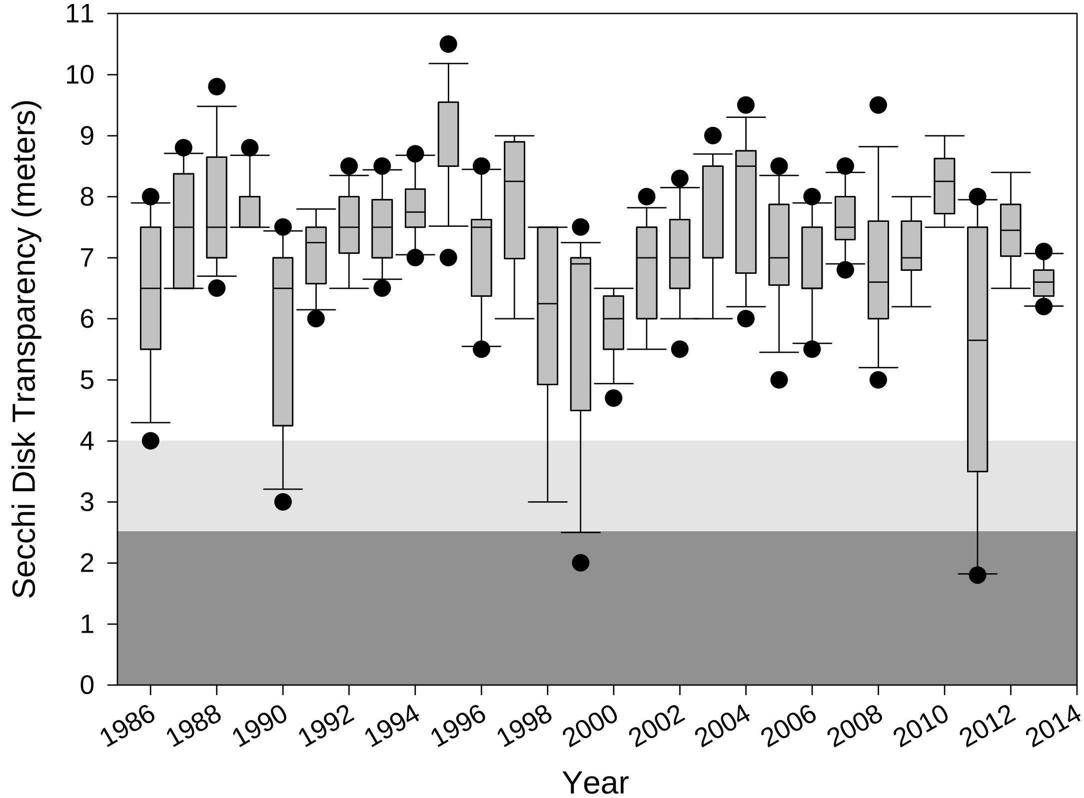
Newfound Lake -- Site 1 Deep
Annual Secchi Disk Transparency Comparisons
Box and Whisker Plots: 1986-2013



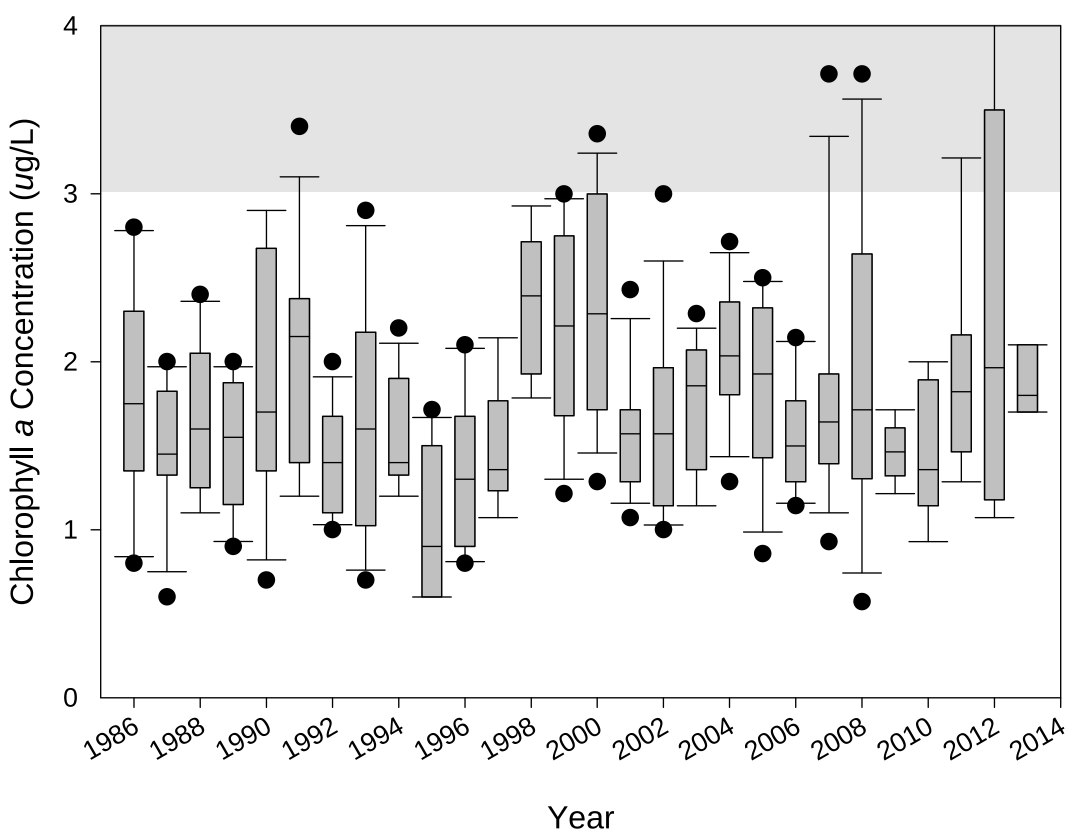
Newfound Lake -- Site 1 Deep
Annual Chlorophyll *a* Comparisons
Box and Whisker Plots: 1986-2013



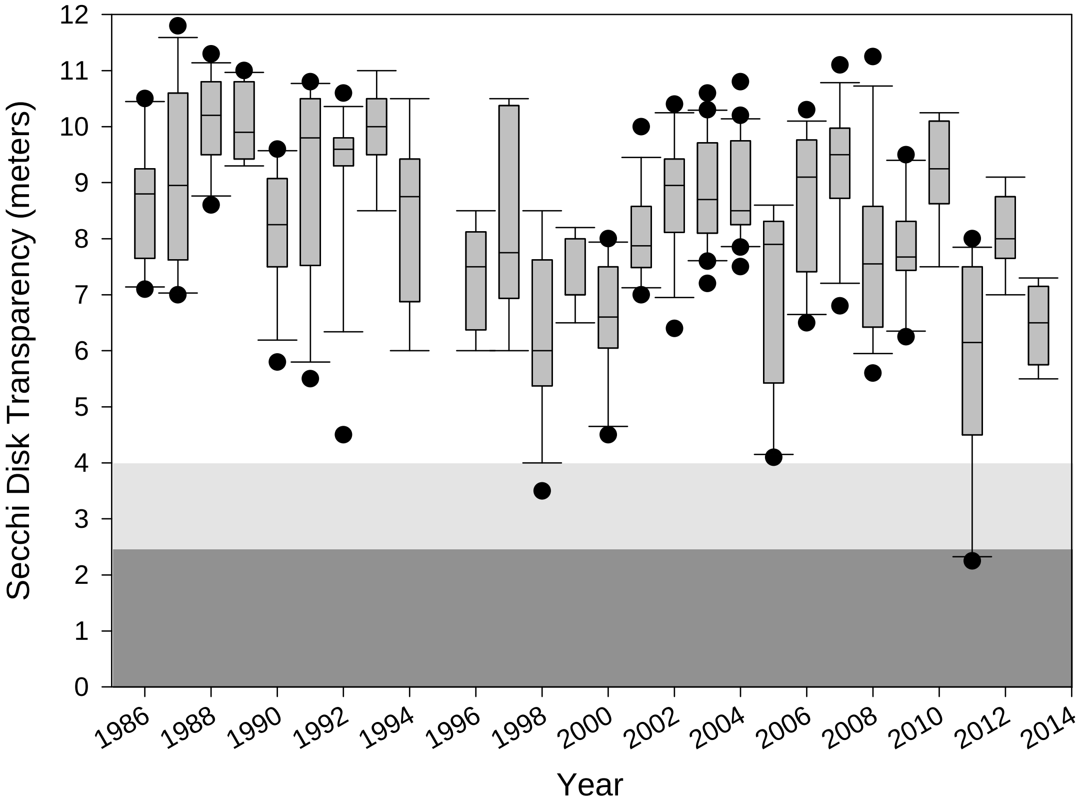
Newfound Lake -- Site 2 Mayhew
Annual Secchi Disk Transparency Comparisons
Box and Whisker Plots: 1986-2013



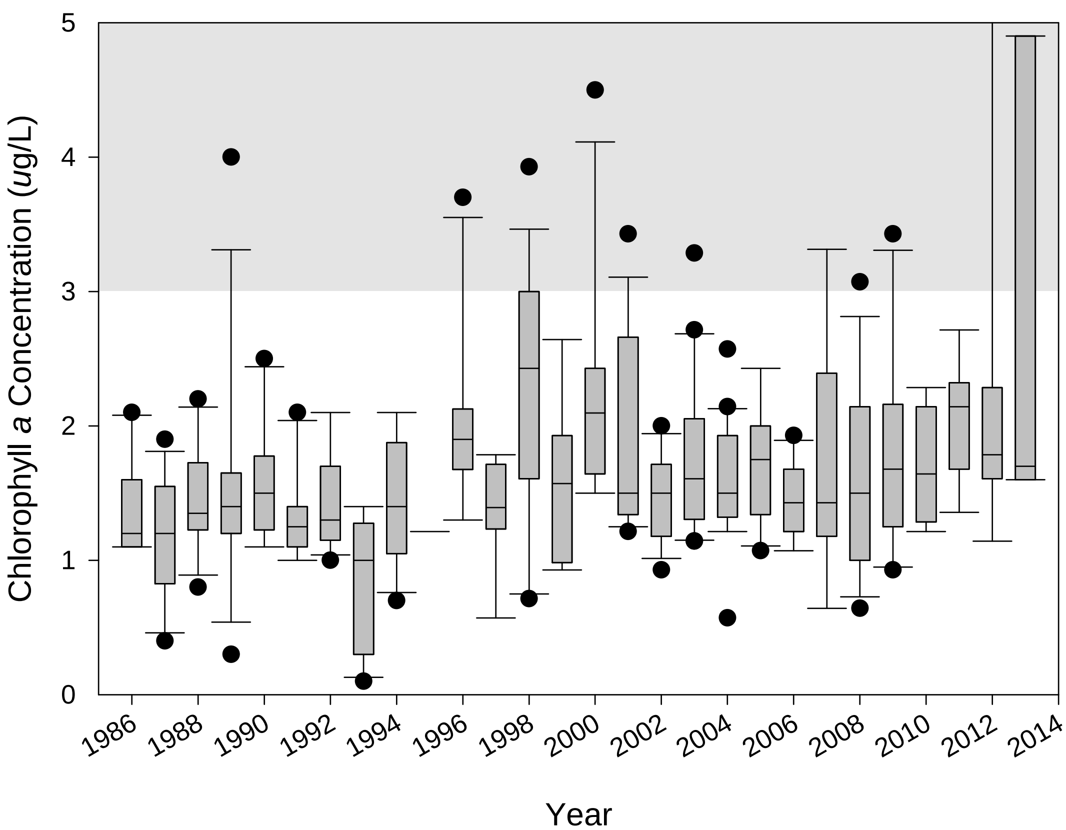
Newfound Lake -- Site 2 Mayhew
Annual Chlorophyll *a* Comparisons
Box and Whisker Plots: 1986-2013



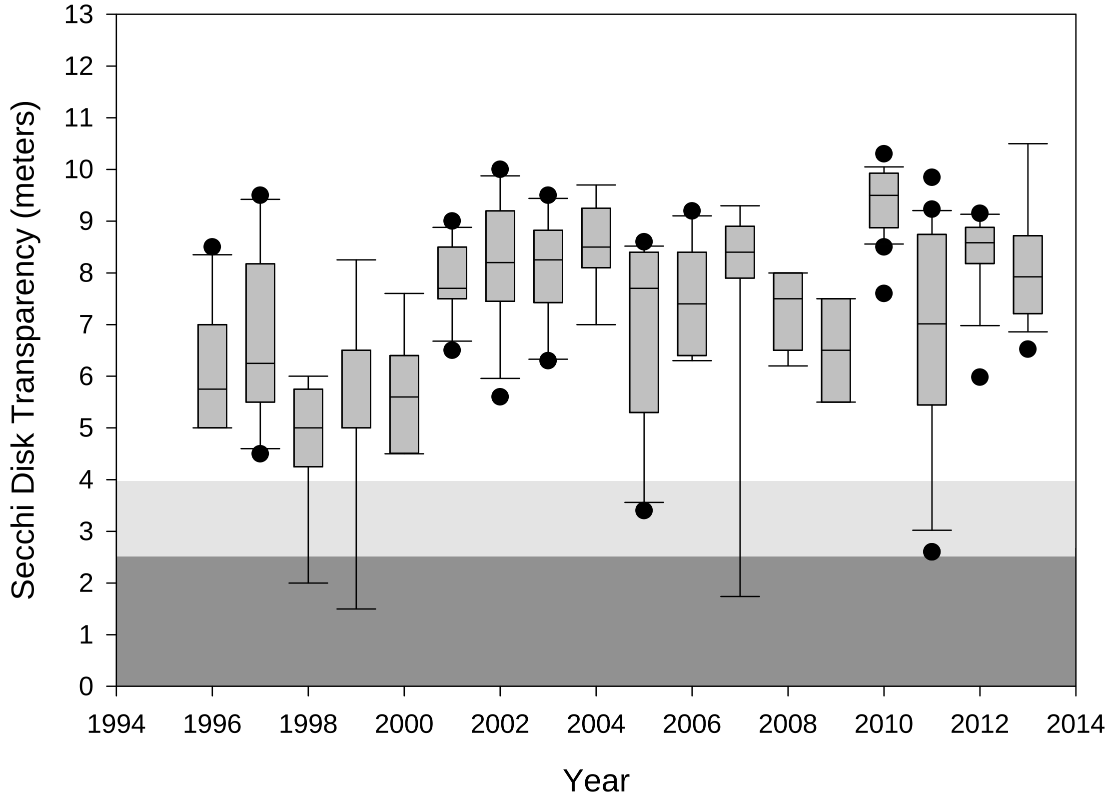
Newfound Lake - Site 3 Pasquaney
Annual Secchi Disk Transparency Comparisons
Box and Whisker Plots: 1986-2013



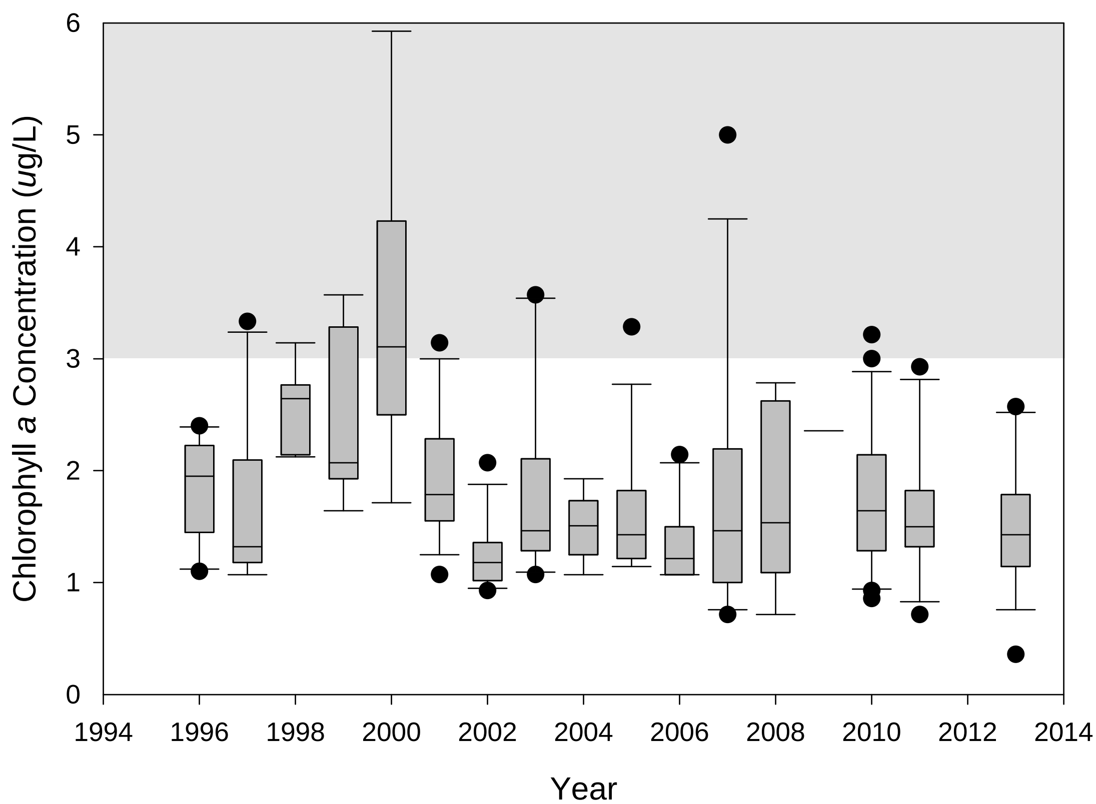
Newfound Lake -- Site 3 Pasquaney
Annual Chlorophyll *a* Comparisons
Box and Whisker Plots: 1986-2013



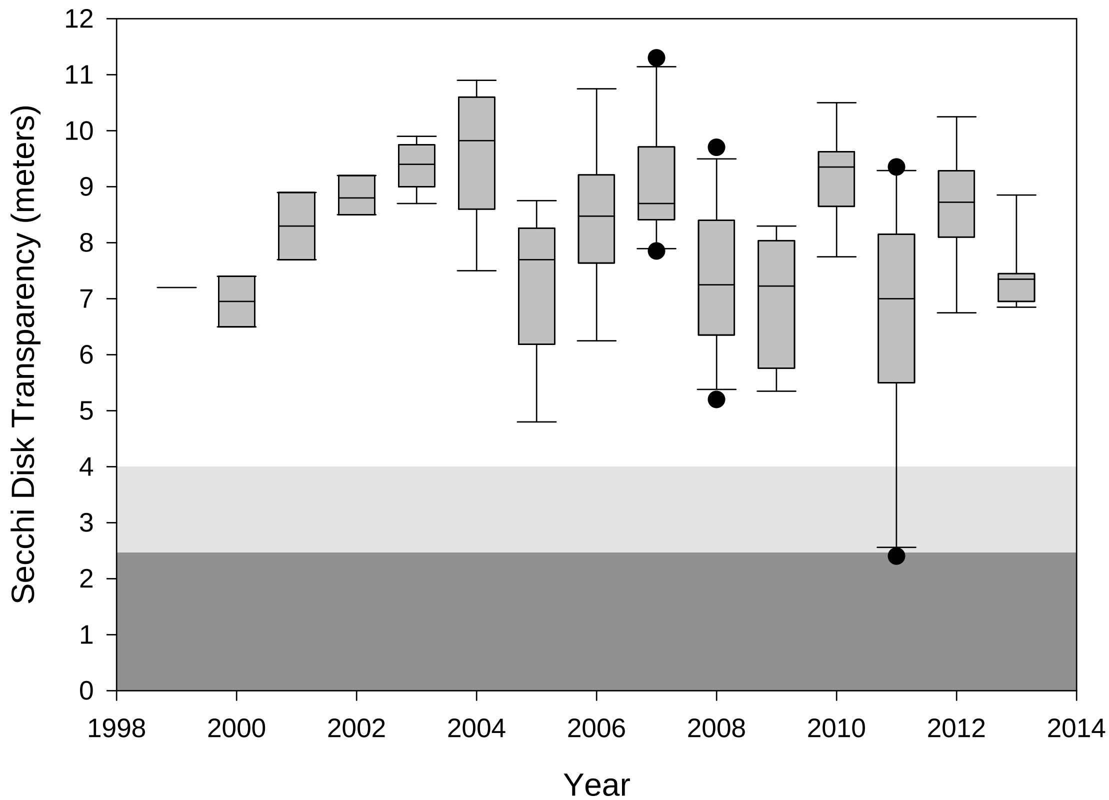
Newfound Lake - Site 4 Loon Island
Annual Secchi Disk Transparency Comparisons
Box and Whisker Plots: 1996-2013



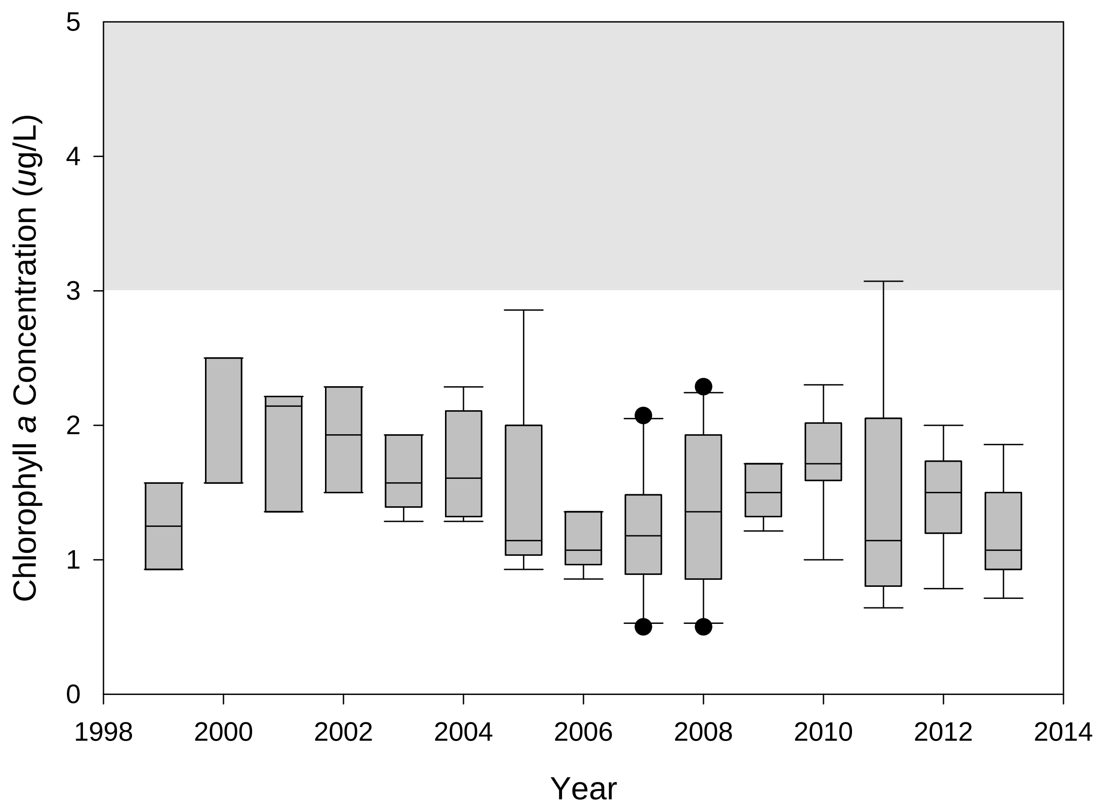
Newfound Lake -- Site 4 Loon Island
Annual Chlorophyll *a* Comparisons
Box and Whisker Plots: 1996-2013



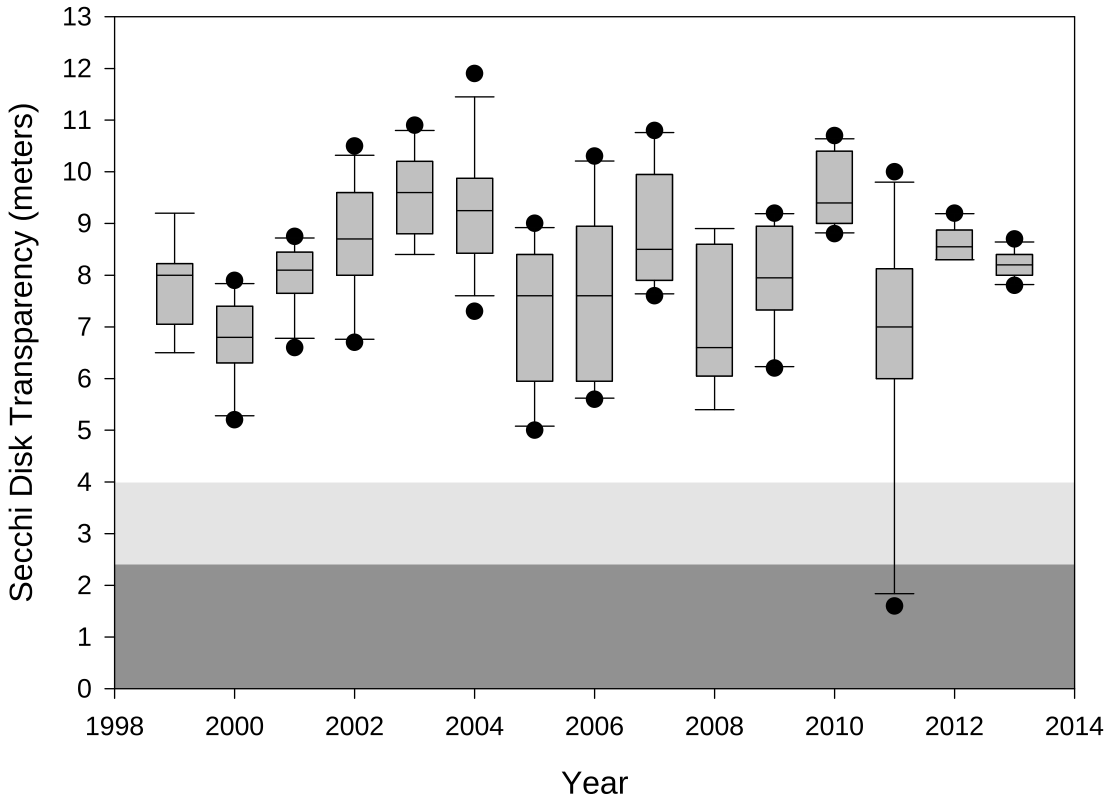
Newfound Lake -- Site 5 Cockermouth
Annual Secchi Disk Transparency Comparisons
Box and Whisker Plots: 1999-2013



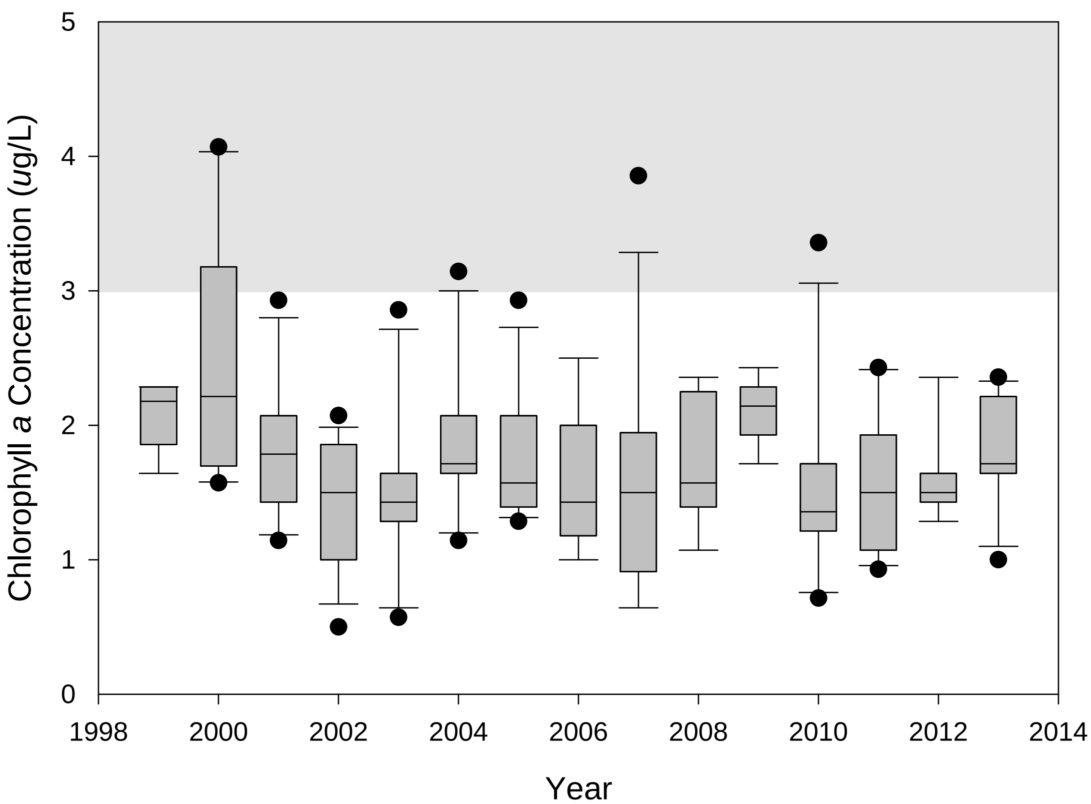
Newfound Lake -- Site 5 Cockermouth
Annual Chlorophyll *a* Comparisons
Box and Whisker Plots: 1999-2013



Newfound Lake - Site 6 Beachwood
Annual Secchi Disk Transparency Comparisons
Box and Whisker Plots: 1999-2013



Newfound Lake -- Site 6 Beachwood
Annual Chlorophyll *a* Comparisons
Box and Whisker Plots: 1999-2013



APPENDIX E

Newfound Lake line graphs that display the median Secchi Disk transparency and chlorophyll *a* concentrations. Regression lines are included in the graphs to display the long term trend for each parameter; the steeper the slope, the more rapid water quality changes are occuring. Solid regression lines indicate statistically significant (P-value ≤ 0.05) trendlines, whereas dashed lines indicate trendlines that are not considered statistically significant (P-value ≥ 0.05).

Long-term trend analysis using linear Regressions

A linear, bivariate regression allows us to identify the relation of two or more variables by producing a single line that best represents the distribution of points in a data set. The linear regression is calculated by a simple mathematical equation, $y = mx + b$, that creates a line that best describes the overall trend in the data; where x = the independent variable, y = the dependent variable, b = y-intercept (the value of y when x is zero) and m = the slope of the line. Ultimately, the slope of the line exemplifies the relationship between the two variables being studied. The distance between the line and the points ("standard error") describes the strength of the relationship. The closer the line is to the data points, the stronger the relationship is; whereas the farther away the points are, the weaker the relationship.

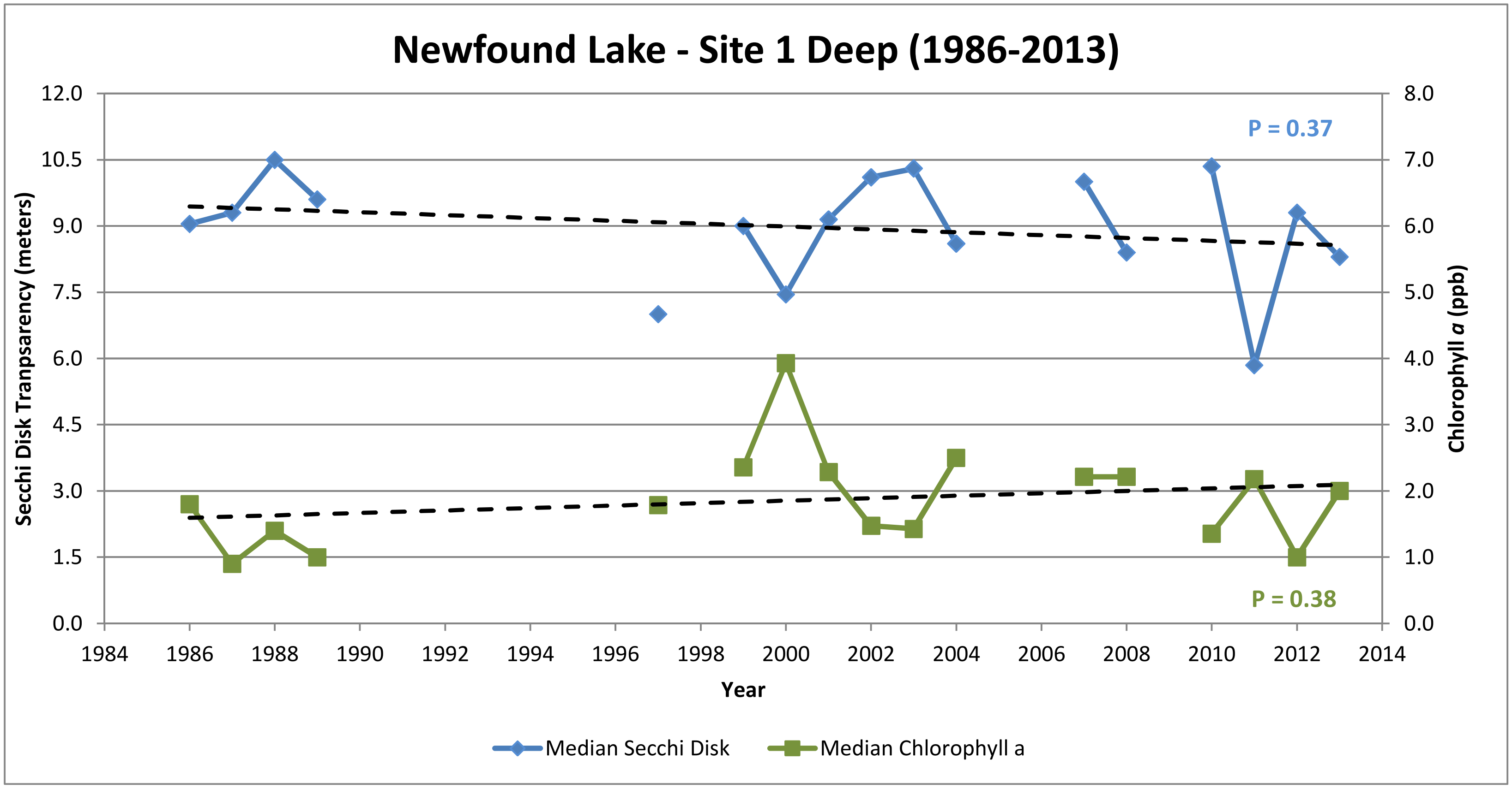
While linear regressions help distinguish patterns in data sets, the relationships or correlations identified do not necessarily mean that one variable is the cause of another, even when the line indicates a strong fit with the data points. In other words, there may be a strong relationship between water clarity (Secchi disk depth) and chlorophyll *a*. However, this does not necessarily mean that the clarity of the water is driven by the algal growth associated with high chlorophyll *a* concentrations. Water clarity can fluctuate due to land use changes, storm events, shoreline erosion, etc. causing changes in not only chlorophyll *a*, but in turbidity and color, which can also drive a decrease in clarity. In order to truly understand a trend, such as a change in water clarity, it is crucial to think about all the factors that play into the change in water quality conditions. Linear regression analysis is the first step to identify the areas that need a closer look by providing connections between variables. However, more vigilant observation and analysis is required to determine a true cause-and-effect relationship.

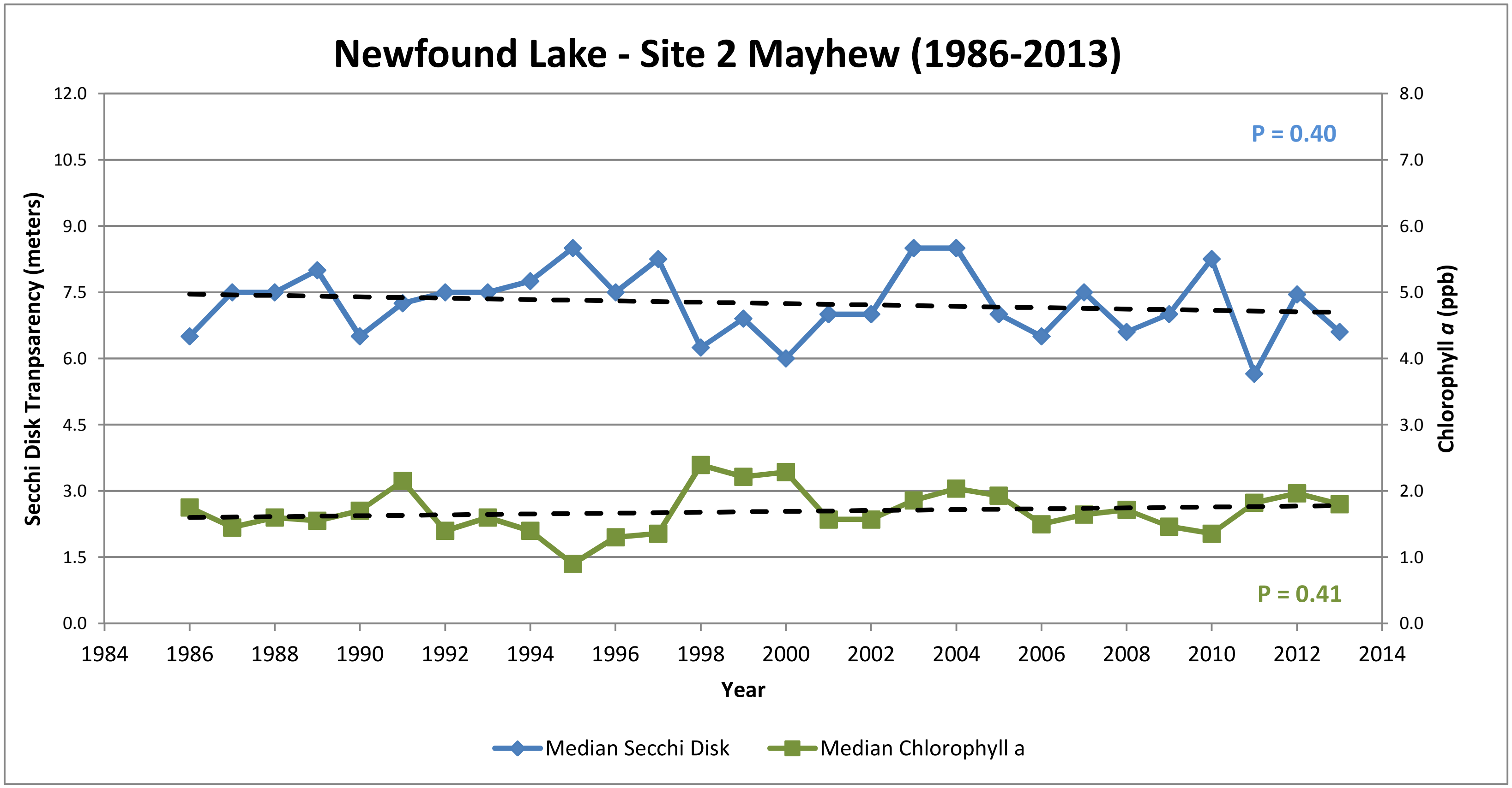
Understanding P-values

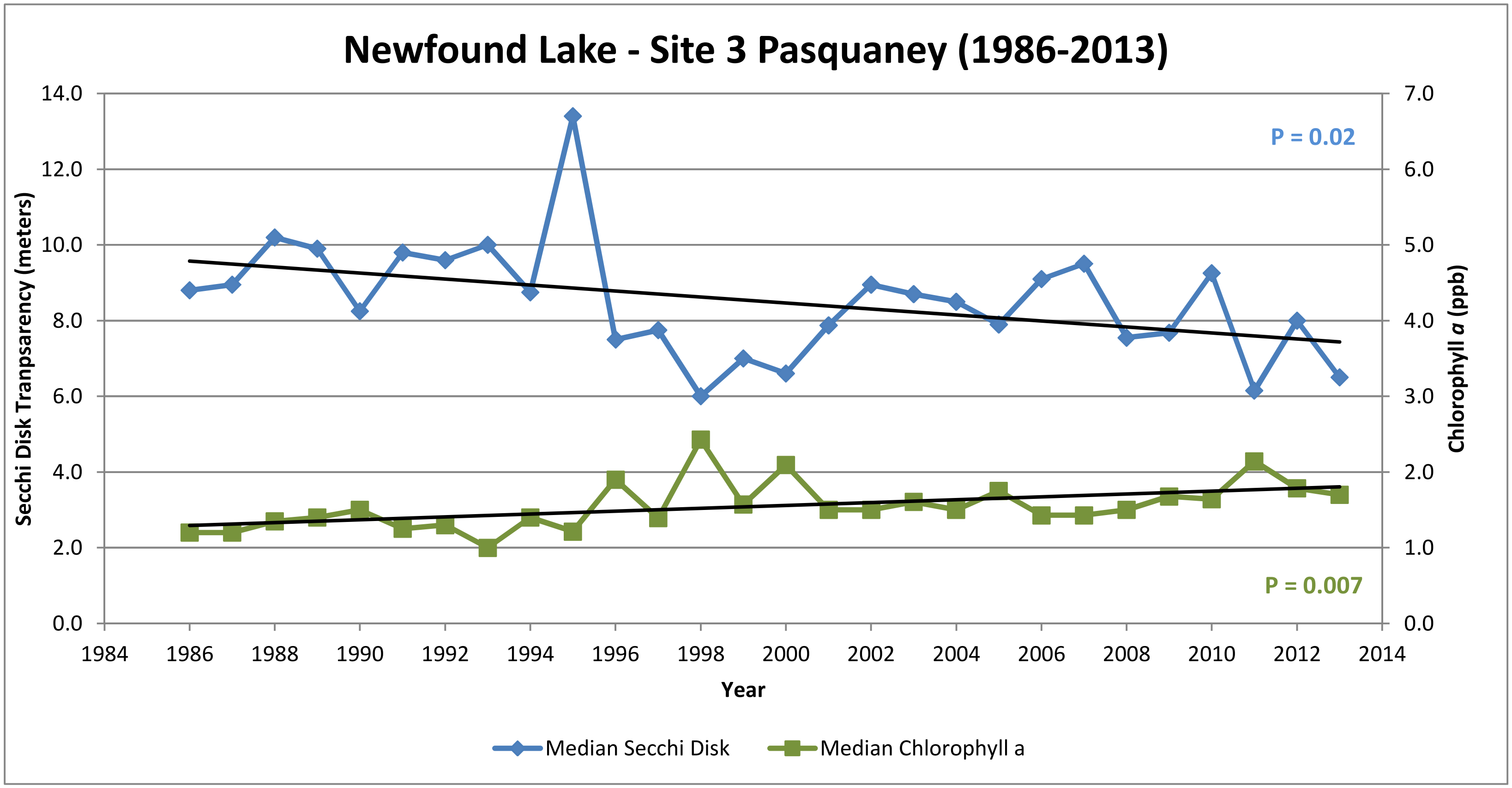
A P-value is a number between 0 and 1 used in statistics to decide whether or not to take the null hypothesis while making a prediction based on collected data. The **null hypothesis (H_O)** is the prediction that there is no difference in the data and that there is virtually no change in the parameter, or the question being studied. For example, the null hypothesis of this study is that there has been no change in water quality over a specified amount of time. If the null hypothesis is not taken and is proven to be untrue, then you take the **alternative hypothesis (H_A),** which is there has been a change in the data and the change in water quality is significant. A P-value identifies the confidence one has to reject the null hypothesis. Numbers closer to 0 indicate strong evidence to reject the null hypothesis and accept the alternative hypothesis; while numbers closer to 1 infer weaker evidence that the null hypothesis should be rejected. Generally, significant P-values are identified as **0.05**, **0.01**, and **0.001**.

For our purposes, a **P-value ≤ 0.05** indicates strong evidence to reject the null hypothesis and accept the alternative hypothesis, which is there has been a change in water quality conditions. A **P-value ≥ 0.05** indicates weaker evidence and therefore the null hypothesis of no change or difference is accepted, while the alternative hypothesis is rejected.

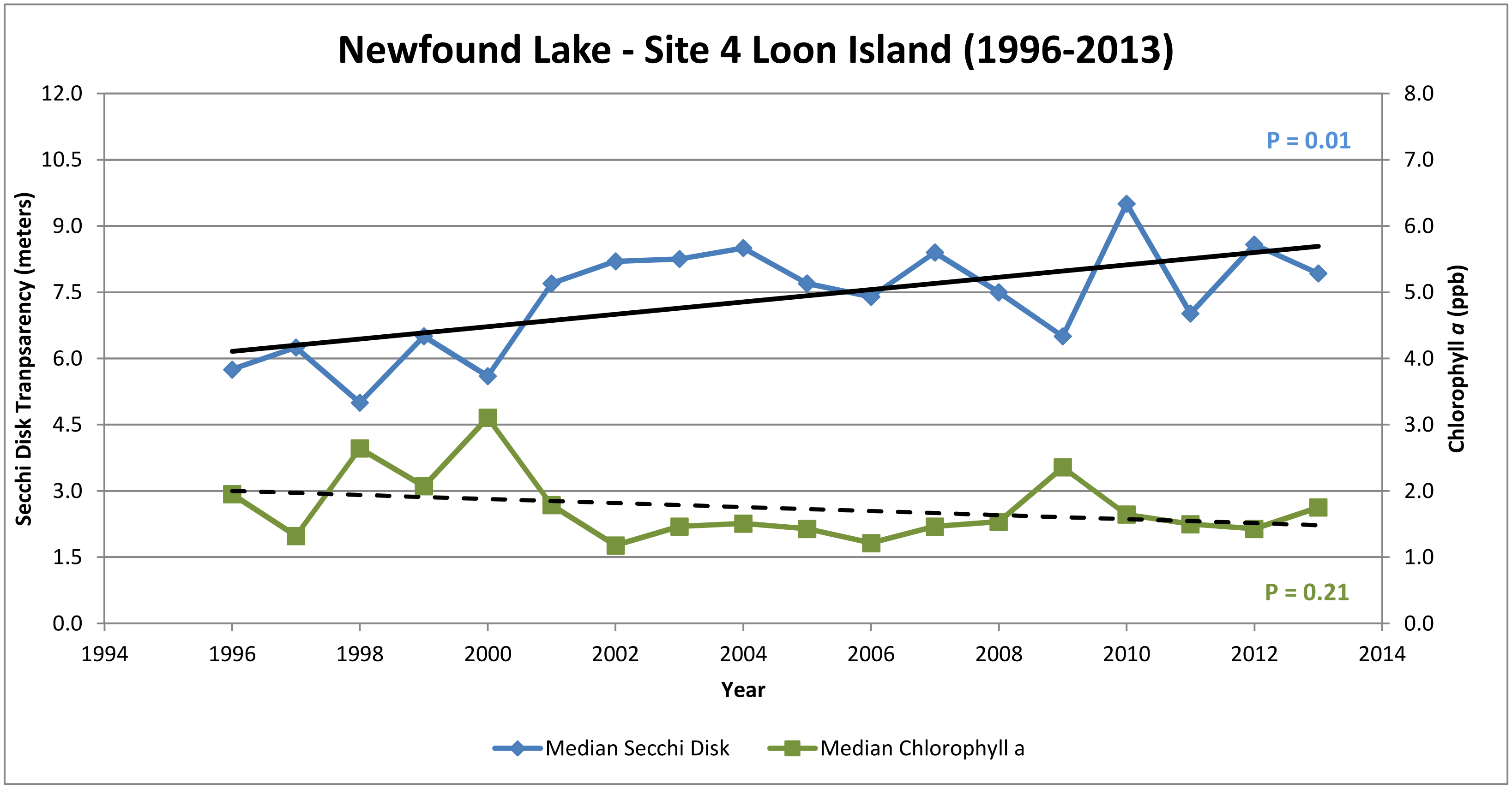
It is important to understand that while a relationship with P-values ≥ 0.05, do not display "statistical significance", it does not mean that there is no importance in what the data is suggesting, just not enough to reject the null hypothesis. The same goes for a P-value ≤ 0.05. Although the trend is considered "significant" it does not mean it is the only important, suggestive changes in water quality conditions. Again, it is important to consider all factors that play into water quality changes and decide which influences play the largest role.


Newfound Lake - Site 1 Deep (1986-2013)
Secchi Disk Tranpsarency (meters)
Chlorophyll a (ppb)
Year
P = 0.37
P = 0.38
12.0
10.5
9.0
7.5
6.0
4.5
3.0
1.5
0.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
Median Secchi Disk
Median Chlorophyll a

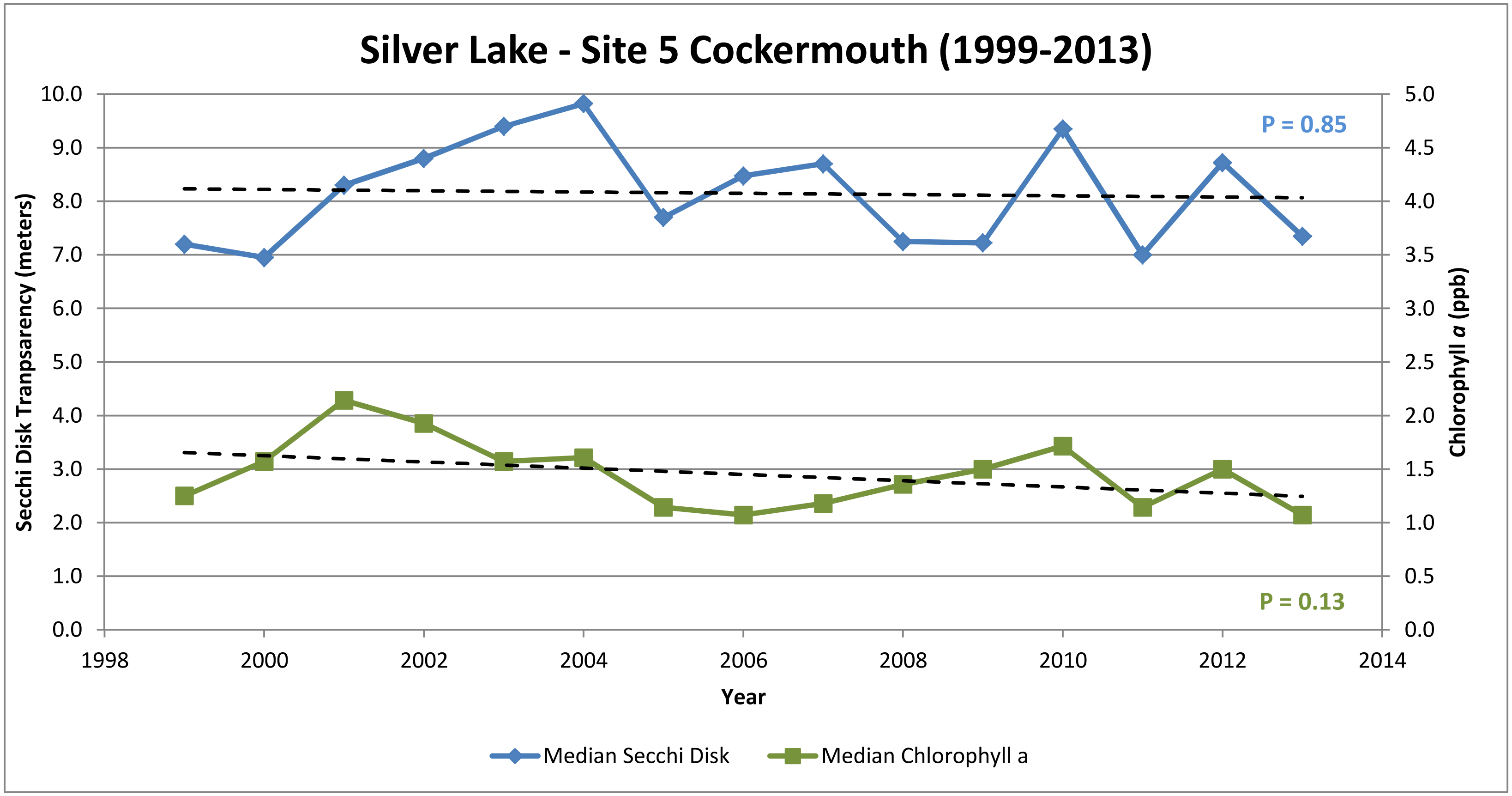

Newfound Lake - Site 2 Mayhew (1986-2013)
P = 0.40
P = 0.41
Secchi Disk Tranpsarency (meters)
Chlorophyll a (ppb)
Year
12.0
10.5
9.0
7.5
6.0
4.5
3.0
1.5
0.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
Median Secchi Disk
Median Chlorophyll a



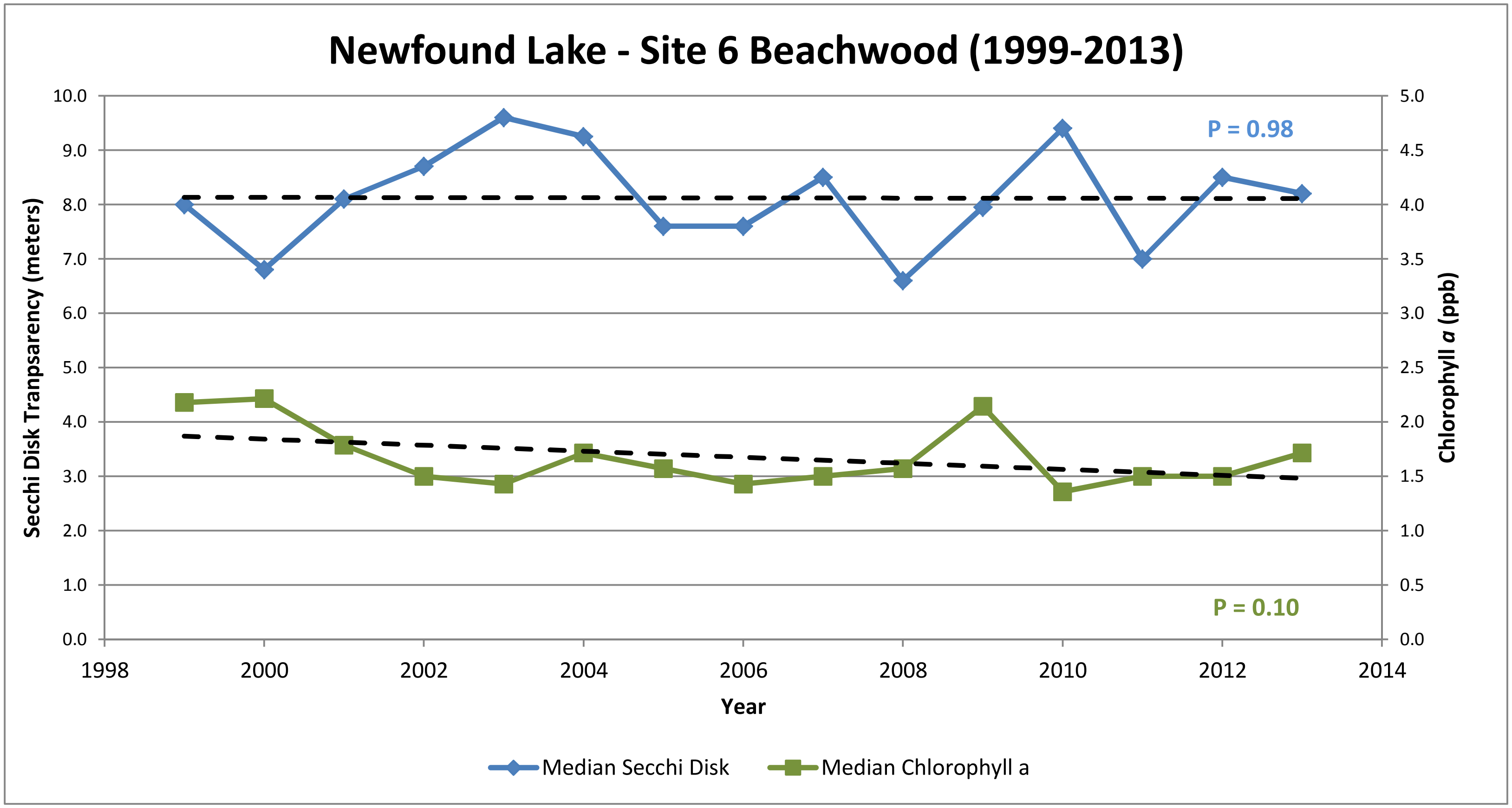
Newfound Lake - Site 3 Pasquaney (1986-2013)
Secchi Disk Tranpsarency (meters)
Chlorophyll a (ppb)
P = 0.02
P = 0.007
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
Year
Median Secchi Disk
Median Chlorophyll a



Newfound Lake - Site 4 Loon Island (1996-2013)
Secchi Disk Tranpsarency (meters)
Chlorophyll a (ppb)
P = 0.01
P = 0.21
Year
12.0
10.5
9.0
7.5
6.0
4.5
3.0
1.5
0.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
Median Secchi Disk
Median Chlorophyll a



Silver Lake - Site 5 Cockermouth (1999-2013)
P = 0.85
P = 0.13
Secchi Disk Tranpsarency (meters)
Chlorophyll a (ppb)
Year
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1998
2000
2002
2004
2006
2008
2010
2012
2014
Median Secchi Disk
Median Chlorophyll a

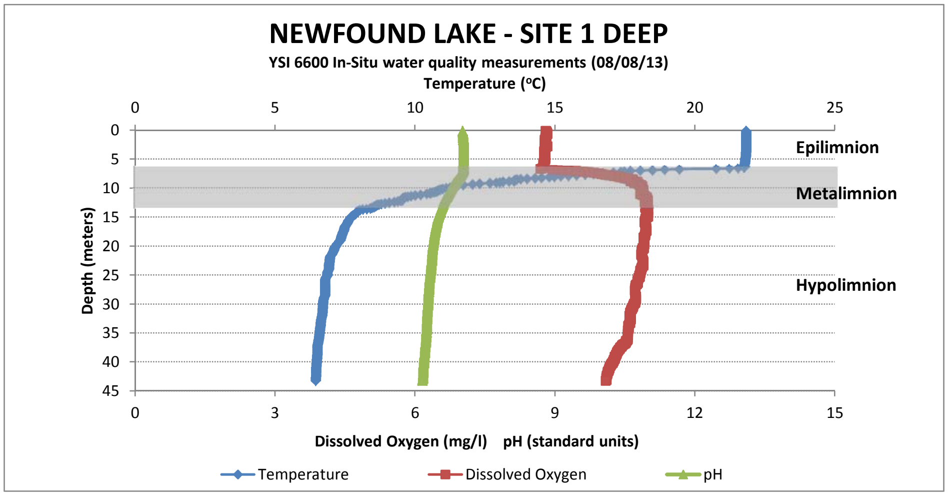


Newfound Lake - Site 6 Beachwood (1999-2013)
P = 0.98
P = 0.10
Secchi Disk Tranpsarency (meters)
Chlorophyll a (ppb)
Year
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
1998
2000
2002
2004
2006
2008
2010
2012
2014
Median Secchi Disk
Median Chlorophyll a

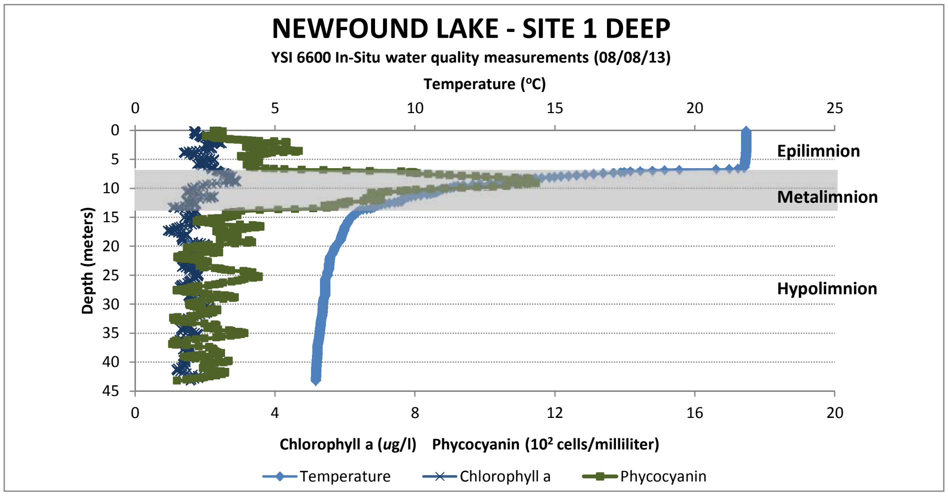
APPENDIX F

Physical, chemical and biological water quality data were collected in Newfound Lake, Sites 1 Deep, 2 Mayhew, 3 Pasquaney, 4 Loon Island, 5 Cockermouth, 6 Beachwood and 8 Follansbee Cove, by the University of New Hampshire Center for Freshwater Biology on August 8, 2013. The water quality data are plotted against depth and include a shaded region on the graphs that partitions the three thermal zones: the epilimnion, the metalimnion and the hypolimnion. *Notice the difference in water quality measurements among the thermal zones.*

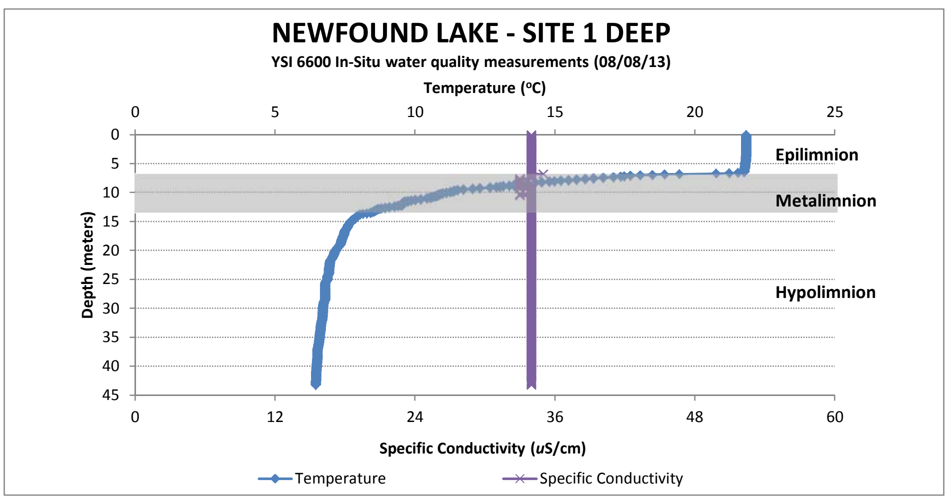
The water quality profile data were collected in-situ with a Yellow Springs Instruments model 6600 V2-4 Sonde equipped with a pressure (depth) sensor, phycocyanin fluorescence probe, chlorophyll fluorescence probe, temperature/conductivity probe, optical oxygen sensor, and a combination low ionic strength pH/redox probe. The chlorophyll *a* and phycocyanin fluorescence data are based on factory calibrated conversion of fluorescence data to chlorophyll *a* values. All profiling data were digitally logged onto a YSI 650 data logger and subsequently downloaded onto a personal computer for further data analysis. The YSI profile data were recorded at five second intervals by slowly lowering the Sonde into the water column at an approximate rate of two centimeters per second.



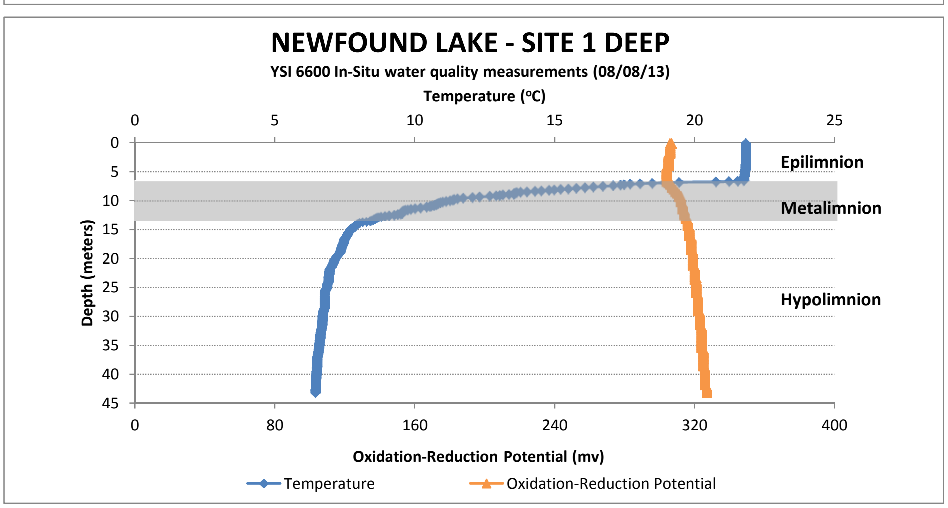
NEWFOUND LAKE - SITE 1 DEEP
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (ºC)
Depth (meters)
Epilimnion
Metalimnion
Hypolimnion
Dissolved Oxygen (mg/l) pH (standard units)
Temperature
Dissolved Oxygen
pH



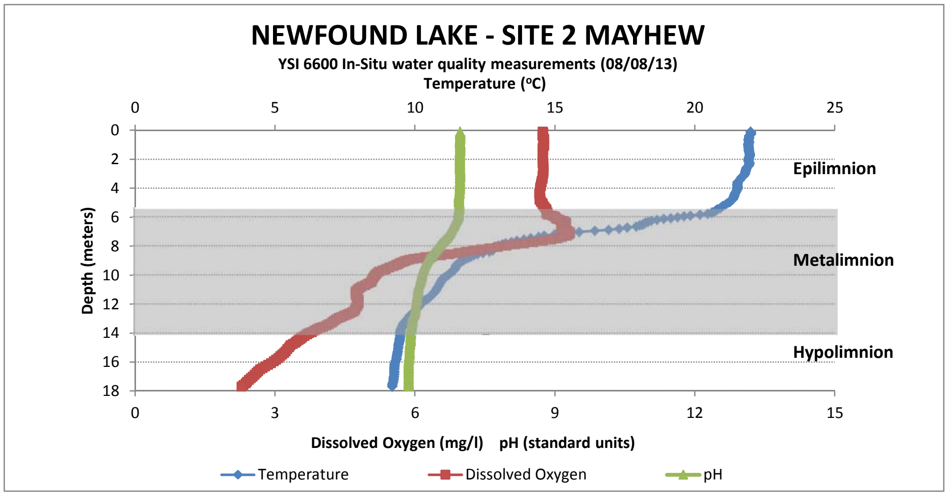
NEWFOUND LAKE - SITE 1 DEEP
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (ºC)
Depth (meters)
Epilimnion
Metalimnion
Hypolimnion
Chlorophyll a (ug/l) Phycocyanin (10² cells/milliliter)
Temperature
Chlorophyll a
Phycocyanin

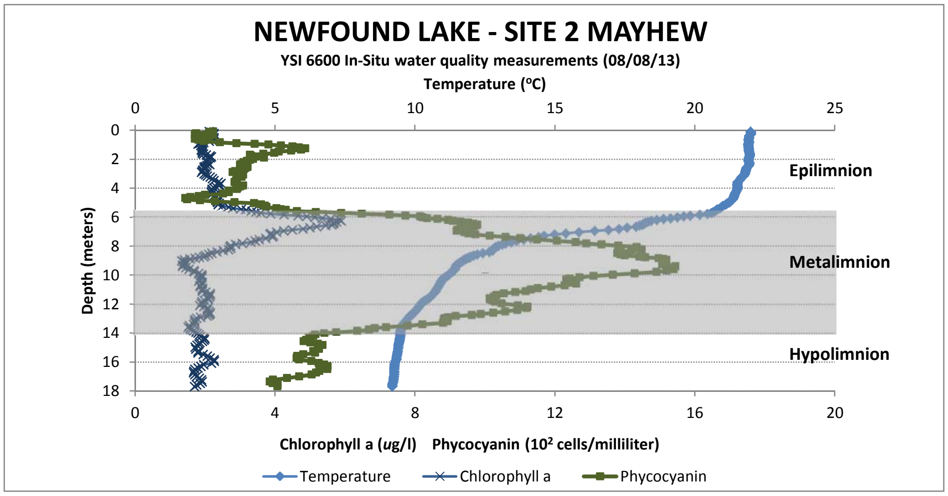


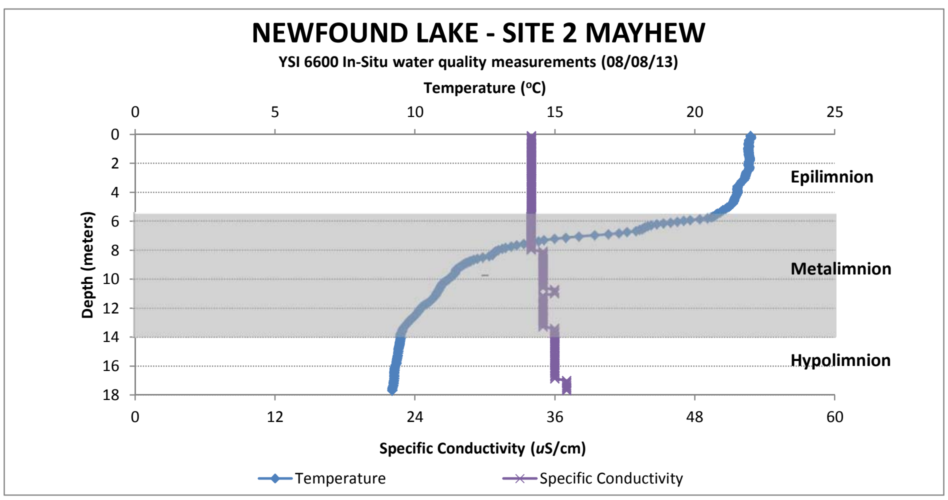
NEWFOUND LAKE - SITE 1 DEEP
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (ºC)
Depth (meters)
Epilimnion
Metalimnion
Hypolimnion
Specific Conductivity (uS/cm)
Temperature
Specific Conductivity

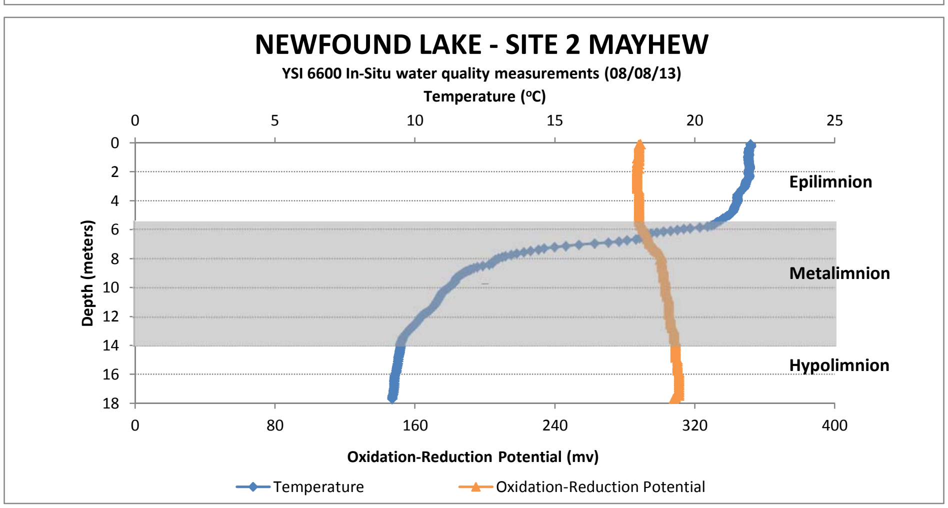


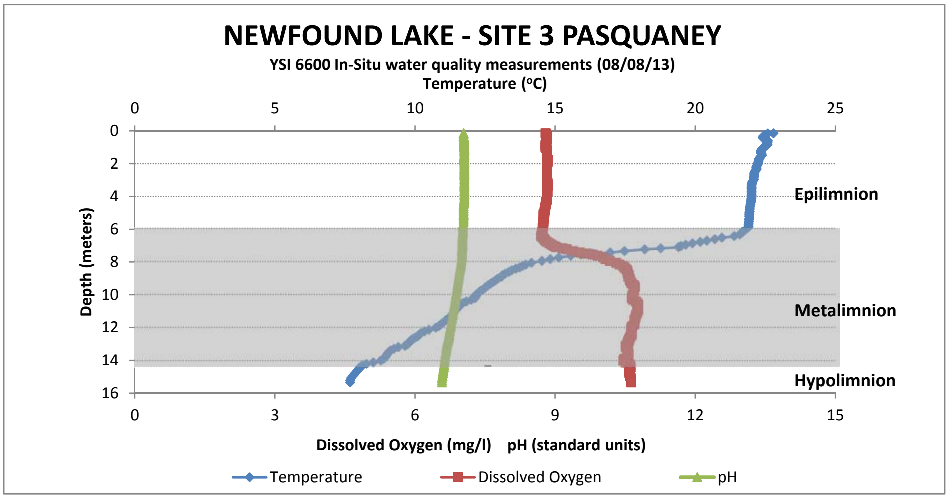
NEWFOUND LAKE - SITE 1 DEEP
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (ºC)
Depth (meters)
Epilimnion
Metalimnion
Hypolimnion
Oxidation-Reduction Potential (mv)
Temperature
Oxidation-Reduction Potential

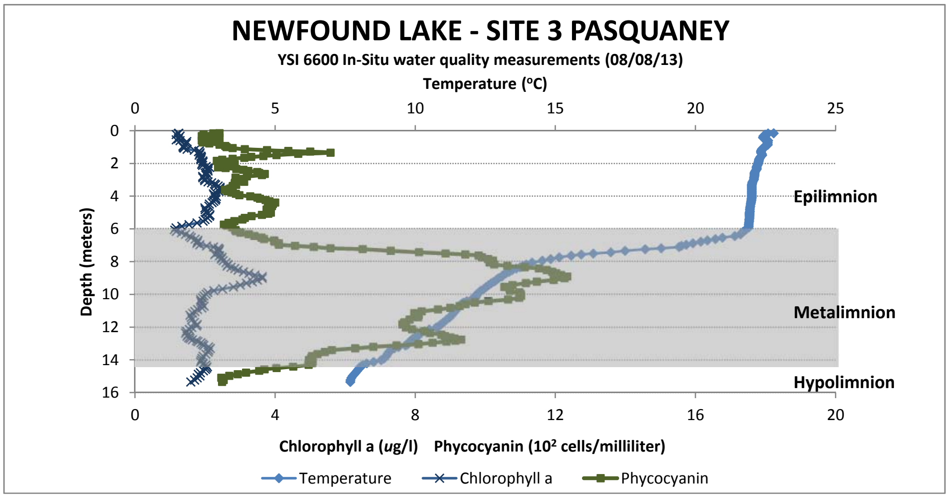

NEWFOUND LAKE - SITE 2 MAYHEW
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (°C)
0 5 10 15 20 25
Depth (meters)
0 2 4 6 8 10 12 14 16 18
Epilimnion
Metalimnion
Hypolimnion
0 3 6 9 12 15
Dissolved Oxygen (mg/l) pH (standard units)
Temperature
Dissolved Oxygen
pH

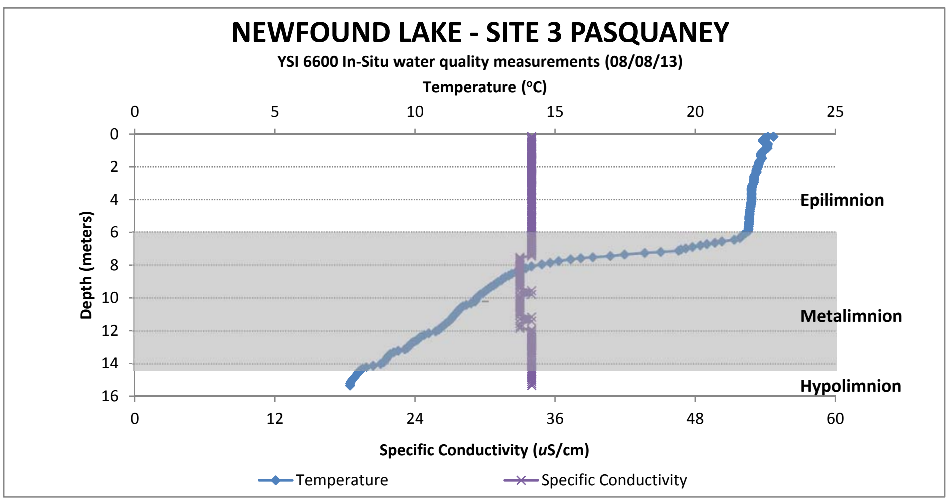

NEWFOUND LAKE - SITE 2 MAYHEW
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (°C)
0 5 10 15 20 25
Depth (meters)
0 2 4 6 8 10 12 14 16 18
Epilimnion
Metalimnion
Hypolimnion
0 4 8 12 16 20
Chlorophyll a (ug/l) Phycocyanin (10² cells/milliliter)
Temperature
Chlorophyll a
Phycocyanin

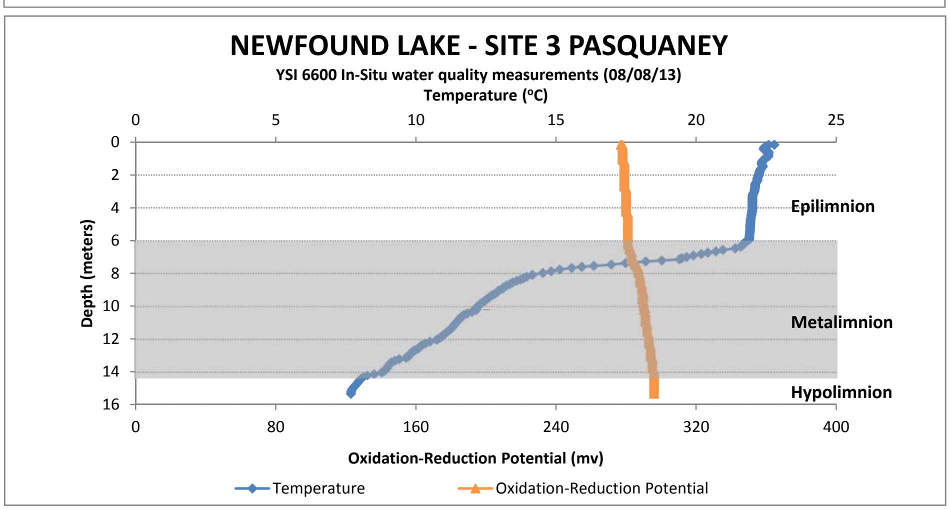

NEWFOUND LAKE - SITE 2 MAYHEW
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (°C)
0 5 10 15 20 25
Depth (meters)
0 2 4 6 8 10 12 14 16 18
Epilimnion
Metalimnion
Hypolimnion
0 12 24 36 48 60
Specific Conductivity (uS/cm)
Temperature
Specific Conductivity

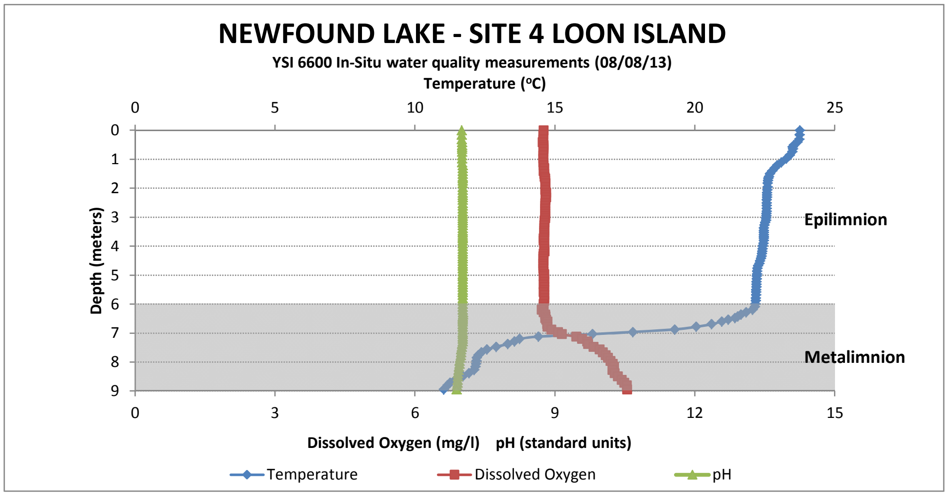

NEWFOUND LAKE - SITE 2 MAYHEW
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (°C)
0 5 10 15 20 25
Depth (meters)
0 2 4 6 8 10 12 14 16 18
Epilimnion
Metalimnion
Hypolimnion
0 80 160 240 320 400
Oxidation-Reduction Potential (mv)
Temperature
Oxidation-Reduction Potential

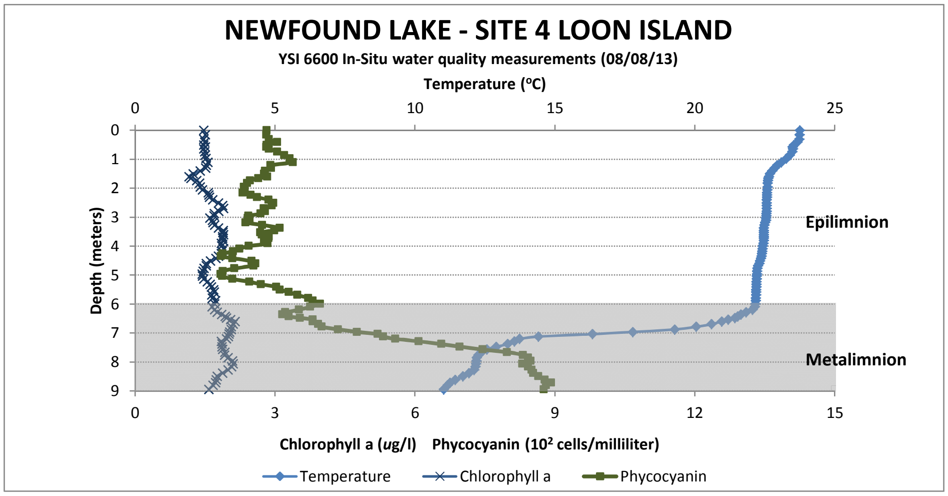

NEWFOUND LAKE - SITE 3 PASQUANEY
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (ºC)
0 5 10 15 20 25
Depth (meters)
0 2 4 6 8 10 12 14 16
Epilimnion
Metalimnion
Hypolimnion
0 3 6 9 12 15
Dissolved Oxygen (mg/l) pH (standard units)
Temperature
Dissolved Oxygen
pH

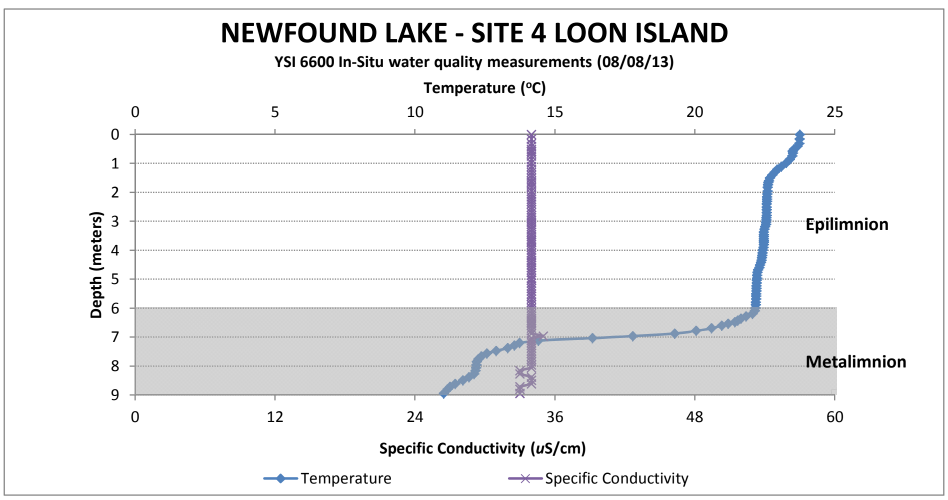

NEWFOUND LAKE - SITE 3 PASQUANEY
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (ºC)
0 5 10 15 20 25
Depth (meters)
0 2 4 6 8 10 12 14 16
Epilimnion
Metalimnion
Hypolimnion
0 4 8 12 16 20
Chlorophyll a (ug/l) Phycocyanin (10² cells/milliliter)
Temperature
Chlorophyll a
Phycocyanin

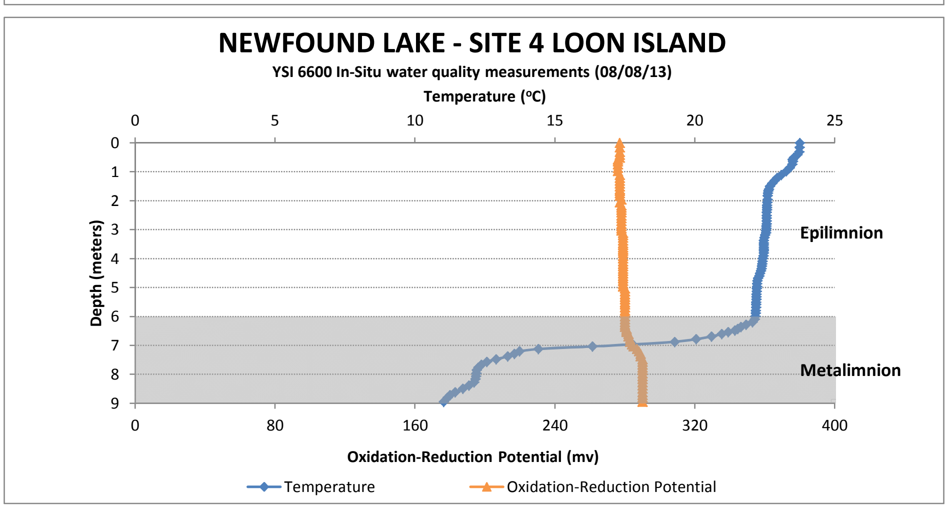

NEWFOUND LAKE - SITE 3 PASQUANEY
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (ºC)
0 5 10 15 20 25
Depth (meters)
0 2 4 6 8 10 12 14 16
Epilimnion
Metalimnion
Hypolimnion
0 12 24 36 48 60
Specific Conductivity (uS/cm)
Temperature
Specific Conductivity

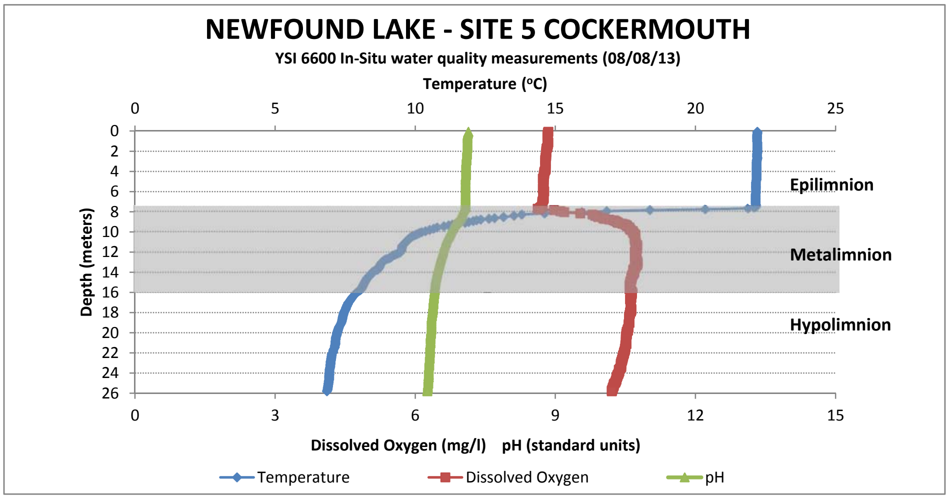

NEWFOUND LAKE - SITE 3 PASQUANEY
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (ºC)
0 5 10 15 20 25
Depth (meters)
0 2 4 6 8 10 12 14 16
Epilimnion
Metalimnion
Hypolimnion
0 80 160 240 320 400
Oxidation-Reduction Potential (mv)
Temperature
Oxidation-Reduction Potential

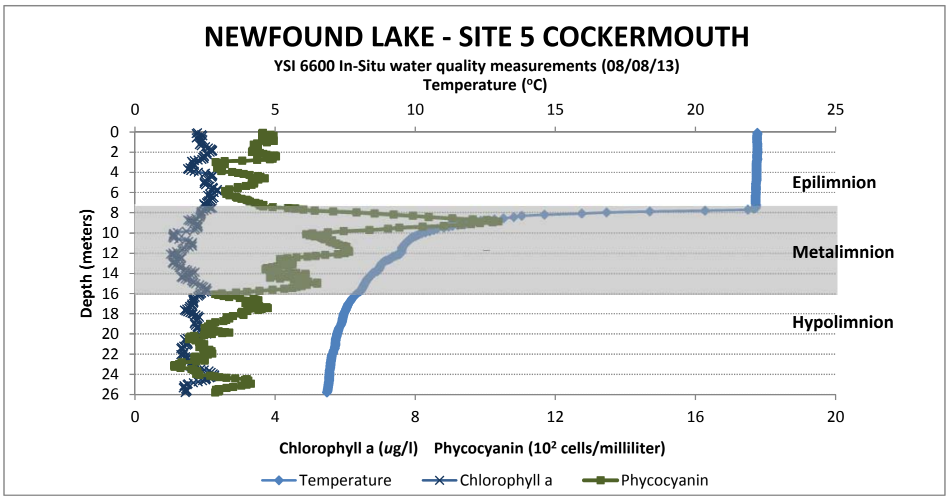

NEWFOUND LAKE - SITE 4 LOON ISLAND
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (°C)
0
5
10
15
20
25
Depth (meters)
0
1
2
3
4
5
6
7
8
9
Epilimnion
Metalimnion
0
3
6
9
12
15
Dissolved Oxygen (mg/l)   pH (standard units)
Temperature
Dissolved Oxygen
pH

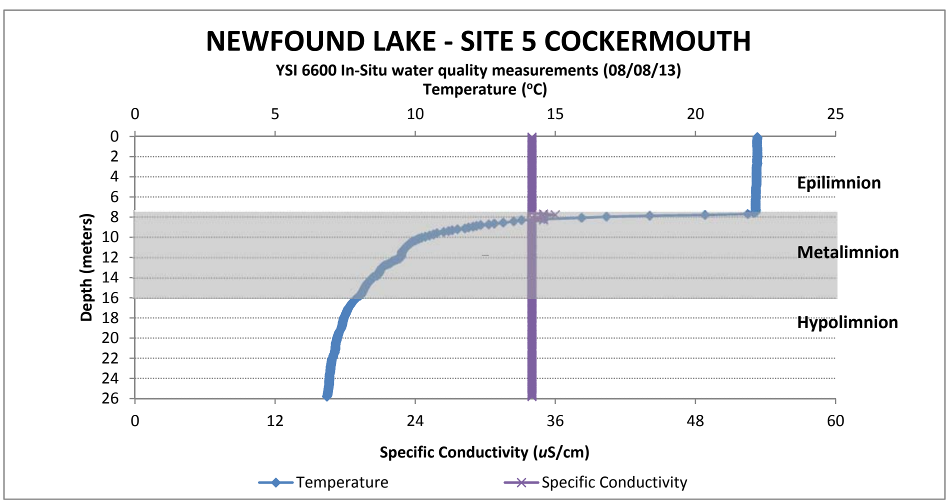

NEWFOUND LAKE - SITE 4 LOON ISLAND
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (°C)
0
5
10
15
20
25
Depth (meters)
0
1
2
3
4
5
6
7
8
9
Epilimnion
Metalimnion
0
3
6
9
12
15
Chlorophyll a (ug/l)   Phycocyanin (10² cells/milliliter)
Temperature
Chlorophyll a
Phycocyanin

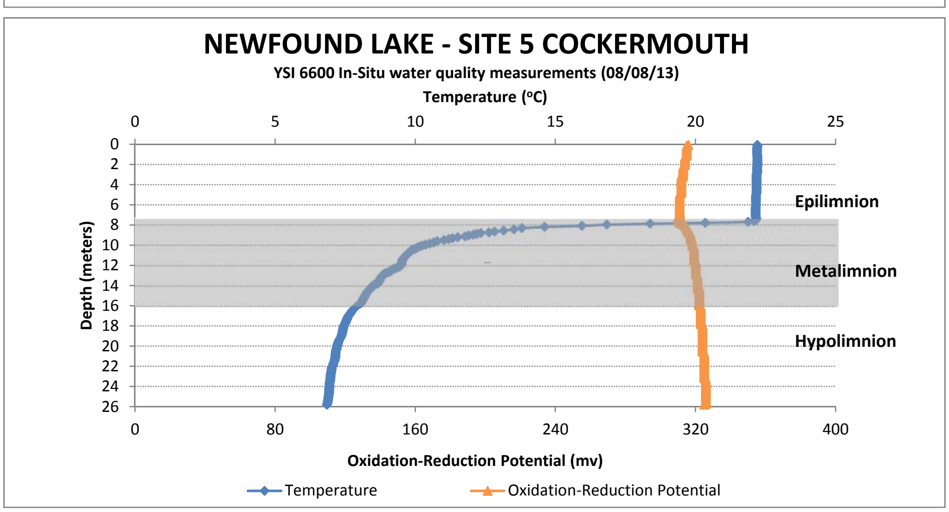

NEWFOUND LAKE - SITE 4 LOON ISLAND
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (°C)
0
5
10
15
20
25
Depth (meters)
0
1
2
3
4
5
6
7
8
9
Epilimnion
Metalimnion
0
12
24
36
48
60
Specific Conductivity (uS/cm)
Temperature
Specific Conductivity

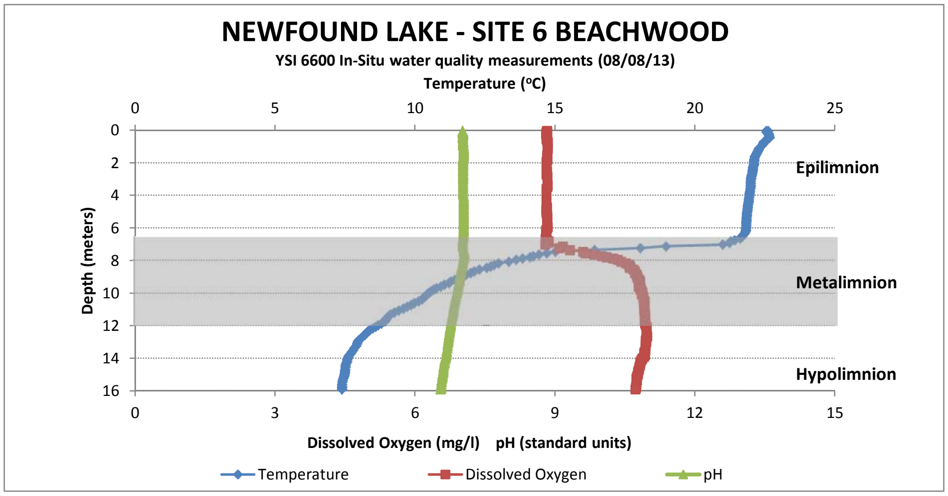

NEWFOUND LAKE - SITE 4 LOON ISLAND
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (°C)
0
5
10
15
20
25
Depth (meters)
0
1
2
3
4
5
6
7
8
9
Epilimnion
Metalimnion
0
80
160
240
320
400
Oxidation-Reduction Potential (mv)
Temperature
Oxidation-Reduction Potential

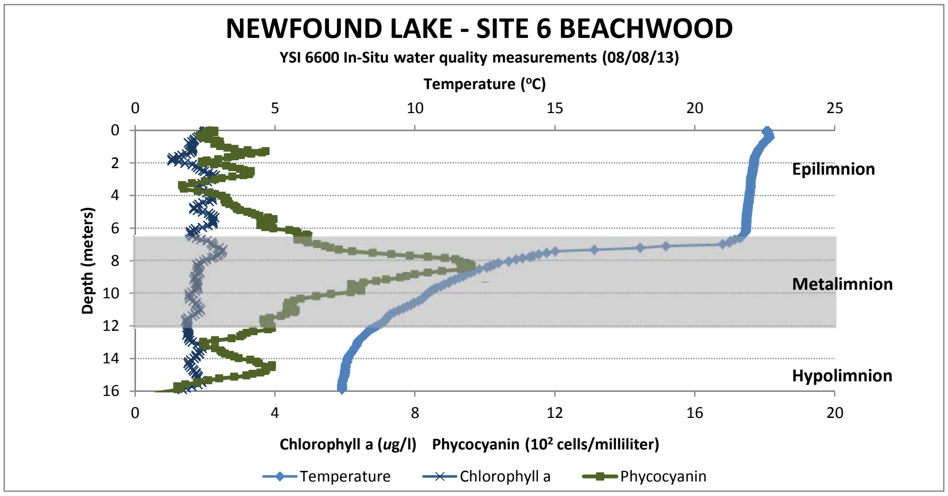

NEWFOUND LAKE - SITE 5 COCKERMOUTH
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (°C)
Depth (meters)
Epilimnion
Metalimnion
Hypolimnion
Dissolved Oxygen (mg/l) pH (standard units)
Temperature
Dissolved Oxygen
pH

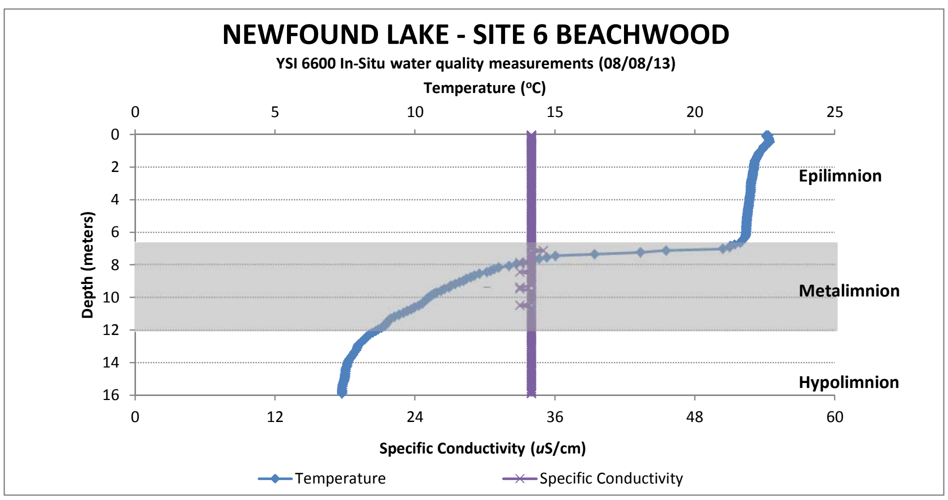

NEWFOUND LAKE - SITE 5 COCKERMOUTH
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (°C)
Depth (meters)
Epilimnion
Metalimnion
Hypolimnion
Chlorophyll a (ug/l) Phycocyanin (10² cells/milliliter)
Temperature
Chlorophyll a
Phycocyanin

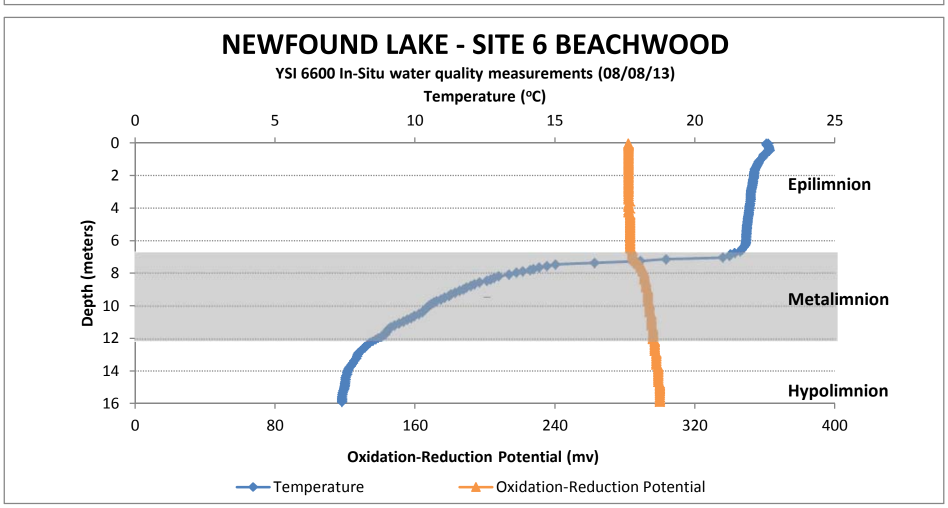

NEWFOUND LAKE - SITE 5 COCKERMOUTH
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (°C)
Depth (meters)
Epilimnion
Metalimnion
Hypolimnion
Specific Conductivity (uS/cm)
Temperature
Specific Conductivity

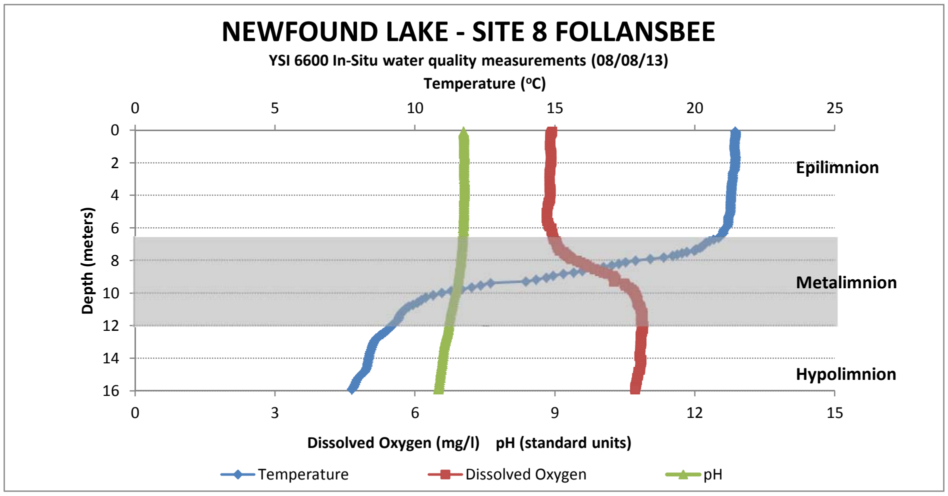

NEWFOUND LAKE - SITE 5 COCKERMOUTH
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (°C)
Depth (meters)
Epilimnion
Metalimnion
Hypolimnion
Oxidation-Reduction Potential (mv)
Temperature
Oxidation-Reduction Potential

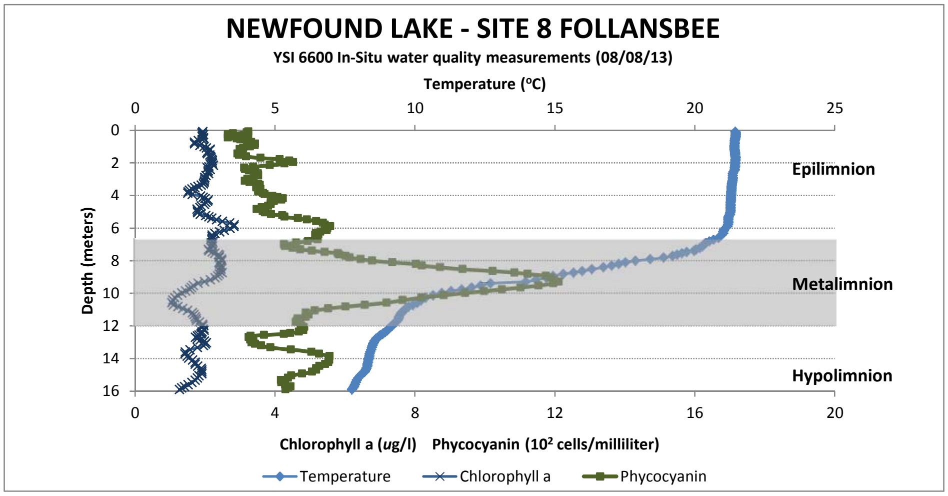

NEWFOUND LAKE - SITE 6 BEACHWOOD
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (°C)
Depth (meters)
Epilimnion
Metalimnion
Hypolimnion
Dissolved Oxygen (mg/l) pH (standard units)
Temperature
Dissolved Oxygen
pH

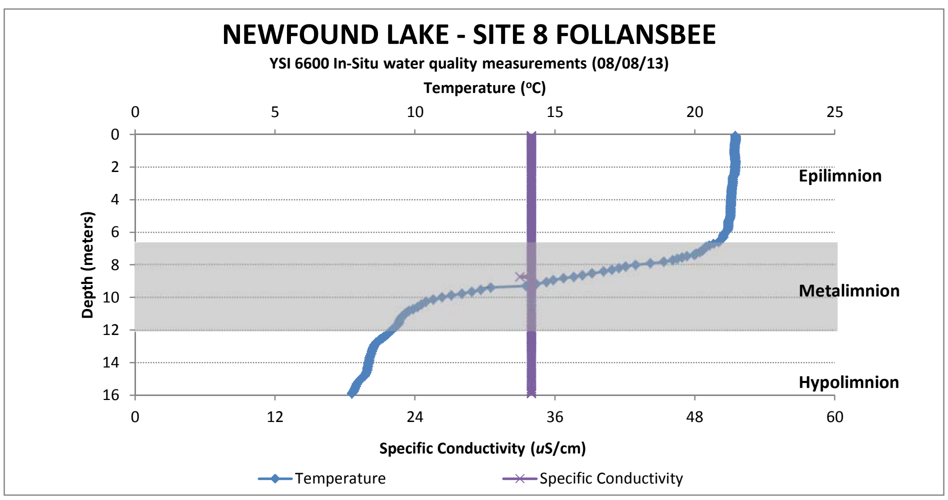

NEWFOUND LAKE - SITE 6 BEACHWOOD
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (°C)
Depth (meters)
Epilimnion
Metalimnion
Hypolimnion
Chlorophyll a (ug/l) Phycocyanin (10² cells/milliliter)
Temperature
Chlorophyll a
Phycocyanin

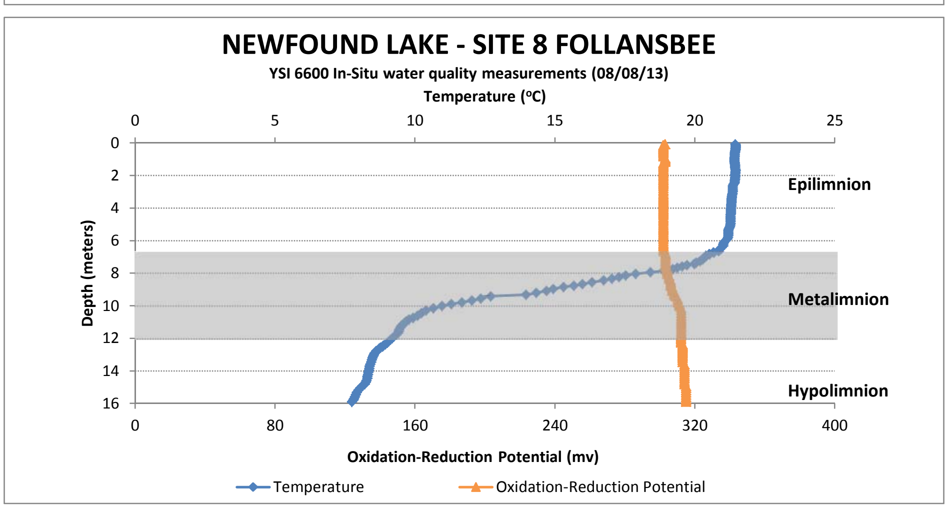

NEWFOUND LAKE - SITE 6 BEACHWOOD
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (°C)
Depth (meters)
Epilimnion
Metalimnion
Hypolimnion
Specific Conductivity (uS/cm)
Temperature
Specific Conductivity


NEWFOUND LAKE - SITE 6 BEACHWOOD
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (°C)
Depth (meters)
Epilimnion
Metalimnion
Hypolimnion
Oxidation-Reduction Potential (mv)
Temperature
Oxidation-Reduction Potential


NEWFOUND LAKE - SITE 8 FOLLANSBEE
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (ºC)
Depth (meters)
Epilimnion
Metalimnion
Hypolimnion
Dissolved Oxygen (mg/l) pH (standard units)
Temperature
Dissolved Oxygen
pH


NEWFOUND LAKE - SITE 8 FOLLANSBEE
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (ºC)
Depth (meters)
Epilimnion
Metalimnion
Hypolimnion
Chlorophyll a (ug/l) Phycocyanin (10² cells/milliliter)
Temperature
Chlorophyll a
Phycocyanin

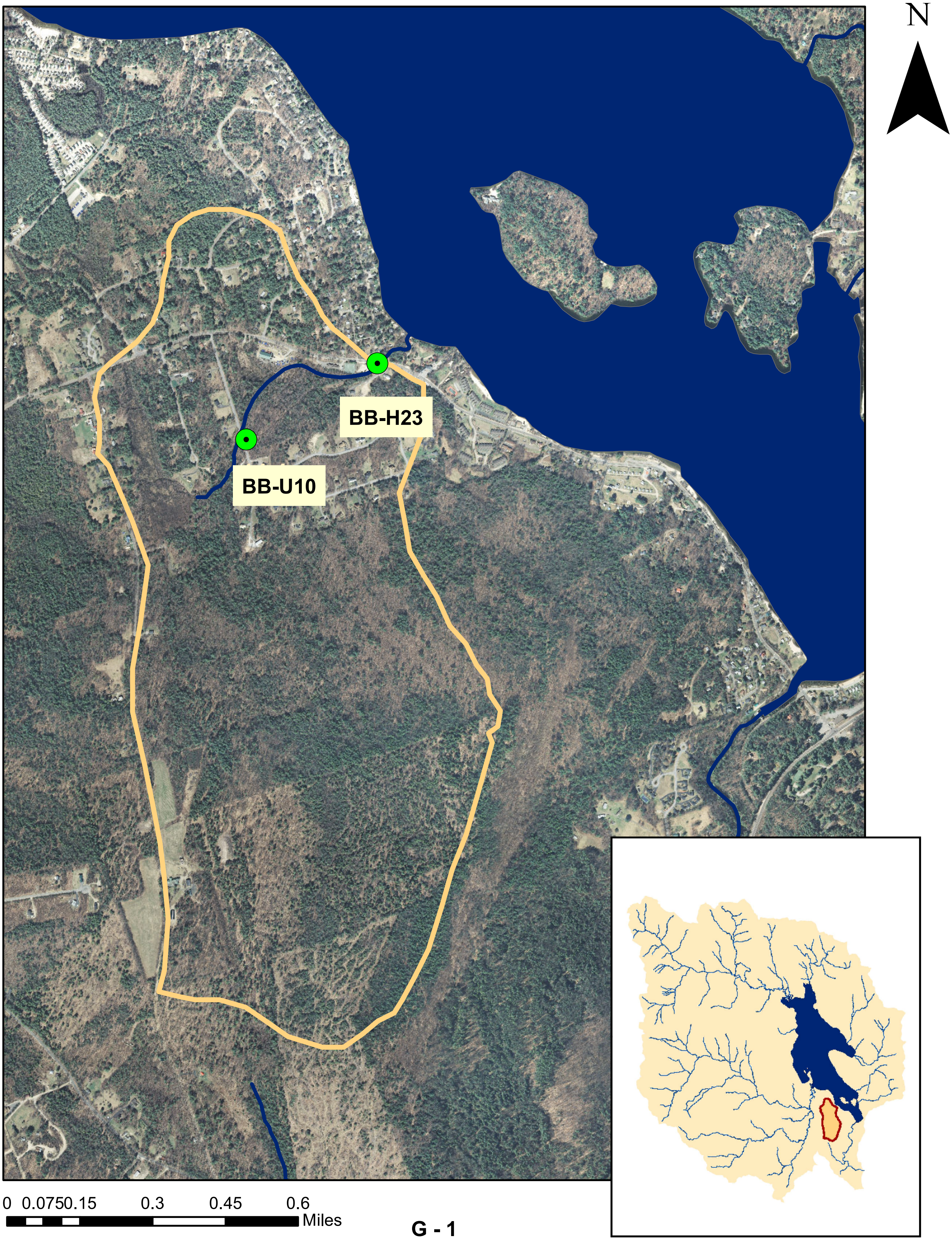

NEWFOUND LAKE - SITE 8 FOLLANSBEE
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (ºC)
Depth (meters)
Epilimnion
Metalimnion
Hypolimnion
Specific Conductivity (uS/cm)
Temperature
Specific Conductivity


NEWFOUND LAKE - SITE 8 FOLLANSBEE
YSI 6600 In-Situ water quality measurements (08/08/13)
Temperature (ºC)
Depth (meters)
Epilimnion
Metalimnion
Hypolimnion
Oxidation-Reduction Potential (mv)
Temperature
Oxidation-Reduction Potential

APPENDIX G

The following subwatershed maps represent active and proposed headwater tributary sampling locations in the Black Brook, Cockermouth River, Dick Brown Brook, Fowler River, Georges Brook, Hemlock Brook, Tilton Brook and Whittemore Brook subwatersheds. Each map includes a vicinity map of the Newfound Lake watershed, which highlights the subwatershed of interest in yellow. Each map also includes the subwatershed boundary (represented by the red lines), sampling points with the site ID information (represented by green points), and tributaries (blue lines).

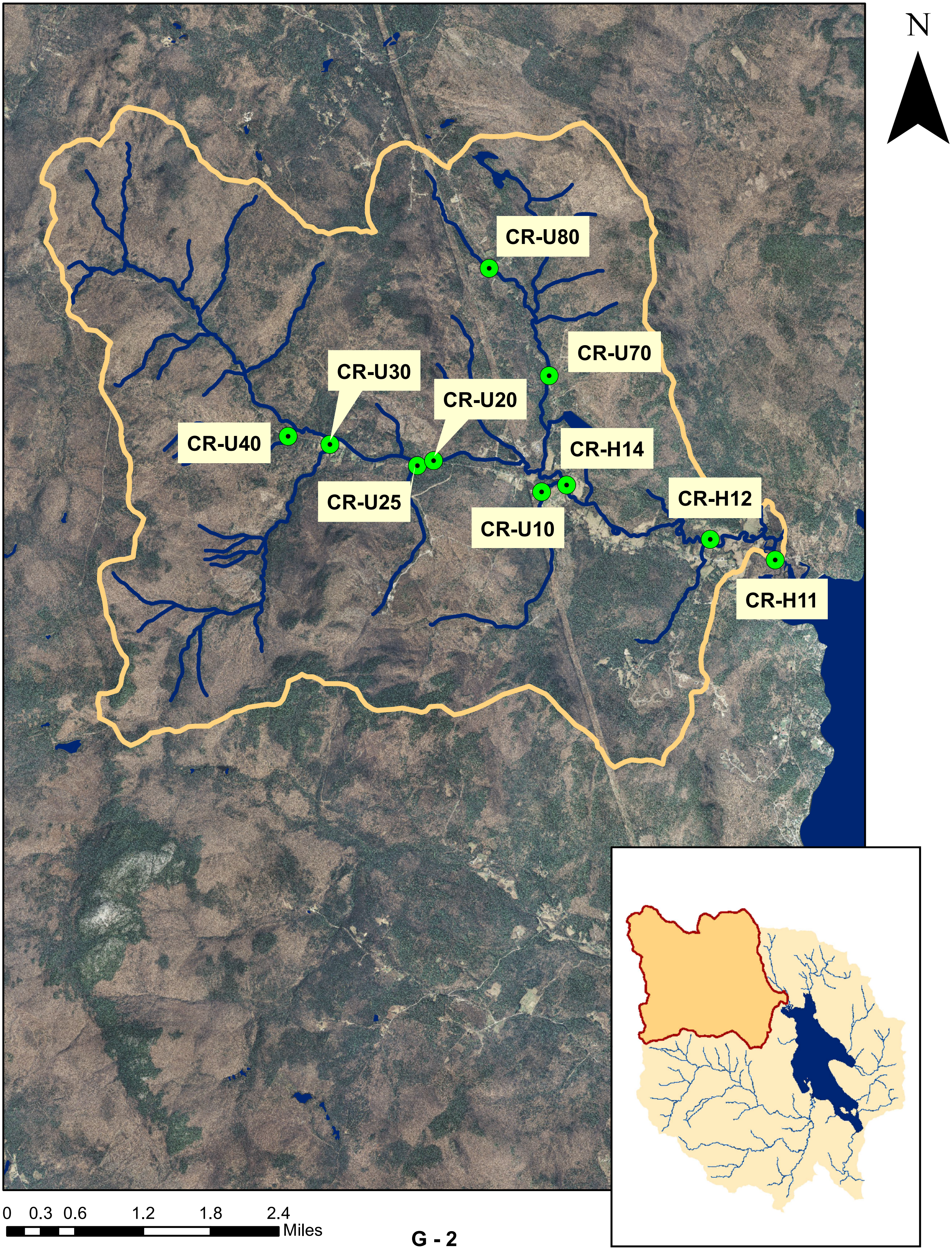
Black Brook Subwatershed



G - 1

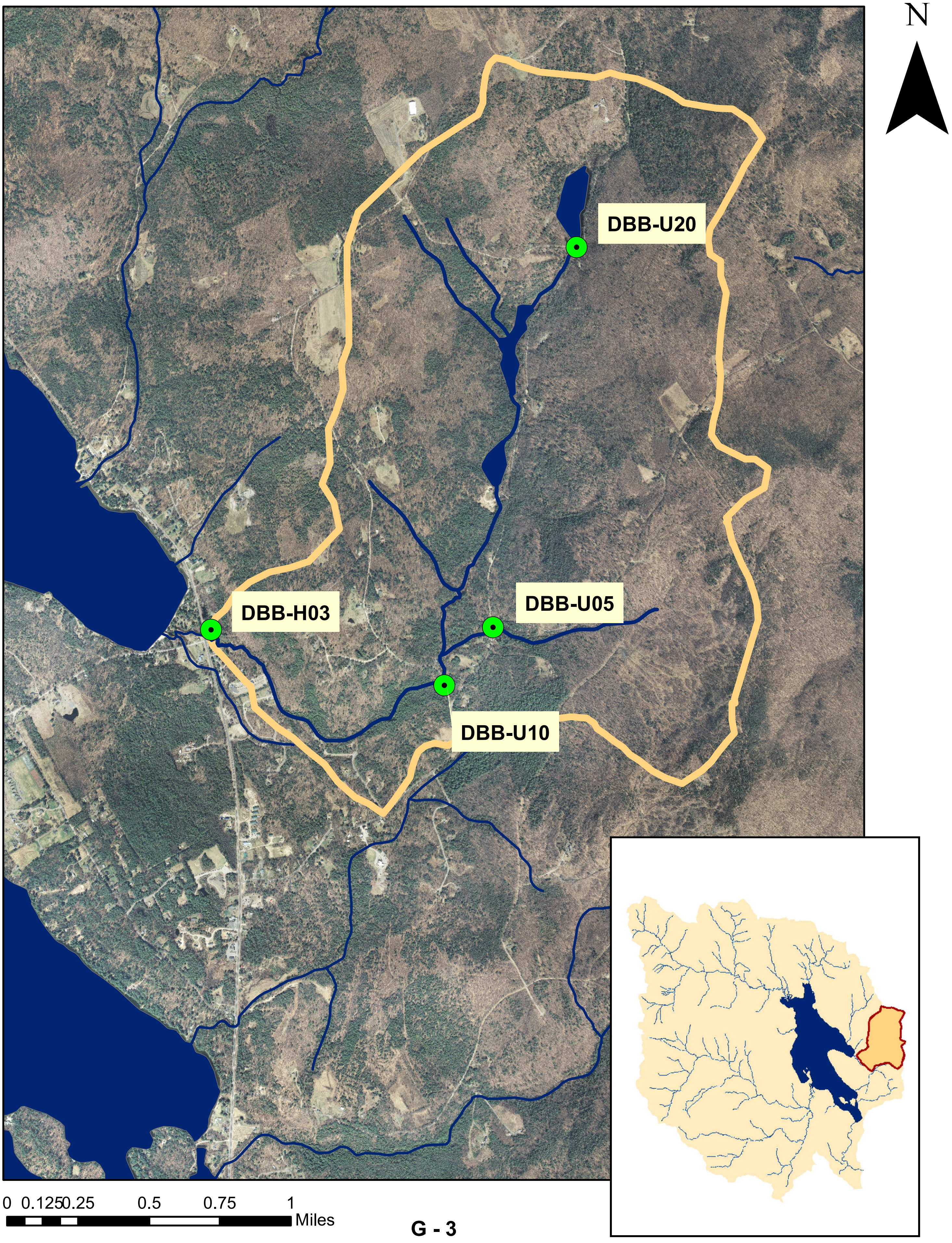
Aerial Orthophoto Source: NH GRANIT
Site location GPS coordinates collected by the UNH Center of Freshwater Biology

Cockermouth River Subwatershed



Aerial Orthophoto Source: NH GRANIT
Site location GPS coordinates collected by the UNH Center of Freshwater Biology

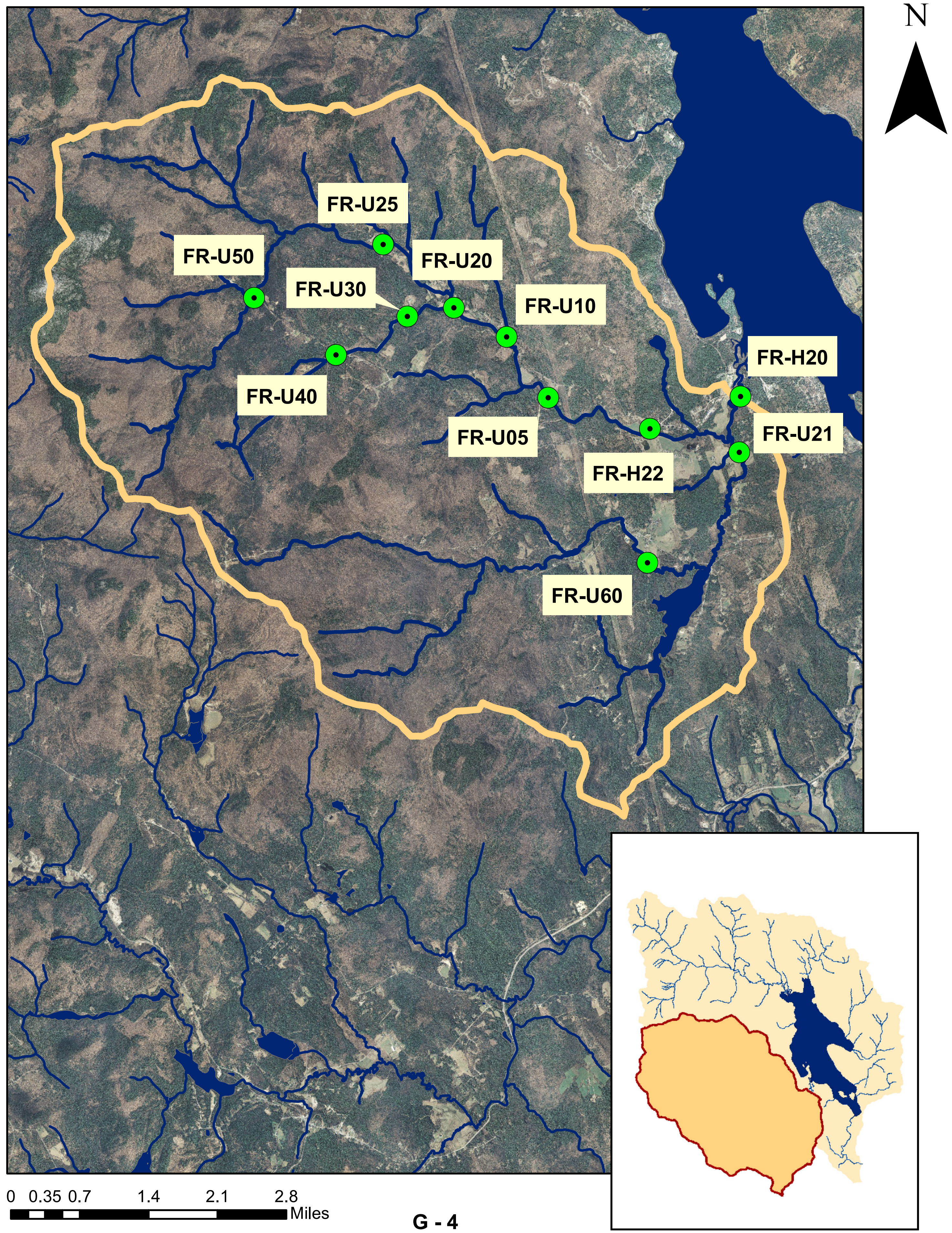
Dick Brown Brook Subwatershed



G - 3

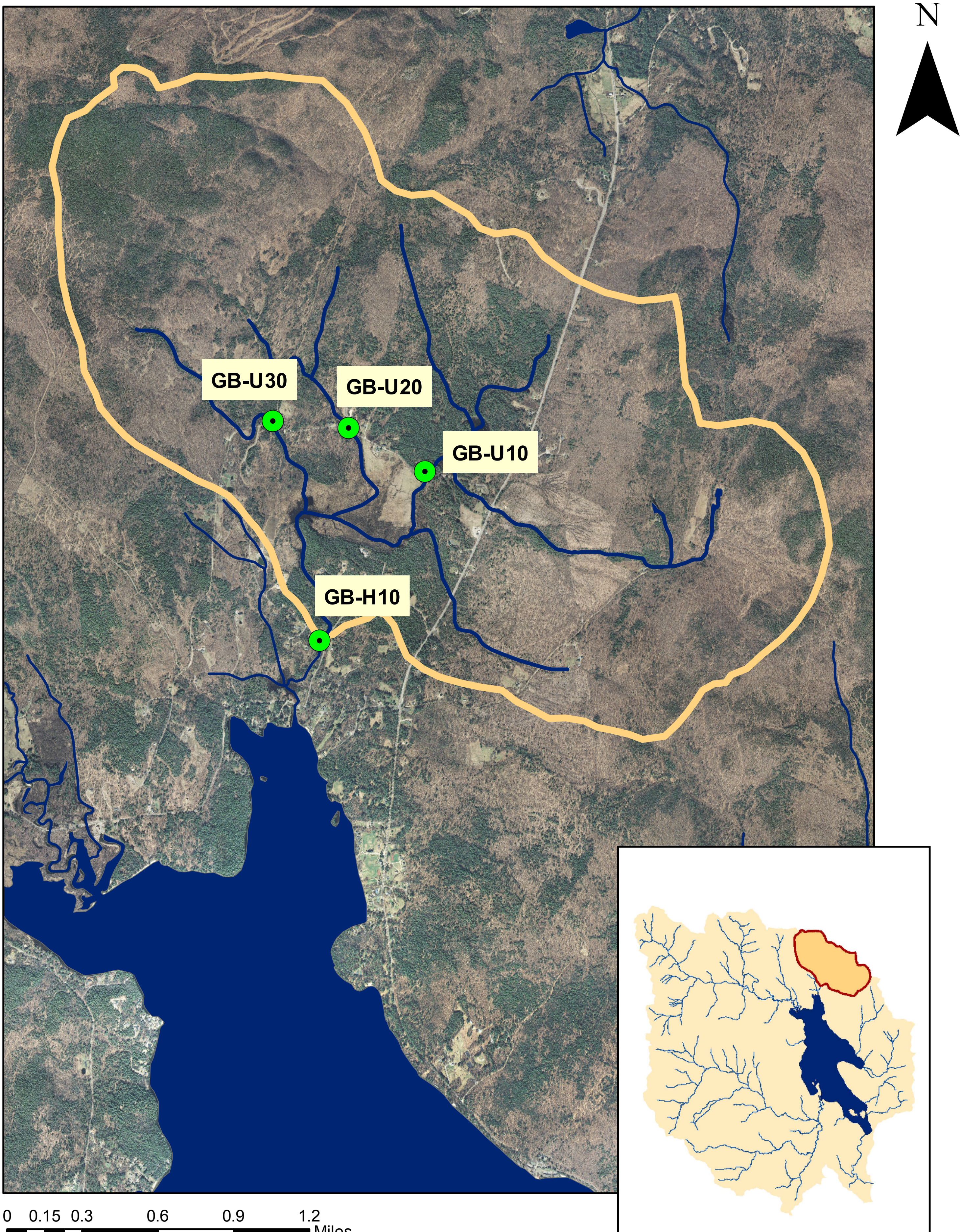
Aerial Orthophoto Source: NH GRANIT
Site location GPS coordinates collected by the UNH Center of Freshwater Biology

Fowler River Subwatershed



Aerial Orthophoto Source: NH GRANIT
Site location GPS coordiniates collected by the UNH Center of Freshwater Biology

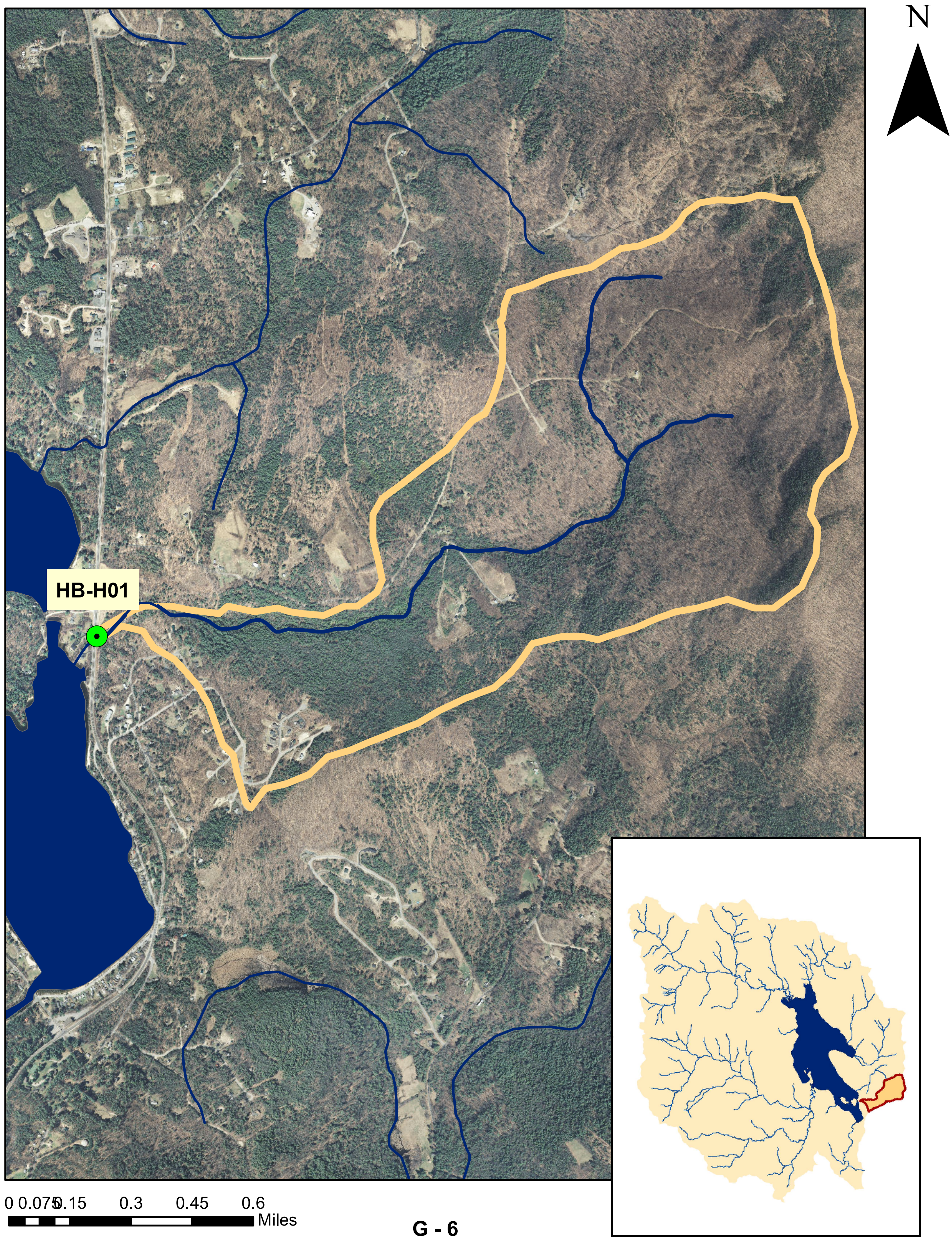
Georges Brook Subwatershed



G - 5

Aerial Orthophoto Source: NH GRANIT
Site location GPS coordiniates collected by the UNH Center of Freshwater Biology

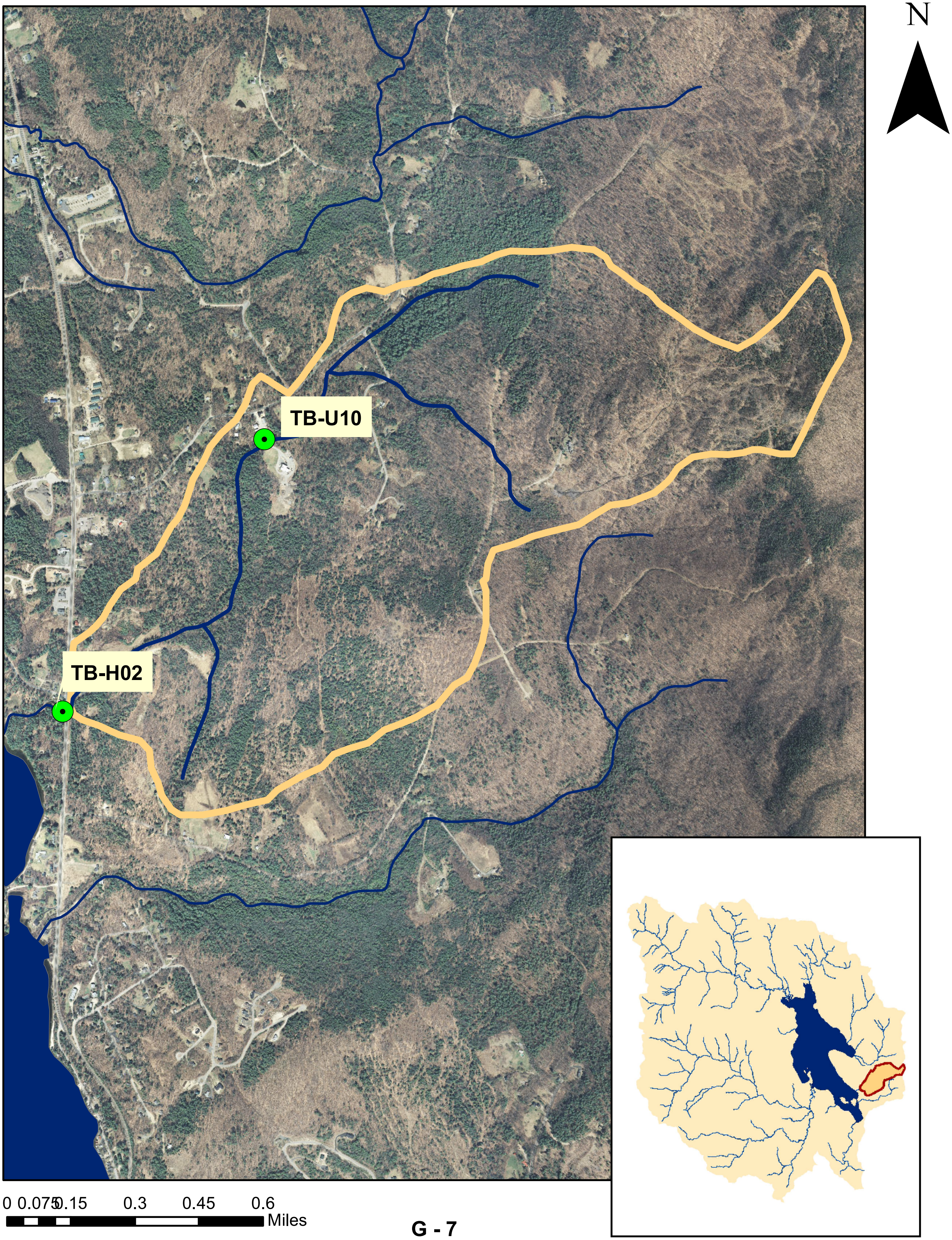
Hemlock Brook Subwatershed



G - 6

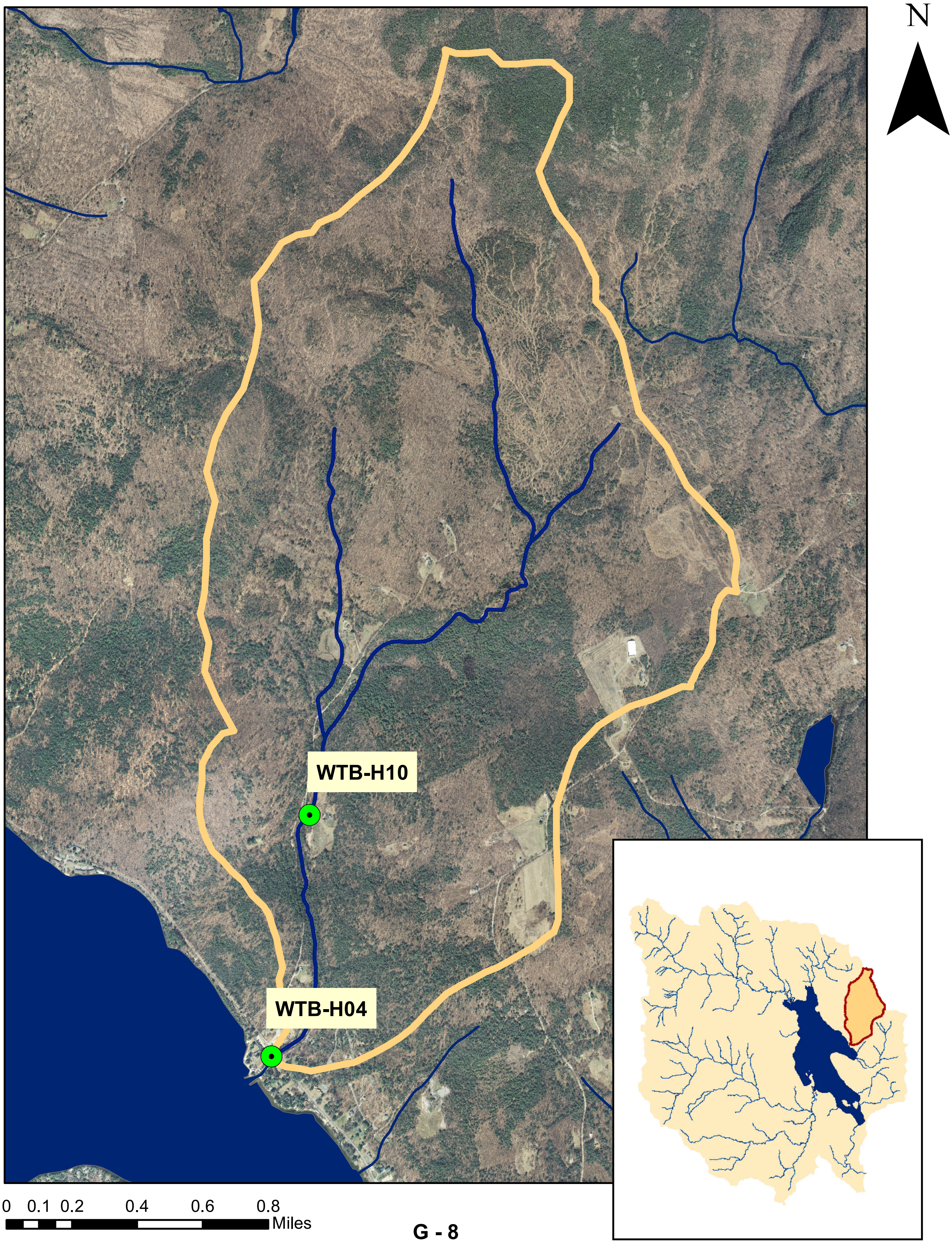
Aerial Orthophoto Source: NH GRANIT
Site location GPS coordinates collected by the UNH Center of Freshwater Biology

Tilton Brook Subwatershed



Aerial Orthophoto Source: NH GRANIT
Site location GPS coordinates collected by the UNH Center of Freshwater Biology

Whittemore Brook Subwatershed

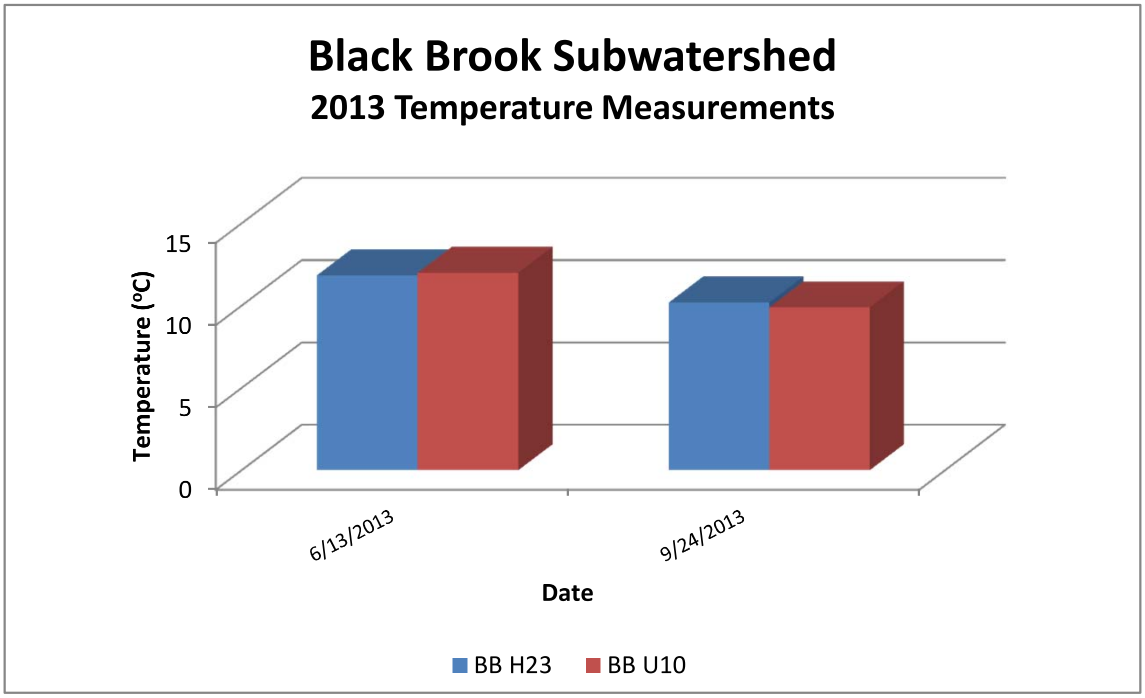


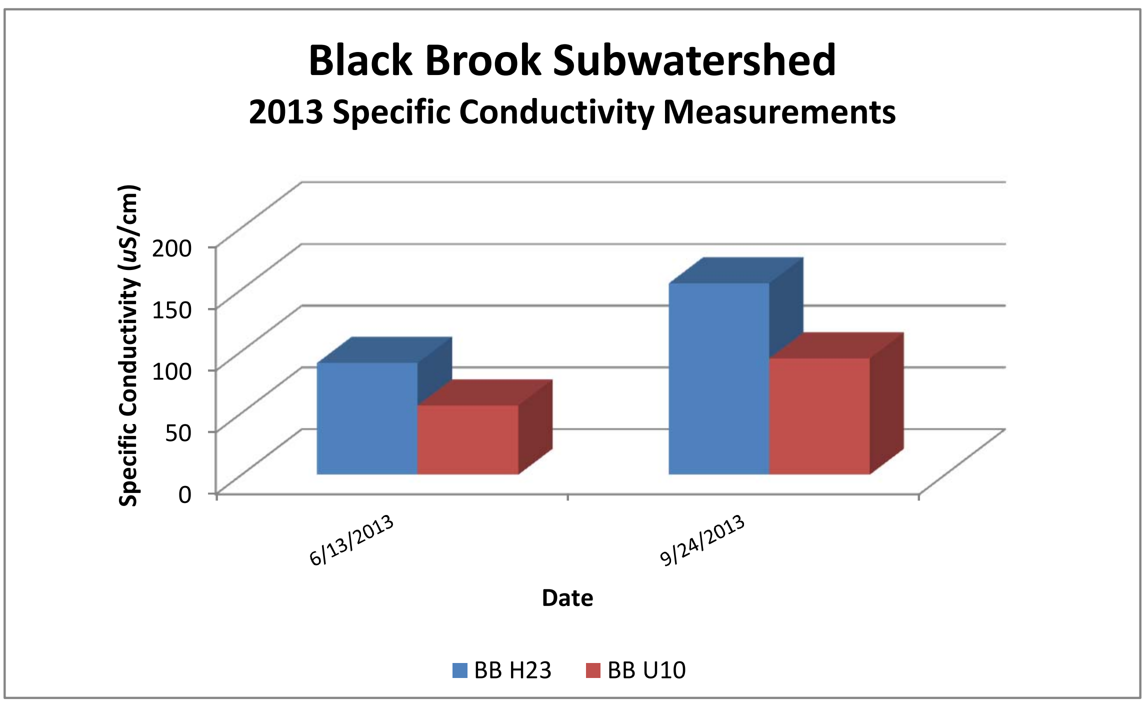
Aerial Orthophoto Source: NH GRANIT
Site location GPS coordinates collected by the UNH Center of Freshwater Biology

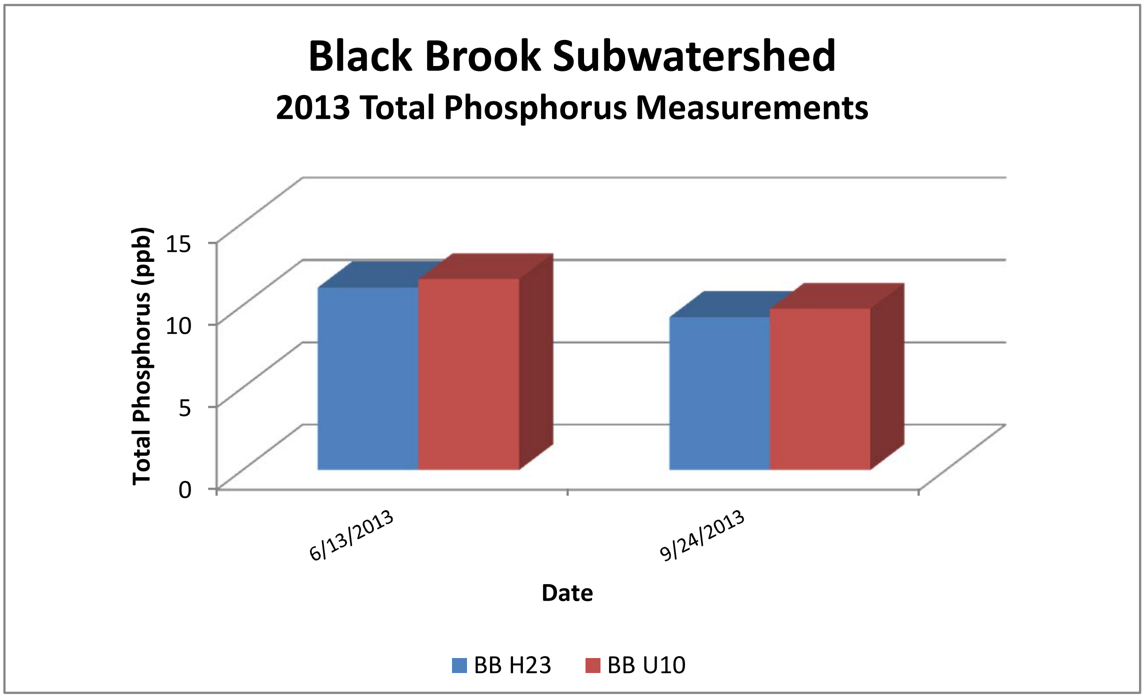
APPENDIX H

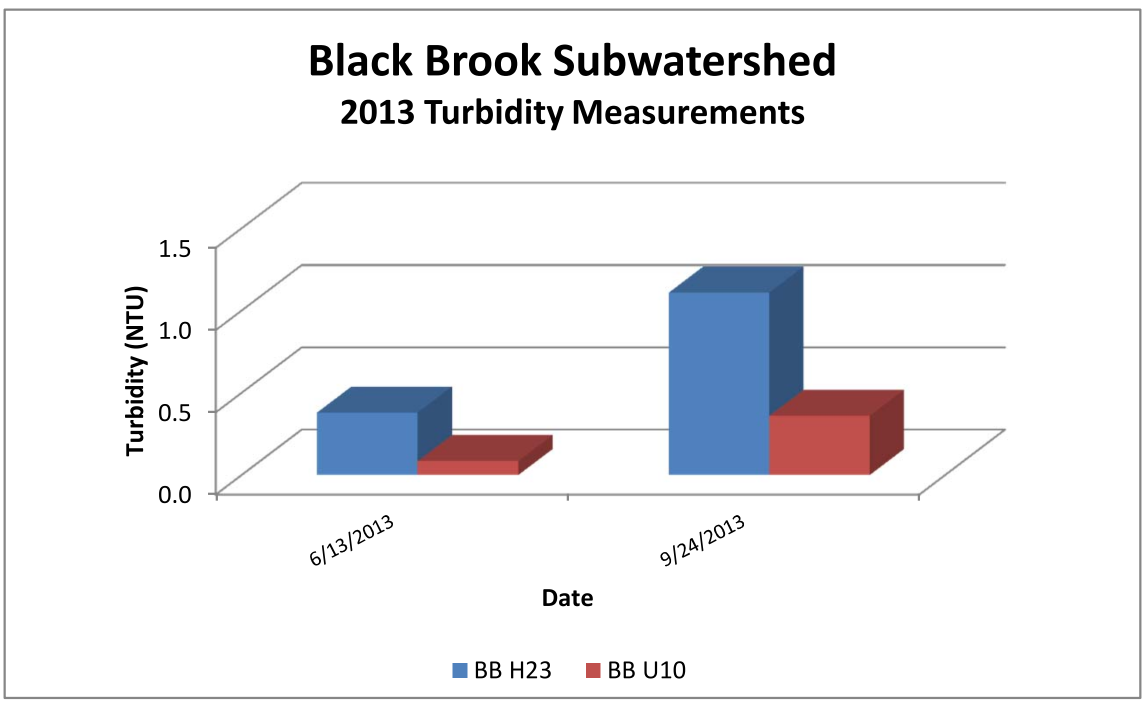
The following inter-site comparisons of the 2013 Newfound Lake headwater tributary data are displayed by sub-watershed: Black Brook, Cockermouth River, Dick Brown Brook, Fowler River, Georges Brook and Whittemore Brook. The vertical bar graphs include temperature, specific conductivity, total phosphorus, turbidity, dissolved oxygen (reported as both milligrams per liter and percent saturation) and pH results that provide insight into seasonal water quality fluctuations and water quality variations among sampling locations.

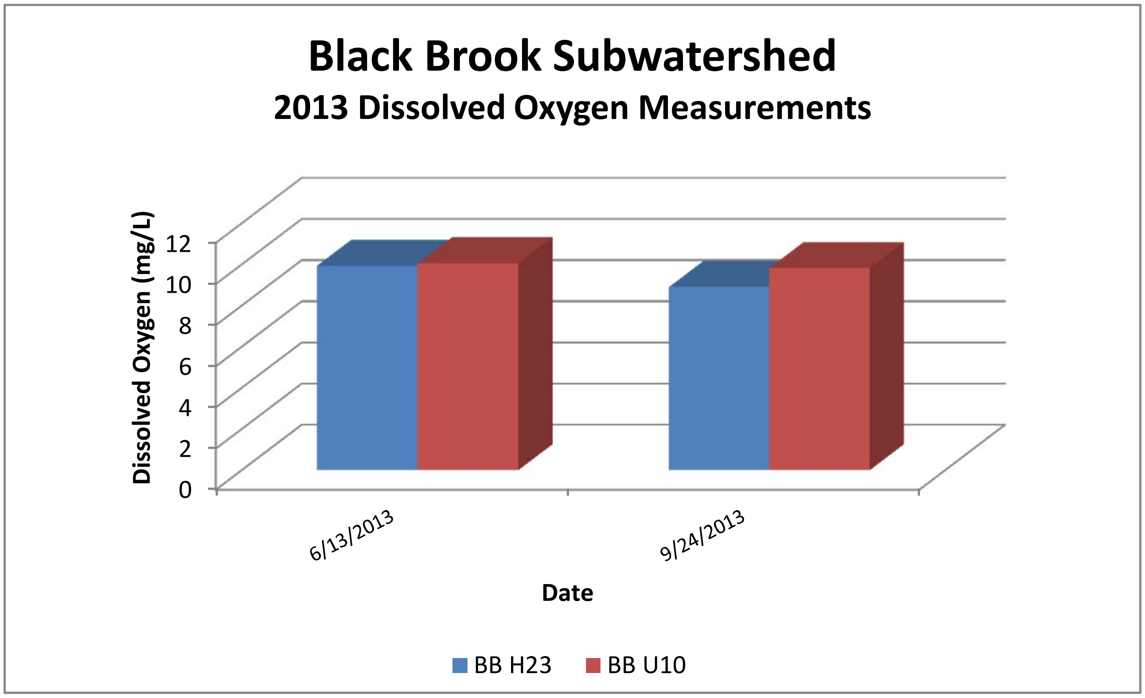
Note: the data depicted in Appendix H are limited to Center for Freshwater Biology data that were collected at all sampling sites during each of the two 2013 sampling events. Refer to Appendix I for a listing of additional water quality data collected at select sampling locations.


Black Brook Subwatershed
2013 Temperature Measurements
Temperature (ºC)
15
10
5
0
6/13/2013
9/24/2013
Date
BB H23
BB U10

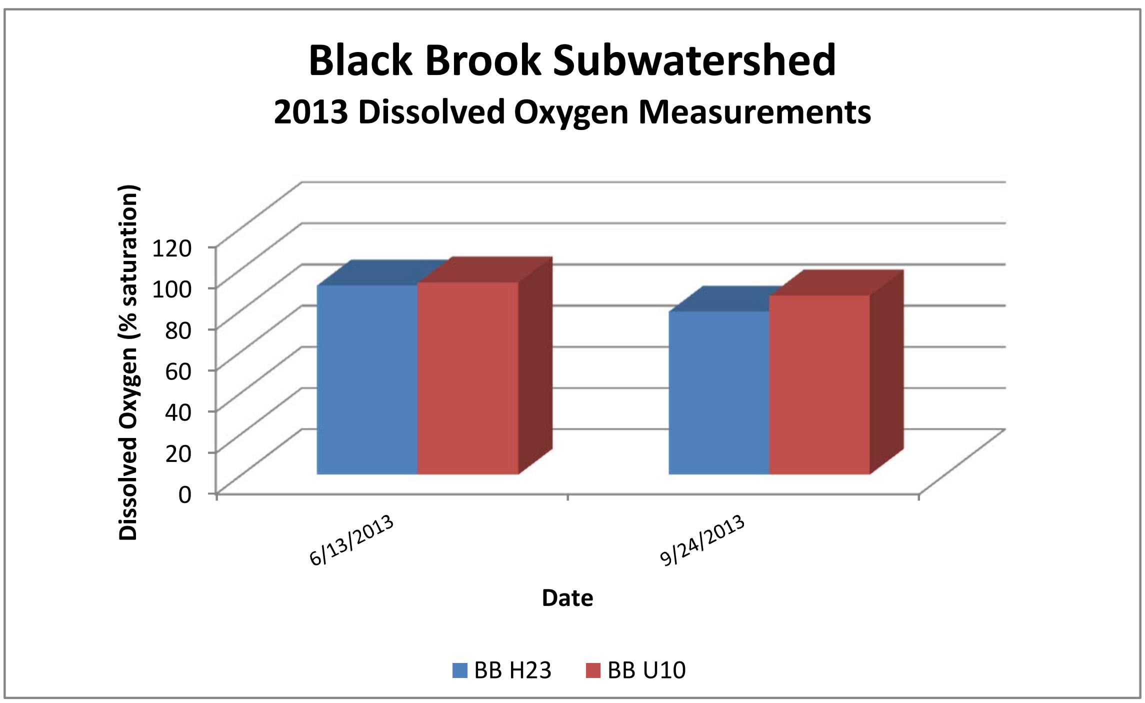

Black Brook Subwatershed
2013 Specific Conductivity Measurements
Specific Conductivity (uS/cm)
200
150
100
50
0
6/13/2013
9/24/2013
Date
BB H23
BB U10


Black Brook Subwatershed
2013 Total Phosphorus Measurements
Total Phosphorus (ppb)
15
10
5
0
6/13/2013
9/24/2013
Date
BB H23
BB U10

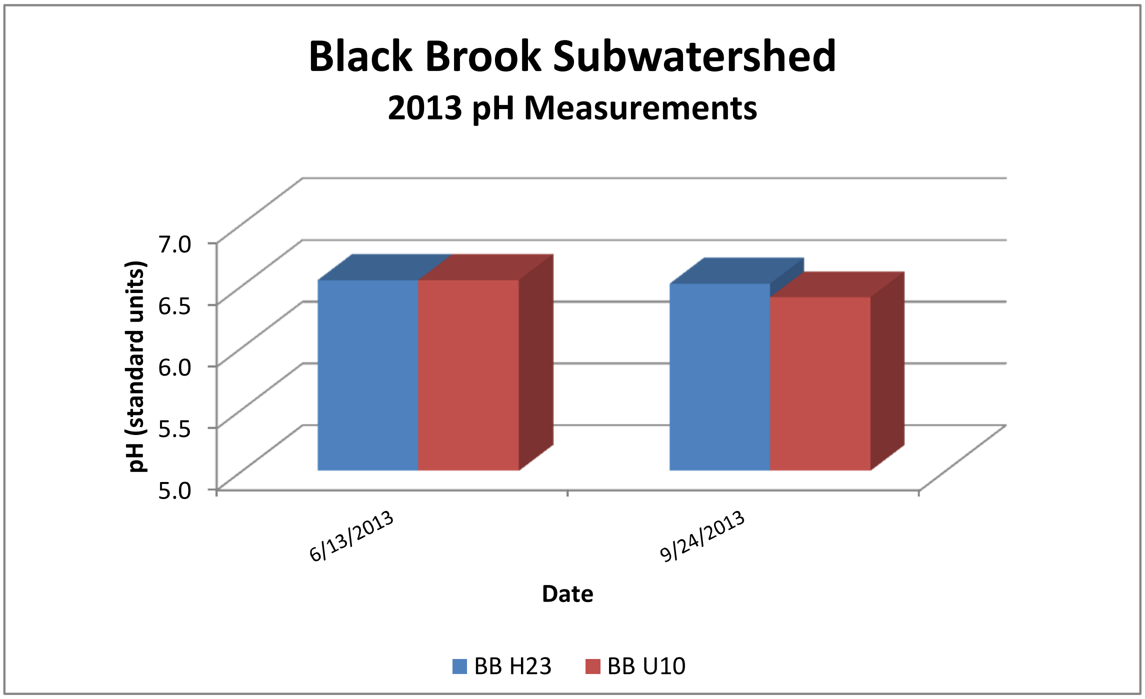

Black Brook Subwatershed
2013 Turbidity Measurements
Turbidity (NTU)
1.5
1.0
0.5
0.0
6/13/2013
9/24/2013
Date
BB H23
BB U10



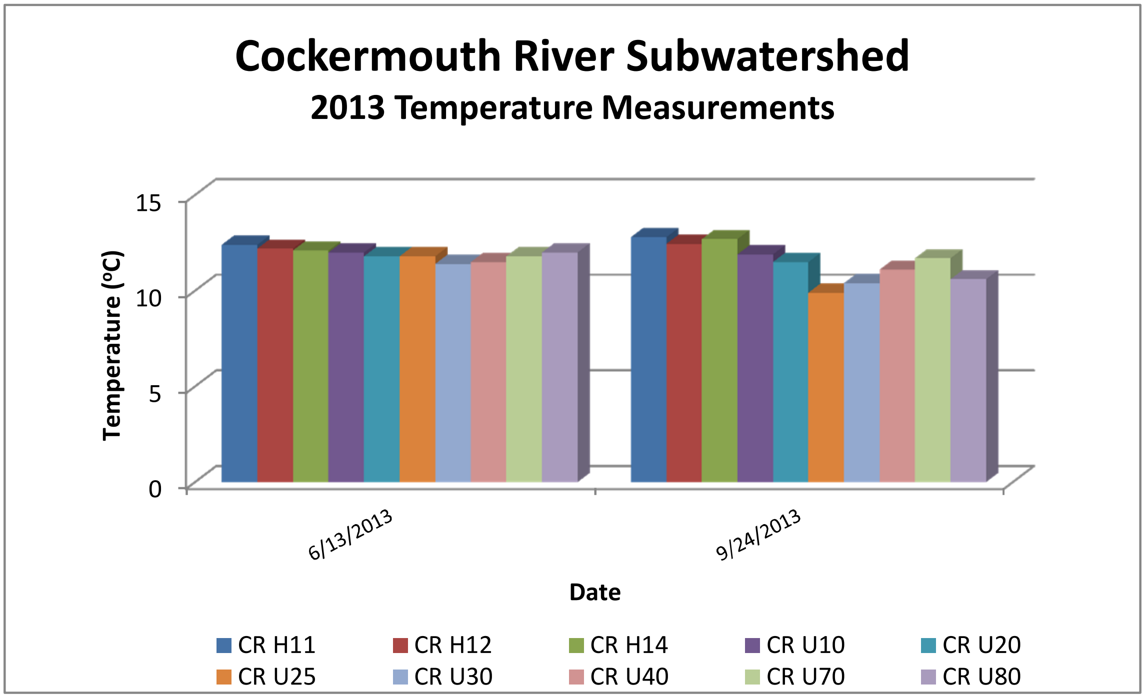
Black Brook Subwatershed
2013 Dissolved Oxygen Measurements
Dissolved Oxygen (mg/L)
12
10
8
6
4
2
0
6/13/2013
9/24/2013
Date
BB H23
BB U10

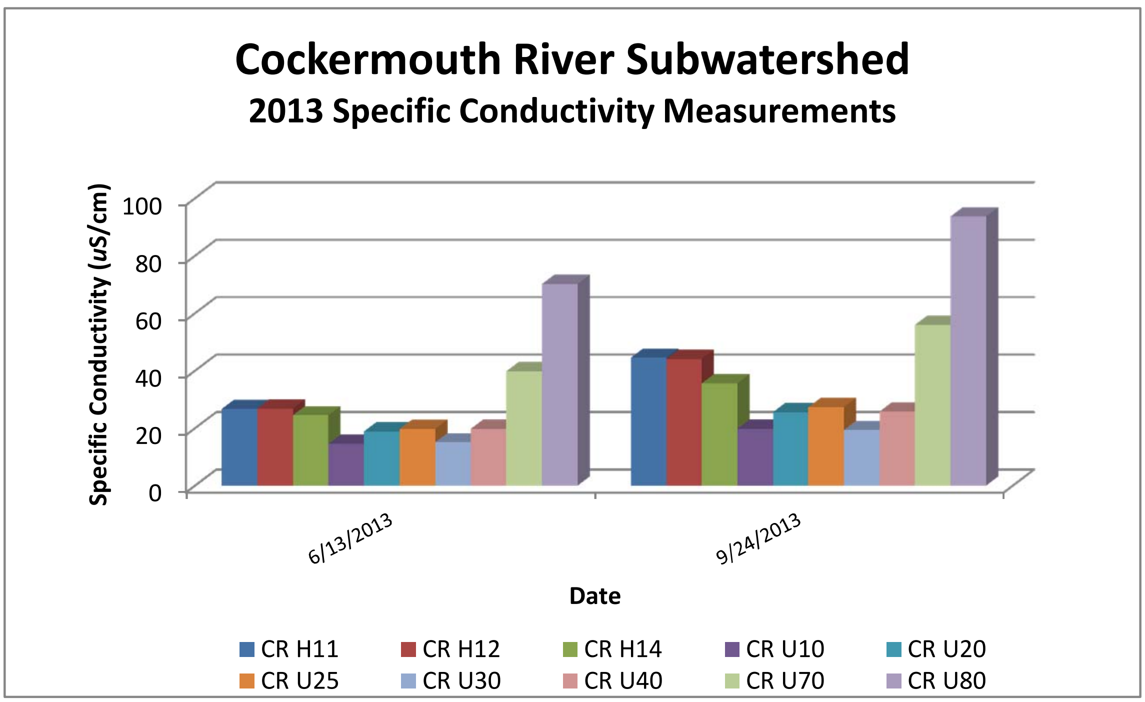


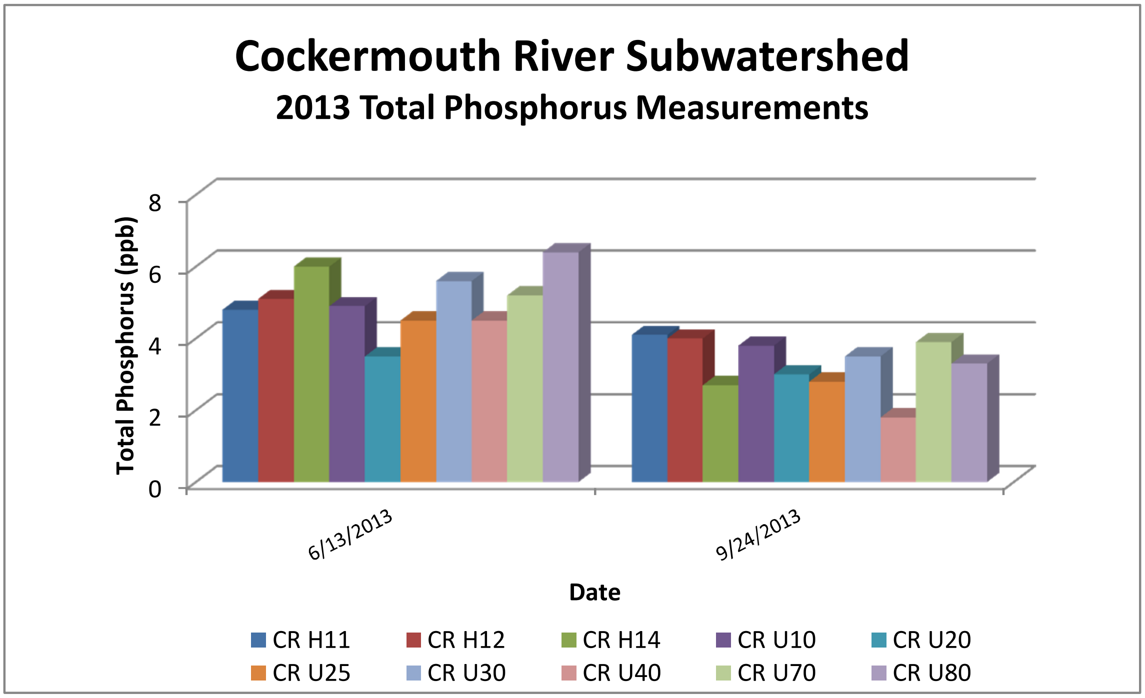
Black Brook Subwatershed
2013 Dissolved Oxygen Measurements
Dissolved Oxygen (% saturation)
120
100
80
60
40
20
0
6/13/2013
9/24/2013
Date
BB H23
BB U10

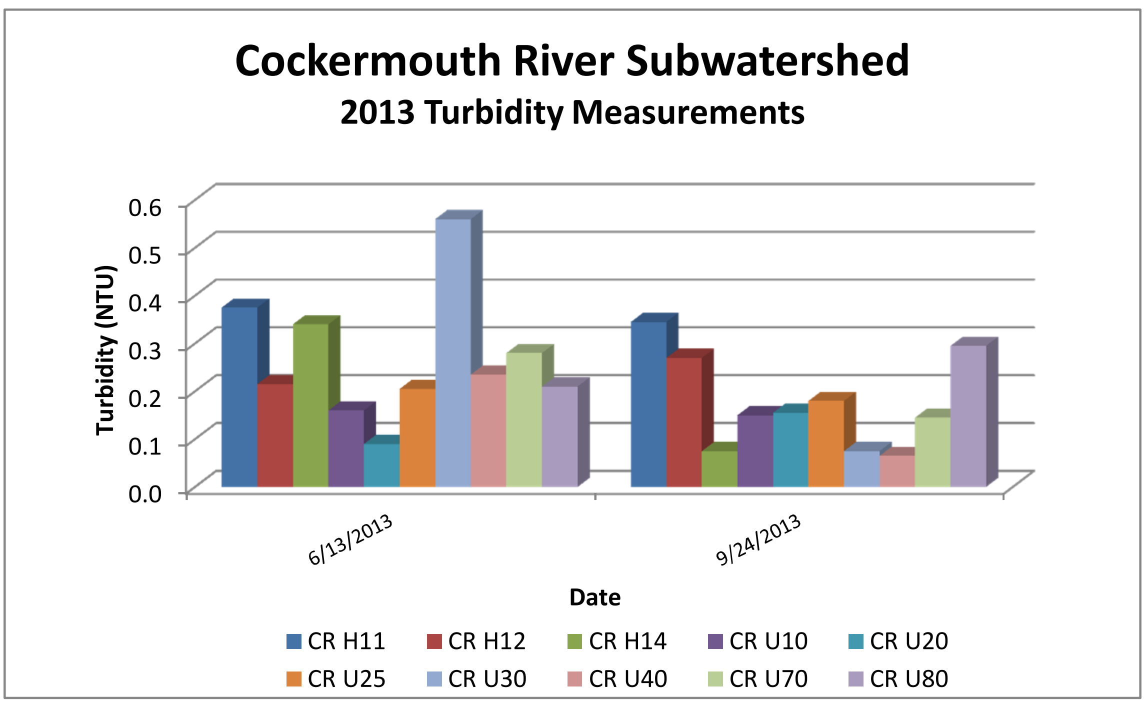


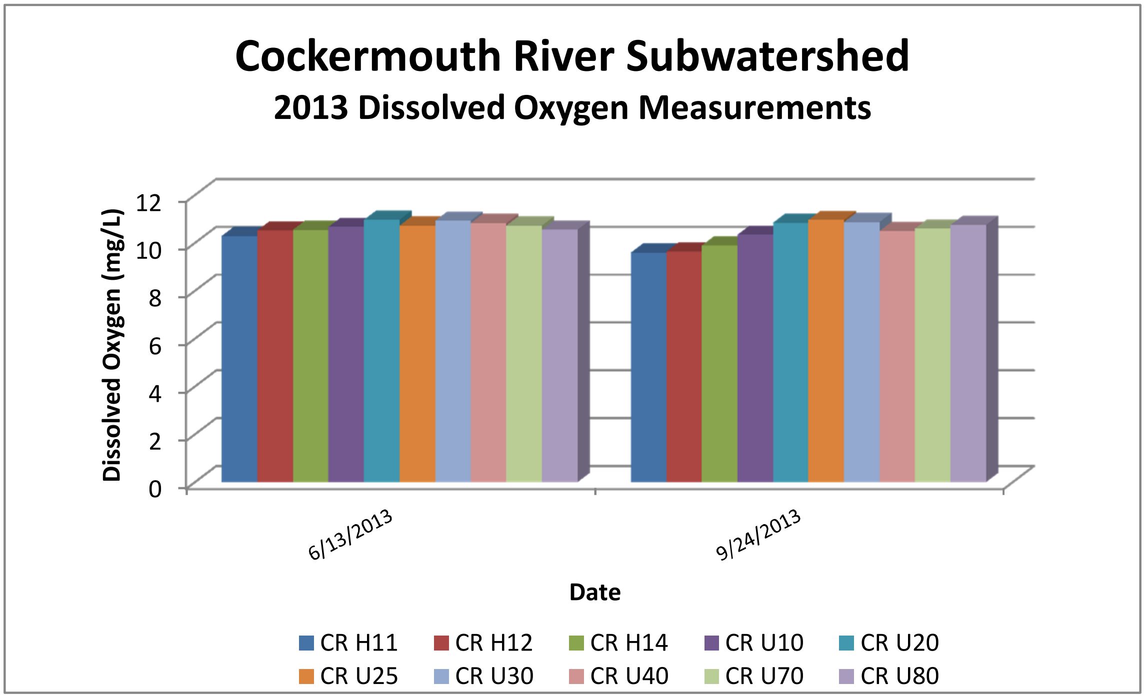
Black Brook Subwatershed
2013 pH Measurements
pH (standard units)
7.0
6.5
6.0
5.5
5.0
6/13/2013
9/24/2013
Date
BB H23
BB U10

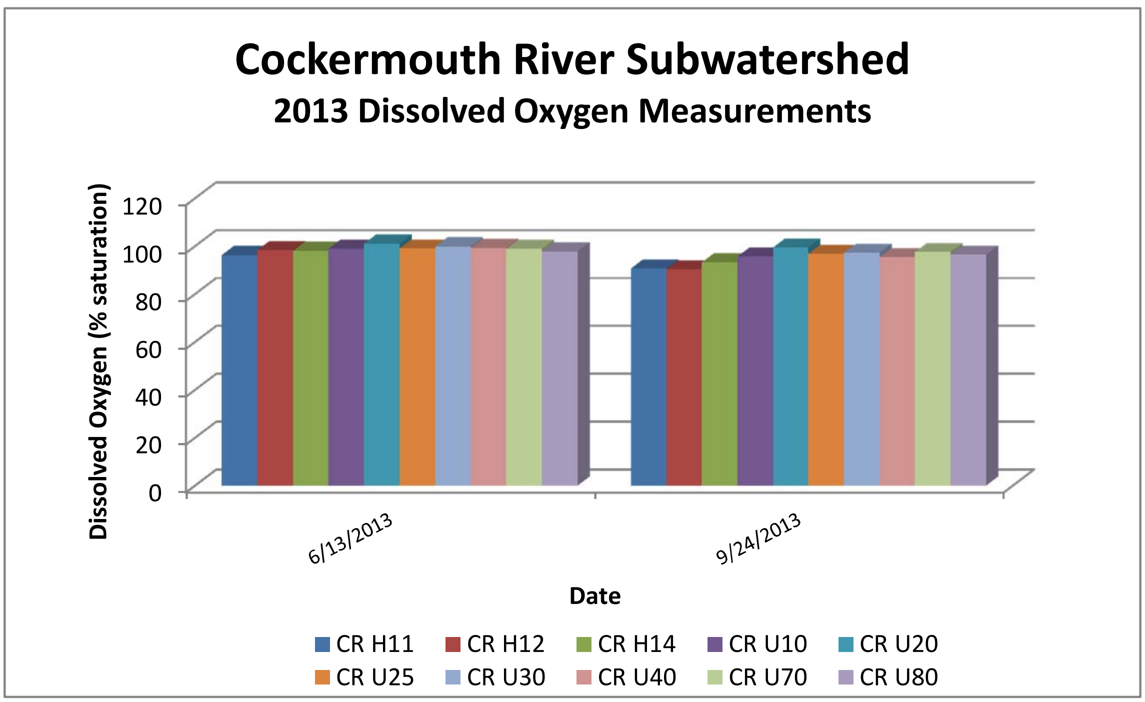

Cockermouth River Subwatershed
2013 Temperature Measurements
Temperature (ºC)
15
10
5
0
6/13/2013
9/24/2013
Date
CR H11
CR H12
CR H14
CR U10
CR U20
CR U25
CR U30
CR U40
CR U70
CR U80

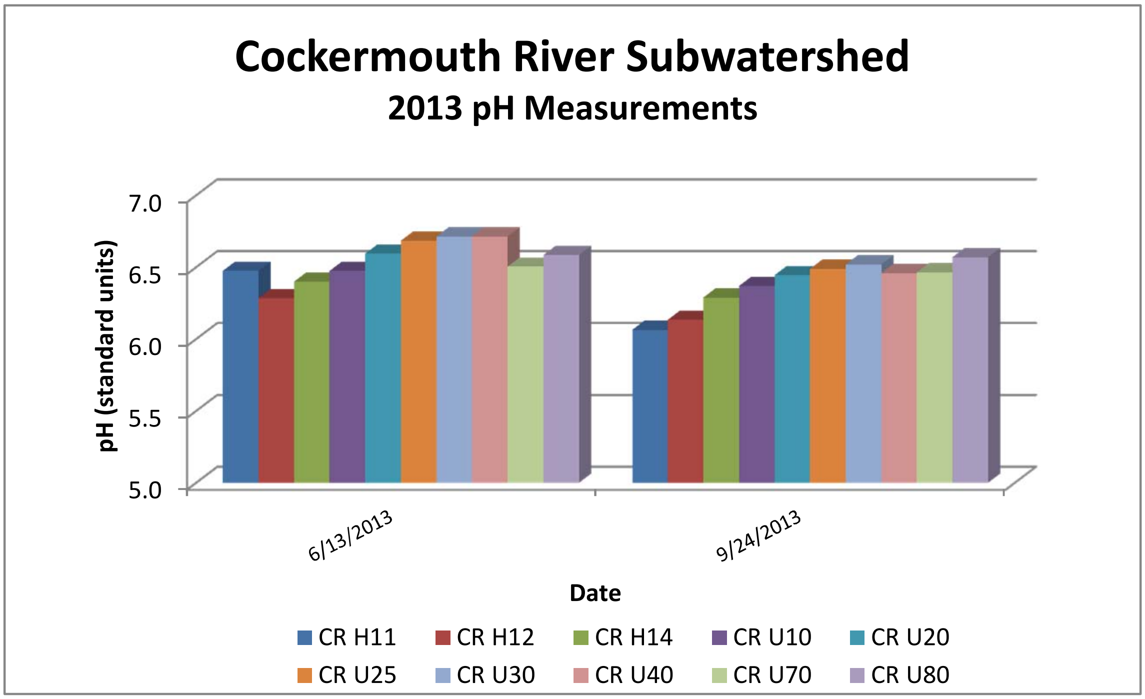

Cockermouth River Subwatershed
2013 Specific Conductivity Measurements
Specific Conductivity (uS/cm)
100
80
60
40
20
0
6/13/2013
9/24/2013
Date
CR H11
CR H12
CR H14
CR U10
CR U20
CR U25
CR U30
CR U40
CR U70
CR U80

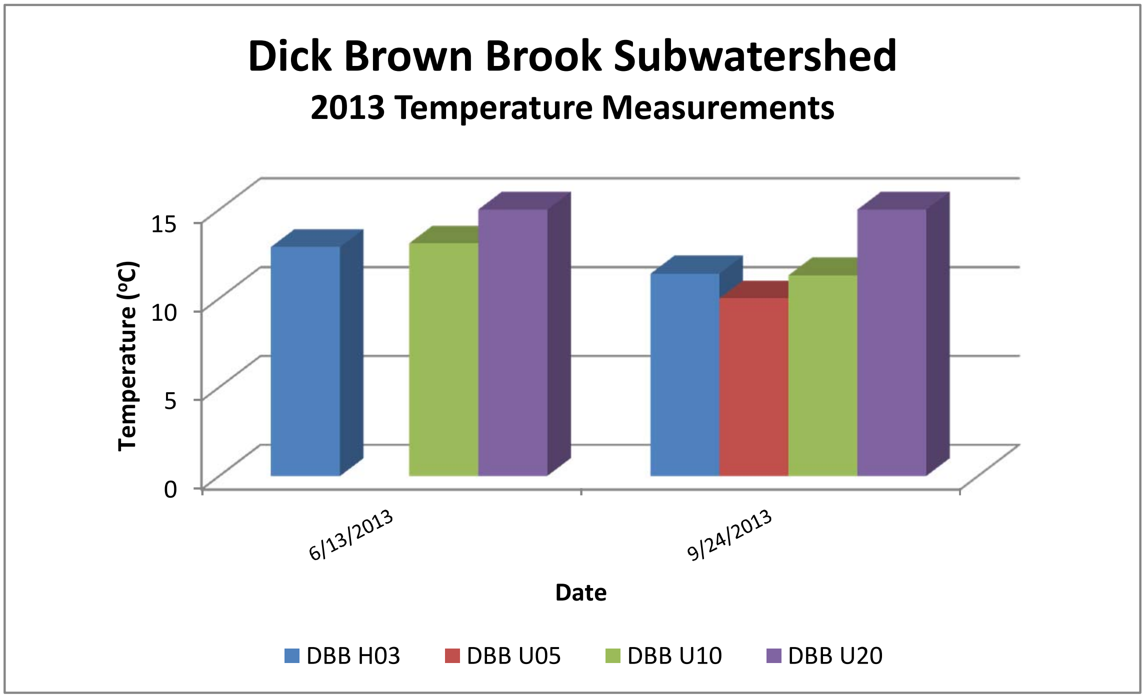

Cockermouth River Subwatershed
2013 Total Phosphorus Measurements
Total Phosphorus (ppb)
0
2
4
6
8
6/13/2013
9/24/2013
Date
CR H11
CR H12
CR H14
CR U10
CR U20
CR U25
CR U30
CR U40
CR U70
CR U80


Cockermouth River Subwatershed
2013 Turbidity Measurements
Turbidity (NTU)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
6/13/2013
9/24/2013
Date
CR H11
CR H12
CR H14
CR U10
CR U20
CR U25
CR U30
CR U40
CR U70
CR U80

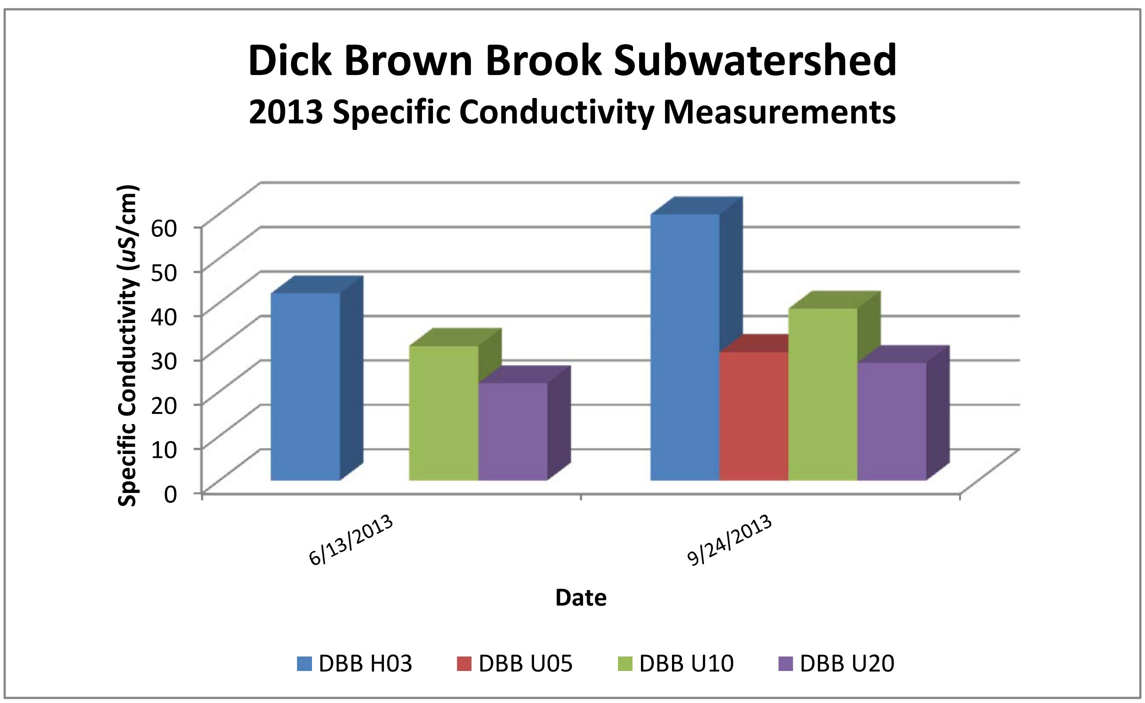

Cockermouth River Subwatershed
2013 Dissolved Oxygen Measurements
Dissolved Oxygen (mg/L)
0
2
4
6
8
10
12
6/13/2013
9/24/2013
Date
CR H11
CR H12
CR H14
CR U10
CR U20
CR U25
CR U30
CR U40
CR U70
CR U80


Cockermouth River Subwatershed
2013 Dissolved Oxygen Measurements
Dissolved Oxygen (% saturation)
0
20
40
60
80
100
120
6/13/2013
9/24/2013
Date
CR H11
CR H12
CR H14
CR U10
CR U20
CR U25
CR U30
CR U40
CR U70
CR U80

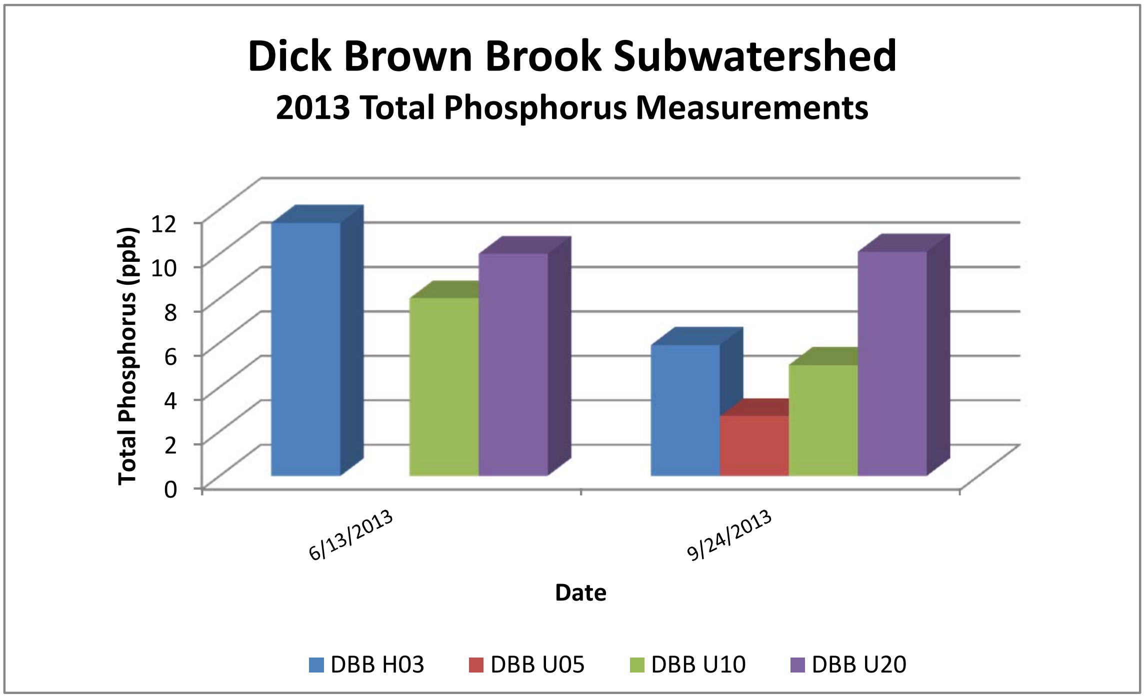

Cockermouth River Subwatershed
2013 pH Measurements
pH (standard units)
7.0
6.5
6.0
5.5
5.0
6/13/2013
9/24/2013
Date
CR H11
CR H12
CR H14
CR U10
CR U20
CR U25
CR U30
CR U40
CR U70
CR U80



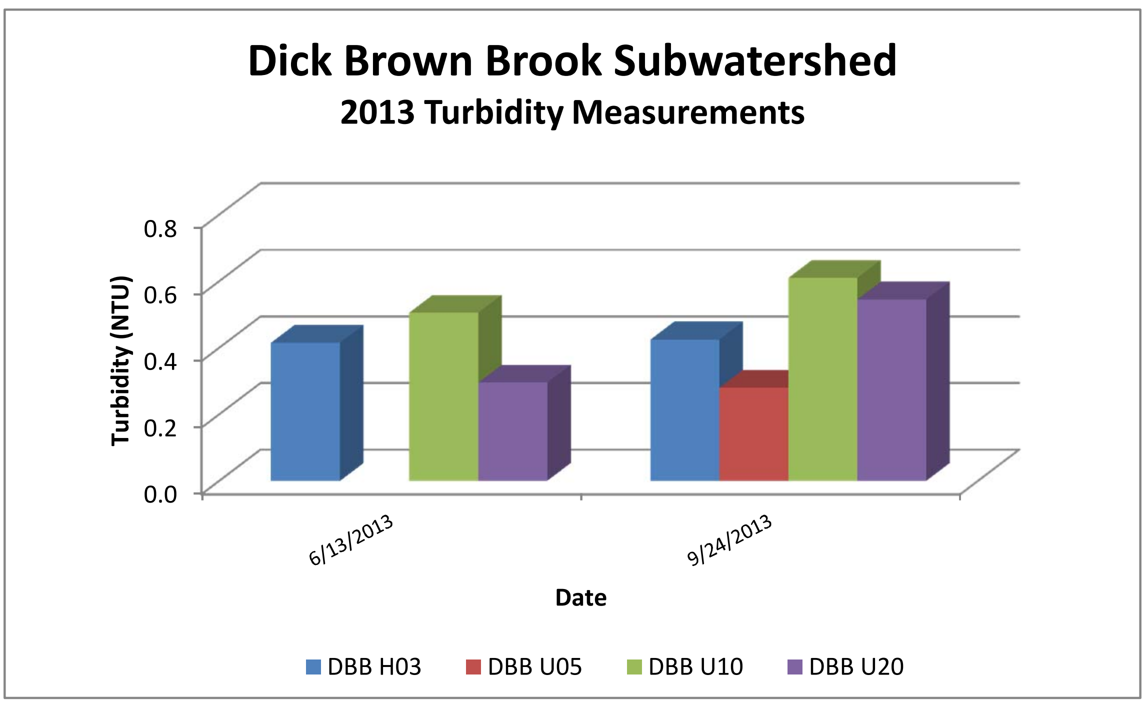
Dick Brown Brook Subwatershed
2013 Temperature Measurements
Temperature (ºC)
15
10
5
0
6/13/2013
9/24/2013
Date
DBB H03
DBB U05
DBB U10
DBB U20



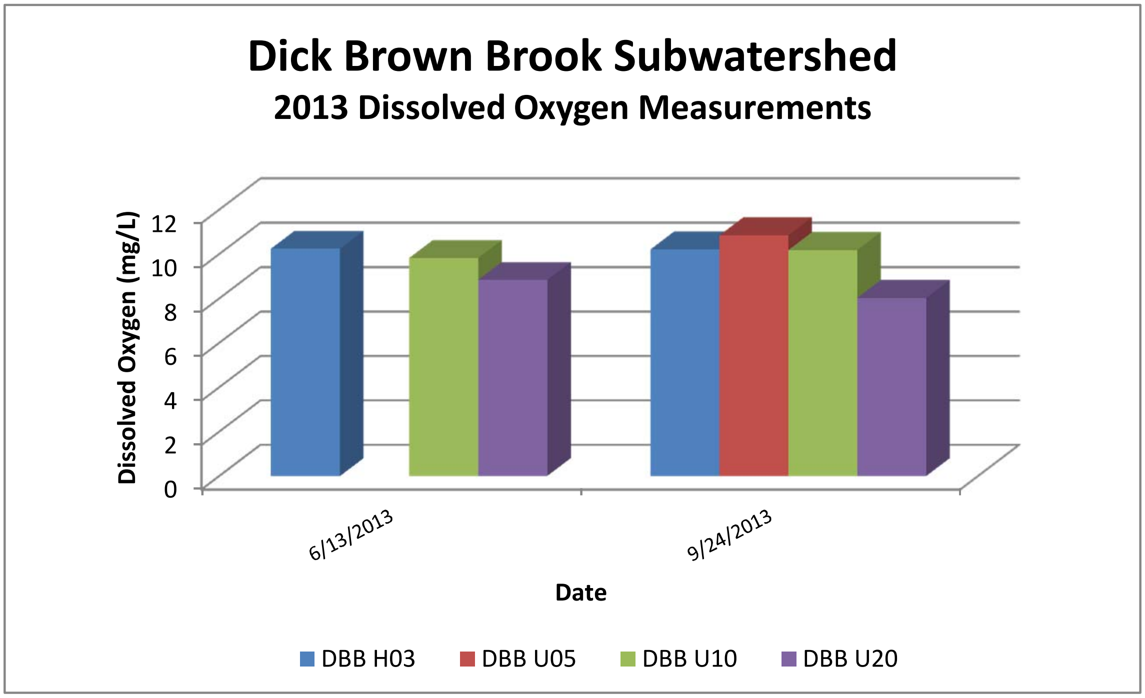
Dick Brown Brook Subwatershed
2013 Specific Conductivity Measurements
Specific Conductivity (uS/cm)
60
50
40
30
20
10
0
6/13/2013
9/24/2013
Date
DBB H03
DBB U05
DBB U10
DBB U20

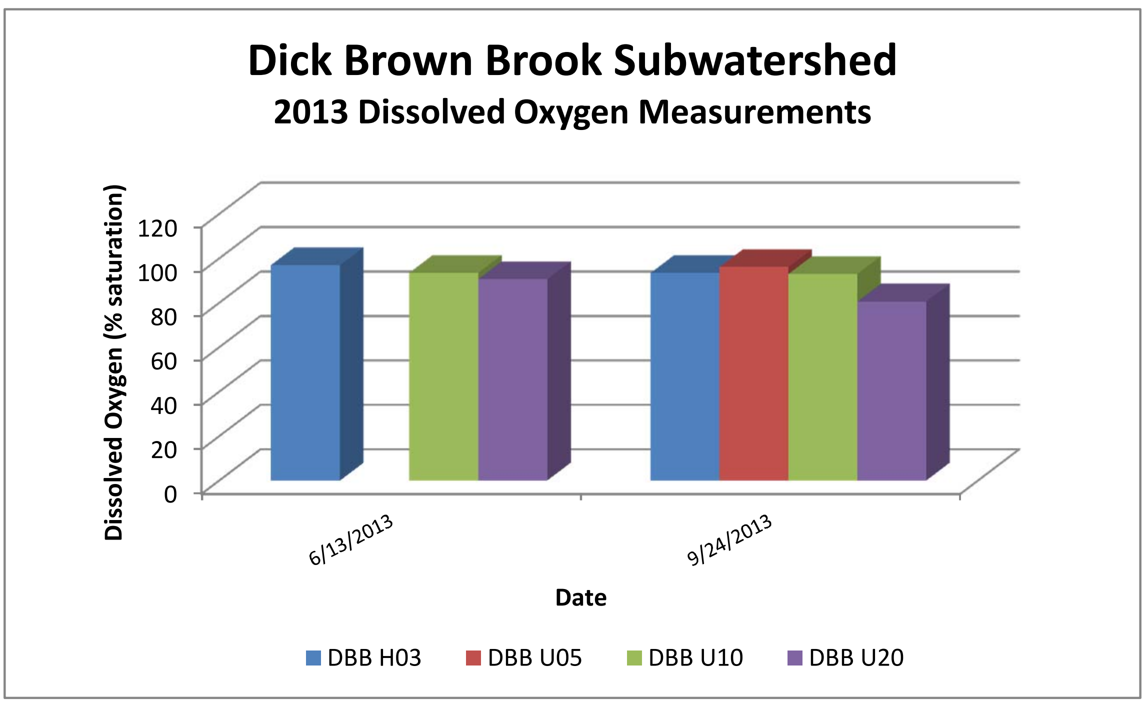


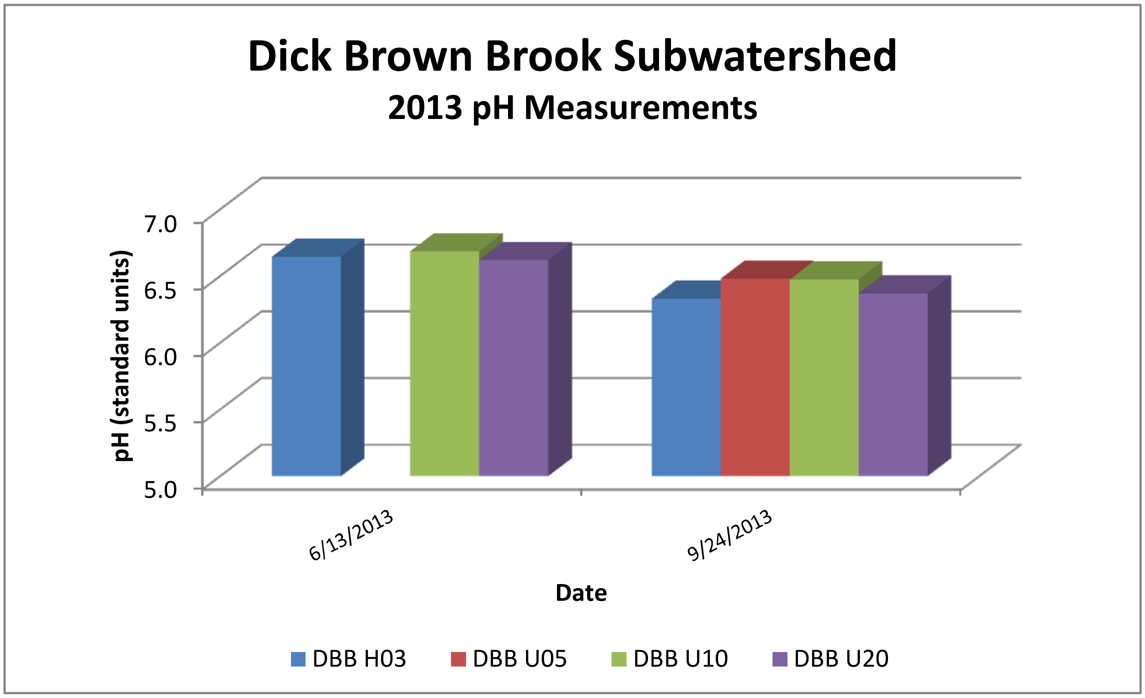
Dick Brown Brook Subwatershed
2013 Total Phosphorus Measurements
Total Phosphorus (ppb)
0
2
4
6
8
10
12
6/13/2013
9/24/2013
Date
DBB H03
DBB U05
DBB U10
DBB U20

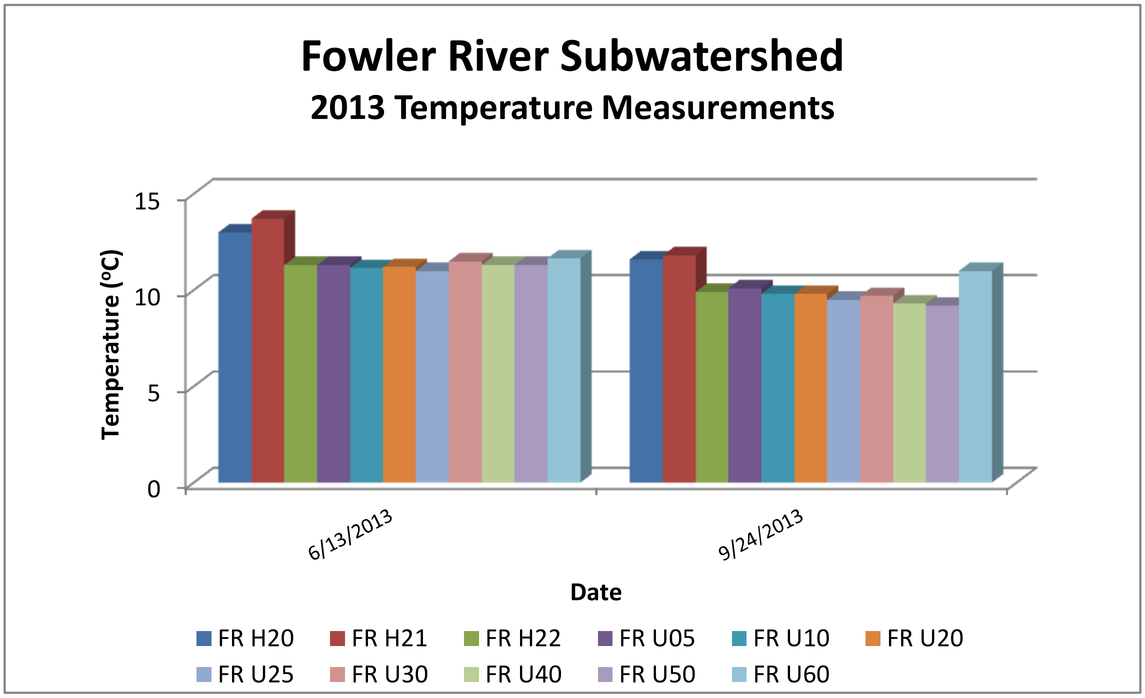


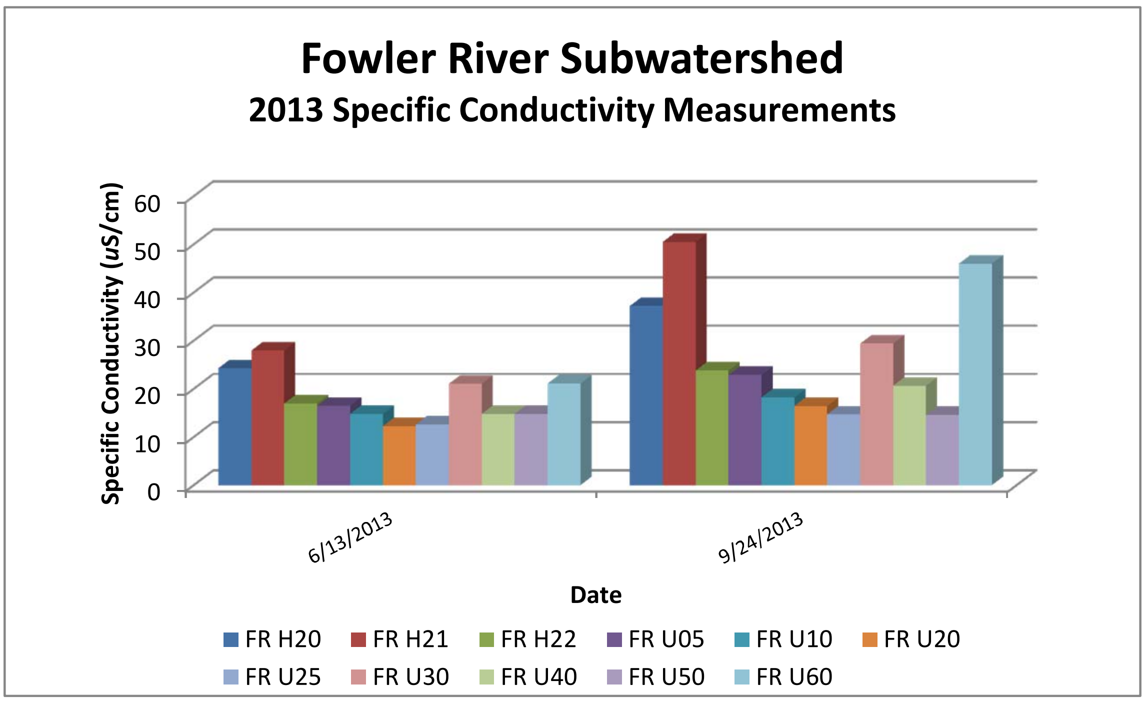
Dick Brown Brook Subwatershed
2013 Turbidity Measurements
Turbidity (NTU)
0.0
0.2
0.4
0.6
0.8
6/13/2013
9/24/2013
Date
DBB H03
DBB U05
DBB U10
DBB U20

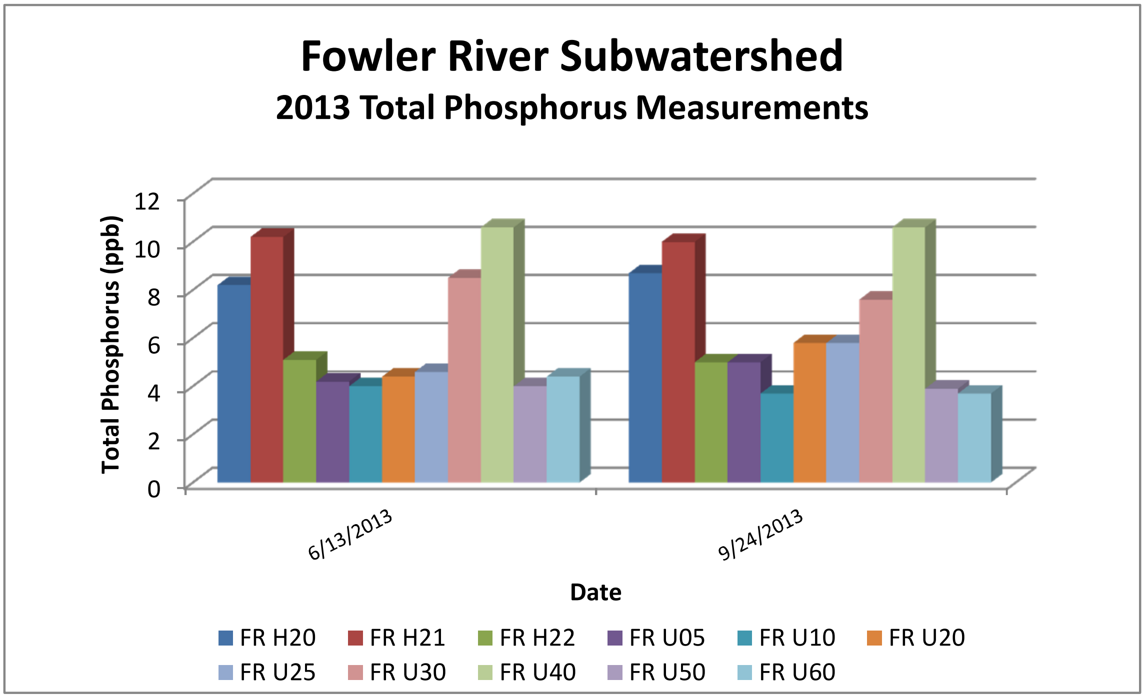

Dick Brown Brook Subwatershed
2013 Dissolved Oxygen Measurements
Dissolved Oxygen (mg/L)
0
2
4
6
8
10
12
6/13/2013
9/24/2013
Date
DBB H03
DBB U05
DBB U10
DBB U20


Dick Brown Brook Subwatershed
2013 Dissolved Oxygen Measurements
Dissolved Oxygen (% saturation)
0
20
40
60
80
100
120
6/13/2013
9/24/2013
Date
DBB H03
DBB U05
DBB U10
DBB U20

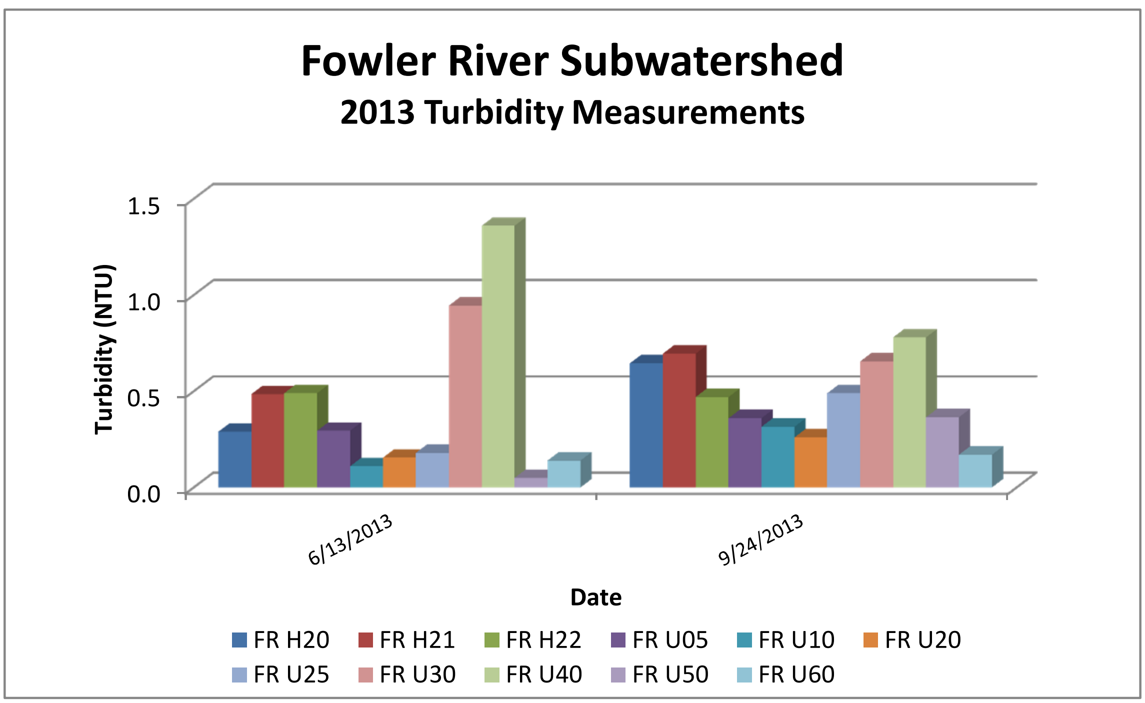

Dick Brown Brook Subwatershed
2013 pH Measurements
pH (standard units)
7.0
6.5
6.0
5.5
5.0
6/13/2013
9/24/2013
Date
DBB H03
DBB U05
DBB U10
DBB U20


Fowler River Subwatershed
2013 Temperature Measurements
15
10
5
0
Temperature (ºC)
6/13/2013
9/24/2013
Date
FR H20
FR H21
FR H22
FR U05
FR U10
FR U20
FR U25
FR U30
FR U40
FR U50
FR U60

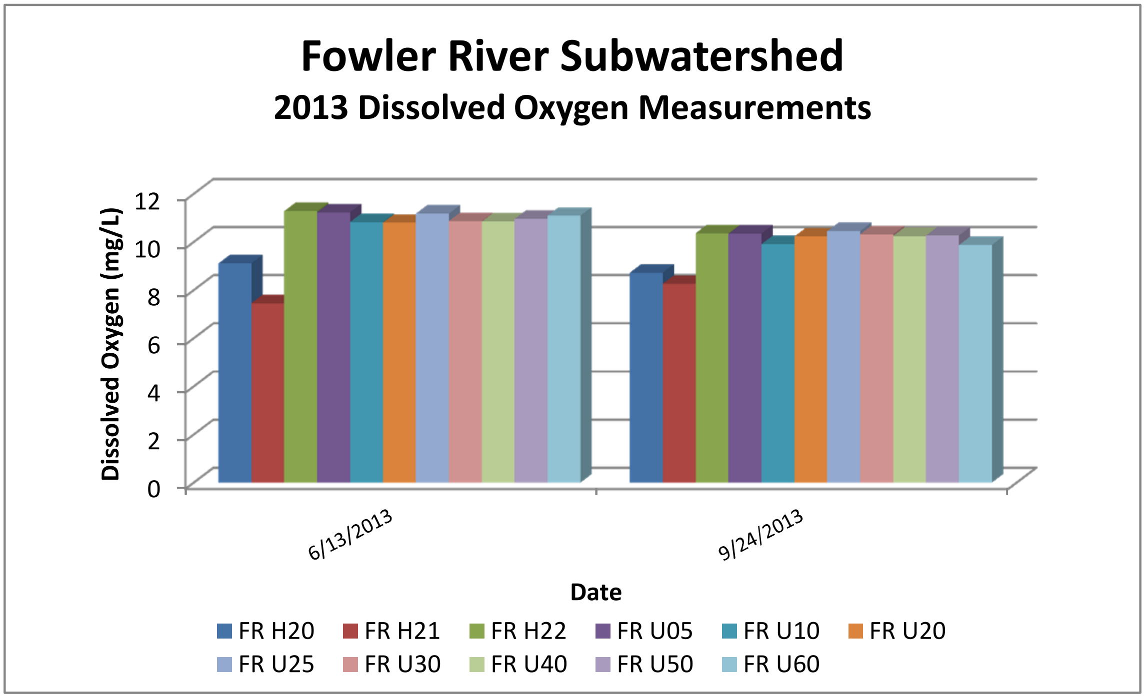

Fowler River Subwatershed
2013 Specific Conductivity Measurements
60
50
40
30
20
10
0
Specific Conductivity (uS/cm)
6/13/2013
9/24/2013
Date
FR H20
FR H21
FR H22
FR U05
FR U10
FR U20
FR U25
FR U30
FR U40
FR U50
FR U60

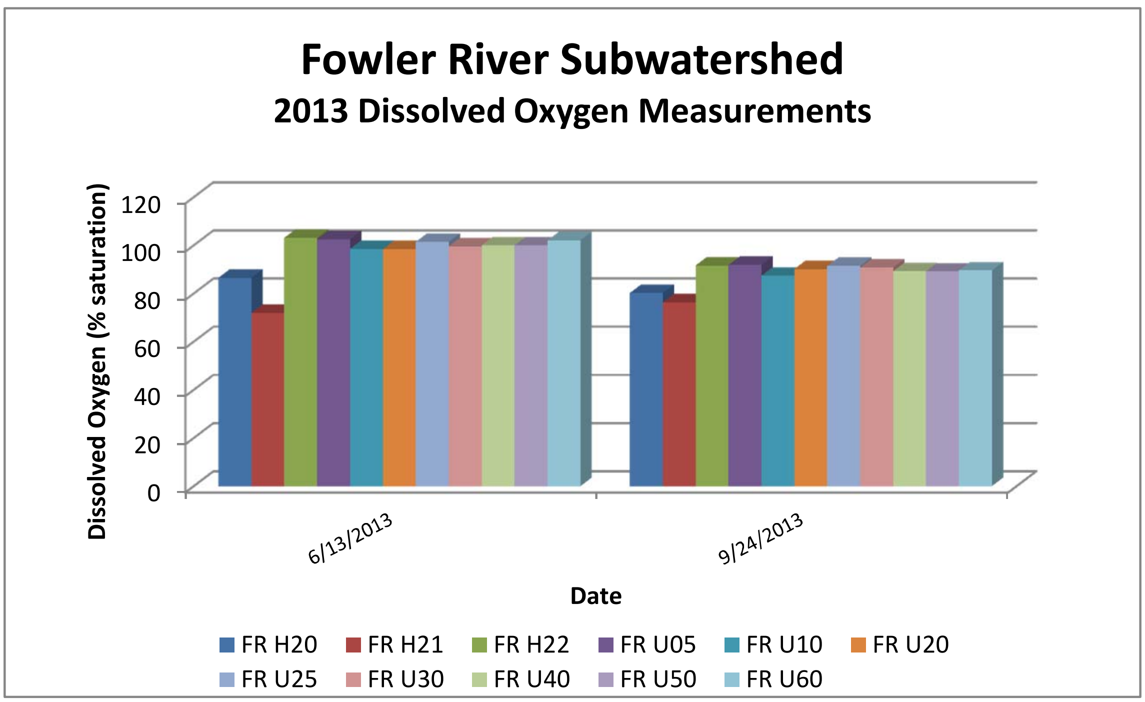


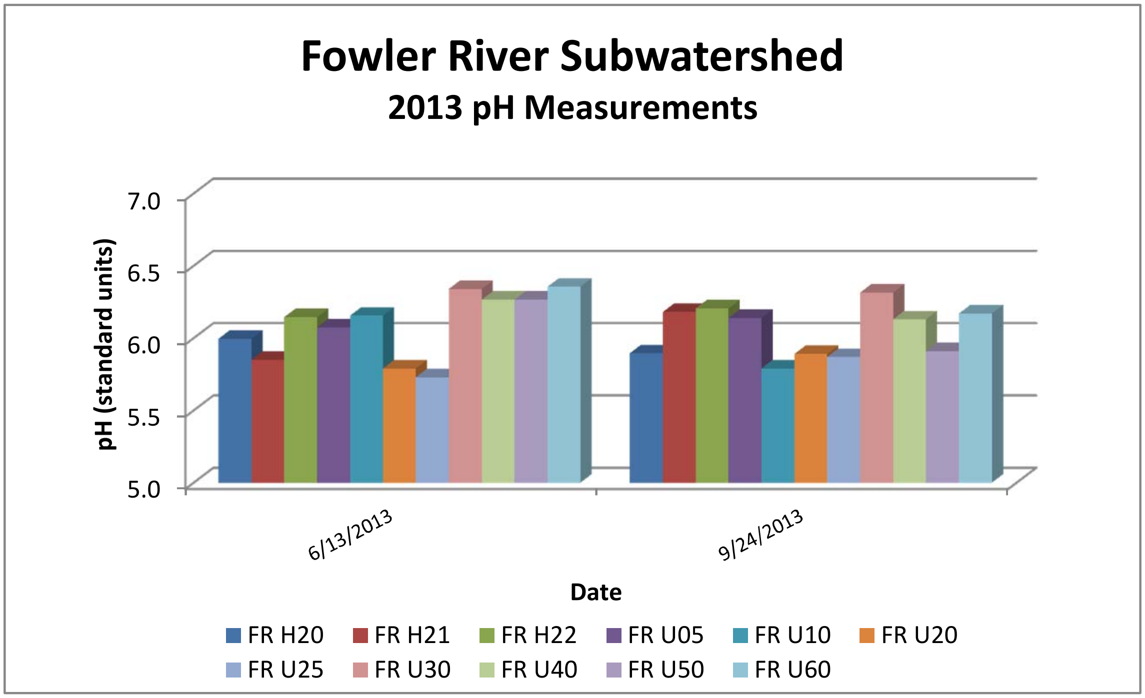
Fowler River Subwatershed
2013 Total Phosphorus Measurements
Total Phosphorus (ppb)
0
2
4
6
8
10
12
6/13/2013
9/24/2013
Date
FR H20
FR H21
FR H22
FR U05
FR U10
FR U20
FR U25
FR U30
FR U40
FR U50
FR U60



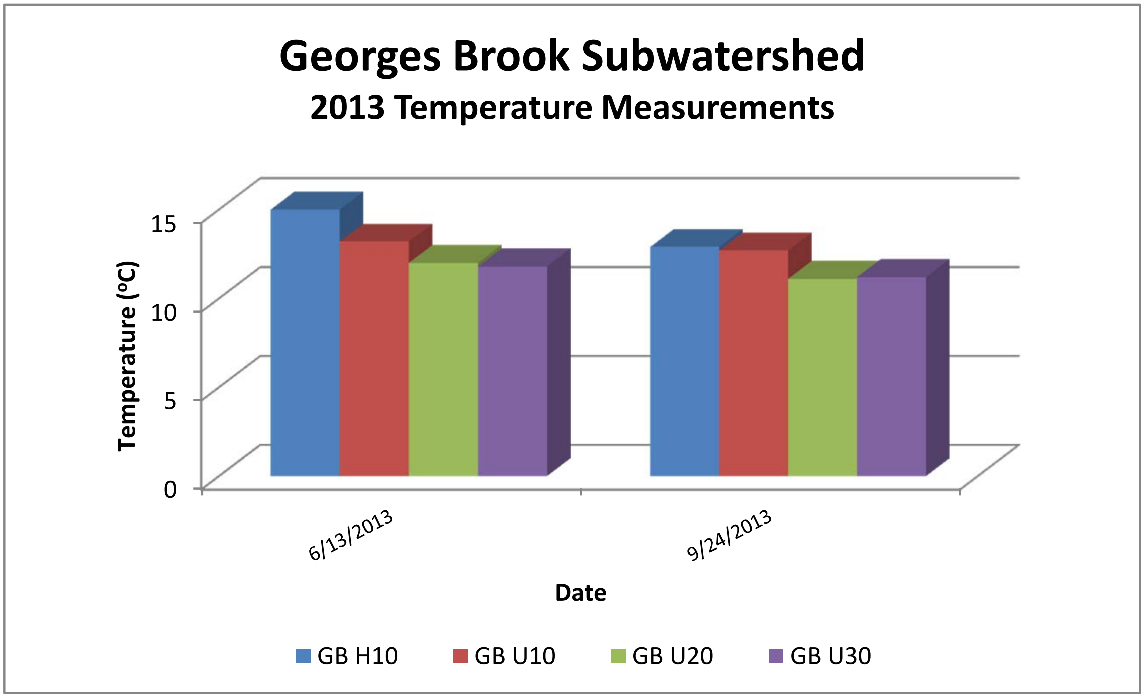
Fowler River Subwatershed
2013 Turbidity Measurements
Turbidity (NTU)
0.0
0.5
1.0
1.5
6/13/2013
9/24/2013
Date
FR H20
FR H21
FR H22
FR U05
FR U10
FR U20
FR U25
FR U30
FR U40
FR U50
FR U60

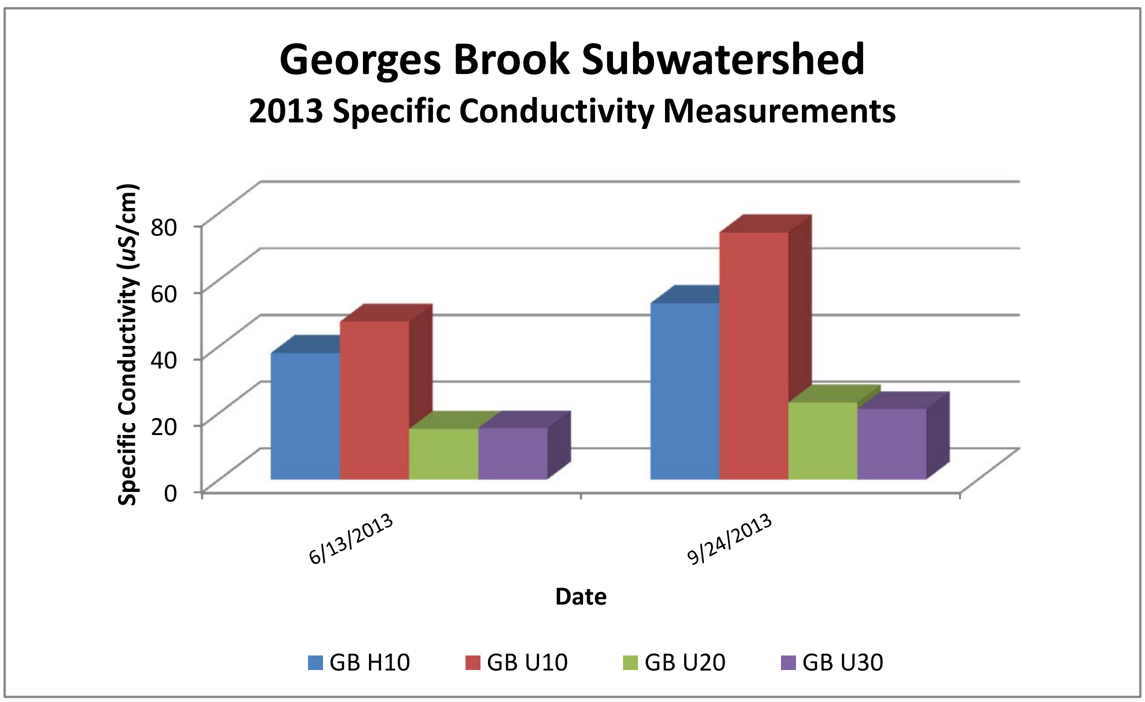

Fowler River Subwatershed
2013 Dissolved Oxygen Measurements
Dissolved Oxygen (mg/L)
0
2
4
6
8
10
12
6/13/2013
9/24/2013
Date
FR H20
FR H21
FR H22
FR U05
FR U10
FR U20
FR U25
FR U30
FR U40
FR U50
FR U60

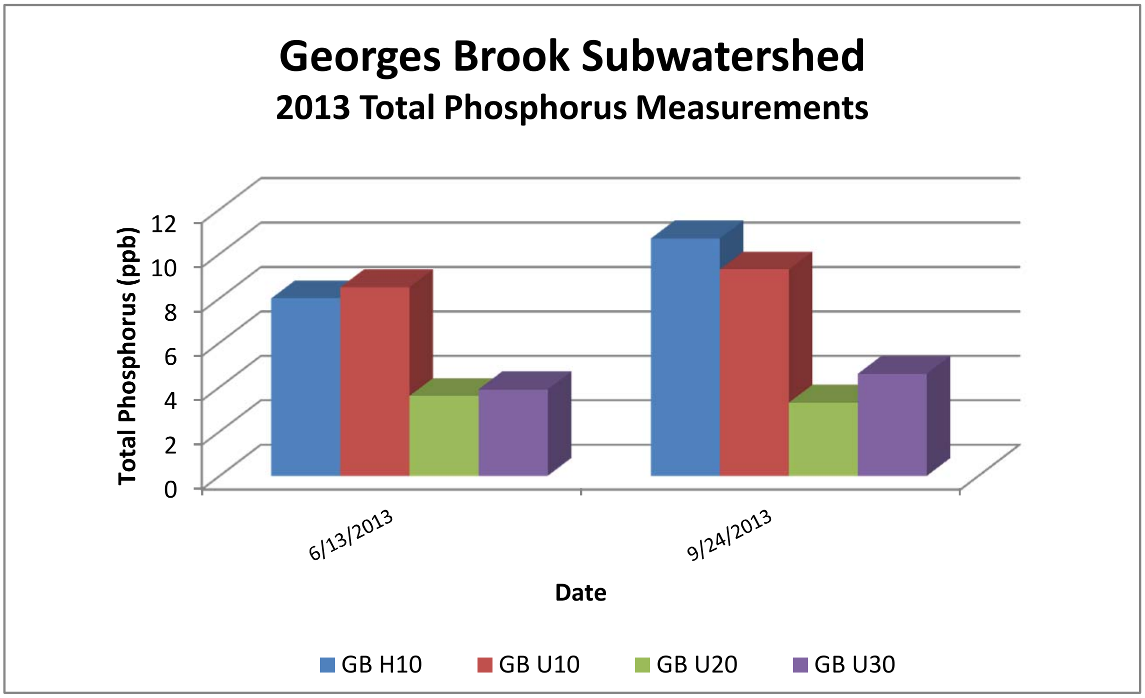

Fowler River Subwatershed
2013 Dissolved Oxygen Measurements
Dissolved Oxygen (% saturation)
0
20
40
60
80
100
120
6/13/2013
9/24/2013
Date
FR H20
FR H21
FR H22
FR U05
FR U10
FR U20
FR U25
FR U30
FR U40
FR U50
FR U60

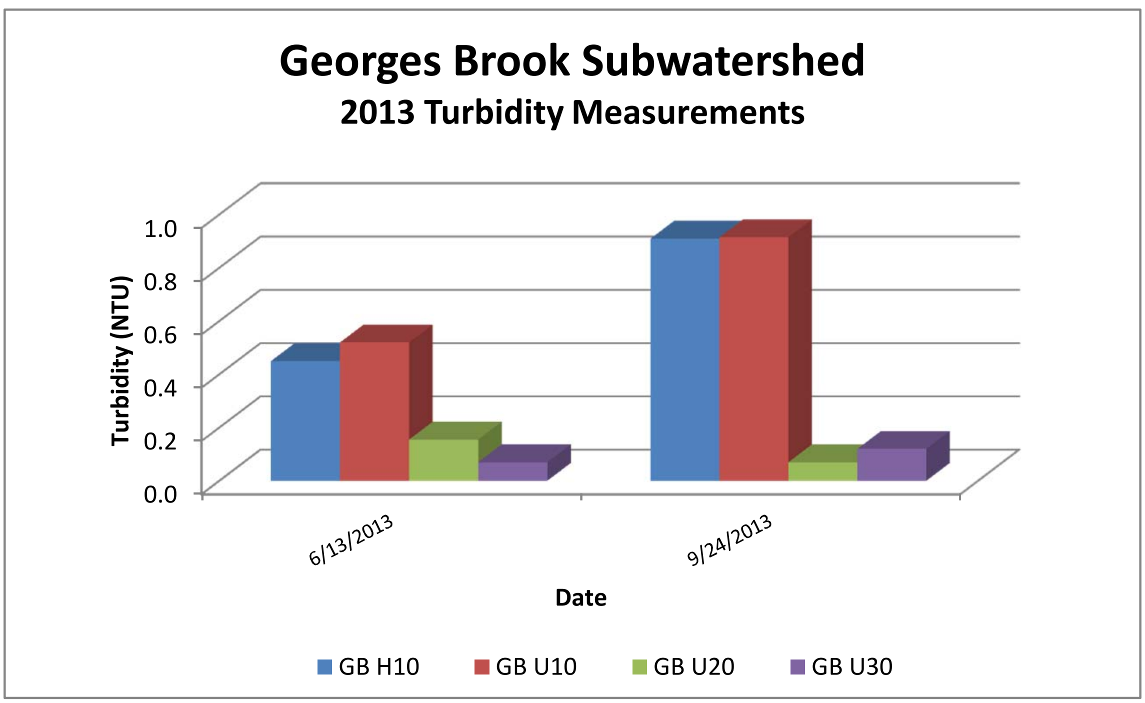


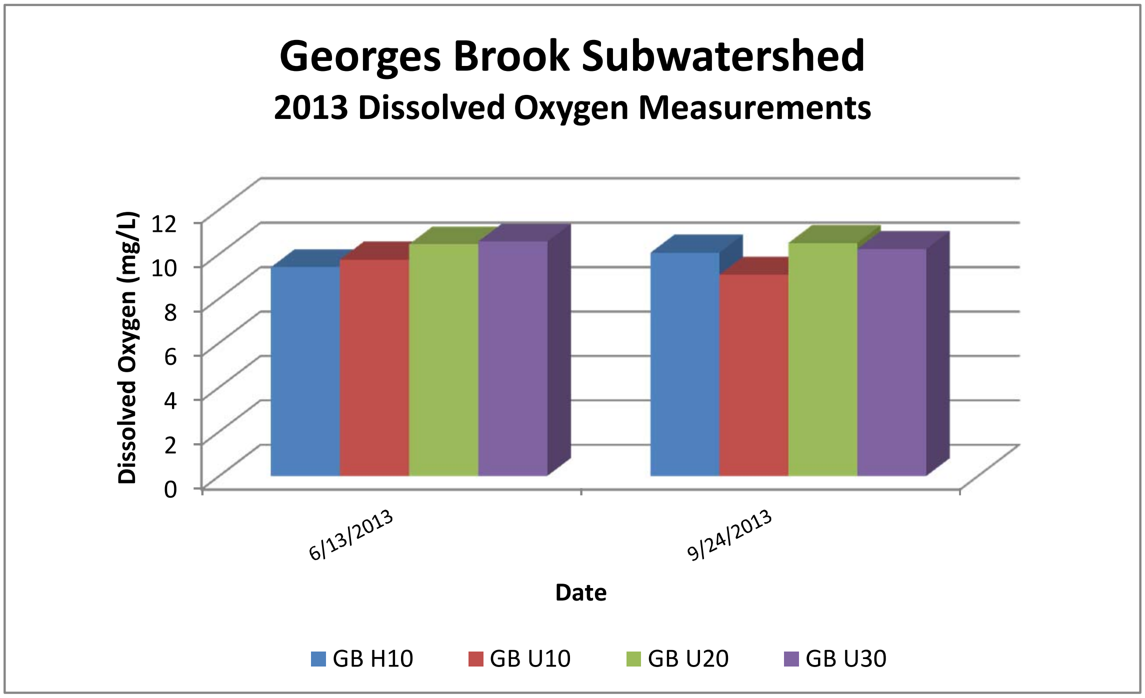
Fowler River Subwatershed
2013 pH Measurements
7.0
6.5
6.0
5.5
5.0
pH (standard units)
6/13/2013
9/24/2013
Date
FR H20
FR H21
FR H22
FR U05
FR U10
FR U20
FR U25
FR U30
FR U40
FR U50
FR U60

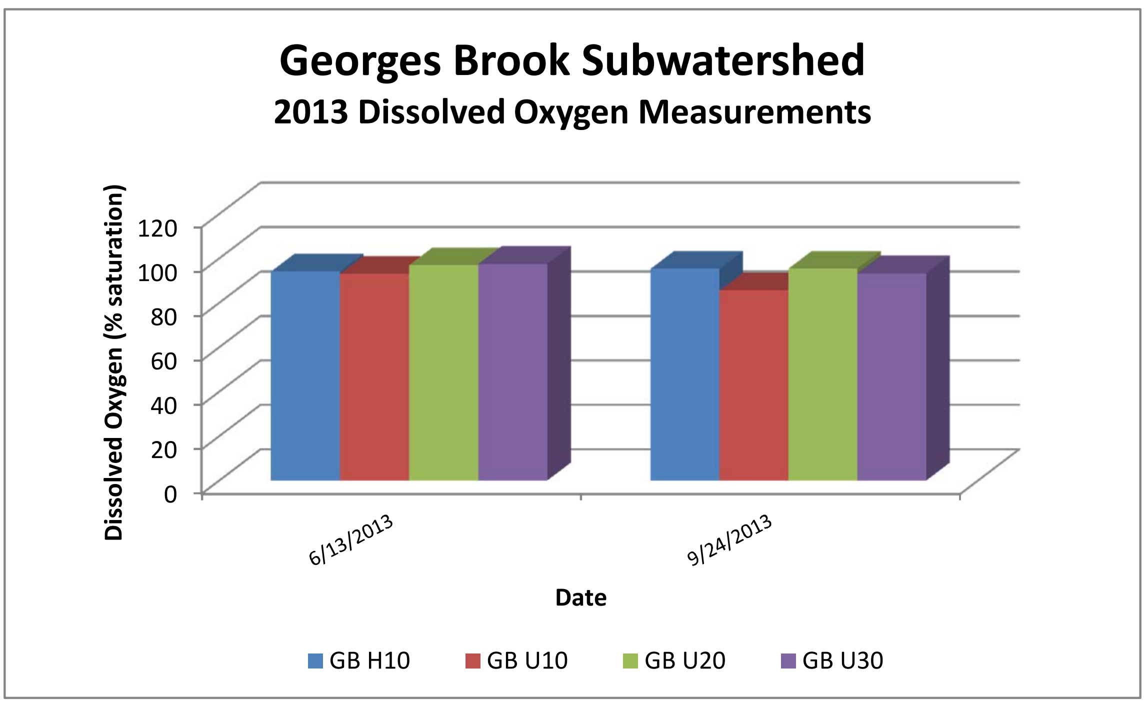

Georges Brook Subwatershed
2013 Temperature Measurements
Temperature (ºC)
15
10
5
0
6/13/2013
9/24/2013
Date
GB H10
GB U10
GB U20
GB U30

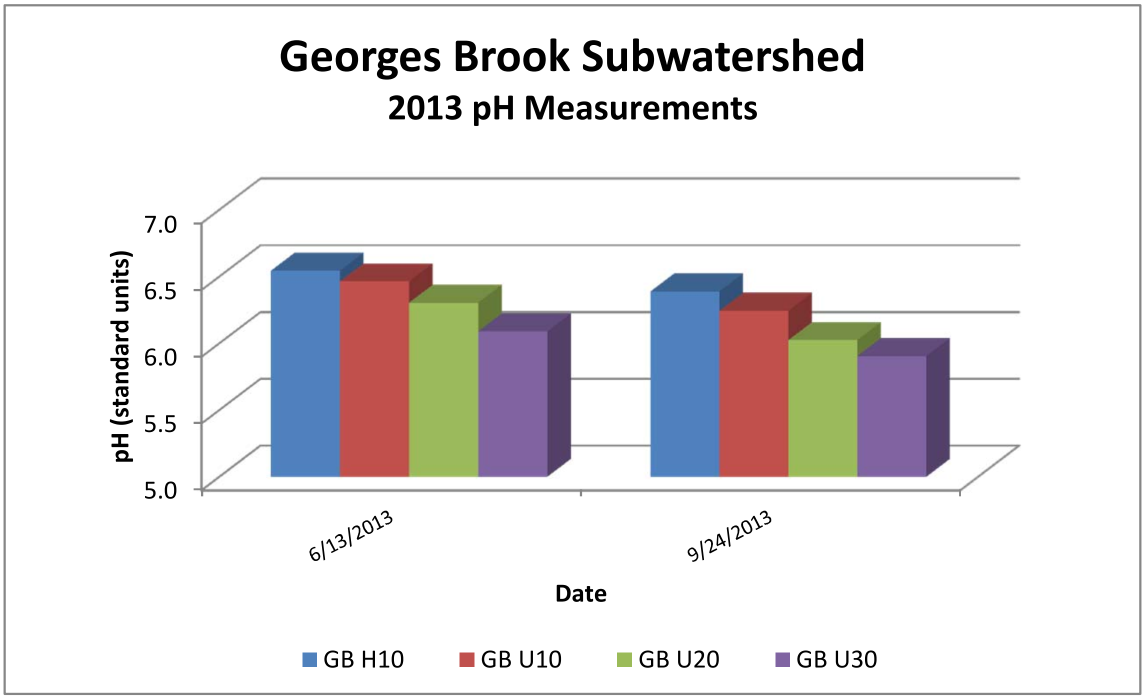

Georges Brook Subwatershed
2013 Specific Conductivity Measurements
Specific Conductivity (uS/cm)
80
60
40
20
0
6/13/2013
9/24/2013
Date
GB H10
GB U10
GB U20
GB U30

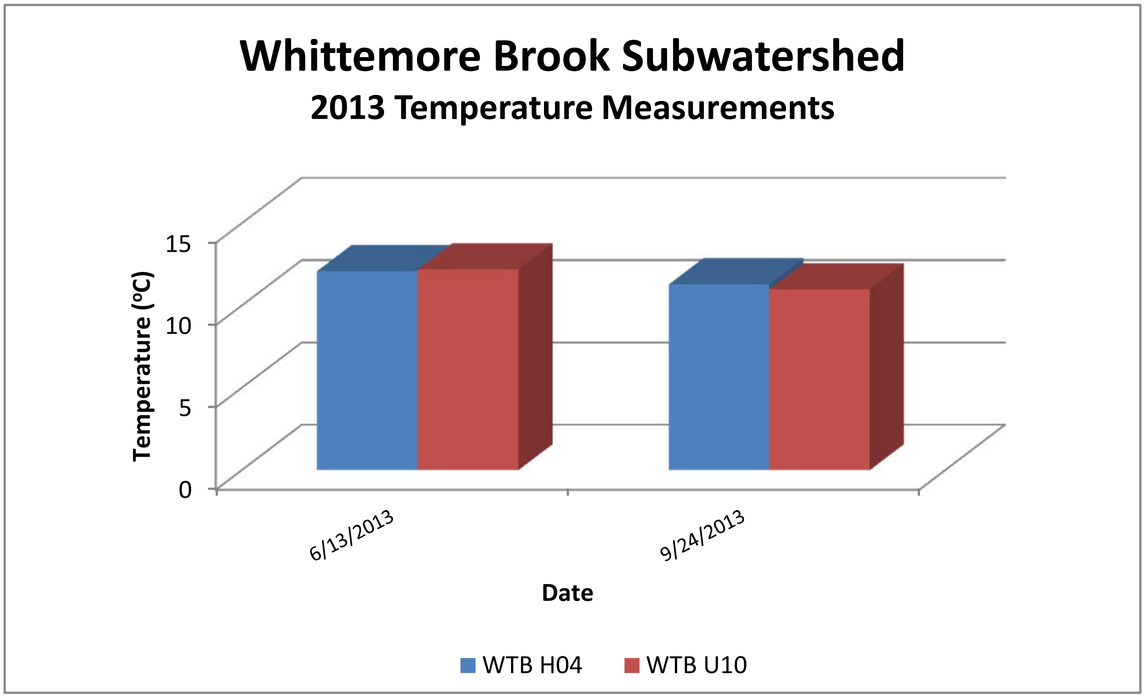

Georges Brook Subwatershed
2013 Total Phosphorus Measurements
Total Phosphorus (ppb)
0
2
4
6
8
10
12
6/13/2013
9/24/2013
Date
GB H10
GB U10
GB U20
GB U30

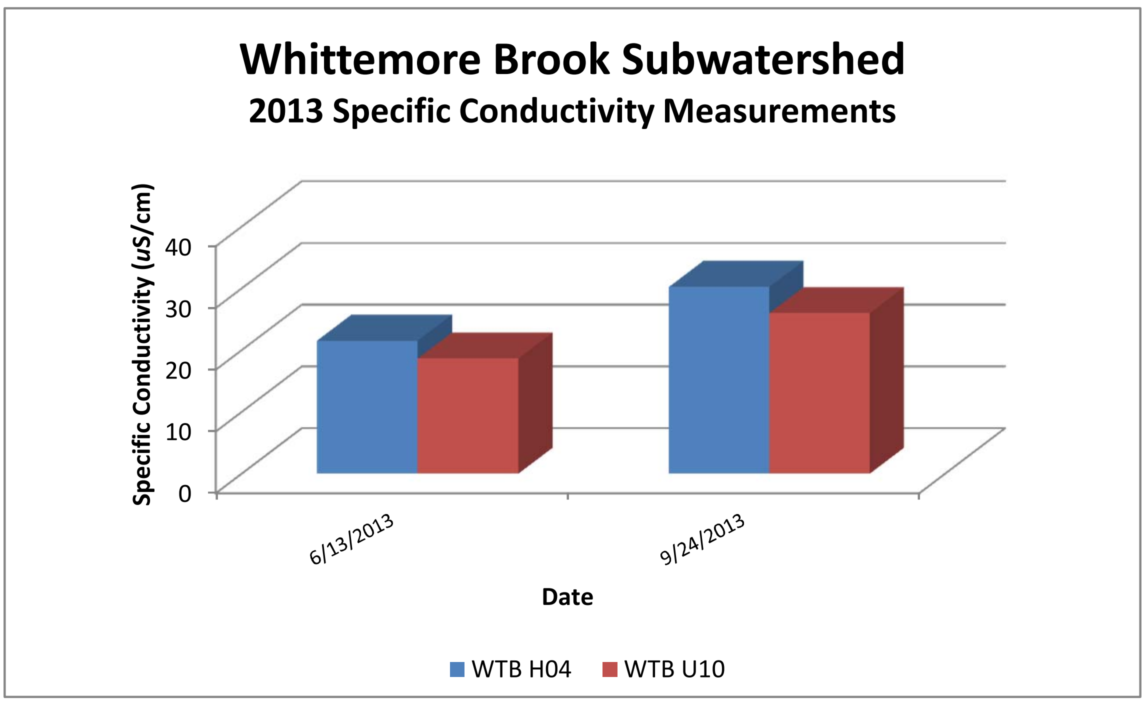

Georges Brook Subwatershed
2013 Turbidity Measurements
Turbidity (NTU)
0.0
0.2
0.4
0.6
0.8
1.0
6/13/2013
9/24/2013
Date
GB H10
GB U10
GB U20
GB U30

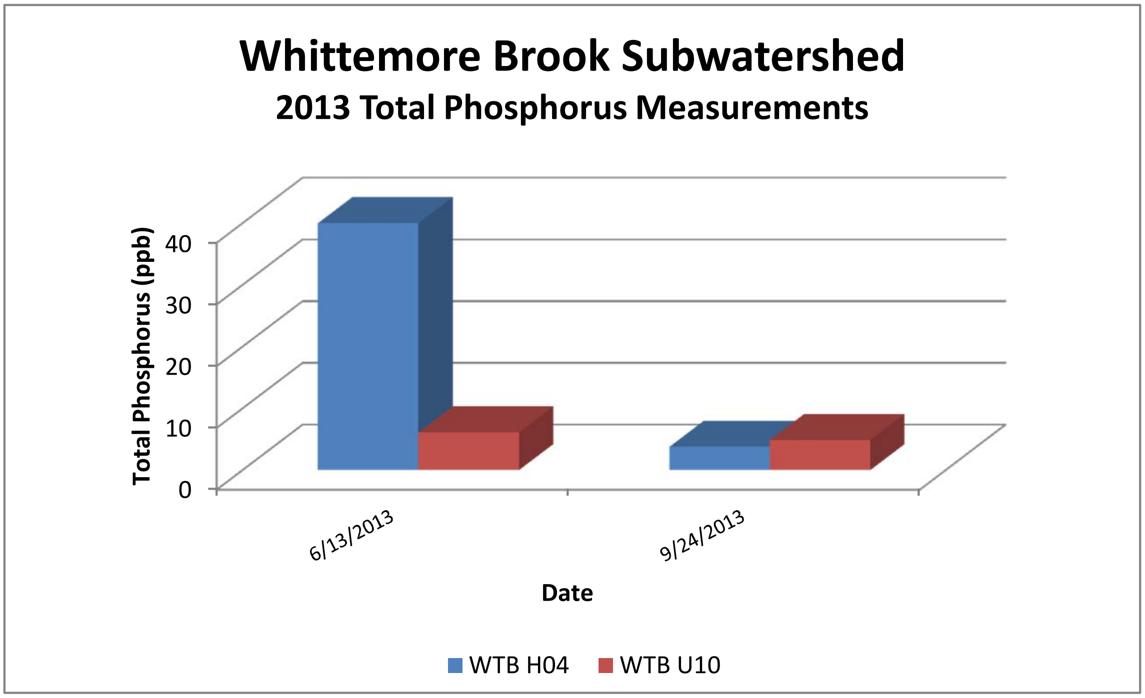

Georges Brook Subwatershed
2013 Dissolved Oxygen Measurements
Dissolved Oxygen (mg/L)
0
2
4
6
8
10
12
6/13/2013
9/24/2013
Date
GB H10
GB U10
GB U20
GB U30


Georges Brook Subwatershed
2013 Dissolved Oxygen Measurements
Dissolved Oxygen (% saturation)
0
20
40
60
80
100
120
6/13/2013
9/24/2013
Date
GB H10
GB U10
GB U20
GB U30

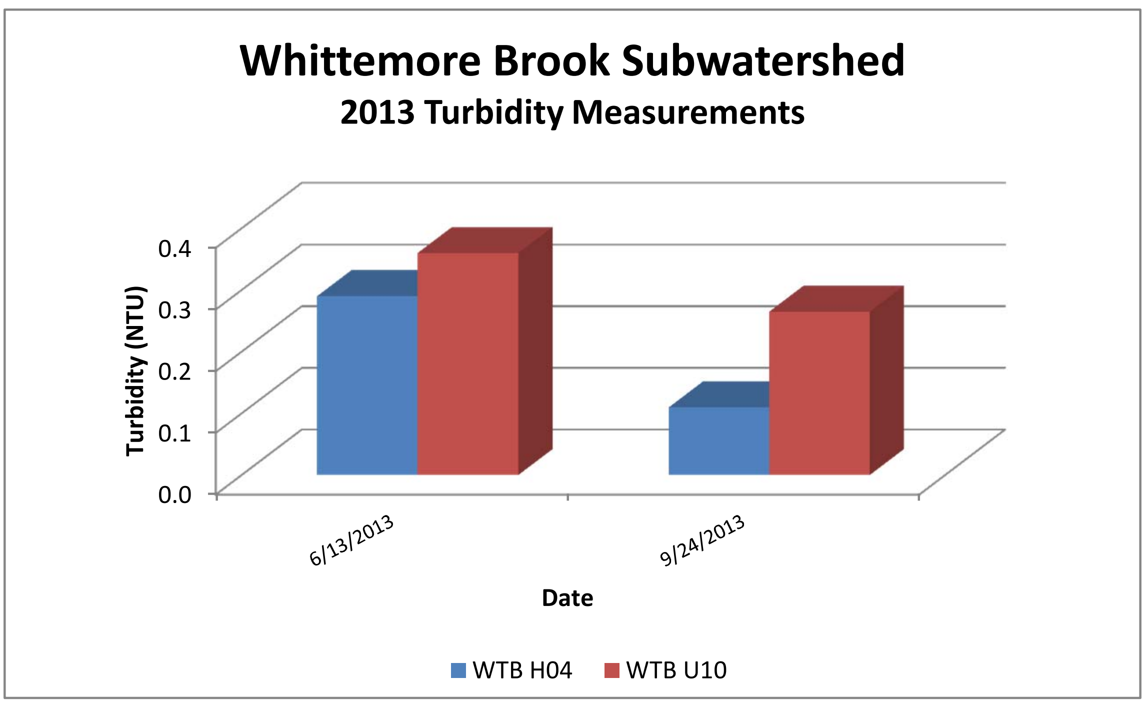

Georges Brook Subwatershed
2013 pH Measurements
pH (standard units)
7.0
6.5
6.0
5.5
5.0
6/13/2013
9/24/2013
Date
GB H10
GB U10
GB U20
GB U30


Whittemore Brook Subwatershed
2013 Temperature Measurements
Temperature (ºC)
0
5
10
15
6/13/2013
9/24/2013
Date
WTB H04
WTB U10

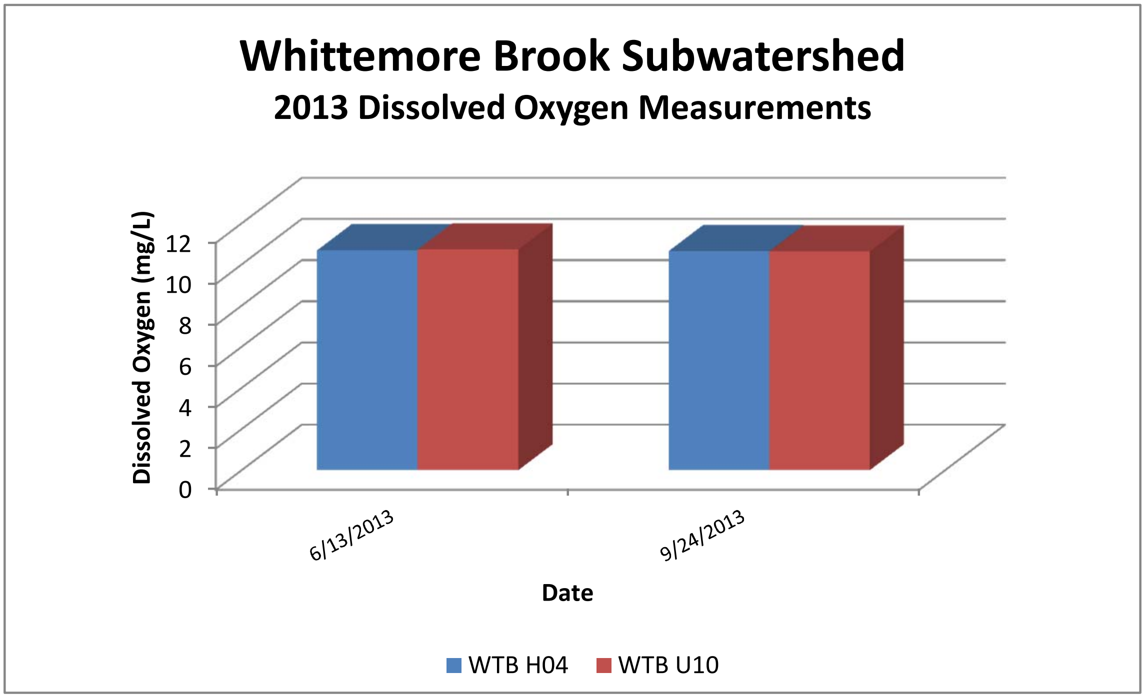

Whittemore Brook Subwatershed
2013 Specific Conductivity Measurements
Specific Conductivity (uS/cm)
0
10
20
30
40
6/13/2013
9/24/2013
Date
WTB H04
WTB U10

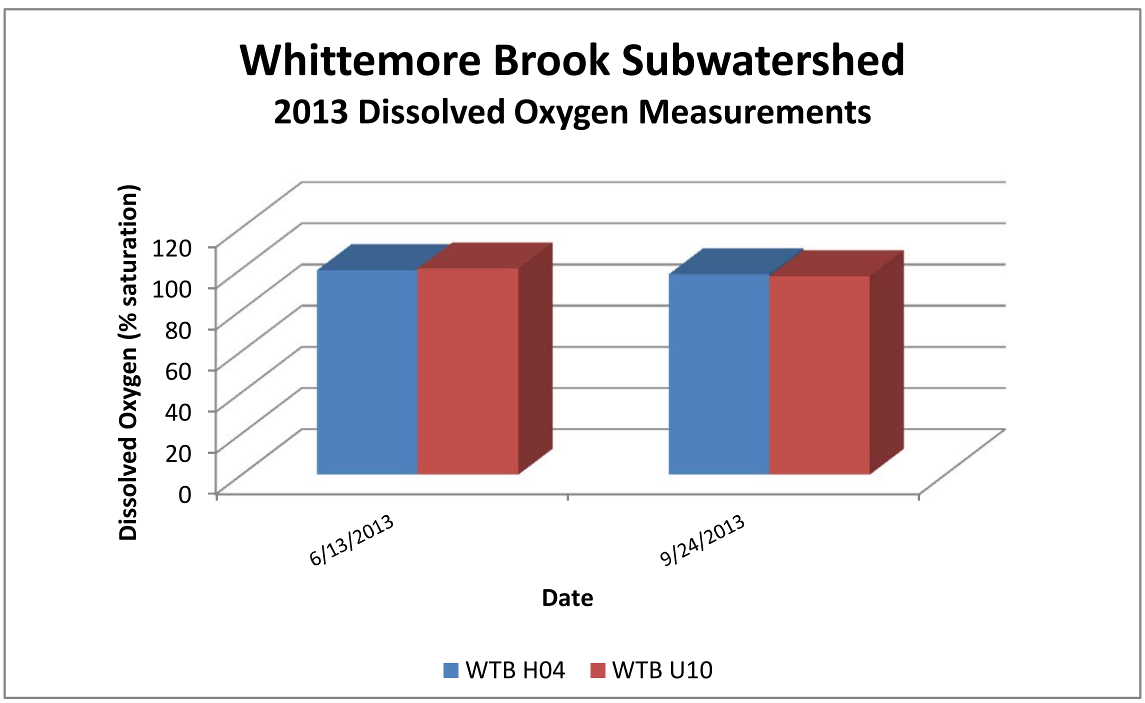


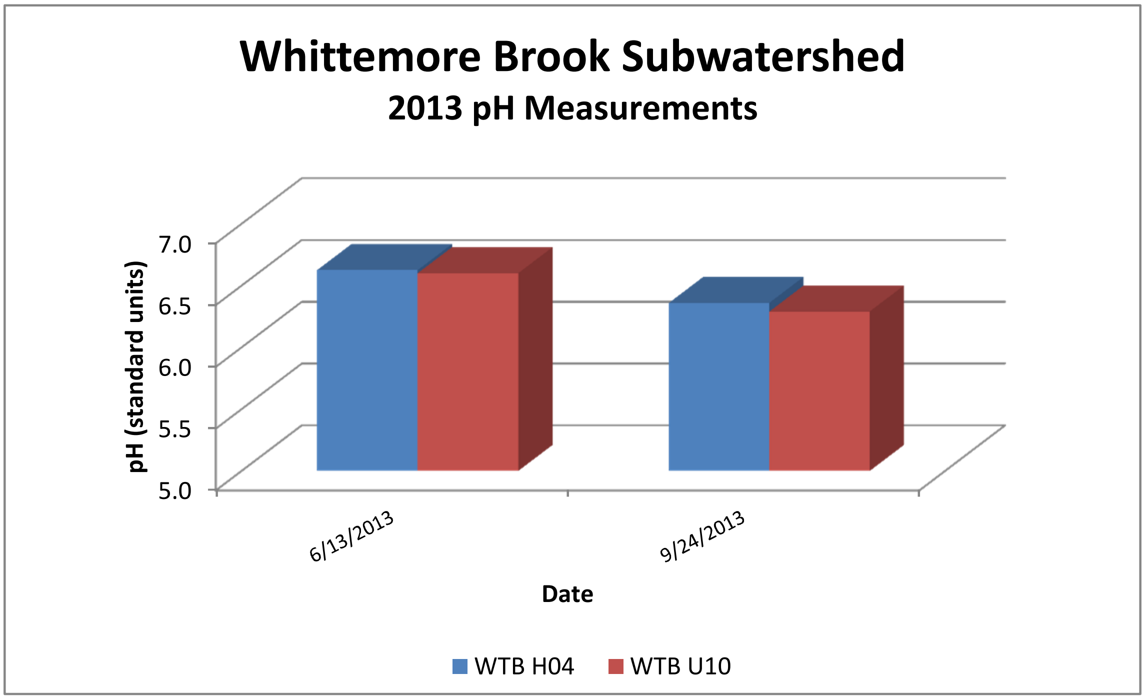
Whittemore Brook Subwatershed
2013 Total Phosphorus Measurements
Total Phosphorus (ppb)
40
30
20
10
0
6/13/2013
9/24/2013
Date
WTB H04
WTB U10



Whittemore Brook Subwatershed
2013 Turbidity Measurements
Turbidity (NTU)
0.4
0.3
0.2
0.1
0.0
6/13/2013
9/24/2013
Date
WTB H04
WTB U10


Whittemore Brook Subwatershed
2013 Dissolved Oxygen Measurements
Dissolved Oxygen (mg/L)
0
2
4
6
8
10
12
6/13/2013
9/24/2013
Date
WTB H04
WTB U10

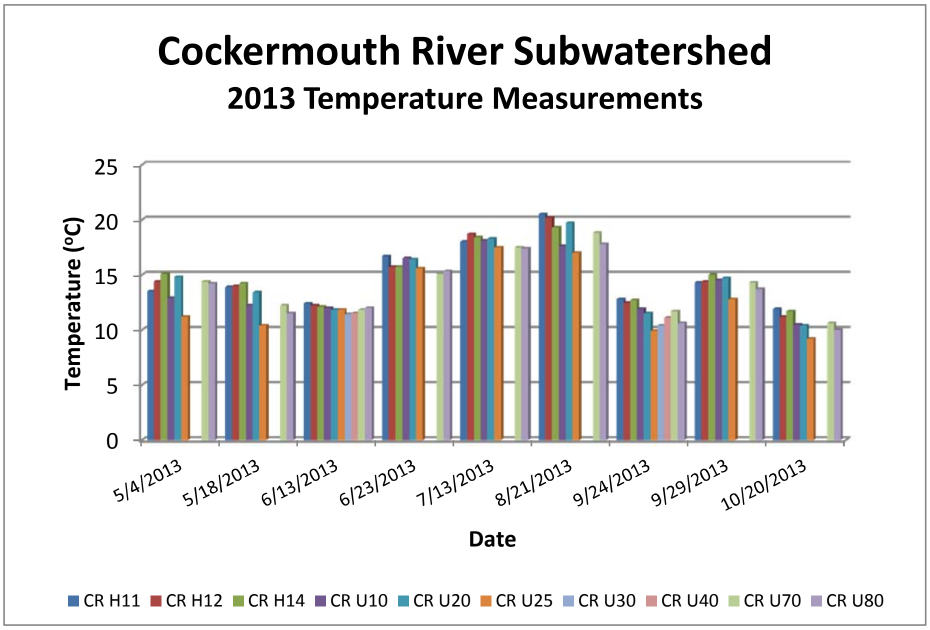

Whittemore Brook Subwatershed
2013 Dissolved Oxygen Measurements
Dissolved Oxygen (% saturation)
0
20
40
60
80
100
120
6/13/2013
9/24/2013
Date
WTB H04
WTB U10

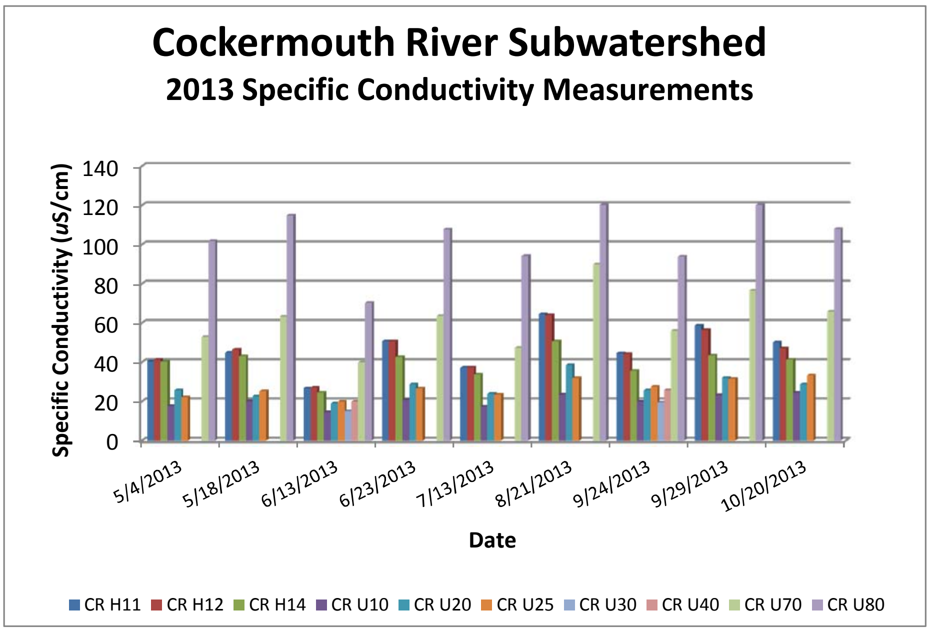

Whittemore Brook Subwatershed
2013 pH Measurements
pH (standard units)
7.0
6.5
6.0
5.5
5.0
6/13/2013
9/24/2013
Date
WTB H04
WTB U10

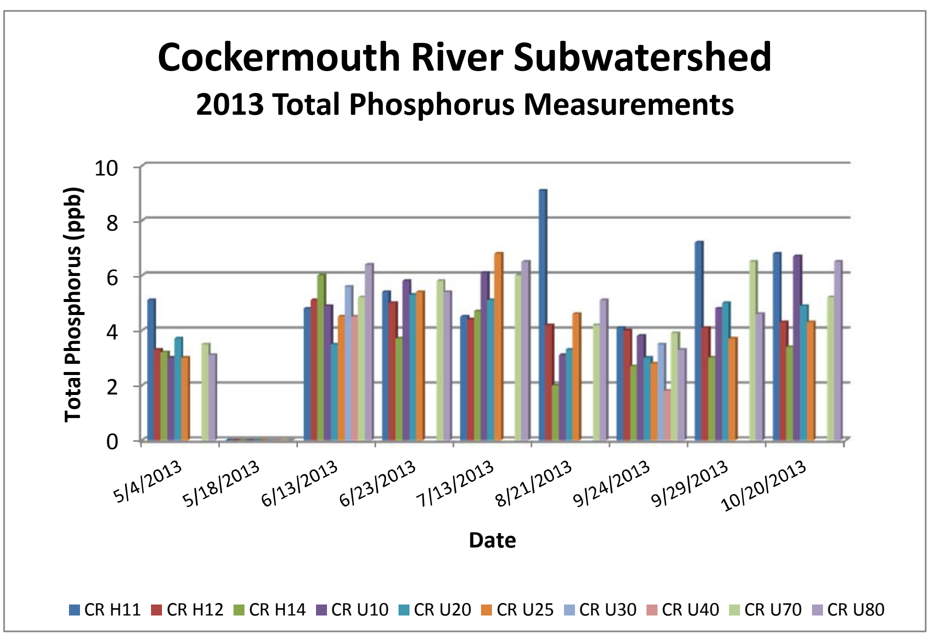
APPENDIX I

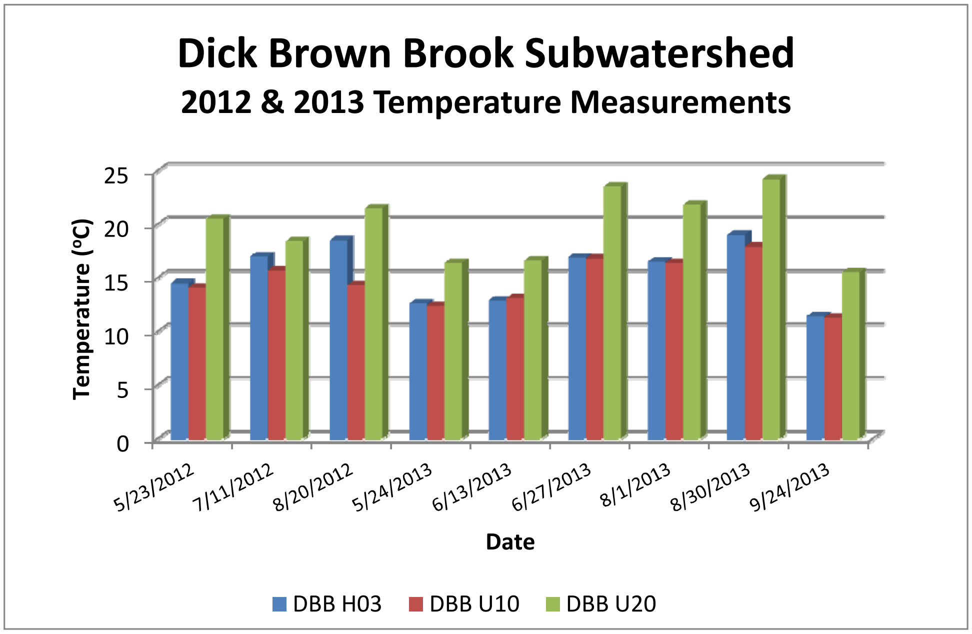
The following inter-site comparisons of the 2012 and 2013 Newfound Lake headwater tributary data are displayed by sub-watershed: Cockermouth River, Dick Brown Brook, Fowler River and Georges Brook. The vertical bar graphs include temperature, specific conductivity and total phosphorus results that provide insight into seasonal water quality fluctuations and water quality variations among sampling locations.

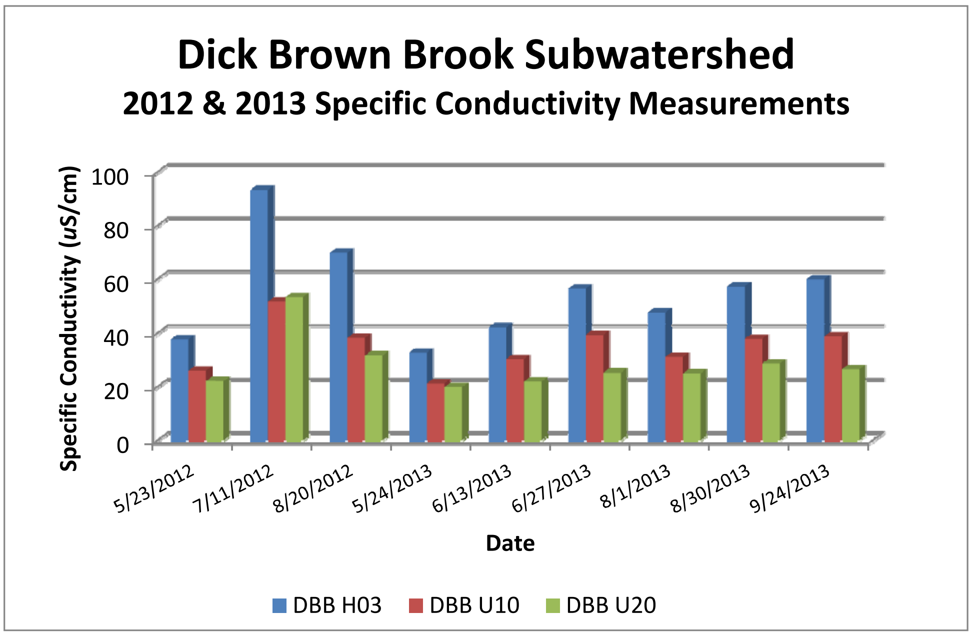
Note: the data depicted in Appendix I are limited to temperature, specific conductivity and total phosphorus measruements that were collected by both the Center for Freshwater Biology field team and the Newfound Lake volunteer monitors. Refer to Appendix H for a listing of supplemental water quality parameters (turbidity, dissolved oxygen and pH) collected on June 13 and September 29, 2013.

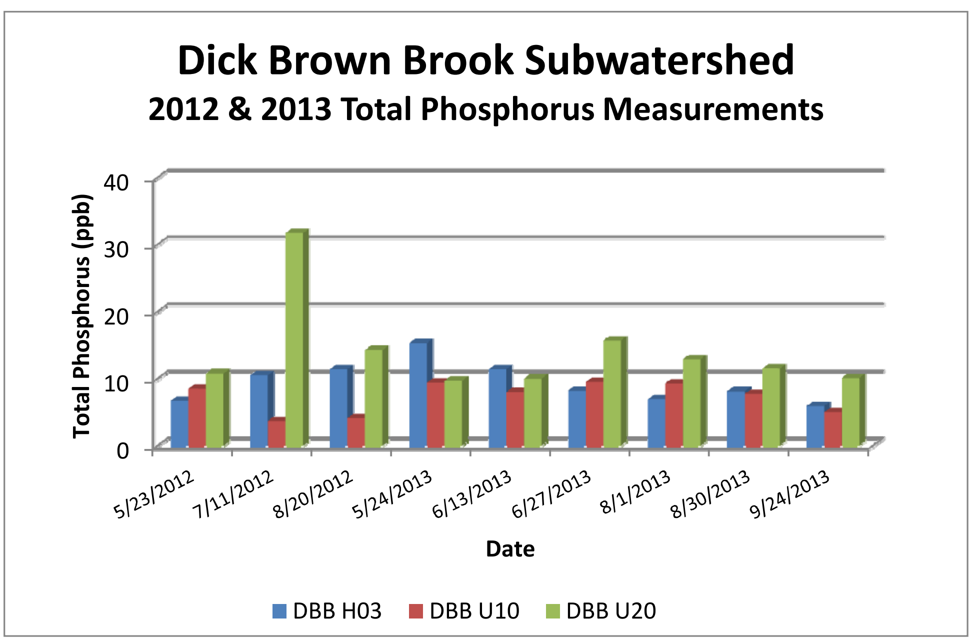

Cockermouth River Subwatershed
2013 Temperature Measurements
Temperature (°C)
25
20
15
10
5
0
5/4/2013
5/18/2013
6/13/2013
6/23/2013
7/13/2013
8/21/2013
9/24/2013
9/29/2013
10/20/2013
Date
CR H11
CR H12
CR H14
CR U10
CR U20
CR U25
CR U30
CR U40
CR U70
CR U80

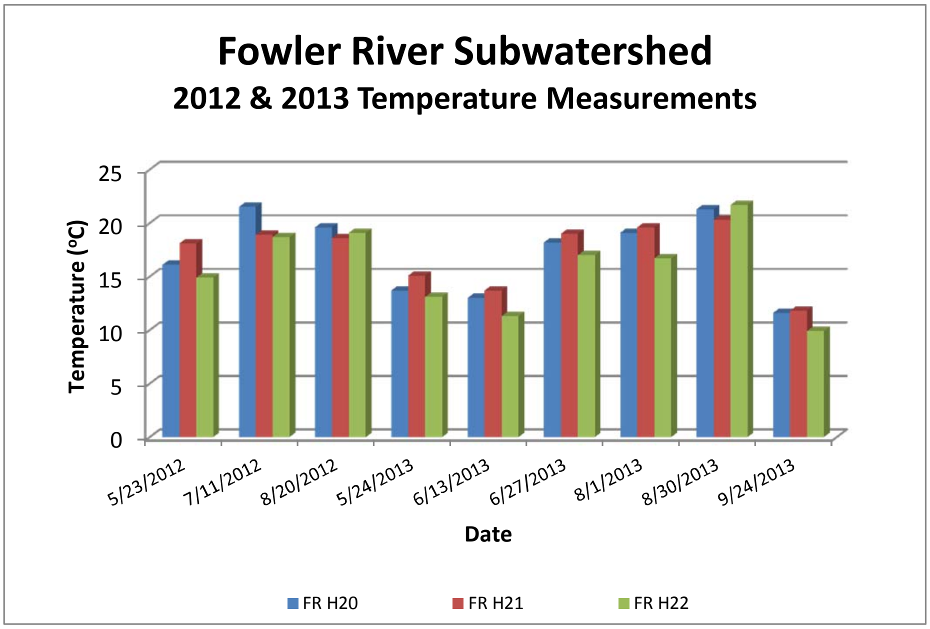

Cockermouth River Subwatershed
2013 Specific Conductivity Measurements
Specific Conductivity (uS/cm)
140
120
100
80
60
40
20
0
5/4/2013
5/18/2013
6/13/2013
6/23/2013
7/13/2013
8/21/2013
9/24/2013
9/29/2013
10/20/2013
Date
CR H11
CR H12
CR H14
CR U10
CR U20
CR U25
CR U30
CR U40
CR U70
CR U80

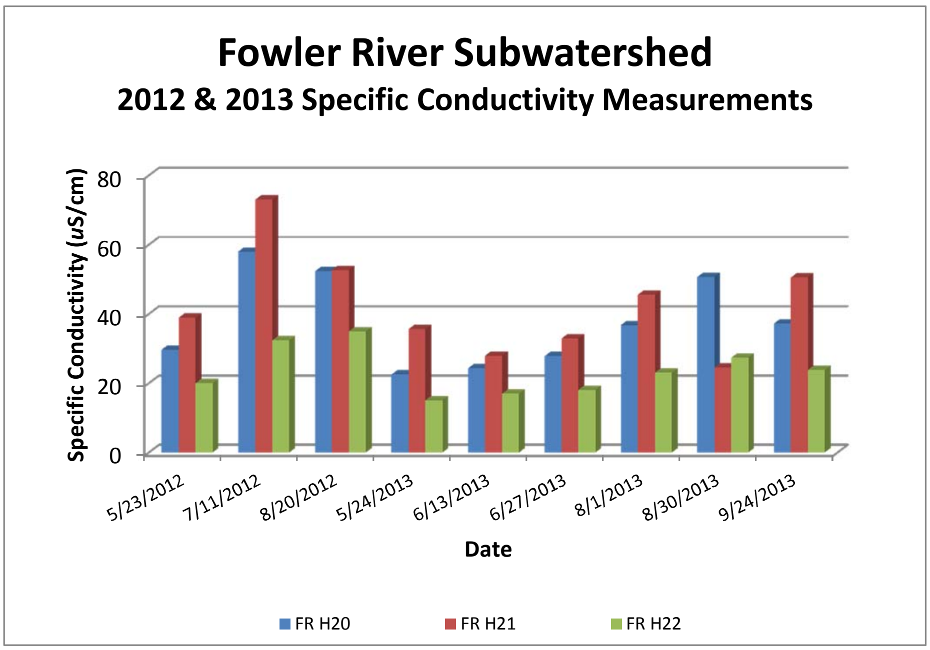

Cockermouth River Subwatershed
2013 Total Phosphorus Measurements
Total Phosphorus (ppb)
10
8
6
4
2
0
5/4/2013
5/18/2013
6/13/2013
6/23/2013
7/13/2013
8/21/2013
9/24/2013
9/29/2013
10/20/2013
Date
CR H11
CR H12
CR H14
CR U10
CR U20
CR U25
CR U30
CR U40
CR U70
CR U80

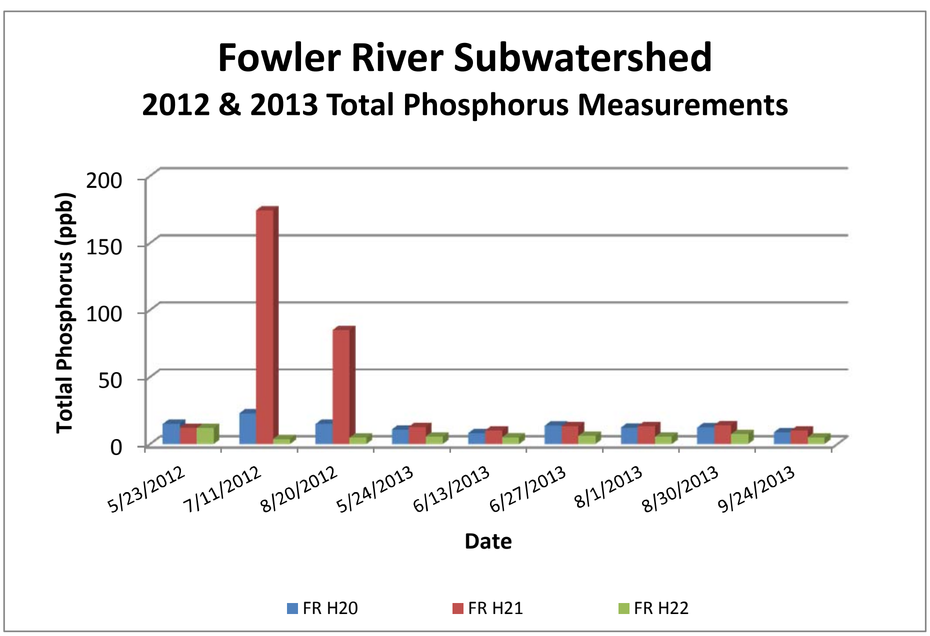

Dick Brown Brook Subwatershed
2012 & 2013 Temperature Measurements
Temperature (°C)
0
5
10
15
20
25
5/23/2012
7/11/2012
8/20/2012
5/24/2013
6/13/2013
6/27/2013
8/1/2013
8/30/2013
9/24/2013
Date
DBB H03
DBB U10
DBB U20

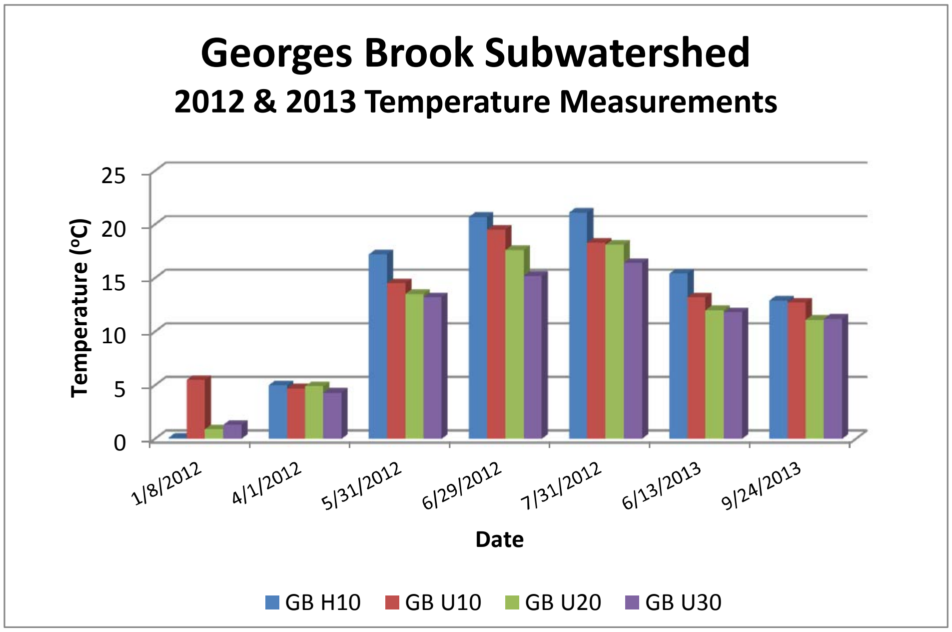

Dick Brown Brook Subwatershed
2012 & 2013 Specific Conductivity Measurements
Specific Conductivity (uS/cm)
0
20
40
60
80
100
5/23/2012
7/11/2012
8/20/2012
5/24/2013
6/13/2013
6/27/2013
8/1/2013
8/30/2013
9/24/2013
Date
DBB H03
DBB U10
DBB U20


Dick Brown Brook Subwatershed
2012 & 2013 Total Phosphorus Measurements
Total Phosphorus (ppb)
0
10
20
30
40
5/23/2012
7/11/2012
8/20/2012
5/24/2013
6/13/2013
6/27/2013
8/1/2013
8/30/2013
9/24/2013
Date
DBB H03
DBB U10
DBB U20

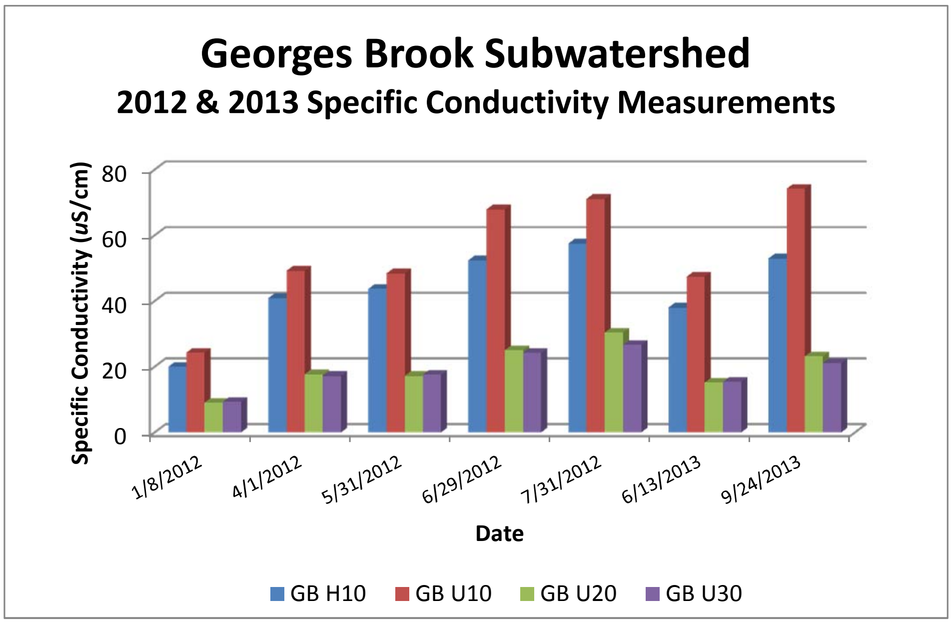

Fowler River Subwatershed
2012 & 2013 Temperature Measurements
Temperature (ºC)
25
20
15
10
5
0
5/23/2012
7/11/2012
8/20/2012
5/24/2013
6/13/2013
6/27/2013
8/1/2013
8/30/2013
9/24/2013
Date
FR H20
FR H21
FR H22


Fowler River Subwatershed
2012 & 2013 Specific Conductivity Measurements
Specific Conductivity (uS/cm)
80
60
40
20
0
5/23/2012
7/11/2012
8/20/2012
5/24/2013
6/13/2013
6/27/2013
8/1/2013
8/30/2013
9/24/2013
Date
FR H20
FR H21
FR H22

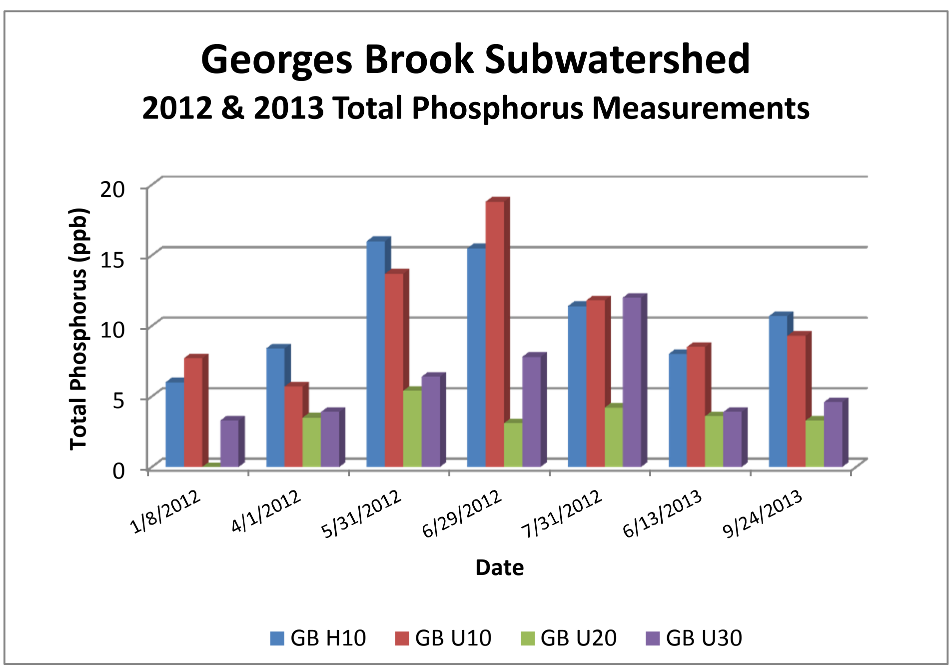

Fowler River Subwatershed
2012 & 2013 Total Phosphorus Measurements
Total Phosphorus (ppb)
200
150
100
50
0
5/23/2012
7/11/2012
8/20/2012
5/24/2013
6/13/2013
6/27/2013
8/1/2013
8/30/2013
9/24/2013
Date
FR H20
FR H21
FR H22



Georges Brook Subwatershed
2012 & 2013 Temperature Measurements
Temperature (ºC)
0
5
10
15
20
25
1/8/2012
4/1/2012
5/31/2012
6/29/2012
7/31/2012
6/13/2013
9/24/2013
Date
GB H10
GB U10
GB U20
GB U30



Georges Brook Subwatershed
2012 & 2013 Specific Conductivity Measurements
Specific Conductivity (uS/cm)
0
20
40
60
80
1/8/2012
4/1/2012
5/31/2012
6/29/2012
7/31/2012
6/13/2013
9/24/2013
Date
GB H10
GB U10
GB U20
GB U30



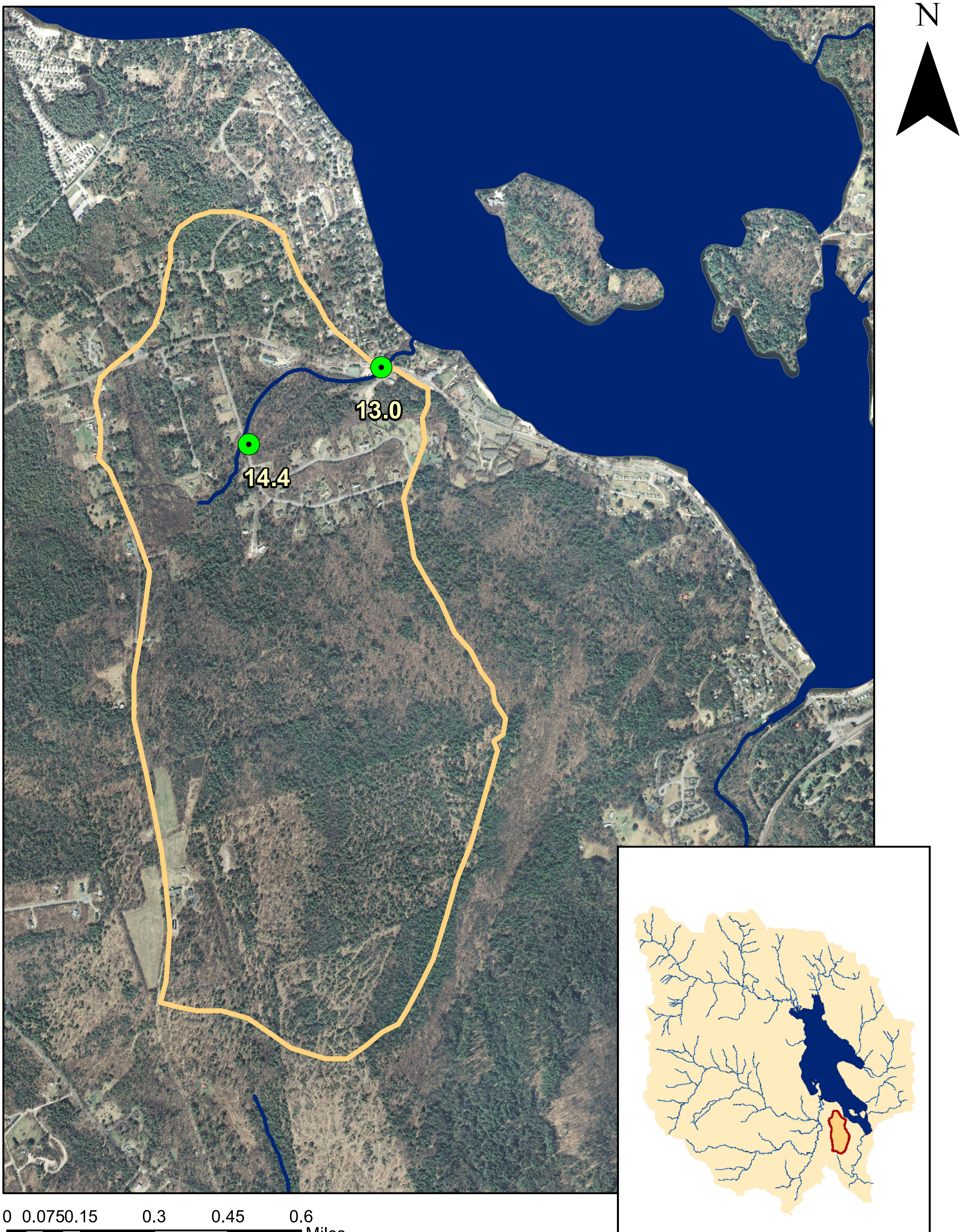
Georges Brook Subwatershed
2012 & 2013 Total Phosphorus Measurements
Total Phosphorus (ppb)
0
5
10
15
20
1/8/2012
4/1/2012
5/31/2012
6/29/2012
7/31/2012
6/13/2013
9/24/2013
Date
GB H10
GB U10
GB U20
GB U30

APPENDIX J

The following subwatershed maps represent active headwater tributary sampling locations in the Black Brook, Cockermouth River, Dick Brown Brook, Fowler River, Georges Brook and Whittemore Brook subwatersheds. Each map includes a vicinity map of the Newfound Lake watershed, which highlights the subwatershed of interest in yellow. Each map also includes the subwatershed boundary (represented by the red lines), sampling points (represented by green points) and tributaries (blue lines). The numbers printed near the respective sampling locations (green points) are median total phosphorus concentrations derived from Center for Freshwater Biology Group paired measurements collected in 2011 and 2013. The graphs provide a visual depiction of spatial water quality variations among sampling locations within the subwatersheds.

Black Brook Subwatershed

Inter-site comparison of median total phosphorus concentrations (2011-2013)

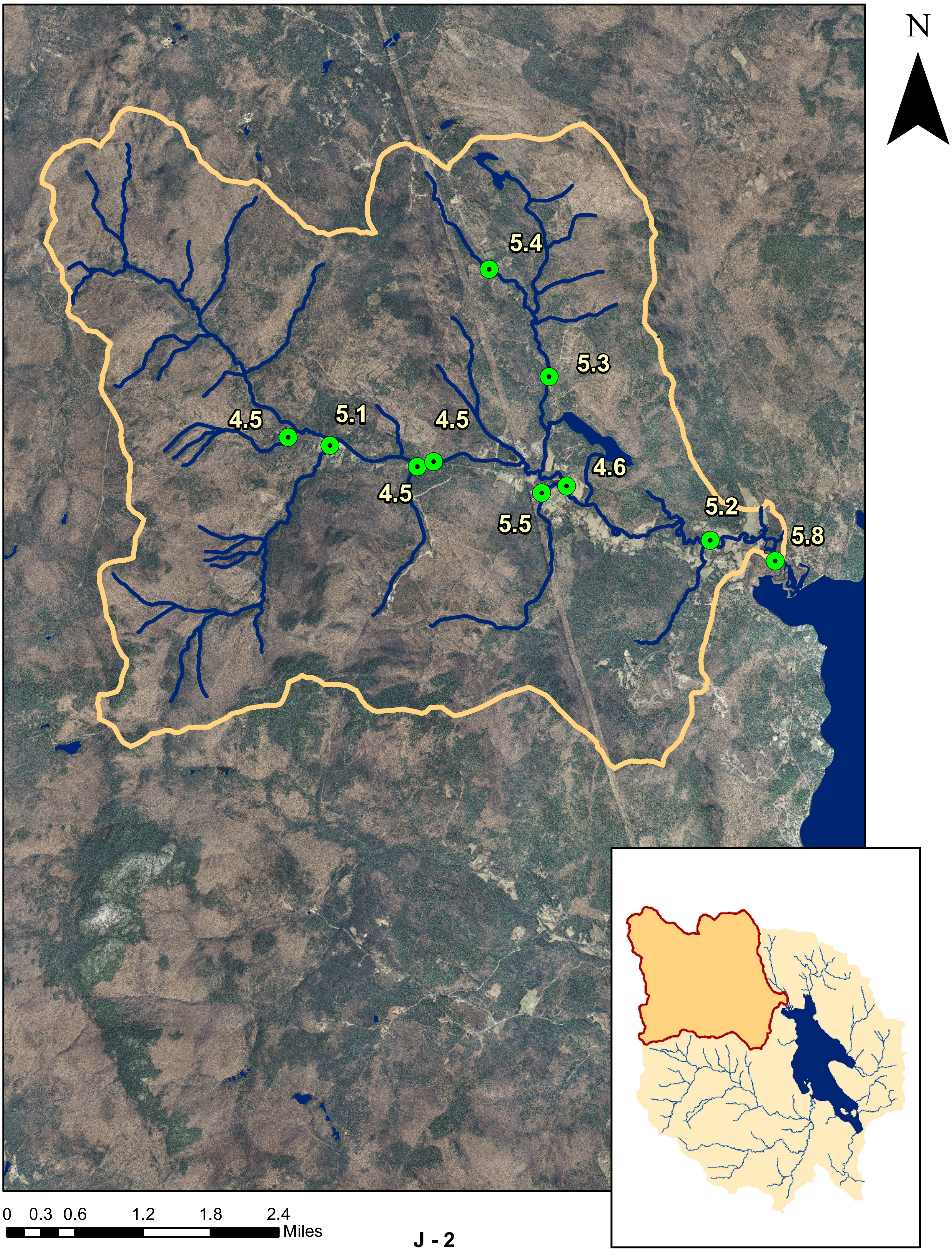


J - 1

Aerial Orthophoto Source: NH GRANIT
Site location GPS coordinates collected by the UNH Center of Freshwater Biology

Cockermouth River Subwatershed

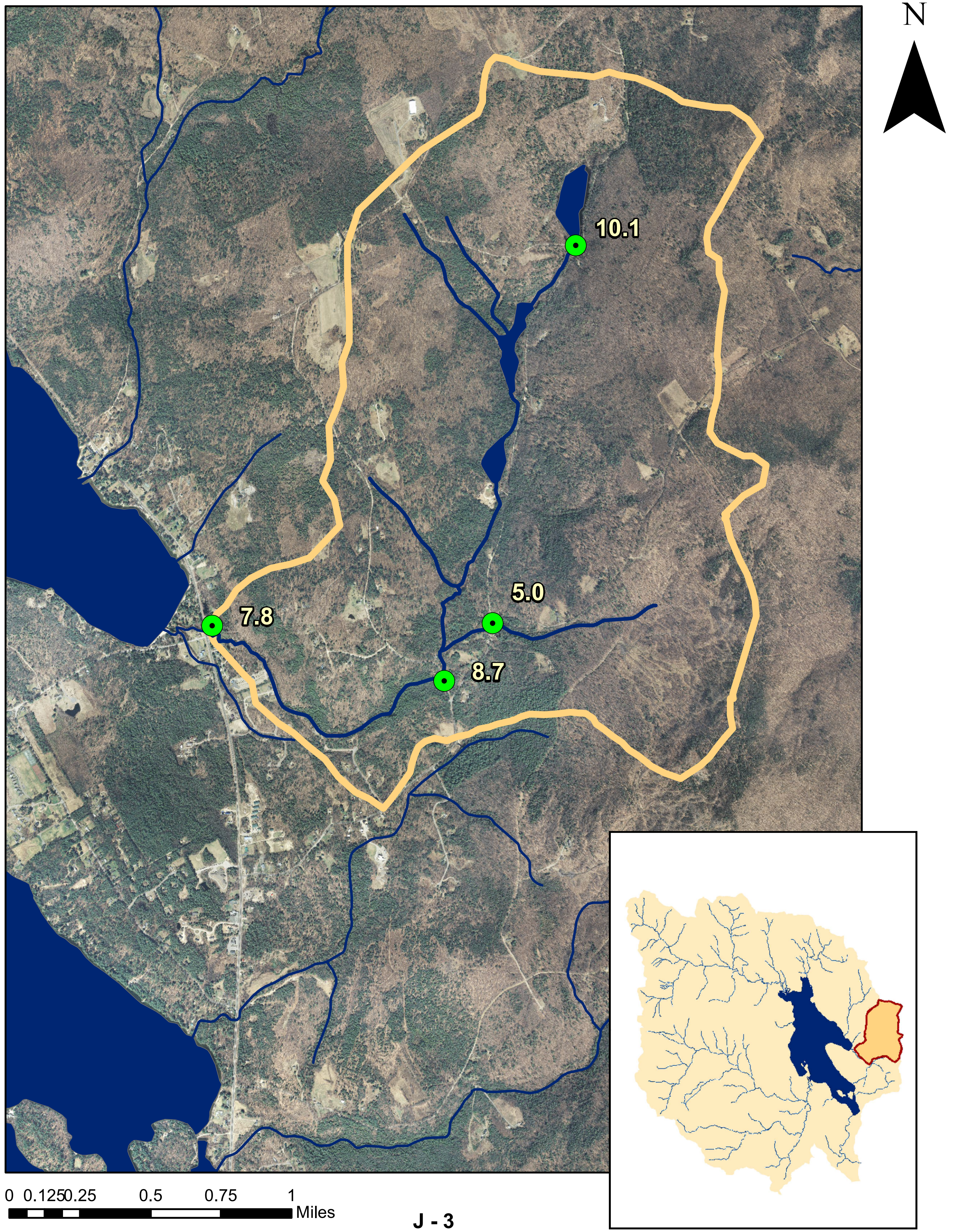
Inter-site comparison of median total phosphorus concentrations (2011-2013)



Aerial Orthophoto Source: NH GRANIT
Site location GPS coordinates collected by the UNH Center of Freshwater Biology

Dick Brown Brook Subwatershed

Inter-site comparison of median total phosphorus concentrations (2011-2013)

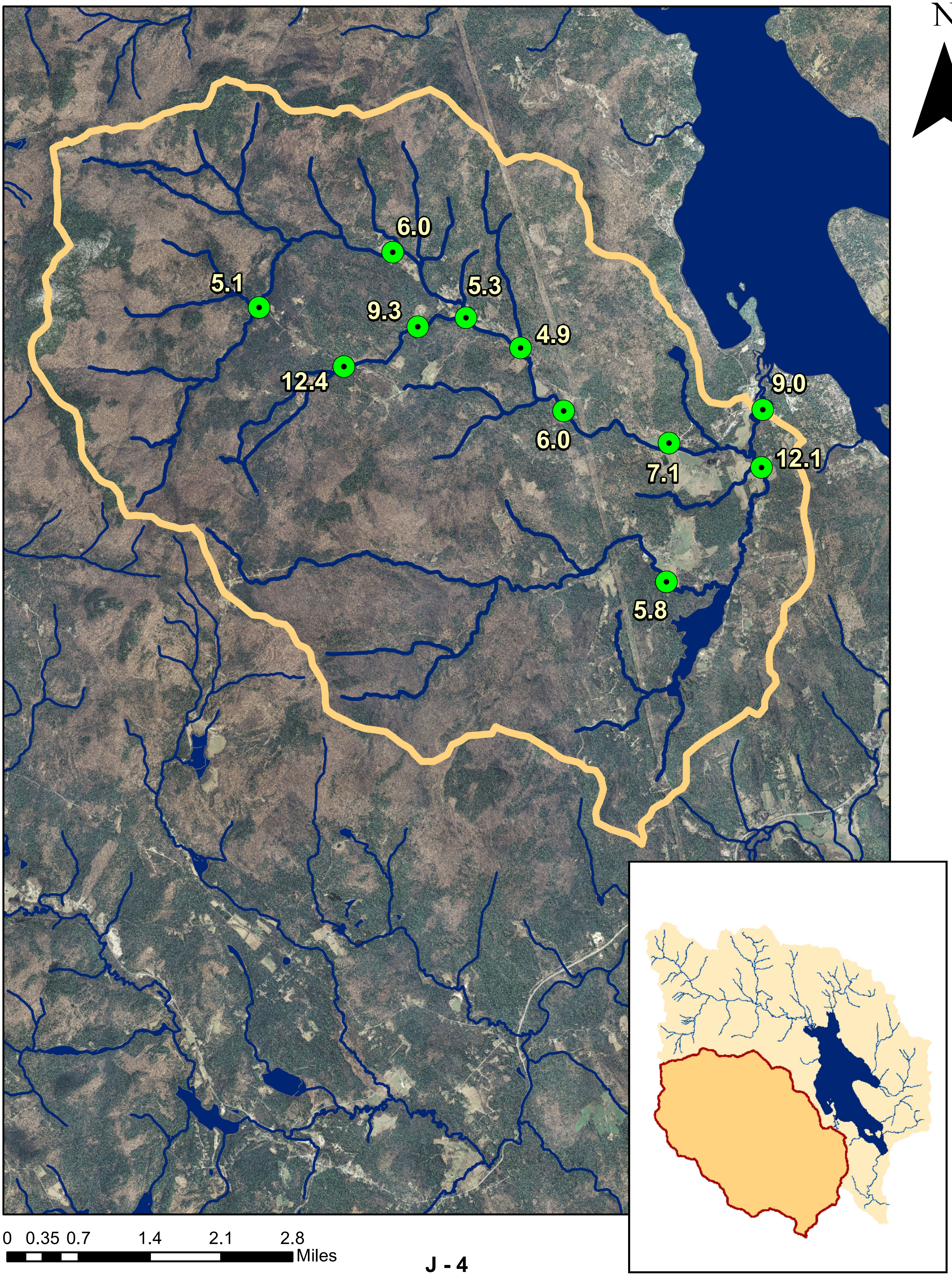


J - 3

Aerial Orthophoto Source: NH GRANIT
Site location GPS coordinates collected by the UNH Center of Freshwater Biology

Fowler River Subwatershed

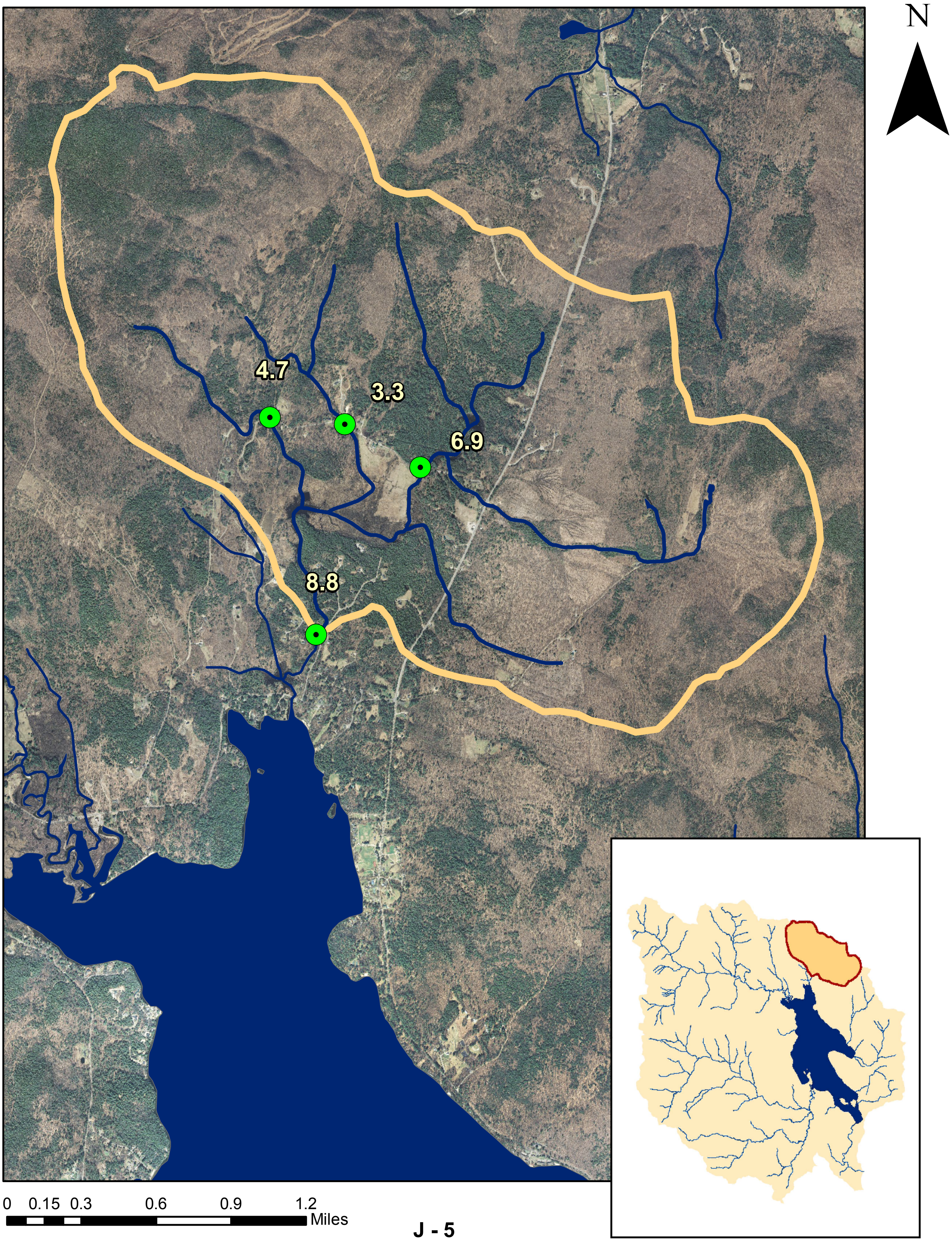
Inter-site comparison of median total phosphorus concentrations (2011-2013)



Aerial Orthophoto Source: NH GRANIT
Site location GPS coordinates collected by the UNH Center of Freshwater Biology

Georges Brook Subwatershed

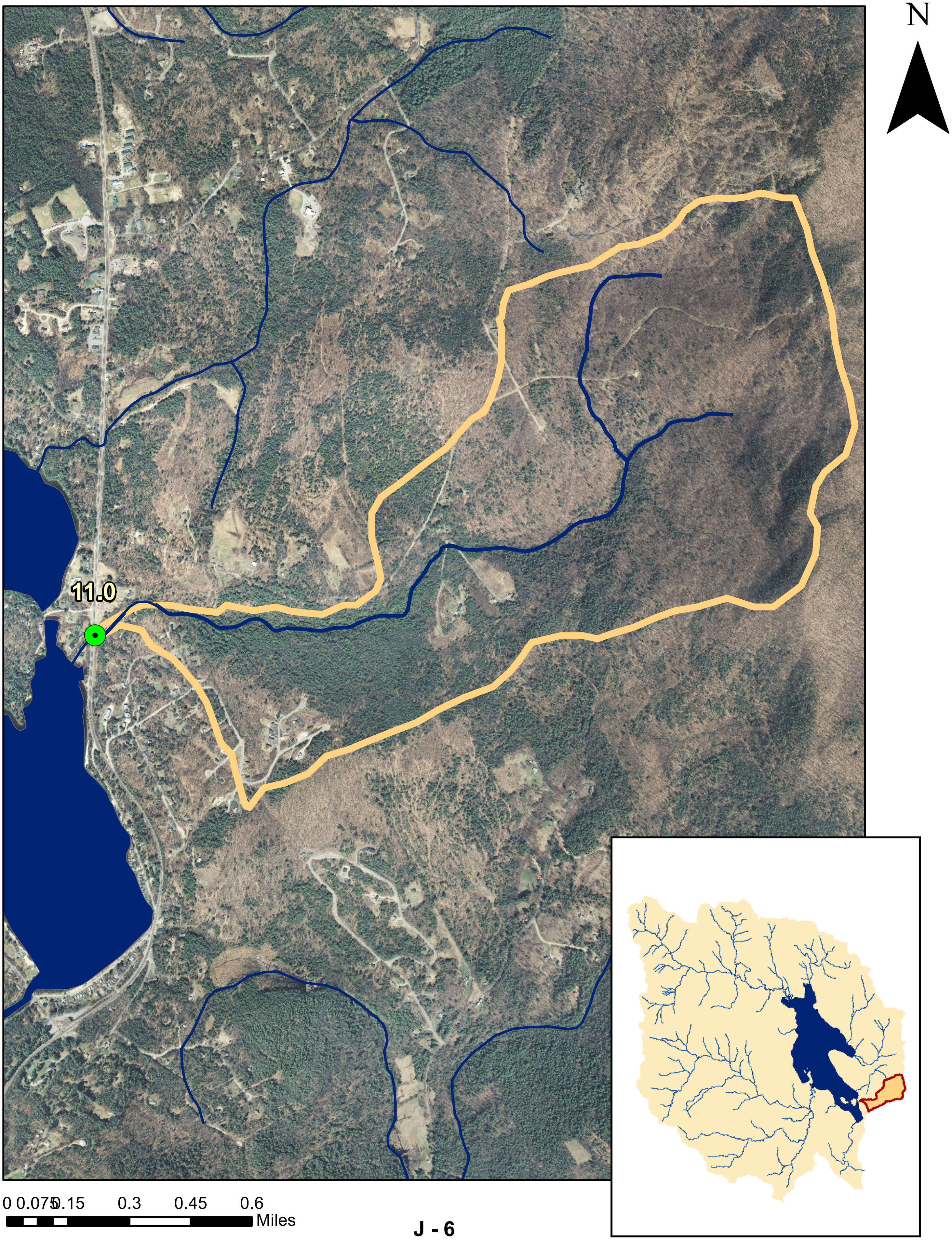
Inter-site comparison of median total phosphorus concentrations (2011-2013)



Aerial Orthophoto Source: NH GRANIT
Site location GPS coordinates collected by the UNH Center of Freshwater Biology

Hemlock Brook Subwatershed

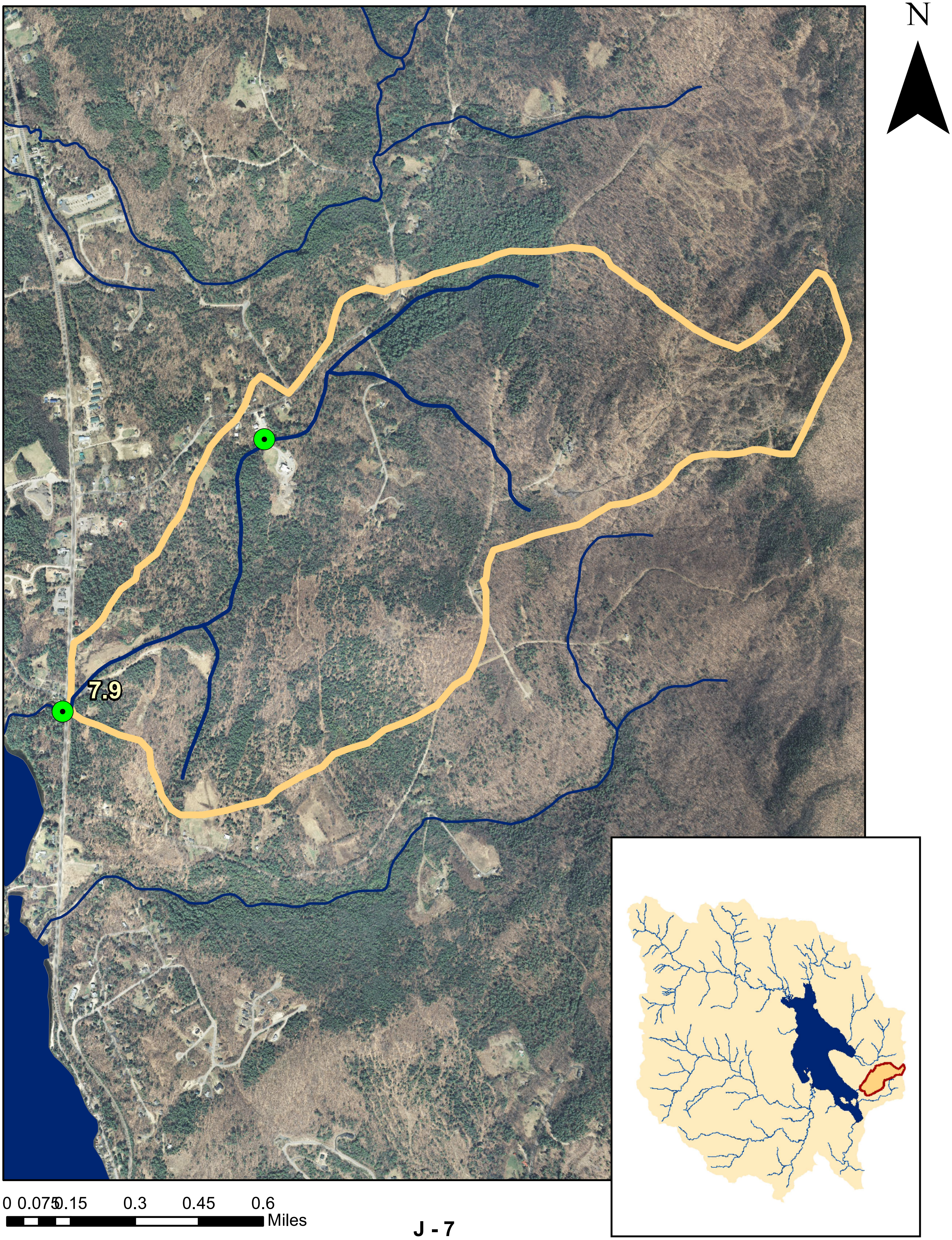
Inter-site comparison of median total phosphorus concentrations (2011-2013)



Aerial Orthophoto Source: NH GRANIT
Site location GPS coordinates collected by the UNH Center of Freshwater Biology

Tilton Brook Subwatershed

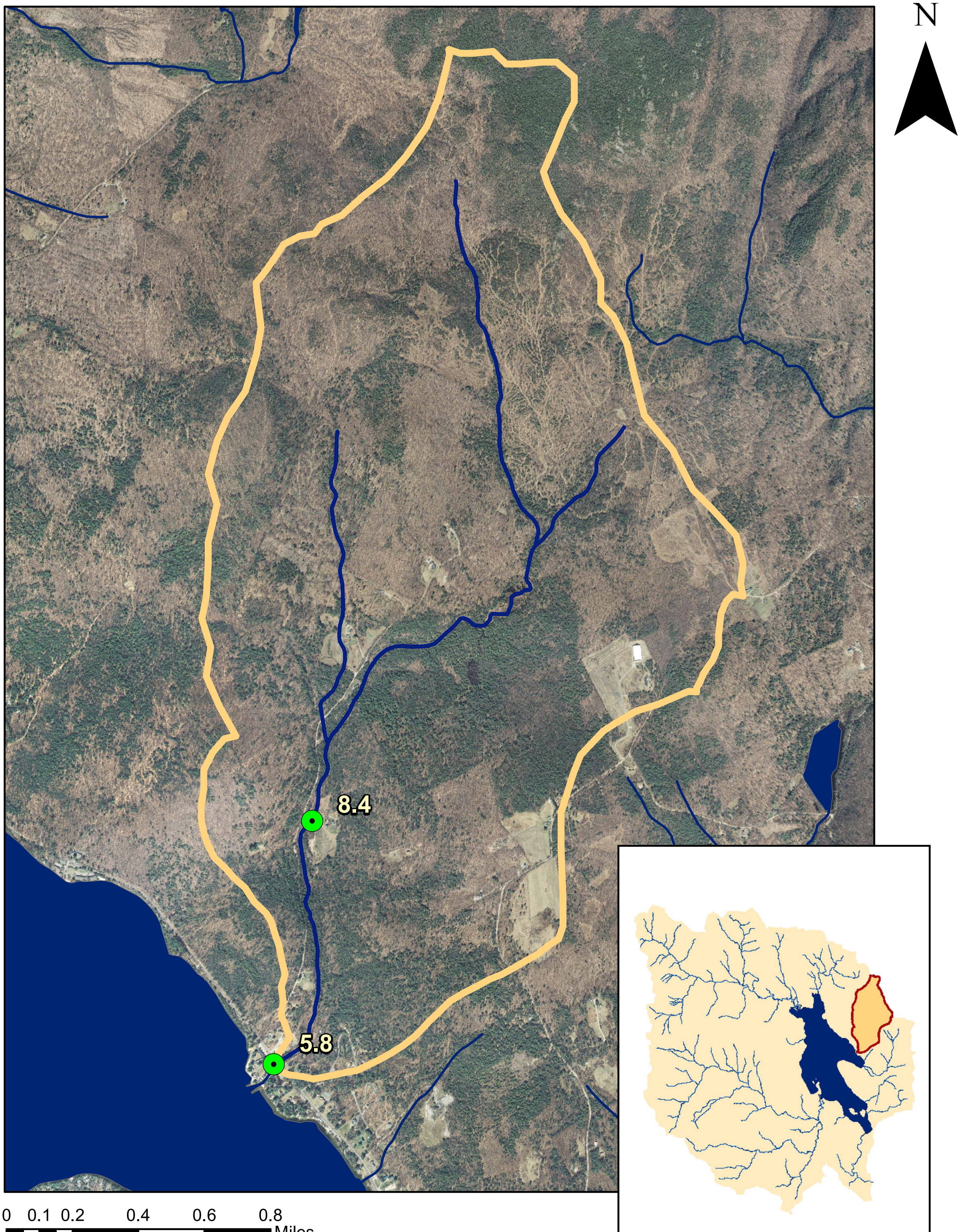
Inter-site comparison of median total phosphorus concentrations (2011-2013)



Aerial Orthophoto Source: NH GRANIT
Site location GPS coordinates collected by the UNH Center of Freshwater Biology

Whittemore Brook Subwatershed

Inter-site comparison of median total phosphorus concentrations (2011-2013)



J - 8

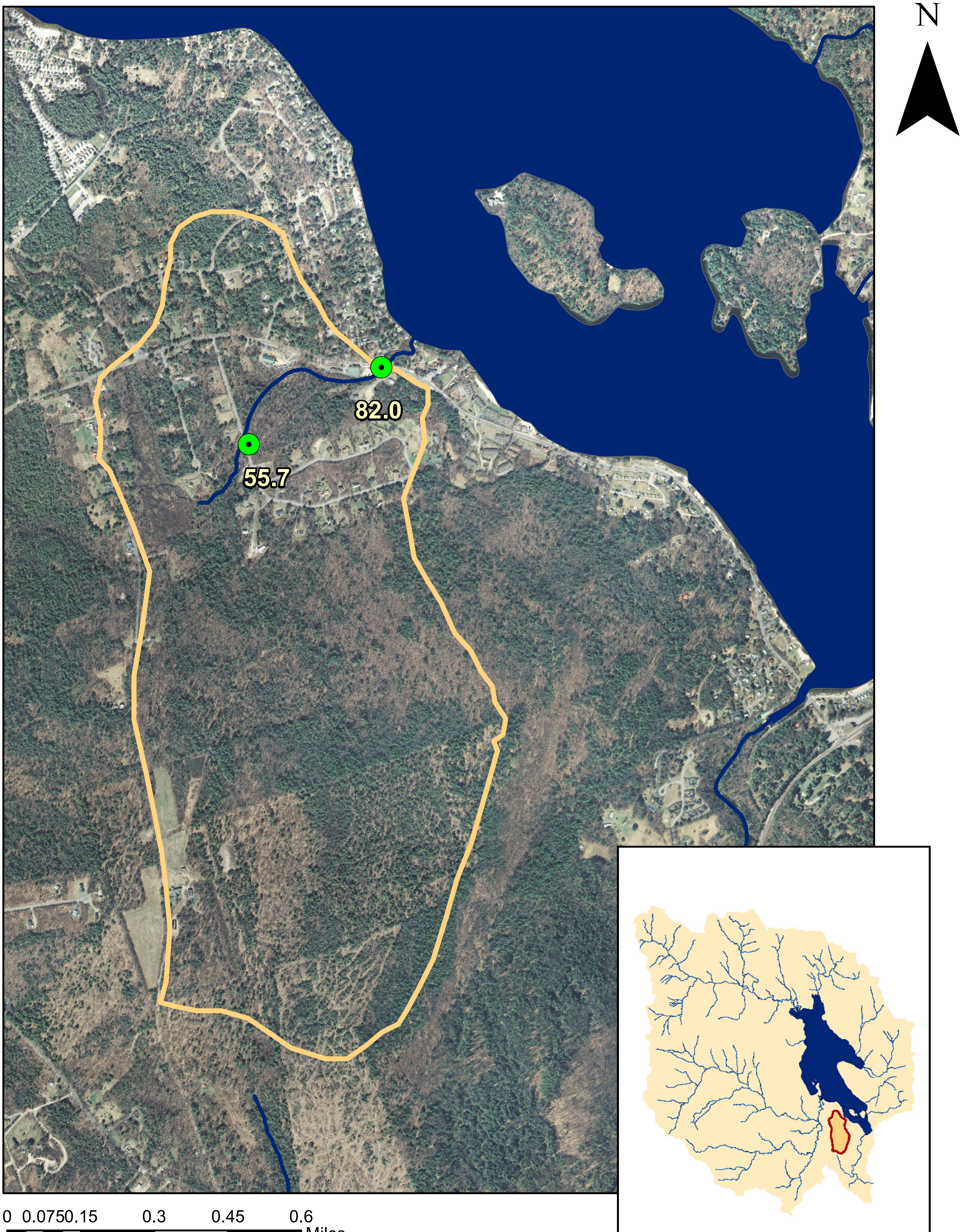
Aerial Orthophoto Source: NH GRANIT
Site location GPS coordinates collected by the UNH Center of Freshwater Biology

APPENDIX K

The following subwatershed maps represent active headwater tributary sampling locations in the Black Brook, Cockermouth River, Dick Brown Brook, Fowler River, Georges Brook and Whittemore Brook subwatersheds. Each map includes a vicinity map of the Newfound Lake watershed, which highlights the subwatershed of interest in yellow. Each map also includes the subwatershed boundary (represented by the red lines), sampling points (represented by green points) and tributaries (blue lines). The numbers printed near the respective sampling locations (green points) are median specific conductivity concentrations derived from Center for Freshwater Biology Group paired measurements collected in 2011 and 2013. The graphs provide a visual depiction of spatial water quality variations among sampling locations within the subwatersheds.

Black Brook Subwatershed

Inter-site comparison of median specific conductivity values (2011-2013)

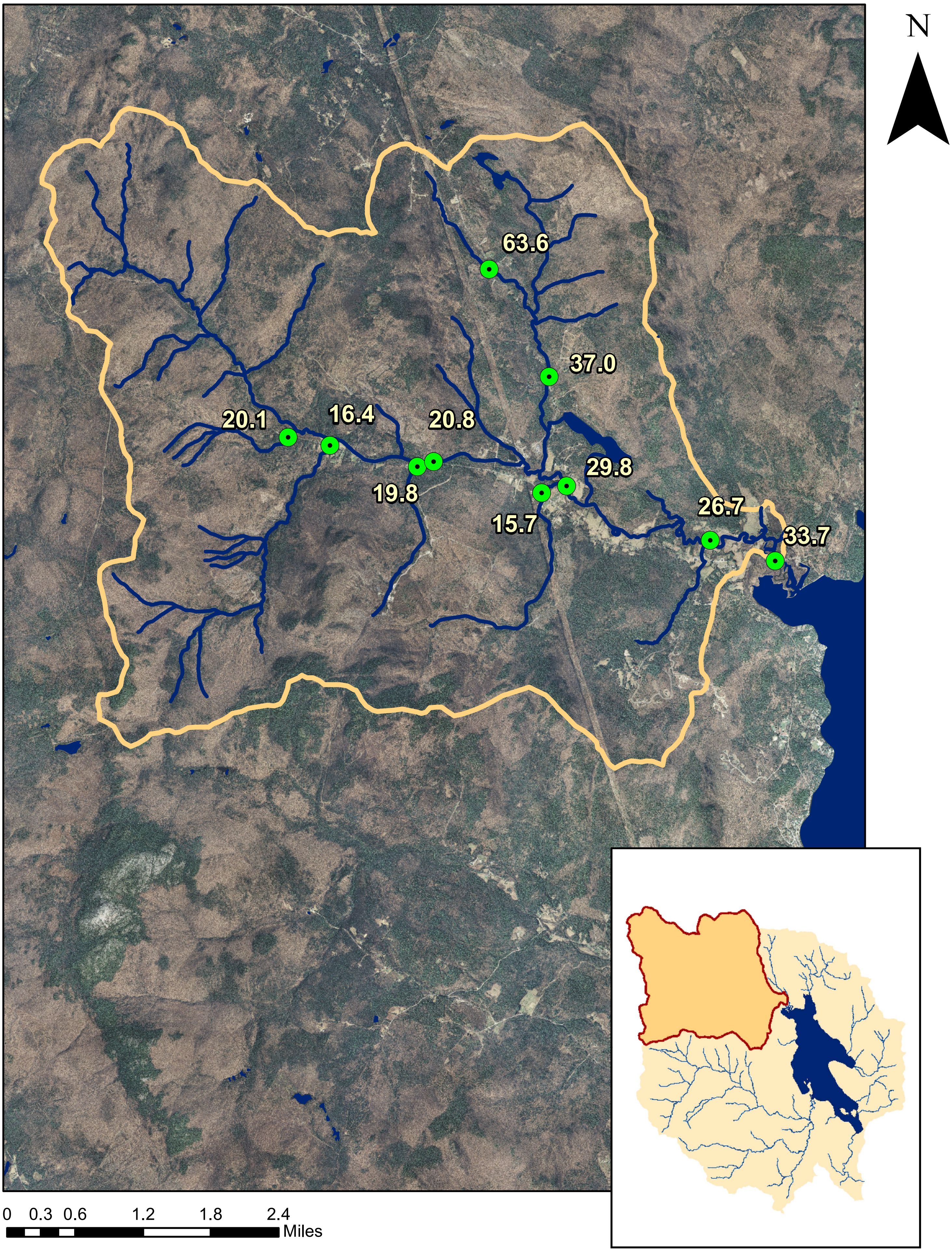


K - 1

Aerial Orthophoto Source: NH GRANIT
Site location GPS coordiniates collected by the UNH Center of Freshwater Biology

Cockermouth River Subwatershed

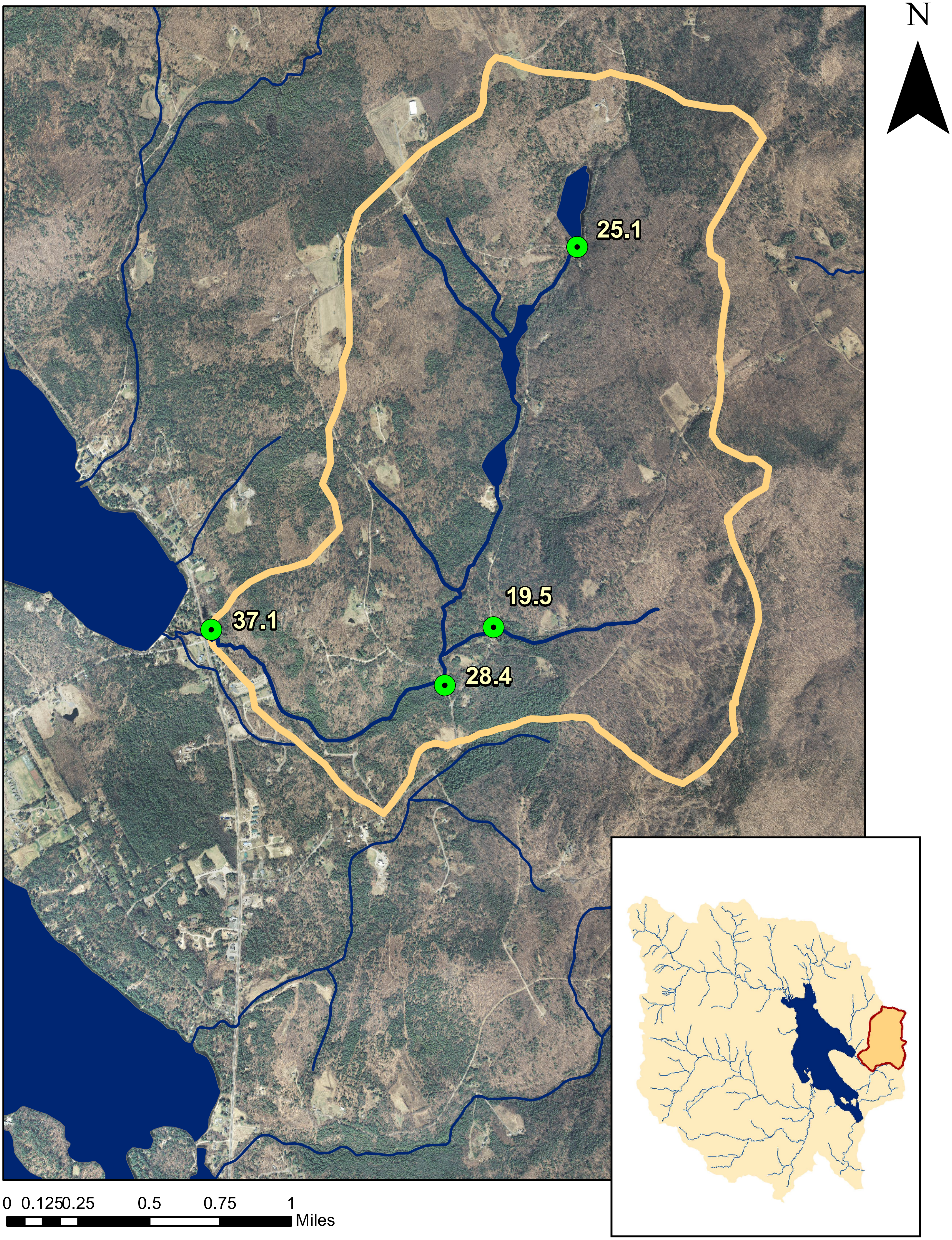
Inter-site comparison of median specific conductivity values (2011-2013)



Aerial Orthophoto Source: NH GRANIT
Site location GPS coordinates collected by the UNH Center of Freshwater Biology

Dick Brown Brook Subwatershed

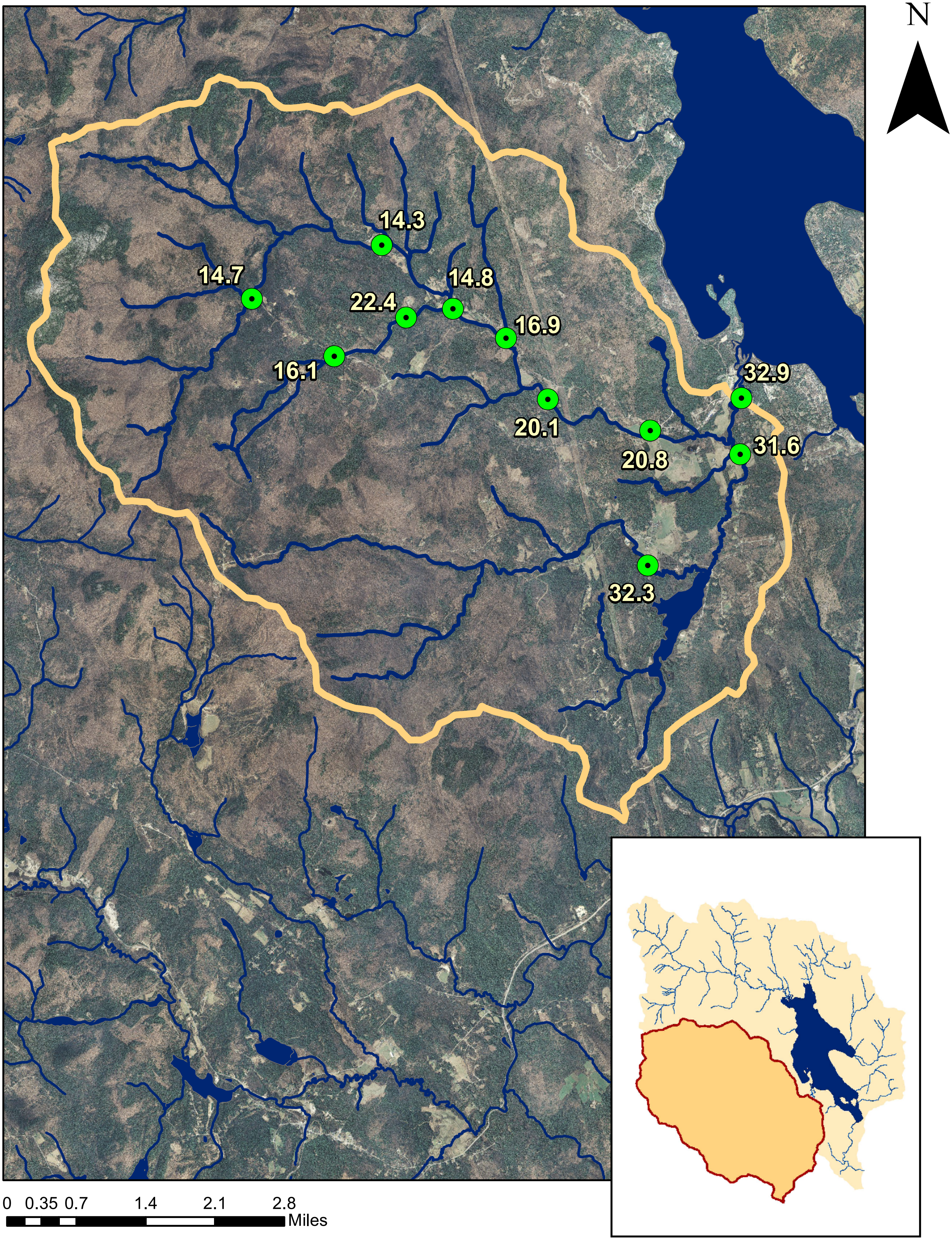
Inter-site comparison of median specific conductivity values (2011-2013)



Aerial Orthophoto Source: NH GRANIT
Site location GPS coordinates collected by the UNH Center of Freshwater Biology

Fowler River Subwatershed

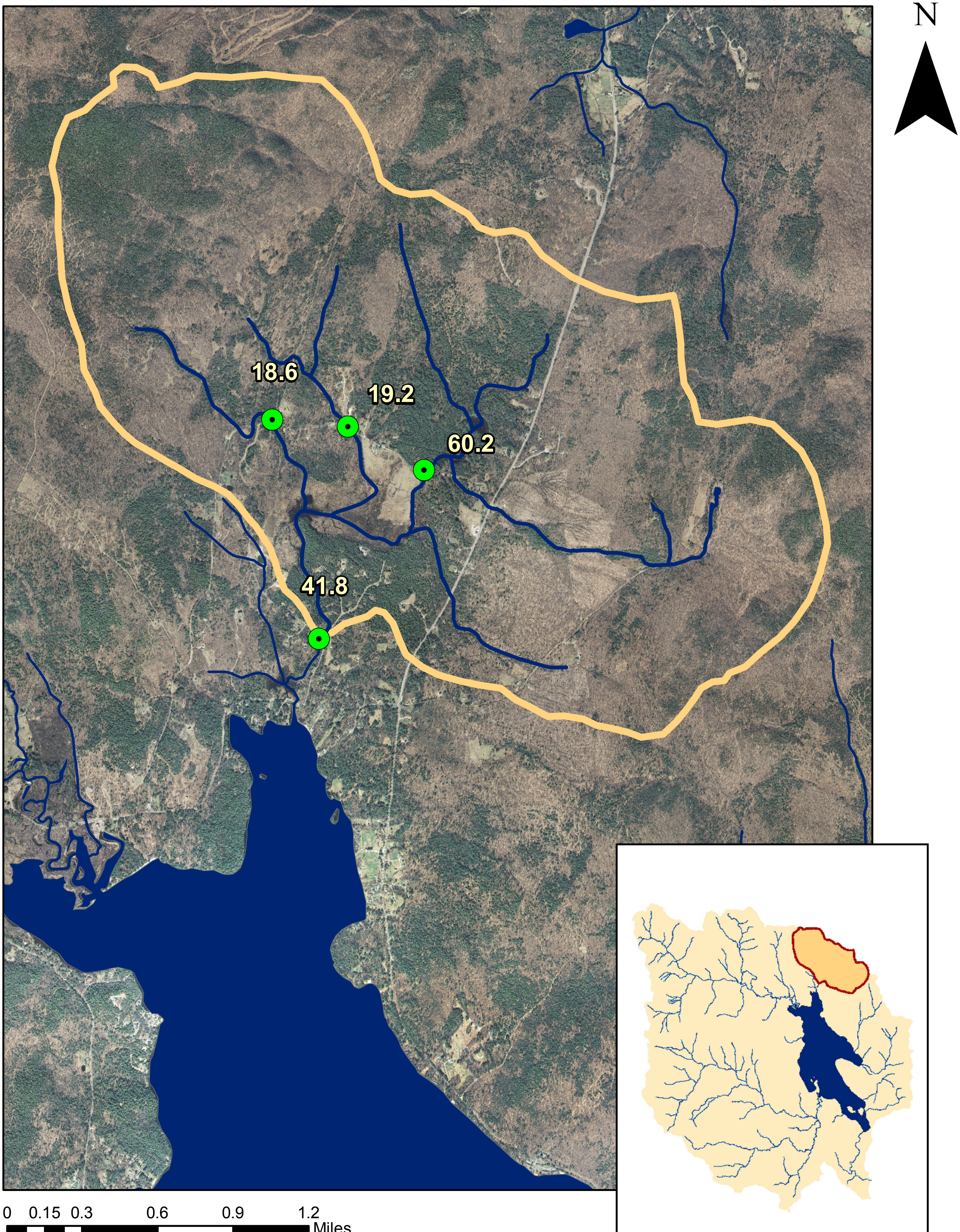
Inter-site comparison of median specific conductivity values (2011-2013)



Aerial Orthophoto Source: NH GRANIT
Site location GPS coordinates collected by the UNH Center of Freshwater Biology

Georges Brook Subwatershed

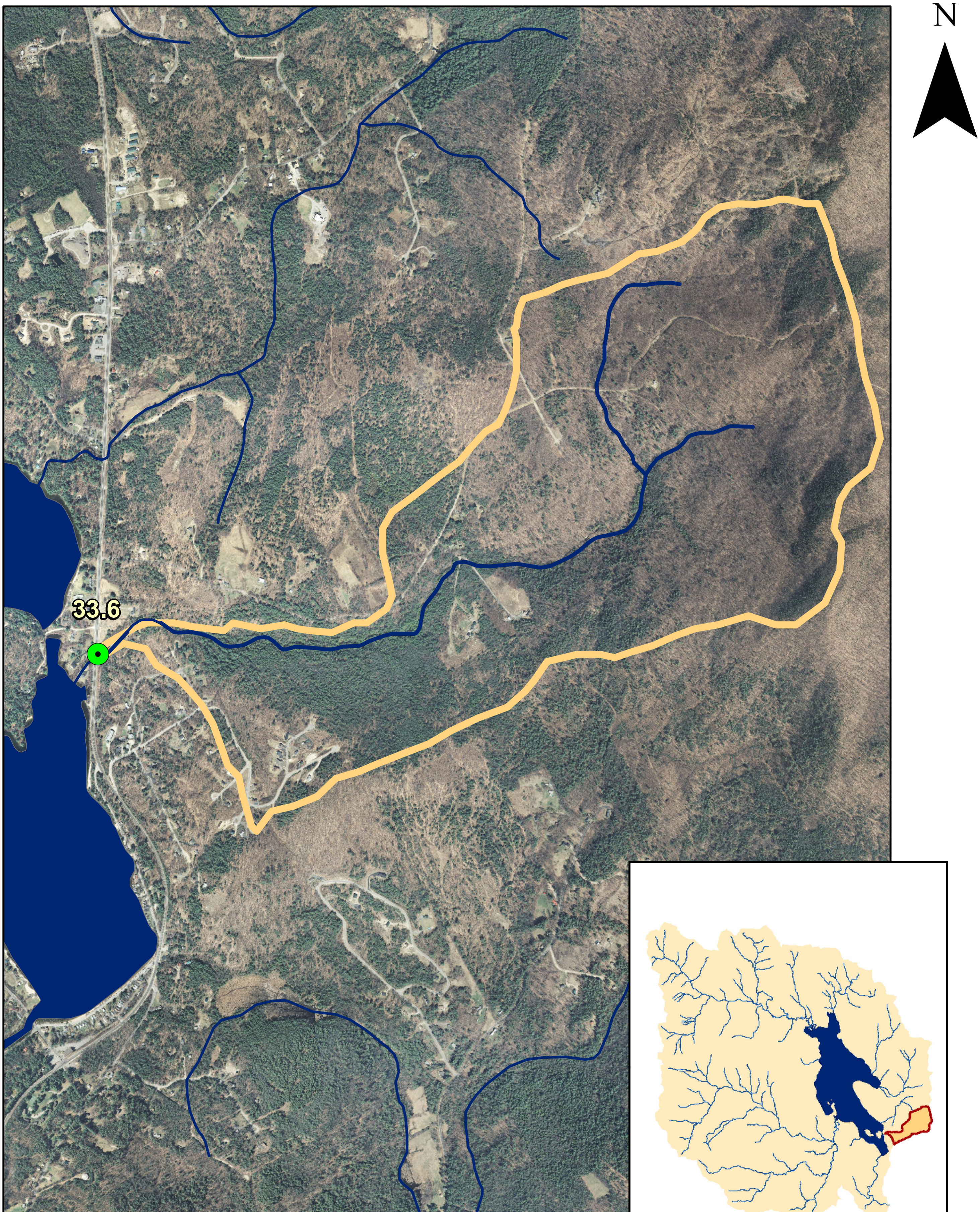
Inter-site comparison of median specific conductivity values (2011-2013)



Aerial Orthophoto Source: NH GRANIT
Site location GPS coordinates collected by the UNH Center of Freshwater Biology

Hemlock Brook Subwatershed

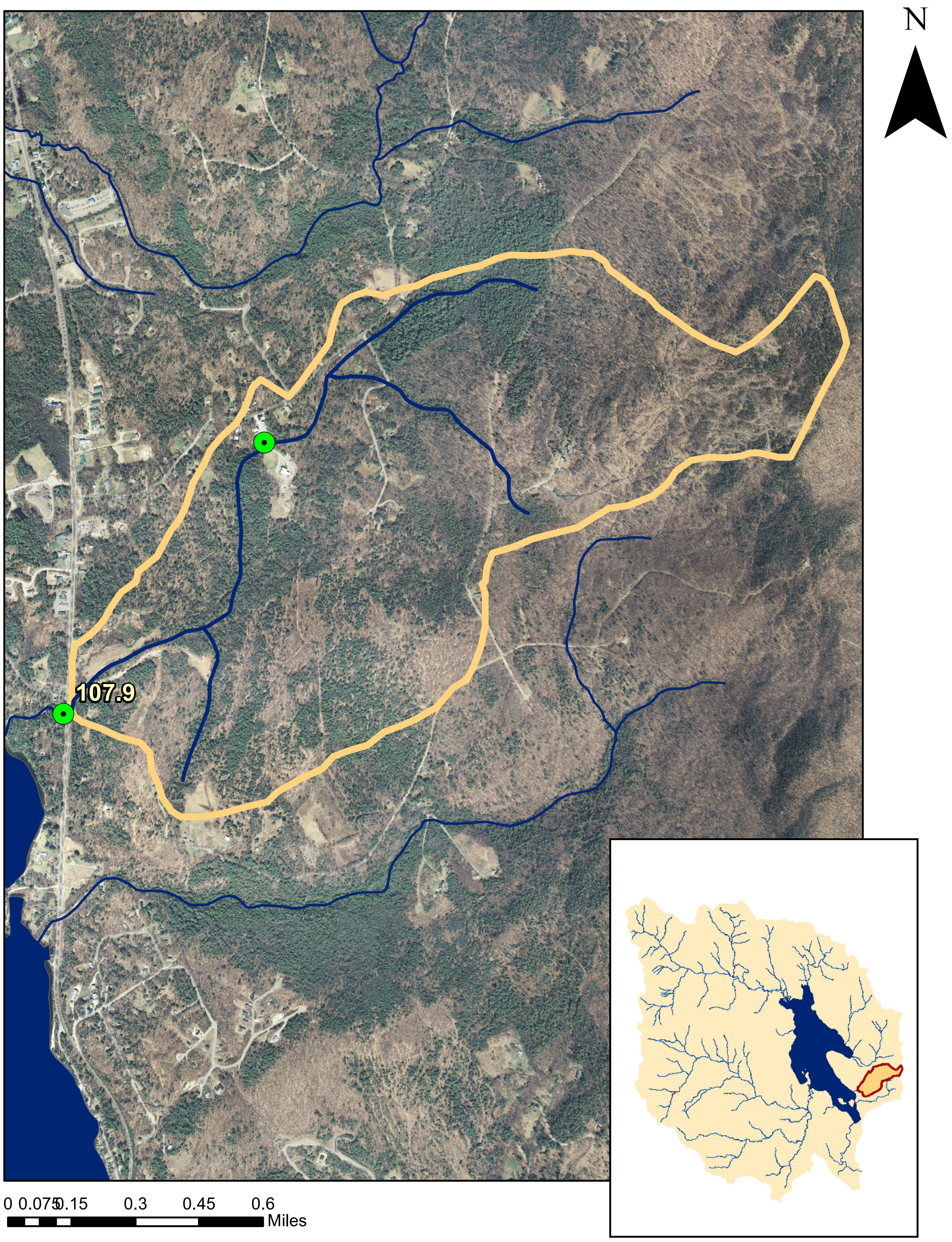
Inter-site comparison of median specific conductivity values (2011-2013)



Aerial Orthophoto Source: NH GRANIT
Site location GPS coordinates collected by the UNH Center of Freshwater Biology

Tilton Brook Subwatershed

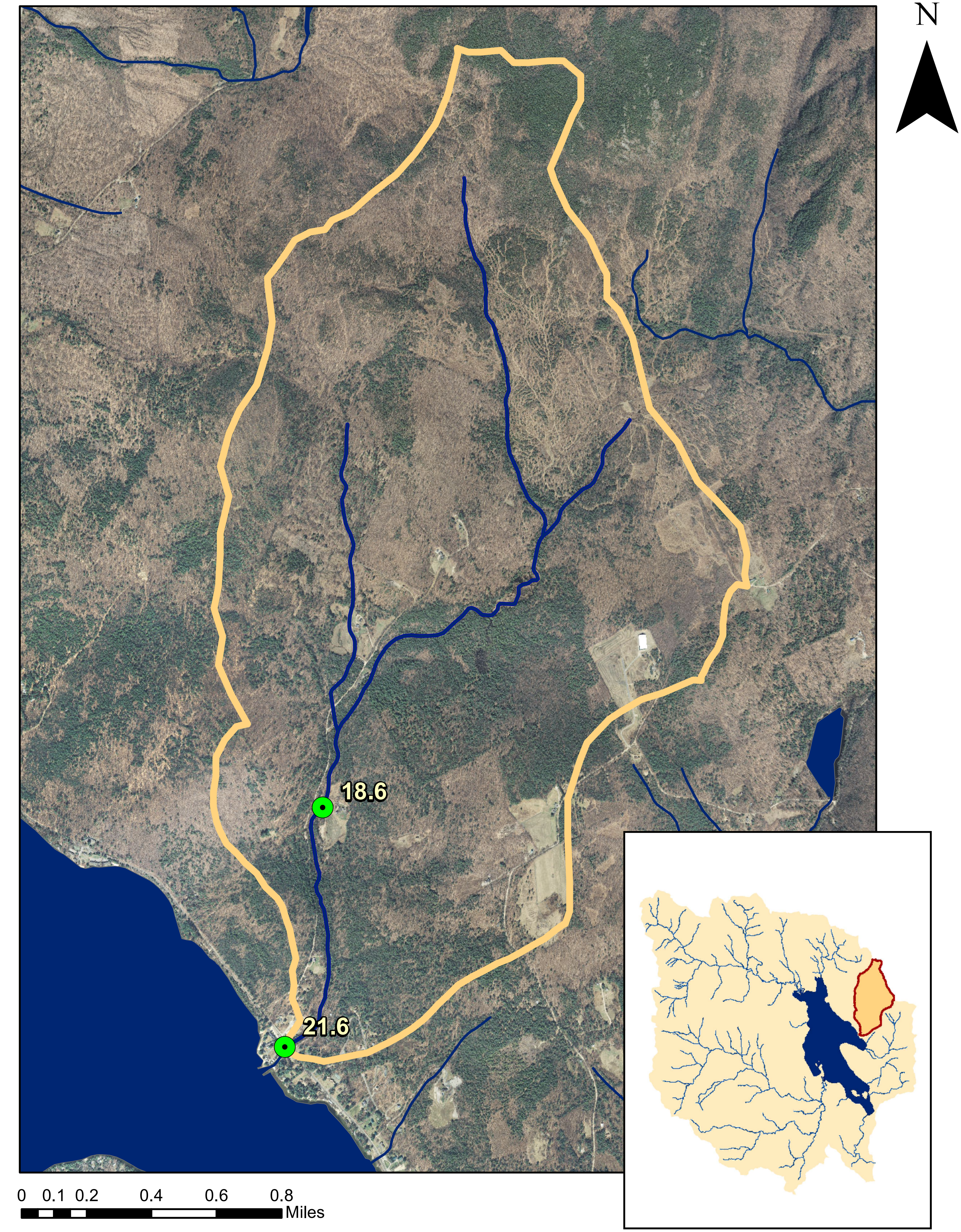
Inter-site comparison of median specific conductivity values (2011-2013)



Aerial Orthophoto Source: NH GRANIT
Site location GPS coordinates collected by the UNH Center of Freshwater Biology

Whittemore Brook Subwatershed

Inter-site comparison of median specific conductivity values (2011-2013)



Aerial Orthophoto Source: NH GRANIT
Site location GPS coordinates collected by the UNH Center of Freshwater Biology