Water Quality Monitoring in the Kayaderosseras Creek Watershed: Summer 2007

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by:

Alicea Cock-Esteb, '09
Alexandra Furman, '09
Lukiana Anka-Lufford, '10
Kim Marsella, Environmental Studies Program
Judith Halstead*, Chemistry Department

* Corresponding Author: Judith Ann Halstead, Professor of Chemistry, Skidmore College, Saratoga Springs, NY 12866

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Abstract

Water quality parameters were determined for one lake and various tributaries throughout the Kayaderosseras Creek Watershed in Saratoga County, NY. Discharge measurements (cubic feet per second) were also determined at eleven sites. Field measurements included dissolved oxygen (DO), temperature, conductivity and pH. Samples were collected and subsequently analyzed for total phosphorous (TP), phosphate, total nitrogen (TN), nitrate, dissolved organic compounds and total suspended solids (TSS). There were three major components of the study. The first focused on Lake Lonely and the impact of the two inlets (Spring Run and Bog Meadow Brook) into Lake Lonely. Spring Run and Bog Meadow Brook were found to contribute significantly to Lake Lonely's nutrient (TN and TP) and salinity loading. Bog Meadow's average summer flow was approximately seventeen percent greater than Spring Run's flow. In order to understand Lake Lonely in relationship to neighboring Saratoga county water bodies (not in the Kayaderosseras Creek Watershed), temperature, dissolved oxygen, specific conductance, secchi depth, TN and TP were also measured in Moreau Lake and Lake Desolation. Lake Lonely was determined to be mesotrophic while Moreau Lake was oligotrophic and Lake Desolation was borderline mesotrophic-oligotrophic. The second portion of the study focused on the Lake Lonely outlet and its confluence with the Kayaderosseras Creek. High conductivity from the Lake Lonely Outlet impacts the overall conductivity of the Kayaderosseras Creek even though the flow is only approximately one fifth of the Kayaderosseras Creek. The third study focused on nine tributaries throughout the Kayaderosseras Creek Watershed and their individual impacts on the Kayaderosseras Creek: Upper Kayaderosseras, Main Kayaderosseras, Glowegee Creek, Geyser Brook, Clover Mill upstream, Clover Mill downstream, Morning Kill, Spring Run (at two different sites), and Bog Meadow Brook (at three different sites). While in 2006, tributaries that were further upstream in the watershed and farther from human habitation and development had lower nutrient levels and conductivity in comparison to those tributaries further downstream in the watershed and adjacent to highways, development and habitation, this was less clear in 2007. Both years Spring Run had higher nutrient and conductivity levels than all other tributaries studied. This study is a part of an ongoing water monitoring study conducted through the Skidmore College Water Resource Initiative.

Introduction

Lake Lonely Study

Lake Lonely is located in the Saratoga Lake Watershed, just southeast of Saratoga Springs, NY (Figure 1). Its surface area is 136 acres with a maximum depth of 12.2 meters and a drainage basin area of 13,632 acres.[1] Its two tributaries, Spring Run and Bog Meadow Brook, flow from the north (Figure 2). Spring Run runs through the city of Saratoga Springs, under Interstate 87, through wetlands and into Lake Lonely. Bog Meadow Brook drains mainly through wetlands though there is also suburban development in the Bog Meadow subwatershed. Both tributaries had more than one sampling site location—at the confluence (Trib.-C), at the intersection of 9P (Trib.-R), and one at Route 29 (BMB-29) for Bog Meadow (for GPS coordinates, see Appendix A.1, C.1). Lake Lonely has one main outlet (LLO) that drains into the Main Kayaderosseras Creek.

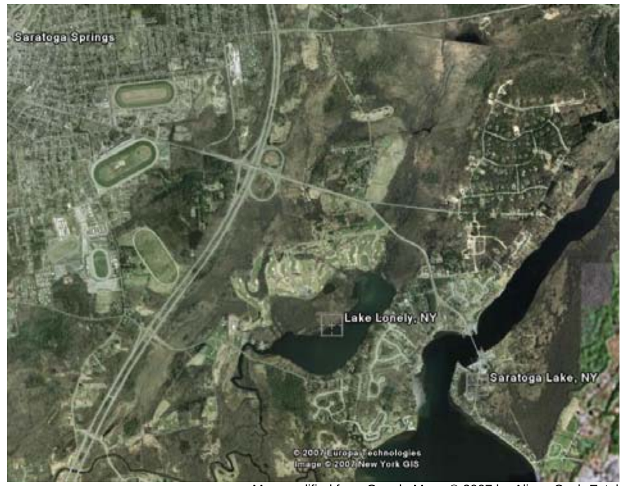

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Figure 1: Lake Lonely, NY.

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Figure 2: Lake Lonely and its tributaries.

Confluence Study

The Lake Lonely Outlet is the last tributary of the Kayaderosseras Creek before it flows into Saratoga Lake (Figure 3). The Kayaderosseras Creek sub-watershed drains approximately 119,680 acres.[2] For this study, there were three site locations on the Kayaderosseras Creek—the Upper Kayaderosseras (in the tributary study), the Main Kayaderosseras at Rte. 9N (MaK-R), and the Main Kayaderosseras just upstream of the confluence with the lake lonely outlet (MaK-C).

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Figure 3: Confluence of the Lake Lonely Outlet with the Main Kayaderosseras Creek.

Tributary Study

Nine tributary sites were selected to study based on previous data collection points from Kristina Connolly and Judy Halstead in the Summer of 2006 as well as general accessibility. These nine sites include: the Upper Kayaderosseras, Clover Mill Creek (upstream and downstream of an old landfill), Glowegee Creek (downstream of the Knolls Atomic Power Laboratory in West Milton, NY, and the site of a USGS monitoring station), and the Mourning Kill (Figure 4). In addition, the Main Kayaderosseras-R, Geyser Brook (which runs through Spa State Park), Spring Run-R, and Bog Meadow Brook-R were studied (for GPS coordinates, see Appendix C.1).

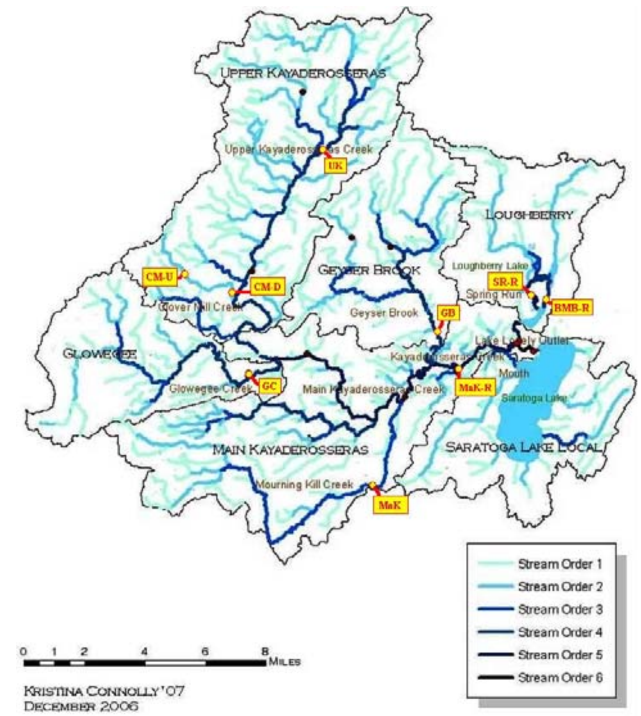

Figure 4: Nine selected tributaries in the Kayaderosseras Creek watershed.

Field Chemistry

Thermal stratification is detected by measuring temperature as a function of depth. Water has a maximum density at 4 °C. Colder, denser water sinks to the bottom of a lake, while warmer, less dense water lies near the surface.[3] There are three main layers in a thermally stratified lake, the epilimnion (or upper layer), the metalimnion (or middle layer), and the hypolimnion (the lower layer).[3] The thermocline is within the metalimnion and is the depth at which the temperature changes the fastest (the point on the graph where the slope is the greatest).[3] Lakes that thermally stratify in the summer will likely produce a pattern for dissolved oxygen (DO).[3] High concentrations of dissolved oxygen are often in the epilimnion due to wind and photosynthesis, while the hypolimnion may have little to no dissolved oxygen because stratification results in little dissolved oxygen input and decomposition consumes the oxygen.

The pH scale quantifies the acidity (or basicity) of the water body. The more extreme the pH is in either direction (more acidic towards pH 1 and more basic towards pH 14), the fewer organisms are able to sustain life. Conductivity is a measure of a water's ability to conduct electricity. The higher the amount of dissolved salts (ions), the higher the conductivity. These ions can be natural or anthropogenic and include minerals. Often specific conductance is measured, which is conductivity normalized to 25 °C. Both suspended organics and inorganics can cloud up water, otherwise known as turbidity. Turbidity can be measured by noting the depth at which a Secchi disk—a weighted disk with diameter of 20 cm divided into alternating black and white quadrants—can no longer be seen in the water. Water samples can also be collected to test for total suspended solids (TSS), an additional indication of turbidity.

Nutrients

Eutrophication is the aging of a lake and can be measured using nutrient levels, dissolved oxygen content, and turbidity. There are four states of aging also classified by productivity (trophic states), known as oligotrophic (youngest or least productive), mesotrophic, eutrophic, and hypereutrophic (oldest or most productive).[3] More eutrophic, more turbid, lakes give lower Secchi disc readings (Table 1).

Phosphorus, preferably measured as total phosphorus, is often the limiting nutrient for plant growth in bodies of fresh water.[4] It enters water naturally via rocks, soil, animal excretion, the atmosphere, and plants.[4] Phosphorus may be added anthropogenically through sewage, agricultural runoff, fertilizers, and atmospheric pollution.[4] Increased levels of phosphorus can lead to the eutrophication of a water body (Table 1). Nitrogen can come from some of the same sources as phosphorus. While phosphorus is generally the limiting nutrient in freshwater systems, nitrogen may also contribute to the eutrophication of water bodies.

Table 1: Trophic State Indicator[5]

Indicator	Oligotrophic	Mesotrophic	Eutrophic	Hypereutrophic
Total Phosphorus (µg P/L)	<10	10-30	30-100	>100
Total Nitrogen (mg N/L)	<0.35	0.35-0.65	0.65-1.2	>1.2
Secchi Disk Depth (m)	>4	4-2	2-1	<1

The trophic state of water body can also be determined using a trophic state index (Table 2, Table 3).

Table 2: Carlson's Trophic State Index (TSI): Possible changes in a north temperate lake as the trophic state changes.[6]

TSI	Attributes	Water Supply
<30	**Oligotrophy:** Clear water, oxygen throughout the year in the hypolimnion	Water may be suitable for unfiltered water supply
30-40	Hypolimnia of shallower lakes may become anoxic	
40-50	**Mesotrophy:** Water moderately clear, increasing probability of hypolimnetic anoxia during summer	Iron, manganese, taste, and odor problems worsen. Raw water turbidity requires filtration.
50-60	**Eutrophy:** Anoxic hypolimnia, macrophyte problems possible	
60-70	Blue-green algae dominate, algal scums and macrophyte problems	Episodes of severe taste and odor possible.
>70	**Hypereutrophy:** (light limited productivity) Dense algae and macrophytes	

Table 3: Equations for calculating TSI values for Total Nitrogen (mg/L), Total Phosphorus (µg/L), and Secchi Depth (m).	
Total Nitrogen (mg/L)[7]	TSI = 54.45 + 14.43 ln (TN)
Total Phosphorus (µg/L)[6]	TSI = 4.15 + 14.42 ln (TP)
Secchi Depth (m)[6]	TSI = 60 - 14.41 ln (SD)

Flow

Stream flow, or discharge, is a numerical value that describes the volume of water moving past a certain point in a given time. Discharge is the integrated product of cross-sectional area and velocity. Several methods can be used to determine flow including manual measurements, a salt tracer method, and using water levels with standard curves of level versus discharge. Flow will vary according to the size of the watershed, the geology, and the time of year. Discharge measurements taken during and after storm events can provide information on how different parts of the watershed respond to these events.

Nutrient Loading

Loading, the total amount of a chemical coming into a lake or passing a point in a stream, can be determined multiplying the flow by the chemical concentrations. Nutrient loading data may be helpful in evaluating the most significant contributors to nutrients within the watershed.

Experimental Methods

Lake Lonely Study—On the Lake

Before going out into the field on June 7, June 27, July 12, and August 7, 2007, five meters were calibrated following the manufacturer manuals for each: two YSI 550A Dissolved Oxygen meters, two YSI 30 Salinity and Conductivity meters, and one YSI 60 pH meter.

On each of the field days samples were collected and a number of chemical properties were measured at a location towards the middle of Lake Lonely (Figure 6). The total depth was found and a Secchi disk was used to determine the turbidity. Using both dissolved oxygen meters, dissolved oxygen in parts per million and percent saturation, as well as temperature were found as a function of depth. Using one of the YSI 30 meters, conductivity and specific conductance were found as a function of depth. A Van Dorn sampler was used to collect water samples at four different depths on June 7, June 27, and July 12, and three different depths on August 7, 2007. An additional five and ten water samples were collected from the surface of the water body to be tested for total suspended solids (TSS) on June 7 and July 12, 2007, respectively.

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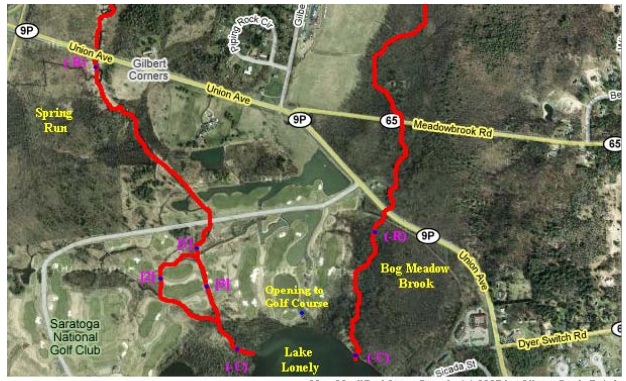
Figure 6: Lake Lonely 2007 sampling site.

Lake Lonely Study—Inlets to Lake Lonely

Following Lake Lonely data and sample collection, data was recorded at both Spring Run-C, Bog Meadow Brook-C, and once at a golf course outlet (an opening into Saratoga National Golf Club in between the Spring Run and Bog Meadow Brook inlets) (Figure 2). At each of these sites the total depth and the distance from Lake Lonely were recorded. The dissolved oxygen, percent saturation, temperature, conductivity and specific conductance were measured. These measurements were recorded at a depth of one-half meter down in Bog Meadow Brook and at one quarter of a meter down in Spring Run. In both creeks two grab samples were taken from the same respective depths as the other data. Five or ten samples were collected from just below the surface of both to determine TSS.



Map Modified from Google (c) 2007 by Alicea Cock-Esteb

Figure 2: Lake Lonely and its tributaries.

In addition, at both of these sites manual flow measurements were taken. Taking stream flow measurements manually was most efficient in channels shallow enough to wade in. This procedure used a top-set rod, a flow meter, a tape measurer, a long nail, and preferably a water-resistant field notebook. This technique involved measuring length, width, and velocity incrementally across the channel. The given channel's width was measured using a tape measure, which was secured to the channel banks. The total width of the stream channel was broken down into six to ten, relatively equal sections. The flow-meter bulb was fastened onto the bottom of the top-set rod, and was pointed upstream for each measurement at a flow depth of 60% of the total depth. At each section, the width (m) was recorded off of the tape measurer, the depth (m) was measured with the top-set rod, and the velocity (ft/s) was recorded using the flow-meter and converted to m/s because at low flow, the meter is more sensitive in ft/s mode. The discharge for each section was then calculated and summed for total discharge of the section. Discharge was reported in both m^3/s and ft^3/s.

Lake Lonely Study—Treatment of Samples in Lab

Once back in the lab, the samples collected via the Van Dorn sampler were filtered and placed into pre-labeled and pretreated bottles to send to the Darrin Freshwater Institute (DFWI) in order to test for nitrates, total nitrogen (TN), total phosphorus (TP), soluble reactive phosphates, and ammonia. The equipment was rinsed three times with doubly deionized water (DDW) before filtration. Filter paper (47 mm diameter, 0.45 micron membrane) was placed in the magnetic vacuum filtration set-up using tweezers and washed with DDW twice. After the DDW was removed, the filter paper was washed with the sample (~20 mL) which was then used to wash the new sample bottle with. The sample (~500 mL) was filtered, placed in the collection bottle, and stored in the cold room.

Following filtration of the Van Dorn samples, TSS were found for each of the samples collected from each of the three water bodies. A glass-fiber filter paper for each sample was washed three times with DDW in a magnetic vacuum filtration set-up. The filter paper was then placed on a watch glass and placed in the drying oven. After one hour the filters were weighed and placed back into the oven. The filters were weighed at half-hour intervals until a constant mass was reached. Once a filter was weighed to constant mass, it was placed in the filter set-up and washed with DDW. A 200 mL sample was filtered and washed with DDW three times. The filtered water was removed and the filter paper was placed back on the watch glass in the oven. Once again the filter papers were weighed to a constant mass (requiring several days). The difference between the final and initial masses was found and the milligrams of total suspended solids per volume filtered were calculated.

Lake Lonely Study—Comparison Lakes

On July 24, 2007 total depth, conductivity, specific conductance, salinity, dissolved oxygen, percent saturation, pH, and Secchi depth were measured on Moreau Lake and Lake Desolation (Figure 7). Two samples were collected at two depths from both lakes to be measured for nitrate, total nitrogen, total phosphorus, soluble reactive phosphates, and ammonia at DFWI.

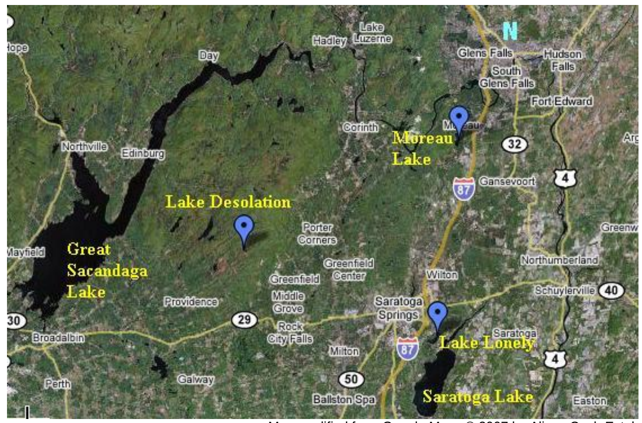


Figure 7: Comparison lakes throughout Saratoga County—Moreau Lake, Lake Desolation, and Lake Lonely.

Lake Lonely Confluence Study

On June 13, June 27, July 5, July 12, and July 25, 2007, total depth, conductivity, specific conductance, salinity, dissolved oxygen, percent saturation, and pH were measured using pre-calibrated meters on the Main Kayaderosseras a few hundred meters upstream of the Confluence (Main Kayaderosseras-C) and the Lake Lonely Outlet (LLO) (Figure 3). Water samples were collected at one half of a meter down on both the Main Kayaderosseras-C and the LLO on June 27 (to be tested at DFWI for nitrates, total nitrogen, total phosphorus, soluble reactive phosphates, and ammonia) and July 25 (to be frozen for future use).

On June 25 and June 26, 2007 three sites were surveyed in the Main Kayaderosseras-C and in the LLO. The

Figure 3: Confluence of the Lake Lonely Outlet with the Main Kayaderosseras Creek (-C).

survey sites were chosen based on proximity to each other and on accessibility—excess vegetation limits surveying ease. A measuring tape was secured to each bank approximately five meters back and perpendicular to the channel. The channel was broken up into segments where noticeable elevation changes occurred (typically every 1 to 3 meters). At known widths, a stadia rod was held vertically at each segment while a height reading was recorded through a level. In addition, readings were taken at the top of each bank, halfway down each bank, and at the water's edge. Back in the lab, all this information was plotted onto six separate graphs, each plotting width versus the corresponding height and including a reference point. An average cross-sectional area was calculated from the surveyed sites.

On June 26, June 27, July 5, July 12, and July 25, 2007 the sodium chloride tracer method was used to determine discharge due to the tedious, time consuming, and possibly dangerous nature of manual flow in large-scale channels. Water levels at each of the six surveyed sites were measured, starting at the Main Kayaderosseras-C_02 (Figure 8). Height measurements on top of the bank and at the water level were found by reading the stadia rod at each of those points from a level location in between them.

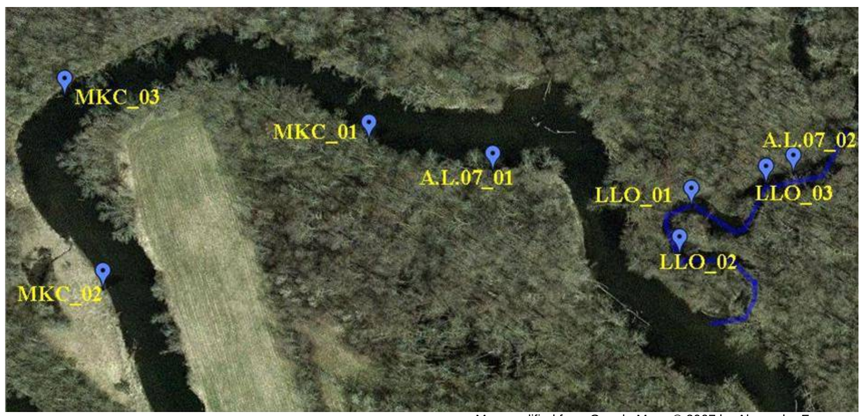


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Figure 8: Each site used for surveying and sodium chloride tracer test relative to the Lake Lonely Outlet and the Main Kayaderosseras Creek-C.

Four buckets were filled up with water in which thirty pounds of salt was dissolved equally. Conductivity was measured at two locations in the creek a known distance apart at one half of a meter deep, every thirty seconds. Once baseline conductivity was established, the salt water was dumped into the creek upstream of both conductivity measuring sites. A gradual rise, peak, and decline in conductivity were recorded at each of the locations. The difference in time between the two peaks in conductivity and the distance between measurements was used to calculate velocity. The same procedure was conducted in the LLO using only twenty pounds of salt. The flow was calculated by multiplying the velocity (distance between conductivity locations divided by the time in between two conductivity peaks) by the cross-sectional area. The cross-sectional area was determined from the initial area calculated by surveying and the changed water level measurements using a digitizer computer program.

On June 27, 2007 two auto loggers were installed at the confluence—one on the Main Kayaderosseras-C (A.L._0701) and one on the LLO (A.L._0702) (Figure 8). The automatic loggers were programmed to measure and record stream gage height every hour. Discharge measured during seasonal changes will allow for the creation of a trend line representing the relationship between gage height and discharge, ultimately estimating discharge on days when flow is not recorded in the field.

Tributary Study

On June 19, July 3, and July 18, 2007, pH, temperature, dissolved oxygen, conductivity and salinity were tested at each of the nine sites previously identified and described (Figure 4). Flow measurements were taken using the manual flow method. In addition, samples were collected at each site and tested for nutrient content including nitrates, total nitrogen, total phosphorus, soluble reactive phosphates, and ammonia.

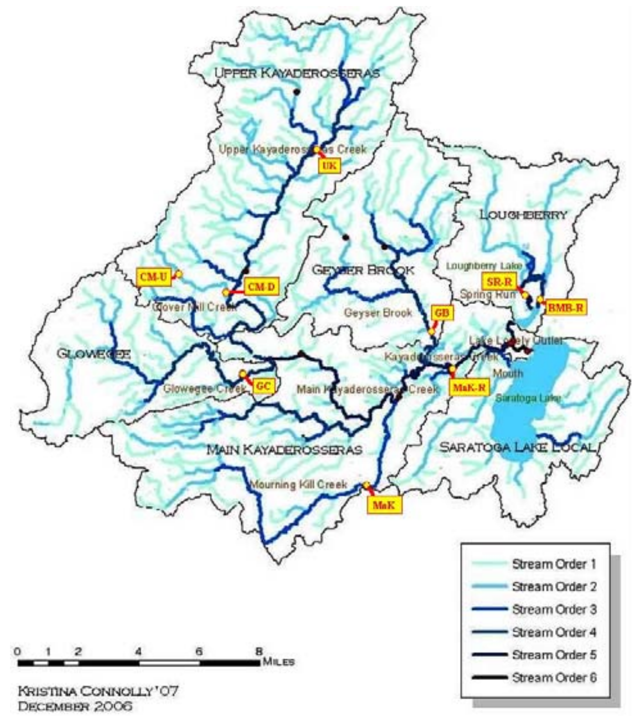


Figure 4: Nine selected tributaries in the Kayaderosseras Creek watershed.

Results and Discussion

Lake Lonely Study—Field Chemistry Measurements

Temperature and dissolved oxygen were measured as a function of depth in Lake Lonely on various dates throughout the summer of 2007 (Figure 9). Lake Lonely, a dimictic[‡] lake, stratifies in the summer into two layers, a well mixed top layer (epilimnion) and a colder deep water layer (hypolimnion). The thermocline or transition zone between these two layers was approximately four to six meters through the summer of 2007. The top layer increased in temperature through the summer, a trend that is expected as days warm. The dissolved oxygen (DO) was well mixed throughout the top layer due to wind and photosynthesis. However, the DO in the bottom layer became depleted, probably due to organic decomposition, as the summer progressed. By August, the bottom few meters were entirely depleted of oxygen, preventing the natural aerobic decay of organic material in the lower layer (Figure 9).

While the dissolved oxygen profile varied throughout the summer study, the average dissolved oxygen (percent saturation) in the thermocline region decreased steadily as the summer progressed. The average dissolved oxygen in the thermocline region was roughly 74% on 6/7/07, 63% on 6/27/07, 57% on 7/12/07, and 21% on 8/7/07. On three out of four of these field measurement dates, the DO profile was observed to go through a minimum in or near the thermocline region, also known as the metalimnion.

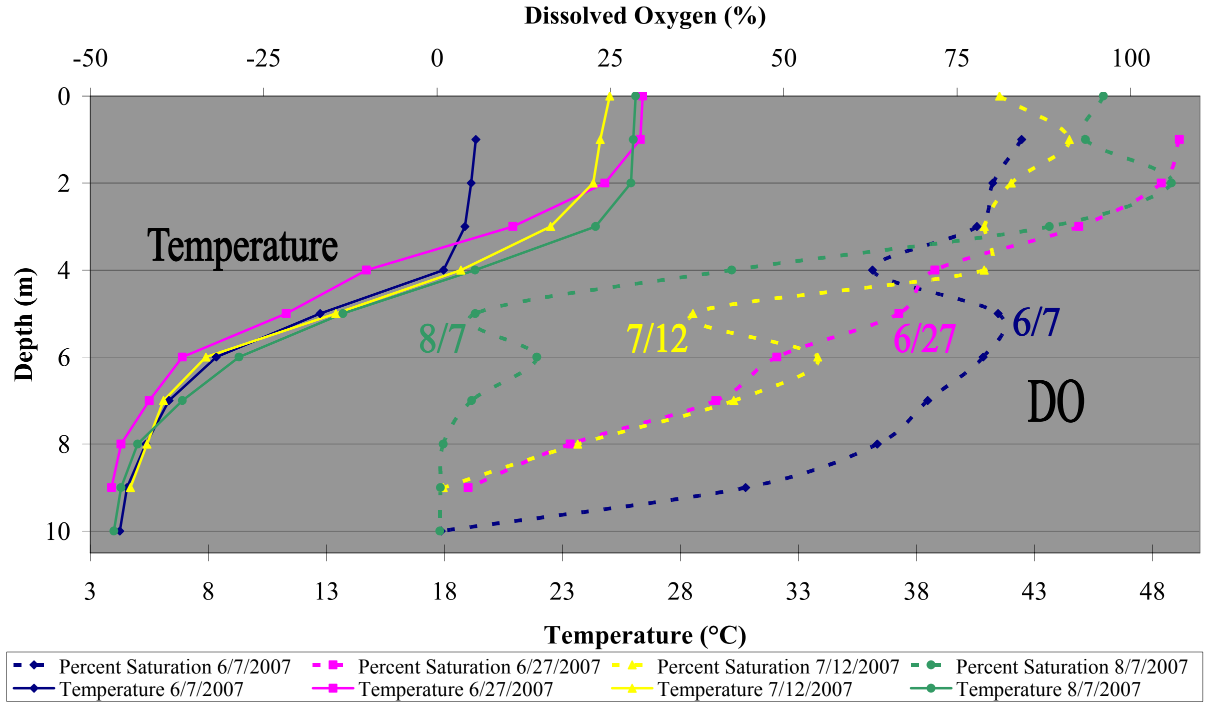
Observation of a maximum in % DO in or near the thermocline region of a lake is not unusual and can be attributed to an increase in photosynthetic activity (e.g. by phytoplankton), as nutrients from the lower layer of the lake (hypolimnion) meet light from the well-mixed top layer of the lake. Photosynthesis is generally thought to be possible throughout the layer from the top of the lake to the depth corresponding to a light intensity of approximately 1% of the surface light intensity.[8,9] This zone is referred to as the photic zone[10] or euphotic zone[8,9]. It is often proposed that the depth of the euphotic zone can be approximated using Secchi disk depth. According to various studies, the euphotic zone depth is 1.7 – 3 times[11,10] the visibility depth of

‡ Dimictic lakes mix (or overturn) twice a year, fall and spring.

the Secchi disk. However, this value range does not apply to any of the observations in the current study. Moreau Lake (Figure 12) appears to have a euphotic zone at 6 meters deep (Figure 12) with a Secchi disk reading of 10 meters—a relationship opposite the literature. No conclusions can be drawn from the Lake Lonely DO profiles about the euphotic zone and its relationship to collected Secchi disk measurements.

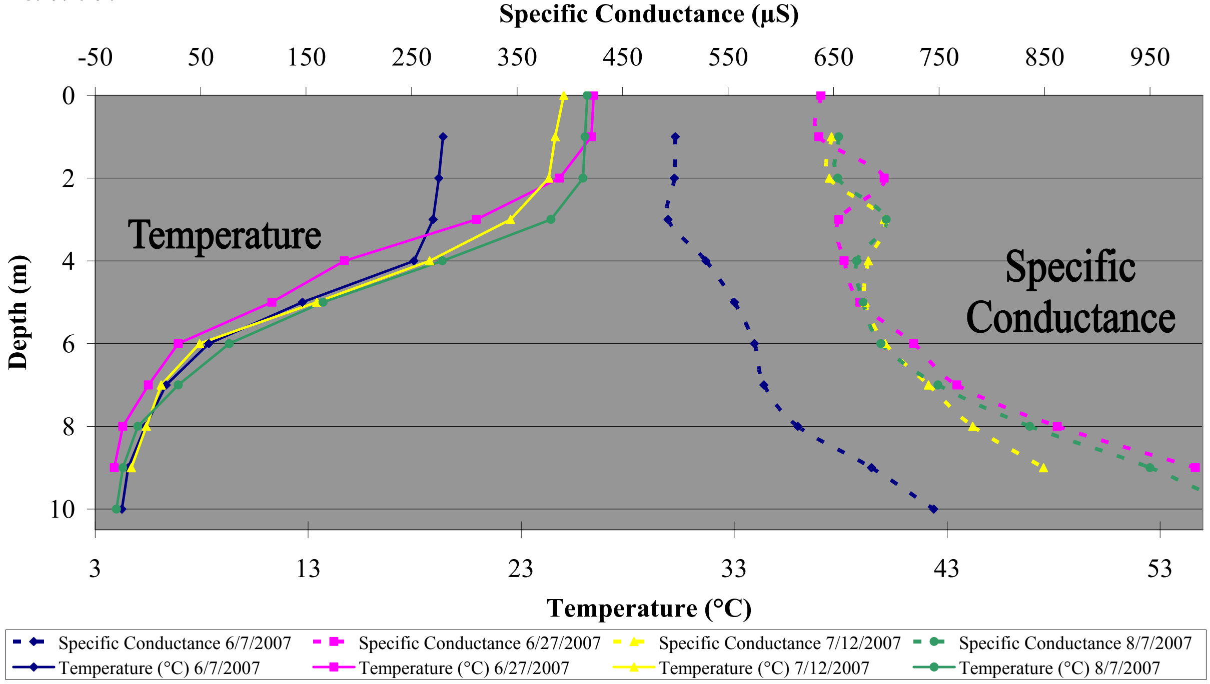
Four types of DO profiles are described by Cole.[8] A DO profile showing a pronounced maximum in the thermocline is referred to as a positive heterograde distribution.[8] In the current work, a classic positive heterograde DO distribution was observed in Moreau Lake on 7/24/07 (Figure 12). Cole also describes a negative heterograde DO profile in which the DO is observed to go through a minimum in the thermocline.[8] This negative heterograde DO profile was observed in the current work on Lake Lonely on 6/7/07, 7/12/07, and 8/7/07. One explanation Cole mentions for negative heterograde DO profiles is the "horizontal movement of water from regions where organic sediments have lowered oxygen levels."[8] The horizontal movement of water in Lake Lonely in the summer of 2007 is consistent with specific conductivity profiles (Figure 10 and 13), as well as the negative heterograde DO profiles (Figure 9).

Figure 9: Temperature (°C) and Dissolved Oxygen (%) as a Function of Depth of Lake Lonely on 6/7/07, 6/27/07, 7/12/07, and 8/7/07.



Specific conductance was measured as a function of depth in Lake Lonely (Figure 10). The main observable trend in the specific conductance was that it rapidly increased towards the bottom of the lake, though the small maxima at or near the thermocline may indicate lateral water movement as already noted. Material contributing to this conductivity could be coming off of the sediments in the lake bottom from deposited inorganics; however, future investigation of this is needed. A contributing factor could be the copper sulfate that is added to the lake yearly in order to control algal growth. This study did not address this question and future investigation is suggested to examine this factor.

Figure 10: Specific Conductance (µS) and Temperature (°C) as a Function of Depth of Lake Lonely on 6/7/07, 6/27/07, 7/12/07, and 8/7/07.



A Secchi disk was used to observe turbidity in Lake Lonely (Table 4). The Secchi disk was visible close to three meters on every date. This Secchi disk depth suggests that Lake Lonely is in a mesotrophic state, as determined by accepted freshwater standards that characterize mesotrophic lakes as having between two and four meter Secchi disk measurements (Table 1).[5]

Table 4: Secchi Disk Depth Measurements on 6/7/07, 6/27/07, 7/12/07, and 8/7/07.

Date	Depth (m)
6/7/2007	3.2
6/27/2007	3.2
7/12/2007	3.0
8/7/2007	3.1

Lake Lonely Study—Field Chemistry Measurements: Comparison Lakes

In order to understand Lake Lonely (measured total depth at site = ~10-11 m) in relationship to neighboring water bodies, temperature (Figure 11), dissolved oxygen (Figure 12), and specific conductance (Figure 13) were measured as a function of depth on both Moreau Lake (measured total depth at site = ~14 m) and Lake Desolation (measured total depth at site = ~6.5 m). While these lakes are nearby, they do not necessarily have similar drainage basin characteristics such as development and geology. All three are dimictic and layers of stratification were observed around three meters for Lake Desolation and five meters for Moreau Lake. Stratification is observed at varying depths in a lake depending on the lake's total depth.

All three lakes showed mixing at the top (as observed from the dissolved oxygen profile) and oxygen depletion towards the bottom. Note that the temperature profile in the epilimnion for Lake Lonely is not as uniform as it is for the other two lakes. This is consistent with the lateral water movement suggested earlier.

Figure 11: Temperature as a Function of Depth of Moreau Lake, Lake Desolation and Lake Lonely, Summer 2007.

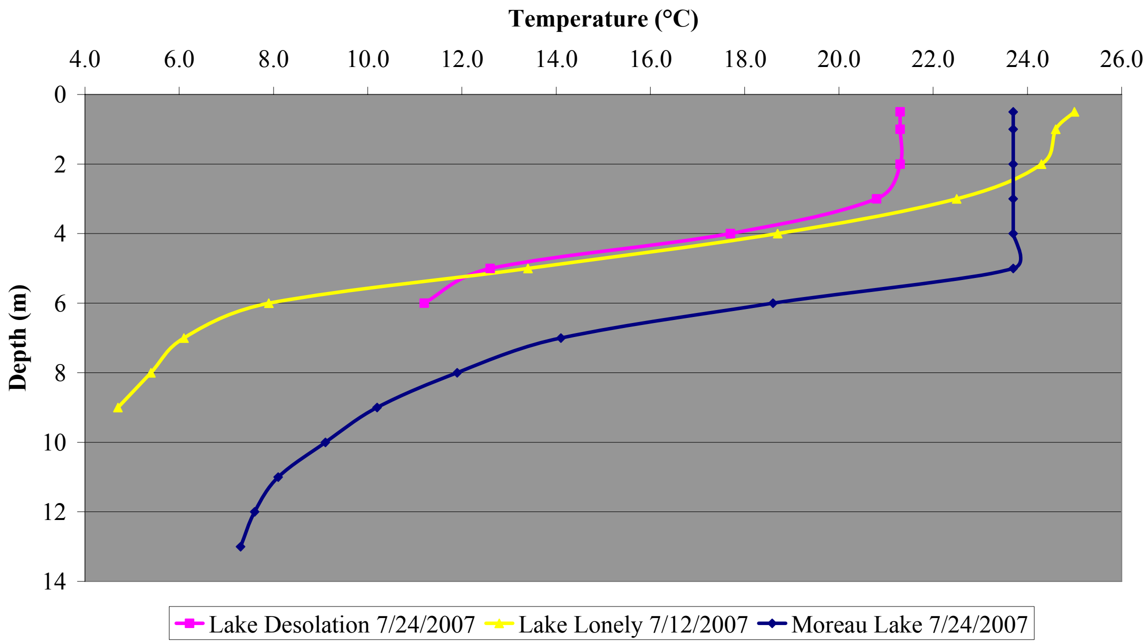


Figure 12: Dissolved Oxygen (%) as a Function of Depth of Moreau Lake, Lake Desolation and Lake Lonely.

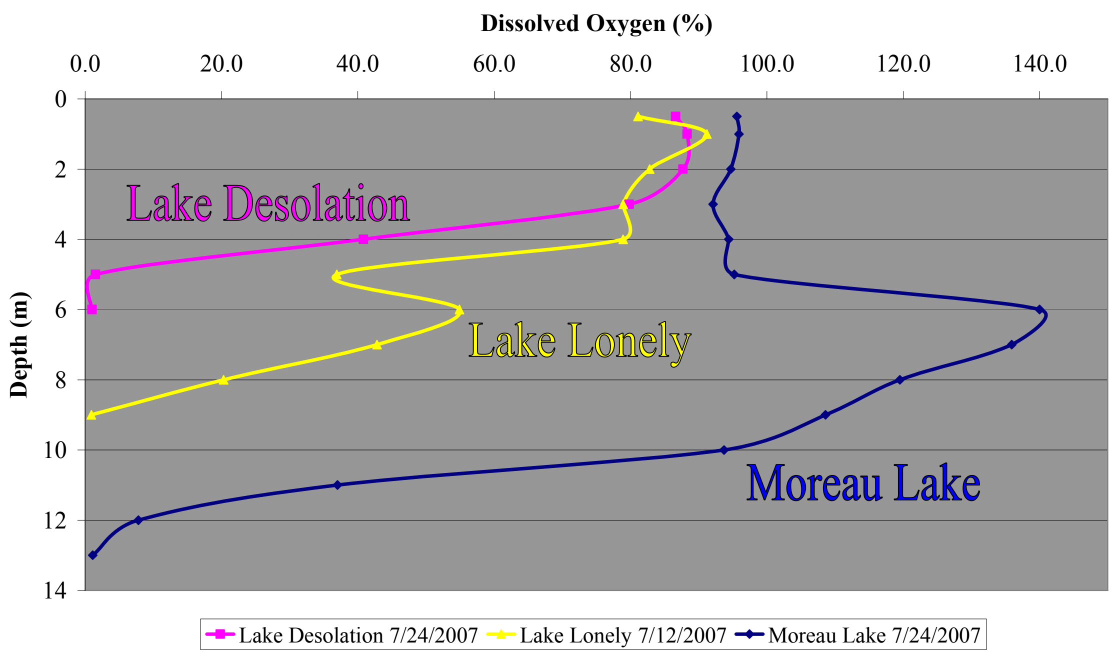
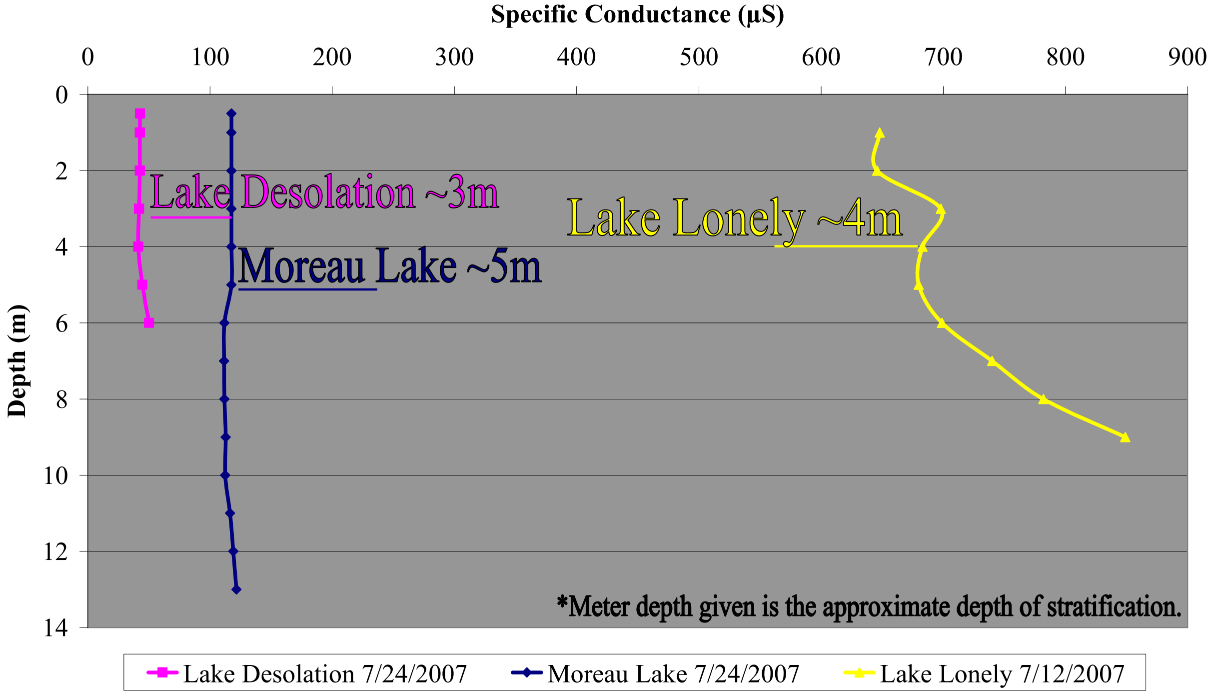


Figure 13: Specific Conductance as a Function of Depth of Moreau Lake, Lake Desolation and Lake Lonely.



While stratification was similar for all three lakes, the specific conductance and dissolved oxygen curves varied. The bottom of each lake was depleted of dissolved oxygen. On July 24, 2007 approximately the bottom 15% of Moreau Lake had dissolved oxygen content less than 10% compared to the bottom 25% of Lake Desolation. In mid-July, the bottom 15% of Lake Lonely had less than 10% dissolved oxygen but in early August, the bottom 30% of the lake had oxygen depleted below 10%.

As previously observed, specific conductance increased by nearly thirty percent from the top to the bottom in Lake Lonely. In comparison, specific conductance remained constant as a function of depth in the other two lakes. Not only was the specific conductance of Lake Lonely changing with depth, it was more than six times greater than both other lakes. Higher specific conductance in Lake Lonely could be due to a number of factors—natural, anthropogenic, or both. Spring Run and Bog Meadow Brook provide natural and anthropogenic sources of conductivity. Contributions to Spring Run's conductivity presumably include road salts from the city of Saratoga Springs, as well as natural minerals due to Saratoga Springs geology.

Secchi disks measurements allowed us to assess the turbidity of all three lakes (Table 5) and thereby characterize their trophic states based on this parameter. Secchi depths suggest mesotrophic status for Lake Lonely and Lake Desolation and oligotrophic for Moreau Lake.

Table 5: Total Depth, Secchi Disk Depth, Thermocline Depth, and pH of Moreau Lake (7/24/07), Lake Desolation (7/24/07), and Lake Lonely (7/12/07).

	Total Depth (m)	Secchi Disk Depth (m)	Thermocline Depth (m)	pH
Moreau Lake	14	10	5	7.81
Lake Desolation	6.5	3	3	7.28
Lake Lonely	10-11	3	4	7.7

Total nitrogen and total phosphorus were investigated as a function of depth in Moreau Lake and Lake Desolation on July 24, 2007 and compared with TN and TP of Lake Lonely on various dates (Figure 14, Figure 15). The surface nutrient values were used in addition to their respective Secchi disk depths to calculate trophic state indices using the Carlson model (Table 6). The calculated Carlson indices confirmed our observation that Lake Lonely is mesotrophic and Moreau Lake is oligotrophic. The indices indicated that Lake Desolation may be borderline between mesotrophic and oligotrophic. For Lake Desolation, the authors are inclined to trust the TSI for TP and TN more than the TSI based on the Secchi depth. Note that Lake Desolation is considerably shallower than the other two lakes studied and anything which recently disturbed the bottom would lower the Secchi depth. For both Lake Desolation and Moreau Lake, conclusions are based on only one day's results and more study is needed.

Figure 14: Total Nitrogen (mg N/L) of Moreau Lake, Lake Desolation, and Lake Lonely as a Function of Depth (m) During Summer 2007

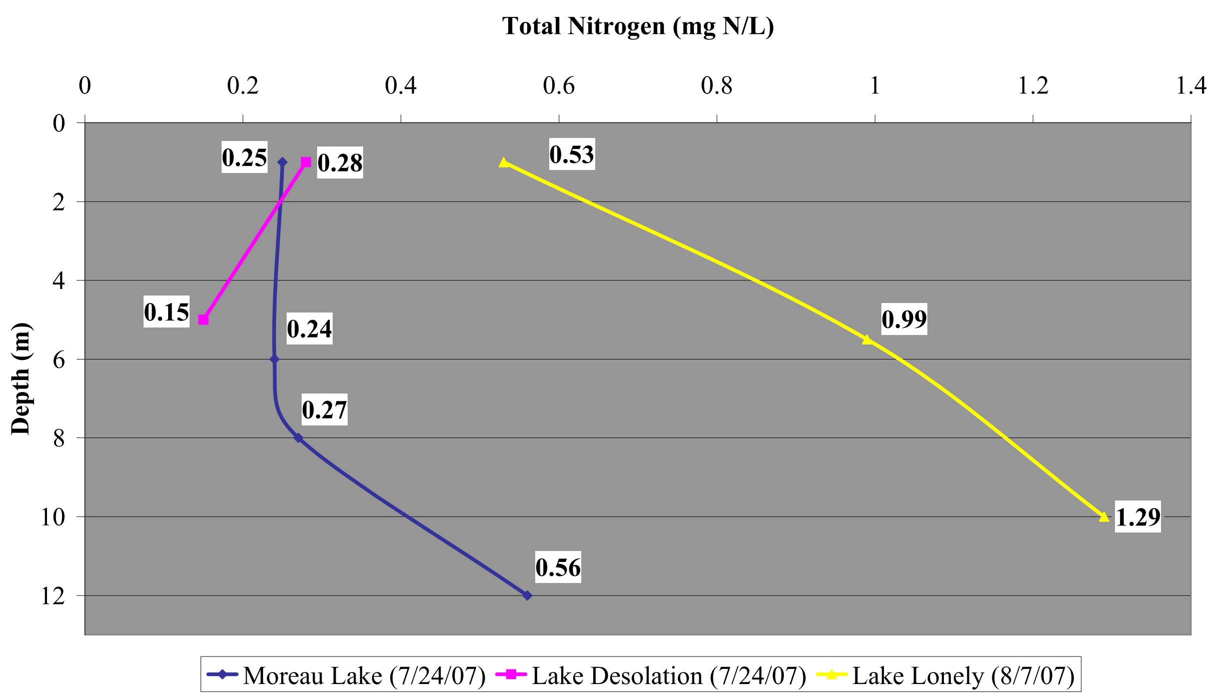


Figure 15: Total Phosphorus (µg P/L) of Moreau Lake, Lake Desolation, and Lake Lonely as a Function of Depth (m) During Summer 2007

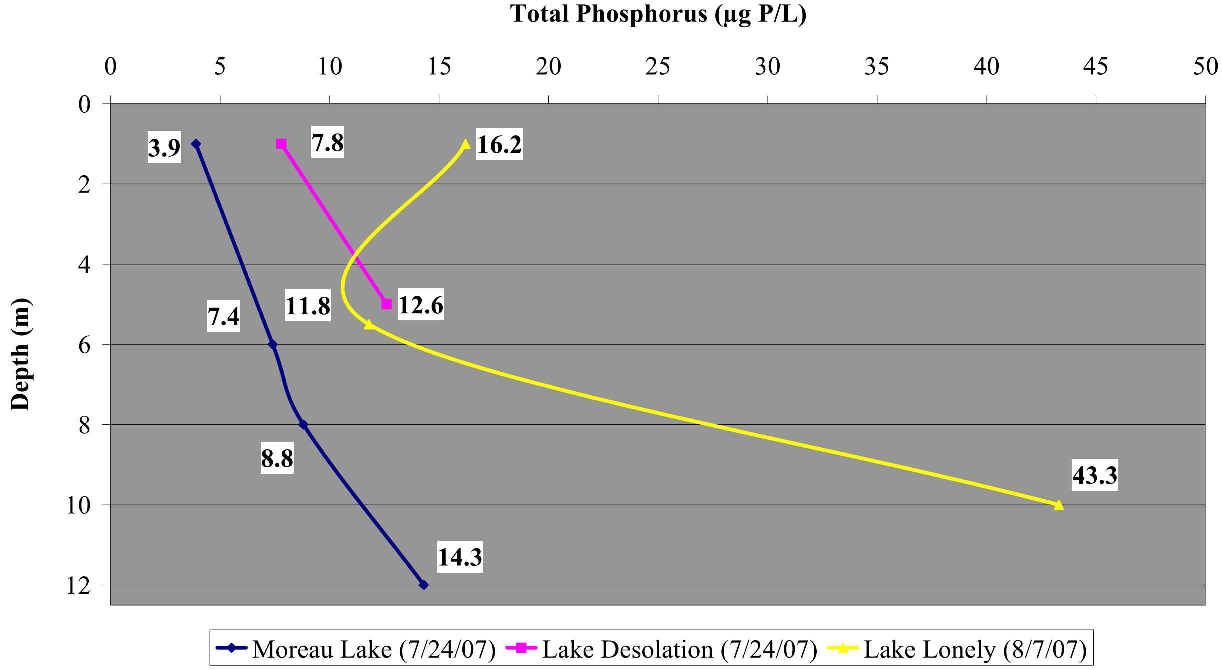


Table 6: Three Carlson Tropic State Indices (TSI) (Table 2, Table 3) for Saratoga County Lakes from Average Summer 2007 Data.

Lake	Secchi Depth	Total Phosphorus	Total Nitrogen	Trophic State
Lake Lonely	44	46	50	Mesotrophic
Lake Desolation	44	34	36	Borderline mesotrophic-oligotrophic
Moreau Lake	27	24	34	Oligotrophic

Lake Lonely Study—Field Chemistry Measurements: Lake Lonely Inlets

On-site measurements of temperature, pH, dissolved oxygen and conductivity were taken at Bog Meadow Brook (-C and –R), Spring Run (-C and –R), and the golf course outlet (Table 7). Dissolved oxygen was higher in Bog Meadow Brook and Spring Run than in the lake as this was expected due to the mixing nature of creeks. Specific conductance of Lake Lonely at the surface seemed to be a mixture of a higher specific conductance in Spring Run and lower specific conductance in Bog Meadow Brook. While the golf course outlet appeared turbid, none of the on-site chemistry investigated indicated negative contributions to Lake Lonely.

Lake Lonely Study—Nutrient and TSS Measurements

Total suspended solids (TSS) were measured at Bog Meadow Brook-C, Spring Run-C and from the surface of Lake Lonely (Figure 16, Appendix A.11, A.12). The surface of Lake Lonely had fewer TSS than Spring Run-C or Bog Meadow Brook-C. Presumably, suspended solids entering Lake Lonely via streams are settling to the bottom of the lake. When the velocity of water decreases, as when streams enter lakes, sedimentation occurs. (Note that, this is why deltas form.)

Nutrients were measured at the Darrin Fresh Water Institute (DFWI) in samples from Lake Lonely at varying depths as well as Bog Meadow Brook-C and Spring Run-C (Figure 17, Figure 18). Total nitrogen (TN) and total phosphorus (TP) increased with depth in Lake Lonely, a trend correlating with the increase in specific conductance deeper in the lake (Figure 10). The significant difference in nutrient levels at the bottom between sampling days could be due to the variation in the sampling depths. Some days samples may have been taken closer to the bottom of the lake.As previously discussed, phosphorus and nitrogen are contributing factors of eutrophication. The range of nitrogen values found for Lake Lonely was 0.68 – 3.33 mg N/L, indicating a eutrophic state. However, the range of phosphorus was 12.1 – 217.8 µg P/L suggesting more of a mesotrophic state. Phosphorus is the limiting nutrient, and the Secchi disk depth (~3 m) correlates with mesotrophic, suggesting that Lake Lonely is likely mesotrophic. Spring Run had the highest levels of TN and TP, followed by Bog Meadow Brook and then the surface of Lake Lonely.

In addition to TN and TP, nitrate, soluble reactive phosphorus, and ammonia were measured by the DFWI (Table 8).

Table 7: Temperature, pH, Dissolved Oxygen, Percent Saturation, Conductivity, and Specific Conductance of Bog Meadow Brook, Spring Run, and the Lake Lonely surface- Summer 2007

Site and Date	Temp. (°C)	pH	Dissolved Oxygen (ppm)	Dissolved Oxygen (%)	Conductivity (µS)	Specific Conductance (µS)
Bog Meadow Brook-C (6/7/07)	13.2		9.12	88.6	243.0	310.8
Bog Meadow Brook-C (6/27/07)	22.8	7.88	8.48	98.0	397.6	415.5
Bog Meadow Brook-R (7/13/07)	17.1	7.53	8.46	89.3	344.3	406.4
Bog Meadow Brook-C (8/7/07)	18.2	7.60	7.35	78.9	373.3	429.8
Bog Meadow Brook-R (8/7/07)	17.6	7.53	7.32	77.3	366.0	427.3
Spring Run-C (6/7/07)	15.4		8.63	88.2	580	713
Spring Run-C (6/27/07)	26.1	8.09	10.25	135.3	1122	1099
Spring Run-R (7/13/07)	17.3	7.75	10.66	113.0	884	1037
Spring Run-C (8/7/07)	20.6	7.64	6.81	76.5	953	1042
Spring Run-R (8/7/07)	18.8	7.82	9.05	97.6	1017	1155
Lake Lonely- (6/7/07)	19.4		7.36	84.3	446.0	500
Lake Lonely (6/27/07)	26.3	8.17	8.85	107.1	652	636
Lake Lonely (7/12/07)	25.0	7.70	6.83	81.1	643	648
Lake Lonely (8/7/07)	26.0	8.22	7.70	93.5	642	655
Golf Course Outlet (6/27/07)	30.5	8.60	10.16	137.8	566	512

Figure 16: Average Total Suspended Solids of Lake Lonely, Spring Run, and Bog Meadow Brook on 6/7/07 and 7/16/07.

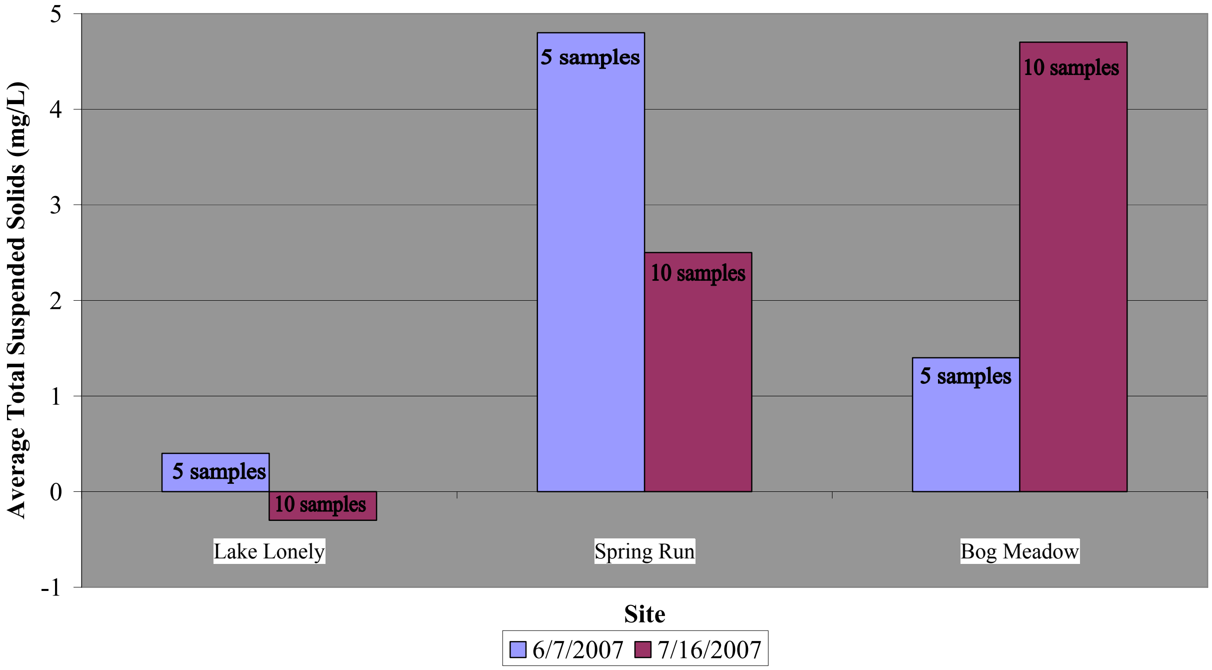


Figure 17: Total Nitrogen (mg N/L) of Lake Lonely as a Function of Depth (m), Spring Run, and Bog Meadow Brook on 6/7/07, 6/27/07, and 8/7/07.

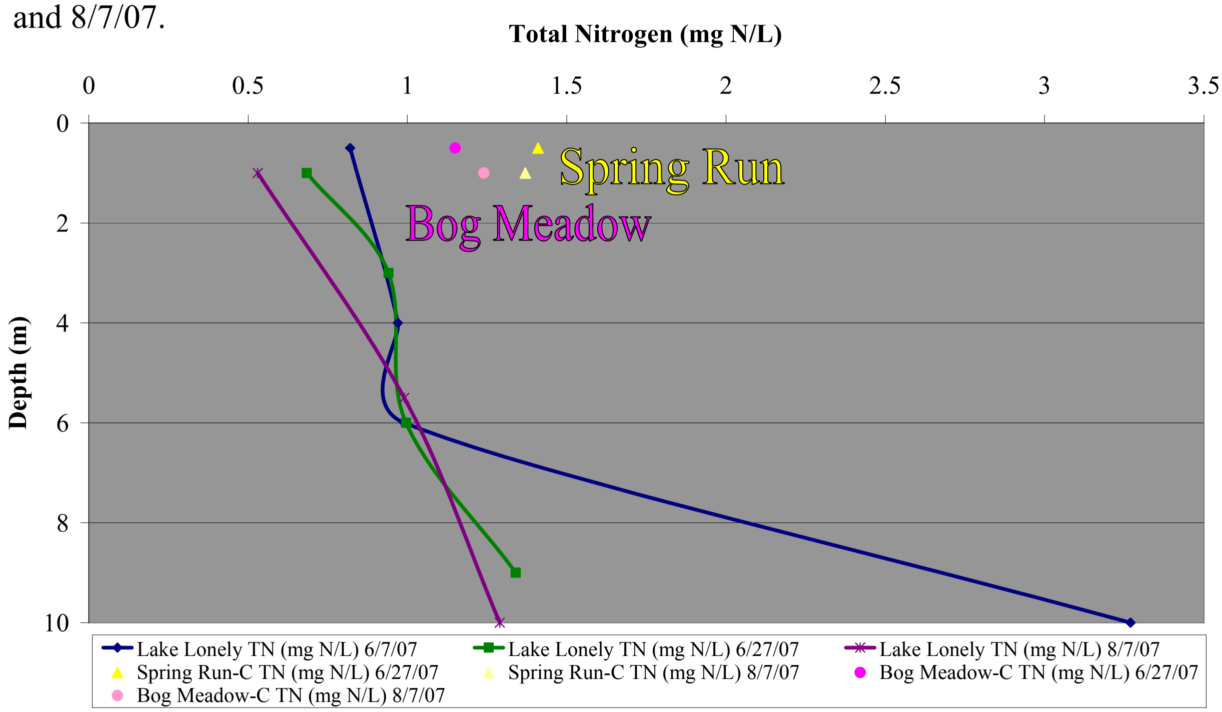


Figure 18: Total Phosphorus (µg P/L) of Lake Lonely as a Function of Depth (m), Spring Run, and Bog Meadow Brook on 6/7/07, 6/27/07, and 8/7/07.

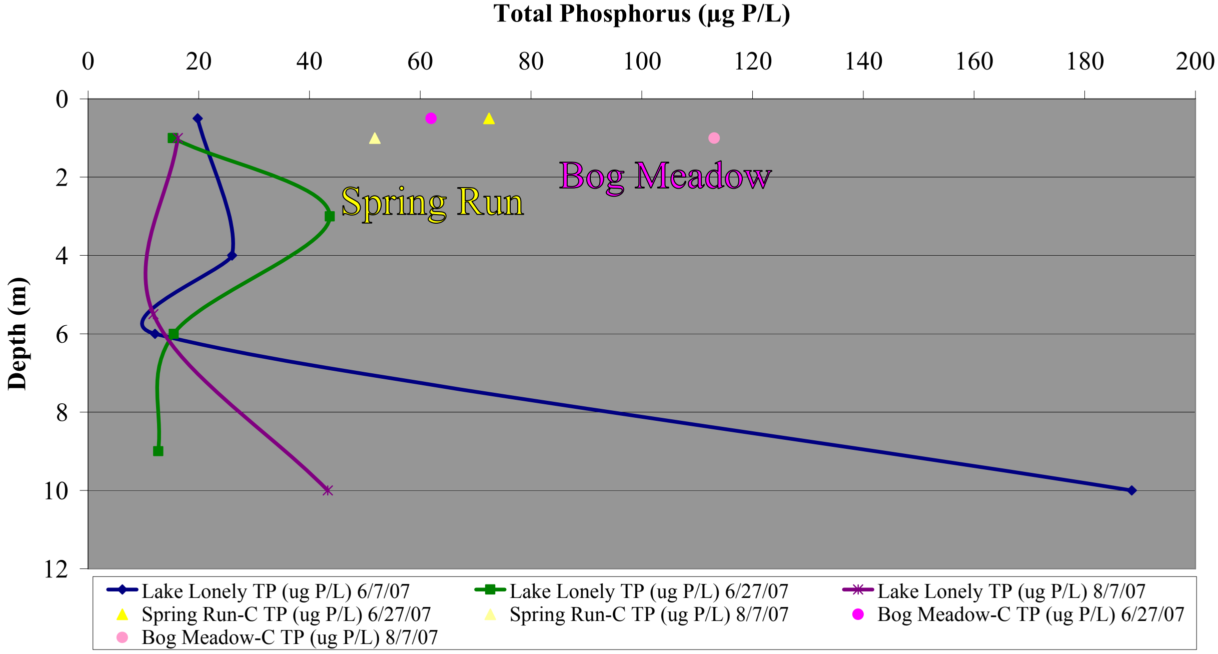


Table 8: Nutrient Data for Lake Lonely on 6/7/07, 6/27/07, and 8/7/07.

Site	NO_3^- (mg N/L)	SRP (µg P/L)	NH_4^+ (mg N/L)
Lake Lonely 0.5m-A (6/7/07)	0.31	15.0	0.54
Lake Lonely 0.5m-B (6/7/07)	0.27	9.2	0.07
Lake Lonely 1 m (6/27/07)	0.33	1.3	0.02
Lake Lonely 1 m (8/7/07)	0.12	5.2	0.001
Lake Lonely 3 m (6/27/07)	0.40	1.5	0.05
Lake Lonely 4 m (6/7/07)	0.35	12.6	0.12
Lake Lonely 6 m (6/7/07)	0.53	8.7	0.10
Lake Lonely 6 m (6/27/07)	0.63	2.7	0.20
Lake Lonely 9 m (6/27/07)	0.58	3.7	0.55
Lake Lonely 10 m-A (6/7/07)	0.57	15.0	0.62
Lake Lonely 10 m-B (6/7/07)	0.54	33.5	0.56

Nutrient data was analyzed from Bog Meadow Brook-C and Spring Run-C (Table 9). The water samples were collected using a grab sample technique, which can yield inconsistent results within one stream. On June 7, two samples for Bog Meadow Brook-C were collected and produced quite different results. Sample B was more consistent with the Bog Meadow Brook-C sample on June 27, 2007. Both of these samples show that Spring Run-C had higher nitrate, TN, and TP values than Bog Meadow Brook-C.

Table 9: Nutrient Data for Bog Meadow Brook and Spring Run on 6/7/07 and 6/27/07.

Site and Date	NO_3^- (mg N/L)	TN (mg N/L)	TP (µg P/L)	SRP (µg P/L)	NH_4^+ (mg N/L)
Bog Meadow-C [A] (6/7/07)	0.32	2.74	126.1	21.6	0.05
Bog Meadow-C [B] (6/7/07)	0.32	1.26	80.6	21.9	0.04
Bog Meadow-C (6/27/07)	0.63	1.15	62.0	19.9	0.04
Bog Meadow-C (8/7/07)	0.38	1.24	113.1	23.5	0.03
Spring Run-C [A] (6/7/07)	0.56	1.33	48.2	19.2	0.11
Spring Run-C [B] (6/7/07)	0.50	1.32	49.7	17.4	0.10
Spring Run-C (6/27/07)	0.91	1.41	72.4	17.5	0.06
Spring Run-C (8/7/07)	0.80	1.37	51.8	20.0	0.05

Lake Lonely Study—Flow Measurements

Average summer discharge was calculated for Spring Run-R (9.27 cfs) and Bog Meadow Brook-R (12.35 cfs). On average, Bog Meadow Brook-R had a discharge 33% greater than Spring Run-R. Note that the hydrographs of these two streams do not parallel each other as much as might be expected (Figure 19). This is most likely due to differences in the geology and geography of each stream.[§] For example, a stream flowing through wetlands would have slower responses to precipitation than bedrock channels or streams in area of high development.

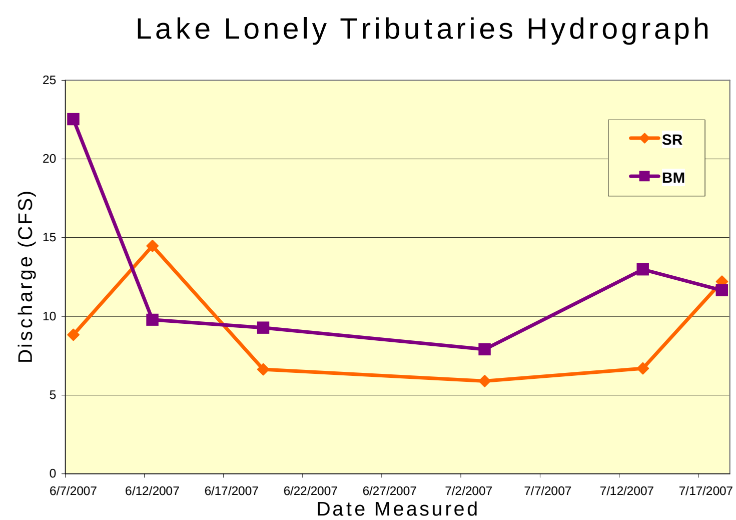


Figure 19: Hydrograph of Spring Run-R and Bog Meadow Brook-R: Summer 2007.

[§] Note the accuracy of the study's Glowegee Creek measurements in comparison with USGS measurements—Page 28

Lake Lonely Study—Nutrient Loading

Using the nutrient data and the flow data approximate nutrient loading values were calculated for each tributary (Figure 31, Figure 32, and Appendix: Tables C17 and C18). For Bog Meadow Brook and Spring Run, approximate nutrient loading values were calculated for three days and four days respectively. While Spring Run-C had somewhat higher nutrient levels than Bog Meadow-C, Bog Meadow had a higher flow than Spring Run, as a result, for these few sampling days, Bog Meadow Brook contributed more nutrients to Lake Lonely than Springs run did (see Appendix C17).

Confluence Study—Field Chemistry Measurements

Chemical properties of the Lake Lonely outlet and the Main Kayaderosseras-C were determined on several occasions (Table 10). The dissolved oxygen average for each was around 7.6 ppm, which fluctuated regularly due to mixing and photosynthesis. The influence of Lake Lonely on its outlet was apparent though by looking at the specific conductance of the Lake Lonely outlet in comparison to the Main Kayaderosseras-C (Figure 20). Specific conductance is thirty percent greater in the LLO than in the Main Kayaderosseras-C.

Figure 20: Specific Conductivity (µS) as a Function of Date of the Main Kayaderosseras and Lake Lonely Outlet.

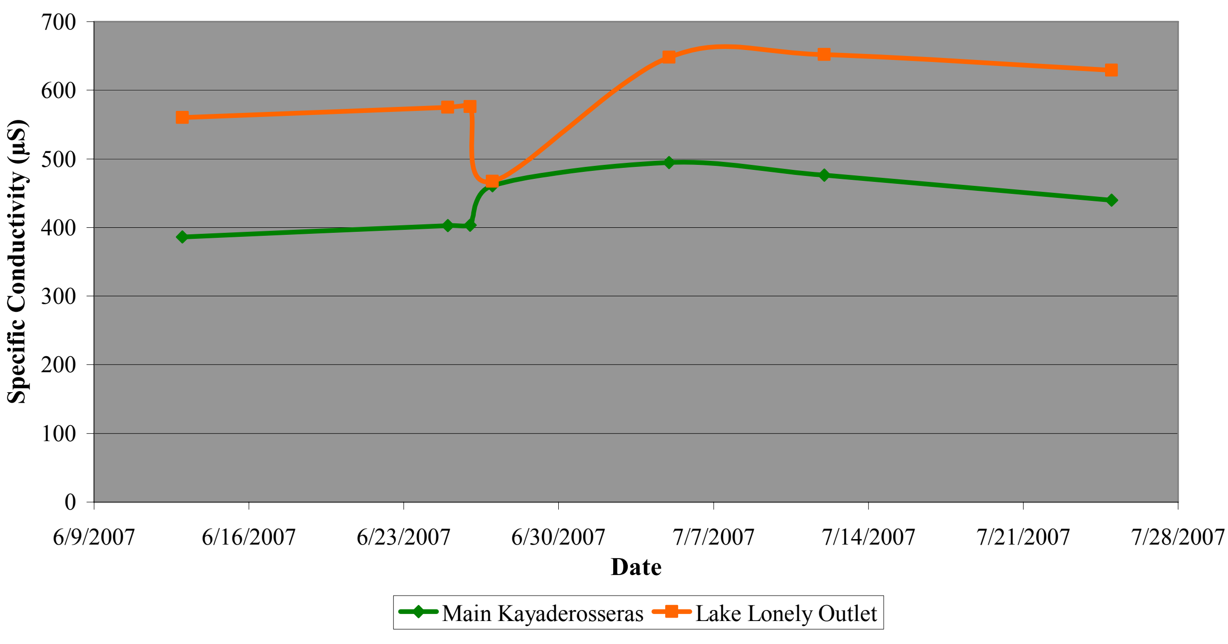


Table 10: Temperature, pH, Dissolved Oxygen, Percent Saturation, Conductivity, Specific Conductivity and Salinity of the Main Kayaderosseras-C and Lake Lonely Outlet - Summer 2007

Site and Date	Temp. (°C)	pH	Dissolved Oxygen (ppm)	Dissolved Oxygen (%)	Conductivity (μS)	Specific Conductivity (μS)	Salinity (ppt)
Main Kayaderosseras-C (6/13/2007)	20.4	7.05	7.77	78.8	352.5	386.3	0.2
Main Kayaderosseras-C (6/27/2007)	25.6	7.86	7.44	88.5	464.9	461.1	0.2
Main Kayaderosseras-C (7/5/2007)	18.4	7.68	8.12	88.8	432.5	494.5	0.2
Main Kayaderosseras-C (7/12/2007)	21.8	7.64	7.33	87.1	448.6	476.3	0.2
Main Kayaderosseras-C (average)	**21.6**	**7.56**	**7.67**	**85.8**	**424.6**	**454.6**	**0.2**
Lake Lonely Outlet (6/13/2007)	23.4	6.38	7.50	72.3	543	560	0.3
Lake Lonely Outlet (6/27/2007)	28.6	7.82	7.75	99.3	493	467	0.2
Lake Lonely Outlet (7/5/2007)	22.6	7.60	7.62	88.7	618	648	0.3
Lake Lonely Outlet (7/12/2007)	25.5	7.67	7.35	88.9	658	652	0.2
Lake Lonely Outlet (average)	**25.0**	**7.37**	**7.56**	**87.3**	**578**	**582**	**0.3**

Confluence Study—Nutrient Measurements

Nutrient values were found for the Lake Lonely Outlet (LLO) and the Main Kayaderosseras-C (Table 11a). The LLO had higher TN, TP, soluble reactive phosphorus, and ammonia levels than the Main Kayaderosseras-C. This is consistent with prior work by Connolly and Halstead done in the summer of 2006 and presented in Table 11b (see Appendix D of reference 12 for more 2006 data). In 2006, the Main Kayaderosseras was sampled both upstream and downstream of the confluence with Lake Lonely Outlet. The nutrients, conductivity, alkalinity levels, and common metal concentrations of the Kayaderosseras mouth were between the higher levels of LLO and the lower levels of the Kayaderosseras Creek upstream.

Table 11a: Lake Lonely Outlet and Main Kayaderosseras-C Nutrient Values on July 27, 2007.

Site	NO_3^- (mg N/L)	TN (mg N/L)	TP (mg P/L)	SRP (ug P/L)	NH_4^+ (mg N/L)
Lake Lonely Outlet	0.24	0.82	0.031	7.1	0.09
Main Kayaderosseras-C	0.32	0.69	0.019	3.9	0.03

Table 11b: Lake Lonely Outlet and Main Kayaderosseras Confluence Main Branch Survey of the Kayaderosseras Creek (7/10/06)

Site	Chloride (mg/L)	Nitrite (mg N/L)	Nitrate (mg N/L)	Sulfate (mg S/L)	TN[1] (mg N/L)	TP[2] (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-C	46.5	<0.05	0.28	3.21	0.29	18.4	8	110.0	0.03
Kayaderosseras Creek 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, 3 Kayaderosseras Creek-C is upstream of the confluence with Lake Lonely Outlet.

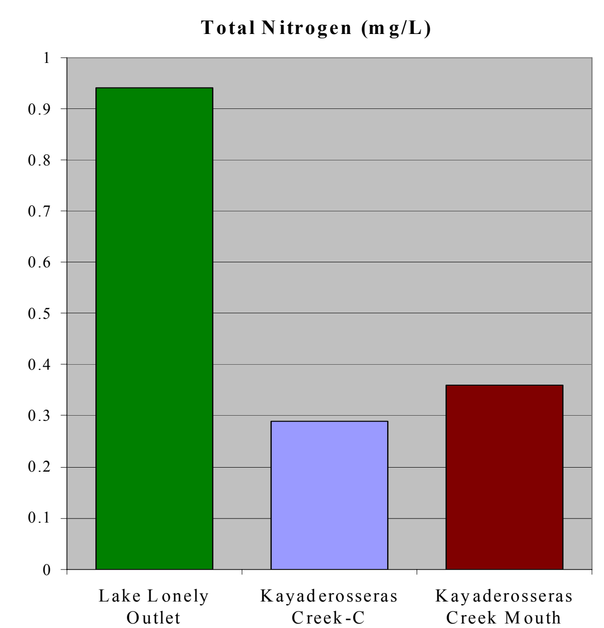


Figure 21: Total Nitrogen near the Confluence, 7/10/06

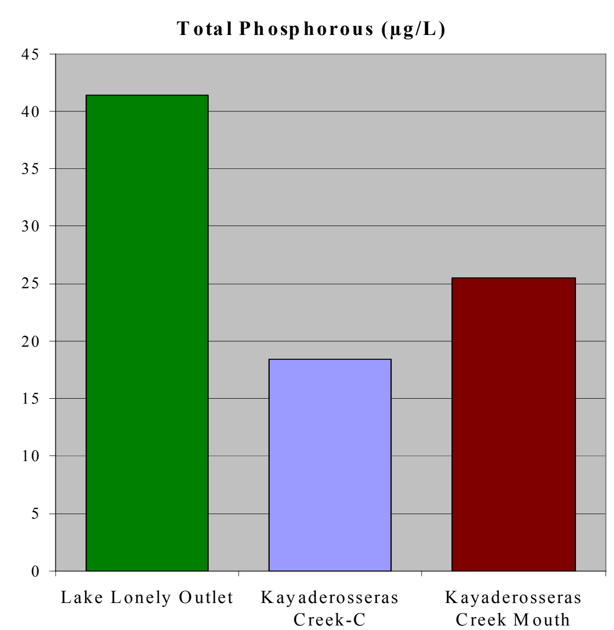


Figure 22: Total Phosphorus near the Confluence, 7/10/06

Confluence Study—Comparison with Past Data

Nitrate (NO_3^-) and total phosphorus (TP) values were measured in 2002, 2003, and 2004 by Hudson Environmental Services, Inc. (Table 12, Table 13).** The current study's 2007 nitrate data is consistent with the 2002 data for the Lake Lonely Outlet, though the total phosphorus levels have almost doubled from about 17 µg/L (9/9/02) to about 31 µg/L (7/27/07) (Table 11). Nitrate and phosphorus in Spring Run-C have both increased from 0.17 mgNO_3^-/L (9/5/02) to ~0.75 mg NO_3^-/L (average 2007) and 17 µgP/L (9/9/02) to ~60 µgP/L (average 2007), respectively (Tables 11, 12 & 13). Nitrates in Spring Run-R have fluctuated—1.53 mg NO_3^-/L (9/5/02) to 0.46 mg NO_3^-/L (9/18/03), and back up to 1.12 mg NO_3^-/L (6/12/07) (Appendix A.10, Table 12) . Total phosphorus for Spring Run-R has increased though from 46 µgP/L (9/9/02) to around 75 µgP/L (average 2007) (Appendix A.10, Table 13). These comparisons are from singular dates in these years and more research is needed.

Table 12: Past Nitrate Data for Lake Lonely Inlets and Outlet.**

	Nitrate (mg/L) 9/5/2002	Nitrate (mg/L) 9/18/2003	Nitrate (mg/L) 9/7/2004
Lake Lonely Outlet	0.23	<0.1	<0.25
Spring Run-C	0.17	0.45	<0.25
Spring Run-R	1.53	0.46	<0.25

Table 13: Past Total Phosphorus Data for Lake Lonely Inlets and Outlet.**

	Phosphorus (mg/L) 9/9/2002	Phosphorus (mg/L) 9/23/2003	Phosphorus (mg/L) 9/7/2004
Lake Lonely Outlet	0.017	0.016	0.16
Spring Run-C	0.017	0.054	0.62
Spring Run-R	0.046	0.039	0.32

Confluence Study—Flow Measurements

Sodium chloride tracer tests were used to measure flow on the Main Kayaderosseras-C and the Lake Lonely Outlet (LLO) (Figure 23). Both streams responded similarly to precipitation events. The Main Kayaderosseras-C's discharge was always greater than that of the LLO—on average, during the summer of 2007, the LLO accounted for twenty percent of the Main Kayaderosseras' discharge at the mouth. Lake Lonely Outlet's average discharge was 25.15 cubic feet per second (CFS) while the Main Kayaderosseras-C's average discharge was 101.15 CFS.

** Personal communication with Zealie Van Raalte, July 2007

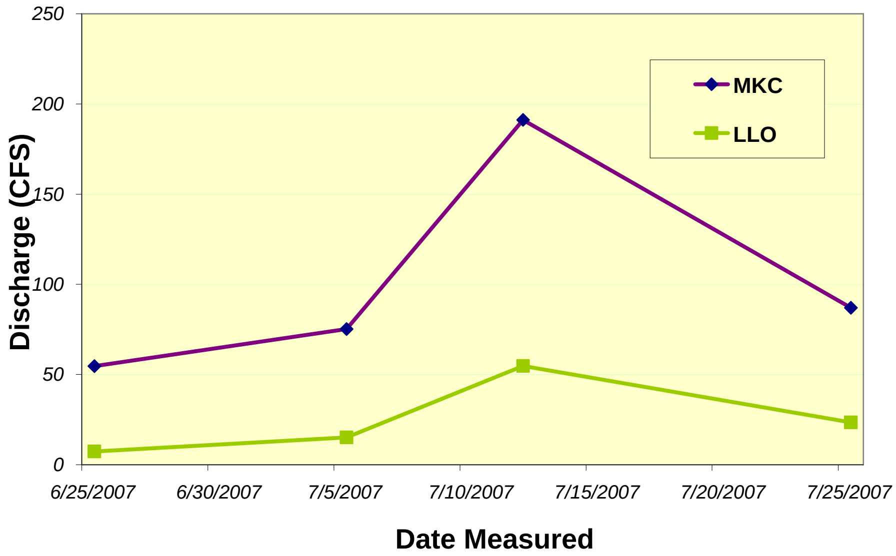


Figure 23: Hydrograph of the Lake Lonely Outlet and Main Kayaderosseras Confluence: Summer 2007.

Tributary Study—Field Chemistry Measurements

Chemical properties of eight tributaries across the watershed were determined including dissolved oxygen and specific conductance (Figure 24, Figure 25). The dissolved oxygen content in 2007 followed a similar pattern to that in 2006. The graph representing specific conductance indicates differences across the watershed (Figure 25). The specific conductance is consistently higher for Spring Run-R and Geyser Brook, the streams flowing through more developed areas. Also note that the most upstream rivers, the Upper Kayaderosseras and Clover Mill Creek – Upstream, had the lowest specific conductance values.

Tributary Study —Nutrient Measurements

Water samples were collected at each of the tributaries in order to assess nutrient values and in turn, nutrient loading (Figure 26, Figure 27). The majority of streams observed showed increases in both TN and TP values from 2006 to 2007. More research is needed in order to determine trends.

Figure 24: Dissolved Oxygen (%) of Nine Tributaries on 6/13/06 and 6/19/07.

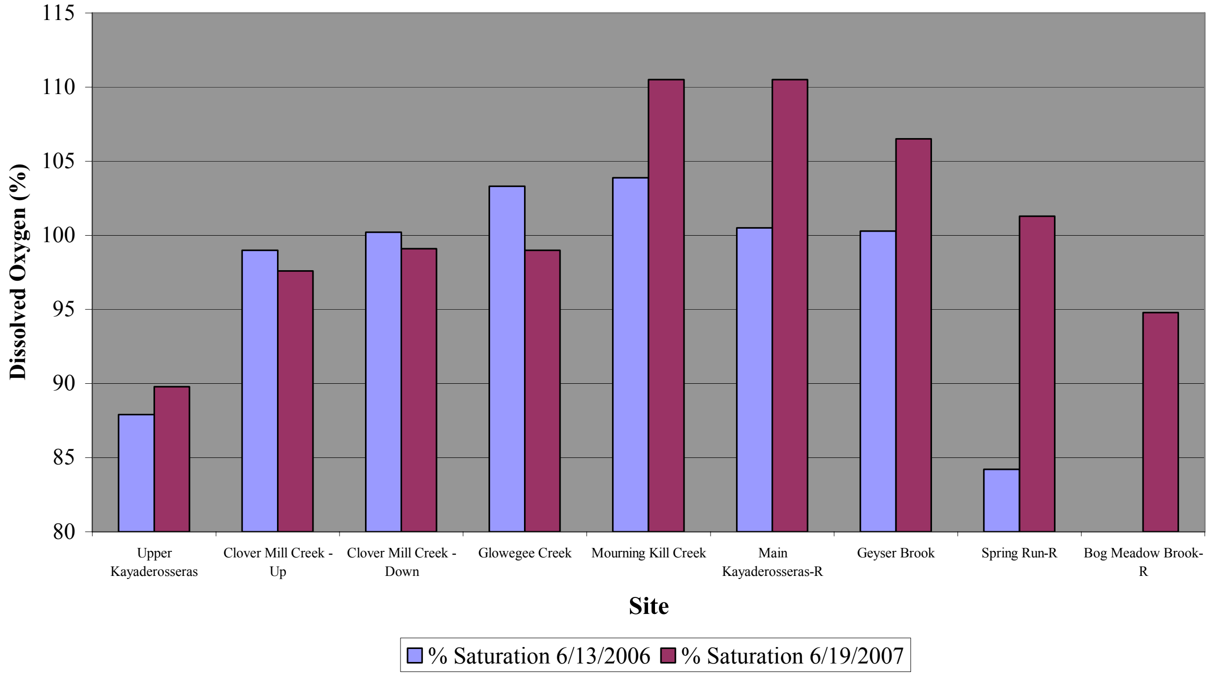


Figure 25: Specific Conductance of Nine Tributaries on 6/13/06 and 6/19/07.

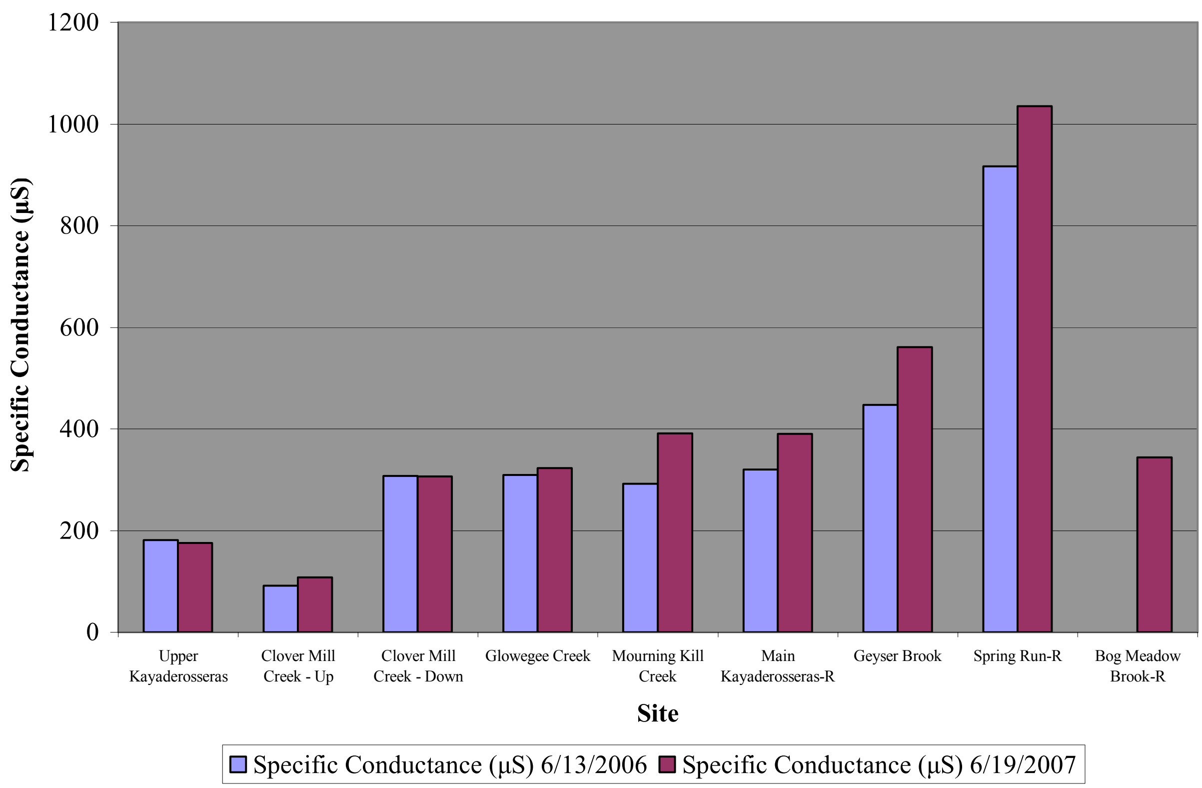


Figure 26: Total Nitrogen of Nine Tributaries on 6/13/06, 6/19/07, and 7/18/07.

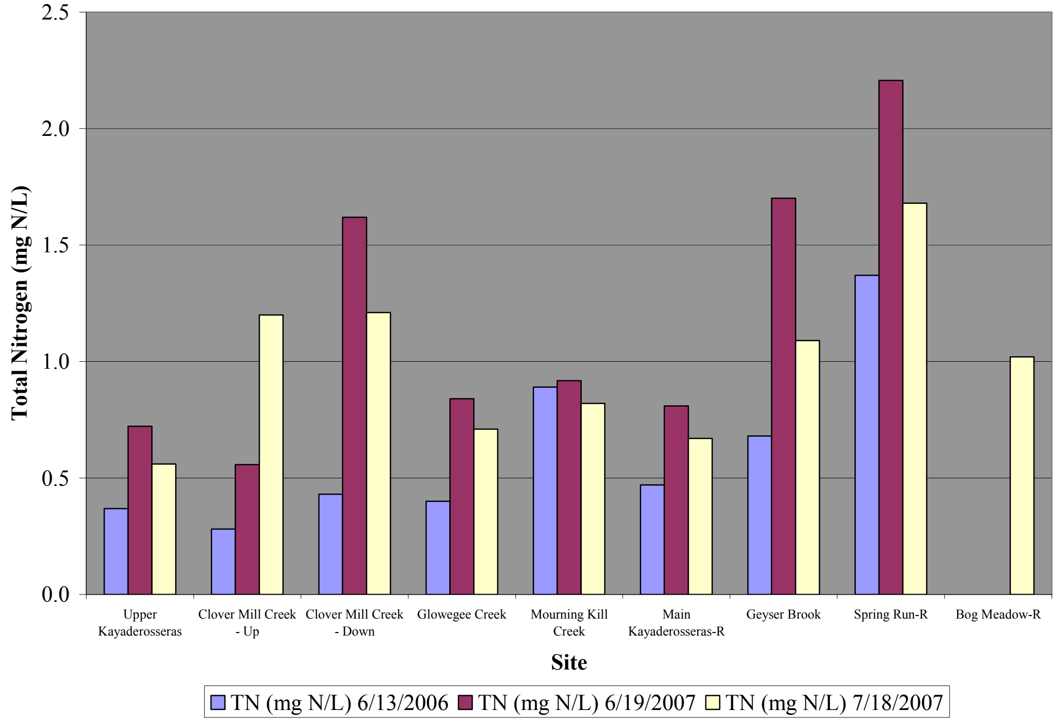
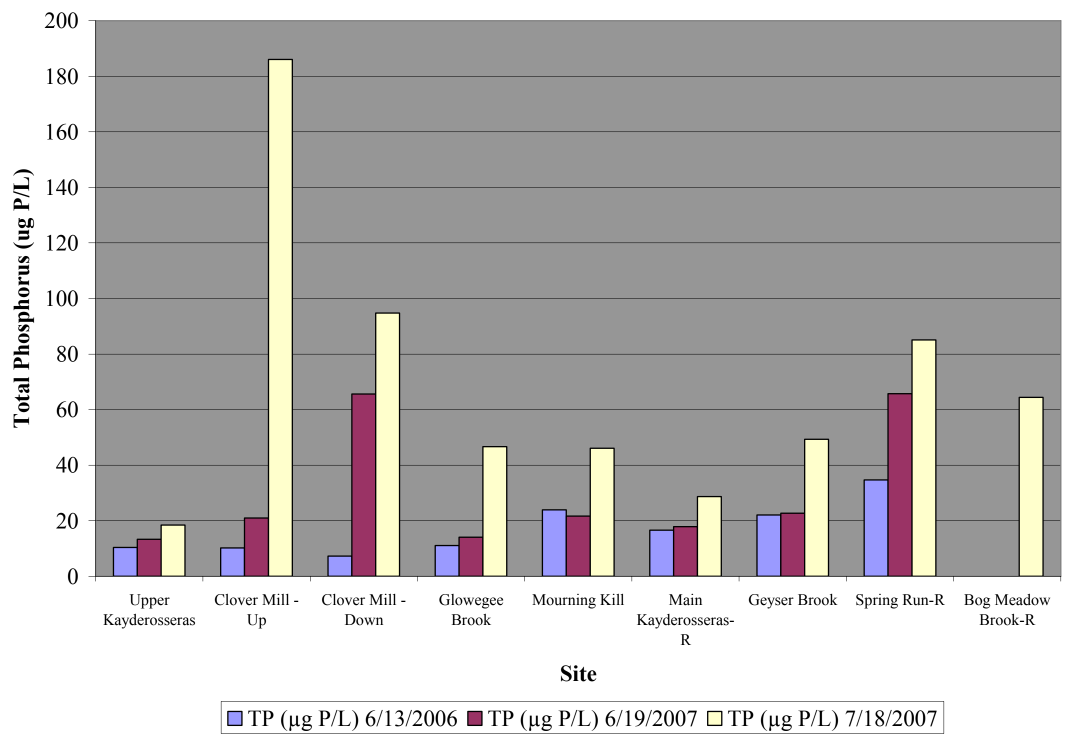


Figure 27: Total Phosphorus of Nine Tributaries on 6/13/06, 6/19/07, and 7/18/07.



Discharge was measured on three days for all nine tributaries studied in the Kayaderosseras Creek sub-watershed (Appendix C.5 and C.16). Discharge data for eight of the tributaries on three days in summer 2007 are shown in Figure 28. Data for the Main Kayaderosseras is in appendix C.5). For all nine sites, the discharge on day two was the lowest and the discharge on day three was the highest. Despite these major similarities, there are some differences in response time to the precipitation event on July 18, 2007. For example, the Mourning Kill had relatively greater increase in flow for the same precipitation event.

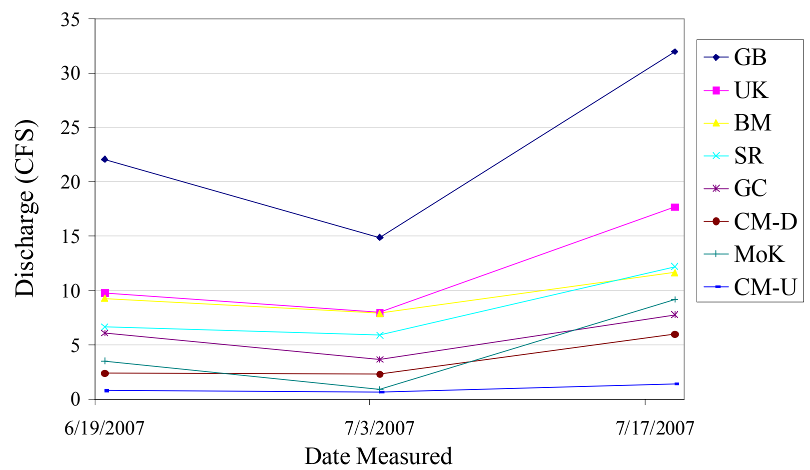


Figure 28: Hydrograph of Eight Tributaries Throughout Kayaderosseras Creek

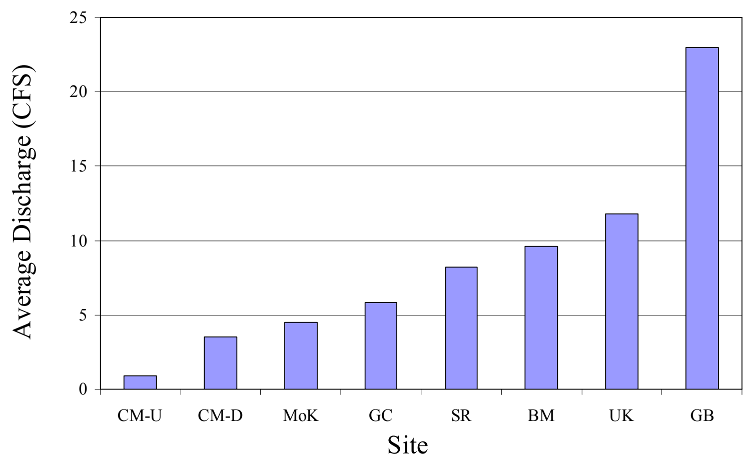


Figure 29: Average discharge of eight tributaries throughout Kayaderosseras Creek Watershed: Summer 2007.

To assess experimental error throughout the season, the calculated discharge of the Glowegee Creek was plotted against the discharge from the USGS Glowegee Creek data (Figure 30). On average, our calculations underestimated the discharge by eight percent relative to the USGS gauge. However, as the summer progressed, the agreement improved and discrepancy in the discharge measurements was only four percent by July 18, 2007(Figure 30).

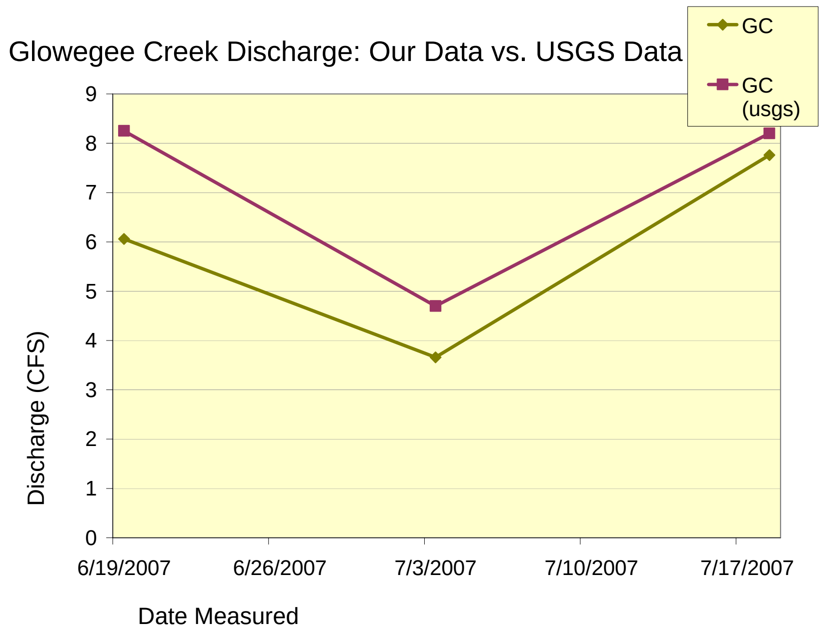


Figure 30: Hydrograph of Glowegee Creek including both our discharge data and the USGS discharge data.

Tributary Study—Nutrient Loading

Using the nutrient data and the flow data approximate nutrient loading values were calculated for each tributary (Figure 31, Figure 32, and Appendix: Tables C17 and C18). For Bog Meadow Brook and Spring Run, approximate nutrient loading values were calculated for three days and four days respectively, and for the rest of the tributaries approximate nutrient loading values were calculated for two days. Due to the higher flows in Bog Meadow Brook, for these few sampling days, Bog Meadow Brook contributed more nutrients to Lake Lonely than Springs run did (see Appendix C17). As expected, the Main Kayaderosseras-R had the highest loading for both TN and TP, due to the large volume and number of tributaries flowing into it. It is interesting to note that Geyser Brook, Spring Run-R, and Bog Meadow Brook-R had the highest values for both TN and TP following the Main Kayaderosseras-R. It was also observed that for most of the streams, there appears to be an increase in loading as the summer progressed in nutrient loading for all of the streams.

Figure 31: Total Nitrogen Loading at Nine Tributaries: Summer 2007

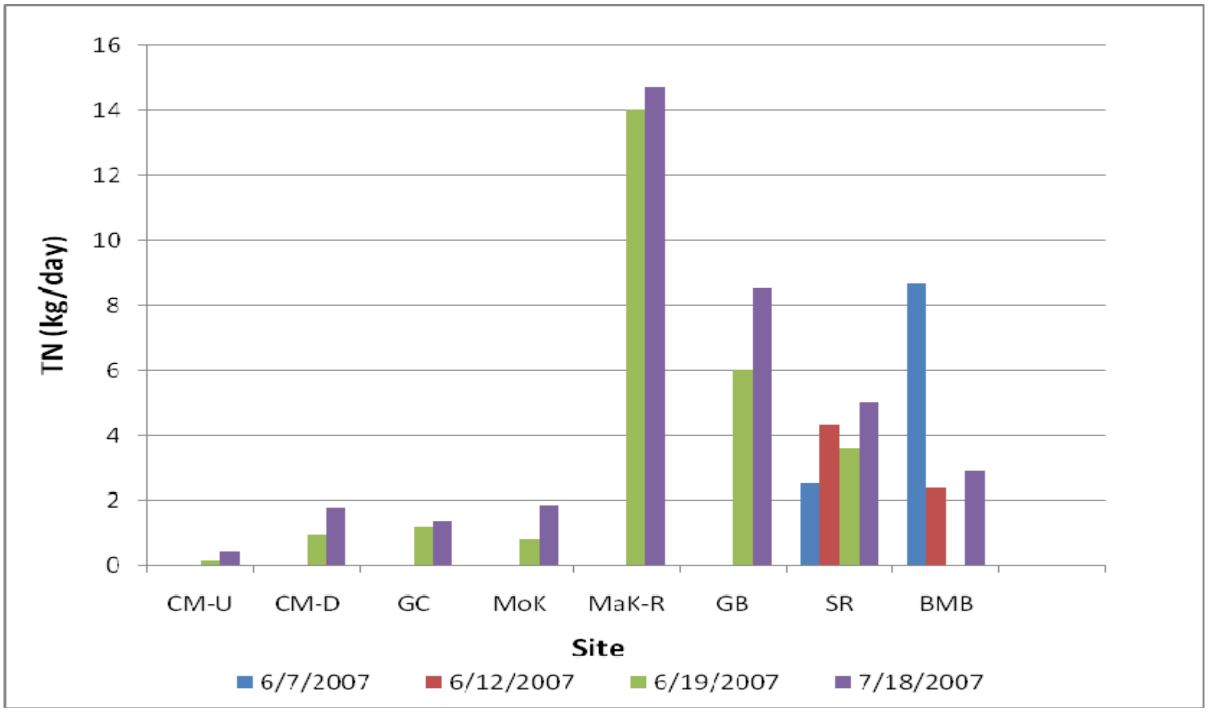
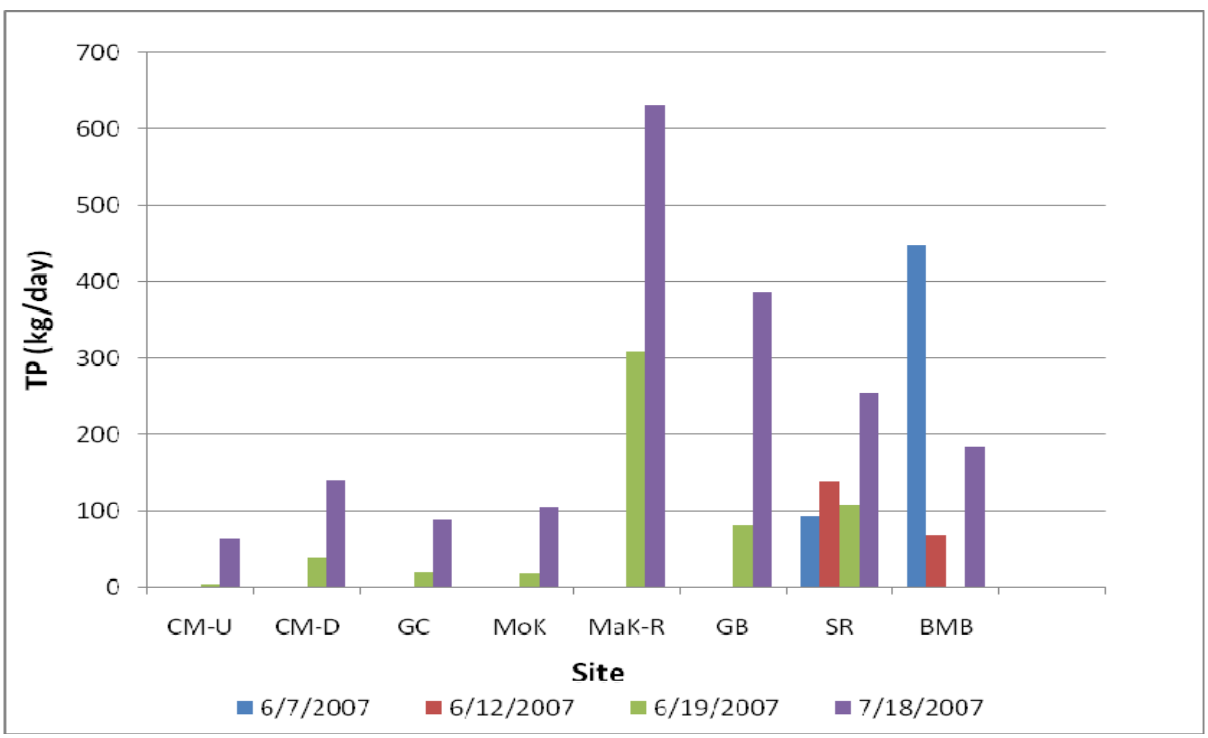


Figure 32: Total Phosphorous Loading at Nine Tributaries: Summer 2007



Conclusions

Lake Lonely Study

Sampling locations on Lake Lonely that were studied had a total depth around 10-11 m and a summer thermocline at approximately four meters in the summer. Dissolved oxygen was depleted (<10% saturation) in the bottom 30% of the lake by 8/7/07. Specific conductance was higher towards the bottom of the lake—850 µS by eight meters. The average Secchi depth for the summer was three meters. In comparison, Lake Desolation (6 meters deep, thermocline at 3 meters) and Moreau Lake (13 meters deep, thermocline at 5 meters) had Secchi depths of three meters and ten meters, respectively. The bottom 25% of Lake Desolation and the bottom 10% of Moreau Lake had depleted levels of dissolved oxygen. In addition, Lake Lonely's specific conductance was more than six times than either Lake Desolation or Moreau Lake and increased with depth while Lake Desolation and Moreau Lake remain consistent with depth. Both TN and TP increase as depth increases in Lake Lonely and indicate a mesotrophic state (from the TP values) or possibly a borderline mesotrophic-eutrophic state (from the TN values). Moreau Lake was oligotrophic and Lake Desolation was borderline mesotrophic-oligotrophic.

Spring Run and Bog Meadow Brook were found to contribute conductivity and nutrients to Lake Lonely. Spring Run had a higher specific conductance (~1100 µS) than Bog Meadow Brook (~400 µS). Spring Run has higher nutrient levels (TN = ~1.41 mg/L, TP = ~72.4 µg/L) than Bog Meadow Brook (TN = ~1.15 mg/L, TP = ~62.0 µg/L). However, since Bog Meadow Brook's flow is on average approximately 60% greater than that of Spring Run, for these few sampling days, Bog Meadow Brook contributed more nutrients to Lake Lonely than Spring Run did (see Appendix C17). Sediments at the bottom of Lake Lonely should also be considered when assessing factors contributing to conductivity and nutrient levels in Lake Lonely. More data is needed in order to more generally assess nutrient loading from these two tributaries.

Confluence Study

The Lake Lonely Outlet contributes conductivity and nutrients to the Kayaderosseras Creek. Nutrients, conductivity, alkalinity levels, and common metal concentrations of the Lake Lonely Outlet are consistently higher than the levels observed in the main Kayaderosseras Creek upstream of the confluence with Lake Lonely Outlet. During the summer of 2007, there was a log jam just downstream of the confluence which made it more difficult to get data from above and below the confluence one the same day. Further study should be conducted downstream of the confluence, closer to the mouth of Saratoga Lake once the large log jam is removed.

Tributary Study

While in 2006, tributaries that were further upstream in the watershed and farther from human habitation and development had lower nutrient levels and conductivity in comparison to those tributaries further downstream in the watershed and adjacent to highways, development and habitation, this was less clear in 2007. Both years Spring Run had higher nutrient and conductivity levels than all other tributaries studied. The majority of streams observed showed increases in both TN and TP values from 2006 to 2007, the increase in TP in Clover Mill Creek in July 2007 was particularly pronounced. In the future, the geology of the subwatershed for each stream will also be considered. As far as we know, Glowegee Creek is the only one of the sites measured to have discharge previously recorded. A study of the Kayaderosseras downstream each confluence would be valuable and should include Gordon Creek, a high stream order creek we have not yet investigated. Future work is anticipated which will look at the relationships between nutrients, cations and anions, sub-watershed development and geology.

As expected, the Main Kayaderosseras-R had the highest loading for both TN and TP, due to the large volume and number of tributaries flowing into it. It is interesting to note that Geyser Brook, Spring Run-R, and Bog Meadow Brook-R had the highest values for both TN and TP following the Main Kayaderosseras-R. It was also observed that for most of the streams, there appears to be an increase in loading as the summer progressed in nutrient loading for all of the streams.

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Appendix

Appendix A.1: GPS Coordinates for Lake Lonely, Spring Run, and Bog Meadow Brook.

Site	UTM
Lake Lonely	18T 0602860, UTM 4767935
Spring Run-C	18T 0602730, UTM 4768307
Bog Meadow Brook-C	18T 0599104, UTM 4772406

Appendix A.2: Temperature, Dissolved Oxygen, Percent Saturation, Conductivity, and Specific Conductance as a Function of Depth on Lake Lonely - 6/7/07

Depth (m)	Temp. (°C)	Dissolved Oxygen (ppm)	Dissolved Oxygen (%)	Conductivity (µS)	Specific Conductance (µS)
1	19.3	8.17	84.3	446	500
2	19.1	7.36	80.2	443	499
3	18.9	7.28	77.9	435	493
4	18.0	6.52	62.8	458	529
5	12.7	8.85	80.9	426	556
6	8.3	9.27	78.8	392	575
7	6.3	8.64	70.8	376	584
8	5.4	8.20	63.5	385	616
9	4.6	5.65	44.5	418	686
10	4.3	0.09	0.6	450	745

Appendix A.3: Temperature, Dissolved Oxygen, Percent Saturation, Conductivity, Specific Conductance, and Salinity as a Function of Depth on Lake Lonely - 6/27/07

Depth (m)	Temp. (°C)	Dissolved Oxygen (ppm)	Dissolved Oxygen (%)	Conductivity (µS)	Specific Conductance (µS)	Salinity (ppt)
0	26.4	8.90		656	638	0.3
1	26.2	8.85	107.1	652	636	0.3
2	24.5	8.83	104.5	687	698	0.3
3	21.1	8.55	92.6	602	655	0.3
4	14.8	7.01	71.8	546	660	0.3
5	10.8	7.04	66.6	500	675	0.3
6	6.5	5.97	49.0	470	726	0.4
7	5.1	5.35	40.2	477	767	0.4
8	4.1	2.03	19.2	525	862	0.4
9	3.8	0.72	4.5	591	993	0.5

Appendix A.4: Temperature, Dissolved Oxygen, Percent Saturation, Conductivity, and Specific Conductance as a Function of Depth on Lake Lonely - 7/12/07

Depth (m)	Temp. (°C)	Dissolved Oxygen (ppm)	Dissolved Oxygen (%)	Conductivity (μS)	Specific Conductance (μS)
0	25	6.83	81.1	643	648
1	24.6	7.52	91.2	638	646
2	24.3	6.74	82.8	660	698
3	22.5	6.81	78.9	600	683
4	18.7	7.3	78.9	530	680
5	13.4	3.81	36.9	472	699
6	7.9	6.55	54.9	471	740
7	6.1	5.24	42.8	492	782
8	5.4	2.45	20.3	549	849
9	4.7	0.1	0.9		

Appendix A.5: Temperature, Dissolved Oxygen, Percent Saturation, Conductivity, and Specific Conductance as a Function of Depth on Lake Lonely - 8/7/07

Depth (m)	Temp. (°C)	Dissolved Oxygen (ppm)	Dissolved Oxygen (%)	Conductivity (μS)	Specific Conductance (μS)
0	26.1	7.76	96.10		
1	26.0	6.70	93.5	642	655
2	25.9	8.49	105.9	642	654
3	24.4	7.34	88.3	690	700
4	19.3	3.91	42.5	593	672
5	13.7	0.46	5.5	535	678
6	9.3	1.70	14.4	488	695
7	6.9	0.55	5.0	488	749
8	5.0	0.09	0.9	519	836
9	4.3	0.07	0.5	574	950
10	4.0	0.06	0.4	619	1034

Appendix A.6: Lake Lonely Nutrient Values on June 7, 2007

Site	TN (mg N/L)	TP (µg P/L)
Lake Lonely 0.5m-A	0.82	19.2
Lake Lonely 0.5m-B	0.82	20.3
Lake Lonely 4 m	0.97	26.0
Lake Lonely 6 m	0.99	12.1
Lake Lonely 10m-A	3.21	217.8
Lake Lonely 10m-B	3.33	159.3

Appendix A.7: Lake Lonely Nutrient Values on June 27, 2007

Site	TN (mg N/L)	TP (µg P/L)
Lake Lonely 1 m	0.68	15.3
Lake Lonely 3 m	0.94	43.7
Lake Lonely 6 m	1.00	15.5
Lake Lonely 9 m	1.34	12.7

Appendix A.8: Temperature, Dissolved Oxygen, Percent Saturation, Conductivity, Specific Conductance, and Salinity as a Function of Depth on Lake Desolation - 7/24/07

Depth (m)	Temp. (°C)	Dissolved Oxygen (ppm)	Dissolved Oxygen (%)	Conductivity (µS)	Specific Conductance (µS)	Salinity (ppt)
0.5	21.3	7.79	86.6	39.2	42.7	0.0
1	21.3	7.72	88.3	39.2	42.6	0.0
2	21.3	6.45	87.7	39.2	42.6	0.0
3	20.8	7.04	79.8	38.6	42.0	0.0
4	17.7	3.91	40.8	36.0	41.3	0.0
5	12.6	0.17	1.5	33.9	44.6	0.0
5.5	11.2	0.11	1.0	37.1	50.1	0.0

Appendix A.9: Temperature, Dissolved Oxygen, Percent Saturation, Conductivity, Specific Conductance, and Salinity as a Function of Depth on Moreau Lake - 7/24/07

Depth (m)	Temp. (°C)	Dissolved Oxygen (ppm)	Dissolved Oxygen (%)	Conductivity (µS)	Specific Conductance (µS)	Salinity (ppt)
0.5	23.7	8.25	95.6	114.7	117.5	0.1
1	23.7	8.25	95.9	114.6	117.5	0.1
2	23.7	8.25	94.7	114.6	117.5	0.1
3	23.7	8.14	92.1	114.6	117.5	0.1
4	23.7	8.09	94.4	114.6	117.5	0.1
5	23.7	7.97	95.2	114.5	117.5	0.1
6	18.6	13.44	140.0	97.9	111.7	0.1
7	14.1	13.93	135.9	88.1	111.5	0.1
8	11.9	13.20	119.5	83.8	111.8	0.1
9	10.2	12.30	108.6	80.9	112.8	0.1
10	9.1	10.78	93.7	78.2	112.4	0.1
11	8.1	4.60	37.0	78.9	116.4	0.1
12	7.6	0.95	7.8	79.6	119.1	0.1
13	7.3	0.13	1.1	80.5	121.6	0.1

Appendix A.10: Spring Run and Bog Meadow Brook Nutrient Values on June 12, 2007

Site	NO_3^- (mg N/L)	TN (mg N/L)	TP (µg P/L)	SRP (µg P/L)	NH_4^+ (mg N/L)
Spring Run-R	1.12	1.92	61.5	21.5	0.11
Spring Run [1]	1.14	1.50	49.7	17.5	0.08
Spring Run [2]	1.04	1.92	60.4	18.6	0.11
Spring Run [3]	0.90	1.70	52.4	14.3	0.13
Bog Meadow Brook -R	0.70	1.20	34.1	16.9	0.05

Appendix A.11: Total Suspended Solids for Samples from Lake Lonely, Spring Run, and Bog Meadow Brook Collected on 6/7/07

	Paper (g)	Paper + TSS (g)	TSS (g)	TSS (mg/L)	Sum TSS (mg/L)	Avg. TSS (mg/L)	Standard Deviation	Relative Deviation (%)
Lake Lonely 1	0.1179	0.1177	-0.0002	-1				
Lake Lonely 2	0.1023	0.1026	0.0003	1.5				
Lake Lonely 3	0.1191	0.1189	-0.0002	-1				
Lake Lonely 4	0.1075	0.1079	0.0004	2				
Lake Lonely 5	0.1176	0.1177	0.0001	0.5	2.0	0.4	1.4	347
Spring Run 1	0.1155	0.1165	0.0010	5				
Spring Run 2	0.1061	0.1073	0.0012	6				
Spring Run 3	0.1141	0.1150	0.0009	4.5				
Spring Run 4	0.0997	0.1004	0.0007	3.5				
Spring Run 5	0.1186	0.1196	0.0010	5	24.0	4.8	0.9	19
Bog Meadow Brook 1	0.1182	0.1188	0.0006	3				
Bog Meadow Brook 2	0.1110	0.1101	-0.0009	-4.5				
Bog Meadow Brook 3	0.1188	0.1197	0.0009	4.5				
Bog Meadow Brook 4	0.1164	0.1171	0.0007	3.5				
Bog Meadow Brook 5	0.1191	0.1192	0.0001	0.5	7.0	1.4	3.6	258

Appendix A.12: Total Suspended Solids for Samples from Lake Lonely, Spring Run, and Bog Meadow Brook Collected on 7/12/07

	Final Pre-Weight (g)	Final Post-Weight (g)	Mass TSS (g)	Mass TSS (g/mL)	Mass TSS (mg/L)	Average Mass (mg/L)	Standard Deviation	Relative Deviation
Lake Lonely-1	0.1104	0.1107	0.0003	8.57143E-07	0.857142857			
Lake Lonely-2	0.1095	0.1096	0.0001	2.85714E-07	0.285714286			
Lake Lonely-3	0.1213	0.1204	-0.0009	-2.57143E-06	-2.571428571			
Lake Lonely-4	0.1191	0.1184	-0.0007	-2E-06	-2			
Lake Lonely-5	0.1184	0.1184	0.0000	0	0			
Lake Lonely-6	0.1165	0.1164	-0.0001	-2.85714E-07	-0.285714286			
Lake Lonely-7	0.1181	0.1180	-0.0001	-2.85714E-07	-0.285714286			
Lake Lonely-8	0.1187	0.1182	-0.0005	-1.42857E-06	-1.428571429			
Lake Lonely-9	0.1191	0.1191	0.0000	0	0			
Lake Lonely-10	0.1185	0.1184	-0.0001	-2.85714E-07	-0.285714286	-0.285714286	1.077496048	-377.1236166
Spring Run-1	0.1185	0.1194	0.0009	2.57143E-06	2.571428571			
Spring Run-2	0.1193	0.1200	0.0007	2E-06	2			
Spring Run-3	0.1188	0.1197	0.0009	2.57143E-06	2.571428571			
Spring Run-4	0.1176	0.1181	0.0005	1.42857E-06	1.428571429			
Spring Run-5	0.1112	0.1125	0.0013	3.71429E-06	3.714285714			
Spring Run-6	0.1181	0.1190	0.0009	2.57143E-06	2.571428571			
Spring Run-7	0.1185	0.1193	0.0008	2.28571E-06	2.285714286			
Spring Run-8	0.1094	0.1101	0.0007	2E-06	2			
Spring Run-9	0.1206	0.1209	0.0003	8.57143E-07	0.857142857			
Spring Run-10	0.1088	0.1100	0.0012	3.42857E-06	3.428571429	2.519480519	0.849703163	33.72533172
Bog Meadow Brook-1	0.1183	0.1198	0.0015	4.28571E-06	4.285714286			
Bog Meadow Brook-2	0.1100	0.1118	0.0018	5.14286E-06	5.142857143			
Bog Meadow Brook-3	0.1196	0.1210	0.0014	0.000004	4			
Bog Meadow Brook-4	0.1192	0.1204	0.0012	3.42857E-06	3.428571429			
Bog Meadow Brook-5	0.1193	0.1214	0.0021	6E-06	6			
Bog Meadow Brook-6	0.1180	0.1192	0.0012	3.42857E-06	3.428571429			
Bog Meadow Brook-7	0.1100	0.1115	0.0015	4.28571E-06	4.285714286			
Bog Meadow Brook-8	0.1179	0.1196	0.0017	4.85714E-06	4.857142857			
Bog Meadow Brook-9	0.1092	0.1113	0.0021	6E-06	6			
Bog Meadow Brook-10	0.1184	0.1202	0.0018	5.14286E-06	5.142857143	4.657142857	0.933624833	20.04715899

Appendix A. 13 Summary of Total Nitrogen (TN) data for Summer 2007 Lakes

Site	7-Jun	12-Jun	20-Jun	28-Jun	18-Jul	24-Jul	8-Aug
Lake Lonely A 0.5m		---	---	---	----	lt 0.01	lt 0.05
Lake Lonely B 0.5m	0.82						
Lake Lonely 4 m	0.82						
Lake Lonely 6 m	0.97						
Lake Lonely A 10m	0.99						
Lake Lonely B 10m	3.21						
Lake Lonely outlet	3.33						
Lake Lonely 1 m				0.82			
Lake Lonely 3 m				0.68			
Lake Lonely 6 m				0.94			
Lake Lonely 9 m				1.00			
Lake Lonely 1m				1.34			
Lake Lonely 5.5m							0.53
Lake Lonely 10 m							0.99
Site	**7-Jun**	**12-Jun**	**20-Jun**	**28-Jun**	**18-Jul**	**24-Jul**	**8-Aug**
Lake Desolation 1m						0.28	
Lake Desolation 5 m						0.15	
Site	**7-Jun**	**12-Jun**	**20-Jun**	**28-Jun**	**18-Jul**	**24-Jul**	**8-Aug**
Lake Moreau 1m						0.25	
Lake Moreau 6m						0.24	
Lake Moreau 8 m						0.27	
Lake Moreau 12 m						0.56	

Appendix A. 14 Summary of Total Phosphorous (TP) data for Summer 2007 Lakes

Site	7-Jun	12-Jun	20-Jun	28-Jun	18-Jul	24-Jul	8-Aug
Lake Lonely A 0.5m		---	---	---	----	lt 0.01	lt 0.05
Lake Lonely B 0.5m	19.2						
Lake Lonely 4 m	20.3						
Lake Lonely 6 m	26.0						
Lake Lonely A 10m	12.1						
Lake Lonely B 10m	217.8						
Lake Lonely outlet	159.3						
Lake Lonely 1 m				30.98			
Lake Lonely 3 m				15.3			
Lake Lonely 6 m				43.7			
Lake Lonely 9 m				15.5			
Lake Lonely 1m				12.7			
Lake Lonely 5.5m							16.2
Lake Lonely 10 m							11.8
Site	**7-Jun**	**12-Jun**	**20-Jun**	**28-Jun**	**18-Jul**	**24-Jul**	**8-Aug**
Lake Desolation 1m						7.8	
Lake Desolation 5 m						12.6	
Site	**7-Jun**	**12-Jun**	**20-Jun**	**28-Jun**	**18-Jul**	**24-Jul**	**8-Aug**
Lake Moreau 1m						3.9	
Lake Moreau 6m						7.4	
Lake Moreau 8 m						8.8	
Lake Moreau 12 m						14.3	

Appendix B.1: Sodium Chloride Tracer Test: Summer 2007.

25-Jun-07	
X section	**Area (m^2)**
MKC_01	30.8
MKC_02	37.2
MKC_03	37.9
Average Area	35.3
X section	**Area (m^2)**
LLO_01	8.7
LLO_02	4.6
LLO_03	4.3
Average Area	5.9
Site	**Velocity (m/s)**
MK-C	0.053
LLO	0.1
Site	**Discharge (m^3/s)**
MK-C	1.86
LLO	0.59

5-Jul-07	
X section	**Area (m^2)**
MKC_01	33.20
MKC_02	42.29
MKC_03	39.55
Average Area	38.35
X section	**Area (m^2)**
LLO_01	9.19
LLO_02	5.14
LLO_03	4.97
Average Area	6.43
Site	**Velocity (m/s)**
MK-C	0.056
LLO	0.067
Site	**Discharge (m^3/s)**
MK-C	2.13
LLO	0.43

12-Jul-07	
X section	**Area (m^2)**
MKC_01	34.63
MKC_02	39.00
MKC_03	41.65
Average Area	38.43
X section	**Area (m^2)**
LLO_01	9.71
LLO_02	5.95
LLO_03	5.28
Average Area	6.98
Site	**Velocity (m/s)**
MK-C	0.14
LLO	0.22
Site	**Discharge (m^3/s)**
MK-C	5.42
LLO	1.55

25-Jul-07	
X section	**Area (m^2)**
MKC_01	34.17
MKC_02	37.82
MKC_03	40.89
Average Area	37.63
X section	**Area (m^2)**
LLO_01	9.44
LLO_02	5.64
LLO_03	4.35
Average Area	6.48
Site	**Velocity (m/s)**
MK-C	0.065
LLO	0.10
Site	**Discharge (m^3/s)**
MK-C	2.46
LLO	0.66

Appendix B.2: Sodium Chloride Tracer Test: Summer 2007.

Date	**Site**	**Area (m^2)**	**L/W (m)**	**Velocity (m/sec)**	Total Discharge (m^3/s)	**Area (ft^2)**	**L/W (ft)**	**Velocity (ft/sec)**	Total Discharge (ft^3/s)
6/25/2007	MK-C	35.300	5.941	0.0439	1.55	379.772	19.488	0.1439	54.63
7/5/2007	MK-C	38.348	6.193	0.0556	2.13	412.565	20.312	0.1822	75.18
7/12/2007	MK-C	38.426	6.199	0.1410	5.42	413.398	20.332	0.4626	191.22
7/25/2007	MK-C	37.630	6.134	0.0655	2.46	404.835	20.121	0.2148	86.94
6/25/2007	LLO	5.900	2.429	0.0351	0.21	63.475	7.967	0.1151	7.31
7/5/2007	LLO	6.435	2.537	0.0667	0.43	69.235	8.321	0.2187	15.14
7/12/2007	LLO	6.979	2.642	0.2222	1.55	75.0783	8.665	0.7289	54.72
7/25/2007	LLO	6.476	2.545	0.1026	0.66	69.666	8.347	0.3364	23.44

Appendix B.3: Manual Flow Measurement at LLO_02 on 6/26/07.

Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Discharge (m^3/s)	Total Discharge (m^3/s)
8.8	80	0.8	0.08	**1.9**	**1.2**	**0.12**	0.2736	0.14 (or 4.9 ft^3/s)
10.7	117	1.17	0.12	**0.3**	**0.96**	**0.12**	0.03456	
10.4	75	0.75	0.12	**1.6**	**0.645**	**0.145**	0.14964	
12	54	0.54	0.17	**1.55**	**0.445**	**0.165**	0.11380875	
13.55	35	0.35	0.16					

Appendix C.1: GPS Coordinates of the Nine Tributary Sites

Site	Longitude & Latitude	UTM
Upper Kayaderosseras	N 43 08 18.9 W 73 52 37.7	18T 0601649 UTM 4766403
Clover Mill Upstream	N 43 04 46.8 W 73 58 05.2	18T 0583994 UTM 4770187
Clover Mill Downstream	N 43 04 12.7 W 73 56 12.9	18T 0586571 UTM 4769158
Glowegee Creek	N 43 01 52.4 W 73 55 38.7	18T 0587378 UTM 4764836
Mourning Kill	N 42 58 31.8 W 73 50 48.5	18T 0594001 UTM 4758739
Main Kayaderosseras-R	N 43 01 50.3 W 73 47 26.9	18T 0598509 UTM 4764926
Geyser Brook	N 43 02 51.0 W 73 48 10.0	18T 0597514 UTM 4766787
Spring Run-R	N 43 04 11.0 W 73 44 42.3	18T 0602170 UTM 4769318
Bog Meadow Brook-R	N 43 03 54.8 W 73 44 0.2	18T 0603130 UTM 4768838

Appendix C.2: Directions to Each Tributary Site Starting from Skidmore College

From Skidmore College campus take Clinton Ave to Daniel's Road, left onto Daniel's Road, right onto 9N.

UK: From Route 9N, turn left onto Bockes Road. The site is approximately 1.8 mils from the intersection. Park at the "Anglers park here" sign.

CM-U: Turn around and make a right onto Squashville. Turn left onto North Creek Road and right onto Middle Grove Road. Go past Stewarts (on right) and over the Kayaderosseras Creek. The Clover Mill Creek Upstream site is a small stream on the left that goes through a culvert on Middle Grove road.

CM-D: From CM-U continue west on Middle Grove Road. Turn left onto Route 29. The site is on the right (south) across the road from the landfill, just upstream of Boy Haven Road. This is not at a road-stream intersection. There is no culvert or bridge.

GC: From CM-D continue east on Route 29. Turn right onto Rock City Road (Route 49), bear right at Y and make a left to stay on Route 49. Continue past Lewis Road to the USGS site at the bridge.

MournK: From GC continue south to Route 45 (North Line Road). Turn left onto Route 45. Turn right onto Route 59 (Middle Line Road). Turn left onto Brookline Road (Route 60) which turns into Route 67. The MournK site is just past an underpass and in from of the Curtis Lumber complex.

MainK-R: From the MournK site continue on Route 67 to Northway (Route 87) Exit 12. Take the Northway to Exit 13 North and head north on Route 9. After crossing over the Kayaderosseras Creek find a place to turn around and head south. Just after crossing the Kayaderosseras Creek again, turn left into the divide. This site is between the north bound and south bound lanes of Route 9.

GB: After the MainK site continue south and find a place to turn around. Take Route 9 north to the Saratoga Spa State Park. Make a left into the first park entrance and take the second right. The site is in the Geyser Picnic area.

SR-R: From the Saratoga Spa State Park head north on Route 9. Take Circular to Union and head east on Union Ave. This site is shortly after you cross the Northway.

BMB-R: Continue east on 9P. Make a right into a small gravel parking lot just past the entrance for the Saratoga National Golf Club. The site is down the path at the first bridge.

Map Modified from Google (c) 2007 by Alicea Cock-Esteb

Appendix C.3: Temperature, pH, and Dissolved Oxygen at the Nine Tributaries on 6/19/07, 7/3/07, and 7/18/07.

Site	Temp. (°C) 6/19/2007	Temp. (°C) 7/3/2007	Temp. (°C) 7/18/2007	pH 6/19/2007	pH 7/3/2007	pH 7/18/2007	DO (ppm) 6/19/2007	DO (ppm) 7/3/2007	DO (ppm) 7/18/2007	% Saturation 6/19/2007	% Saturation 7/3/2007	% Saturation 7/18/2007
UK	18.1	14.6	20.6	7.59	7.43	7.43	8.44	9.37	7.79	89.8	92.4	86.8
CM-U	13.5	11.5	14.1	7.79	7.43	7.79	9.98	11.01	10.26	97.6	101.4	100.8
CM-D	16.3	13.3	16	8.24	7.85	7.86	9.62	10.68	9.71	99.1	102.2	99.8
GC	20.4	15.4	19.4	8.16	7.56	7.66	8.97	8.5	7.75	99.0	85.3	84.2
MoK	24.5	18.3	20.2	8.42	8.08	7.71	9.17	10.63	8.8	110.5	113.2	92.1
MaK	23.4	17.8	20.6	8.34	7.77	7.61	9.49	9.62	7.33	110.5	103	83
GB	21.6	17.3	17.8	7.98	7.89	7.7	9.55	10.46	9.91	106.5	110	95
SR	22.6	18.3	16.8	7.78	7.78	7.72	8.75	10.92	8.7	101.3	117.2	89
BMB	22.6	17.6	17.3	7.95	7.6	7.65	8.14	9.57	8.01	94.8	98.7	84.3

Appendix C.4: Conductivity and Salinity at the Nine Tributaries on 6/19/07, 7/3/07, and 7/18/07.

Site	Cond. (µS) 6/19/2007	Cond. (µS) 7/3/2007	Cond. (µS) 7/18/2007	S. Cond. (µS) 6/19/2007	S. Cond. (µS) 7/3/2007	S. Cond. (µS) 7/18/2007	Sal. (ppt) 6/19/2007	Sal. (ppt) 7/3/2007	Sal. (ppt) 7/18/2007
UK	203.0	181.8	197.1	175.6	226.6	215.2	0.1	0.1	0.1
CM-U	138.0	119.1	121.2	107.8	160.6	151.9	0.1	0.1	0.1
CM-D	370.3	326.4	311.2	306.8	420.6	377.1	0.2	0.2	0.2
GC	356.7	324.5	346	323.1	396.7	387.4	0.2	0.2	0.2
MoK	400.6	417.1	410.8	390.8	478.4	452	0.2	0.2	0.2
MaK	407.2	418.2	430.9	391.7	484.2	470.6	0.2	0.2	0.2
GB	614.0	641.1	590.1	561.0	758.2	681	0.3	0.4	0.3
SR	1086	1060.3	936	1035	1216.2	1114	0.5	0.6	0.6
BMB	364.8	358.9	342.8	344.3	421.7	401.2	0.2	0.2	0.2

Appendix C.5: Total Discharge at Tributaries: Summer 2007.

Date	Site	Total Discharge (m^3/s)	Total Discharge (ft^3/s)
19-Jun-07	GB	0.410	22.05
3-Jul-07	GB	0.422	14.89
18-Jul-07	GB	0.906	31.99
19-Jun-07	CM-D	0.0676	2.39
3-Jul-07	CM-D	0.0650	2.30
18-Jul-07	CM-D	0.170	6.0
19-Jun-07	CM-U	0.0226	0.81
3-Jul-07	CM-U	0.0184	0.65
18-Jul-07	CM-U	0.0397	1.40
19-Jun-07	GC	0.160	6.06
19-Jun-07	GC *(usgs)*	*NA*	8.25
3-Jul-07	GC	0.104	3.66
3-Jul-07	GC *(usgs)*	*NA*	4.7
5-Jul-07	GC *(usgs)*	*NA*	7.6
12-Jul-07	GC *(usgs)*	*NA*	16.1
13-Jul-07	GC *(usgs)*	*NA*	10.5
18-Jul-07	GC	0.220	7.76
18-Jul-07	GC *(usgs)*	*NA*	8.2

Date	Site	Total Discharge (m^3/s)	Total Discharge (ft^3/s)
19-Jun-07	MaK	2.004	76.35
3-Jul-07	MaK	1.556	54.89
18-Jul-07	MaK	2.544	89.79
25-Jun-07	MKC	1.548	54.63
5-Jul-07	MKC	2.130	75.18
12-Jul-07	MKC	5.419	191.22
25-Jul-07	MKC	2.464	86.94
19-Jun-07	UK	0.277	9.77
3-Jul-07	UK	0.226	7.97
18-Jul-07	UK	0.501	17.67
25-Jun-07	LLO	0.207	7.31
26-Jun-07	LLO_02	0.143	5.18
5-Jul-07	LLO	0.429	15.14
12-Jul-07	LLO	1.551	54.72
25-Jul-07	LLO	0.664	23.44
19-Jun-07	MoK	0.0991	3.52
3-Jul-07	MoK	0.0242	0.87
18-Jul-07	MoK	0.260	9.17

Appendix C.6: Total Discharge at Spring Run and Bog Meadow Brook: Summer 2007.

Date	Site	Total Discharge (m^3/s)	Total Discharge (ft^3/s)
7-Jun-07	SR [2]*	0.048*	1.93*
7-Jun-07	SR [3]*	0.171*	6.89*
7-Jun-07	SR [2+3]	0.219	8.82
12-Jun-07	SR [2]*	0.073*	4.6*
12-Jun-07	SR [3]*	0.187*	9.88*
12-Jun-07	SR [2+3]	0.260	14.48
12-Jun-07	SR [1]*	0.221*	7.89*
12-Jun-07	SR-R	0.267	14.92
19-Jun-07	SR-R	0.188	6.64**
3-Jul-07	SR-R	0.167	5.89**
13-Jul-07	SR-R	0.190	6.69
18-Jul-07	SR-R	0.346	12.21**

7-Jun-07	BMB-R	0.502	22.53
12-Jun-07	BMB-R	0.228	9.78
19-Jun-07	BMB-R	0.255	9.28**
3-Jul-07	BMB-R	0.224	7.90**
13-Jul-07	BMB-R	0.369	12.98
18-Jul-07	BMB-R	0.330	11.65**
18-Jul-07	BMB-29	0.552	19.49

*These points do not corespond to the entire flow of Spring Run.
The flow at location SR [2+3] should be approximately equal to the flow at SR-R.
** Only these points were used in the calculation of the (three-day) summer 2007 average listed in Appendix C.16 and
.

Appendix C.7: Spring Run Manual Discharge Measurements: Summer 2007.

SR [2]: 6/7/07

Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0	0	0	0	**1**	**0.33333**	**-0.0081**	-0.0027	0.05
1	50	0.5	-0.0122	**1**	**0.64**	**-0.0008**	-0.0005	
2	78	0.78	0.01067	**1**	**0.83**	**0.00991**	0.00822	
3	88	0.88	0.00915	**1**	**0.82**	**0.0122**	0.01	
4	76	0.76	0.01524	**1**	**0.73**	**0.01067**	0.00779	
5	70	0.7	0.0061	**1**	**0.685**	**0.0061**	0.00418	
6	67	0.67	0.0061	**1**	**0.66**	**0.01067**	0.00704	
7	65	0.65	0.01524	**1**	**0.645**	**0.01982**	0.01278	
8	64	0.64	0.02439	**1**	**0.57**	**0.00203**	0.00116	
9	50	0.5	0.00305					

SR [3]: 6/7/07

Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0	0	0	0	**1**	**0.38667**	**0.06911**	0.02672	0.17
1	58	0.58	0.10366	**1**	**0.62**	**0.05945**	0.03686	
2	66	0.66	0.01524	**1**	**0.68**	**0.04726**	0.03213	
3	70	0.7	0.07927	**1**	**0.71**	**0.04726**	0.03355	
4	72	0.72	0.01524	**1**	**0.72**	**0.04116**	0.02963	
5	72	0.72	0.06707	**1**	**0.36**	**0.03354**	0.01207	
6	0	0	0					

SR-R: **6/12/07**	*10:00 a.m., upstream of bridge, very fine mud and sand, wetlands, lots of vegatation*					**GPS= 18t0602208, utm4769341**		
Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0	0	0	0	**0.9**	**0**	**0**	0	0.27
0.9	23	0.23	0.07927	**0.9**	**0.23**	**0.12348**	0.02556	
1.8	23	0.23	0.16768	**0.9**	**0.265**	**0.21037**	0.05017	
2.7	30	0.3	0.25305	**0.9**	**0.32**	**0.28049**	0.08078	
3.6	34	0.34	0.30793	**0.9**	**0.34**	**0.29726**	0.09096	
4.5	34	0.34	0.28659	**0.8**	**0.17**	**0.14329**	0.01949	
5.3	0	0	0					

SR [1]: **6/12/07**	*7:20 a.m., limestone rock*					**GPS= 18t0602603, utm4768762**		
Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0	22	0.22	0.08537	**0.4**	**0.14667**	**0.13415**	0.00787	0.22
0.4	28	0.28	0.20122	**0.4**	**0.25**	**0.27439**	0.02744	
0.8	34	0.34	0.34756	**0.4**	**0.31**	**0.39939**	0.04952	
1.2	36	0.36	0.45122	**0.4**	**0.35**	**0.43293**	0.06061	
1.6	32	0.32	0.41463	**0.4**	**0.34**	**0.375**	0.051	
2	32	0.32	0.33537	**0.4**	**0.32**	**0.18902**	0.0242	
2.4	30	0.3	0.04268					

SR [2]: 6/12/07	*9:02 a.m., sandy channel bottom, wetlands, lots of vegatation*					**GPS= 18t0602438, utm4768485**		
Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0	0	0	0	**0.8**	**0**	**0**	0	0.07
0.8	28	0.28	0.00915	**0.8**	**0.29**	**0.06555**	0.01521	
1.6	30	0.3	0.12195	**0.8**	**0.305**	**0.10061**	0.02455	
2.4	31	0.31	0.07927	**0.8**	**0.32**	**0.05183**	0.01327	
3.2	48	0.33	0.02439	**0.6**	**0.325**	**0.0625**	0.01219	
3.8	32	0.32	0.10061	**0.9**	**0.16**	**0.0503**	0.00724	
4.7	0	0	0					

SR [3]: 6/12/07	*8:42 a.m., rocky channel bottom, turbid water, uniform*					**GPS= 18t0602592, utm4768507**		
Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0	0	0	0	**0.8**	**0**	**0.01829**	0	0.19
0.8	28	0.28	0.02744	**0.8**	**0.14**	**0.08384**	0.00939	
1.6	30	0.3	0.14024	**0.8**	**0.29**	**0.20579**	0.04774	
2.4	31	0.31	0.27134	**0.8**	**0.305**	**0.27287**	0.06658	
3.2	33	0.33	0.27439	**0.6**	**0.32**	**0.21341**	0.04098	
3.8	32	0.32	0.15244	**0.9**	**0.325**	**0.07622**	0.02229	
4.7	0	0	0					

SR-R: 6/19/07								
Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0	26	0.26	0.22256	**0.7**	**0.17333**	**0.14837**	0.018	0.19
0.7	30	0.3	0.2378	**0.7**	**0.29**	**0.22713**	0.04611	
1.4	28	0.28	0.21646	**0.7**	**0.28**	**0.19665**	0.03854	
2.1	28	0.28	0.17683	**0.8**	**0.26**	**0.1753**	0.03646	
2.9	24	0.24	0.17378	**0.7**	**0.24**	**0.16616**	0.02791	
3.6	24	0.24	0.15854	**0.65**	**0.235**	**0.1372**	0.02096	
4.25	23	0.23	0.11585					

SR-R: 7/3/07	*1:18 p.m., partly cloudy skies*							
Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0.5	10	0.1	0.01829	**0.5**	**0.15**	**0.02744**	0.00206	0.17
1	24	0.24	0.16768	**0.5**	**0.265**	**0.22104**	0.02929	
1.5	29	0.29	0.27439	**0.5**	**0.255**	**0.24543**	0.03129	
2	22	0.22	0.21646	**0.13**	**0.21**	**0.21646**	0.00591	
2.13	20	0.2	0.21646	**0.87**	**0.195**	**0.125**	0.02121	
3	19	0.19	0.03354	**0.5**	**0.205**	**0.10823**	0.01109	
3.5	22	0.22	0.18293	**0.5**	**0.23**	**0.18902**	0.02174	
4	24	0.24	0.19512	**0.5**	**0.22**	**0.17988**	0.01979	
4.5	20	0.2	0.16463	**0.5**	**0.18**	**0.15854**	0.01427	
5	16	0.16	0.15244	**0.5**	**0.14**	**0.10976**	0.00768	
5.5	12	0.12	0.06707	**0.5**	**0.11**	**0.04573**	0.00252	
6	10	0.1	0.02439					

SR-R:
7/13/07 *9:34 a.m., sunny day*

Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0.5	20	0.2	0.05183	**0.5**	**0.3**	**0.07774**	0.01166	0.19
1	30	0.3	0.15549	**1**	**0.27**	**0.125**	0.03375	
2	24	0.24	0.09451	**1**	**0.23**	**0.11585**	0.02665	
3	22	0.22	0.1372	**1**	**0.25**	**0.19665**	0.04916	
4	28	0.28	0.2561	**1**	**0.25**	**0.21494**	0.05373	
5	22	0.22	0.17378	**0.5**	**0.17**	**0.12805**	0.01088	
5.5	12	0.12	0.08232	**0.5**	**0.11**	**0.0686**	0.00377	
6	10	0.1	0.05488					

SR-R:
7/18/07 *rainy, cloudy, overcast*

Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0.3	34	0.34	0.0122	**0.7**	**0.51**	**0.01829**	0.00653	0.35
1	30	0.3	0.16768	**1**	**0.32**	**0.17988**	0.05756	
2	34	0.34	0.19207	**1**	**0.37**	**0.21037**	0.07784	
3	40	0.4	0.22866	**1**	**0.38**	**0.23323**	0.08863	
4	36	0.36	0.2378	**1**	**0.33**	**0.24085**	0.07948	
5	30	0.3	0.2439	**1**	**0.245**	**0.14024**	0.03436	
6	19	0.19	0.03659	**0.35**	**0.185**	**0.02287**	0.00148	
6.35	18	0.18	0.00915					

Appendix C.8: Bog Meadow Brook Manual Discharge Measurements: Summer 2007.

BMB-R: 6/7/07

Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0	0	0	0	**0.9**	**0.56**	**0.04878**	0.02459	0.50
0.9	84	0.84	0.07317	**0.9**	**0.96**	**0.08537**	0.07376	
1.8	108	1.08	0.09756	**0.9**	**1.06**	**0.14329**	0.1367	
2.7	104	1.04	0.18902	**0.9**	**0.925**	**0.17835**	0.14848	
3.6	81	0.81	0.16768	**1**	**0.625**	**0.16159**	0.10099	
4.6	44	0.44	0.15549	**1**	**0.22**	**0.07774**	0.0171	
5.6	0	0	0					

BMB-R: 6/12/07 *8:10 a.m.* **GPS= 18t0603187, utm4768775**

Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0	81	0.81	0	**0.9**	**0.54**	**0**	0	0.23
0.9	99	0.99	0.05183	**0.9**	**0.945**	**0.07622**	0.06482	
1.8	90	0.9	0.10061	**0.9**	**0.765**	**0.12348**	0.08501	
2.7	63	0.63	0.14634	**0.9**	**0.465**	**0.14482**	0.06061	
3.6	30	0.3	0.14329	**0.9**	**0.15**	**0.12652**	0.01708	
4.5	0	0	0.10976	**0.8**	**0**	**0.05488**	0	
5.3	0	0	0					

BMB-R: 6/19/07								
Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0	22	0.22	0	**0.75**	**0.14667**	**0**	0	0.26
0.75	74	0.74	0.03963	**0.75**	**0.81**	**0.05793**	0.03519	
1.5	88	0.88	0.07622	**0.75**	**0.9**	**0.10518**	0.071	
2.25	92	0.92	0.13415	**0.75**	**0.85**	**0.11433**	0.07288	
3	78	0.78	0.09451	**0.75**	**0.65**	**0.09909**	0.0483	
3.75	52	0.52	0.10366	**0.75**	**0.39**	**0.09604**	0.02809	
4.5	26	0.26	0.08841	**0.8**	**0.13**	**0.04421**	0.0046	
5.3	0	0	0					

BMB-R: 7/3/07	*1:47p.m*							
Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0.5	50	0.5	-0.0152	**0.5**	**0.75**	**-0.0229**	-0.0086	0.22
1	90	0.9	0.0061	**0.5**	**0.91**	**0.02896**	0.01318	
1.5	92	0.92	0.05183	**0.5**	**0.945**	**0.06098**	0.02881	
2	97	0.97	0.07012	**0.5**	**0.945**	**0.08384**	0.03962	
2.5	92	0.92	0.09756	**0.5**	**0.85**	**0.11585**	0.04924	
3	78	0.78	0.13415	**0.5**	**0.77**	**0.13262**	0.05106	
3.5	76	0.76	0.1311	**0.5**	**0.62**	**0.11738**	0.03639	
4	48	0.48	0.10366	**0.5**	**0.37**	**0.07622**	0.0141	
4.5	26	0.26	0.04878					

BMB-R:
7/13/07 *10:37 a.m., sunny & clear*

Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0.5	64	0.64	0.01524	**0.5**	**0.96**	**0.02287**	0.01098	0.37
1	94	0.94	0.01524	**0.5**	**0.97**	**0.05488**	0.02662	
1.5	100	1	0.09451	**0.5**	**1**	**0.10213**	0.05107	
2	100	1	0.10976	**0.5**	**0.96**	**0.14787**	0.07098	
2.5	92	0.92	0.18598	**0.5**	**0.87**	**0.16311**	0.07095	
3	82	0.82	0.14024	**0.5**	**0.76**	**0.16921**	0.0643	
3.5	70	0.7	0.19817	**0.5**	**0.64**	**0.14634**	0.04683	
4	58	0.58	0.09451	**0.5**	**0.45**	**0.09146**	0.02058	
4.5	32	0.32	0.08841	**0.5**	**0.22**	**0.0503**	0.00553	
5	12	0.12	0.0122					

BMB-R: 7/18/07

Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0.7	86	0.86	0.03049	**0.7**	**1.29**	**0.04573**	0.0413	0.33
1.4	100	1	0.06707	**0.7**	**1**	**0.08537**	0.05976	
2.1	100	1	0.10366	**0.7**	**0.925**	**0.13262**	0.08587	
2.8	85	0.85	0.16159	**0.7**	**0.785**	**0.15549**	0.08544	
3.5	72	0.72	0.14939	**0.7**	**0.61**	**0.10671**	0.04556	
4.2	50	0.5	0.06402	**0.7**	**0.32**	**0.05488**	0.01229	
4.9	14	0.14	0.04573					

BMB-29: 7/18/07								
Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0.5	60	0.6	0.39024	**0.5**	**0.9**	**0.58537**	0.26341	0.55
1	48	0.48	0.17073	**1**	**0.425**	**0.1997**	0.08487	
2	37	0.37	0.22866	**1**	**0.38**	**0.29421**	0.1118	
3	39	0.39	0.35976	**1**	**0.275**	**0.26524**	0.07294	
4	16	0.16	0.17073	**1.45**	**0.15**	**0.08841**	0.01923	
5.45	14	0.14	0.0061					

Appendix C.9: Upper Kayaderosseras Manual Discharge Measurements: Summer 2007.

UK: 6/19/07								
Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0.5	4	0.04	0.1372	**0.6**	**0.02667**	**0.09146**	0.00146	0.28
1.1	6	0.06	0.17073	**0.95**	**0.095**	**0.16159**	0.01458	
2.05	13	0.13	0.15244	**0.85**	**0.165**	**0.20579**	0.02886	
2.9	20	0.2	0.25915	**1**	**0.2**	**0.32012**	0.06402	
3.9	20	0.2	0.3811	**1.1**	**0.22**	**0.39634**	0.09591	
5	24	0.24	0.41159	**1.5**	**0.2**	**0.22713**	0.06814	
6.5	16	0.16	0.04268	**1.05**	**0.125**	**0.03049**	0.004	
7.55	9	0.09	0.01829					

UK:
7/3/07 *9:15 a.m., sunny day*

Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0.5	2	0.02	0.04573	**0.5**	**0.03**	**0.0686**	0.00103	0.23
1.1	3	0.03	0.13415	**0.6**	**0.065**	**0.1372**	0.00535	
2.05	10	0.1	0.14024	**0.95**	**0.12**	**0.1875**	0.02138	
2.9	14	0.14	0.23476	**0.85**	**0.15**	**0.28354**	0.03615	
3.9	16	0.16	0.33232	**1**	**0.185**	**0.38567**	0.07135	
5	21	0.21	0.43902	**1.1**	**0.17**	**0.30945**	0.05787	
6.5	13	0.13	0.17988	**1.5**	**0.115**	**0.18902**	0.03261	
7.45	10	0.1	0.19817					

UK:
7/18/07 *10:15am*

Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
1	10	0.1	0.12195	**1**	**0.15**	**0.18293**	0.02744	0.50
2	12	0.12	0.21951	**1**	**0.17**	**0.29421**	0.05002	
3	22	0.22	0.3689	**1**	**0.21**	**0.40396**	0.08483	
4	20	0.2	0.43902	**1**	**0.22**	**0.4497**	0.09893	
5	24	0.24	0.46037	**1**	**0.26**	**0.5061**	0.13159	
6	28	0.28	0.55183	**1**	**0.24**	**0.33384**	0.08012	
7	20	0.2	0.11585	**1**	**0.17**	**0.16311**	0.02773	
8	14	0.14	0.21037					

Appendix C.10: Clover Mill-Upstream Manual Discharge Measurements: Summer 2007.

CM-U: 6/19/07

Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0	0	0	0	**0.3**	**0**	**0**	0	0.02
0.3	11	0.11	0.14329	**0.3**	**0.12**	**0.20427**	0.00735	
0.6	13	0.13	0.26524	**0.3**	**0.12**	**0.24695**	0.00889	
0.9	11	0.11	0.22866	**0.3**	**0.105**	**0.15091**	0.00475	
1.2	10	0.1	0.07317	**0.3**	**0.09**	**0.07165**	0.00193	
1.5	8	0.08	0.07012	**0.1**	**0.075**	**0.03506**	0.00026	
1.6	7	0.07	0	**0.1**	**0.07**	**-0.0183**	-0.0001	
1.7	7	0.07	-0.0366	**0.1**	**0.06**	**-0.0381**	-0.0002	
1.8	5	0.05	-0.0396	**0.1**	**0.06**	**-0.0381**	-0.0002	
1.9	7	0.07	-0.0366					

CM-U: 7/3/07

Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0.25	4	0.04	-0.0244	**0.25**	**0.06**	**-0.0366**	-0.0005	0.02
0.5	5	0.05	0.04573	**0.25**	**0.065**	**0.04726**	0.00077	
0.75	8	0.08	0.04878	**0.25**	**0.085**	**0.07165**	0.00152	
1	9	0.09	0.09451	**0.25**	**0.095**	**0.16768**	0.00398	
1.25	10	0.1	0.24085	**0.25**	**0.115**	**0.26829**	0.00771	
1.5	13	0.13	0.29573	**0.25**	**0.12**	**0.16616**	0.00498	
1.75	11	0.11	0.03659					

CM-U: 7/18/07								
Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0.5	10	0.1	0.0061	**0.5**	**0.15**	**0.00915**	0.00069	0.04
1	13	0.13	0.24085	**0.5**	**0.145**	**0.29268**	0.02122	
1.5	16	0.16	0.34451	**0.5**	**0.17**	**0.20884**	0.01775	
2	18	0.18	0.07317					

Appendix C.11: Clover Mill-Downstream Manual Discharge Measurements: Summer 2007.

CM-D: 6/19/07 *use downstream tree on right bank downstream of sandbar*								
Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0	0	0	0	**0.55**	**0**	**0**	0	0.07
0.55	7	0.07	0.05488	**0.55**	**0.075**	**0.10061**	0.00415	
1.1	8	0.08	0.14634	**0.55**	**0.1**	**0.23323**	0.01283	
1.65	12	0.12	0.32012	**0.55**	**0.12**	**0.29878**	0.01972	
2.2	12	0.12	0.27744	**0.55**	**0.125**	**0.25**	0.01719	
2.75	13	0.13	0.22256	**0.5**	**0.135**	**0.20274**	0.01369	
3.25	14	0.14	0.18293					

CM-D: 7/3/07

Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0.5	18	0.18	0.09451	**0.5**	**0.27**	**0.14177**	0.01914	0.07
1	13	0.13	0.125	**0.5**	**0.125**	**0.15396**	0.00962	
1.5	12	0.12	0.18293	**0.5**	**0.1**	**0.20122**	0.01006	
2	8	0.08	0.21951	**0.5**	**0.105**	**0.21494**	0.01128	
2.5	13	0.13	0.21037	**0.5**	**0.15**	**0.19817**	0.01486	
3	17	0.17	0.18598					

CM-D: 7/18/07

Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0.3	14	0.14	0.10061	**0.3**	**0.21**	**0.15091**	0.00951	0.17
0.6	20	0.2	0.27439	**0.4**	**0.2**	**0.28963**	0.02317	
1	20	0.2	0.30488	**0.5**	**0.19**	**0.32774**	0.03114	
1.5	18	0.18	0.35061	**0.5**	**0.21**	**0.33689**	0.03537	
2	24	0.24	0.32317	**0.5**	**0.23**	**0.30793**	0.03541	
2.5	22	0.22	0.29268	**0.5**	**0.23**	**0.3064**	0.03524	
3	24	0.24	0.32012					

Appendix C.12: Glowegee Creek Manual Discharge Measurements: Summer 2007.

GC: 6/19/07

Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0	0	0	0	**1**	**0**	**0**	0	0.16
1	22	0.22	0.0122	**1**	**0.23**	**0.0503**	0.01157	
2	24	0.24	0.08841	**1**	**0.26**	**0.10061**	0.02616	
3	28	0.28	0.1128	**1**	**0.285**	**0.14024**	0.03997	
4	29	0.29	0.16768	**1**	**0.295**	**0.16006**	0.04722	
5	30	0.3	0.15244	**1**	**0.295**	**0.11738**	0.03463	
6	29	0.29	0.08232	**1**	**0.195**	**0.0625**	0.01219	
7	10	0.1	0.04268					

GC: 7/3/07 *9:53 a.m.*

Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0	31	0.31	0.0061	**1**	**0.465**	**0.00915**	0.00425	0.10
1	31	0.31	0.0061	**1**	**0.325**	**0.02591**	0.00842	
2	34	0.34	0.04573	**1**	**0.345**	**0.07165**	0.02472	
3	35	0.35	0.09756	**1**	**0.335**	**0.08994**	0.03013	
4	32	0.32	0.08232	**1**	**0.37**	**0.05945**	0.022	
5	42	0.42	0.03659	**1**	**0.375**	**0.02591**	0.00972	
6	33	0.33	0.01524	**1**	**0.315**	**0.0122**	0.00384	
7	30	0.3	0.00915	**0.4**	**0.32**	**0.00457**	0.00059	
7.4	34	0.34	0					

GC: **7/18/07** *11:30am*								
Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0	37	0.37	0.0122	**1**	**0.555**	**0.01829**	0.01015	0.22
1	42	0.42	0.0122	**1**	**0.38**	**0.03811**	0.01448	
2	34	0.34	0.06402	**1**	**0.37**	**0.09299**	0.03441	
3	40	0.4	0.12195	**1**	**0.44**	**0.12043**	0.05299	
4	48	0.48	0.1189	**1**	**0.47**	**0.09146**	0.04299	
5	46	0.46	0.06402	**1**	**0.43**	**0.08232**	0.0354	
6	40	0.4	0.10061	**1**	**0.42**	**0.07012**	0.02945	
7	44	0.44	0.03963	**0.3**	**0.41**	**0.02134**	0.00263	
7.3	38	0.38	0.00305					

Appendix C.13: Mourning Kill Manual Discharge Measurements: Summer 2007.

MoK: **6/19/07** *1:42 p.m., bedrock channel, boulders up to 0.5m wide*								
Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0	0	0	0	**1**	**0**	**0**	0	0.10
1	22	0.22	0.07317	**1**	**0.28**	**0.16463**	0.0461	
2	34	0.34	0.2561	**0.8**	**0.31**	**0.19665**	0.04877	
2.8	28	0.28	0.1372	**0.2**	**0.25**	**0.0686**	0.00343	
3	22	0.22	0	**0.5**	**0.18**	**0**	0	
3.5	14	0.14	0	**0.5**	**0.105**	**0.01524**	0.0008	
4	7	0.07	0.03049	**0.55**	**0.045**	**0.02591**	0.00064	
4.55	2	0.02	0.02134					

MoK: 7/3/07 *10:40a.m.*								
Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0.7	4	0.04	0.06402	**0.6**	**0.06**	**0.09604**	0.00346	0.02
1.3	14	0.14	0.05793	**0.8**	**0.13**	**0.07012**	0.00729	
2.1	12	0.12	0.08232	**0.7**	**0.12**	**0.08537**	0.00717	
2.8	12	0.12	0.08841	**0.7**	**0.11**	**0.0625**	0.00481	
3.5	10	0.1	0.03659	**0.7**	**0.06**	**0.02591**	0.00109	
4.2	2	0.02	0.01524	**0.7**	**0.055**	**0.00915**	0.00035	
4.9	9	0.09	0.00305	**0.7**	**0.045**	**0.00152**	4.8E-05	
5.6	0	0	0					

MoK: 7/18/07 *12:00pm*								
Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0.5	26	0.26	0.25	**0.5**	**0.39**	**0.375**	0.07313	0.26
1	28	0.28	0.14024	**1**	**0.305**	**0.16159**	0.04928	
2	33	0.33	0.18293	**1**	**0.345**	**0.19055**	0.06574	
3	36	0.36	0.19817	**1**	**0.315**	**0.15396**	0.0485	
4	27	0.27	0.10976	**1**	**0.225**	**0.0686**	0.01543	
5	18	0.18	0.02744	**0.8**	**0.15**	**0.06555**	0.00787	
5.8	12	0.12	0.10366					

Appendix C.14: Main Kayaderosseras-R Manual Discharge Measurements: Summer 2007.

MaK-R:
6/19/07 *2.23 p.m.*

Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0	0	0	0	**2**	**0**	**0**	0	2.00
2	44	0.44	0.46951	**2**	**0.46**	**0.48476**	0.44598	
4	48	0.48	0.5	**2**	**0.485**	**0.46799**	0.45395	
6	49	0.49	0.43598	**2**	**0.495**	**0.38567**	0.38181	
8	50	0.5	0.33537	**2**	**0.5**	**0.40091**	0.40091	
10	50	0.5	0.46646	**2.2**	**0.39**	**0.375**	0.32175	
12.2	28	0.28	0.28354	**1.8**	**0.22**	**0.27439**	0.10866	
14	16	0.16	0.26524	**1.55**	**0.11**	**0.2439**	0.04159	
15.55	6	0.06	0.22256	**1.45**	**0.055**	**0.11128**	0.00887	
17	5	0.05	0					

MaK-R: 7/3/07

Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0.5	14	0.14	0.02134	**1.5**	**0.21**	**0.03201**	0.01008	1.56
2	40	0.4	0.26829	**2**	**0.4**	**0.36585**	0.29268	
4	40	0.4	0.46341	**2**	**0.41**	**0.4253**	0.34875	
6	42	0.42	0.3872	**2**	**0.53**	**0.35823**	0.37973	
8	64	0.64	0.32927	**2**	**0.54**	**0.3064**	0.33091	
10	44	0.44	0.28354	**2**	**0.4**	**0.19512**	0.1561	
12	36	0.36	0.10671	**2**	**0.36**	**0.05183**	0.03732	
14	36	0.36	-0.003					

MaK-R: **7/18/07** *12:45pm*								
Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
1	22	0.22	0.21951	**2**	**0.33**	**0.32927**	0.21732	2.54
3	58	0.58	0.31707	**2**	**0.57**	**0.31707**	0.36146	
5	56	0.56	0.31707	**2**	**0.73**	**0.30335**	0.4429	
7	90	0.9	0.28963	**2**	**0.91**	**0.32774**	0.59649	
9	92	0.92	0.36585	**2**	**0.85**	**0.3628**	0.61677	
11	78	0.78	0.35976	**2**	**0.71**	**0.21799**	0.30954	
13	64	0.64	0.07622					

Appendix C.15: Geyser Brook Manual Discharge Measurements: Summer 2007.

GB: **6/19/07** *3:00 p.m.*								
Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0	14	0.14	-0.0244	**1.5**	**0.09333**	**-0.0163**	-0.0023	0.41
1.5	18	0.18	0	**0.5**	**0.2**	**0.0686**	0.00686	
2	22	0.22	0.1372	**1**	**0.24**	**0.13567**	0.03256	
3	26	0.26	0.13415	**1**	**0.255**	**0.31555**	0.08046	
4	25	0.25	0.49695	**1**	**0.265**	**0.5**	0.1325	
5	28	0.28	0.50305	**1**	**0.32**	**0.5**	0.16	
6	36	0.36	0.49695	**1**	**0.34**	**0.47713**	0.16223	
7	32	0.32	0.45732	**1**	**0.16**	**0.22866**	0.03659	
8	0	0	0					

GB:
7/3/07 *12:15p.m*

Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
0.3	10	0.1	0.14634	**0.7**	**0.15**	**0.21951**	0.02305	0.42
1	22	0.22	0.16159	**1**	**0.24**	**0.33537**	0.08049	
2	26	0.26	0.50915	**1**	**0.23**	**0.52134**	0.11991	
3	20	0.2	0.53354	**1**	**0.2**	**0.52287**	0.10457	
4	20	0.2	0.5122	**1**	**0.2**	**0.37652**	0.0753	
5	20	0.2	0.24085	**0.7**	**0.13**	**0.15701**	0.01429	
5.7	6	0.06	0.07317	**1.3**	**0.06**	**0.05488**	0.00428	
7	6	0.06	0.03659					

GB: 7/18/07

Tape Reading (m)	Depth (cm)	Depth (m)	Velocity (m/sec)	**Section Width (m)**	**Mean Depth (m)**	**Mean Velocity (m/sec)**	Segment Discharge (m^3/s)	Total Discharge (m^3/s)
1	32	0.32	0.27134	**1**	**0.48**	**0.40701**	0.19537	0.91
2	42	0.42	0.54268	**1**	**0.395**	**0.55183**	0.21797	
3	37	0.37	0.56098	**1**	**0.335**	**0.54116**	0.18129	
4	30	0.3	0.52134	**1**	**0.34**	**0.3186**	0.10832	
5	38	0.38	0.11585	**1**	**0.34**	**0.21494**	0.07308	
6	30	0.3	0.31402	**1**	**0.24**	**0.31555**	0.07573	
7	18	0.18	0.31707	**1**	**0.17**	**0.32165**	0.05468	
8	16	0.16	0.32622	**1**	**0.18**	**0.30488**	0.05488	

Appendix C.16: Average Discharge (cfs) for Nine Tributaries in the Kayaderosseras Creek Watershed for three days* in Summer 2007.

UK	11.80
CM-U	0.95
CM-D	3.56
GC	5.83
MoK	4.52
MaK-R	73.68
GB	22.98
SR-R	8.25
BMB-R	9.61

*June 9,2007, July 3, 2007 and July 18, 2007.

Appendix C.17: Estimates of Total Nitrogen and Total Phosphorus Nutrient Loading Calculations for the Nine Tributaries on 6/19/07 and 7/18/07.

6/19/2007	TN	Flow	Loading
Site	mg N / L	m^3 / sec	Kg / day
Upper Kayderosseras	0.72	0.2770	1.73
Clover Mill Upper	0.56	0.0226	0.11
Clover Mill Down	1.62	0.0676	0.95
Glowegee Creek	0.84	0.1595	1.16
Mourning Kill	0.92	0.0991	0.79
Main Kayderosseras-R	0.81	2.0044	14.02
Geyser Brook	1.70	0.4101	6.03
Spring Run	2.21	0.1880	3.58

6/19/2007	TP	Flow	Loading
Site	µg P / L	m^3 / sec	Kg / Day
Upper Kayderosseras	13.35	0.2770	31.94
Clover Mill Upper	20.96	0.0226	4.094
Clover Mill Down	65.59	0.0676	38.29
Glowegee Brook	14.07	0.1595	19.4
Mourning Kill	21.68	0.0991	18.57
Main Kayderosseras-R	17.88	2.0044	309.6
Geyser Brook	22.70	0.4101	80.44
Spring Run	65.71	0.1880	106.7

7/18/2007	TN	Flow	Loading
Site	mg N / L	m^3 / sec	Kg / Day
Upper Kayderosseras	0.56	0.5007	2.42
Clover Mill Upper	1.20	0.0397	0.41
Clover Mill Down	1.21	0.1698	1.78
Glowegee Creek	0.71	0.2199	1.35
Mourning Kill	0.82	0.2599	1.84
Main Kayderosseras-R	0.67	2.5445	14.73
Geyser Brook	1.09	0.9064	8.54
Spring Run	1.68	0.3459	5.02
Bog Meadow	1.02	0.3302	2.91

7/18/2007	TP	Flow	Loading
Site	µg P / L	m^3 / sec	Kg / Day
Upper Kayderosseras	18.42	0.5007	79.68
Clover Mill Upper	186.00	0.0397	63.73
Clover Mill Down	94.80	0.1698	139.1
Glowegee Brook	46.70	0.2199	88.71
Mourning Kill	46.10	0.2599	103.5
Main Kayderosseras-R	28.70	2.5445	631
Geyser Brook	49.30	0.9064	386.1
Spring Run	85.10	0.3459	254.3
Bog Meadow	64.40	0.3302	183.7

Appendix C.18: Examples of Total Nitrogen and Total Phosphorus Nutrient Loading Calculations for Spring Run and Bog Meadow Brook on Several Dates

Spring Run

Date	Flow	TN	TN Loading	TP	TP Loading
	$\frac{m^3}{sec}$	$\frac{mg\ N}{L}$	$\frac{Kg}{day}$	$\frac{\mu g\ P}{L}$	$\frac{g}{day}$
6/7/07	0.219	1.33	2.52	49.0	92.7
6/12/07	0.260	1.92	4.31	61.5	138.2
6/19/07	0.188	2.21	3.59	65.71	106.7
7/18/07	0.346	1.68	5.02	85.10	254.4

Bog Meadow Brook

Date	Flow	TN	TN Loading	TP	TP Loading
	$\frac{m^3}{sec}$	$\frac{mg\ N}{L}$	$\frac{Kg}{day}$	$\frac{\mu g\ P}{L}$	$\frac{g}{day}$
6/7/07	0.502	2.00	8.68	103.3	448.0
6/12/07	0.228	1.20	2.36	34.1	67.2
7/18/07	0.330	1.02	2.91	64.40	183.7

Appendix C. 19 Summary of Total Nitrogen (TN) data for Summer 2007 Tributaries

Site	7-Jun	12-Jun	20-Jun	28-Jun	18-Jul	24-Jul	8-Aug
Filter Blank		---	---	---	----	lt 0.01	lt 0.05
Site	**7-Jun**	**12-Jun**	**20-Jun**	**28-Jun**	**18-Jul**	**24-Jul**	**8-Aug**
Upper Kaydeross Creek			0.72		0.56		
Main Kaydeross Creek			0.81		0.67		
Clover Mill Creek Upstream			0.56		1.20		
Clover Mill Creek Downstream			1.62		1.21		
Glowegee Creek			0.84		0.71		
Mourning Kill Creek			0.92		0.82		
Geyser Brook			1.70		1.09		
Lost Pond			0.62				
Site	**7-Jun**	**12-Jun**	**20-Jun**	**28-Jun**	**18-Jul**	**24-Jul**	**8-Aug**
Spring Run A 0.25m	1.33						
Spring Run B 0.25m	1.32						
Spring Run		1.92	2.21	1.41	1.68		
Spring Run pre-split		1.50					
Spring Run West split		1.92					
Spring Run East split		1.70					
Spring Run C							1.37
Spring Run R							1.60
Site	**7-Jun**	**12-Jun**	**20-Jun**	**28-Jun**	**18-Jul**	**24-Jul**	**8-Aug**
Bog Meadow A	2.74						
Bog Meadow B	1.26						
Bog Meadow Brook		1.20		1.15	1.02		
Bog Meadow Brook 29					1.47		
Bog Meadow C							1.24
Bog Meadow R							0.70

Appendix C. 20 Summary of Total Phosphorous (TP) data for Summer 2007 Tributaries

Site	7-Jun	12-Jun	20-Jun	28-Jun	18-Jul	24-Jul	8-Aug
Filter Blank		---	---	---	---	----	lt 1.0
Site	**7-Jun**	**12-Jun**	**20-Jun**	**28-Jun**	**18-Jul**	**24-Jul**	**8-Aug**
Upper Kaydeross Creek			13.3		18.4		
Main Kaydeross Creek			17.9		28.7		
Clover Mill Creek Upstream			21.0		186.0		
Clover Mill Creek Downstream			65.6		94.8		
Glowegee Creek			14.1		46.7		
Mourning Kill Creek			21.7		46.1		
Geyser Brook			22.7		49.3		
Lost Pond			16.5				
Site	**7-Jun**	**12-Jun**	**20-Jun**	**28-Jun**	**18-Jul**	**24-Jul**	**8-Aug**
Spring Run A 0.25m	48.2						
Spring Run B 0.25m	49.7						
Spring Run		61.5	65.7	72.4	85.1		
Spring Run pre-split		49.7					
Spring Run West split		60.4					
Spring Run East split		52.4					
Spring Run C							51.8
Spring Run R							34.5
Site	**7-Jun**	**12-Jun**	**20-Jun**	**28-Jun**	**18-Jul**	**24-Jul**	**8-Aug**
Bog Meadow A	126.1						
Bog Meadow B	80.6						
Bog Meadow Brook		34.1		62.0	64.4		
Bog Meadow Brook 29					55.6		
Bog Meadow C							113.1
Bog Meadow R							40.3

Appendix D.1: Optical Brighteners Pilot Study Report

Abstract

Optical brighteners are now extremely common in laundry detergents. Since waste water from laundry machines generally contains these dyes and fluorescence is relatively easy to detect, the use of optical brighteners to detect leaking septic tanks and leaking sewage systems seems promising. The potential for the use of fluorescence spectroscopy in the detection of optical brighteners in natural waters of the Kayaderosseras Creek sub-watershed was investigated. In the laboratory, both standards containing laundry detergent and field samples are analyzed with the Skidmore Department of Chemistry's Shimadzu scanning spectrofluorimeter in an effort to determine the presence of optical brighteners.

Introduction

Optical brighteners are dyes found in laundry detergent that absorb light in the ultraviolet region of the electromagnetic radiation spectrum and, as a result of this absorption, subsequently emit light in the blue (visible) region of the electromagnetic radiation spectrum. This re-emission is called fluorescence (Figure 1).

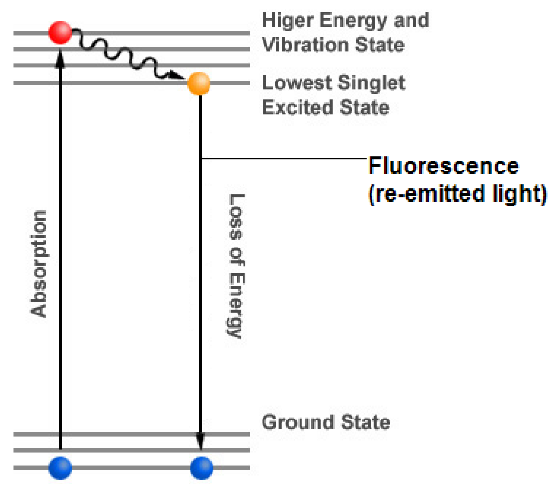


Figure 1: Transition of molecules (optical brighteners) giving rise to absorption and fluorescence emission spectra.

Currently these dyes are added to nearly all laundry detergents. Optical brighteners strongly adsorb to cloth surfaces, which is different from absorption. Adsorption is a process in which the molecules of the dye are strongly attracted to the cloth molecular surface and stick tightly to that surface. Absorption is not a surface phenomenon but rather a bulk (or volume) phenomenon. Consequently, substances absorbed tend to be held less tightly than substances adsorbed on surfaces. For example, a sponge may absorb water but it will release the water when you squeeze it. Optical brighteners adsorbed on clothing generally stay on the clothing through each washing and drying and, in fact, are essentially reapplied each time an item of clothing is washed.

When clothing begins to age and white clothing looks yellowed or colored clothing begins to look faded and dull, the addition of optical brighteners is believed to make the clothing look better since, in the presence of ultraviolet light, some blue light will now be emitted in addition to the original colors in the clothing. In a normally lit room, this blue light emission is not noticeable except, the detergent manufactures assume, as a "brightening" of the clothing. However, if you are in a very dark room with a source of U.V. lights (e.g. a "black light") you will notice that some parts of your clothing, especially white areas, seem to have a bluish white glow. This is the optical brightener glowing. Without optical brightener (or other dyes that fluoresce) you generally will not be able to see your clothing under a "black light".

Since optical brighteners are now extremely common in laundry detergents, wastewater from laundry machines generally contains these dyes. Wastewater from laundry machines ultimately enters either septic tanks or municipal wastewater treatment systems. Optical brighteners may be harmful to aquatic animals and plants. However, currently the greatest interest in this relatively new area of inquiry is in the identification of optical brighteners in streams and lakes for the detection of possible leaks from septic tanks or leaking pipes from municipal wastewater treatment systems. The use of optical brighteners to detect septic leaks has tremendous potential since fluorescence is relatively easy to detect.

In this project the Skidmore Department of Chemistry's Shimadzu scanning spectrofluorimeter was used to conduct initial investigations of the presence of optical brighteners in the Kayaderosseras Creek sub-watershed.

Experimental Methods

Eight solutions of laundry detergent were made by placing 0.001 mL, 0.007 mL, 0.1 mL, 1 mL, 3 mL, 5 mL, 7 mL and 10 mL of Arm and Hammer liquid laundry detergent in 1000 mL volumetric flasks and diluting to the mark with DDW. Fluorescence excitation spectra and fluorescence emission spectra were determined for the laundry detergent standards using a Shimadzu RF5301 Spectrofluorimeter. (For operating instructions, Appendix D.1)

Two concentrated solutions of twinning tea were made by soaking a tea bag in 50 mL of room temperature DDW for 10 minutes. Then 1 mL and 10 mL of the above solution were placed in 1000 mL volumetric flasks and diluted to the mark with DDW.

Fluorescence excitation spectra and fluorescence emission spectra were determined for all natural water samples using a Shimadzu RF5301 Spectrofluorimeter.

Results and Discussion

Laundry Detergent

The fluorescence excitation spectrum of the laundry detergent had a λmax at 340 nanometers (nm) (Figure 1). In turn, 340 nm was chosen as the wavelength for excitation for subsequent fluorescence emission spectra.

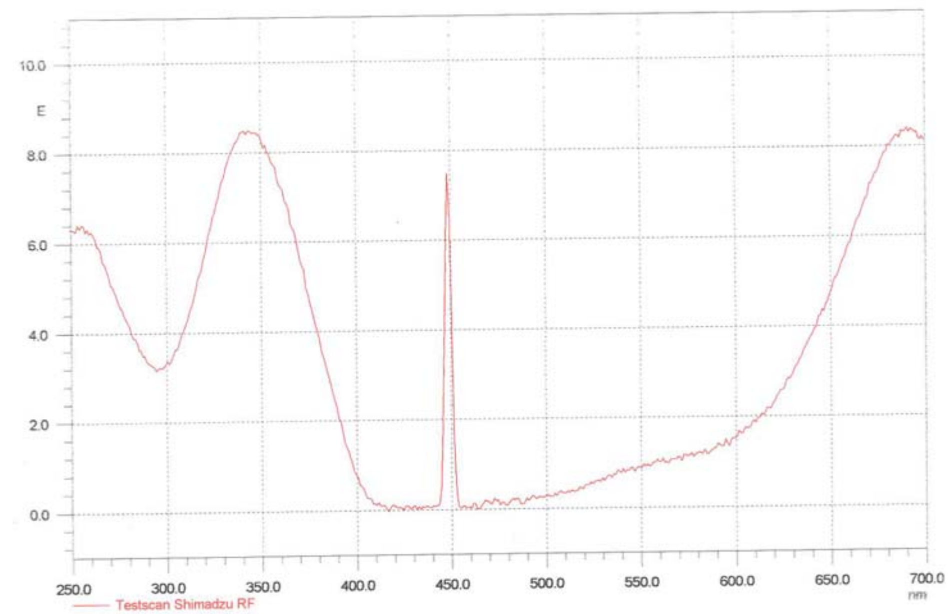


Figure 1: Fluorescence excitation spectrum of a 0.001 mL /1000 mL solution of laundry detergent (emission λ = 430 nm).

Various concentrations were measured and compared to their respective fluorescence intensity in order to create a calibration curve (Figure 2).

The fluorescence emission spectrum of the laundry detergent gave a λmax at approximately 430 nm (Figure 3).

Tea (Tannins) Solution

The fluorescence emission spectrum of the tea solution gave a λmax at approximately 450 nm (Figure 4). However, the overall spectrum was extremely similar to the spectrum for the laundry detergent.

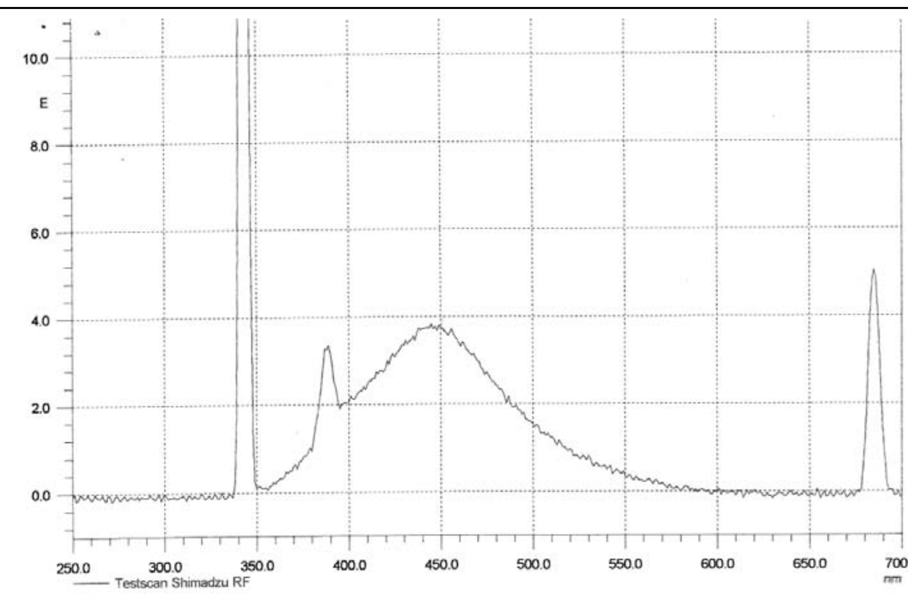


Figure 4: Fluorescence emission spectrum of 10 mL/1000 mL Twinning's tea solution (excitation λ = 340 nm).

F

detergent (excitation λ = 340 nm).

Lake and Stream Samples

The vast majority of the natural water samples measured produced similar spectra to that of the laundry detergent and tea. For example, the spectrum of Spring Run (Figure 5) had a λmax at approximately 430 nm similar to the λmax of the laundry detergent (Figure 3). (Appendix D.3 for other natural water spectra)

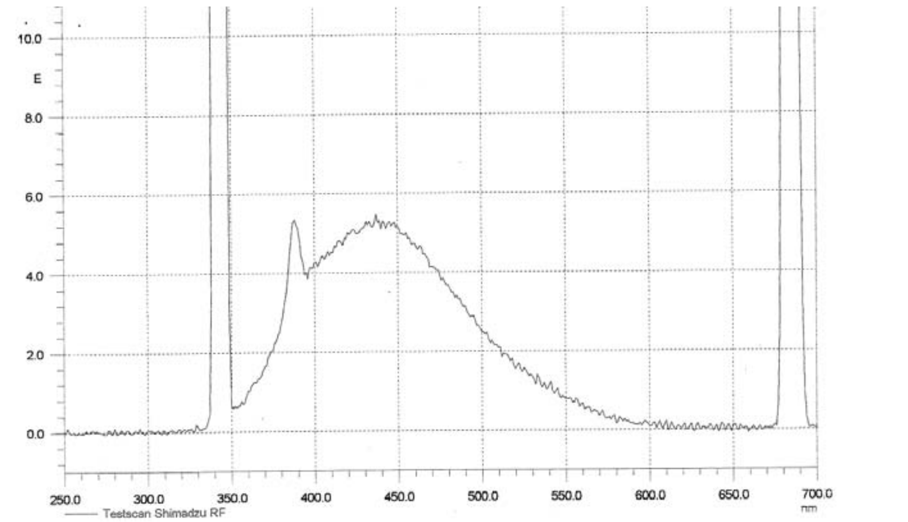


Figure 5: Fluorescence emission spectra of Spring Run (excitation λ = 340 nm).

There were some natural water spectra, however, that displayed characteristics more similar to the spectrum of the tea solution rather than the laundry detergent. For example, Bog Meadow Brook (Figure 6), Clover Mill Creek and Upper Kayaderosseras (Appendix D.2) had a λmax at 450 nm similar to the λmax of the tea emission spectra (Figure 4). While there was a small variation in the λmax, all the spectra were very similar.

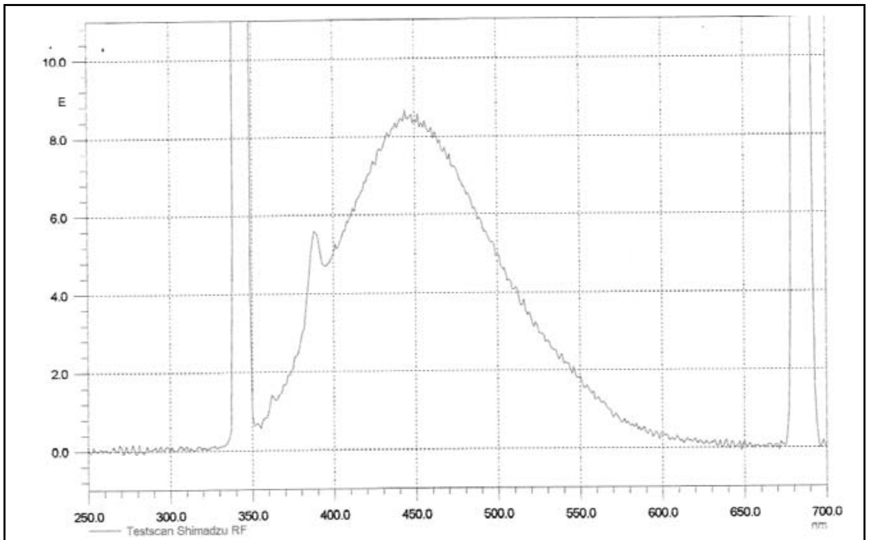


Figure 6: Fluorescence emission spectra of Bog Meadow Brook (excitation λ = 340nm).

Quantitative Assessment of Fluorescence of Various Natural Water Samples

Relative fluorescence intensities of the fluorescence emission spectra of various lake and stream samples (emission λ = 430nm, excitation λ =340 nm) can be measured (Table 2). Note that it is unclear at this time for most of the samples whether this fluorescence is due to optical whiteners or natural tannins and/or other humic substances.

Table 2: Table showing fluorescence intensities of the various natural water samples (excitation λ =340nm).

Water Body	**Fluorescence Intensity**
Main Kayaderosseras	11
Mourning Kill	11
Upper Kayaderosseras	10
Bog Meadow	8.8
Lake Lonely Outlet	7
Glowegee	7
Lake Desolation	6.1
Lake Lonely	6
Clover Mill Downstream	6
Lost Pond- Adirondacks	5.5
Spring Run	5.5
Clover Mill Upstream	5
Geysers Brook	5
Bog Meadow Route 29	4.8
Upper Hudson	4
Lake Monreau	1.5
Tap Water	1
DDW	0

Conclusions

Optical Brightener Pilot Study

Results show that it is unclear for most of the samples whether the fluorescent peaks in the natural water samples are due to either optical whiteners or other humic substances or both. Perhaps HPLC or another method could be used to separately determine the fluorescence intensities of both humic- like organic matter and optical brighteners in natural water bodies.

Appendix D.2: Operating Instructions for Shimadzu RF5301 Spectrofluorimeter

1. Turn on the power and switch the lamp ON. The lamp should be allowed to warm up at least 30 minutes prior to use.

2. Launch HYPER RF application from the desktop. The instrument will now go through a self diagnostic routine which will take 2 minutes.

3. From the "Instrument" tab, choose RF 5300

4. From "On line RF" choose *parameters*. In the dialog box:
    - Input a file name and text.
    - Choose the spectrum type (emission/excitation; range or fixed wavelength)
    - Enter the wavelength ranges/numbers as appropriate.
    - Set the resolution to the number you need (in nm)

An example of this is shown in the table below:

Parameters				
Spectrometer Type:		Emission		
Excitation Wave Length :		340 nm		
Emission Wave Length Range:		Start – 250 nm	End – 700nm	
Recording Range:		Low – 0.000	High – 100.000	
Sampling Interval :		1		
Slit Width:		Excitation- 3	Emission-3	

- Select the "MORE" button to set

  The recording range *(0 to 50)*
  Scanning speed *(fast)*
  Sensitivity *(high)*
  Response time *(Auto)*

5. To run the samples first load the blank in a clean 4-way fluorescence cuvette. Put the cuvette in the sample holder compartment, close the cover and press start. The spectrum should appear on the screen. When the blank has finished running press auto-zero. The instrument is now ready to test the samples/standards.

6. Load the samples and press "start".

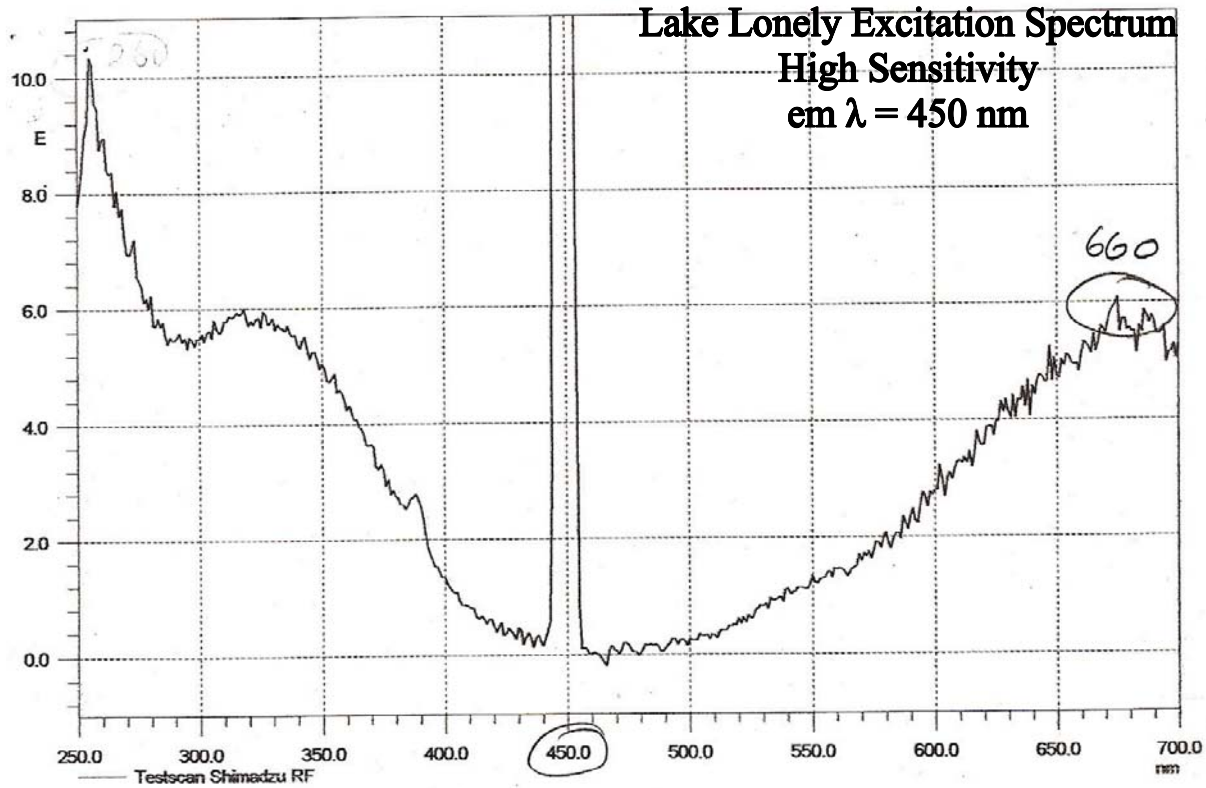
7. To enlarge the spectrum, first click on the spectrum, select ***Autoscale*** from the pull down menu of the "Graph" tab.

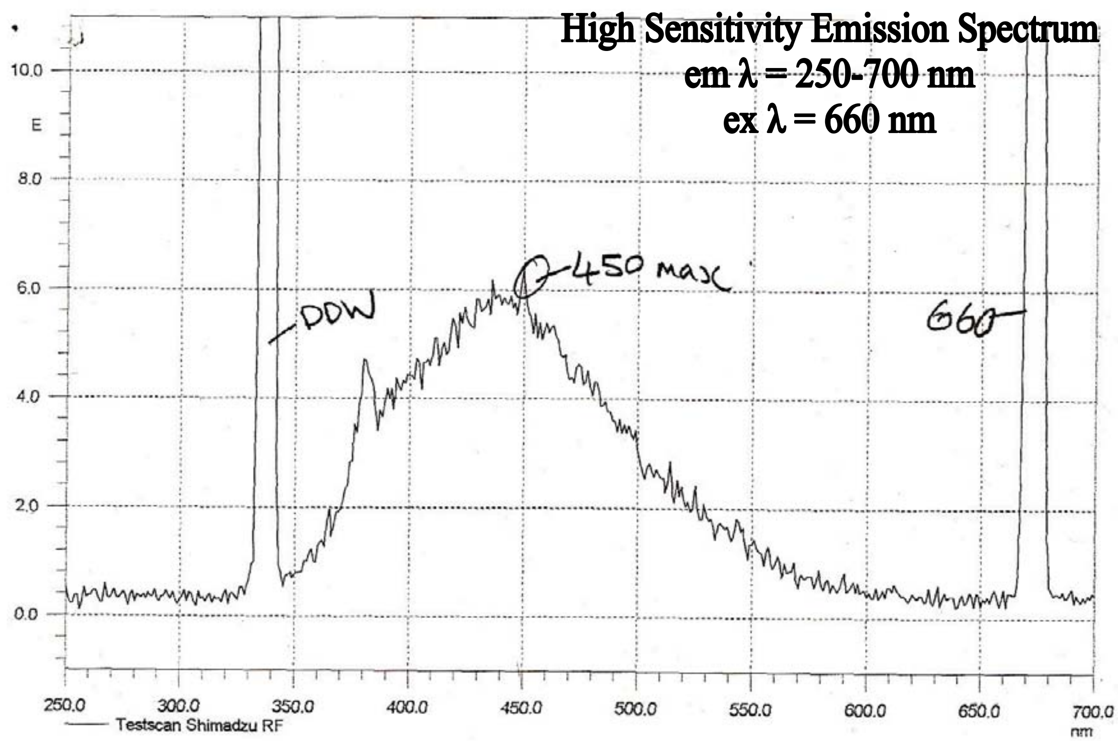
8. To find the peak wavelengths and intensities, choose ***peak table*** from the pull down menu of the "Calc" tab.

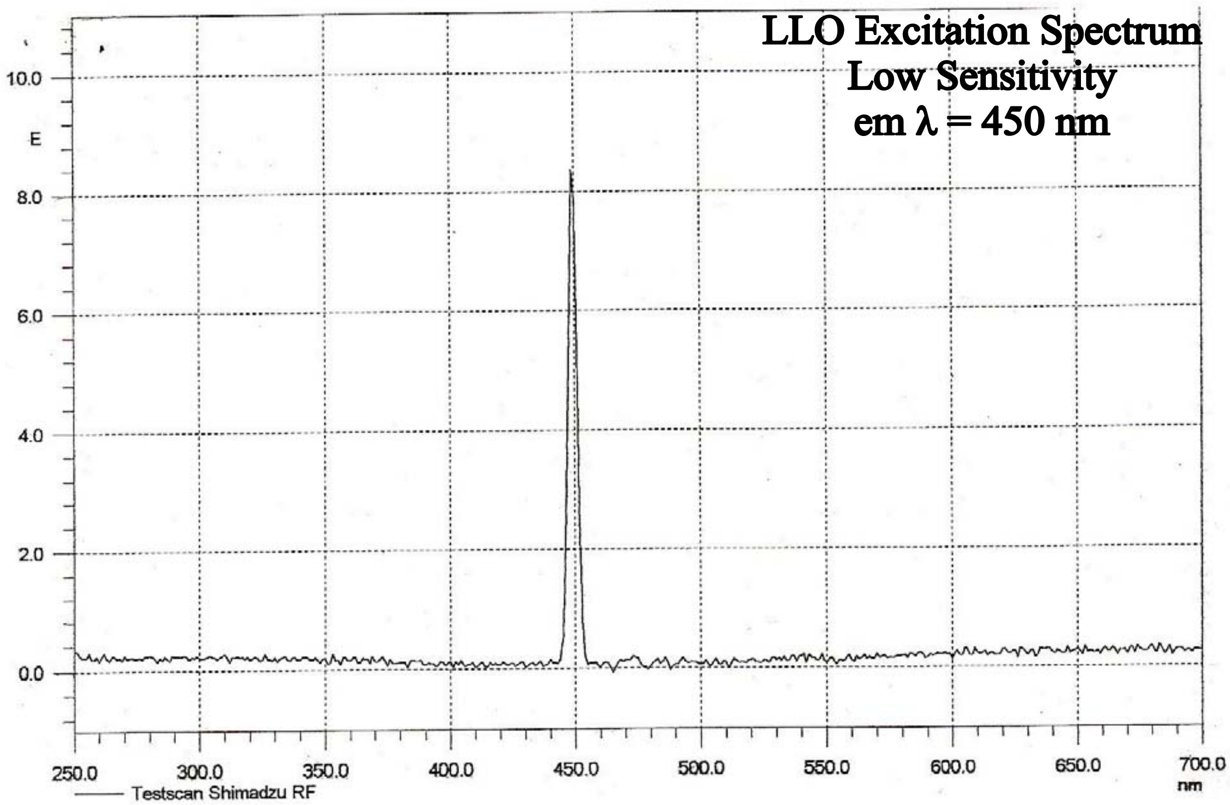
9. Click on the Printer icon to print your spectrum, information and peak table.

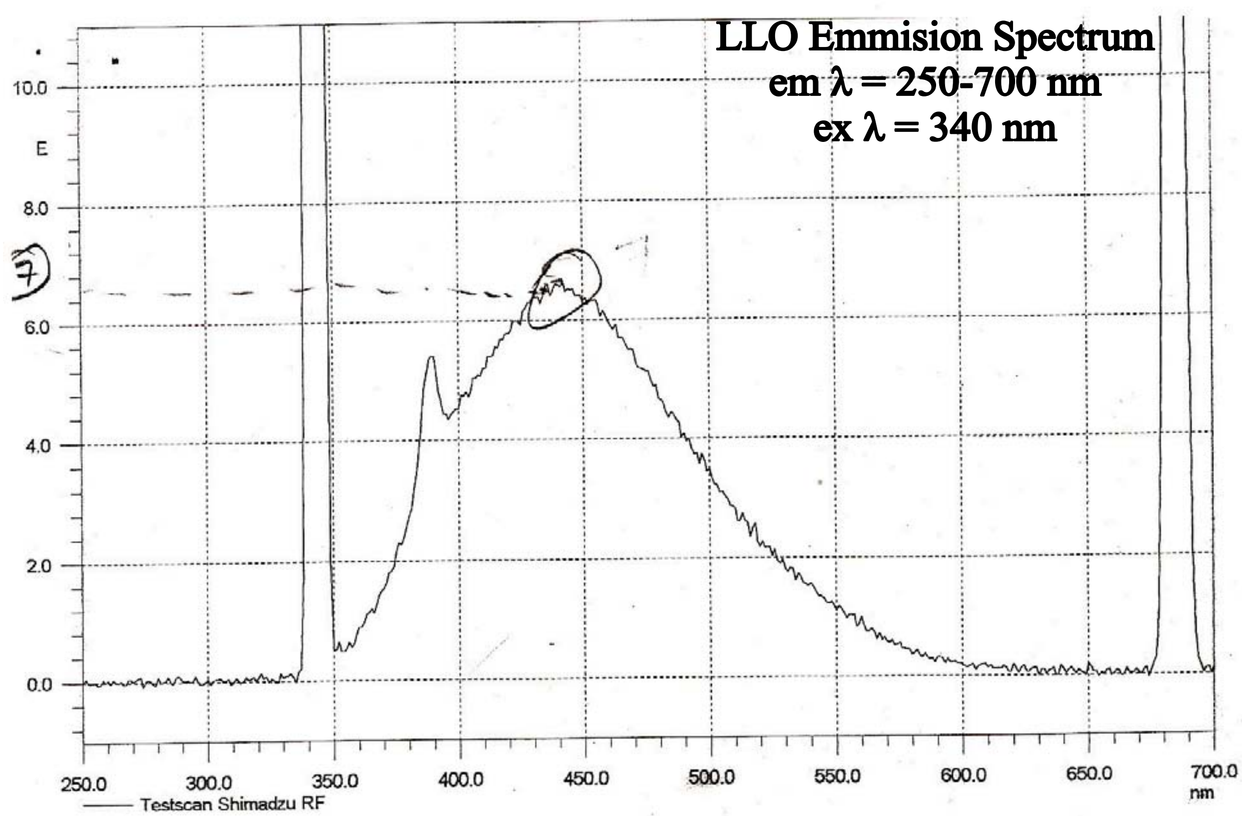
10. If you need to save your data, save on floppy disks and not on the hard drive.

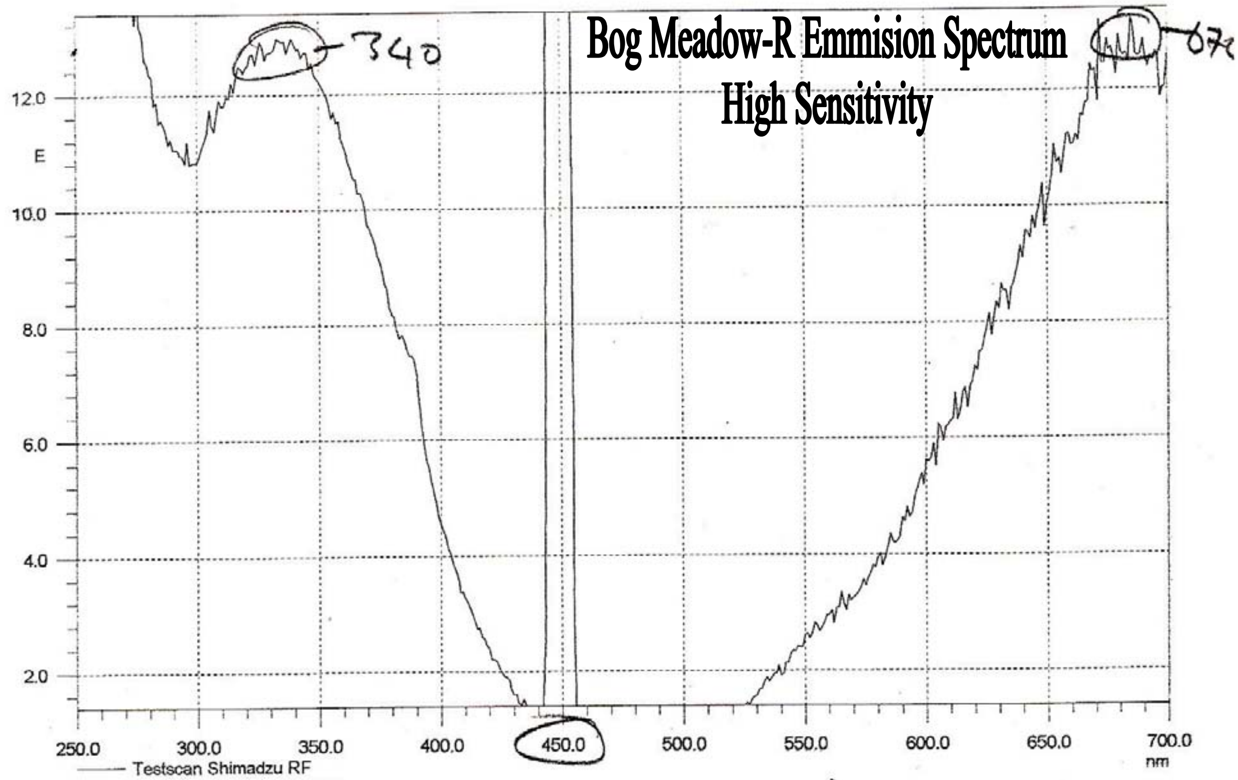
Appendix D.3: Natural Water Sample Spectra



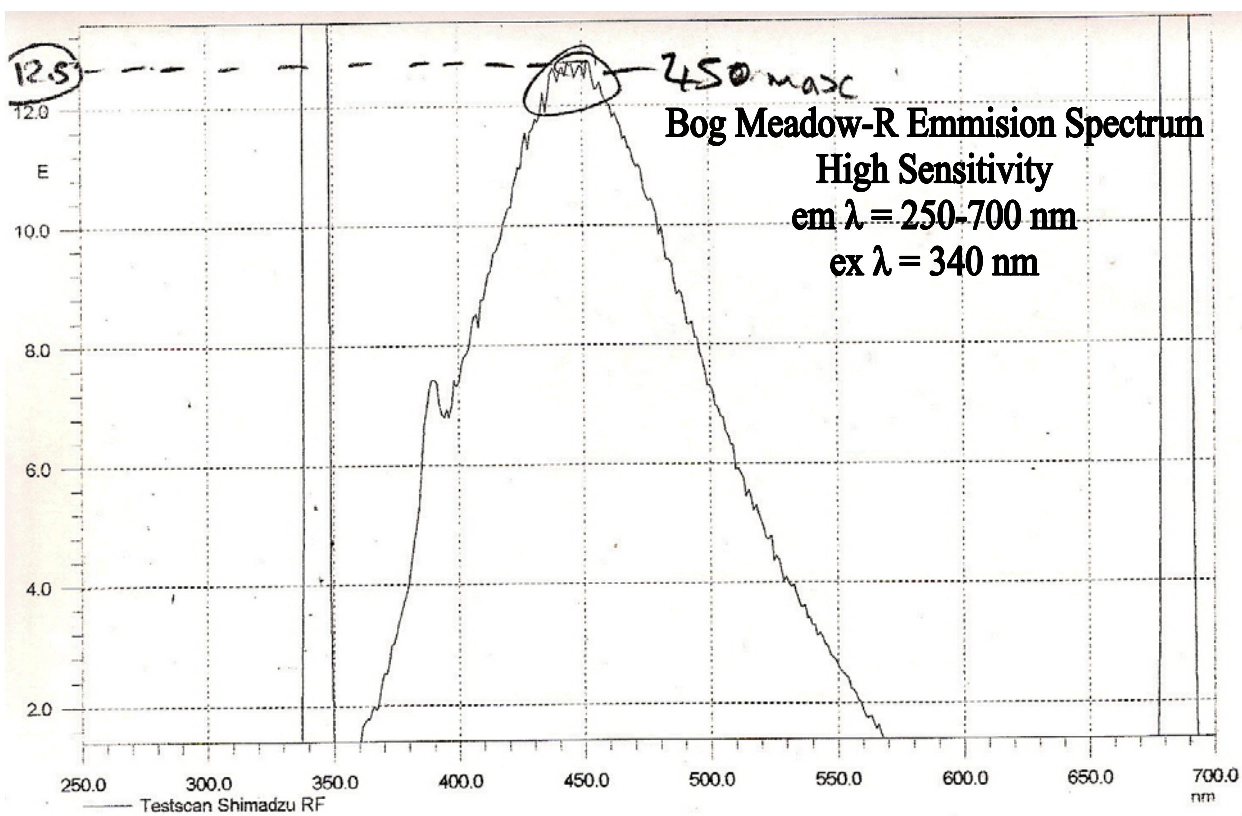



LLO Excitation Spectrum
Low Sensitivity
em λ = 450 nm
10.0
E
8.0
6.0
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

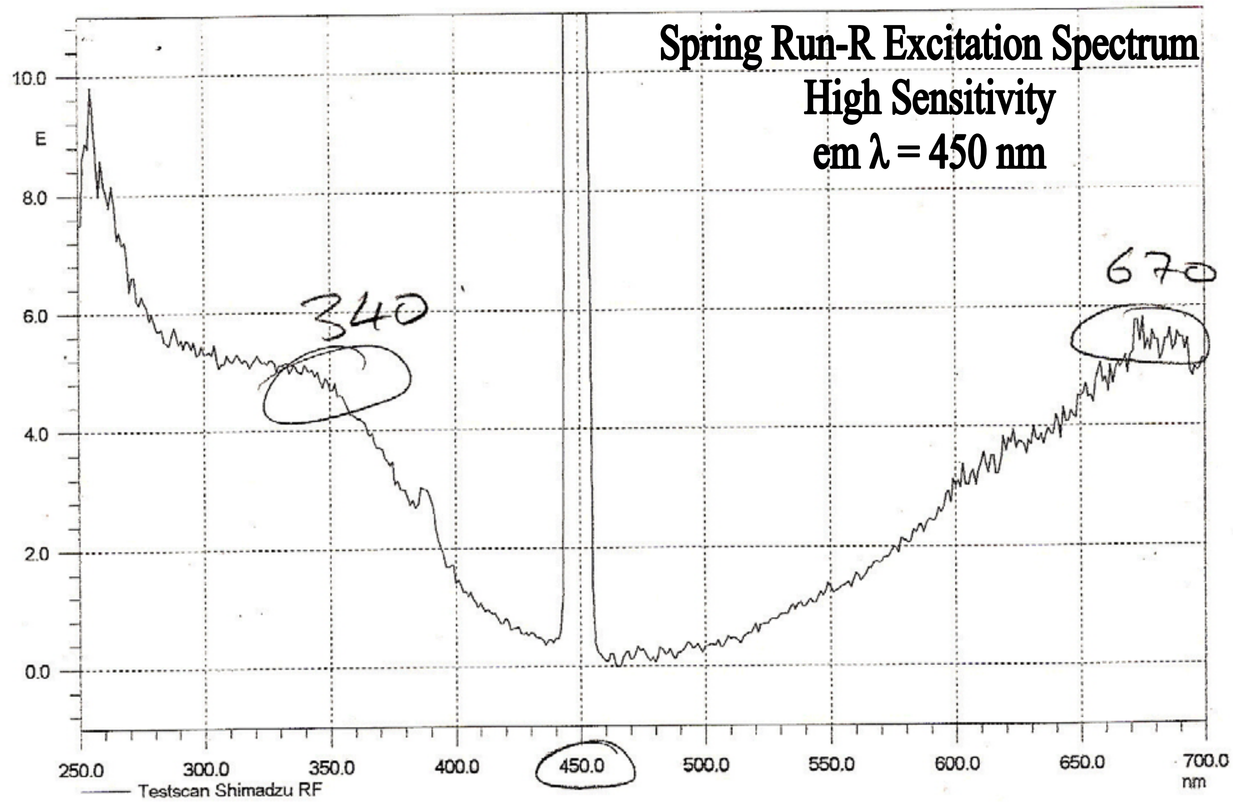

LLO Emmision Spectrum
em λ = 250-700 nm
ex λ = 340 nm
10.0
E
8.0
7
6.0
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

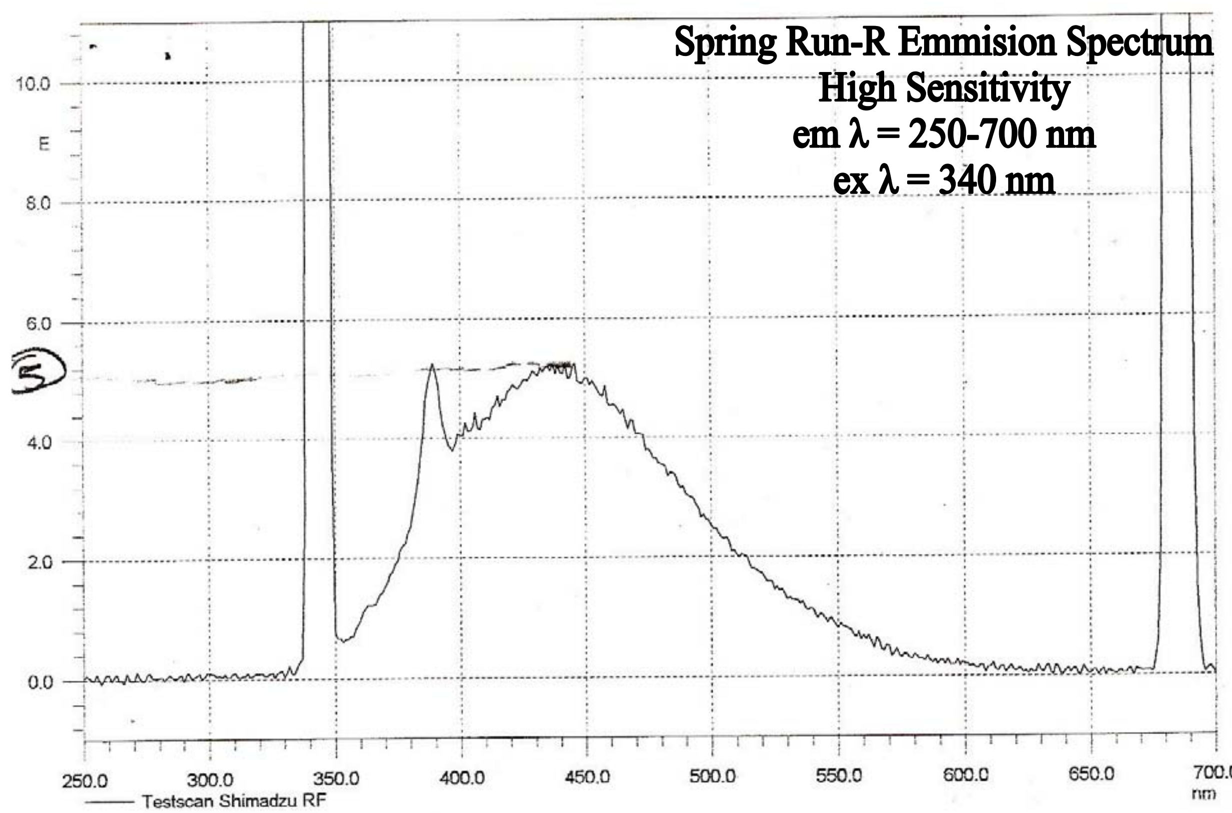


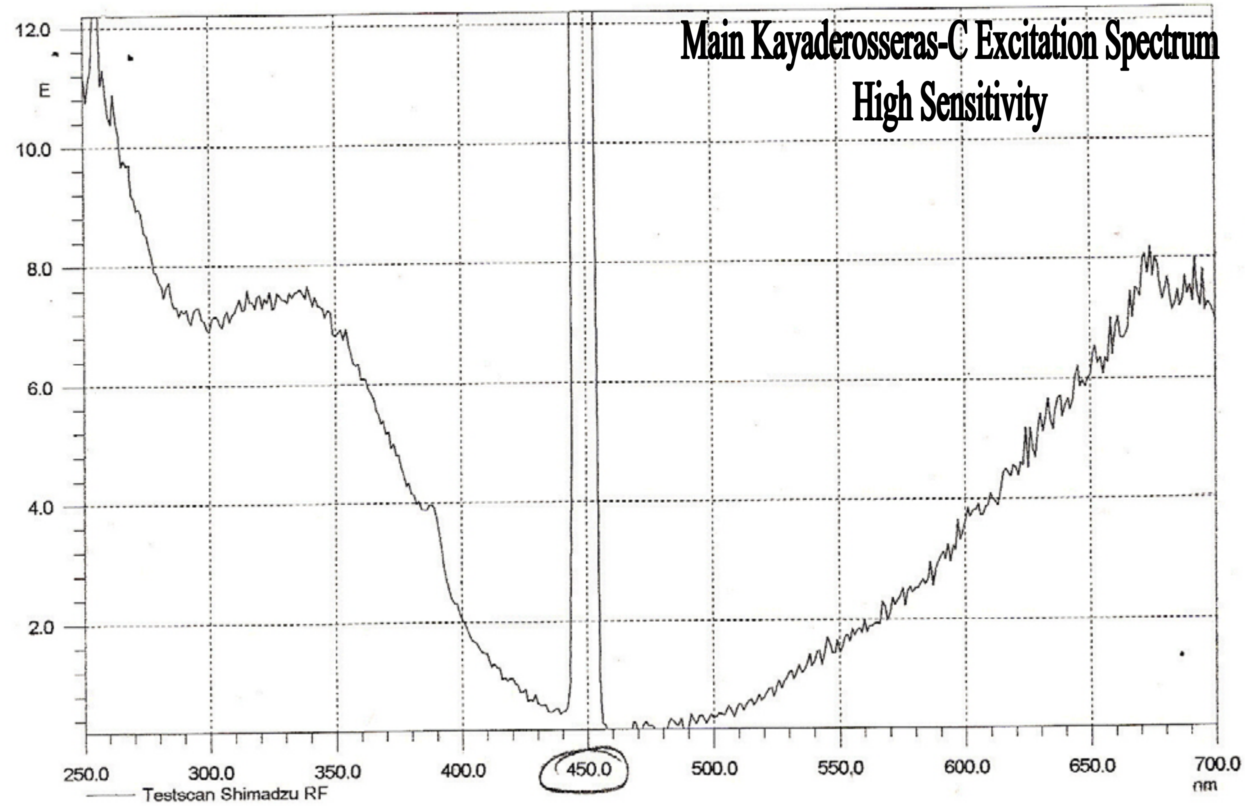
Bog Meadow-R Emmision Spectrum
High Sensitivity
340
12.0
E
10.0
8.0
6.0
4.0
2.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

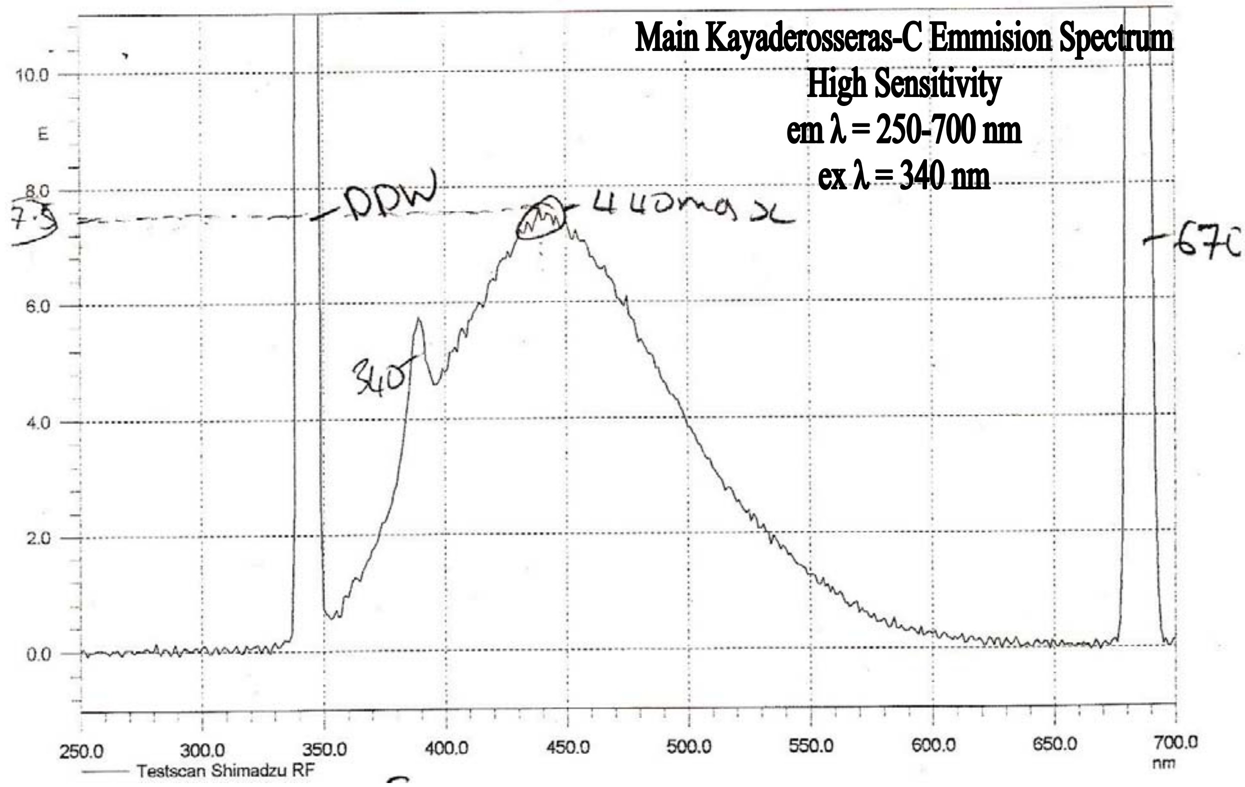


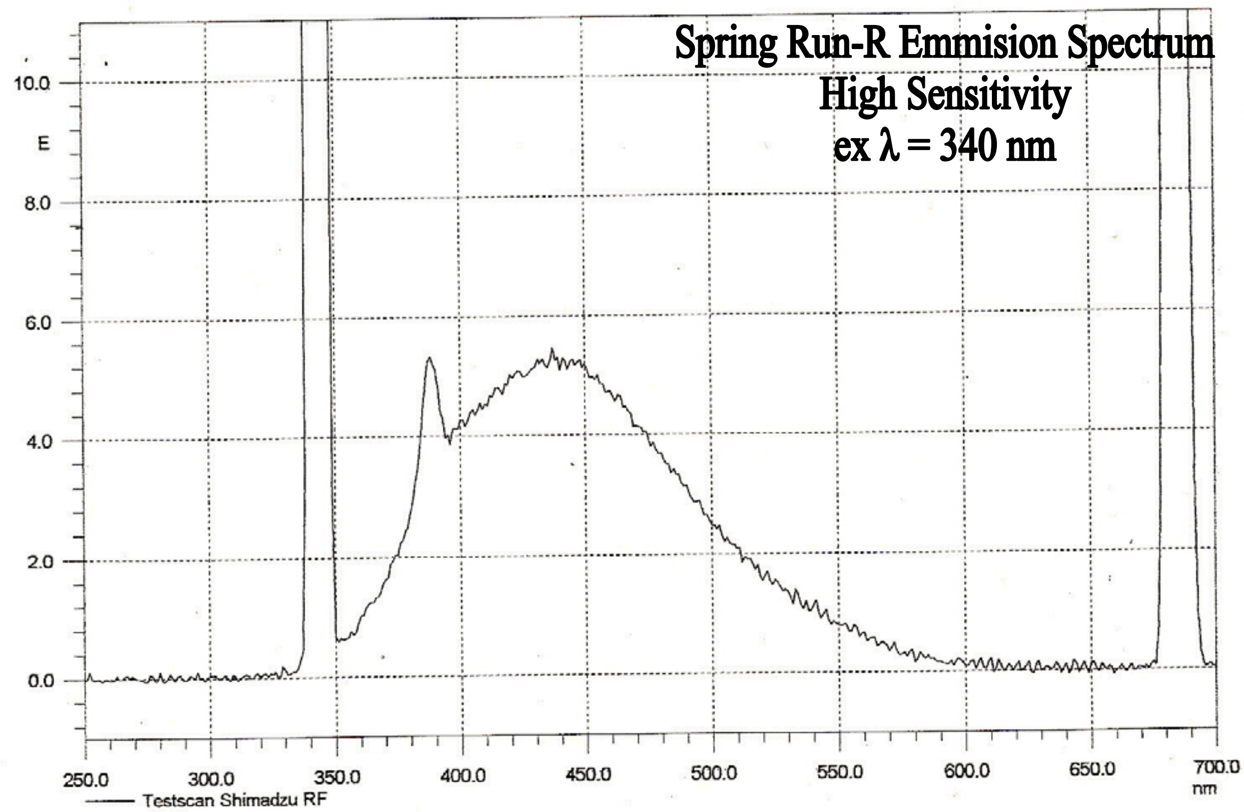
Bog Meadow-R Emmision Spectrum
High Sensitivity
em λ = 250-700 nm
ex λ = 340 nm
12.5
450 max
12.0
E
10.0
8.0
6.0
4.0
2.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

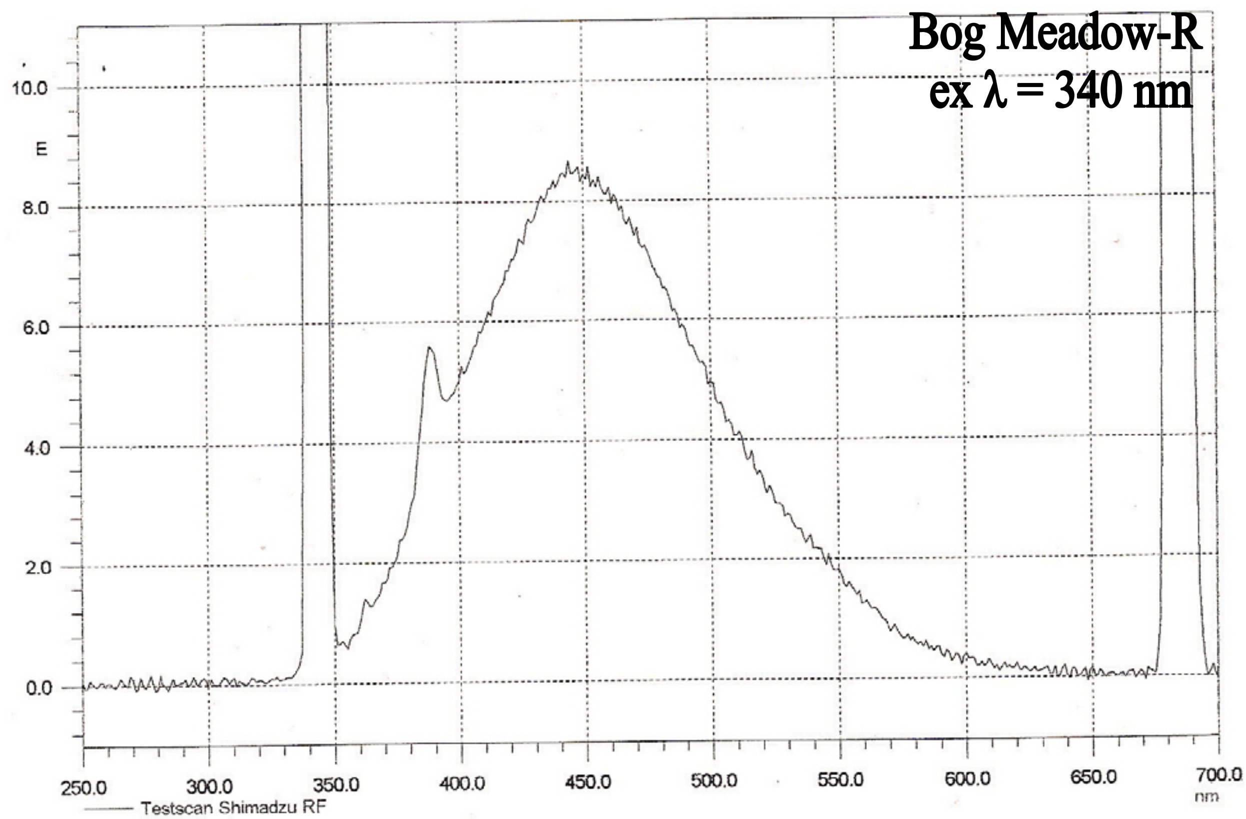

Spring Run-R Excitation Spectrum
High Sensitivity
em λ = 450 nm
340
670
10.0
E
8.0
6.0
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

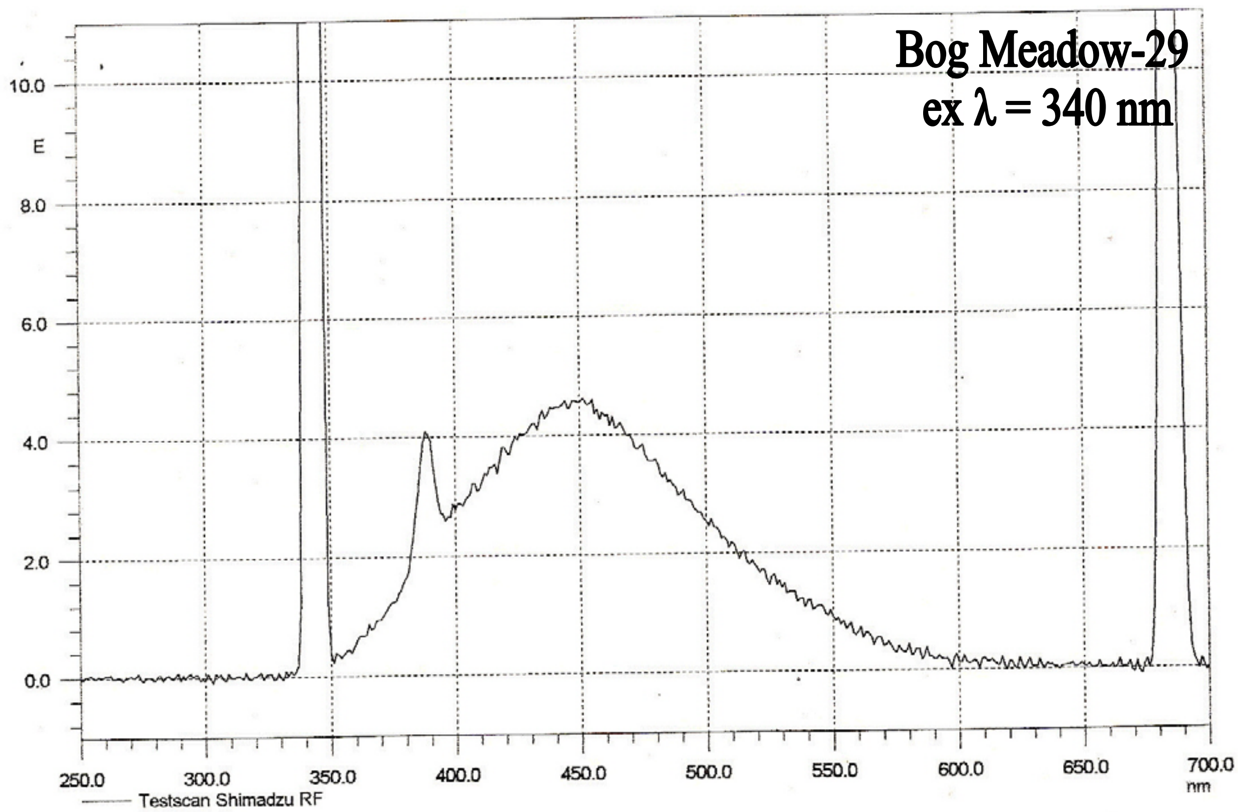

Spring Run-R Emmision Spectrum
High Sensitivity
em λ = 250-700 nm
ex λ = 340 nm
10.0
E
8.0
6.0
5
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

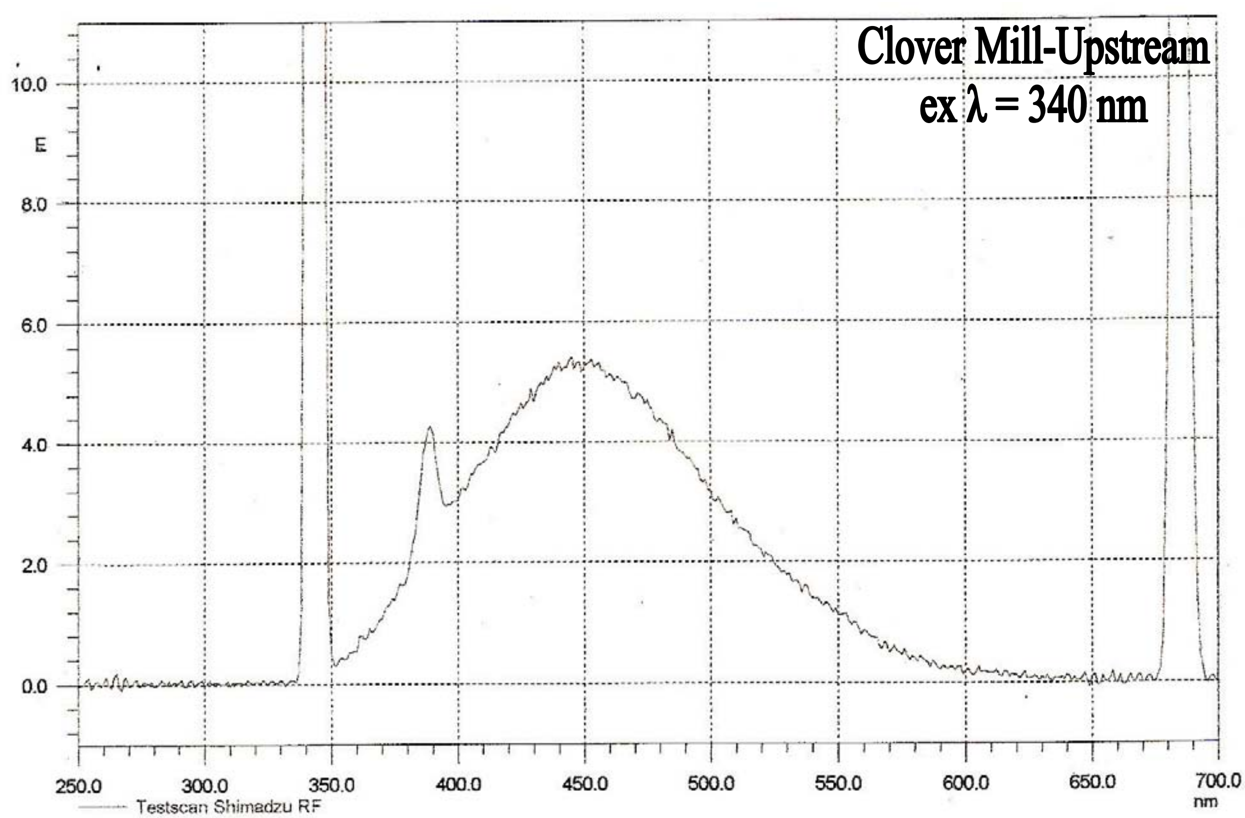

Main Kayaderosseras-C Excitation Spectrum
High Sensitivity
12.0
E
10.0
8.0
6.0
4.0
2.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

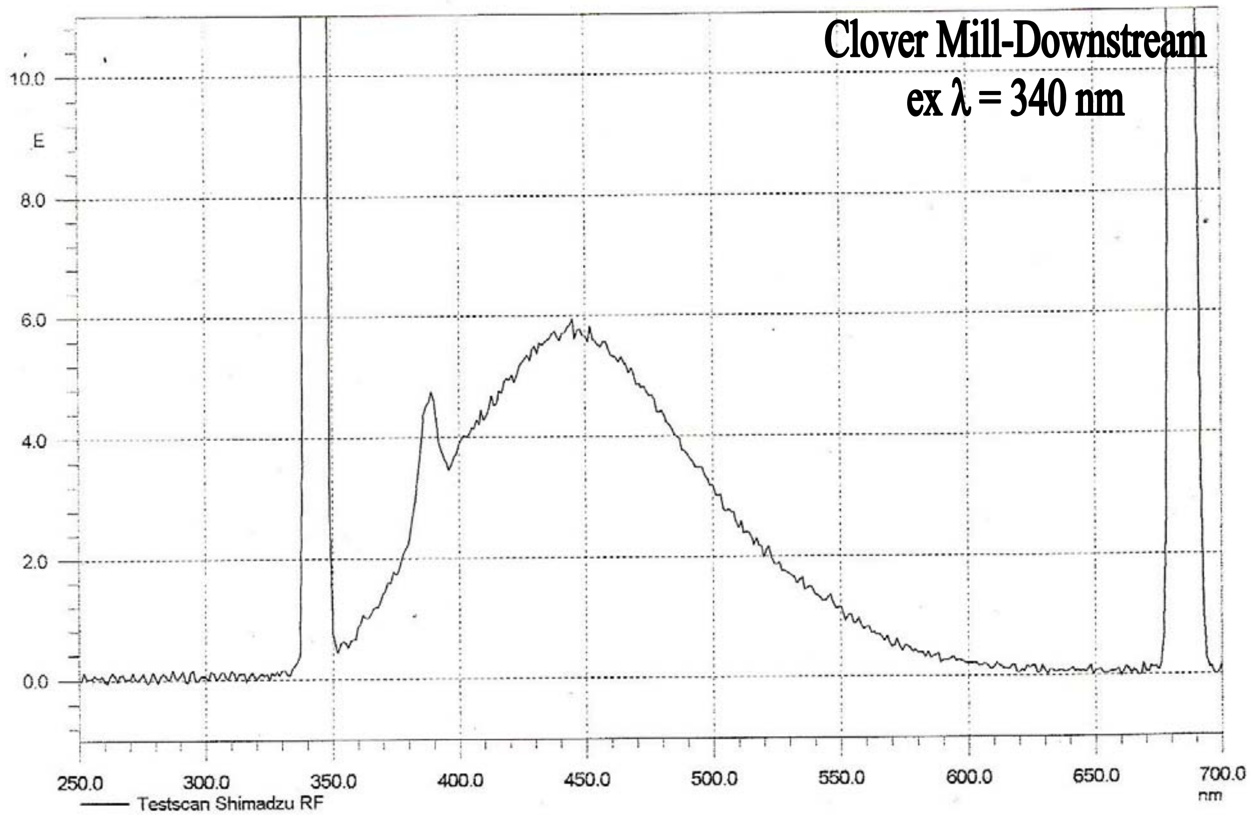

Main Kayaderosseras-C Emmision Spectrum
High Sensitivity
em λ = 250-700 nm
ex λ = 340 nm
10.0
E
8.0
6.0
4.0
2.0
0.0
7.5
DDW
440max
670
340
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

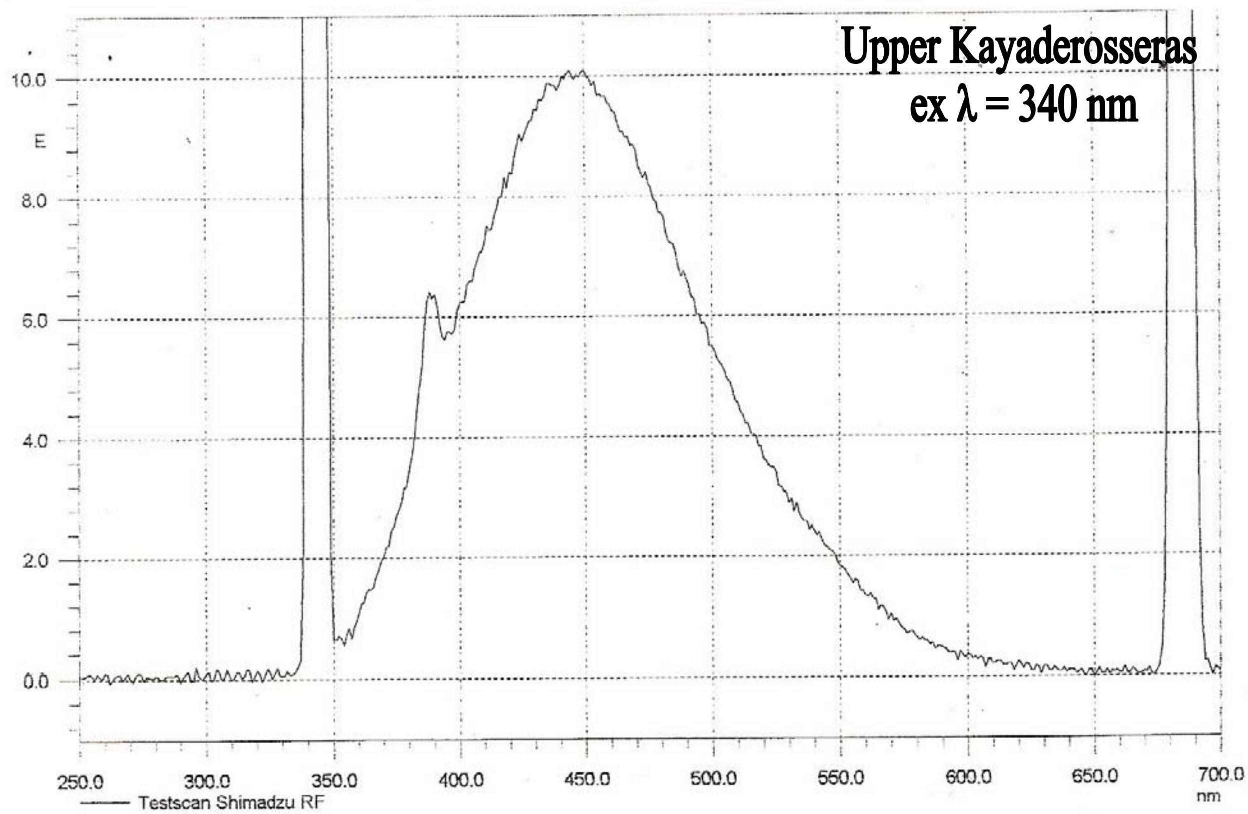

Spring Run-R Emmision Spectrum
High Sensitivity
ex λ = 340 nm
10.0
E
8.0
6.0
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

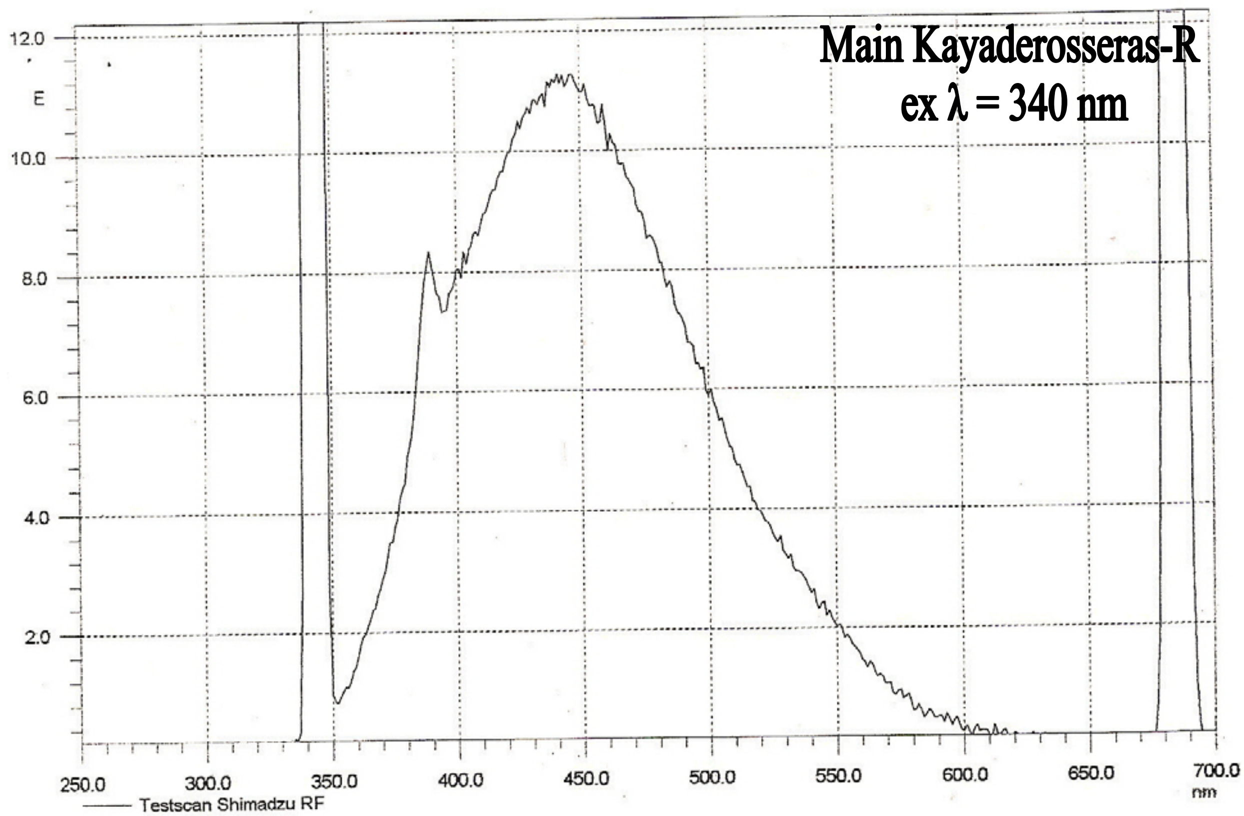

Bog Meadow-R
ex λ = 340 nm
10.0
E
8.0
6.0
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

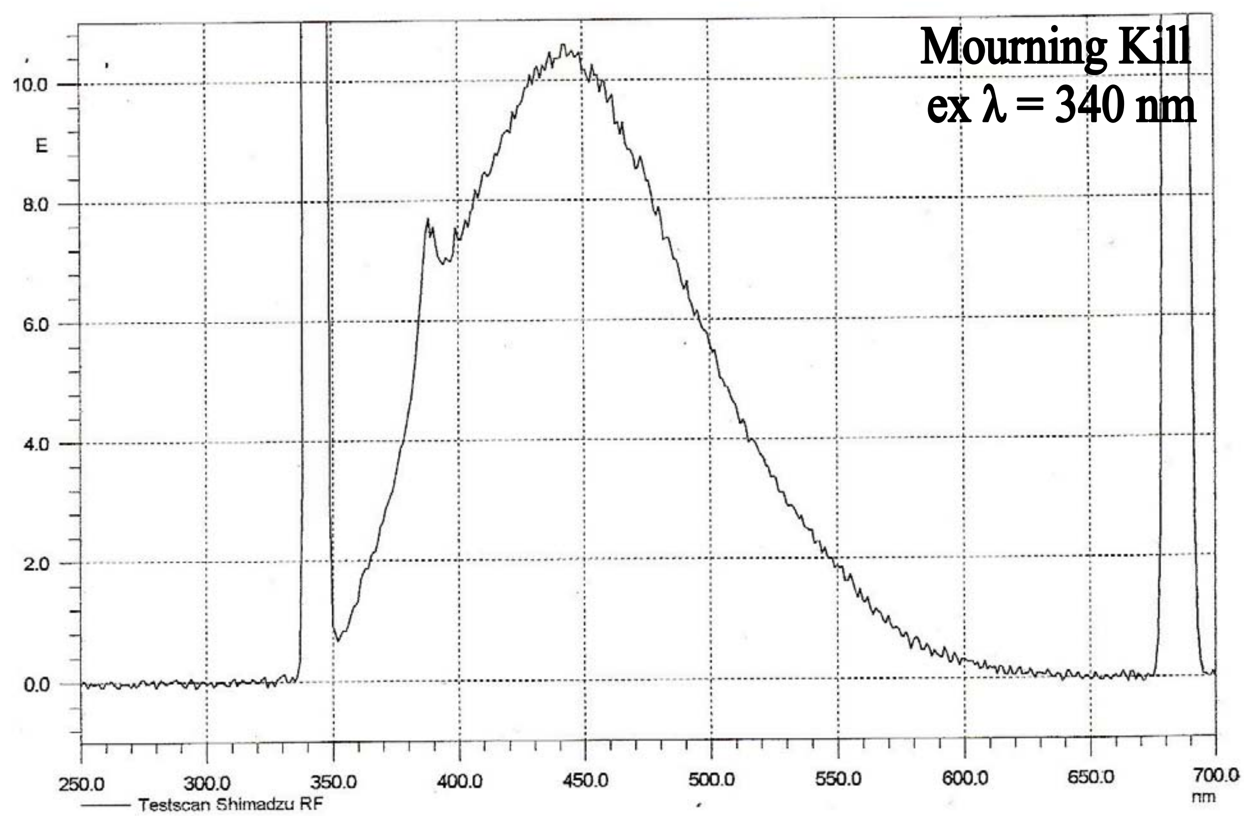

Bog Meadow-29
ex λ = 340 nm
10.0
E
8.0
6.0
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

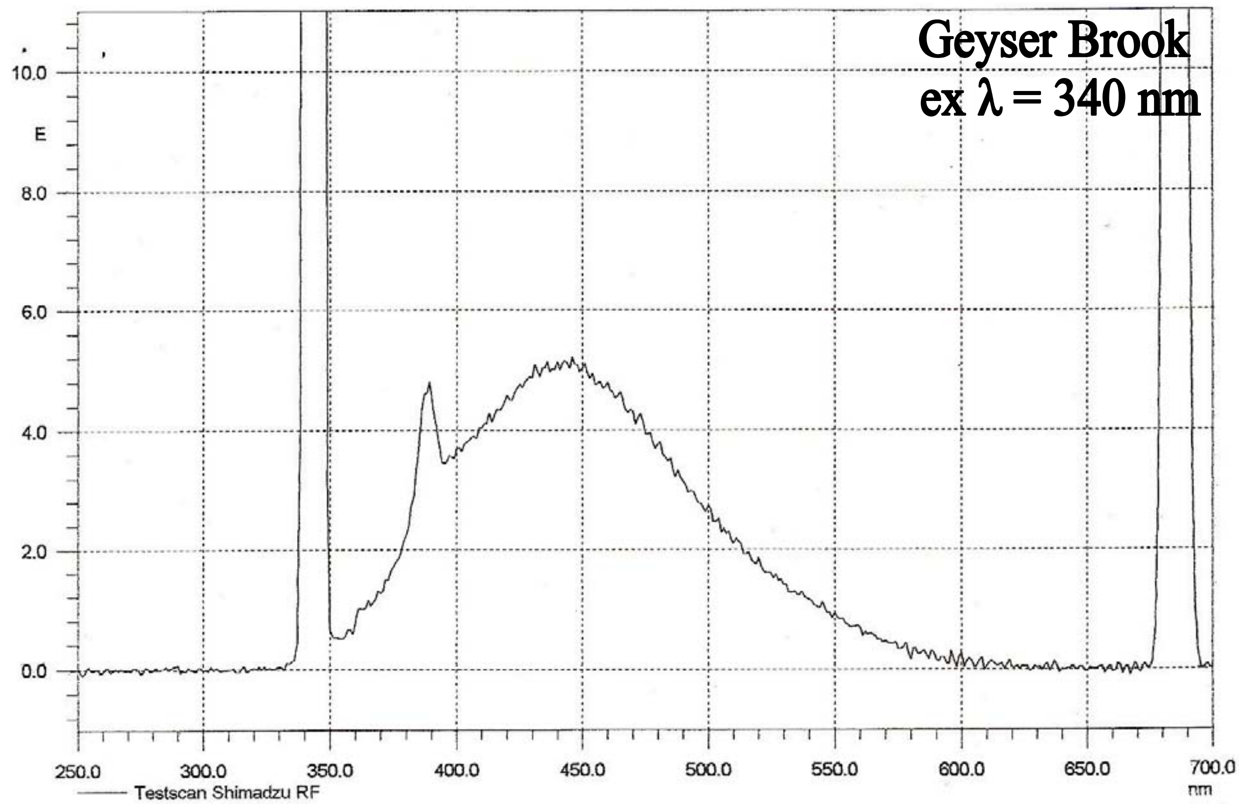

Clover Mill-Upstream
ex λ = 340 nm
10.0
E
8.0
6.0
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

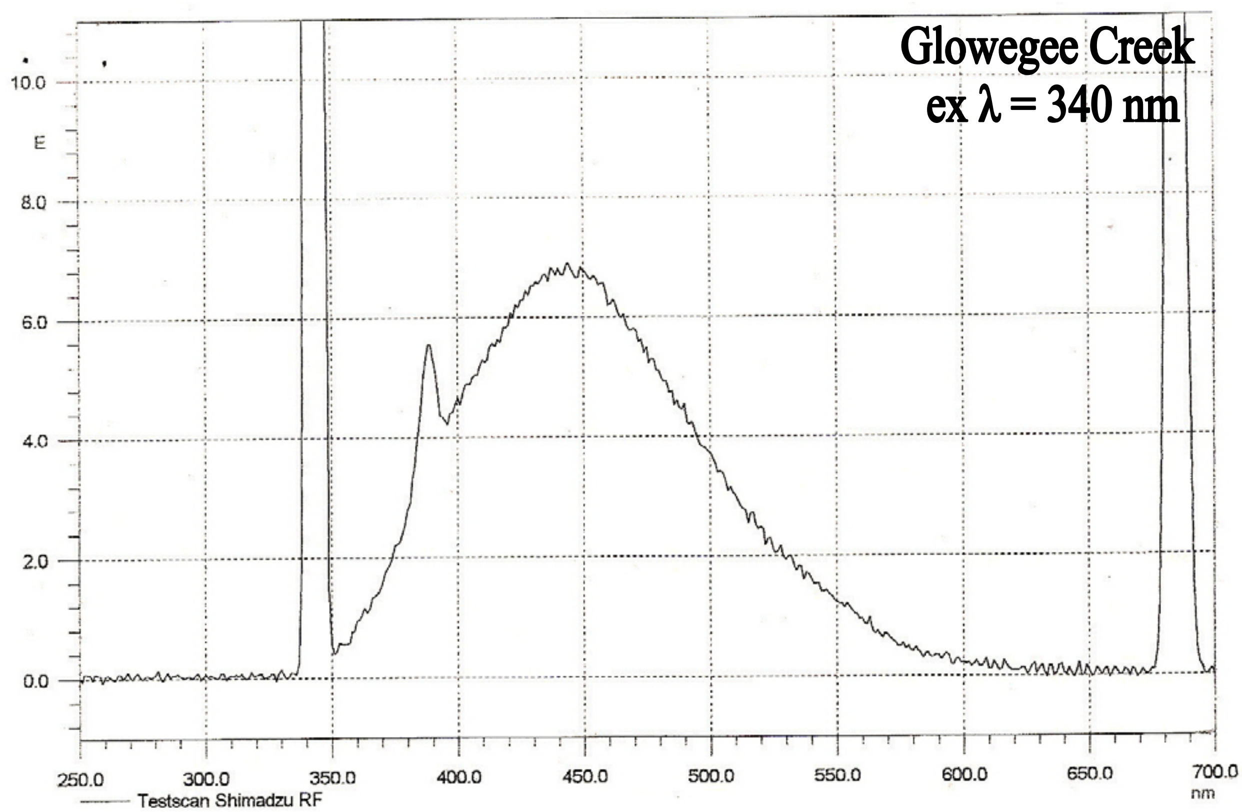

Clover Mill-Downstream
ex λ = 340 nm
10.0
E
8.0
6.0
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

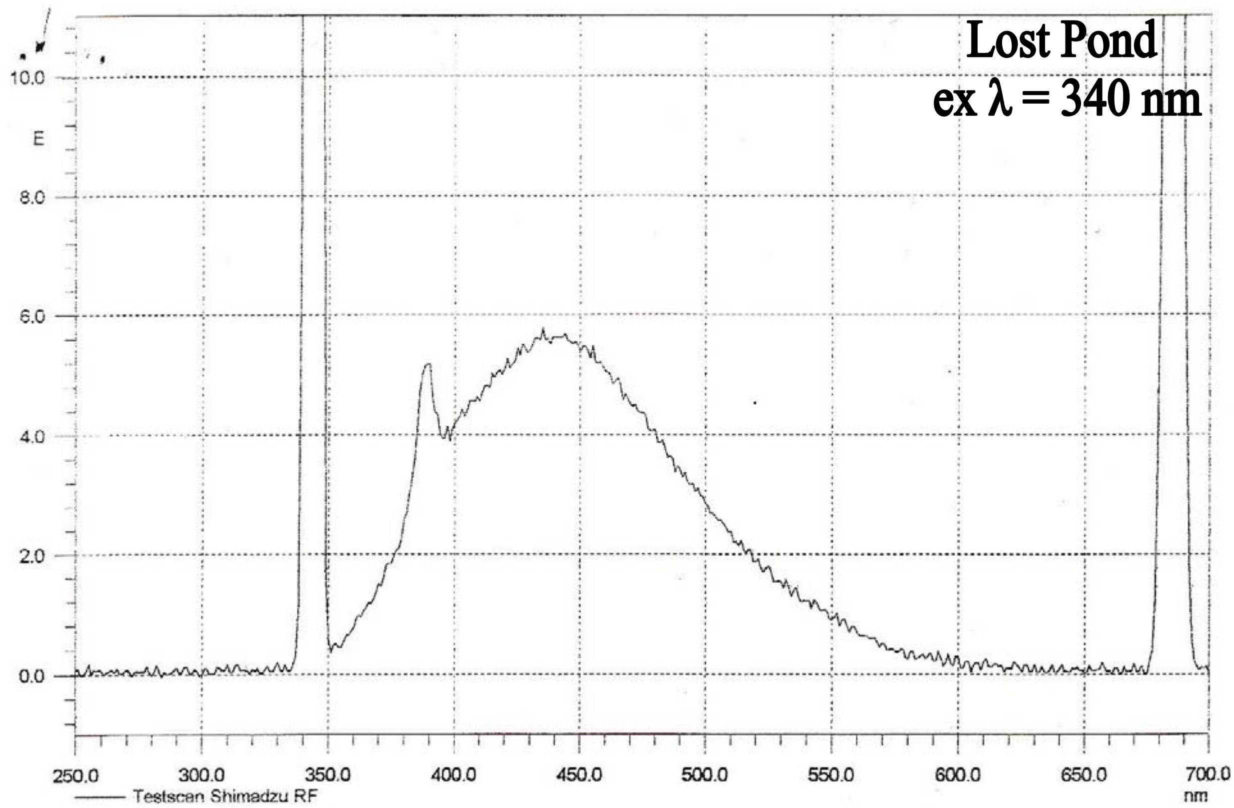

Upper Kayaderosseras
ex λ = 340 nm
10.0
E
8.0
6.0
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

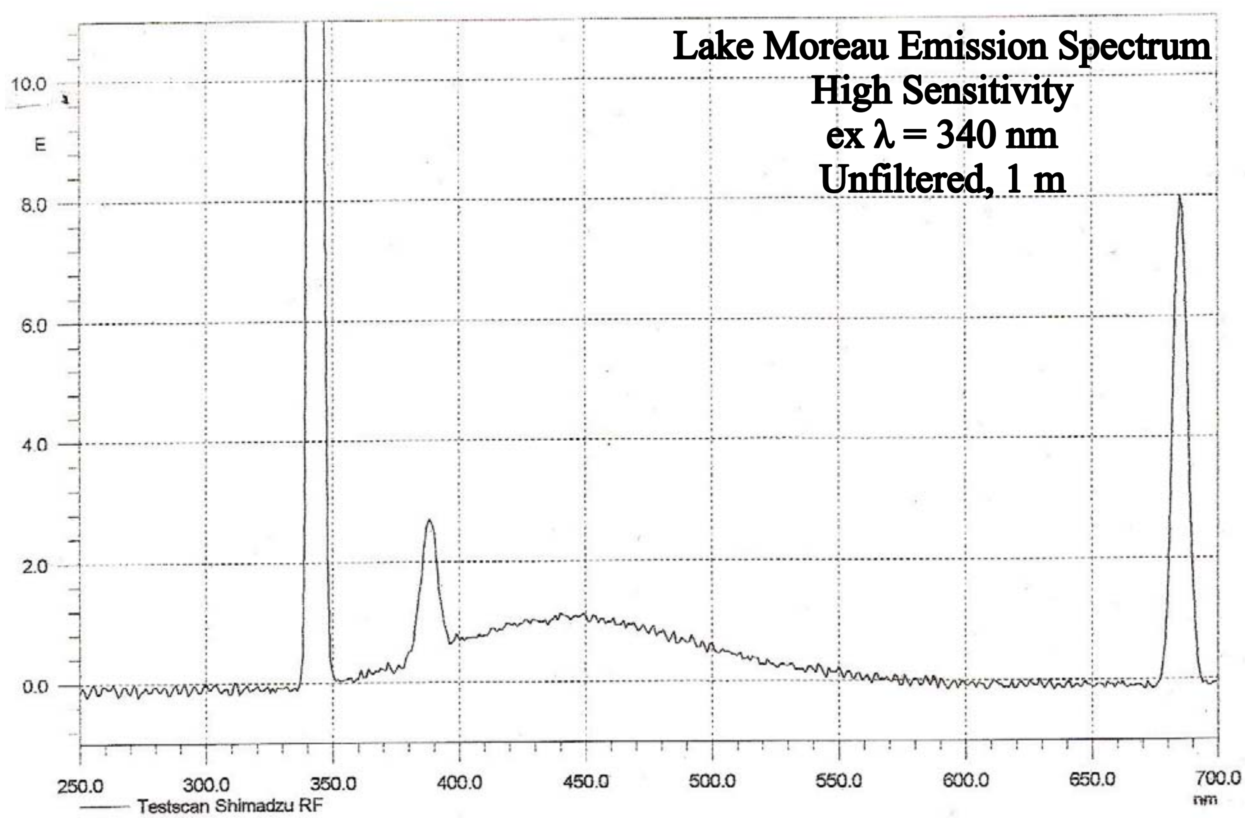

Main Kayaderosseras-R
ex λ = 340 nm
12.0
E
10.0
8.0
6.0
4.0
2.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

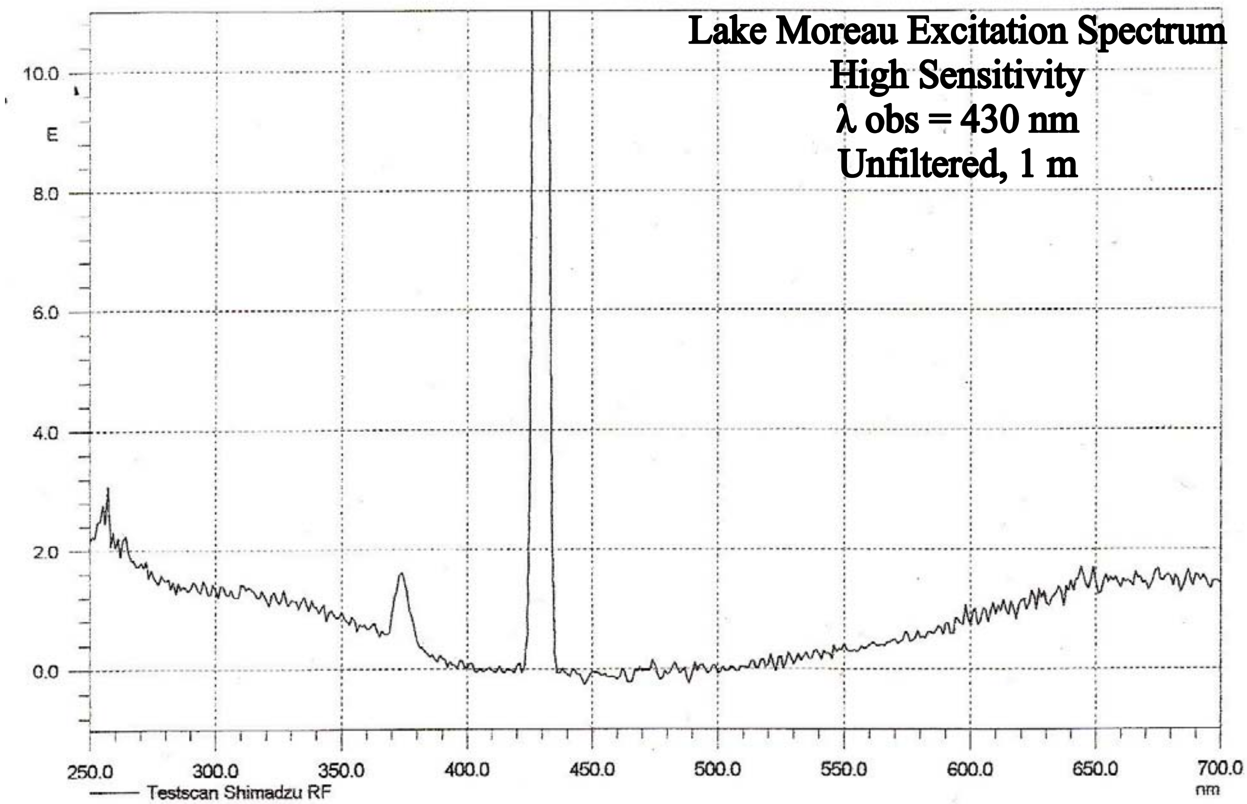

Mourning Kill
ex λ = 340 nm
10.0
E
8.0
6.0
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

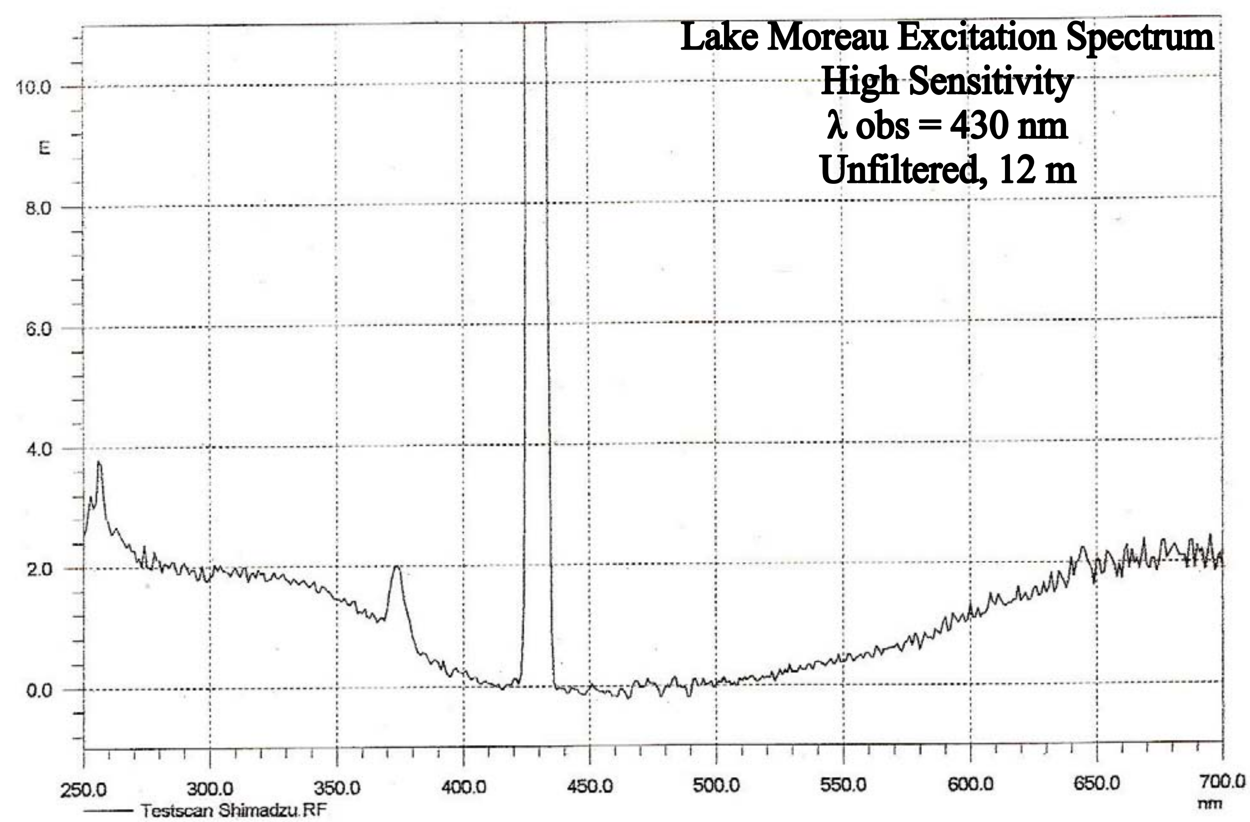

Geyser Brook
ex λ = 340 nm
10.0
E
8.0
6.0
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

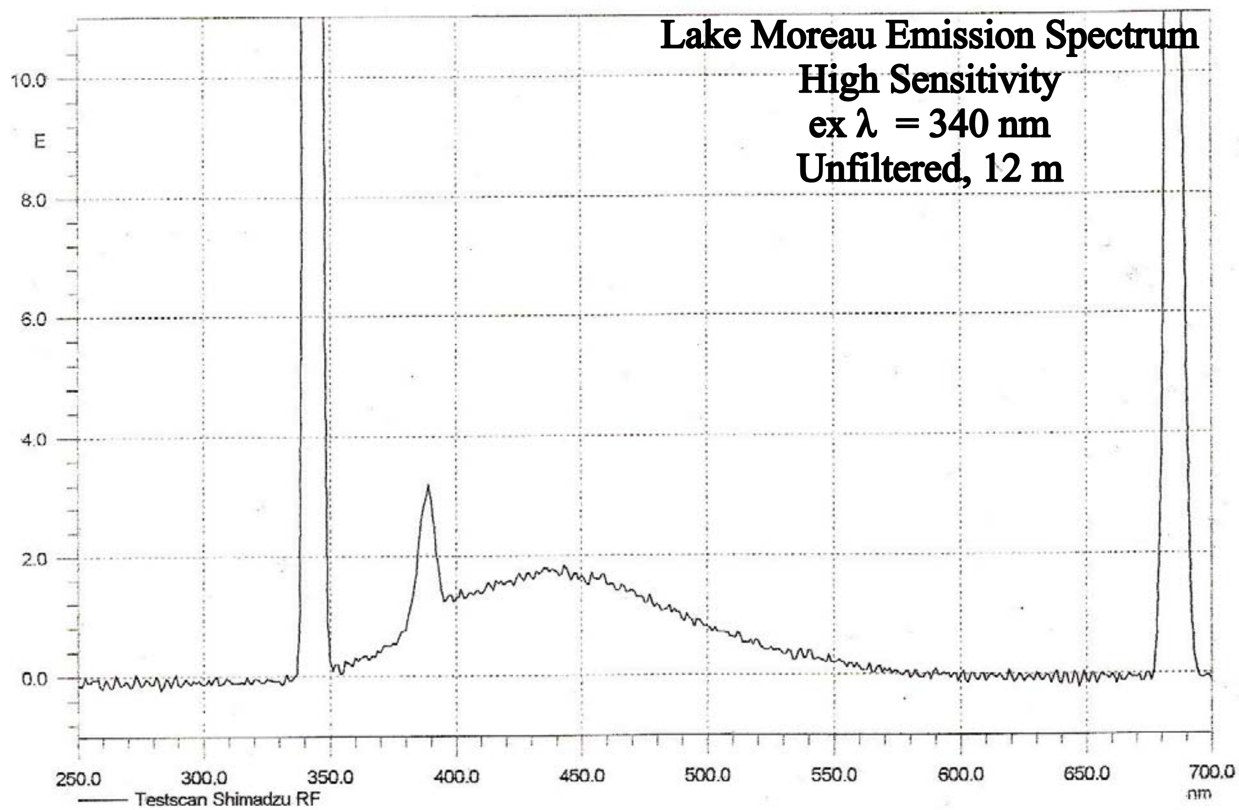

Glowegee Creek
ex λ = 340 nm
10.0
E
8.0
6.0
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

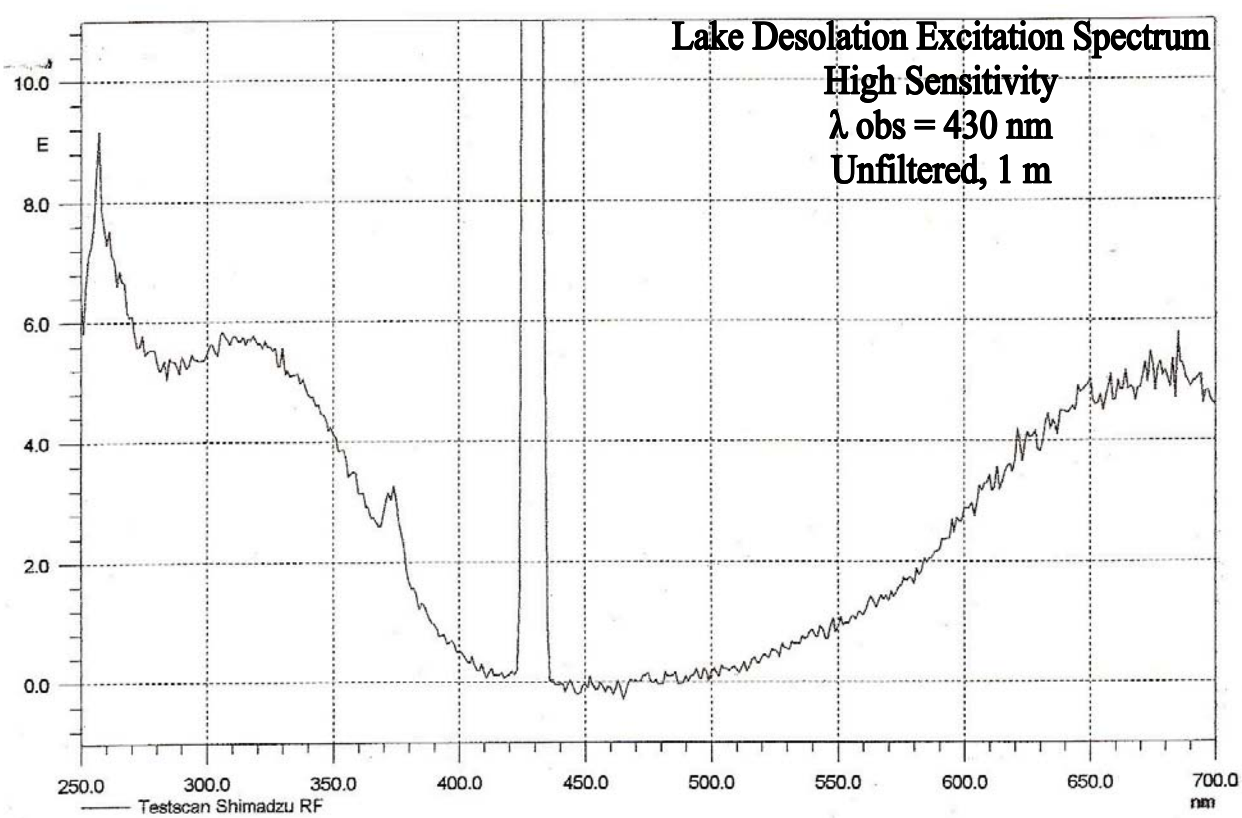

Lost Pond
ex λ = 340 nm
10.0
E
8.0
6.0
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

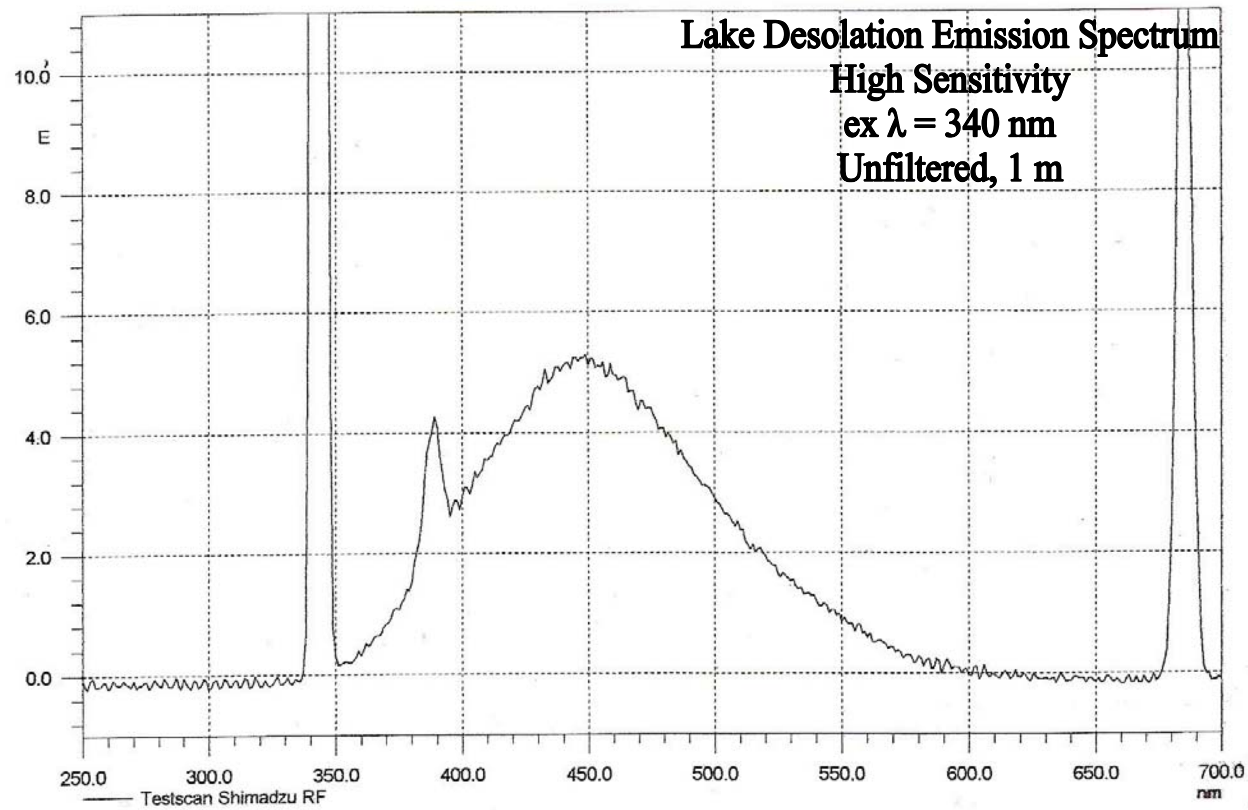

Lake Moreau Emission Spectrum
High Sensitivity
ex λ = 340 nm
Unfiltered, 1 m
10.0
E
8.0
6.0
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

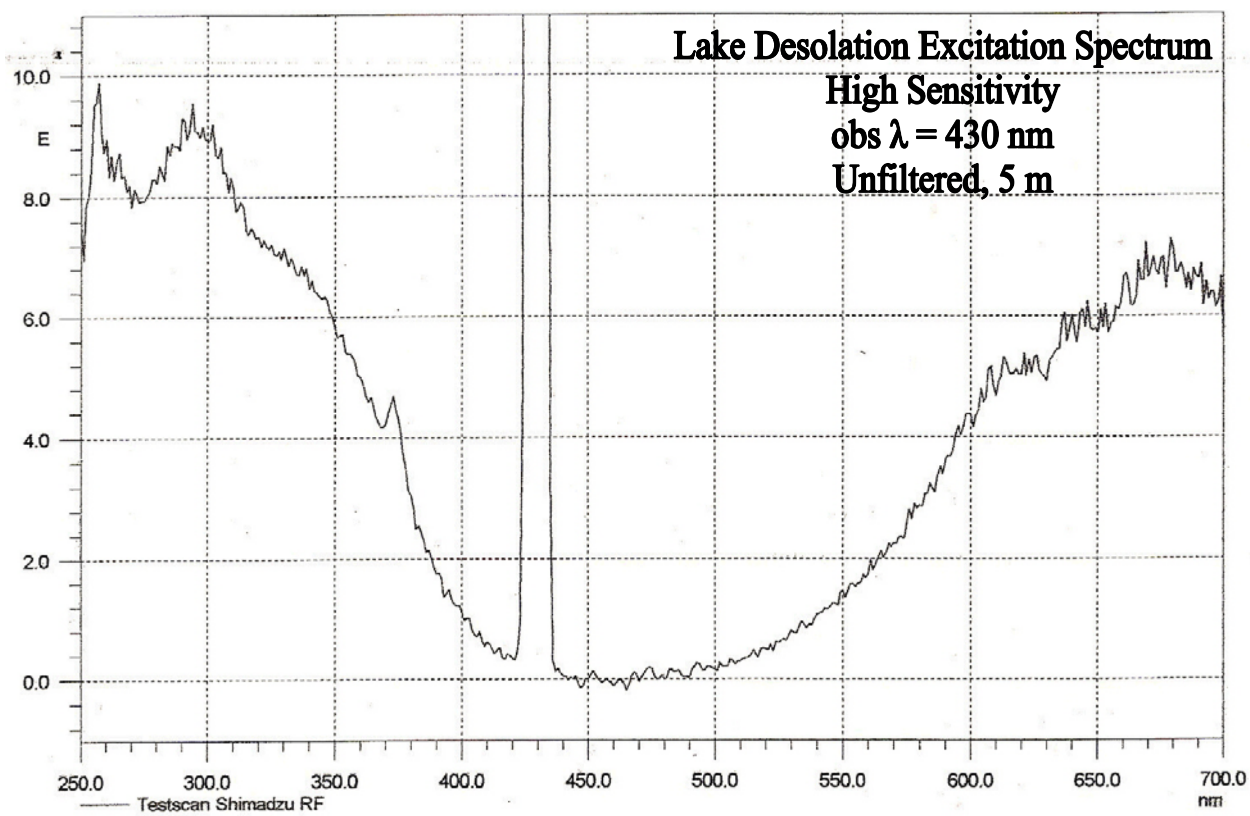

Lake Moreau Excitation Spectrum
High Sensitivity
λ obs = 430 nm
Unfiltered, 1 m
10.0
E
8.0
6.0
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

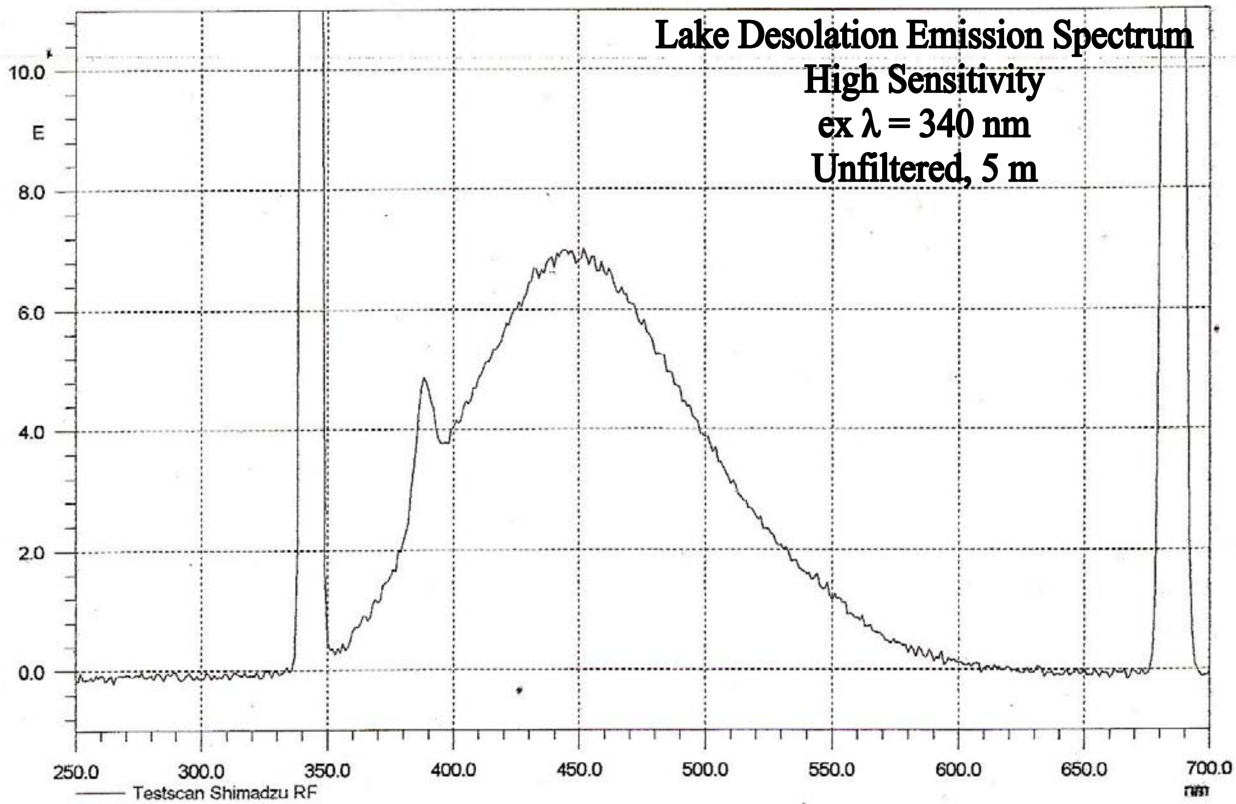

Lake Moreau Excitation Spectrum
High Sensitivity
λ obs = 430 nm
Unfiltered, 12 m
10.0
E
8.0
6.0
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

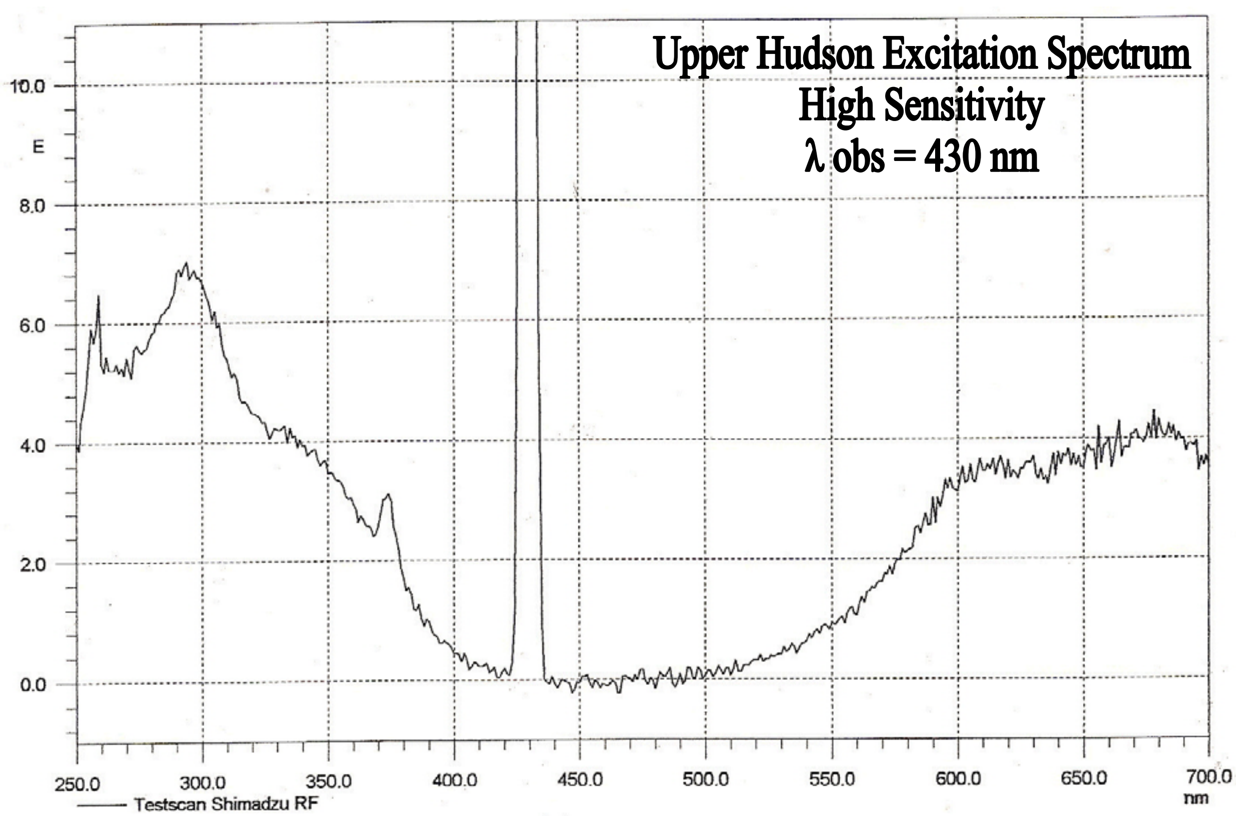

Lake Moreau Emission Spectrum
High Sensitivity
ex λ = 340 nm
Unfiltered, 12 m
10.0
E
8.0
6.0
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

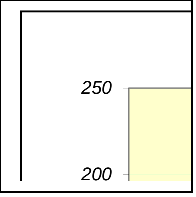

Lake Desolation Excitation Spectrum
High Sensitivity
λ obs = 430 nm
Unfiltered, 1 m
10.0
E
8.0
6.0
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

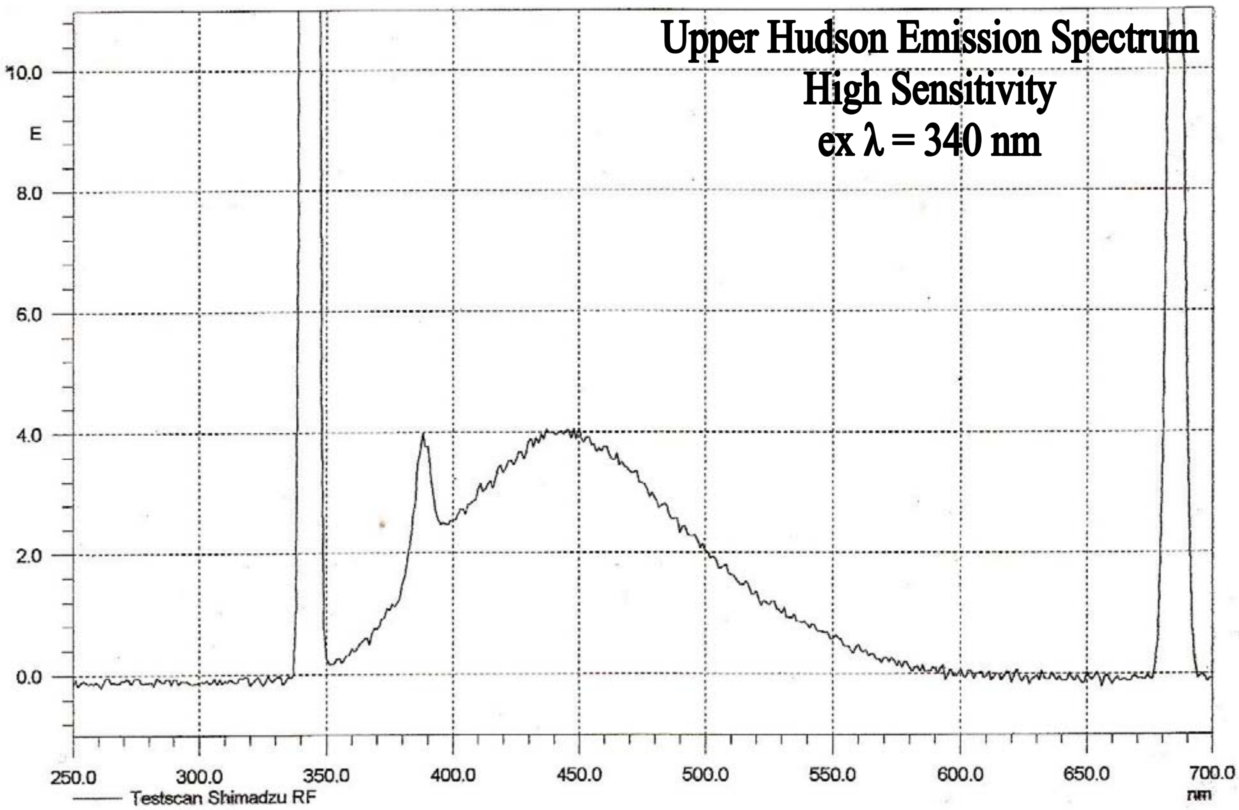

Lake Desolation Emission Spectrum
High Sensitivity
ex λ = 340 nm
Unfiltered, 1 m
10.0
E
8.0
6.0
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF


Lake Desolation Excitation Spectrum
High Sensitivity
obs λ = 430 nm
Unfiltered, 5 m
10.0
E
8.0
6.0
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF


Lake Desolation Emission Spectrum
High Sensitivity
ex λ = 340 nm
Unfiltered, 5 m
10.0
E
8.0
6.0
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF


Upper Hudson Excitation Spectrum
High Sensitivity
λ obs = 430 nm
10.0
E
8.0
6.0
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF


250
200


Upper Hudson Emission Spectrum
High Sensitivity
ex λ = 340 nm
10.0
E
8.0
6.0
4.0
2.0
0.0
250.0
300.0
350.0
400.0
450.0
500.0
550.0
600.0
650.0
700.0
nm
Testscan Shimadzu RF

3-9-10 JAH