A Chemical and Anthropogenic Impact Study of Lake Lonely

Lukiana Anka-Lufford, Jonathan D. Betz, Alexandria M. Cooper, Alexandra L. Daly, Saranya Soundararajan, Ashley M. Stingel, and Grace A. Winschel;
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and

Judith A. Halstead
Professor of Chemistry

Department of Chemistry
Skidmore College
815 N. Broadway
Saratoga Springs, NY 12866

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Abstract: *This investigation contributes to an understanding of Lake Lonely's trophic state, overall health, and role in the Saratoga Lake-Kayaderosseras Creek watershed. In February and April 2007, dissolved oxygen (DO), temperature, conductivity and pH were determined in Lake Lonely as a function of depth. In February, the average DO saturation was 81.5%. In mid and late April, respectively, the average DO saturation was 119.6% and 102.5%. The water was colder in February (averaging 2.4 ºC) than in April (averaging 6.3ºC in mid April and 9.0 ºC in late April); stratification was not observed on any of these dates. Conductivity was moderately high, with February and mid and late April specific conductivity averaging 602 µS, 601.3 µS and 605.0 µS, respectively. On all three dates, the pH was slightly basic, averaging 7.8, 8.1 and 7.8 in February, mid April and late April, respectively. In late April, the Secchi disk reading was 2.2m.*

Water samples were also collected in various parts of the lake and subsequently analyzed for major anions, major cations, total phosphorous (TP), phosphate, total nitrogen (TN) and total suspended solids (TSS). Chloride, nitrate and sulfate concentrations were determined by ion chromatography, bicarbonate concentration by potentiometric titration, and sodium, potassium, calcium and magnesium concentrations by inductively coupled plasma spectrometry. From these ion balances were calculated, giving cation to anion equivalence ratios, in milliequivalents per liter, ranging from 0.688 to 0.939. Determination of TP AND TN is especially important, since excess nutrients can lead to algal blooms, DO depletion and, ultimately, cultural eutrophication. Mid April samples were analyzed by the Darrin Fresh Water Institute for total phosphorous, which averaged 15.4 parts per billion (ppb), and for total nitrogen, which averaged 1.09 parts per million (ppm). From these values, as well as from Secchi disk readings, it was determined that Lake Lonely is most likely mesotrophic. In order to support this conclusion, further studies will be performed on Lake Lonely and its inlets. This experiment and continuing studies are part of the ongoing, long-term water quality monitoring of the Kayaderosseras Creek and its tributaries by the Skidmore College Water Resource Initiative (WRI).

INTRODUCTION

Geography

Lake Lonely is located in the city of Saratoga Springs, a few miles southeast of the Adirondack Park in upstate New York (Figure 1). Saratoga Springs is a small city with a year-round population of 26,047, a number that fluctuates greatly due to increased summer tourism associated with the historic Saratoga Raceway[1]. Lake Lonely lies approximately 3 miles (4.8 kilometers) to the southeast of downtown Saratoga Springs within a partially developed northeastern deciduous forest. Lake Lonely is one of a few water bodies in the Saratoga Lake watershed, which covers 13,632 acres (55.2 square kilometers) in Saratoga County[2]. Lake Lonely is 136 acres[2] (0.2125 square miles or 0.55 square km), and

Figure 1. Flow direction and location of Lake Lonely with respect to Saratoga Lake.

is 40 feet (12.2 m) in depth at its deepest point[3]. Lake Lonely is used for swimming, fishing and other recreational activities[3]. The Lake Lonely Outlet enters the Kayaderosseras Creek shortly before the Kayaderosseras Creek runs into Saratoga Lake, a potential drinking source for the city of Saratoga Springs. This is one of the main reasons for studying the chemical characteristics of and anthropogenic impact on Lake Lonely.

Spring Run, an inlet of Lake Lonely, is piped through parts of Saratoga Springs with the storm water collection system[4]. Storm water is rainfall that runs off roofs, roads and other surfaces, flowing into gutters, streams, rivers and creeks. This water contains contaminants, including road salts[5]. The storm water collection system pollutes Spring Run, which in turn pollutes Lake Lonely[4]. Water also enters Lake Lonely from Bog Meadow Brook, a lesser-studied inlet. Both inlets flow into the northern edge of Lake Lonely – Spring Run from the City of Saratoga Springs, slightly to the northwest, and Bog Meadow Brook slightly toward the northeast. Other water sources in the Saratoga Lake-Kayaderosseras watershed that were used for comparison include Lake Lonely Outlet, Kayaderosseras Creek, Loughberry Lake, Geyser Brook and Mourning Kill Creek.

Saratoga Lake is a class A water source, whereas Lake Lonely is a class B water source. The New York State Department of Environmental Conservation characterizes class A water sources as waters that can be used for drinking water and class B water sources as waters that can be used for swimming and other contact recreation, but not for drinking water[6].

Cultural Eutrophication

The impact of cultural eutrophication includes both ecological and societal effects. Ecological effects include changes in species composition and dominance, decreased biodiversity, reductions in harvestable fish and shellfish, dissolved oxygen depletion, increased turbidity and color and odor problems. Societal effects include decreased resource value of eutrophic water bodies and the impedance of recreation, hunting, fishing and aesthetic enjoyment. These are important considerations for both visitors to Lake Lonely and residents living nearby.

In addition, because Lake Lonely acts as an intermediate reservoir for urban runoff pollutants from downtown Saratoga Springs and the town of Wilton, measuring nutrient levels and other chemical and physical characteristics of Lake Lonely may be helpful in determining whether Saratoga Lake, a much larger lake downstream of Lake Lonely, is an appropriate option for a future public water source for the city of Saratoga Springs. Some of these pollutants are harmful because they expedite cultural eutrophication, the process by which anthropogenic addition of nutrients to water bodies accelerates eutrophication, the natural aging process for aquatic systems.

Due to the importance of dissolved oxygen (DO) in eutrophication, DO levels, in addition to measurements of nitrate and phosphate, comprise the first major group of characteristics investigated in the current Lake Lonely study.

DO is integral to aerobic respiration by aquatic organisms and aerobic decomposition; depletion of DO is therefore potentially devastating to the biodiversity of a water body. DO levels are increased by photosynthesis, especially on sunny days, and also by direct contact with atmospheric oxygen, especially on windy days. Added nutrients increase the rate of biological growth and subsequently that of aerobic respiration and of oxygen-consuming organic decomposition. Dissolved oxygen measured as a function of depth, is an important part of this evaluation, as DO depletion at the bottom of the lake prevents the decomposition of organic materials which have settled there.

Geologically young water bodies are generally categorized as oligotrophic and have high levels of dissolved oxygen but relatively low levels of nutrients and biological activity. This does not mean, however, that there is no biological activity in these water bodies. Many common aquatic species, including fish, become established during this stage. Geologically older water bodies are categorized as eutrophic, and have low levels of dissolved oxygen but high levels of nutrients. Although these lakes may experience high rates of algal growth in surface waters, low levels of dissolved oxygen in the water column, especially at the bottom, can lead to deaths among many species, including fish and shellfish, and affect biodiversity. Water bodies with intermediate characteristics are characterized as mesotrophic. Water bodies exhibiting extreme dissolved oxygen depletion are characterized as hypereutrophic, and often have very high rates of algal growth in the surface waters only because the input of oxygen from the atmosphere still suffices to support life. Biodiversity is often severely decreased in hypereutrophic water bodies.

Efforts have been made for the past several decades to both increase the overall understanding of and reduce the impact of cultural eutrophication around the world. In particular, environmental field studies have shown the effects of, and have identified anthropogenic nutrients that lead to, increased rates of eutrophication. One example is the Experimental Lakes Area study, overseen by the Central and Arctic Region of Fisheries and Oceans Canada, which has investigated the effects of eutrophication in 58 lakes and their watersheds in northeastern Ontario since 1968. In one particular experiment, on ELA Lake 226, researchers measured the effects of added carbon, nitrate and phosphate in the experimentally modified lake. After dividing the lake into two halves with a plastic barrier, researchers added carbon and nitrate to one side and carbon, nitrate and phosphate to the other. Significantly increased biological activity on the side to which all three nutrients were added showed that phosphorus was the limiting nutrient in this lake[7]. Studies like this have led to some political progress in decreasing the causes of cultural eutrophication. This study in particular helped pave the way for the U.S.-Canada Water Quality Agreement of 1972, which prohibited the use of phosphorous in household detergents and soaps in the United States and Canada[8].

In addition to dissolved oxygen, phosphorous and nitrogen, as well as the amount of total suspended solids, are important indicators of possible anthropogenic impact. For this reason, these factors were investigated as a key part of this Lake Lonely study. Dissolved salts, often from winter road salt runoff, are an additional indicator of human impact, and so chloride concentrations and overall water conductivity were also determined. Field measurements also included pH. Although Lake Lonely was not predicted to be particularly acid sensitive, pH measurements confirmed that the dominant acid-neutralizing species was bicarbonate, the concentration of which was crucial to the ion balance, another common water characterization technique.

Nitrogen and phosphorus are available in several forms for uptake by phytoplankton and macrophytes that produce biomass[7]. Although structurally and nutritionally integral to the biota, in high concentrations these nutrients expedite eutrophication, a lake's natural aging process[9]. Since its nutrient load directly affects trophic state, an analysis of Lake Lonely's nitrogen and phosphorus contents is relevant to both the lake's ecosystem and its human environs.

The bacterial oxidation and reduction of sundry nitrogen compounds in the water yield forms of nitrogen photosynthetically assimilated by aquatic vegetation[7]. Most important to the biota are inorganic nitrate (NO_3^-) and ammonia (NH_3), which collectively supply the greater part of nitrogen available in the lake[9]. Nitrate is formed from the bacterial oxidation of organic and inorganic nitrogenous compounds[7]. Ammonia derives from bacterial organic decomposition, which progresses as follows:

Dead matter $\rightarrow NH_3 \rightarrow NO_2^- \rightarrow NO_3^-$

Ammonia is present predominantly as NH_4^+ and NH_4OH, the ratio of which depends greatly on pH and should be at a level favoring ammonium's preponderating as a good nitrogen source over the potentially toxic ammonium hydroxide[9]. (Table 1)

Table 1. Ratio of ammonia to ammonium hydroxide at differing pH values[9].

pH.	NH_4^+ : NH_4OH.
6.0	3000:1
7.0	300:1
8.0	30:1
9.5	1:1

The total nitrogen content is equivalent to the inorganic nitrogen (nitrate (NO_3^-) and nitrite (NO_2^-) and the total Kjeldahl nitrogen (ammonia (NH_3) and organic nitrogen)[9].

The spring surface nitrate and ammonia concentrations of an archetypical north temperate dimictic lake, such as Lake Lonely, would decrease throughout the growing season as the phytoplankton crop, uptaking these compounds, burgeoned, a subsequent autumnal increase, maximizing in winter months, corresponding to the phytoplankton's decline[10]. As the first product of organic decomposition, ammonia may exhibit elevated concentrations attributable to a predomination of decomposition over photosynthesis during the growing season[9]. In this hypothetical lake, deeper nitrogen concentrations would generally exceed those of the surface—the surface water's interaction with the atmosphere would afford it more dissolved oxygen and thereby facilitate greater phytoplankton activity; additionally, some deeper nitrogen would be replenished by organic decomposition[10]. Summertime oxygen depletion, born of insufficient oxygen levels to meet photosynthetic demands, hinders organic decomposition, further contributing to the decline of nitrogen-containing compounds[10].

Leached from the soil at much slower rate than nitrogen, phosphorus is often the limiting nutrient of a lake's productivity[9]. Algal concentration and trophic state of lakes correspond to levels of phosphorus, the nutrient often regarded as the primary factor in eutrophication[9]. Although present in both organic and inorganic forms, the phosphorus in lake water is largely comprised of that "organically bound with living material or associated with decaying material[9]." Paramount in lake metabolism is the total phosphorus (TP) content, consisting of particulate phosphorus and the soluble fraction[9]. Particulate phosphorus, that in suspension with particulate matter, includes three forms: phosphorus 1) in living organisms, 2) absorbed into mineral phases of rock and soil, and 3) adsorbed onto dead particulate organic matter[9]. Total soluble phosphorus (TSP) contains inorganic orthophosphate (soluble reactive phosphorus, SRP) along with other, less soluble forms available for uptake and biomass production[9].

TSP input would flow into a typical north temperate dimictic lake during high runoff periods such as spring melt; during the growing season the system's TSP would be depleted and converted to biomass[9].

Total suspended solids (TSS) is a water quality measurement referring to the dry-weight measurement of the filterable solids in a water sample[11]. TSS encompasses such materials as silt, industrial waste and organic matter that in high concentrations cause a myriad of problems, both ecological and societal[11]. TSS can clog pipes, machinery and fish gills as well as reduce fish growth and reproduction[11]. Blocking light, TSS can preclude photosynthesis, thereby decreasing dissolved oxygen concentrations and killing plants, of which the decomposition increases biochemical oxygen demand[11]. Excessive suspended solids may thus essentially eliminate aquatic life[11]. Additionally, suspended solids can aid and abet the transport of dangerous bacteria and chemical pollutants by providing them with mobile sediments by which to travel downstream[11]. Despite their harmful effects, TSS can form precipitatable complexes with toxic substances, inhibiting their absorption by organisms[11].

Chloride and Conductivity

The second group of measurements taken includes chloride concentration and conductivity, which are indicators of anthropogenic impact, especially road salt runoff. Chloride, with one or more associated cations, enters lakes in runoff polluted by road salts, fertilizers, and human and animal wastes that are washed into the watershed through storm drains, which in this case may flow into Lake Lonely via Spring Run. The Environmental Protection Agency includes chloride in the category of "nuisance chemicals," and thus it falls under the non-mandatory National Secondary Drinking Water Regulations[12]. Chloride and the cations, such as sodium and calcium, often chemically associated with it are not considered to pose a major threat to human health, except perhaps to those requiring low-sodium diets. However, analyzing chloride concentrations and water conductivity may allow future researchers to infer if other pollutants like automobile gasoline or oil, which are more difficult to detect in water samples, might also be washed into the water from the same roads.

Conductivity is defined as the measure of the ability of water to pass an electrical current. It is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate and phosphate anions. A low conductivity is therefore preferred, as high amounts of nutrients and inorganic dissolved solids can have negative effects on lake health. Conductivity is also affected by temperature: the warmer the water, the higher the conductivity. For this reason, conductivity is reported as specific conductivity, which is the measured conductivity normalized to 25°C. This eliminates the complication of comparing conductivity values measured at different temperatures. The conversion between conductivity and specific conductivity for typical freshwater lakes is given by the equation:

$$\text{specific conductivity} = \text{conductivity}/(1+0.0191(\text{temperature} - 25°\text{C}))$$ [13].

Selected Physical and Chemical Characteristics

The final category of measurements includes basic characteristics of aquatic systems like Lake Lonely. The first two, pH and acid neutralizing capacity, represent an important part of the ion balance performed on the Lake Lonely samples.

The negative logarithm of the hydrogen ion concentration gives the pH of a solution, which is a measure of the acidity or alkalinity of a solution. Solutions with a pH less than seven are considered acidic, while those with a pH greater than seven are considered basic or alkaline. A pH of exactly seven is considered neutral, as this is the pH of pure water at 25°C. A freshwater body's pH determines the solubility and biological availability of chemical constituents such as nutrients and heavy metals. It also determines the range of organisms that can exist in that specific ecosystem and whether or not the water is suitable for human consumption.

Acid neutralizing capacity is a measure of the ability of a water body to resist a change in pH with the addition of an acid. Although Lake Lonely was not predicted to be highly acid sensitive, ANC can be used to determine the amount of bicarbonate buffer in the water, which is important for a complete ion balance. Measurements of pH confirmed that the constituent contributing most to the water's acid neutralizing capacity was indeed bicarbonate and not some other form, like carbonate. The third component of this group, temperature, provided useful information about the degree of vertical stratification in the lake. This is important to consider before making conclusions about seasonal trends or the water body's trophic state.

Additionally, Secchi disk measurements were taken to determine turbidity and as an indicator of trophic state. Turbidity is measured using a Secchi disk, a round plate with alternating black and white quadrants. It is lowered via a rope into the water and the depth at which it is last visible corresponds to a trophic state: oligotrophic, mesotrophic, eutrophic or hypereutrophic. An oligotrophic lake has clear waters whereas a hypereutrophic lake has turbid waters.

Ion Balance

On February 1, 2007, water samples were collected from three sites on Lake Lonely (Figure 2). These samples were subsequently analyzed to generate a winter ion balance profile for the lake. All aqueous ions within a given water body possess a reactive capacity, which is expressed as equivalence and, for aqueous ions, is equal to the absolute value of the charge on the ion. Thus, a divalent anion such as sulfate (SO_4^{2-}) would have an equivalence value of two equivalents, or reactive units, per mole of substance. Normality is a concentration term based on equivalence that is expressed as equivalents per liter of water. It is calculated by multiplying the equivalence of a substance by its molar concentration.

Figure 2 Winter Sites A, B and C on Lake Lonely

A ratio of the major cations (Ca^{2+}, Mg^{2+}, Na^+ and K^+) to the major anions (Cl^-, NO_3^-, SO_4^{2-}

and HCO_3^-) in meq/L in a given water body is expected to be around 1. If this ratio differs significantly from 1, i.e., by more than twenty percent, it can suggest that an unknown solute is present in the water body and/or the data collection and analysis techniques are unreliable (L. Eichler, personal communication). Thus, if the cation to anion ratio lies near 1, it can be assumed that such techniques were conducted reliably.

In order to generate this ion balance profile, three techniques were used: ion chromatography, inductively-coupled plasma spectroscopy and potentiometric titration. Ion chromatography was used to determine the anion concentrations, excluding bicarbonate, whereas inductively coupled plasma spectroscopy was used to determine the cation concentrations. Bicarbonate concentration cannot be determined through use of ion chromatography because of the specific eluent ($NaHCO_3$) used in the apparatus. Instead, bicarbonate concentration was determined through potentiometric titration. This value is often reported as alkalinity, or, alternatively, as the acid-neutralizing capacity (ANC) of a water sample.

METHODS

Field Data

On February 1, 2007, gasoline-powered augers were used to drill three holes at winter sites A, B and C (Figure 2) through the surface ice surface on Lake Lonely in Saratoga Springs, NY. The depth of the water was determined at each site. Temperature, conductivity, pH and dissolved oxygen content were measured as a function of depth at each site (Appendix A: Tables A1-A9). A Global Positioning System (GPS) reading was taken to determine the exact location of the sites. Temperature, conductivity, pH and dissolved oxygen content were again measured in mid April off the Crescent Avenue Bridge. The Lake Lonely Outlet was flooded on our mid-April field day. The water level was nearly to the bridge, near-by homes were flooded and the water extended well past the Lake Lonely Boat Livery shop. Late April measurements were taken from boats at roughly the same location as winter site C. A Secchi disk was used in both mid and late April.

Sample Preparation and Storage

Various samples were collected and filtered for ANC, IC, and ICP analysis. Approximately 1-2 mL of nitric acid per 100 ml of sample were added to samples saved ICP analysis. ANC, IC and ICP samples, along with those to be analyzed for ammonium and phosphate, were subsequently stored in a cold room and analyzed within two months. Samples for subsequent analysis for TP and TN were frozen without further treatment.

Ion Balance and Specific Ion Concentrations

The bicarbonate concentration for each sample was calculated by determining its acid-neutralizing capacity. On each February sample, a potentiometric titration was performed, throughout which an AR20 pH meter was used to monitor the pH. (Appendix B: Tables B1-B6) From the bicarbonate equivalence point (i.e., the steepest point of the curve), the concentration of bicarbonate was determined. (Appendix B: Figures B1-B9)

The concentrations of anions (excluding bicarbonate) for each water sample were determined through ion chromatography. On March 19, 2007, standards of known concentrations for each ion of interest were run through a Dionex ICS-90 ion chromatograph equipped with an ASA-9 separator column. From these data, a calibration curve for each analyte was generated. Water samples from the February collection were then run through the apparatus. (Appendix B: Table B7, Figures B11, B12, and B13) The concentration of each ion in these samples was calculated from the generated calibration curves. (Appendix B: Tables B8, B9, and B10)

The cation concentrations were determined similarly through the use of inductively coupled plasma spectroscopy. Known-concentration standards were run through the Spectro Analytical Flame-EOP inductively coupled plasma spectrometer; data obtained were plotted to produce calibration curves. (Appendix B: Tables B11, B13, and B15, Figures B14-B25) The February samples were then run through the ICP. The concentration of each cation of interest was subsequently calculated using the calibration curves. (Appendix B: Tables B12, B14, and B16)

The cation and anion concentrations were then converted to milliequivalents per liter. From this, cation to anion ratios was determined.

Total Suspended Solids

A type A/E glass fiber filter for each of five sampling sites—three Lake Lonely sites, South Pond and the upper Kayaderosseras Creek— was weighed and its mass recorded. Each filter was placed onto a watch glass and permitted to dry in an oven held at 103° C-105°C. The filters were massed once after thirty minutes and once more after an hour to ensure constancy. A filtration system—one for each sampling site—was rinsed thoroughly with doubly deionized water. A sample from each site was run through a filtration system with one of the type A/E glass fiber filters previously dried to constant mass. Subsequent to filtration, the water sample in the collection flask was discarded and the filter removed and placed onto a watch glass to again dry to constant mass in an oven for analysis of total suspended solids. Having dried overnight, the filter was then massed several times throughout the day and days later to ensure constancy. (Appendix C: Table C2)

Phosphate, total phosphorus and total nitrogen

Phosphate, total phosphorus and total nitrogen were determined on the class's samples by the Darren Fresh water Institute.

RESULTS

Field Data

Water depths recorded in February were 7.5 meters, 8 meters and 9.75 meters at winter sites A, B and C respectively. In mid April, water under the Crescent Avenue Bridge was measured to be 2m deep. The main lake was inaccessible due to heavy flooding. Water measured in late April was 11m deep. Temperature was measured and graphed as a function of depth (Figure 3; Appendix A: Tables A1 and A2).

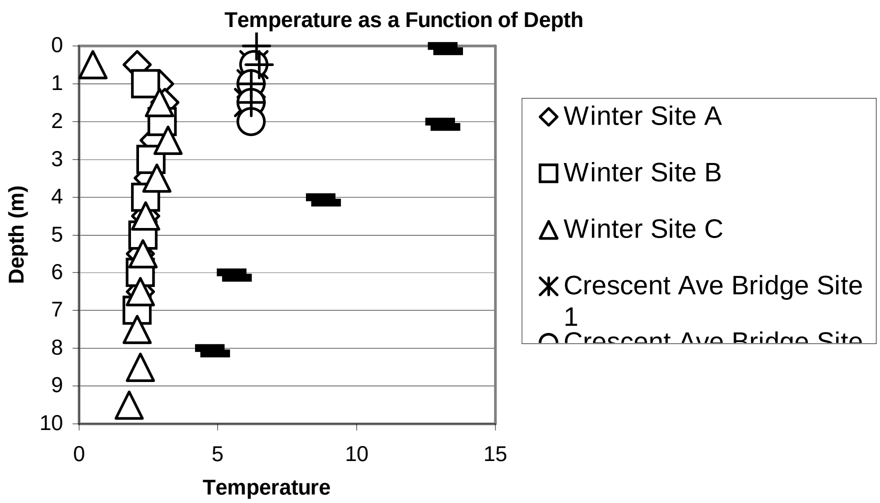

Figure 3 Temperature in Celsius given as a function of depth in meters.

Conductivity readings from February increased with depth. Specific conductivity in February ranged from 390μS to 773μS, with an average of 602μS. Specific conductivity in mid April also averaged 602μS (Figure 4; Appendix A: Tables A3 and A4).

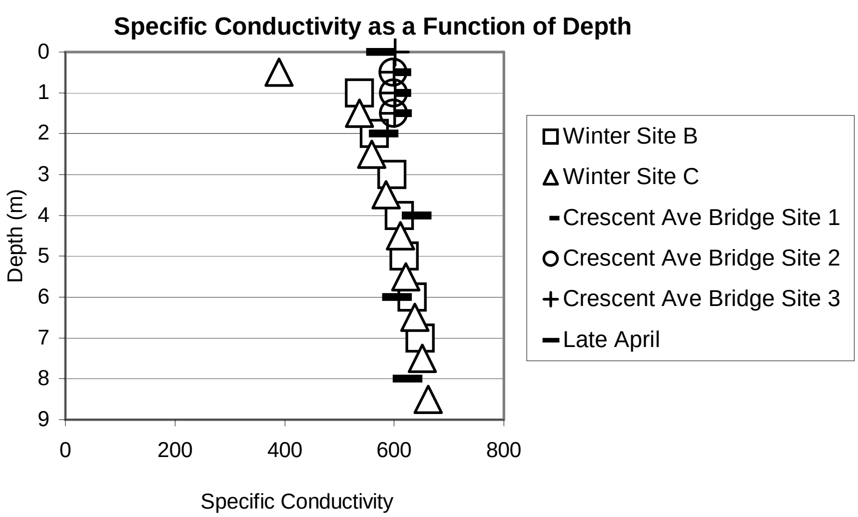

Figure 4 Specific Conductivity as a function of depth as measured from February, mid April and late April.

The pH was determined to be basic for February, mid April and late April, averaging 7.83, 8.1 and 7.8, respectively. Data obtained in February showed that pH remained essentially constant as a function of depth (Figure 5; Appendix Tables A5 and A6).

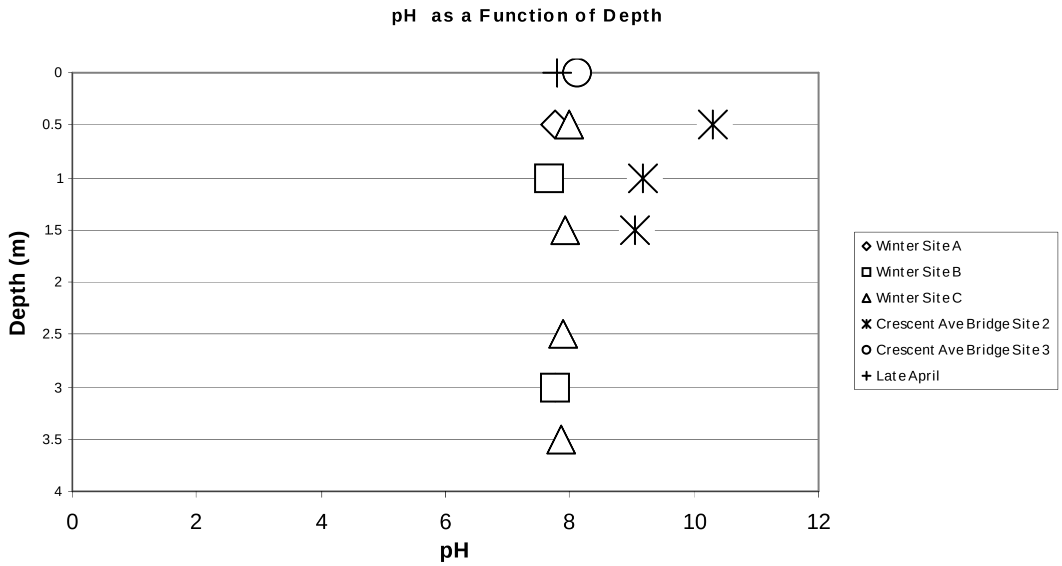

Figure 5 February pH values measured as a function of depth.

In the winter and early April data the dissolved oxygen was relatively constant as a function of depth consistent with recent mixing. However, in late April the dissolved oxygen was lower in the bottom of the lake than near the top. Despite the lack of stratification in the lake, an inverse relationship between percent dissolved oxygen and depth was observed during February, mid April and late April (Figure 6; Appendix Tables A7 and A8).

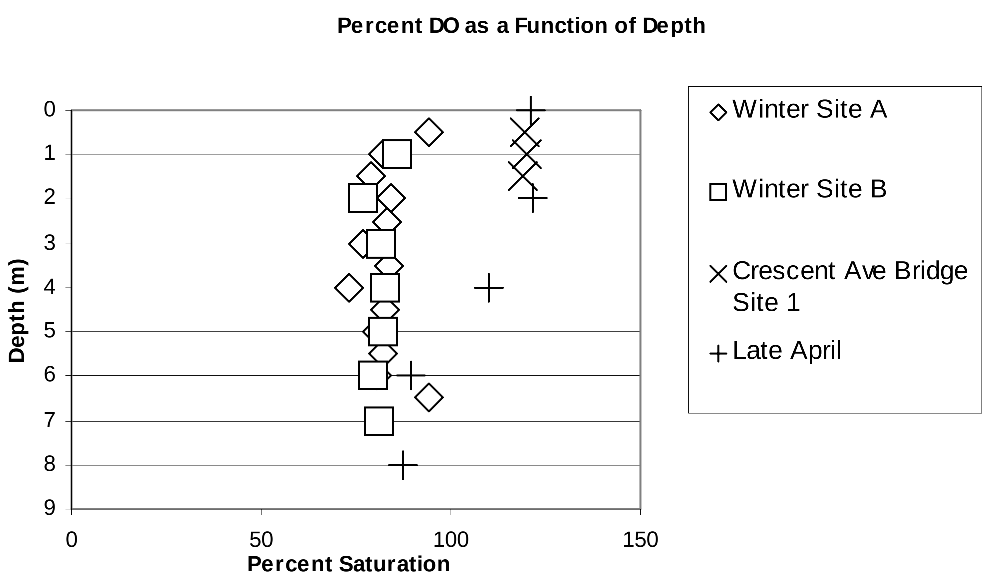

Figure 6 Dissolved oxygen as a function of depth as measured in February, mid April and Late April.

Secchi disk depth in mid April was measured to be 2 m. In late April, the Secchi disk depth was 2.2 m. (Appendix Table A9)

Ion Balance

The cation to anion ratio for winter site A was determined to be 0.939 (Table 2). This suggests that all major ions have been accounted for and that the methods used were reliable. (Appendix B: Tables B8 and B12) The cation to anion ratio for winter site B was determined to be 0.821 (Table 3; Appendix B: B9 and B14). This value, like that of site A, does not deviate significantly from 1.

Table 2. Summary of winter site A's ion balance profile.

Major Anions	**Meq/L**
Chloride	2.03
Nitrate	0.104
Sulfate	0.283
Bicarbonate	1.76
Total:	4.177
Major Cations	**Meq/L**
Calcium	2.386
Magnesium	0.612
Potassium	0.012
Sodium	0.913
Total:	3.923
Cation/Anion Ratio:	0.939

Table 3. Summary of winter site B's ion balance profile.

Major Anions	**Meq/L**
Chloride	1.696
Nitrate	0.072
Sulfate	0.279
Bicarbonate	2.3
Total:	4.347
Major Cations	**meq/L**
Calcium	2.061
Magnesium	0.627
Potassium	0.0165
Sodium	0.864
Total:	3.569
Cation/Anion Ratio:	0.821

Table 4. Summary of winter site C's ion balance profile.

Major Anions	**meq/L**
Chloride	2.532
Nitrate	0.056
Sulfate	0.289
Bicarbonate	2.3
Total:	5.177
Major Cations	**meq/L**
Calcium	1.996
Magnesium	0.581
Potassium	0.012
Sodium	0.974
Total:	3.563
Cation/Anion Ratio:	0.688

Chloride and Conductivity

Figure 7 gives the area (in μS*min) beneath each chloride peak as a function of chloride's concentration (in ppm) in each standard solution analyzed by the ICS-90. (Appendix B: Table B7, Figure B11) From this calibration curve, the concentration (in ppm) of chloride was determined in each analyte solution. (Table 5)

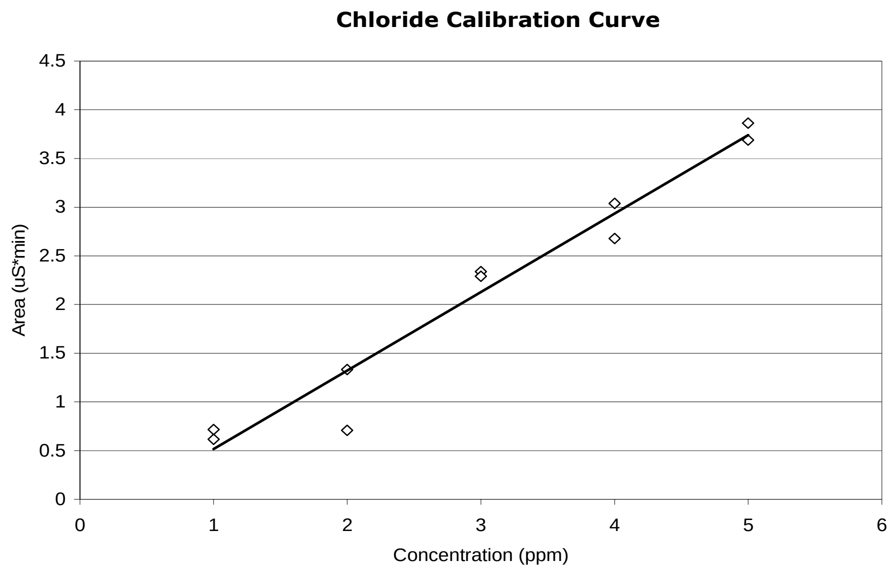

Figure 7 Chloride calibration curve generated by plotting area beneath each chloride peak againt concentration of chloride in known standards.

Average winter chloride concentration at each site in Lake Lonely varied between 60.2 and 89.8 ppm. Bottom samples ranged from 106.6 to 131.0 ppm, while top samples ranged from 60.2 to 89.8 ppm. (Table 5; Appendix B: Table B8)

Table 5. Summary of chloride concentrations for Lake Lonely.

Site.	Cl^- (meq/L)	Cl^- (ppm)
Winter Site A (Top).	2.03	72.0
Winter Site A (Bottom).	3.01	106.6
Winter Site A (Average).	2.52	89.3
Winter Site B (Top).	1.70	60.2
Winter Site B (Bottom).	3.51	124.5
Winter Site B (Average).	2.61	92.4
Winter Site C (Top).	2.53	89.8
Winter Site C (Bottom).	3.69	131.0
Winter Site C (Average).	3.11	110.4
Crescent Ave. Bridge 1 (Top).	2.86	101.7
Crescent Ave. Bridge 1 (Bottom).	2.45	86.9
Crescent Ave. Bridge 2 (Top).	2.86	101.5
Crescent Ave. Bridge 2 (Bottom).	2.86	101.5
Crescent Ave. Bridge 3 (Top).	2.87	101.8
Crescent Ave. Bridge 3 (Bottom).	2.89	102.3
Crescent Ave. Bridge (Average).	2.80	99.3

Specific conductivity in Lake Lonely averaged 601.6 µS in February, 601.4 µS in mid April and 605.0 µS in late April (Figure 4, Table 6; Appendix A: Tables A3 and A4).

Table 6. Specific conductivity for Lake Lonely sites in February, mid and late April.

	Specific Conductivity (µS)					
Depth (m)	Winter Site B	Winter Site C	Crescent Ave Bridge Site 1	Crescent Ave Bridge Site 2	Crescent Ave Bridge Site 3	Late April
0.0					602.0	575.6
0.5		390.0	604.0	598.0	600.0	
1.0	537.0		604.0	599.0	602.0	
1.5		536.8	605.0	599.0	601.0	
2.0	563.5					580.6
2.5		559.4				
3.0	596.0					
3.5		585.3				
4.0	609.8					640.2
4.5		611.1				
5.0	618.6					
5.5		621.3				
6.0	632.4					605.1
6.5		637.8				
7.0	647.0					
7.5		651.4				
8.0						623.7
8.5		661.8				
9.0						
9.5		772.5				
Site Average:	600.6	602.7	604.3	598.7	601.2	605.0
Day Average	601.7		601.4			605.0

Nitrogen

Figure 8 gives the area (in µS*min) beneath each nitrate peak as a function of nitrate concentration (in ppm) in each standard solution analyzed by the ICS-90. (Appendix B: Table B7 and Figure B12) From this calibration curve the concentration (in ppm) of nitrate was determined in each analyte solution (Table 6).

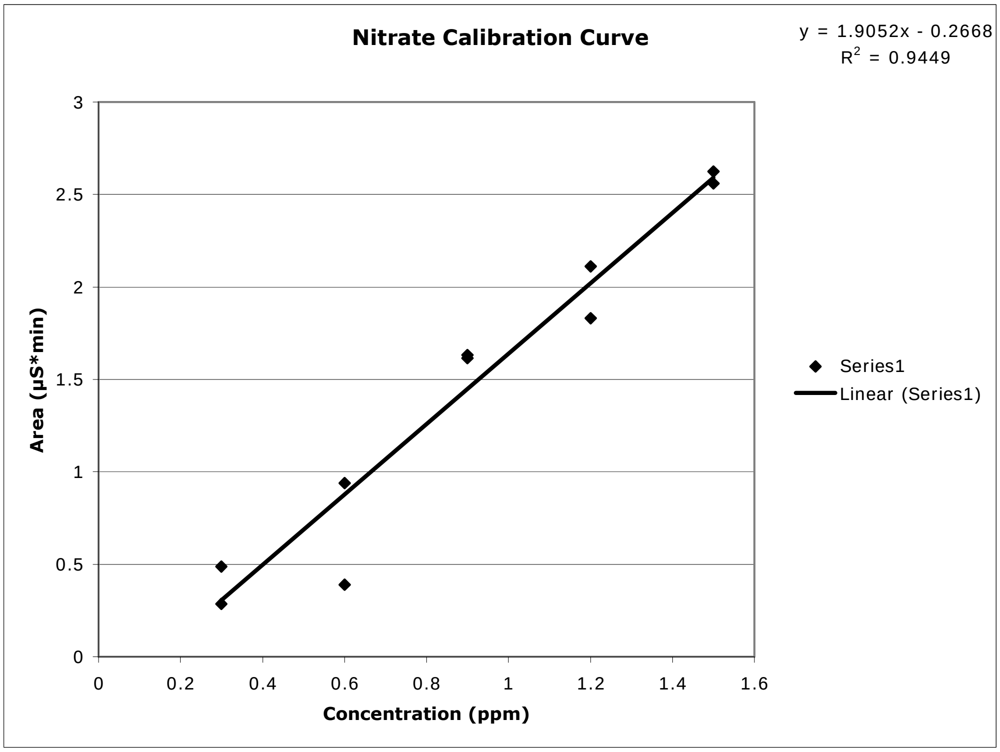

Figure 8 Area beneath each nitrate peak versus concentration.

Table 7 gives the mean concentration of nitrate in ppm at each winter site at the surface and near the bottom (Appendix B: Table B9); Table 8 gives the concentrations in ppm of nitrate, ammonia and total nitrogen at each Crescent Avenue Bridge site at the surface and near the bottom. (Appendix C: Table C1)

Table 7 Nitrate concentrations at Lake Lonely Sites A, B, and C

Site.	NO_3^- (mg N/L)
A Top.	0.907
A Bottom.	0.750
B Top.	1.003
B Bottom.	0.883
C Top.	0.786
C Bottom.	1.011

Table 8 Concentrations of nitrate, ammonia, and TN at mid April sites

Site.	NO_3^- (mg N/L)	NH_3 (mg N/L)	Total Nitrogen (mg N/L).
1 Top.	0.546	0.066	1.11
1 Bottom.	0.651	0.035	1.09
2 Top.	0.543	0.065	1.08
2 Bottom.	0.542	0.071	1.07
3 Top.	0.547	0.072	1.10
3 Bottom.	0.546	0.071	1.06

Phosphorus

Table 9 gives the concentrations in ppb of SRP and TP at each Crescent Ave. Bridge site at the surface and near the bottom. (Appendix C: Table C1) Values are relatively precise, consistent with the sites' propinquity to each other. Although site 3's SRP value may appear anomalously high, the samples analyzed were obtained by grabbing; these deviant values are therefore may not be attributable to any dramatic chemical difference between the sites.

Table 9. Phosphorous concentrations at mid April sites.

Site.	TP (ppb P).	SRP (ppb P).
1 Top.	17.0	2.1
1 Bottom.	15.8	2.4
2 Top.	14.7	1.6
2 Bottom.	14.7	1.9
3 Top.	15.2	10.8
3 Bottom.	14.9	6.4

Total Suspended Solids

Table 10 gives the total suspended solids in g/L of the mean winter site values as well as of South Pond and the Upper Kayaderosseras Creek. (Appendix C: Table C2)

Table 10. Total suspended solids values for several sites; analyzed on April 5, 2007.

Sampling Site	Number of Samples	TSS (mg/L)
Lake Lonely Winter Site Mean.	3	11.1 +/- 6.2
South Pond.	2	4.6 +/- 3.7

DISCUSSION

Field Data

The density of water maximizes at 4°C. Water becomes denser as temperatures approach 4°C. As water measured at these temperatures was found relatively close to the surface rather than at the bottom of the lake, it was surmised that no stratification had occurred in February (Figure 3; Appendix A: Table A1). Note stratification was already beginning in late April.

The conductivity values determined for Lake Lonely are high compared to the 505μS value reported in Connolly and Halstead's June 2006 study for the specific conductivity of Lake Lonely Outlet[15]. (Table 6; Appendix A: Tables A3 and A4) This lower conductivity may be a result of the greater distance between the sample sites and Spring Run, which has a specific conductivity of 917μS, as determined in Connolly and Halstead's June 2006 study. In February, specific conductivity increased with depth suggesting that material from the sediment on the bottom is contributing to the conductivity. Specific conductivity values from late April follow the similar trend for conductivity as a function of depth though not as dramatically. This suggests that Lake Lonely may have been recently mixed in late April. (Figure 4; Appendix A: Tables A3 and A4) despite the apparent stratification from temperature measurements.

As a function of depth, pH levels recorded for Lake Lonely in February remained consistently basic, showing the absence of acidification. (Figure 5; Appendix A: Tables A5 and A6) Values fell between those received by the Frey et al study of Lake Lonely published in 1999,[16] which averaged 8.46. This is also consistent with the acid neutralizing capacity data presented in this report.

In February, percent DO averaged 81.5% (Figure 6; Appendix A: Tables A7 and A8). This can be compared to the 61.9% DO given by Connolly and Halstead for the Lake Lonely Outlet in July 2006[15]. A prolonged ice cover might seal the lake off from the atmosphere, depleting surface oxygen and obstructing photosynthesis, which would then fail to replenish the oxygen supply in the lake[10]. The abnormally high temperatures of the winter of 2006/2007, however, allowed less time for ice cover and more for photosynthesis, increasing DO content. Even more significant than ice cover is decomposition occurring in the lake. The greater rate of decomposition in summer months contributes to the low concentration of DO recorded in July 2006 by Connolly and Halstead in the Lake Lonely Outlet.

The lake water was fairly clear when sampled on April 19, as indicated by the Secchi disk measurement. (Appendix A: Table A9) This reading only gave a general suggestion on transparency, as the water sampled was only two meters deep and the disc was visible at all depths from the bridge It eliminated the possibility of the lake's characterization as hypereutrophic or eutrophic, however a trophic state could not be definitively identified[12]. Measurements made in late April near winter site C determined Lake Lonely is mesotrophic as the Secchi disk was seen to a depth of 2.2m[14]. April Secchi disk measurements are probably not as meaningful as Secchi disk measurements later in the year since a recent turnover may be contributing to turbidity. Measurements should be made in June, July and August. These values can then be compared to those reported by Frey et al in a study of Lake Lonely. Secchi disk readings ranged from 2.9 m on June 1, 1995 to 3.5m on June 22 of the same year[16].

Ion Balance

The ANC of the Lake Lonely winter sites indicates, as expected, that the lake is not acid-sensitive. The deviation of the cation to anion ratios from 1 greatly increased with increasing distance from the Bog Meadow Brook inlet. This may suggest that a cation not analyzed by this study becomes increasingly concentrated with increasing distance from the inlet. From site A to site C, there was a decrease in calcium as well as an increase in chloride concentration. This greatly contributed to the deviation of the cation to anion ratios from 1. Site A, the closest to the Bog Meadow Brook inlet, had the closest ion balance to 1, while site B was intermediate, and site C deviated from 1 the most (Tables 2, 3 and 4). This suggests that the water from Bog Meadow Brook has an impact on the water chemistry of Lake Lonely.

Chloride and Conductivity

Chloride concentrations ranged from 60.2 ppm to 131.0 ppm in February (Table 5; Appendix B: Table B8). These 2007 Lake Lonely chloride values were higher (74 ppm) than other local water sources such as the Lake Lonely Outlet (64.1 ppm) and Kayaderosseras Creek main (46.5 ppm) and mouth (47.3 ppm)[15], as measured by Connolly and Halstead in July 2006. Chloride concentration in Lake Lonely, however, is lower than that of Spring Run, which had a chloride concentration of 160 ppm[15]. Spring Run's chloride concentration is the highest when compared to those of other local sample sites (Appendix C: Tables C3 and C4, Figure C1) This is probably because Spring Run acts as the storm sewer for Saratoga Springs by collecting the storm water runoff from the city, which contains road salts, especially during winter months.

Lake Lonely has an average specific conductivity of 605 μS and an average chloride concentration of 74 ppm. Lake Lonely's February 2007 conductivity is higher than that of the Lake Lonely Outlet in July 2006(500 μS), but lower than that of Spring Run in July 2006(915 μS). In fact, Spring Run has the highest specific conductivity of the water bodies in the Saratoga Lake-Kayaderosseras Creek watershed studied by Skidmore College students and faculty in 2006 and in the spring of 2007[15].

Nitrogen

February nitrate levels in Lake Lonely approximately correspond to April total nitrogen content at Crescent Avenue Bridge (Tables 7 and 8; Appendix B: Table B9; Appendix C: Table C1). This may indicate low phytoplankton activity in winter, the nitrate therefore remaining in high concentrations in the winter and converting to other forms in the spring. However, this also may simply be a coincidence, the samples having been taken at different sites in entirely different weather conditions, with exceptionally high waters at the Crescent Avenue Bridge during mid April sampling. According to the Sutherland et al., Stewart and Markello (1974) report, mean annual surface concentrations for six western New York lakes ranged from 0.25 ppm to 1.25 ppm N and peaked in winter[17]. Therefore, February 2007 Lake Lonely nitrate values seem moderately high in comparison. By April, however, nitrate at Crescent Ave. Bridge dropped to ~50% of the total nitrogen, indicating the nitrate's consumption by phytoplankton and subsequent conversion to organic nitrogen, or dilution. Mid April data are relatively precise, consistent with the sites' proximity to each other.

In their June 2006 Saratoga Lake Tributary Study (Table 11; Appendix D), Connolly and Halstead report for other tributaries nitrate and ammonia values significantly lower than those of the Crescent Ave. Bridge in mid April 2007, consistent with the phytoplankton upsurge that would have occurred in these water bodies by June last year but had not yet occurred when the Crescent Ave. Bridge samples were analyzed[15]. The precipitous drop in ammonia of June 2006 may also indicate a depletion of dissolved oxygen, which would have deterred organic decomposition and ultimately decreased ammonia concentrations. Spring Run, an inlet of Lake Lonely, exhibits nitrate and ammonia concentrations significantly higher than do the other water bodies analyzed in this study.

Table 11. Nitrogen, Connelly and Halstead (Saratoga Lake Tributary Survey, June 13, 2006).[15]

Site.	NO_3^- (ppm N).	NH_3 (ppm N).
Upper Kayaderosseras.	0.12	0.01
Clover Mill Creek – Upstream.	0.16	< 0.01
Clover Mill Creek – Downstream.	0.26	0.02
Glowegee Creek.	0.12	0.01
Mourning Kill Creek.	0.47	< 0.01
Geyser Brook.	0.41	0.03
Spring Run.	0.95	0.06

Connelly and Halstead report in their July 2006 Saratoga Main Branch Survey (Table 12; Appendix D) nitrogen values in the Kayaderosseras Creek main and mouth moderately higher than those reported for the Kayaderosseras in June 2006, suggesting a slight abatement of phytoplankton activity[13]. Although in the Kayaderosseras main and mouth nitrate comprised an appreciable fraction of the total nitrogen, in the Lake Lonely Outlet phytoplankton was such that nearly all of the nitrate was consumed and converted to organic nitrogen.

Table 12. Nitrogen, Connelly and Halstead (Saratoga Main Branch Survey, July 10, 2006).[15]

Site.	NO_3^- (ppm N).	NH_3 (ppm N).	TN (ppm N).
Lake Lonely Outlet.	0.04	0.05	0.94
Main Kayaderosseras Creek.	0.28	0.03	0.29
Mouth.	0.24	0.06	0.46

Although the Lake Lonely outlet data reported by Aulenbach et al. (Table 13) are mean annual values and their direct comparison to the limited data obtained in this 2007 study would therefore be incomplete and inconclusive, it can be conjectured that nitrogen content in Lake Lonely has somewhat decreased in the last thirty years. However, additional data must be obtained for definitive conclusions to be made.

Table 13. Nitrogen, Aulenbach et al. (1976).[17]

			NO_3^- (ppm N).			NH_3 (ppm N).			TN (ppm N).	
Site.	Reference.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.
LL Outlet.	1.	1.072	1.60	0.40	.802	3.30	0.04	1.758	3.55	0.68

Phosphorus

Connolly and Halstead report in their July 2006 Saratoga Main Branch Survey (Table 14) values significantly lower than those obtained in this study[13]. It is surmised that the extensive flooding at the Crescent Ave. Bridge site diluted the water; had samples been taken under normal conditions, phosphorus content would likely have been higher. In summer 2006, TP in the Kayaderosseras mouth, downstream of confluence with Lake Lonely, falls between the high Lake Lonely outlet value and the low Kayaderosseras main value, suggesting that Lake Lonely has an effect on the nutrient load of the Kayaderosseras mouth, and subsequently Saratoga Lake.

Table 14. Phosphorus, Connolly and Halstead (Saratoga Main Branch Survey, July 10, 2006).[15]

Site.	Total Phosphorus (ppb P)
Lake Lonely Outlet.	41.4
Main Kayaderosseras Creek.	18.4
Mouth.	25.5

Again, even though direct comparison to the mean annual data reported by Aulenbach et al. (Table 15) yields nothing conclusive, it is conceivable that, given the staggering magnitude of the 1973/1974 SRP and TP concentrations, phosphorus content has considerably dropped since, attributable to the development of the Saratoga County Sewage Treatment Facility in the late 1970s and early 1980s.

Table 15. Phosphorus, Aulenbach (1976).[17]

			Orthophosphate (ppb P).			Total P (ppb P).	
Site.	Reference.	Mean.	Max.	Min.	Mean.	Max.	Min.
LL Outlet.	1.	136	290	16	410	650	250
LL Outlet.	2.	144	370	27	220	630	60

Total Suspended Solids

Lake Lonely February 2007 samples exhibit significantly higher TSS than South Pond, consistent with its high nutrient content. The phenomenon which contributes nutrients to the lake might also bring additional suspended solids and/or slow the decompostion of organic matter. Table 16 gives the TSS in g/L as reported by Halstead and Connolly in their September 2006 Saratoga Lake Tributary Study[15]. Halstead and Connolly surmise that "tourism, agriculture and lawn care," anthropogenic TSS sources that would have been at a minimum at the time of this study's sample collection, considerably contributed to these elevated TSS values. Spring Run again showed a high value, contributing these TSS to Lake Lonely[15].

CONCLUSIONS

Field Data

Lake Lonely is slightly basic with an average pH of 7.92 and, as of February 2007, has a moderately high DO content perhaps due to the low rate of decomposition occurring in winter and early spring months. The high conductivity in Lake Lonely can probably be attributed to the tributary Spring Run, although more studies on Bog Meadow Brook are necessary. No stratification of Lake Lonely is believed to have existed in February. This may be due to the atypical weather conditions, including a late freeze, that had taken place in the months leading up to and during this experiment. Modest stratifiation was obersved in late April. No conclusion can be drawn form the Secchi disk measurements (which was showed somewhat more turbidity than other measurements in recent years) since turnover may have occurred recently. More measurements, especially during summer, are necessary to make a meaningful conclusion based on this.

Specific conductivity was moderately high, ranging from 390 to 720 μS, with an average of 602 μS. This value is higher than the conductivity of most other area water bodies studied by Skidmore students and faculty in 2006 and 2007. The only higher value was determined at Spring Run, which empties into Lake Lonely. This suggests that the pollutants and solutes in Spring Run, which also serves as the storm water sewer for the city of Saratoga Springs, have a significant impact on the overall health of Lake Lonely. Further study is needed on Bog Meadow Brook.

The average pH of all three winter sites on Lake Lonely was 7.8, showing that the lake is slightly basic, consistent with its high acid neutralizing capacity. Additionally, the dissolved oxygen concentration in Lake Lonely at this time averaged 11.2 mg/L or 81.5%. These February 2007 values are higher than those determined by the Frey and Thomas study of Lake Lonely, which gave values of 5.9 to 8.45 mg/L for February 19, 1996. More DO measurements are necessary to determine seasonal trends and compare to previous values.

Similar results were determined in mid April from Crescent Avenue Bridge, as well as in late April from a location approximately at winter site C. During the mid April data and sample collection, Lake Lonely was extremely flooded. As a result, boats could not be taken onto Lake Lonely, and samples were taken from the Crescent Avenue Bridge, which is not near the original winter sites. At the Crescent Avenue Bridge sites, the water was only 2 m deep, which prevented any determination of the presence or lack of stratification. The pH measurements from Crescent Avenue Bridge in mid April were slightly higher than that determined in February, averaging at 8.1.

In late April, field measurements were taken from a rowboat at the approximate location of winter site C. The depth at this site was 11.5 m. The increased depth is due in part to being nearer to the center of the lake, and in part due to flood conditions, which increased the overall depth of the lake. Secchi disk readings taken at this time were measured at 2.2 m. While this value is lower than those determined by Frey and Thomas, more measurements, especially during the summer months, are necessary to determine a meaningful Secchi reading. As expected, the pH of Lake Lonely was again basic. The water had high specific conductivity, and dissolved oxygen content averaged 102.5%. The high DO may be attributed in part to the flood.

Acid Neutralizing Capacity and Ion Balance

The ANC's of Lake Lonely winter sites, as well as of other local bodies, indicate that none are acid-sensitive. The pH of the winter samples indicates that bicarbonate is the dominant carbonate species within the system, contributing most greatly to the carbonate concentration included in the ion balance. The ion balance for the winter samples gave cation to anion ratios ranging from 0.688 at winter site C to 0.939 at winter site A. The deviation from 1 suggests that a cation was not accounted for during analysis. A major contribution to this deviation, however, was a decrease in calcium, as well as an increase in chloride, from Site A to Site C. Site A, the closest to the Bog Meadow Brook inlet, had the closest ion balance to 1, while Site B was intermediate, and Site C deviated from 1 the most. This suggests that the water from Bog Meadow Brook has an impact on the water chemistry of Lake Lonely, which indicates the need for further studies on both Bog Meadow Brook and Spring Run.

Nutrients

Nutrients, specifically nitrate, total nitrogen, phosphate and total phosphorous, were analyzed as indicators of trophic state. February samples were analyzed for nitrate concentration using the Skidmore ICS-90, and mid April samples were analyzed for both nitrate and total nitrogen by the Darrin Fresh Water Institute. Nitrate concentration ranged from 0.75 to 1.01 ppm in February, and 0.54 to 0.65 ppm in mid April. Total nitrogen ranged from 1.06 to 1.11 ppm (1060-1110 ppb) in the mid April samples. The difference in nitrate concentrations is likely due to an increase in biological consumption of nitrate by phytoplankton, which is more likely to occur as summer approaches.

No phosphate or total phosphorous data were obtained from February samples. Mid April samples from Crescent Avenue Bridge (analyzed by the Darrin Fresh Water Institute) had total phosphorous ranging from 14.7 to 17.0 ppb, with soluble reactive phosphate concentrations ranging from 1.6 to 10.8 ppb. It is possible that both nitrogen and phosphate concentrations taken in mid April were low due to dilution by flood waters.

Trophic State

The findings of this study suggest that Lake Lonely is either mesotrophic or eutrophic. Since phosphorus, the nutrient most affecting trophic state, is present in concentrations indicative of mesotrophism, Lake Lonely is likely mesotrophic; however, the guidelines given above (Table 16) apply to annual mean values; therefore, further study of Lake Lonely is necessary for a full assessment of its trophic state.

Table 16 Nutrient-based guidelines for the interpretation of trophic state.[12]

	Oligotrophic.	Mesotrophic.	Eutrophic.	Hypereutrophic.
Phosphorus (ppb).	0-10	10-30	30-100	>100
Nitrogen (ppb).	0-350	350-650	650-1200	>1200

Based on nutrient data and Secchi disk readings, it was concluded that Lake Lonely is most likely mesotrophic. However, summer data is needed for a more definate conclusion. While the total nitrogen present in April samples suggests that Lake Lonely may be eutrophic, both the total phosphorous concentration and the Secchi disk readings suggest that Lake Lonely is mesotrophic. Based on the above data and the fact that phosphate is the biologically limiting factor, Lake Lonely is most likely mesotrophic. However, the accepted trophic state indication values are based on annual average values, not values obtained from only one sample collection on one day, as all three of these data are. To make a more decisive conclusion on the trophic state of Lake Lonely, continued, yearlong studies with an emphasis on summer data are needed.

Chloride and Conductivity

Although Spring Run has comparatively high chloride concentrations, these concentrations are still much lower than the New York state limit of 250 ppm[7]. This limit is used to test a water body's suitability as a drinking water supply with regard to salty taste and odor. The high chloride level of Spring Run is probably due, at least in part, to winter road salting operations, as Spring Run serves as a storm sewer for the city of Saratoga Springs. In this way, storm water runoff from the city of Saratoga Spring directly affects the water chemistry and characteristics of Lake Lonely.

In previously studied tributaries in the Saratoga Lake watershed, Spring Run has the highest conductivity level (915 μS) along with the highest chloride concentration (160 ppm).[15] Lake Lonely Outlet also has a comparatively higher chloride concentration (64.1 ppm) and conductivity level (500 μS)[15]. Lake Lonely is slightly higher in conductivity (605 μS) and chloride concentration (74 ppm) compared to Lake Lonely Outlet, but lower than Spring Run. Spring Run, an inlet of Lake Lonely, contributes significantly to this conductivity value[15]. The lower conductivity level in Lake Lonely Outlet may be due to its location farther from the Spring Run inlet.

Continuing Studies

Many of the conclusions reached by this study are based on limited data and sample collection. Also more meaningful date on water chemsitry can be obtained during summer months and this class was restricted to the spring semester. In order to determine seasonal trends and the overall trophic state of Lake Lonely, more studies must be conducted, especially during the summer months. Year-round studies will allow for the determination of seasonal trends and give further insight as to how greatly atypical weather patterns affected this specific study. In addition, the results of this study indicate that the water chemistry and significance of both inlets, but especially of Bog Meadow Brook, need to be studied.

In the summer of 2007, Professor Judy Halstead, along with Alicea Cock-Esteb ('09), will continue to study water quality in the Saratoga Lake watershed, with a focus on Lake Lonely and its inlets. This study will include pH, temperature, dissolved oxygen and conductivity measurements on Lake Lonely and at both Spring Run and Bog Meadow Brook. Secchi disk measurements will also be taken during this study. These measurements will be especially important as they can be compared with the Frey and Thomas study done before the creation of the Saratoga National Golf Course.

Also in the summer of 2007, Professor Judy Halstead will be working with Lukiana Anka-Lufford ('10) to study the effects of optical brighteners in detecting anthropogenic pollution of the Saratoga Lake – Kayaderosseras Creek watershed. Optical brighteners are commonly used in detergents and may be easily detectable in natural water bodies. The presence of these may be indicators of pollution from sewage and waster water systems.

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APPENDIX A

Temperature

Table A1 Winter Temperature Data

Depth (m)	Temperature (ºC)		
	Winter Site A	Winter Site B	Winter Site C
0	--	--	
0.5	2.1	--	0.5
1.0	2.9	2.4	
1.5	3.1		2.9
2.0	3.0	3.0	
2.5	2.7		3.2
3.0	2.6	2.6	
3.5	2.5		2.8
4.0	2.4	2.4	
4.5	2.4		2.4
5.0	2.3	2.3	
5.5	2.2		2.3
6.0	2.2	2.2	
6.5	2.2		2.2
7.0		2.1	
7.5			2.1
8.0			
8.5			2.2
9.0			
9.5			1.8

Table A2 Spring Temperature Data

Depth (m)	Temperature (ºC)			
	Crescent Ave Bridge Site 1	Crescent Ave Bridge Site 2	Crescent Ave Bridge Site 3	Late April (~Site C)
0.0			6.4	13.1
0.5	6.3	6.3	6.5	
1.0	6.2	6.2	6.2	
1.5	6.1	6.2	6.2	
2.0		6.2		13.0
4.0				8.7
6.0				5.5
8.0				4.7

Conductivity and Specific Conductivity

Table A3 Winter Conductivity Data

	Conductivity (µS)		Specific Conductivity (µS)	
Depth (m)	Winter Site B	Winter Site C	Winter Site C	Winter Site B
0.5		390.0	207.5	
1.0	305.2			537.0
1.5		536.8	310.2	
2.0	326.7			563.5
2.5		559.4	326.5	
3.0	341			596.0
3.5		585.3	337.1	
4.0	346.6			609.8
4.5		611.1	347.3	
5.0	350.4			618.6
5.5		621.2	351.9	
6.0	357			632.4
6.5		637.8	360.1	
7.0	364			647.0
7.5		651.4	366.5	
8.0				
8.5		661.8	373.6	
9.5			430.2	

Table A4 Spring Conductivity

Depth (m)	Conductivity (µS)			Specific Conductivity (µS)			
	Crescent Ave Bridge Site 1	Crescent Ave Bridge Site 2	Crescent Ave Bridge Site 3	Crescent Ave Bridge Site 1	Crescent Ave Bridge Site 2	Crescent Ave Bridge Site 3	Late April (~Site C)
0.0		385.1	388.0			602.0	575.6
0.5	385.9	384.8	389.0	604.0	598.0	600.0	
1.0	385.7	384.2	387.0	604.0	599.0	602.0	
1.5	385.5	383.8	386.1	605.0	599.0	601.0	
2.0							580.6
4.0							640.2
6.0							605.1
8.0							623.7

pH

Table A5 Winter pH Data

Depth (m)	pH		
	Winter Site A	Winter Site B	Winter Site C
0.5	7.76		7.99
1.0		7.68	
1.5			7.92
2.0			
2.5			7.89
3.0	7.76	7.77	
3.5			7.85

Table A6 Spring pH Data

Depth (m)	pH		
	Crescent Ave Bridge Site 2	Crescent Ave Bridge Site 3	Late April (~Site C)
0.0		8.13	7.8
0.5	10.30		
1.0	9.18		
1.5	9.04		

Dissolved Oxygen

Table A7 Winter Dissolved Oxygen Data

Depth	DO Percent Saturation		Concentration DO (mg/L)		
	Winter Site A	Winter Site B	Winter Site A	Winter Site B	Winter Site C
0.5	94.0		12.67		13.57
1.0	82.1	86.0	11.25	11.4	
1.5	78.8		10.89		10.59
2.0	84.1	77.0	10.50	10.12	
2.5	83.0		11.38		10.06
3.0	77.1	81.5	11.25	10.88	
3.5	83.5		10.67		10.25
4.0	73.3	82.5	11.42	11.15	
4.5	82.7		10.00		10.39
5.0	80.5	82.2	11.56	11.12	
5.5	82.0		10.98		10.62
6.0	80.3	79.4	11.20	10.83	
6.5	94.0		10.99		10.82
7.0		81.3		11.19	
7.5					9.99
8.0					
8.5					13.57
9.5					10.59

Table A8 Spring Dissolved Oxygen Data

Depth (m)	DO Percent Saturation		DO Concentration (mg/L)	
	Crescent Ave Site 1	Late April	Crescent Ave Site 2	Crescent Ave Site 3
0.0		121.1	14.57	
0.5	119.4		14.10	13.95
1.0	120.2		13.9	13.75
1.5	119.1		13.87	13.80
2.0		121.5		14.00
4.0		110.0		
6.0		89.3		
8.0		87.2		

Secchi Disk Readings

Table A9 Secchi Disk Readings

	Crescent Ave Site 1	Crescent Ave Site 2	Crescent Ave Site 3	Late April
Secchi Disk Reading	2.0+*	2.0+*	2.0+*	2.2m
*Crescent Ave Bridge Sites were only 2.0m deep. Secchi disk was visible to bottom.				

APPENDIX B

Table B1 Titration table for Lake Lonely site A, sample A; collected February 1, 2007.

ph	HCl added	change in pH/change in volume
7.06	0	0
7.06	1	-0.02
7.04	2	-0.06
6.98	3	-0.07
6.91	4	-0.06
6.85	5	-0.11
6.74	6	-0.04
6.7	7	-0.04
6.66	8	-0.04
6.62	9	-0.03
6.59	10	-0.03
6.56	11	-0.06
6.5	12	-0.06
6.44	13	-0.04
6.4	14	-0.03
6.37	15	-0.04
6.33	16	-0.04
6.29	17	-0.04
6.25	18	-0.05
6.2	19	-0.03
6.17	20	-0.03
6.14	21	-0.04
6.1	22	-0.04
6.06	23	-0.02
6.04	24	-0.03
6.01	25	-0.05
5.96	26	-0.06
5.9	27	-0.05
5.85	28	-0.03
5.82	29	-0.08
5.74	30	-0.03
5.71	31	-0.03
5.68	32	-0.05
5.63	33	-0.04
5.57	34.5	-0.1
5.52	35	-0.06
5.46	36	-0.04
5.42	37	-0.07
5.35	38	-0.13
5.22	39	-0.1
5.12	40	-0.12
5	41	-0.15
4.85	42	-0.26
4.59	43	-0.18
4.5	43.5	-0.28
4.36	44	-0.28
4.22	44.5	-0.26
4.09	45	-0.26
3.96	45.5	-0.2
3.86	46	-0.16
3.78	46.5	-0.1
3.73	47	-0.12
3.67	47.5	-0.08
3.63	48	-0.1
3.58	48.5	-0.08
3.54	49	-0.04
3.52	49.5	-0.06
3.49	50	

Table B2 Titration data for Lake Lonely site A, sample J; collected February 1, 2007.

pH	HCl added	change in pH/change in

		volume
7.47	0	-0.04
7.43	1	-0.12
7.31	2	-0.1
7.21	3	-0.09
7.12	4	-0.05
7.07	5	-0.05
7.02	6	-0.08
6.94	7	-0.05
6.89	8	-0.07
6.82	9	-0.04
6.78	10	-0.04
6.74	11	-0.04
6.7	12	-0.04
6.66	13	-0.02
6.64	14	-0.03
6.61	15	-0.03
6.58	16	-0.03
6.55	17	-0.05
6.5	18	-0.03
6.47	19	-0.03
6.44	20	-0.03
6.41	21	-0.04
6.37	22	-0.04
6.33	23	-0.03
6.3	24	-0.09
6.21	25	-0.04
6.17	26	-0.02
6.15	27	-0.03
6.12	28	-0.03
6.09	29	-0.05
6.04	30	-0.07
5.97	31	-0.09
5.88	32	0.08
5.96	33	-0.12
5.84	34	-0.04
5.8	35	-0.05
5.75	36	-0.04
5.71	37	-0.05
5.66	38	-0.06
5.6	39	-0.1
5.5	40	-0.1
5.4	41	-0.13
5.27	42	-0.17
5.1	43	-0.28
4.82	44	-0.28
4.54	45	-0.23
4.31	46	-0.17
4.14	47	-0.13
4.01	48	-0.09
3.92	49	-0.03
3.89	50	-0.12
3.77	51	-0.033333333
3.72	52.5	-0.04
3.7	53	-0.04
3.66	54	0.01
3.67	55	-0.08
3.59	56	-0.03
3.56	57	-0.03
3.53	58	-0.02
3.51	59	-0.03
3.48	60	

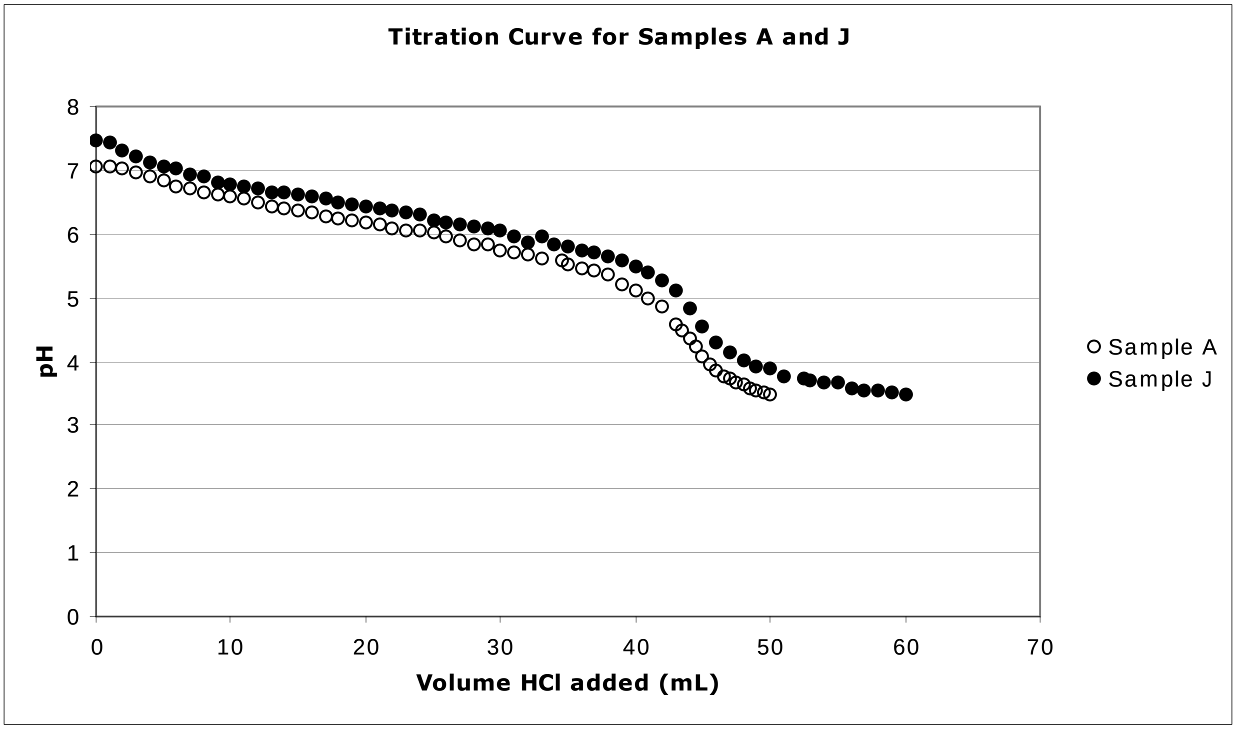


Figure B1 Titration curves for Lake Lonely site A, samples A and J.

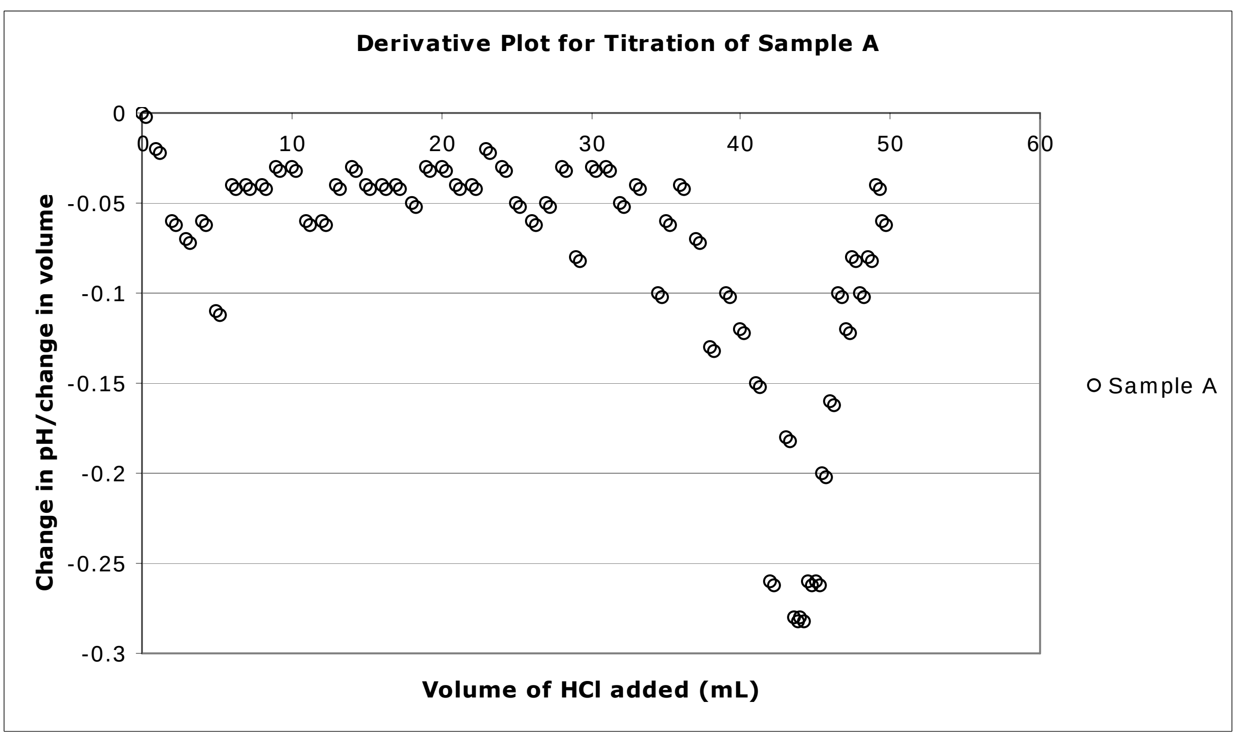


Figure B2 Derivative plot for the titration of sample A.

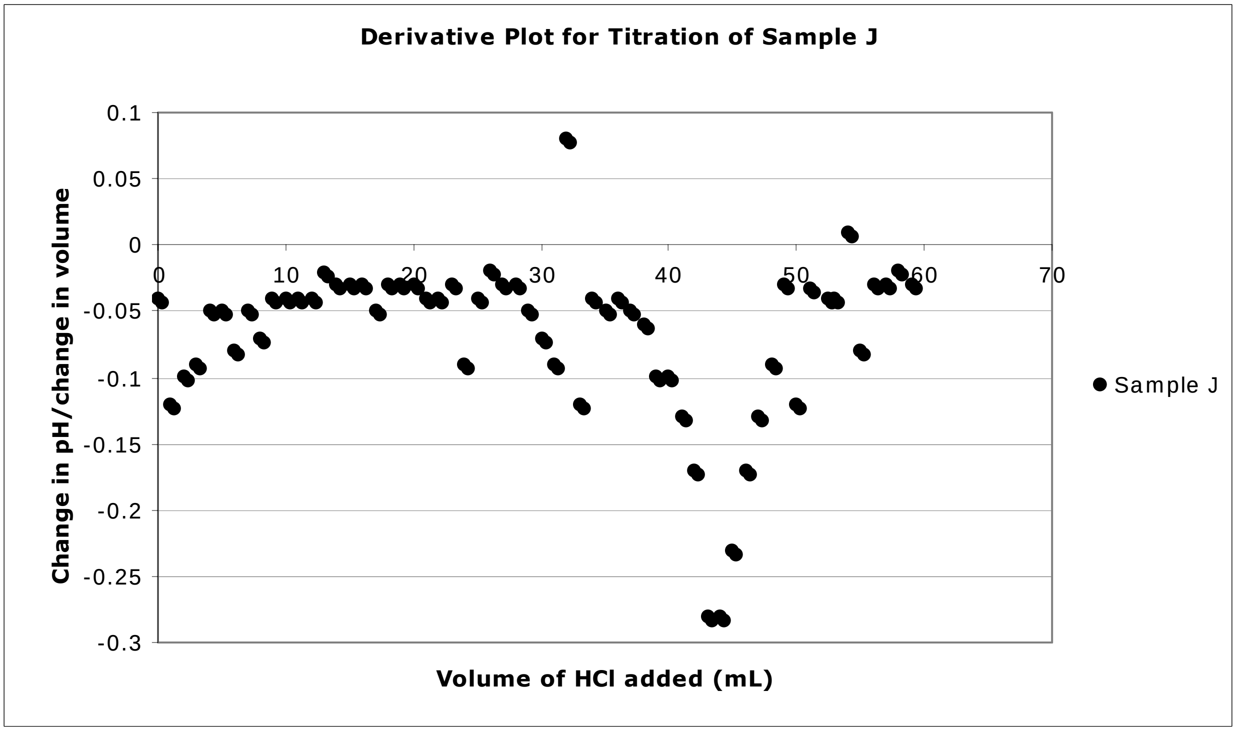


Figure B3 Derivative plot for the titration of sample J.

Table B3 Titration table for Lake Lonely site B, sample S; collected February 1, 2007.

ph	HCl added	change in pH/change in volume
7.67	0	0
7.69	0.5	0.04
7.7	1	0.02
7.66	1.5	-0.08
7.63	2	-0.06
7.62	2.5	-0.02
7.59	3	-0.06
7.57	3.5	-0.04
7.54	4	-0.06
7.51	4.5	-0.06
7.48	5	-0.06
7.42	5.5	-0.12
7.35	6	-0.14
7.29	6.5	-0.12
7.24	7	-0.1
7.18	7.5	-0.12
6.89	8	-0.58
6.85	8.5	-0.08
6.88	9	0.06
6.89	9.5	0.02
6.81	10	-0.16
6.77	10.5	-0.08
6.75	11	-0.04
6.65	11.5	-0.2
6.58	12	-0.14
6.56	12.5	-0.04
6.46	13	-0.2
6.44	13.5	-0.04
6.36	14	-0.16
6.3	14.5	-0.12
6.28	15	-0.04
6.19	15.5	-0.18
6.11	16	-0.16
6.05	16.5	-0.12
6.01	17	-0.08
5.97	17.5	-0.08
5.93	18	-0.08
5.92	18.5	-0.02
5.88	19	-0.08
5.84	19.5	-0.08
5.76	20	-0.16
5.7	20.5	-0.12
5.61	21	-0.18
5.51	21.5	-0.2
5.36	22	-0.3
5.17	22.5	-0.38
4.84	23	-0.66
4.53	23.5	-0.62
4.28	24	-0.5
4.12	24.5	-0.32
4.02	25	-0.2
3.93	25.5	-0.18
3.86	26	-0.14
3.8	26.5	-0.12
3.75	27	-0.1
3.71	27.5	-0.08
3.66	28	-0.1
3.63	28.5	-0.06
3.6	29	-0.06
3.58	29.5	-0.04
3.55	30	-0.06
3.54	30.5	-0.02
3.52	31	-0.04
3.5	31.5	-0.04
3.49	32	-0.02
3.47	32.5	-0.04
3.46	33	-0.02
3.44	33.5	-0.04
3.43	34	-0.02
3.41	34.5	-0.04
3.4	35	-0.02
3.39	35.5	-0.02
3.38	36	-0.02
3.38	36.5	0
3.37	37	-0.02
3.36	37.5	-0.02
3.35	38	-0.02
3.34	38.5	-0.02
3.33	39	-0.02
3.33	39.5	0
3.32	40	-0.02
3.31	41.5	-0.02
3.3	42	-0.02
3.28	42.5	-0.04
3.29	43	0.02
3.28	43.5	-0.02
3.27	44	-0.02
3.27	44.5	0
3.27	45	0
3.26	45.5	
3.26	46	
3.26	46.5	
3.25	47	
3.25	47.5	

Table B4 Titration table for Lake Lonely site B, sample L; collected February 1, 2007.

ph	HCl added	change in pH/change in volume
7.6	0	0
7.52	0.5	-0.08
7.43	1	-0.09
7.32	1.5	-0.11
7.23	2	-0.09
7.15	2.5	-0.08
7.09	3	-0.06
7.02	3.5	-0.07
6.96	4	-0.06
6.9	4.5	-0.06
6.85	5	-0.05
6.79	5.5	-0.06
6.75	6	-0.04
6.67	6.5	-0.08
6.63	7	-0.04
6.58	7.5	-0.05
6.55	8	-0.03
6.48	8.5	-0.07
6.45	9	-0.03
6.42	9.5	-0.03
6.38	10	-0.04
6.34	10.5	-0.04
6.31	11	-0.03
6.27	11.5	-0.04
6.25	12	-0.02
6.22	12.5	-0.03
6.18	13	-0.04
6.14	13.5	-0.04
6.10	14	-0.04
6.07	14.5	-0.03
6.04	15	-0.03
6.00	15.5	-0.04
5.97	16	-0.03
5.93	16.5	-0.04
5.89	17	-0.04
5.85	17.5	-0.04
5.81	18	-0.04
5.78	18.5	-0.03
5.71	19	-0.07
5.65	19.5	-0.06
5.59	20	-0.06
5.52	20.5	-0.07
5.44	21	-0.08
5.29	21.5	-0.15
5.06	22	-0.23
4.86	22.5	-0.2
4.43	23	-0.43
4.14	23.5	-0.29
3.93	24	-0.21
3.79	24.5	-0.14
3.68	25	-0.11
3.58	25.5	-0.1
3.4	26	-0.18
3.27	26.5	-0.13
3.2	27	-0.07

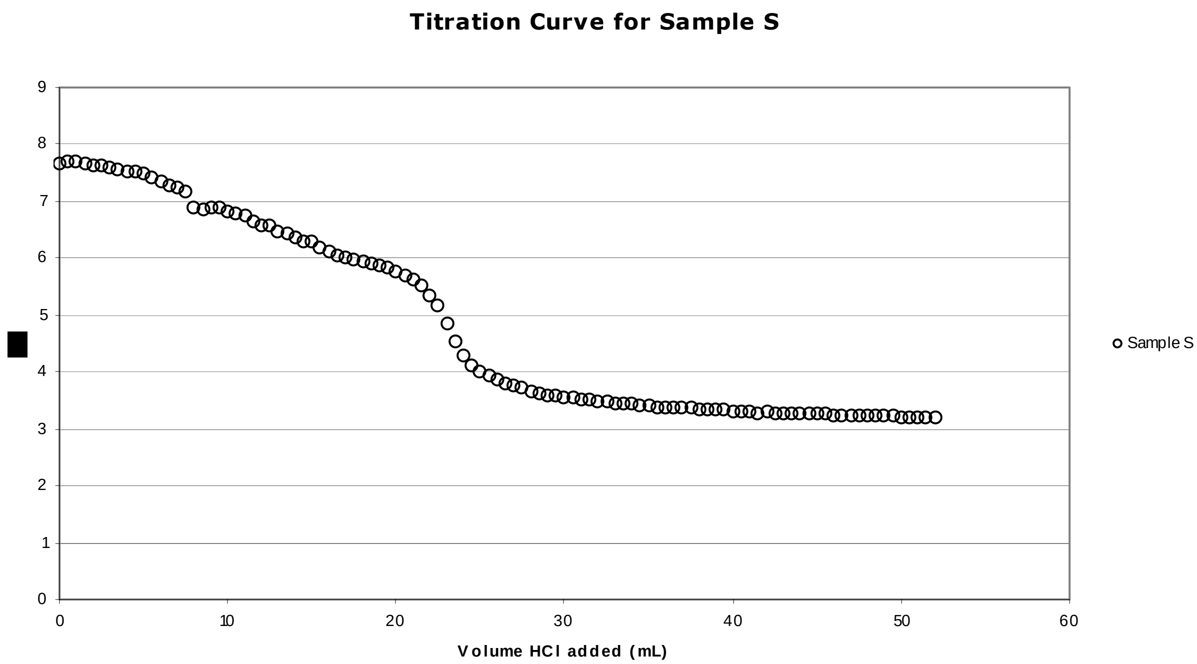


Figure B4 Titration curve for Lake Lonely site B, sample S.

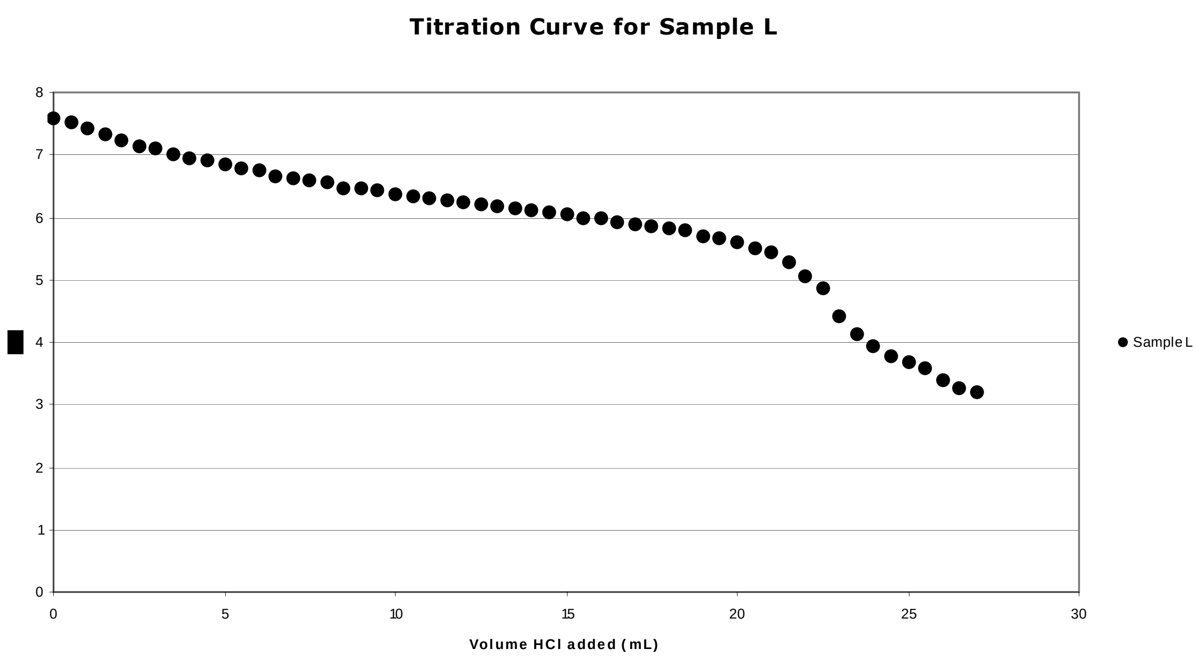


Figure B5 Titration curve for Lake Lonely site B, sample L.

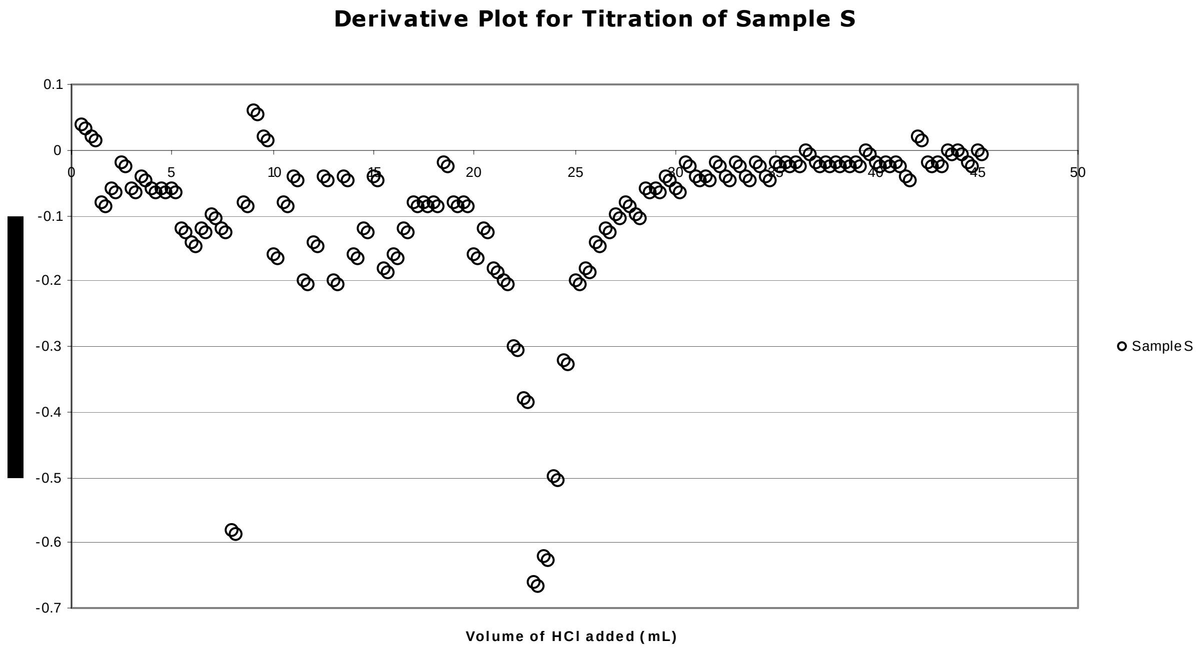


Figure B6 Derivative plot for the titration of sample S.

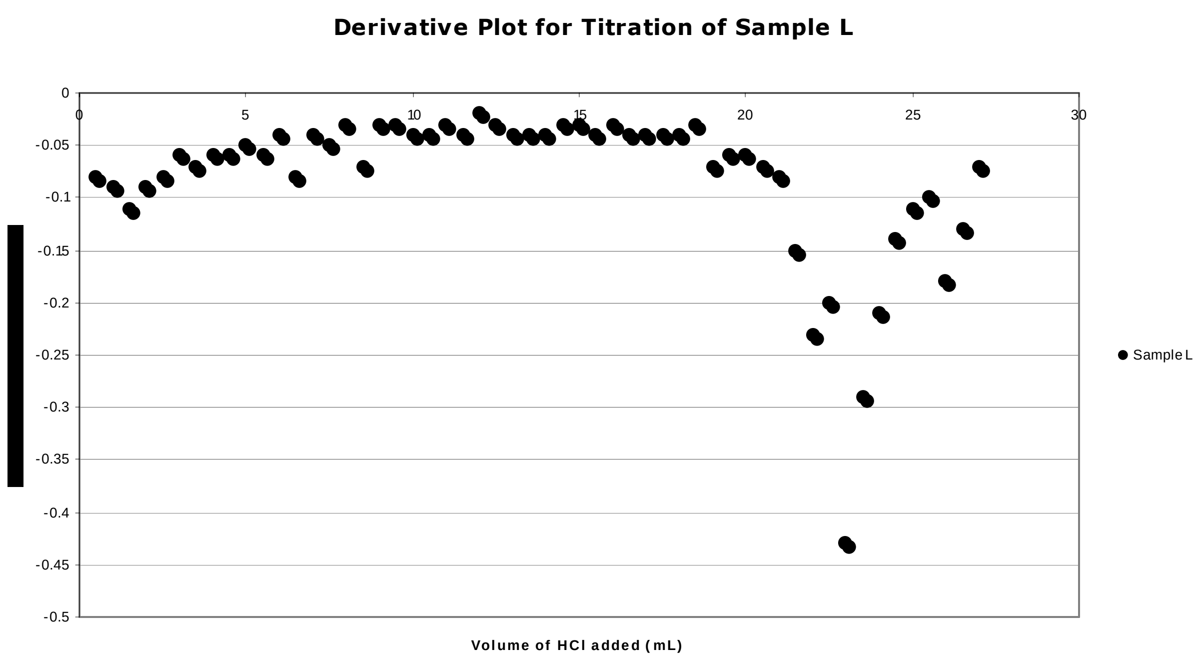


Figure B7 Derivative plot for the titration of sample L.

Table B5 Titration table for Lake Lonely site C, sample X; collected February 1, 2007.

Ph	HCl added	change in pH/change in volume
7.52	0	0
7.32	1	-0.2
7.16	2	-0.16
7.02	3	-0.14
6.94	4	-0.08
6.88	5	-0.06
6.82	6	-0.06
6.74	7	-0.08
6.67	8	-0.07
6.54	9	-0.13
6.47	10	-0.07
6.4	11	-0.07
6.31	12	-0.09
6.21	13	-0.1
6.17	14	-0.04
6.1	15	-0.07
6.04	16	-0.06
5.97	17	-0.07
5.88	18	-0.09
5.67	19	-0.21
5.55	20	-0.12
5.35	21	-0.2
5.08	22	-0.27
4.51	23	-0.57
4.23	23.5	-0.28
3.99	24	-0.24
3.85	24.5	-0.14
3.73	25	-0.12
3.63	25.5	-0.1
3.56	26	-0.07
3.5	26.5	-0.06
3.45	27	-0.05
3.42	27.5	-0.03
3.39	28	-0.03
3.35	28.5	-0.04
3.32	29	-0.03
3.31	29.5	-0.01
3.29	30	-0.02
3.27	30.5	-0.02
3.25	31	-0.03
3.24	31.5	-0.01
3.22	32	-0.02
3.2	32.5	-0.02
3.19	33	-0.01
3.17	33.5	-0.02
3.16	34	-0.01
3.14	34.5	-0.02
3.13	35	-0.01
3.12	35.5	-0.01
3.11	36	-0.01
3.11	36.5	0
3.1	37	-0.01
3.1	37.5	0
3.08	38	-0.02
3.08	38.5	0
3.06	39	-0.02
3.06	39.5	0
3.05	40	-0.01
3.05	40.5	0
3.04	41	-0.01
3.04	41.5	0
3.02	42	-0.02
3.02	42.5	0
3.01	43	-0.01
3.01	43.5	0
3	44	-0.01

Table B6 Titration data for Lake Lonely site C, sample Y; collected February 1, 2007.

pH	HCl added	change in pH/change in volume
7.41	0.0	0.00
7.12	1.0	-0.29
6.93	2.1	-0.19
6.78	3.0	-0.15
6.68	4.1	-0.10
6.59	5.0	-0.09
6.48	6.1	-0.11
6.41	7.0	-0.07
6.34	8.0	-0.07
6.26	9.0	-0.08
6.19	10.0	-0.07
6.15	11.0	-0.04
6.10	12.0	-0.05
6.03	13.0	-0.07
5.97	14.0	-0.06
5.82	15.0	-0.15
5.70	16.1	-0.12
5.61	17.0	-0.09
5.55	18.0	-0.06
5.40	19.0	-0.15
5.23	20.0	-0.17
5.04	21.0	-0.19
4.58	22.1	-0.46
3.96	23.0	-0.62
3.79	23.5	-0.17
3.62	24.0	-0.17
3.51	24.5	-0.11
3.43	25.0	-0.08
3.35	25.5	-0.08
3.30	26.0	-0.05
3.25	26.5	-0.05
3.21	27.0	-0.04
3.18	27.5	-0.03
3.14	28.0	-0.04
3.11	28.5	-0.03
3.08	29.0	-0.03
3.06	29.5	-0.02
3.04	30.0	-0.02
3.02	30.5	-0.02
3.00	31.0	-0.02
2.98	31.5	-0.02

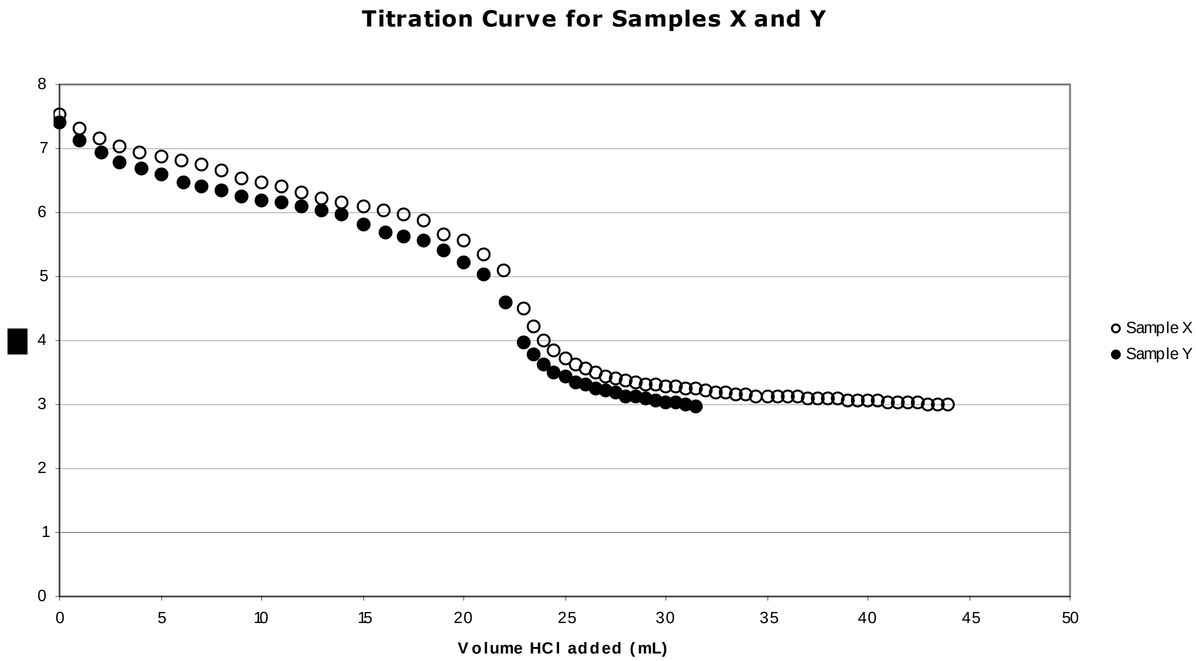


Figure B8 Titration curves for Lake Lonely site C, samples X and Y.

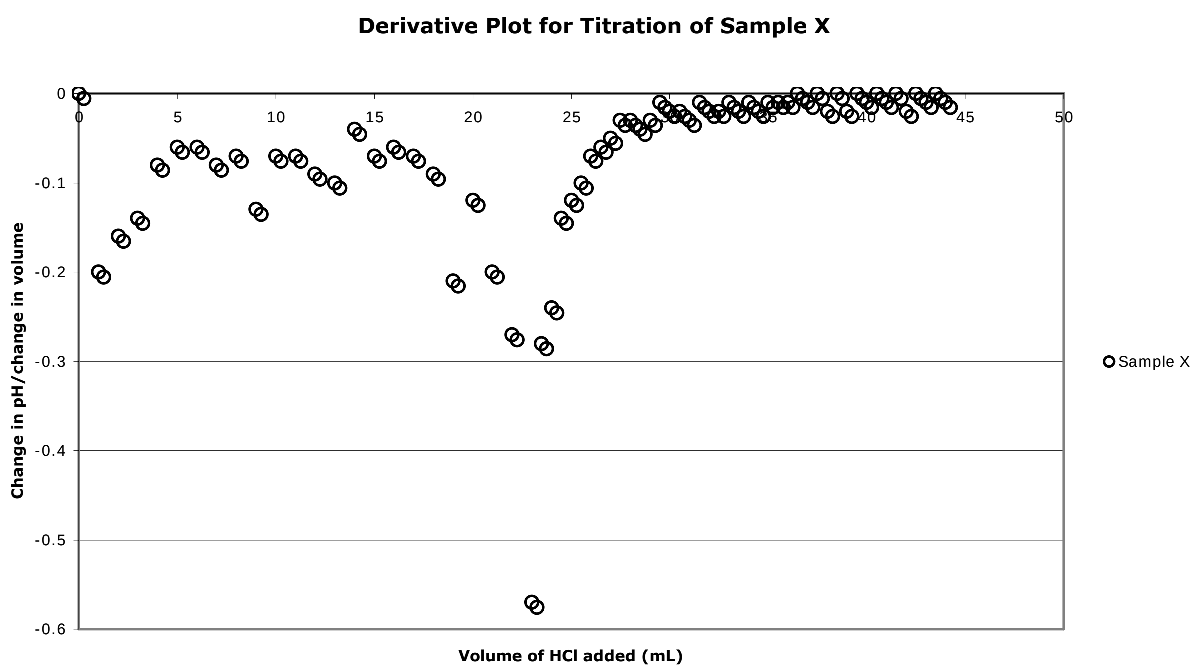


Figure B9 Derivative plot for the titration of sample X.

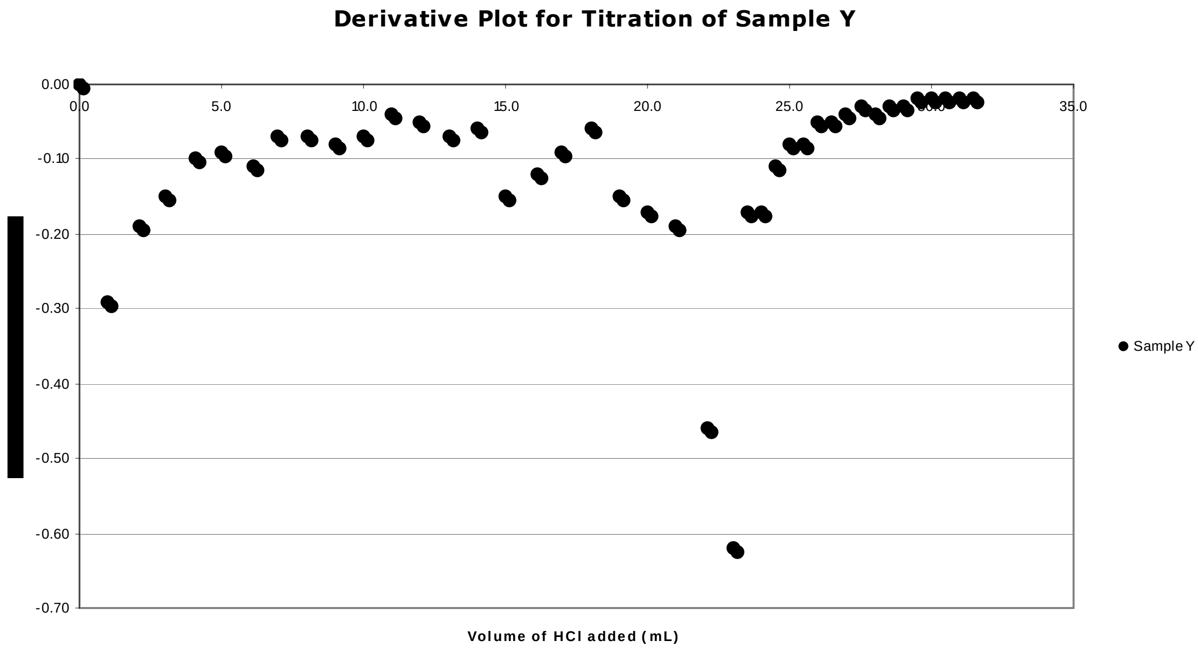


Figure B10 Derivative plot for the titration of sample Y.

Anion Concentrations

Table B7 Anion standard concentration and area values.

Cl- ppm	Area	NO_3^- ppm	Area	SO_4^{2-} ppm	Area
1	0.617	0.3	0.287	0.3	n/a
1	0.717	0.3	0.488	0.3	0.527
2	0.707	0.6	0.391	0.6	0.401
2	1.332	0.6	0.938	0.6	0.963
3	2.337	0.9	1.616	0.9	1.651
3	2.291	0.9	1.633	0.9	1.67
4	2.678	1.2	1.832	1.2	1.836
4	3.039	1.2	2.11	1.2	2.157
5	3.862	1.5	2.623	1.5	2.657
5	3.688	1.5	2.561	1.5	2.579

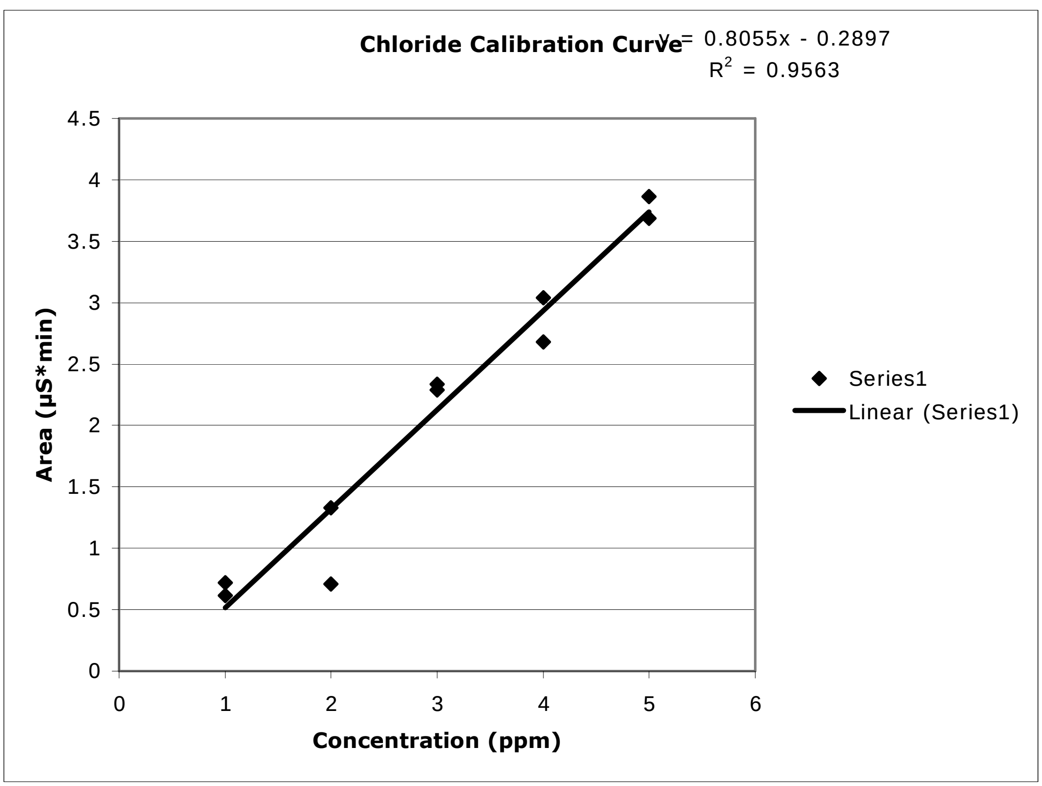


Figure B11 Chloride calibration curve.

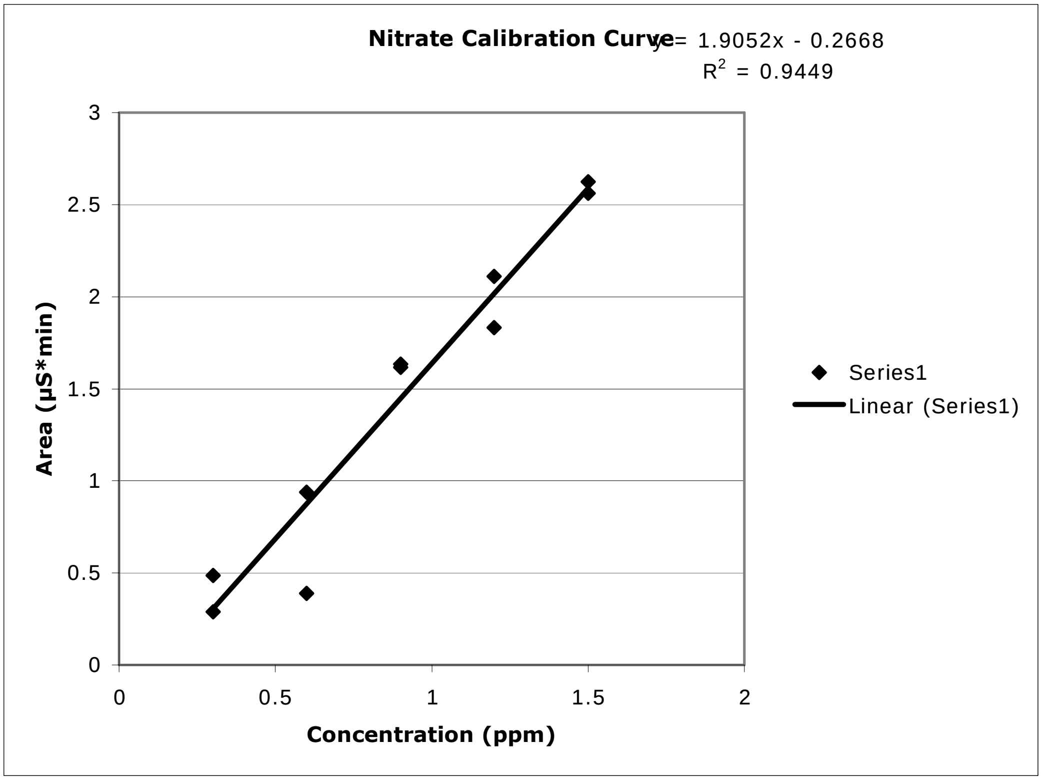


Figure B12 Nitrate calibration curve

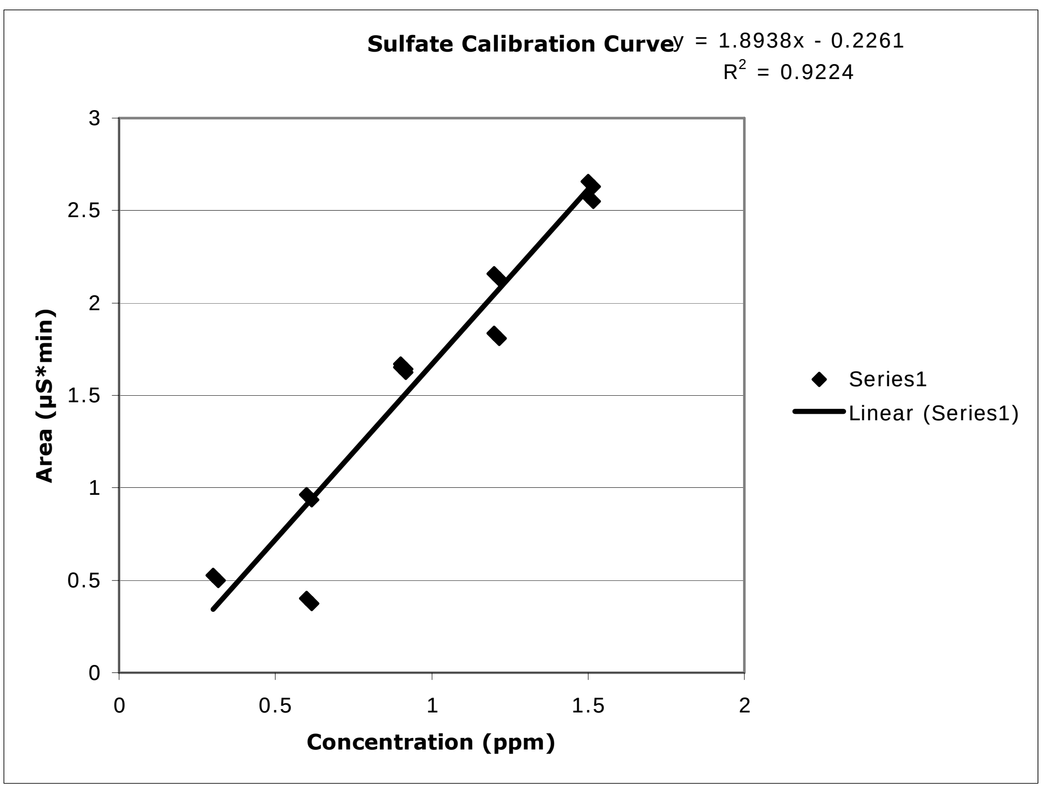


Figure B13 Sulfate calibration curve.

Table B8 Lake Lonely chloride concentration and area values.

Chloride (ppm)	**Area**	**Sample**
72.04804469	57.745	**A TOP 1**
71.90900062	57.633	**A TOP 2**
71.96238361	57.676	**A TOP 3**
106.8810677	85.803	**A BOT 1**
106.3124767	85.345	**A BOT 2**
106.6662942	85.63	**A BOT 3**
60.06170081	48.09	**B TOP 1**
60.302545	48.284	**B TOP 2**
60.23674736	48.231	**B TOP 3**
124.1684668	99.728	**B BOT 1**
124.6315332	100.101	**B BOT 2**
124.7234016	100.175	**B BOT 3**
89.61849783	71.898	**C TOP 1**
89.87299814	72.103	**C TOP 2**
89.86058349	72.093	**C TOP 3**
129.9226567	104.363	**C BOT 1**
132.4341403	106.386	**C BOT 2**
130.5173184	104.842	**C BOT 3**

Table B9 Lake Lonely nitrate concentration and area values.

Nitrate (ppm)	**Area**	**Sample**
1.447098747	1.456	**A TOP 1**
1.45297853	1.463	**A TOP 2**
1.455498438	1.466	**A TOP 3**
1.201827773	1.164	**A BOT 1**
1.202667742	1.165	**A BOT 2**
1.198467896	1.16	**A BOT 3**
1.599133152	1.637	**B TOP 1**
1.607532843	1.647	**B TOP 2**
1.608372812	1.648	**B TOP 3**
1.404260323	1.405	**B BOT 1**
1.418539798	1.422	**B BOT 2**
1.415179921	1.418	**B BOT 3**
1.253905856	1.226	**C TOP 1**
1.256425764	1.229	**C TOP 2**
1.261465578	1.235	**C TOP 3**
1.615092565	1.656	**C BOT 1**
1.617612472	1.659	**C BOT 2**
1.622652286	1.665	**C BOT 3**

Table B10 Lake Lonely sulfate concentration and area values.

Sulfate (ppm)	Area	Sample
4.538018798	8.368	**A TOP 1**
4.540658993	8.373	**A TOP 2**
4.529042138	8.351	**A TOP 3**
4.836888795	8.934	**A BOT 1**
4.824215862	8.91	**A BOT 2**
4.89972542	9.053	**A BOT 3**
4.473070018	8.245	**B TOP 1**
4.466205513	8.232	**B TOP 2**
4.475710212	8.25	**B TOP 3**
5.638979829	10.453	**B BOT 1**
5.690199599	10.55	**B BOT 2**
5.688087443	10.546	**B BOT 3**
4.627785405	8.538	**C TOP 1**
4.628841483	8.54	**C TOP 2**
4.633593833	8.549	**C TOP 3**
5.913560038	10.973	**C BOT 1**
5.926232971	10.997	**C BOT 2**
5.924120815	10.993	**C BOT 3**

Cation Concentrations

Group A:

Table B11 Cation standard concentration and intensity values.

Na^+ (ppm)	Intensity	K^+ (ppm)	Intensity	Mg^{2+} (ppm)	Intensity	Ca^{2+} (ppm)	Intensity
80	589821	2	13147	32	336170	48	8469610
80	583812	2	12869	32	300725	48	7618620
40	296332	1	5804	16	146775	24	3769330
40	296795	1	5849	16	158660	24	3660225
20	141004	0.5	2380	8	76500	12	1725090
20	141894	0.5	2446	8	75670	12	1938955

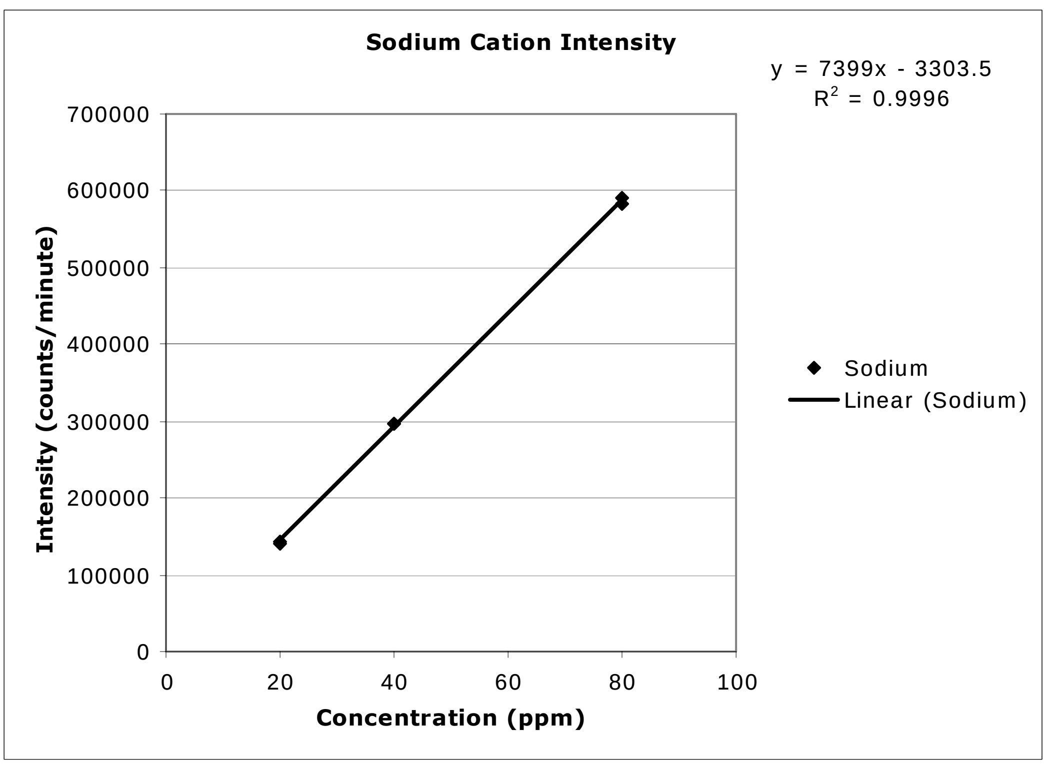


Figure B14 Sodium calibration curve.

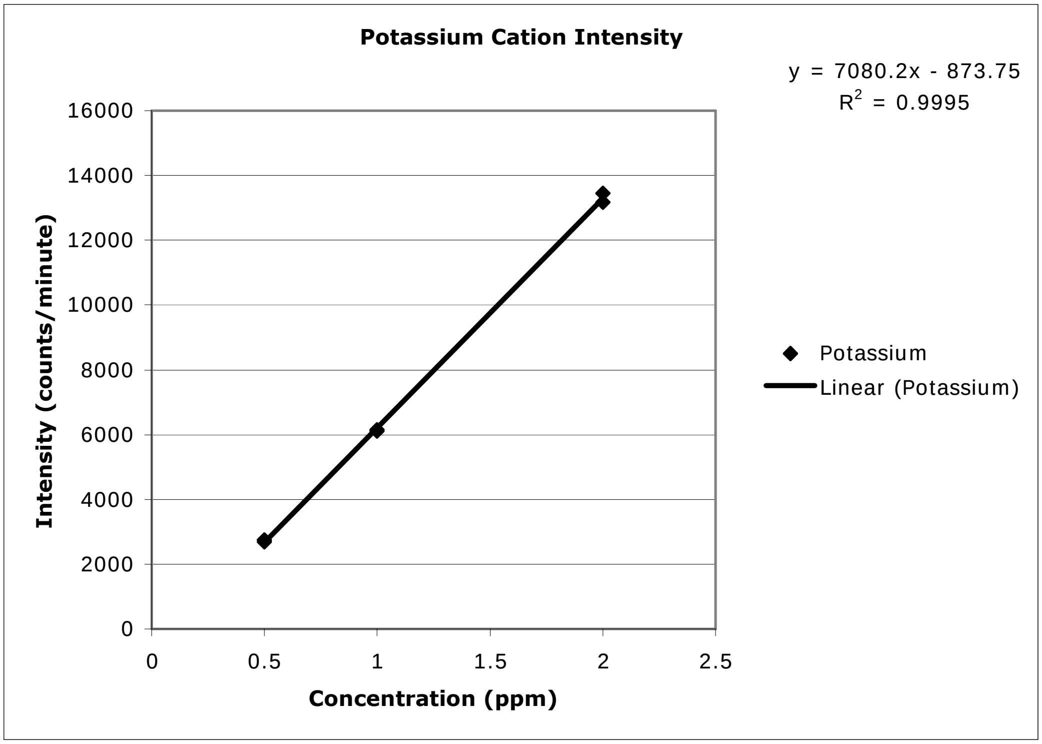


Figure B15 Potassium calibration curve.

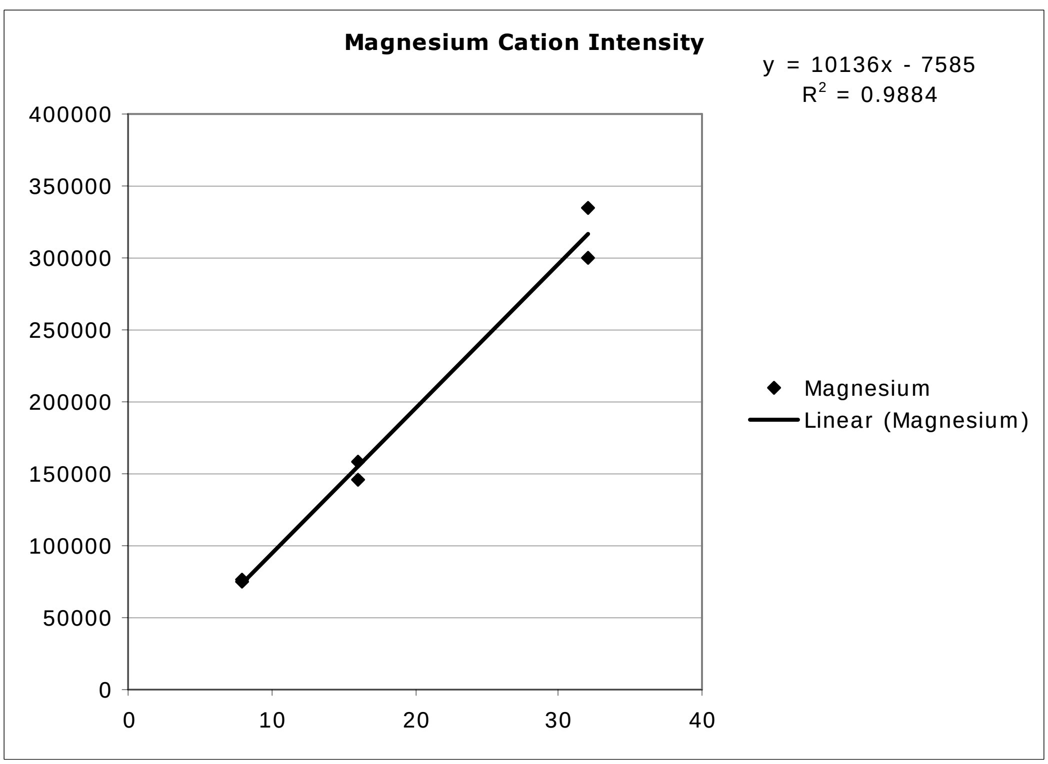


Figure B16 Magnesium calibration curve.

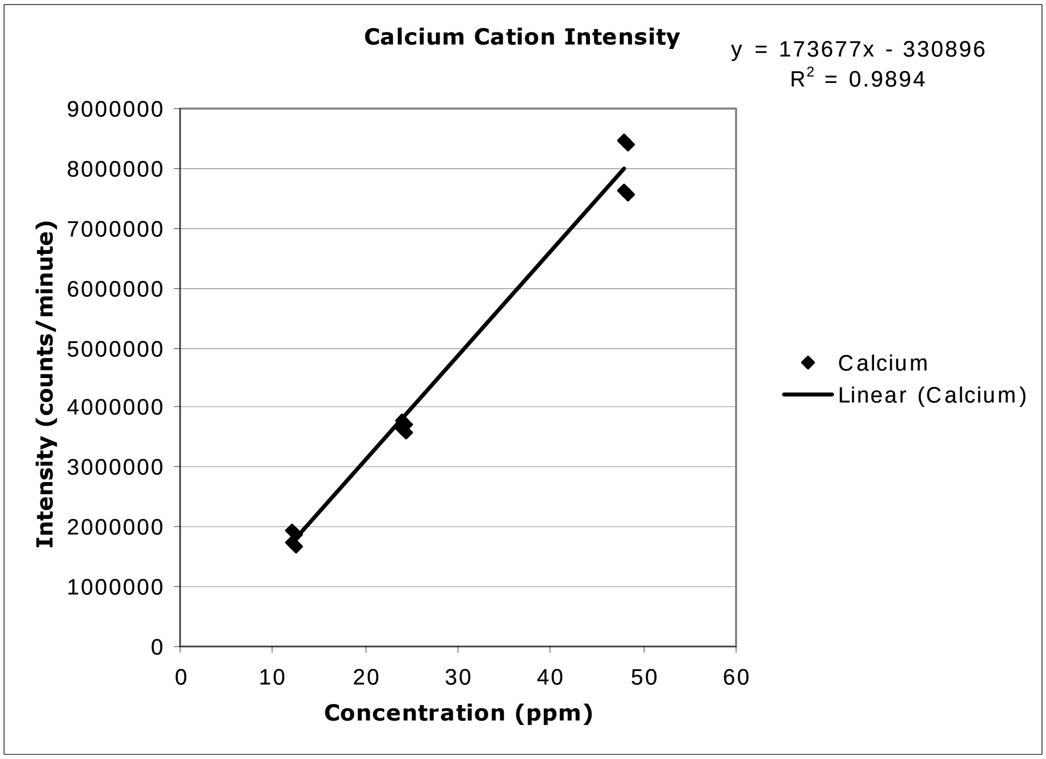


Figure B17 Calcium calibration curve.

Table B12 Raw intensity values and Lake Lonely Site A cation concentrations.

Ca^{2+}	Sample	intensity	intensity - blank avg	Concentration (ppm)	Avg. Conc. (ppm)	Lake Sample Average in meq/L
	lake1	7698660	7696910	46.23269633	47.18427599	2.355
					Rounded Avg. in ppm	
	lake2	8030945	8029195	48.13585564		
	Blank1	1445	1750		47.184	
	Blank2	2055				
	std1-1	8471360	8469610			
	std1-2	7620370	7618620			
	std2-1	3771080	3769330			
	std2-2	3661975	3660225			
	std3-1	1726840	1725090			
	std3-2	1940705	1938955			

Mg^{2+}	sample	intensity	intensity - blank avg	Concentration (ppm)	Avg. Conc. (ppm)	Lake Sample Average in meq/L
	lake1	68775	69580	7.612963694	7.953088004	0.654
					Rounded Avg. in ppm	
	lake2	75670	76475	8.293212313		
	Blank1	-375	-805		7.953	
	Blank2	-1235				
	std1-1	335365	336170			
	std1-2	299920	300725			
	std2-1	145970	146775			
	std2-2	157855	158660			
	std3-1	75695	76500			
	std3-2	74865	75670			

Na^{+}	sample	intensity	intensity - blank avg	Concentration (ppm)	Avg. Conc. (ppm)	Lake Sample Average in meq/L
	lake1	153301	152927	21.11508312	21.29024193	0.926
					Rounded Avg. in ppm	
	lake2	155893	155519	21.46540073		
	Blank1	348	374		21.29	
	Blank2	400				
	std1-1	590195	589821			
	std1-2	584186	583812			
	std2-1	296706	296332			
	std2-2	297169	296795			
	std3-1	141378	141004			
	std3-2	142268	141894			

K^+	**sample**	**intensity**	**intensity - blank avg**	**Concentration (ppm)**	**Avg. Conc. (ppm)**	**Lake Sample Average in meq/L**
	lake1	3289	2985	0.545005791	0.549031101	0.014
	lake2	3346	3042	0.553056411	**Rounded Avg. in ppm**	
	Blank1	288	304		0.549	
	Blank2	320				
	std1-1	13451	13147			
	std1-2	13173	12869			
	std2-1	6108	5804			
	std2-2	6153	5849			
	std3-1	2684	2380			
	std3-2	2750	2446			

Group B:

Table B13 Cation standard concentration and intensity values.

Na^+ (ppm)	Intensity	K^+ (ppm)	Intensity	Mg^{2+} (ppm)	Intensity	Ca^{2+} (ppm)	Intensity
80	583544	2	14386	32	299265	48	9012740
40	306880	1	8016	16	153995	24	4599680
20	151838	0.5	4890	8	73335	12	2194040

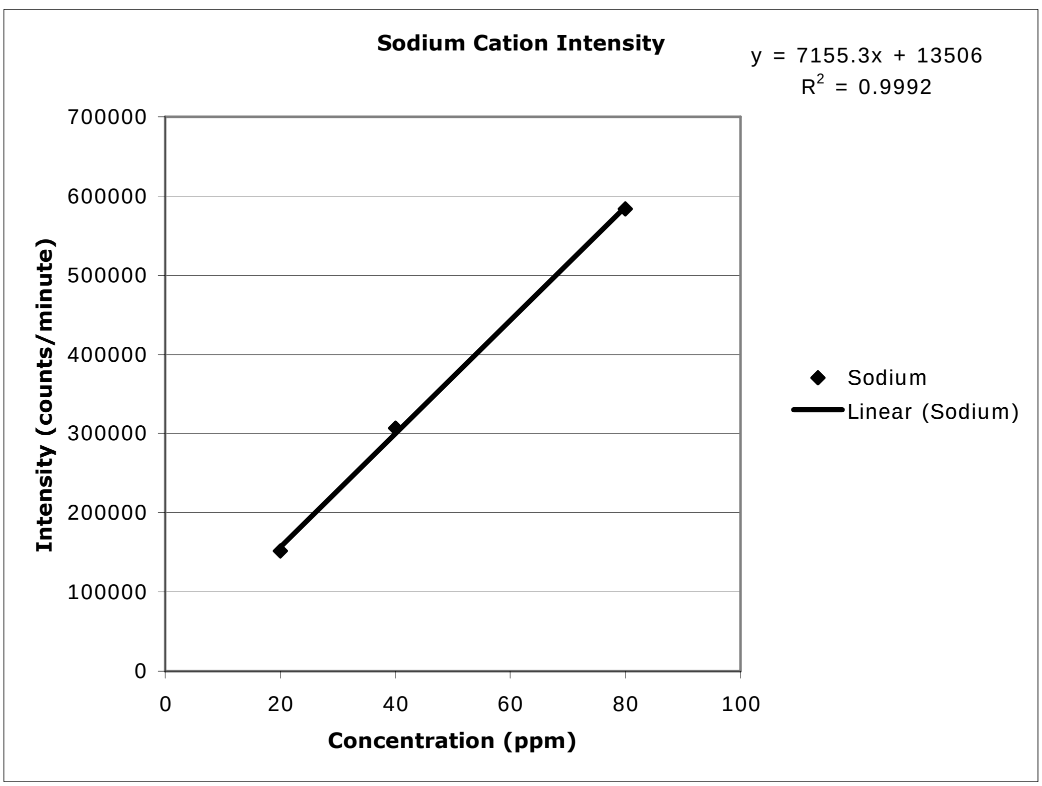


Figure B18 Sodium calibration curve.

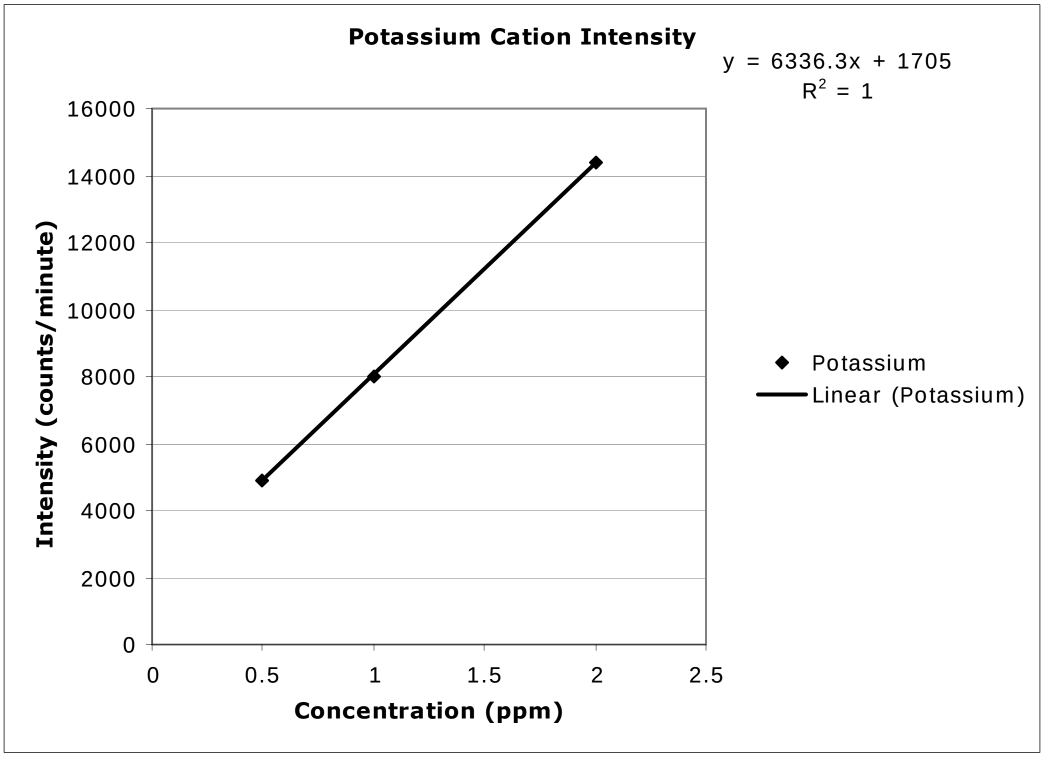


Figure B19 Potassium calibration curve.

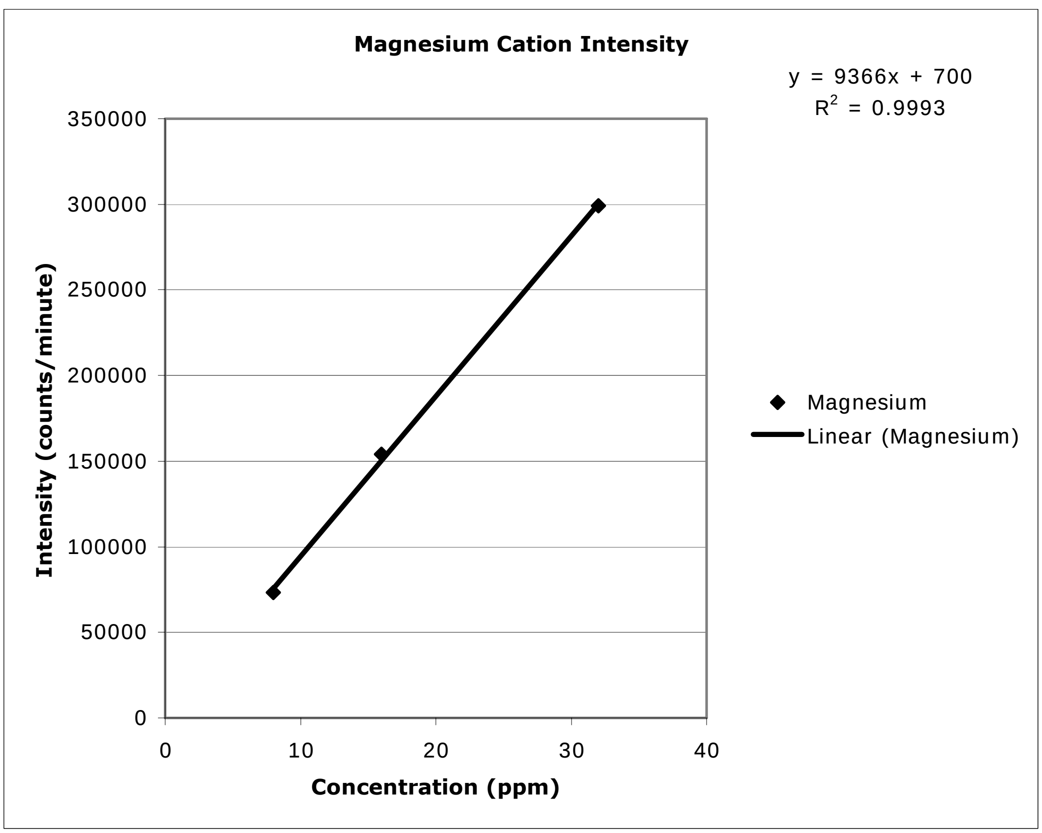


Figure B20 Magnesium calibration curve.

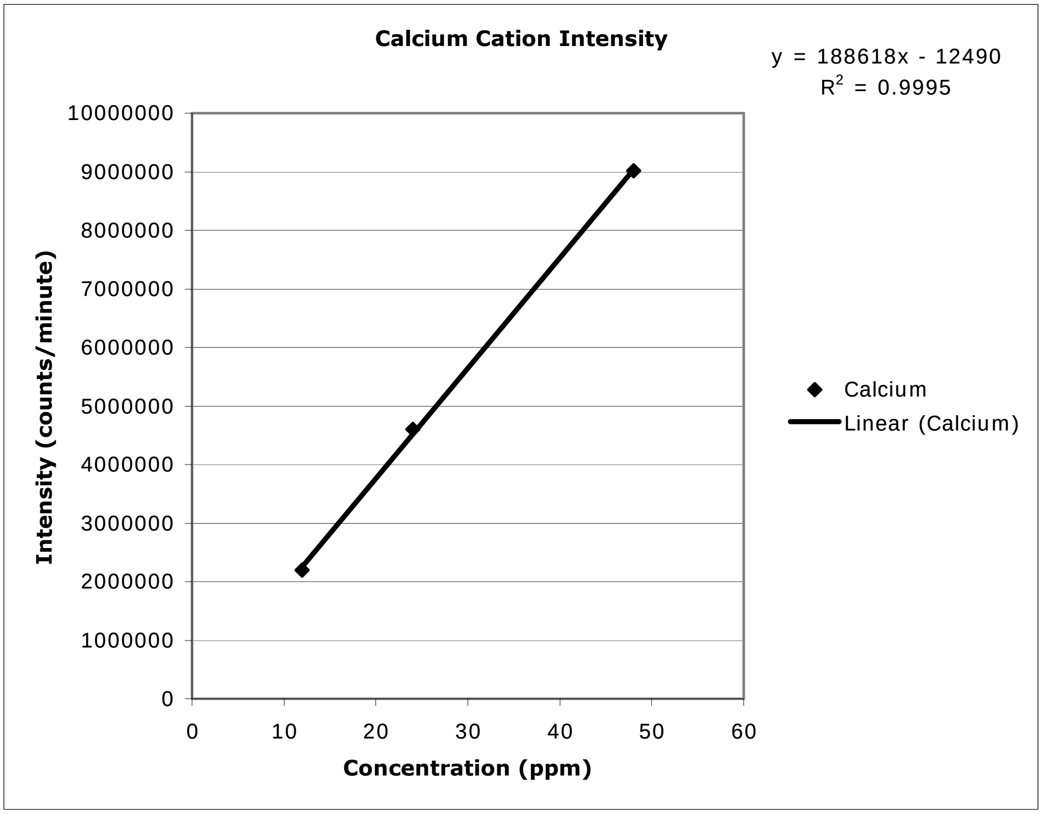


Figure B21 Calcium calibration curve.

Table B14 Raw intensity values and Lake Lonely Site B cation concentrations.

Ca	sample	intensity	Concentration (ppm)	Avg. Conc. (ppm)	Lake Sample Average in meq/L
	lakeA	7605890	40.391	41.30533333	2.061
	lakeB	7669880	40.73	**Rounded Avg. in ppm**	
	lakeC	8059510	42.795	41.305	
	Std1	9012740	48		
	Std2	4599680	24		
	Std3	2194040	12		

	sample	intensity	Concentration (ppm)	Avg. Conc. (ppm)	Lake Sample Average in meq/L
Mg	lakeA	71605	7.57	7.620666667	0.627
	lakeB	70425	7.444	**Rounded Avg. in ppm**	
	lakeC	74205	7.848	7.621	
	Std1	299265	32		
	Std2	153995	16		
	Std3	73335	8		

	sample	intensity	Concentration (ppm)	Avg. Conc. (ppm)	Lake Sample Average in meq/L
Na	lakeA	162630	20.841	19.86366667	0.864
	lakeB	153402	19.551	**Rounded Avg. in ppm**	
	lakeC	150882	19.199	19.864	
	Std1	583544	80		
	Std2	306880	40		
	Std3	151838	20		

	sample	intensity	Concentration (ppm)	Avg. Conc. (ppm)	Lake Sample Average in meq/L
K	lakeA	5916	0.665	0.645333333	0.0165
	lakeB	5686	0.628	**Rounded Avg. in ppm**	
	lakeC	5778	0.643	0.645	
	Std1	14386	2		
	Std2	8016	1		
	Std3	4890	0.5		

Group C:

Table B15 Cation standard concentration and intensity values.

Na^{+} (ppm)	Intensity	K^{+} (ppm)	Intensity	Mg^{2+} (ppm)	Intensity	Ca^{2+} (ppm)	Intensity
20	169540	3112	0.5	8	101055	12	2649370
20	172549	3083	0.5	8	97745	12	2468300
40	342572	6439	1	16	190500	24	5556660
40	340978	6566	1	16	184935	24	5051325
80	639558	15364	2	32	392630	48	10868855
80	654675	15805	2	32	408120	48	10182920

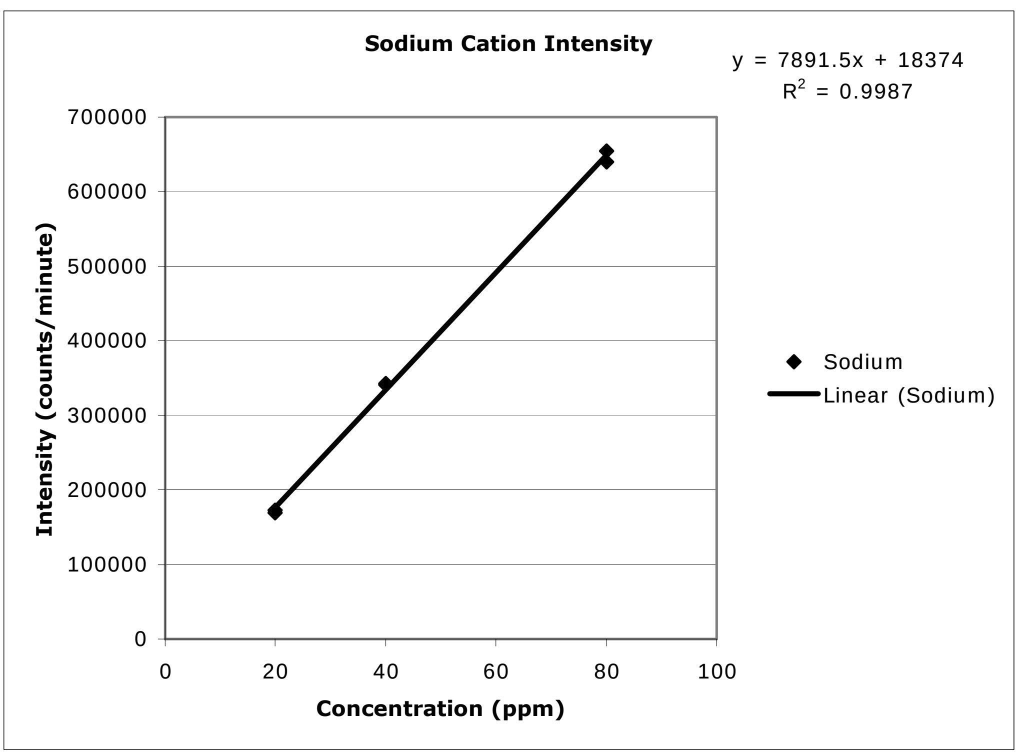


Figure B22. Sodium calibration curve.

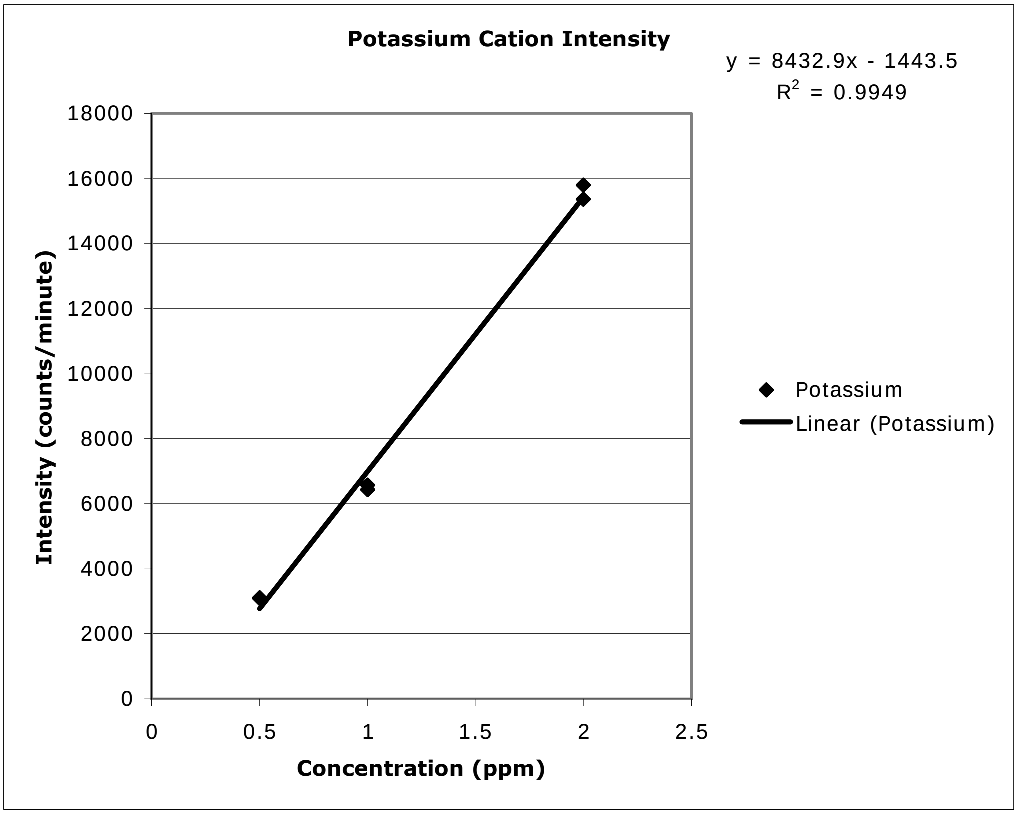


Figure B23 Potassium calibration curve.

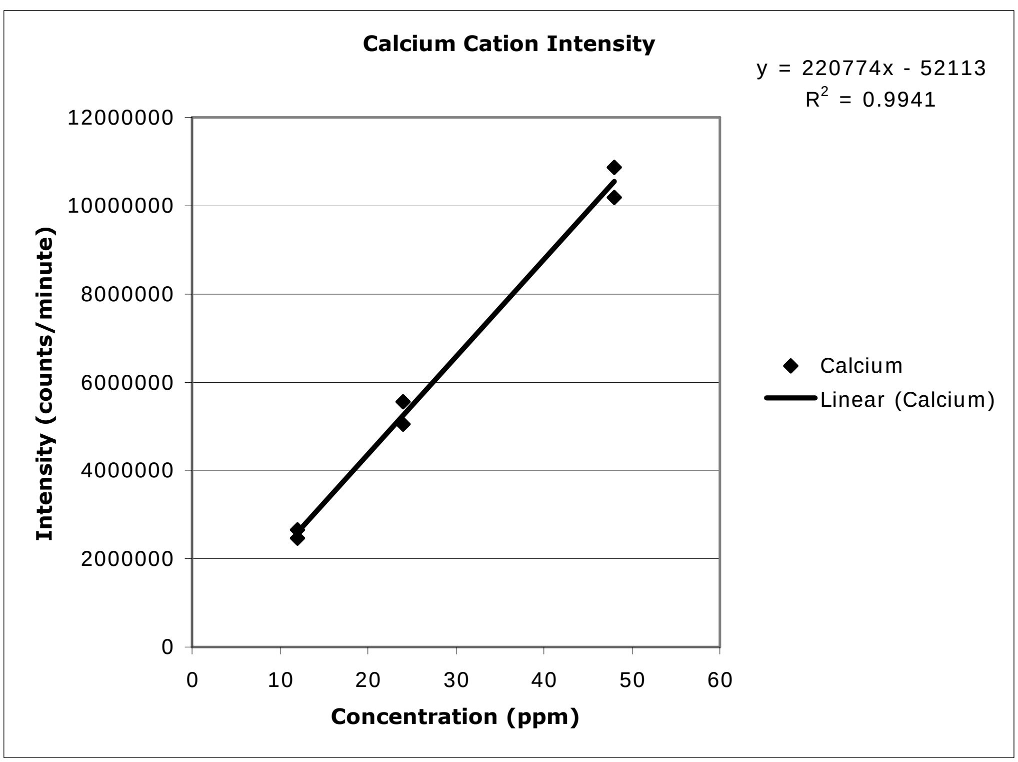


Figure B24 Calcium calibration curve.

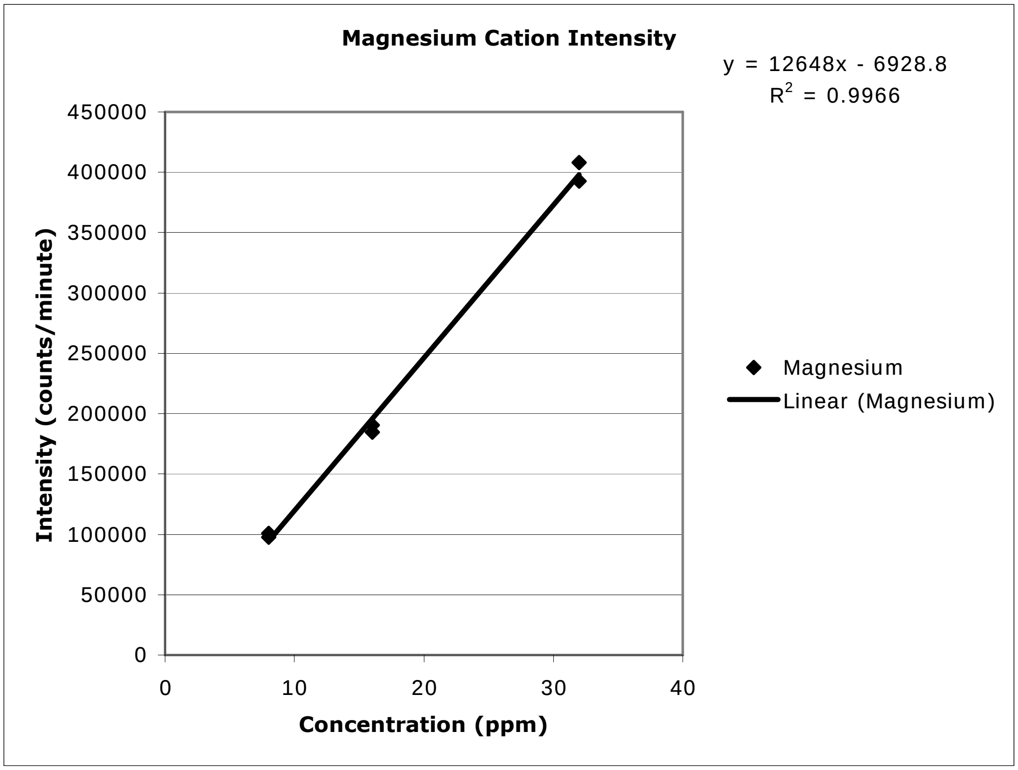


Figure B25 Magnesium calibration curve.

Table B16 Raw sodium intensity values and Lake Lonely Site C sodium concentrations.

Sodium			
Sample Tested	**Intensity**	**ppm (Na^+)**	**M Na^+**
Tapwater	367912	46.55280999	0.002024035
Cblank	497	-2.265348793	-9.84934E-05
Cblankb	584	-2.254324273	-9.80141E-05
Csample	176578	22.3072293	0.00096988
Csampleb	178216	22.5147944	0.000978904
Csamplec	177232	22.39010328	0.000973483
CS1	169540	21.41538364	0.000931104
CS1b	172549	21.79667997	0.000947682
CS2	342572	43.34176012	0.001884424
CS2b	340978	43.13977064	0.001875642
CS3	639558	80.97541659	0.00352067
CS3b	654675	82.89102199	0.003603957
	Blank average	-2.259836533	
sample ppm average	**22.40404232**	**Sample meq/L Average**	**0.974088797**

Table B17 Raw potassium intensity values and Lake Lonely site C potassium concentrations.

Potassium			
Sample Tested	**Intensity**	**ppm (K^+)**	**M K^+**
Tapwater	6906	0.808025709	2.07186E-05
Cblank	53	0.177459711	4.55025E-06
Cblankb	131	0.186709198	4.78742E-06
Csample	3908	0.45251337	1.15738E-05
Csampleb	3970	0.459865527	1.17619E-05
Csamplec	4025	0.466387601	1.19287E-05
CS1	3112	0.358121168	9.18259E-06
CS1b	3083	0.354682256	9.09442E-06
CS2	6439	0.752647369	1.92987E-05
CS2b	6566	0.767707432	1.96848E-05
CS3	15364	1.811002146	4.6436E-05
CS3b	15805	1.863297324	4.77769E-05
	Blank Ave.	0.182084455	
sample ppm average	**0.459588833**	**Sample meq/L Average**	**0.011754791**

Table B18 Raw calcium intensity values and Lake Lonely site C calcium concentrations.

Calcium			
Sample Tested	**Intensity**	**ppm (Ca^{2+})**	**M Ca^{2+}**
Tapwater	11267765	50.92179106	0.001273045
Cblank	25700	0.352455452	8.81139E-06
Cblankb	25415	0.351164539	8.77911E-06
Csample	8529380	38.51822452	0.000961082
Csampleb	9047485	40.8649909	0.001019636
Csamplec	8990315	40.6060383	0.001013175
CS1	2649370	11.88460824	0.000297115
CS1b	2468300	11.06444826	0.000276611
CS2	5556660	25.05323317	0.000626331
CS2b	5051325	22.76430875	0.000569108
CS3	10868855	49.11492069	0.001227873
CS3b	10182920	46.00796516	0.001150199
	Blank average	0.351809996	
sample ppm average	**39.99641791**	**Sample meq/L Average**	**1.995928834**

Table B19 Raw magnesium intensity values and Lake Lonely site C magnesium concentrations.

Magnesium			
Sample Tested	**Intensity**	**ppm (Mg^{2+})**	**M Mg^{2+}**
Tapwater	108470	8.582384567	0.000353185
Cblank	485	0.58616382	2.4122E-05
Cblankb	-645	0.496821632	2.04453E-05
Csample	85115	6.735847565	0.000277195
Csampleb	87705	6.940623023	0.000285622
Csamplec	88020	6.965528147	0.000286647
CS1	101055	7.99612587	0.000329059
CS1b	97745	7.734424415	0.000318289
CS2	190500	15.06799494	0.000620082
CS2b	184935	14.62800443	0.000601975
CS3	392630	31.04917774	0.001277744
CS3b	408120	32.27387729	0.001328143
	Blank average	0.541492726	
sample ppm average	**6.880666245**	**Sample meq/L Average**	**0.566309979**

APPENDIX C

Nutrients

Table C1 Spring (April 17, 2007) Samples, Analyzed By Darrin Fresh Water Institute

Site	Concentrations of Various Analytes					
	Cl^- (ppm)	NO_3^- (ppm)	TN (ppm)	TP (ppb)	SRP (ppb)	NH4 (ppm)
Crescent Ave Bridge Site 1 (Top)	101.7	0.546	1.11	17.0	2.1	0.066
Crescent Ave Bridge Site 2 (Top)	101.5	0.543	1.08	14.7	1.6	0.065
Crescent Ave Bridge Site 3 (Top)	101.8	0.547	1.10	15.2	10.8	0.072
Crescent Ave Bridge Site 1 (Bottom)	86.9	0.651	1.09	15.8	2.4	0.035
Crescent Ave Bridge Site 2 (Bottom)	101.5	0.542	1.07	14.7	1.9	0.071
Crescent Ave Bridge Site 3 (Bottom)	102.3	0.546	1.06	14.9	6.4	0.071

Total Suspended Solids

Table C2 Total Suspended Solids

Sampling Site.	Volume of Sample.	Filter Paper.	Filter Paper + Solids.	Solids.
Group A Lake Lonely.	500.0 mL	0.1112 g	0.1185 g	0.0073 g
Group B Lake Lonely.	500.0 mL	0.120 g	0.122 g	0.002 g
Group C Lake Lonely.	400.0 mL	0.1009 g	.1068 g	0.0059 g
South Pond.	500.0 mL	0.1186 g	0.1222 g	0.0036 g
South Pond.	500.0 mL	0.115 g	0.116 g	0.001 g
Upper Kayaderosseras.	500.0 mL	0.1205 g	0.1223 g	0.0018 g

Chloride Data for Selected Other Sites

Table C2 Area of Standard Solutions

Cl- ppm	**Area**
16.66666667	9.456
16.66666667	8.886
13.33333333	6.917
13.33333333	6.927
10	5.486
6.666666667	3.407
6.666666667	3.013
3.333333333	1.774
3.333333333	1.769

Figure C1 Chloride Calibration Curve

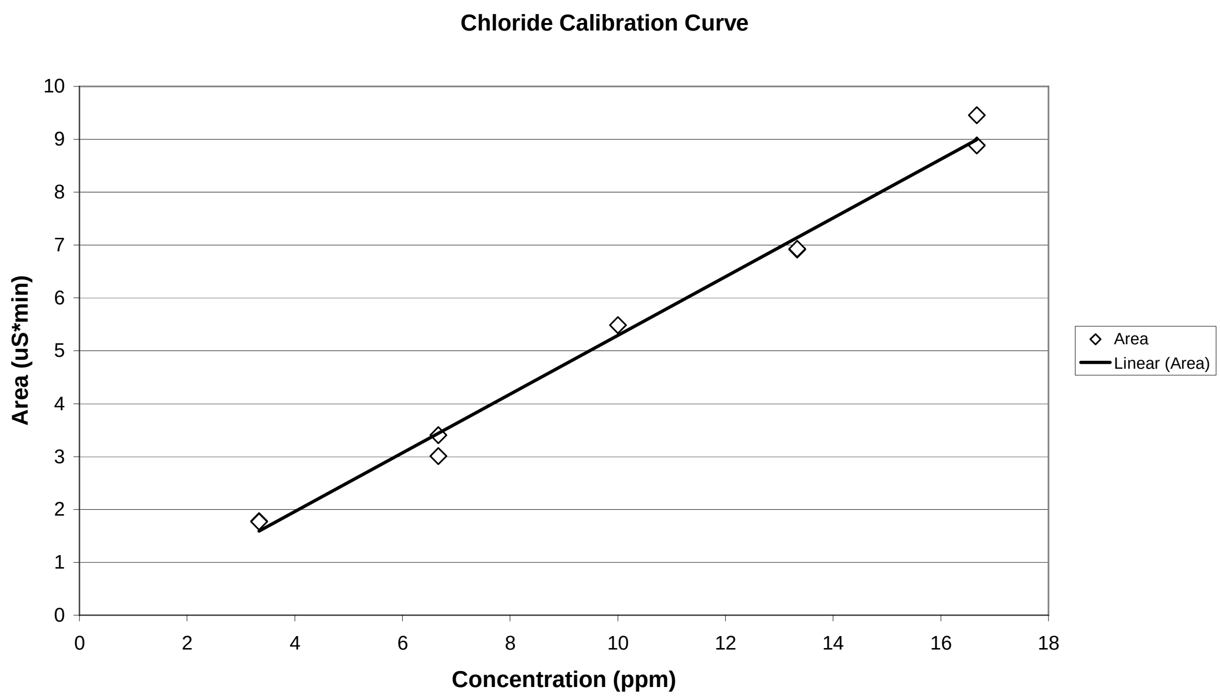


Table C4 Chloride Concentrations at other Sites

Site	Area	Cl- ppm
Tap water	83.522	150.877904
Tap water	83.533	150.897713
Main KC	47.623	86.2299658
Main KC	47.8	86.5487124
Geyser Brook	68.69	124.168017
Geyser Brook	68.947	124.63083
CMC Downstream	72.229	130.541149
CMC Downstream	72.873	131.700882
CMC Upstream	6.924	12.9380515
CMC Upstream	6.973	13.0262921
Mourning Kill	60.481	109.385017
Mourning Kill	60.616	109.628129
Spring Run	202.831	365.732937
Spring Run	203.752	367.3915
GGC	35.045	63.5791464
GGC	35.338	64.1067891
UKC Old #4	21.178	38.6070592
UKC Old #4	21.255	38.745723
Well water	82.701	149.399424
Well water	81.479	147.198811

APPENDIX D:

Water Quality Monitoring in the Kayaderosseras Creek and Saratoga Lake: Past, Present and Future
(Summer 2006)

Kristina Connolly, Class of 2007, Skidmore College
Judith A. Halstead, Professor of Chemistry, Skidmore College
Environmental Studies Program and Department of Chemistry

Abstract:

Temperature, conductivity, specific conductance, salinity, dissolved oxygen (DO) and pH were measured at eleven different sites on the Kayaderosseras Creek and its tributaries. Total suspended solids (TSS) and alkalinity were determined from some of the collected samples while other samples were filtered and analyzed for total nitrogen (TN), total phosphorus (TP), nitrate, nitrite, sulfate, chloride, and ammonia at the Darrin Fresh Water Institute (DFWI). Three of the sites were also tested for alkalinity, dissolved organic carbon (DOC), potassium, sodium, calcium, magnesium, and iron. Tributaries in close proximity to human recreation and habitation, municipalities, and roadways had poorer water quality in comparison to more isolated tributaries. An event sampling study was performed on Clover Mill Creek to assess the effect of rainfall on water quality parameters. Maps using Geographic Information Systems (GIS) were created to display sampling sites and to delineate sub-watersheds in Saratoga Lake's watershed.

Introduction:

The Skidmore College Environmental Studies Program Water Resources Initiative (WRI) is pursuing long-term water quality monitoring of the Kayaderosseras Creek and its tributaries. We hope to develop an understanding of the water chemistry of the creek and its watershed and detect any developing trends. Analysis of DO, nutrients and TSS can tell us about the trophic state of a water body. Cultural eutrophication is caused by anthropogenic addition of nutrients or organic matter to a water body. Nutrients may come from lawn or garden care, inadequately treated sewage, industrial processes, or agricultural runoff. The addition of nitrates and phosphates speeds up the eutrophication process by increasing plant and algal growth. When excessive plant and algal growth dies its decomposition consumes oxygen, leaving the body of water with decreased dissolved oxygen content. DO measures the gaseous dissolved oxygen in a body of water. DO increases come from photosynthesis and diffusion from the atmosphere. DO decreases as a result of decomposing natural and anthropogenic organic matter. When DO concentrations become too low it is harmful to aquatic life and organic matter doesn't decompose. As a result, the water body appears muddy as it is filled with dead organic matter. Not only does the water body become aesthetically unpleasing, it can harbor pathogens. As TSS increase the water also becomes more expensive to treat at a water treatment plant for human consumption, since suspended solids must be removed before disinfection of water.

When in the field, the conductivity, specific conductance, salinity, dissolved oxygen, pH, and temperature of each tributary were measured. Conductivity and specific conductance measure water's ability to pass an electric current, which is affected by inorganic dissolved solids and temperature. As the concentration of inorganic dissolved solids increases and as the temperature of the water becomes warmer, conductivity increases. Salinity measures the concentration of dissolved salt in a body of water, which, when highly concentrated, can negatively affect the abundance of certain plants and animals, decreasing species diversity.

Experimental Methods:

Summer and Fall Tributary Studies

Dissolved oxygen, conductivity, pH, and temperature were measured at eight tributaries. At each sampling site the GPS unit was used to record the latitude and longitude of the site. Comments concerning location, neighbors, conditions, weather, and landmarks about the sampling site were recorded. Water samples were collected and filtered for TSS and alkalinity analysis. Some samples were sent to the Darrin Fresh Water Institute for further analysis. Other samples were analyzed at Skidmore College by ion chromatography. In order to analyze the samples, the ion chromatograph needed to be calibrated. See Appendix A for calibration curves created by running standards of 1ppm to 5ppm multiple times through the ion chromatograph.

Event Sampling

For the event sampling study on Clover Mill Creek samples were taken on 6/13/07 which corresponded to the base flow for the stream and then again on 6/26/07 and 6/27/07. On 6/25 and 6/26 it rained very heavily and we initially believed our samples were taken at peak flow. However, it continued to rain hard and, judging from the USGS gauge on the Glowegee, peak flow probably occurred sometime between 6/26 and 6/26.

Main Branch Survey

The confluence of the Main Kayaderosseras and Lake Lonely Outlet was accessed by canoe. Temperature, conductivity, specific conductance, salinity, DO, pH, TSS, alkalinity, nutrients, major cations and major anions were determined on the Kayaderosseras both above and below the confluence and on Lake Lonely Outlet above the confluence. A GPS unit was used to record the latitude and longitude of at each of the three sites.

Results and Discussion:

Summer Assessment of Tributaries in Saratoga Lake Watershed, Saratoga County, New York

The eight tributaries surveyed are spread out across the watershed—some streams adjacent to development and dense habitation, others in isolation. Tributaries that are isolated and farther from human habitation and development (Upper Kayaderosseras Creek, Clover Mill Creek Upstream, and Glowegee Creek) have lower nutrient levels in comparison to those tributaries adjacent to highways, development and habitation (Clover Mill Creek Downstream, Main Kayaderosseras Creek, Mourning Kill Creek, Geyser Brook, and Spring Run) (Table 1).

Spring Run flows from Congress Park underneath the city of Saratoga Springs where it is piped with storm water runoff and collects potential sewage leaks. As a result, Spring Run has twice as much or more ammonia, nitrate, and sulfate levels, almost double nitrite levels, and significantly less DO than all other tributaries studied. Due to the decreased amount of DO, Spring Run also has a high level of TSS. It also has higher conductivity levels (Table 2).

Table 1: Nutrient Specific Data of Eight Tributary Monitoring in Saratoga Lake Watershed-Saratoga Lake Tributary Survey (6/13/06)

Site	Ammonium[5] (mg N/L)	Nitrite[5] (mg N/L)	Nitrate[5] (mg N/L)	Sulfate[5] (mg S/L)	DO[1,4] (mg/L)	DO[1,4] (%)	TN[2,5] (mg N/L)	TP[3,5] (µg P/L)
Upper Kayaderosseras	0.01	<0.05	0.12	1.55	8.55	87.9	0.37	10.4
Clover Mill Creek - Upstream	<0.01	<0.05	0.16	1.90	10.46	99.0	0.28	10.2
Clover Mill Creek - Downstream	0.02	<0.05	0.26	2.51	10.26	100.2	0.43	7.3
Glowegee Creek	0.01	0.05	0.12	1.91	9.83	103.3	0.40	11.1
Main Kayaderosseras Creek	0.02	0.05	0.23	2.97	9.47	100.5	0.47	16.6
Mourning Kill Creek	<0.01	0.05	0.47	3.25	9.45	103.9	0.89	23.9
Geyser Brook	0.03	0.05	0.41	5.39	9.50	100.3	1.37	34.7
Spring Run	0.06	0.08	0.95	7.92	7.72	84.2	0.68	22.1
Doubly Deonized Water	<0.01	<0.05	<0.01	<0.20	7.75	84.8	-	-

[1] Dissolved Oxygen, [2] Total Nitrogen, [3] Total Phosphorus, [4] Field Measurements taken by Kristina Connolly and Judy Halstead, [5] Samples taken by Kristina Connolly and Judy Halstead and analyzed by Darrin Fresh Water Institute

Table 2: Monitoring Eight Tributaries in Saratoga Lake Watershed-Saratoga Lake Tributary Survey (6/13/06)

Site	Temperature[2] (°C)	TSS[1] (mg/L)	Salinity[2] (ppt)	Conductivity[2] (µS)	Specific Conductance[2] (µS)	Chloride[3] (mg/L)
Upper Kayaderosseras	16.7	0.18	0.1	151.4	180.8	25.7
Clover Mill Creek - Upstream	12.7	0.73	0.0	69.8	91.5	28.6
Clover Mill Creek - Downstream	14.1	0.73	0.1	242.7	307.1	48.9
Glowegee Creek	17.4	0.18	0.1	263.4	309.2	34.9
Main Kayaderosseras Creek	18.2	1.27	0.2	278.1	320.3	51.6
Mourning Kill Creek	20.1	1.09	0.1	263.8	292.0	50.8
Geyser Brook	17.7	3.82	0.2	384.3	447.2	81.4
Spring Run	19.1	4.36	0.5	812.0	917.0	160.9

[1] Total Suspended Solids, [2] Field Measurements taken by Kristina Connolly and Judy Halstead, [3] Samples taken by Kristina Connolly and Judy Halstead and analyzed by Darrin Fresh Water Institute

Fall Assessment of Tributaries in Saratoga Lake Watershed, Saratoga County, New York

The Mourning Kill, the Main Kayaderosseras, Spring Run, and Clover Mill Creek Downstream have higher levels of conductivity and lower levels of dissolved oxygen due to the nutrient loading that occurs as a function of their location in the watershed. These data are all consistent with summer data. However, conductivity, temperature, and total suspended solids have all decreased with the changing seasons (Tables 1, 2, 3, 4).

Table 3: Fall Assessment of Tributaries in Saratoga Lake Watershed, Saratoga County, New York-Saratoga Lake Watershed Tributary Survey (9/20/06)

Site	T[1,4] (°C)	TSS[2,4] (mg/L)	Conductivity[5] (µS)	Specific Conductance[5] (µS)	DO[3,5] (mg/L)	DO[3,5] (%)	pH[5]	Turbidity[5] (NTU)
Upper Kayaderosseras	12.6	0.18	68.8	90.3	10.25	96.7	7.94	1.89
Clover Mill Creek - Upstream	11.9	1.09	119.1	159.0	10.30	95.6	8.13	2.12
Clover Mill Creek - Downstream	12.7	0.18	307.2	402.0	9.87	94.1	8.46	3.16
Glowegee Creek	14.6	0.55	302.8	377.8	8.77	86.5	8.23	2.05
Main Kayaderosseras Creek	15.0	0.18	247.4	305.7	9.17	90.7	8.25	2.17
Mourning Kill Creek	15.6	0.36	376.7	338.0	9.52	95.6	8.17	4.73
Spring Run	16.0	0.72	353.8	427.4	8.80	89.5	8.17	5.62

[1] Temperature, [2] Total Suspended Solids, [3] Dissolved Oxygen, [4] Samples taken by and analyzed by Kristina Connolly, [5] Field Measurements taken by Kristina Connolly

Table 4: Laboratory Analysis of Fall Chloride and Nitrate Concentrations, Analyzed by Ion Chromatography-Saratoga Lake Watershed Tributary Survey (9/20/06)

Site	Chloride	Nitrate
Upper Kayaderosseras Creek	7.971	0.246
Clover Mill Creek - Upstream	10.414	0.564
Clover Mill Creek - Downstream	34.579	0.701
Glowegee Creek	31.753	0.909
Main Kayaderosseras Creek	28.737	0.389
Mourning Kill Creek	35.973	0.434
Spring Run	50.742	0.564

Event Sampling

Since the Clover Mill Creek has a low temperature, it is likely that groundwater is a significant source of water for the creek. It was proposed that Clover Mill Creek (downstream of the Austro Brothers Landfill) may have higher nutrient levels than Clover Mill Creek (upstream of the Austro Brothers Landfill) because of nutrient loading in the stream due to the landfill. Since rain may permeate the landfill and carry nutrients from the landfill as runoff into Clover Mill Creek, nutrient levels may increase after rainfall. Nutrient levels are higher downstream of the landfill than upstream of the landfill, but the ratio of nutrient levels downstream to upstream did not significantly increase with rainfall (Table 5). In addition, the rainfall (5.6 cm) on June 26, 2006 may have predominantly created runoff and not deeply permeate the ground since the storm was heavy and short-lived. The TSS following the storm was significantly higher presumably due to soil erosion.

Table 5: Event Sampling on the Clover Mill Creek Upstream and Downstream of Austro Brothers Landfill

Site and Date	T*[1] (°C)	TSS[2,4] (mg/L)	Salinity[5] (ppt)	Conductivity[5] (µS)	Specific Conductance[5] (µS)	DO[3,5] (mg/L)	DO[3,5] (%)
Upstream (6/13/06)	12.7	0.73	0.0	69.8	91.5	10.46	99.0
Downstream (6/13/06)	14.1	0.73	0.1	242.7	307.1	10.26	100.2
Upstream (6/26/06)	14.7	121.82	0.0	80.6	100.4	9.86	97.1
Downstream (6/26/06)	16.3	126.00	0.1	244.6	293.4	9.60	97.7
Upstream (6/27/06)	16.1	126.36	0.0	53.3	64.4	9.49	96.0
Downstream (6/27/06)	17.2	28.00	0.1	196.0	230.6	9.44	98.1

*Temperature is an average taken from both the conductivity meter and the dissolved oxygen meter.

[1] Temperature, [2] Total Suspended Solids, [3] Dissolved Oxygen, [4] Samples taken by Kristina Connolly and Judy Halstead and analyzed by Kristina Connolly, [5] Field Measurements taken by Kristina Connolly and Judy Halstead

Table 6: Event Sampling on the Clover Mill Creek Upstream and Downstream of Austro Brothers Landfill-Nutrients

Site and Date	NH_4[1] (mg N/L)	Cl[2] (mg/L)	NO_2[3] (mg N/L)	NO_3[4] (mg N/L)	SO_4[5] (mg S/L)	TN[6] (mg N/L)	TP[7] (µg P/L)
Upstream (6/26/06)	0.04	6.7	<0.05	0.11	1.24	0.32	17.0
Downstream (6/26/06)	0.05	40.6	<0.05	0.16	1.71	0.49	17.9
Upstream (6/27/06)	<0.01	21.9	<0.05	0.07	1.48	0.24	12.2
Downstream (6/27/06)	0.02	52.9	<0.05	0.11	1.77	0.40	15.7

[1] Ammonium, [2] Chloride, [3] Nitrite, [4] Nitrate, [5] Sulfate, [6] Total Nitrogen, [7] Total Phosphorus

Main Branch Study: The Confluence of the Main Kayaderosseras and Lake Lonely Outlet

To determine the effect of flow from the Lake Lonely outlet (LLO) to Saratoga Lake, the Kayaderosseras Creek, the Lake Lonely outlet (LLO), and the mouth of the Kayaderosseras where it flows into Saratoga Lake, were assessed (Tables 7, 8, & 9). LLO, which is fed by Spring Run (Tables 1 & 2), has significantly higher nutrient data than the Kayaderosseras Creek (upstream of confluence with Lake Lonely) and the mouth of the Kayaderosseras Creek (Table 7).

Table 7: Main Branch Survey of the Kayaderosseras Creek Analyzed by Darrin Fresh Water Institute-Saratoga Lake Watershed Survey (7/10/06)

Site	Chloride (mg/L)	Nitrite (mg N/L)	Nitrate (mg N/L)	Sulfate (mg S/L)	TN (mg N/L)	TP (mg P/L)	pH	Alkalinity (mg/L $CaCO_3$)	Ammonia (mg N/L)
Lake Lonely Outlet	64.1	<0.05	0.04	3.20	0.94	41.4	7.8	132.0	0.05
Kayaderosseras Creek	46.5	<0.05	0.28	3.21	0.29	18.4	8	110.0	0.03
Mouth	47.3	0.05	0.24	3.19	0.36	25.5	7.9	114.5	0.06

[1] Total Nitrogen, [2] Total Phosphorus

The Kayaderosseras Creek (upstream of the confluence) has the lowest nutrient levels of these three sites. The nutrients, conductivity, alkalinity levels, and common metal concentrations of the Kayaderosseras mouth fall in between the high levels of LLO and the low levels of the Kayaderosseras Creek upstream (Tables 8 & 9).

Table 8: Three Sampling Location Main Branch Survey of the Kayaderosseras Creek Field and Lab Data-Saratoga Lake Watershed Main Branch Survey (7/10/06)

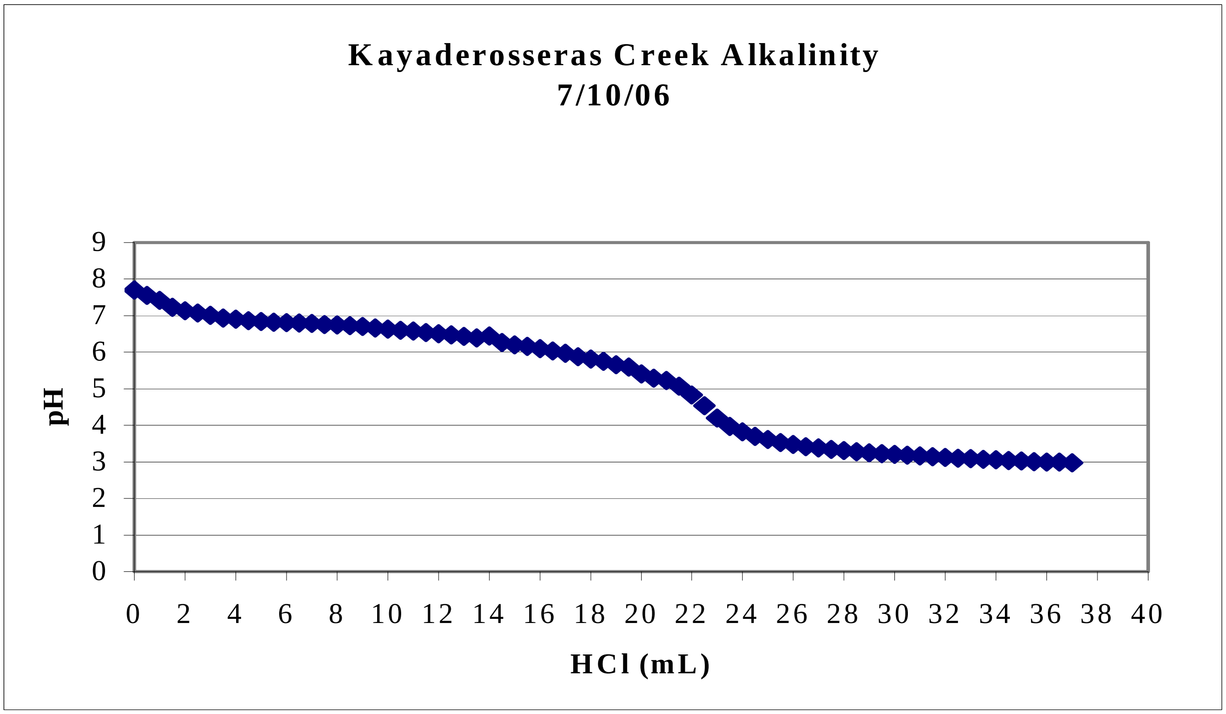
Site	T[1,5] (°C)	TSS[2,4] (mg/L)	Salinity[5] (ppt)	Conductivity[5] (μS)	Specific Conductance[5] (μS)	DO[3,5] (mg/L)	DO[3,5] (%)	pH[5]
Lake Lonely Outlet	24.5	9.27	0.2	500.0	505.0	5.18	61.9	7.55
Kayaderosseras Creek	21.8	9.82	0.2	368.3	393.4	7.79	88.3	8.04
Mouth	22.6	8.18	0.2	396.0	415.5	6.63	77.4	7.84

[1] Temperature, [2] Total Suspended Solids, [3] Dissolved Oxygen, [4] Samples taken by Kristina Connolly and Judy Halstead and analyzed by Kristina Connolly, [5] Field Measurements taken by Kristina Connolly and Judy Halstead

Table 9: Main Branch Survey of the Kayaderosseras Creek Analyzed by Darrin Fresh Water Institute-Saratoga Lake Watershed Main Branch Survey (7/10/06)

Site	Potassium (mg/L)	Sodium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Iron (mg/L)	Total Organic Carbon (mg/L)
Lake Lonely Outlet	1.92	40.0	22.44	8.2	0.14	5.14
Kayaderosseras Creek	1.23	27.7	14.13	9.8	<0.05	2.99
Mouth	1.39	24.9	16.70	9.4	0.11	7.94

Figure 1: Alkalinity Titration Using 0.002 M HCl for Kayaderosseras Creek



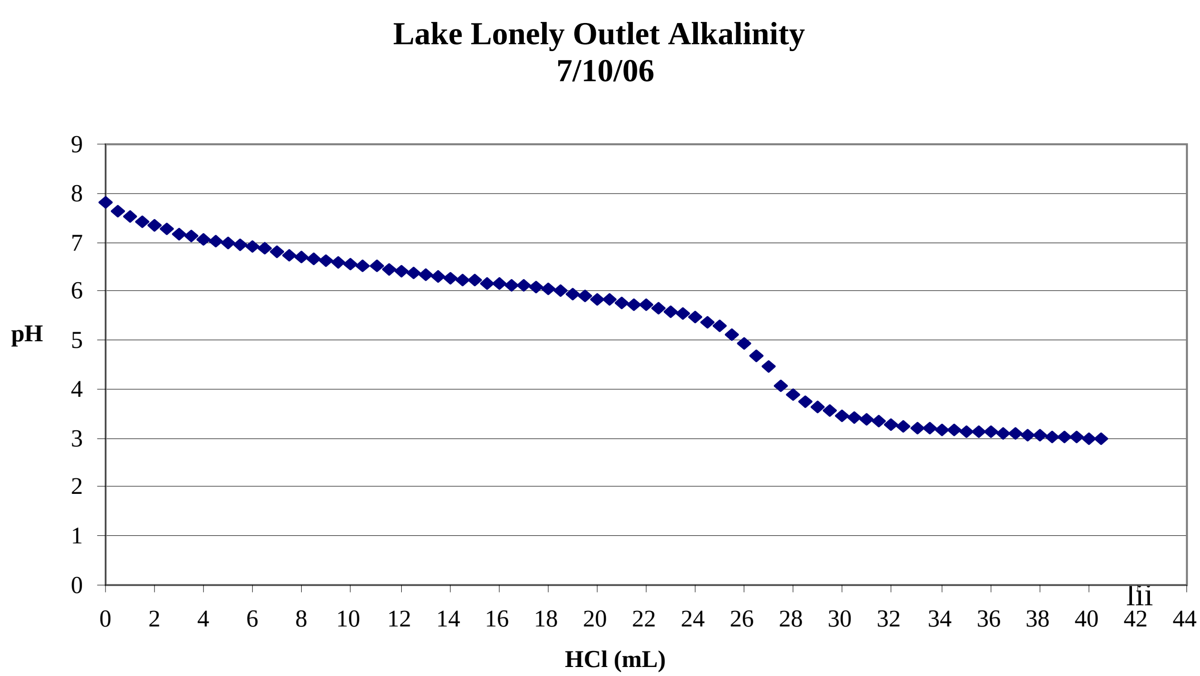
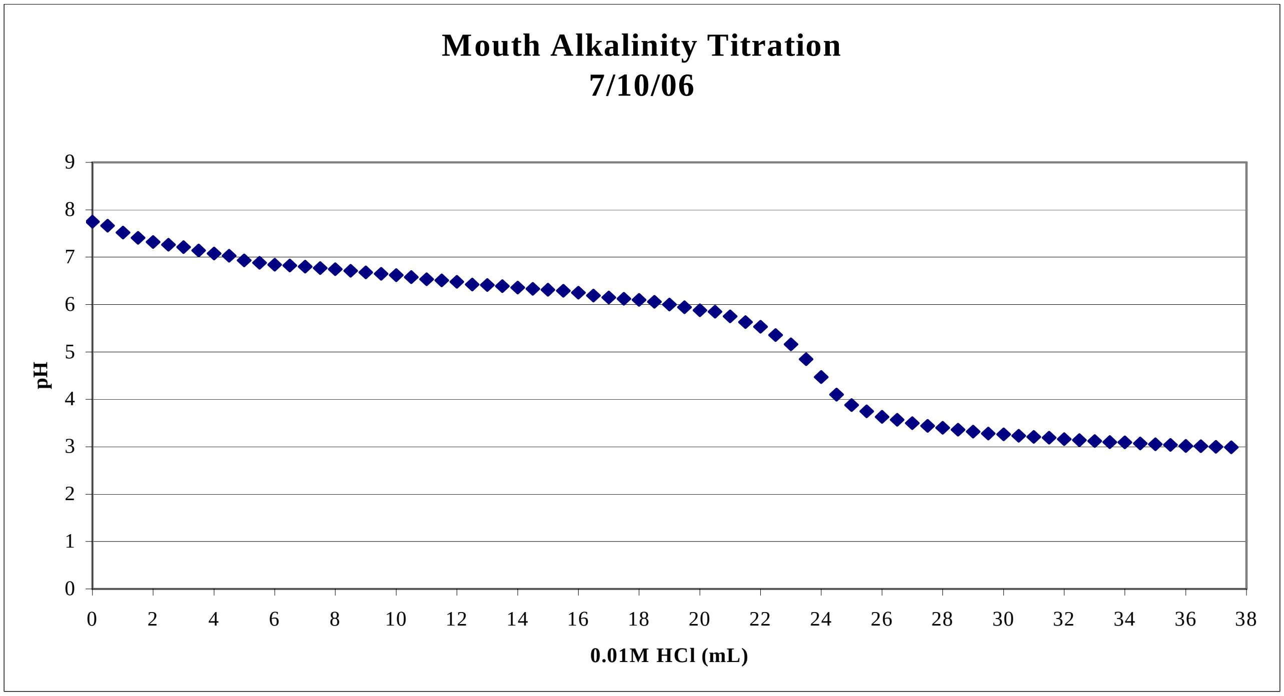


Figure 2: Lake

Lonely Outlet Alkalinity Titration Using 0.002 M HCl

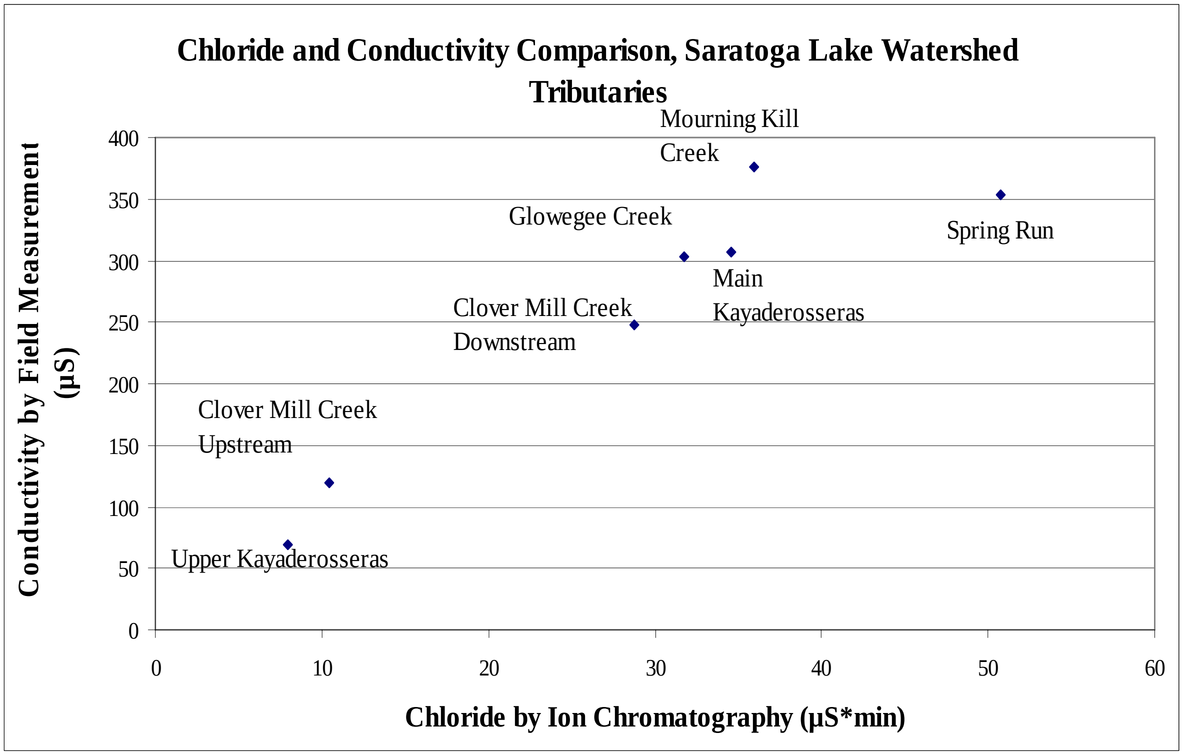
Figure 3: Kayaderosseras Creek Mouth Alkalinity Titration Using 0.002 M HCl



The relationship between conductivity and chloride concentration

There appears to be a nearly proportional relationship between conductivity and chloride (Figure 4). For any points that do not correspond to this relationship due to high conductivity with low chloride, it can be assumed that there is bicarbonate present which is providing a higher conductivity level. Isolated tributaries have lower conductivity and chloride levels than those tributaries in close proximity to development and habitation (Figure 4).

Figure 4: Correlation between Chloride and Conductivity



Using the information from Tables 3 and 4, Figure 4 was constructed. This shows a directly proportional relationship between conductivity and chloride.

Conclusions:

Tributaries that are isolated and farther from human habitation and development have lower nutrient levels and conductivity in comparison to those tributaries adjacent to highways, development and habitation. Spring Run has by far the highest nutrient and conductivity levels, as well as the lowest DO and highest TSS levels. Spring Run runs under and through Saratoga Springs and connects with storm drains under the city.

Currently the USGS Glowegee Flow Gauge is the only flow gauge in the Kayaderosseras Creek watershed. We hope to install a few flow gauges on some other tributaries this fall, or more likely, next spring or summer. It is important to know the percentage of flow that Spring Run and Lake Lonely contribute to Saratoga Lake. With flow measurement we could determine how much of the nutrient loading to Saratoga Lake comes from individual tributaries. For example, the higher the percentage of flow coming from Spring Run, the more urgent monitoring and remediation is at this tributary.

It is clear that there has been an influx of nutrients into the Kayaderosseras Creek and its tributaries. The influx of nutrients is caused by human activity, development, municipalities, industrial processes, and recreation. This influx is grounds for future monitoring and possible remediation. Water chemistry characteristics can be influenced and changed by many factors including the seasons, temperature, precipitation, recent human recreation, or tourist season in Saratoga Springs. It is important to observe water chemistry characteristics over several years and several seasons. In addition to continuing water chemistry monitoring and beginning water flow monitoring, in the future, we plan to compare our results with past water quality monitoring data which was collected and organized during this study.

Total nitrogen and total phosphorus may be used to estimate the trophic state of the stream although the guidelines presented in Table 10 are strictly applicable only to lakes. The concentrations of nitrogen and phosphorus in the Kayaderosseras Creek and the Mouth are both indications of a mesotrophic state, while the concentrations in the Lake Lonely Outlet in this study suggest a eutrophic state.

Table 10: Trophic Table for Phosphorus and Nitrogen Levels in Fresh Lakes

Nutrient	Oligotrophic	Mesotrophic	Eutrophic	Hypereutrophic
Phosphorus (ppb)	0-10	10-30	30-100	>100
Nitrogen (ppb)	0-350	350-650	650-1200	>1200

Since the Lake Lonely Outlet has a confluence with the Kayaderosseras Creek and concentrations at the Mouth are higher than in the main Kayaderosseras Creek, this suggests that the Lake Lonely Outlet is significantly influencing the trophic state of the Mouth of the

Kayaderosseras.

The water quality monitoring of the Kayaderosseras Creek and its tributaries in Saratoga Lake watershed is primarily intended to serve as a baseline for future water quality monitoring and water chemistry research projects. This knowledge may be useful for policy decision making, preserving the watershed and reducing contaminates.

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Appendix:
Figure 1:

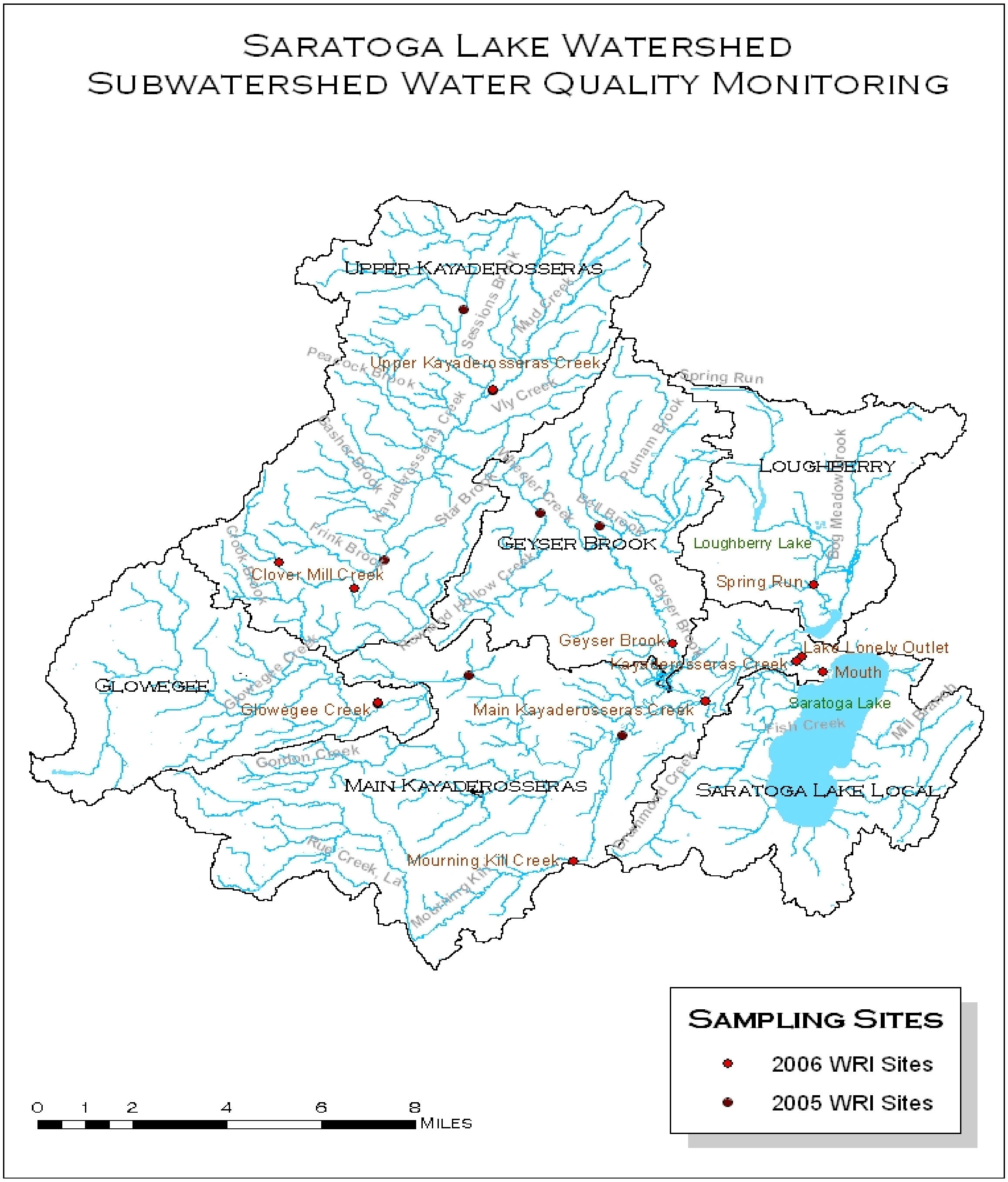


Figure A1 shows Saratoga Lake watershed with its sub watersheds (Upper Kayaderosseras, Glowegee, Geyser Brook, Main Kayaderosseras, Loughberry, and Saratoga Lake Local) delineated as well as 2005 and 2006 WRI sampling sites and their respective streams.

Figure A2: Comparison of Tributaries Closest To and Farthest From Development

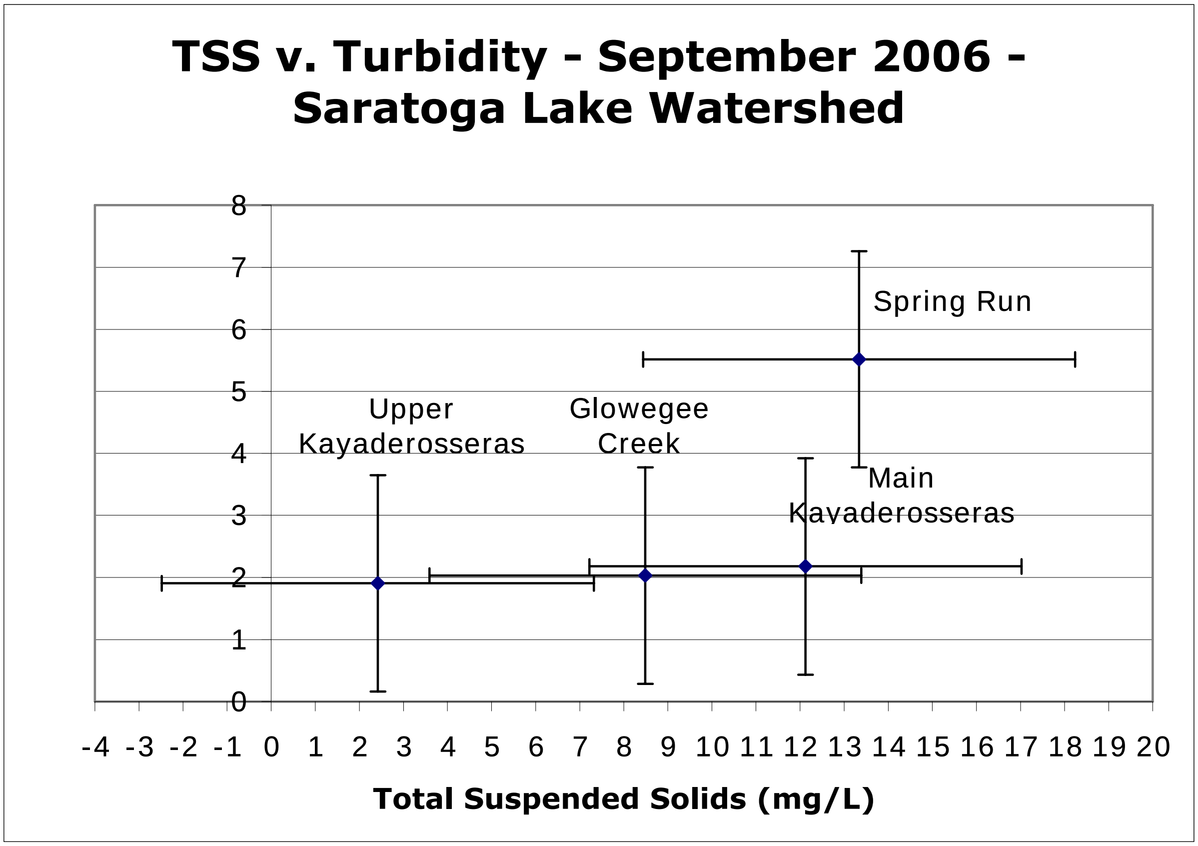
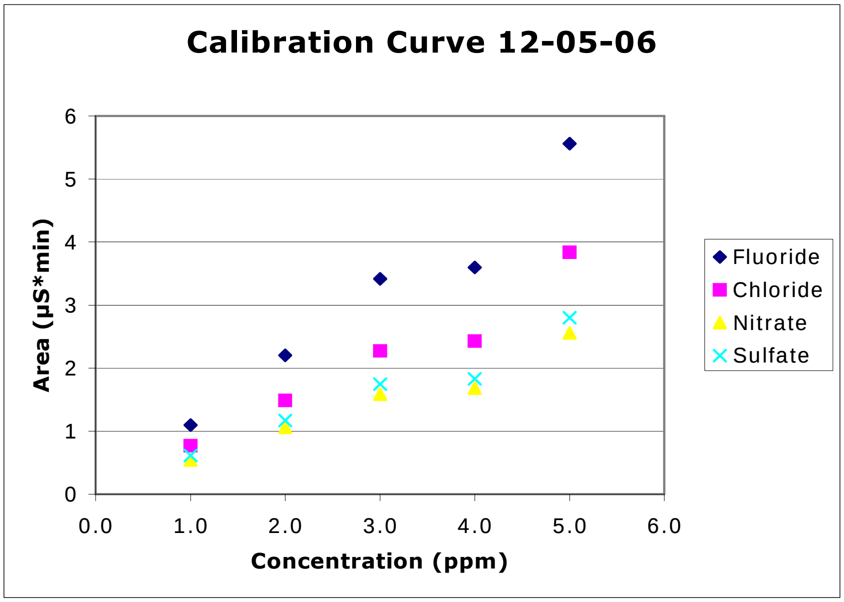


Figure A2 shows there is a rough, but noticeable correlation between total suspended solids and turbidity. As total suspended solids increases, turbidity should also increase because it measures water clarity. There is also a correlation between proximity to development and increased turbidity and total suspended solids. As shown, Spring Run's turbidity and total suspended solids are much higher than the other streams and is therefore much more impacted by development.

Figure A3: Ion Chromatograph Standard Calibration Curve



Calibration Curve 12-05-06
Area (µS*min)
0
1
2
3
4
5
6
0.0
1.0
2.0
3.0
4.0
5.0
6.0
Concentration (ppm)
Fluoride
Chloride
Nitrate
Sulfate