NUTRIENT and SEDIMENT LOSS FROM ONEIDA LAKE TRIBUTARIES

The South Shore Tributaries

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Cover Photograph by Gary Reichert
Sunset from Lower South Bay, Oneida Lake

SUMMARY

1. Discharge, nutrient loss and soil loss from 11 sites on eight tributaries of the southern watershed of Oneida Lake were determined for three baseline periods (4 August 1999, 23 September 1999, 26 October 1999) and three hydrometeorological events (6 January 2000, 1 March 2000, 19 May 2000). These estimates were based on instantaneous measurements of discharge and estimates of nutrients at one point in time.

2. During three precipitation events (10-11 January 2000, 24-26 February 2000, 18-20 May 2000) loss of nutrients and soil (total suspended solids) from Oneida Creek were estimated based on continuous measurements of discharge and composite water samples from the ascending and descending portion of the event hydrograph.

3. Dissolved oxygen concentrations were high (>8.16 mg/L) and more than adequate to support aquatic biota at all sites on sampling dates.

4. In general, pH for all tributaries was well above neutrality exceeding a pH of 8.0 for all events and exceeding a pH of 7.5 for all nonevents. Although the Oneida Lake area receives acid precipitation (pH<5.5), the tributaries draining the watersheds were not affected by acid precipitation.

5. Phosphorus is an element required for plant growth whether on land or in the water. The loss of total phosphorus from the southern Oneida Lake subwatersheds during hydrometeorological events was always higher than baseline losses. Considering daily areal loading, Cowaselon Creek at Gee Road (site CW1) delivered more phosphorus (>31.3 g P/ha) to downstream ecosystems than any other subwatershed during events. Limestone Creek at Rt. 5 (site LS1), Canaseraga Creek (site CN1), Cowaselon Creek (site CW2), and Oneida Creek (site ON1) had comparatively high event losses of total phosphorus relative to other southern Oneida Lake subwatersheds. Converting to English units, Cowaselon Creek (site CW1), which had the highest areal loading to Oneida Lake, delivered 1,278 lbs of phosphorus per storm event day.

6. Nitrate is a measure of the soluble forms of nitrogen that are used readily by plants for growth. The six watersheds that were contributing the largest amount of nitrate to downstream habitats during events in descending order were: Cowaselon Creek (site CW1)(343 g/ha/day), Canaseraga Creek (332 g/ha/day), Cowaselon Creek (site CW2) (287 g/ha/day), Clockville Creek (274 g/ha/day), Limestone Creek (site LS1) (263 g/ha/day) and Oneida Creek 237 g/ha/ day).

7. Concentration of TKN was higher in events than during non-events suggesting that organic material is being swept off the watershed during precipitation events. In descending order, the greatest loss of total Kjeldahl nitrogen from the watershed to downstream ecosystems occurred in: Cowaselon Creek (CW1), Canaseraga Creek (CN1), Cowaselon Creek (CW2), Limestone Creek (LS1), Chittenango Creek (CH2) and Oneida Creek (ON1).

8. The loss of suspended solids is a measurement of the loss of soil and other materials suspended in the water from a watershed and can be used as a measure of soil erosion. Several watersheds are losing suspended materials at higher levels compared to other Oneida Lake subwatersheds. Cowaselon Creek (sites CW1 and CW2), Butternut Creek, Canaseraga Creek, and Oneida Creek delivered in excess of 6000 g/ha/day of suspended solids to Oneida Lake during events. For Cowaselon Creek, about 256 tons of soil per storm event day was transported into Oneida Lake.

9. Total phosphorus loading was highly correlated with total suspended solid loss from Oneida Lake watersheds during events (r^2= 0.94). Similarly, total Kjeldahl nitrogen loading was highly correlated with total suspended solid loss from Oneida Lake watersheds during events (r^2= 0.86).

10. Chloride is a component of deicing salt. Cowaselon Creek (sites CW1 and CW2) followed by Canaseraga (site CN1), Chittenango (site CH2), and Limestone Creek (LS1 and LS2) delivered the highest amount of salt to downstream systems on an areal basis.

11. Estimates of event loss of materials and nutrients from Oneida Creek indicate that loads based on continuous estimates of discharge and automated water sampling representing the entire day are substantially lower than estimates calculated from an average discharge at one point in time and one estimate of material and nutrient concentration.

12. There are some unusual results that need to be investigated further. Average discharge during events at two upstream sites (site LS2 and CH1) was half the downstream site (site CN2) in Chittenango Creek. Such a discharge increase in a few miles is unusual and difficult to explain unless another source of water exists. Again in the Chittenango subwatershed but now in the headwaters of Limestone and Butternut creeks, the load of soil carried by the upstream tributaries (sites LS1 and BN1) is almost twice (~260,000 kg/day) as large than the downstream site LS2 (86,000 kg/day). It is unusual for such a large decrease in stream loading at downstream site during an event. Where did the soil being carried by the stream go? Several explanations are provided.

13. By comparison to watersheds with various land uses in western and central New York, phosphorus losses from some Oneida Lake tributaries appear to be very high. This result must be viewed with substantial caution as explained in the text. Nevertheless they do provide some insight as to the magnitude of the phosphorus loading to Oneida Lake.

14. The foundation for evaluating nutrient and soil losses from subwatersheds of Oneida Lake has been laid by the Central New York Regional Planning and Development Board. During storm events several watersheds (Cowaselon Creek, Limestone Creek (site LS1), Canaseraga Creek, Oneida Creek and Chittenango Creek) appeared to have high losses of nutrients and materials. Even though Oneida Lake is eutrophic and has likely been eutrophic since at least the 1600s, the high event loss of nutrients, especially phosphorus, and total suspended solids (soil) from the various subwatersheds further enhance the

productivity of Oneida Lake and continue to contribute to siltation of fish spawning grounds. However, it is important to stress that the data presented are suggestive but are not conclusive at this time. There are simply too few data points.

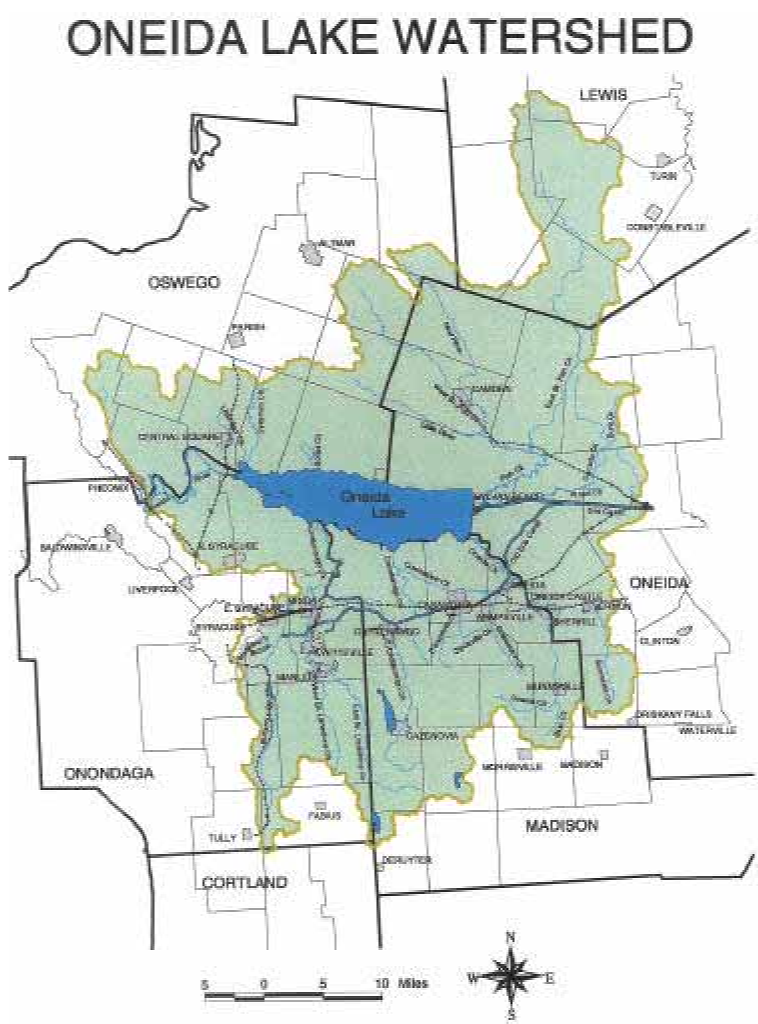
15. Several recommendations are provided on sampling including sampling strategy, frequency of sampling, timing of sampling in a watershed, discharge measurements, compositing of samples, segment analysis, etc.

INTRODUCTION

Freshwater resources have historically played an instrumental role in community development and economic sustainability. Oneida Lake is not an exception. The Oneida Lake region provides numerous recreational attractions, outstanding fishing, aesthetic appeal, and economic opportunities for thousands of people (CNYRPDB 2000). This recreational usage and economic value is predicated on the availability of high quality water resources and angling opportunities in Oneida Lake and its tributaries. Needless to say, agriculture also has a major economic impact in the Oneida Lake watershed. Loss of important agriculture resources, such as soil and nutrients, from a watershed is of concern to the land owner, to the Soil and Water Conservation District, and eventually to lake residents because of the potential impact they have on lake water quality and fishery resources. Remediation and protection of soil and water resources depend largely on the identification of both the cause and effect of elements likely to reduce their economic and social value.

Why Care About the Oneida Lake Watershed?

Oneida Lake is a naturally eutrophic lake (Greeson and Meyer 1969); that is, the lake has a high productivity of plants – especially phytoplankton. Eutrophication is a natural process of aging of a body of water. However, the rate at which it occurs can be accelerated by human influence in the watershed, a process often referred to as cultural eutrophication. Why care about the Oneida Lake watershed? The Oneida Lake Book (CNYRPDB 2000) perhaps states it best. The water quality of Oneida Lake is directly influenced by land use practices in the



lake's watershed. As precipitation falls on the landscape, it washes or carries materials, such as soil, cow manure, nutrients, pesticides, etc., from the land surface into nearby streams and eventually into Oneida Lake influencing water quality. Land usage that includes agriculture and urban living will have a greater potential to deliver nutrients and soil to a lake than a forested watershed. The secret to protecting a lake's water quality is to remediate and to protect the lake's watershed. Similarly, remediation of watersheds will serve to protect and improve fish spawning and nursery areas of sport fishes utilizing Oneida Lake tributaries.

In recognition of the need to acquire a uniform, organized approach to addressing surface water degradation and given the diverse nature of non-point sources of pollution, the Central New York Regional Planning and Development Board organized the Oneida Lake and Watershed Task Force. The Task Force is an alliance of agencies, organizations, elected officials, and citizens interested in the protection of water resources in the Oneida Lake Watershed. Because of the increased population and development pressure and because of water quality concerns south of Oneida Lake, monitoring of southern tributaries of Oneida Lake was initiated first. The intent is to expand this effort into the entire Oneida Lake watershed. Determination of sources and magnitude of soil and nutrient losses from a watershed is prerequisite to remedial action and essential to making cost-effective land management decisions as it reduces the likelihood of costly miscalculations based on the assumption of soil and nutrient sources and modeling rather than their actual identification. The goal of this report is to provide:

- An interpretive summary of chemistry trends for each subwatershed in the southern Oneida Lake watershed;
- A prioritization of the southern region tributaries, based on nutrient and soil loss; and
- A comparison between nutrient and soil loss from Oneida Lake subwatersheds to other central New York watersheds with different land use practices.

The Subwatersheds

Derived from Saltman (2000)

Chittenango Creek (133.37 mi^2) and Its Tributaries (Butternut and Limestone Creeks): Chittenango Creek (Appendix 1) begins in the Madison County Town of Nelson and flows north for 50 miles before emptying into Oneida Lake. Approximately equal areas are drained by the main stream and its principal tributaries, Limestone and Butternut Creeks. The Creek is a highly valued trout fishery with portions of the gorge designated as special trout fishing areas by NYSDEC. Agriculture is the primary land use with an estimated 60 farms, including 37 dairies. There are 3,330 dairy cows and 2,238 young stock. There are also several cash grain and beef operations, with at least one sheep operation and two pig operations.

Chittenango Creek is listed on the Priority Waterbodies List because of development pressure. Stream bank erosion is a moderate concern. Logjams north of the Village of the Chittenango are thought to play a role in the flooding of lowlands near Oneida Lake. Butternut Creek, a tributary of Chittenango Creek, supports spawning trout and is impacted by nutrients and urban runoff. Both Limestone and Butternut Creeks have USGS monitoring stations on them.

Cowaselon Creek and Its Tributaries (Canaseraga, Canastota and Clockville Creeks): Several tributaries, including Canaseraga and Clockville Creeks, that originate in the uplands of the central part of Madison County, flow north and join the main creek after descending the escarpment onto the Oneida Lake plain (Appendix 1). Exceptional trout fisheries are located in the upland areas. The watershed is intensively used for agriculture (~40%) with an estimated 59 daily farms (5,310 dairy cows and 3,346 young stock). In addition, a number of beef and sheep farms are in operation. About 29% of the watershed is forested. A sewage treatment plant is operated in the watershed.

Cowaselon and Canseraga Creeks are listed on the Priority Waterbodies List (NYSDEC 1996) because of loss of fish habitat and elevated stream temperatures in channeled sections. In the upland portion of the watershed in areas of intensive dairy farming, there have been problems associated with mismanagement of manure and contamination of surface waters. Loss of riparian habitat is also a concern. There is a substantial concern over loss of wetland habitat in the watershed, especially in the lake plain, and in the Canastota muckland. Near the limestone escarpment, a concern exists over agriculture and nutrient runoff in areas of crop production affecting groundwater resources.

Oneida Creek: Oneida Creek watershed is the largest (172.74 mi^2) of the eight subwatersheds investigated in this study. Of the 76 farms within the watershed, 34 are considered to be dairy farms. Discharge of the creek has been monitored by the USGS at Sconondoa Street in the City of Oneida since 1949. The City of Oneida Sewage Treatment Plant empties into Oneida Creek, which is on the Waterbody Priority List because of fish habitat loss due to sedimentation and nutrients (NYSDEC 1996). A user survey in 1997 documented several Issues of Concern in the watershed (Anonymous 1997). These concerns include removal of riparian vegetation, sedimentation, septic systems, stream bank erosion and barnyard runoff. Steep slopes in the uplands and high stream gradients create significant sediment and nutrient loading in the lower sections of the creek. Significant stream bank erosion problems also occur within the Stockbridge Valley.

DEFINITIONS

Total Phosphorus - A measure of all forms of the element phosphorus. Phosphorus is an element required for plant growth on land or in water. In lakes, phosphorus is often the limiting factor of phytoplankton growth and is the cause of eutrophication, or overproduction, of lakes. Phosphorus may enter a watershed in soluble or organic form from several sources including sewage, heavy-duty detergents, fertilizer and agricultural waste. Some forms of phosphorus are more available to and cause more immediate activity in plants.

Dissolved Phosphorus - A measure of the most available and active form of phosphorus.

Nitrate and Nitrite- A measure of the soluble forms of nitrogen used readily by plants for growth. Sources of nitrates in the environment are many and include barnyard waste and fertilizer.

Total Kjeldahl Nitrogen- The Kjeldahl method is a convenient method of analysis for nitrogen but cannot be used for all types of nitrogen compounds. It is, however, a good measure of organic nitrogen, including ammonia. Manure, for example, contains a large amount of organic nitrogen.

Chloride- A measure of the mineral, most commonly found as sodium chloride (NaCl), dissolved in water. NaCl naturally occurs in deep layers of local bedrock. Mined, it is stored and spread as a de-icing agent on roads and other pavements.

Total Suspended Solids - A measure of the loss of soil and other materials suspended in the water from a watershed. Water-borne sediments act as an indicator, facilitator and agent of pollution. As an indicator, they add color to the water. As a facilitator, sediments often carry other pollutants, such as nutrients and toxic substances. As an agent, sediments smother organisms and clog pore spaces used by some species for spawning.

Specific Conductance – A measure of the ability of water to conduct an electric current which is a function of the quantity of total dissolved solids in the water. The higher the specific conductance the higher the amount of total dissolved solids in the water.

Dissolved Oxygen – The measurement of dissolved oxygen is one of the most frequently used and the most important environmental factors affecting aquatic life and of the capacity of water to receive organic matter without causing an impairment.

pH - pH is a measure of the amount of the acid present in water. For example, a low pH may be indicative of water receiving industrial wastes, acid precipitation, etc.

METHODS

Manual South Shore Tributary Monitoring

Personnel from the Cornell Biological Field Station collected stream water samples at 11 sites on eight tributaries (Figure 1) on six sampling dates. These samples are considered "grab" or "instantaneous" samples. That is, samples and discharge were taken at one instance in time as opposed to continuous measurements. Initially, only one of these dates was considered to be a nonevent or baseline sample – that of 4 August 2000. However, after reviewing the discharge data (Appendix 2), it was evident that two other samplings dates (23 September 1999 and 26 October 1999) had relatively low flows even though they had been declared precipitation events. The policy of "...sampling one day after the rain event… to insure that the runnoff water had a chance to move through the watershed to streams" (Carrie Wafer, personal communication) should be reconsidered. It is possible and likely that an event discharge may have passed through the watershed prior to sampling giving a low discharge. As a result of the low flows on three dates, we have designated three sampling dates as nonevent periods (4 August 1999, 23 September 1999, 26 October 1999) and three as occurring during hydrometeorological events (6 January 2000, 1 March 2000, 19 May 2000). The 19 May event was due to a snowmelt, while the other two were rain events. A rain event was defined as the first rainfall in 72 hours since a previous rainfall that exceeded 0.1 inch. On each sampling date, stream velocity and depth measurements were taken at one to three locations within the stream. In general, the wider the stream the greater the number of velocity measurements taken. On some occasions, only one velocity and water depth measurement were taken because of high flow conditions.

Sample bottles, ice packs, and a cooler were received from Life Science Laboratories, Inc. (LSL) prior to each sampling date. The Kemmerer water bottle was acid rinsed with 50:50 HCl:deionized water followed by deionized water prior to taking stream water samples - usually from a bridge.

Calibration of Field Equipment: Except for the factory calibrated temperature probe, the Hydrolab Multi–Probe was calibrated before each anticipated sampling effort following the manufacture's directions. pH was calibrated using VWR Scientific pre-made pH 7 and pH 10 standards, while conductivity was calibrated using a pre-made 500 µS/cm standard from the Hydrolab Corporation.

Tributary Sampling Strategy: Water temperature, dissolved oxygen, conductivity and pH were taken in the field with a Hydrolab Multi-Probe from the main channel of the stream. During extremely high discharge conditions, the Hydrolab would skim along the steam surface instead of sinking in the fast-moving main channel. In this situation, the Hydrolab measurements were taken from a slower moving part of the stream.

All other samples were taken in the field and analyzed in the laboratory after preservation. Composite water chemistry samples were created for each sampling site. In larger streams, three or more horizontal sections (e.g., left, middle and right) and multiple depths (surface, middle and bottom) were sampled. In smaller streams, one or two horizontal sections (e.g., middle and one side) and one or two depths were sampled (typically the middle because the water was shallow). Except for the first Kemmerer water bottle sample, where half of the sample was used to rinse the compositing bucket, all subsequent samples were poured into a large five gallon "compositing" bucket. Two subsamples were taken. A one-liter, unpreserved, and unfiltered subsample of the composite water sample was taken with an acid-rinsed Nalgene Beaker for nitrate, nitrite, chloride, and dissolved phosphorus. This subsample was filtered in the laboratory by Life Sciences Laboratory (LSL). A second 500-mL subsample of the composite water sample was collected for total phosphorus, total suspended solids, ammonia, and total Kjeldahl nitrogen and preserved with approximately 10 mL of a 1:1 dilution of sulfuric acid. All subsamples were placed on ice until they were delivered to LSL Labs.

The location of all sampling sites is presented in the Appendix 3. Generally, it took ~ seven hours to complete the field sampling of all sites (C. Wafer, Personal Communication, Cornell Biological Field Station).

Automated Event Sampling on Oneida Creek

During three hydrometeorological events (10-11 January, 24-25 February and 18-19 May 2000), water samples were taken over a 24-hour period with a Sigma StreamLine 800SL Portable Liquid Sampler at the USGS Gauging Station (Station Number 04243500). Samples were collected from one depth at the center of the stream every 15 minutes for a 24-hour period. The individual hourly samples were then merged as follows:

1. An initial sample (single sample or composite) representing the beginning of the event.
2. A composite representing the ascending limb of the storm hydrograph.
3. A composite representing the peak of the hydrograph.
4. A composite representing the ascending limb of the storm hydrograph.
5. An end sample (single sample or composite) approximately non-event flows.

Water Chemistry

Water chemistry analysis included total phosphorus (TP), total Kjeldahl nitrogen (TKN), dissolved phosphorus (soluble reactive phosphorus), nitrate, nitrite, chloride and total suspended solids (TSS). All water chemistry analyses were performed by Life Sciences Laboratory (ELAP # 10248) using standard EPA (Environmental Protection Agency, 1979) methods (Table 1). New York State Department of Health's Environmental Laboratory Approval Program includes biannual proficiency audits, annual inspections, written documentation on all samples, reagents and equipment and, in general, good laboratory practices.

Samples were analyzed according to the following schedule.

- Within one day of sample collection - nitrate, nitrite and chloride.
- Within one week of sample collection - suspended solids.
- Within two weeks of sample collection - Dissolved phosphorus, total phosphorus, ammonia, and total Kjeldahl nitrogen.

Table 1. Analytical methodology used by Life Sciences Laboratory.

Analyte	Method
Dissolved phosphorus	EPA 365.1
Total Phosphorus (sulfuric acid digestion)	EPA 365.1
Total Suspended Solids	EPA 160.2
Ammonia	EPA 350.1
Total Kjeldahl nitrogen	EPA 351.2
Chloride, Nitrite, Nitrate (Ion chromatography)	EPA 300.2

Physical Measurements - Stream Velocity and Cross-Sectional Area:

A Global Water flow probe was used to measure water velocity. In the original data sheets, velocities were listed as km/sec. After discussion with Carrie Wafer of the Cornell Biological Field Station and discussions with the manufacturer, it was determined that the velocity readings were in m/sec after multiplication by 0.1. All velocities used in this report have been changed to reflect this correction.

By adding a 15-foot extension to the flow probe, velocity was measured during high event flows from a bridge. Despite the added weight and support, it was impossible to submerse the probe more than a few inches below the surface during extremely high flows, which were encountered on 6 January 2000, 1 March 2000 and 15 May 2000.

Stream Width: Stream width was measured at the bridge crossing each stream once during the study period. Two measurements of stream width were taken at Cowaselon Creek (site CW2) to accommodate periods when the stream overflowed its banks.

Since a morphometric map did not exist for each stream, a cross-sectional area of the stream was estimated by dividing the stream width into segments and assuming a rectangular shape. The number of segments was determined from the number of velocity measurements across the stream.

Discharge and Losses from the Watershed (Loading):
South shore tributary discharge was estimated by multiplying velocity times the cross-sectional area of the appropriate horizontal segment. Losses of nutrients and soil were estimated by multiplying discharge by the corresponding concentration in the water sample.

For the automated event sampling at Oneida Creek, "provisional" discharge data (every 30 minutes) was provided by Henry J. Zajd and Edward Bugliosi of the United States Geological Survey (USGS). Loading to Oneida Lake was calculated by multiplying instantaneous discharge (every 30 minutes) obtained from the USGS gaging station times the composite nutrient and total suspended solids concentrations from the appropriate composite water samples (initial pre-event sample, ascending limb, peak, descending limb, final post-event sample). There is some concern that the 10-11 January and 19-20 February discharge data may be affected by ice damning (H. Zajd, personal communication). However, Kevin Angel, the field technician, notes that ice was not present in the stream during the 19-20 February sampling period and that the 10-11 January samples was taken during a period where there was "No frost in the ground, no snow, and saturated soils" (Appendix 4)

Watershed Area: The watershed area used in all loading calculations represents the area of the watershed upstream from the sampling site. This information was provided by Don Jordan of the Syracuse Onondaga County Planning Agency.

RESULTS and DISCUSSION
Concentration of Analytes

Dissolved Oxygen (Table 2):

Dissolved oxygen concentrations were high and more than adequate to support aquatic biota at all sites on all sampling dates. Oxygen concentrations were always lower during baseline flows for each site on each stream when compared to event concentrations. For example, oxygen concentrations in Butternut Creek were lower during baseline flow (mean = 10.03 mg/L) than during event flows (mean = 12.05 mg/L). This increase is likely due to the sampling strategy. All baseline flow samples were taken during the late summer and fall (average temperature range for all streams = 11.9 to 15.8^{o}C) while all event samples were taken in the winter and early spring when water temperature was seasonally low (average temperature range for all streams = 4.8 to 8.4^{o}C). The solubility of oxygen in water increases with decreasing temperature. Thus, the higher oxygen concentrations observed during events were probably due to colder water temperatures that that can hold more oxygen during the winter and spring.

Specific Conductance (Table 2):

Specific conductance, which reflects the amount of total dissolved solids in water, varied significantly between subwatersheds and within a watershed between an event and a nonevent. Specific conductance was often twice as high during baseline conditions than during events. The lower specific conductance observed during events suggest a dilution effect during periods of high flow.

A comparison of the southern subwatersheds of Oneida Lake indicates that average baseline specific conductance was the highest at both sampling sites on Cowaselon Creek (site CW1 and CW2)(average of two sites = 1458 µS/cm) and on Canastota Creek (site CT1)(1511 µS/cm) and was the lowest at Chittenango (sites CH1 and CH2)(average of two sites = 929 µS/cm) and Limestone Creeks (site LS1)(940 µS/cm). These data suggest that the amount of dissolved solids in the water was greatest in Cowaselon and Canastota Creeks and lowest in Chittenango and Limestone Creeks.

pH (Table 2):

In general, pH for all tributaries was well above neutrality exceeding a pH of 8.0 for all events and exceeding a pH of 7.5 for all nonevents. Although the Oneida Lake area received acid precipitation (pH<5.5), the tributaries draining the watersheds were not affected by acid precipitation. The soils of the southern subwatersheds provided a source of carbonate and bicarbonate that buffer the effect of acid precipitation.

Chloride (Table 2):

The average baseline or nonevent concentration of chloride ranged from a low of 23.0 at Clockville Creek (site CK1) to a high of 63.0 and 67.3 mg/L at Limestone (LS2) and Butternut Creeks (BN1). For all sampling sites, the average event concentration was always lower than the average baseline concentration for a given stream (Fig. 2). Event chloride concentrations ranged from 15.3 mg/L (Clockville Creek, site CK1) to 44.3 mg/L (Limestone Creek, site LS2). The average event concentration of chloride appeared to be lower than the average nonevent concentrations perhaps because of the higher volume of water occurring during a hydrometeorological event diluting the chloride concentrations. However, there were no baseline (nonevent) samples taken during the spring when event samples were taken to allow a valid comparison. Higher values of chloride usually reflect the use of deicing salt in the watershed during the winter and spring seasons. In western and central New York, chloride (and sodium) concentrations are generally higher during baseline flow than storm events in the winter and spring than during the summer and fall (e.g., Makarewicz and Lewis 1998a, 1998b).

Total Phosphorus (Table 2):

Phosphorus is an element required for plant growth whether on land or in the water. In lakes, phosphorus is often the limiting factor of phytoplankton growth and is the cause of eutrophication, or overproduction, of lakes. Phosphorus may enter a stream from the watershed as a result of sewage disposal, heavy fertilizer use for lawns or agriculture, and through erosion of soil. Watersheds that have streams with high phosphorus concentrations are potentially the cause of increased phytoplankton and macrophyte (weed) production in lakes. Cowaselon Creek (site CW1) had the highest event concentration (159 µg/L) followed closely by Oneida Creek (130 µg/L) (Fig. 3). A surprisingly high level of total phosphorus was observed during baseline flows in Oneida Creek (164 µg/L). Unlike the other sampling sites, most of the phosphorus was as the dissolved form, rather than particulate form, suggesting a source other than soil (e.g., sewage effluent, fertilizer, etc.)(Table 2). The lowest concentrations of total phosphorus were observed during baseline flows at Limestone (site LS1) (13 µg/L) and Butternut (site BN1) (17 µg/L) Creeks (Table 2).

Total phosphorus concentrations increased in seven of 11 monitoring sites during runoff events. This suggests that phosphorus was being lost from the watershed as particulate matter, probably from soil erosion. On Canastota Creek, Clockville Creek, Oneida Creek, and Limestone Creek (LS2), a decrease in total phosphorus concentration occurred during events.

Dissolved Phosphorus (Table 2):

The highest dissolved phosphorus concentrations were observed during baseline conditions at Oneida Creek (136 µg/L) followed by Limestone (LS2, 59 µg/L), Canastota (55 µg/L) and Chittenango Creeks (CH1, 50 µg/L). Unlike total phosphorus, dissolved phosphorus levels generally decreased during events (Fig. 3).

Total Suspended Solids (Table 2):

Total suspended solid concentrations in stream water generally reflect the amount of suspended materials (e.g., soils) being lost from a watershed. The average total suspended solids concentration in the southern Oneida Lake tributaries varied significantly between subwatersheds and within a watershed between an event and a nonevent. Average total suspended solids concentrations increased significantly in all tributaries during events, except Limestone Creek at site LS2, where concentration of TSS decreased from 37.7 mg/L during baseflow to 29.0 mg/L during events (Fig. 4). On all other creeks, the increased volume of water flowing over the landscape during an event washed and carried surficial material (e.g., soils) increasing the amount of suspended materials in the water. This result is typical of tributaries draining urban and agricultural watersheds. The percent increase in TSS from baseline to event conditions was often substantial. They were as follows: Limestone Creek (site LS1)(740% increase; 5 to 42 mg/L), Cowaselon Creek (site CW 1)(567%, 9.3 to 62.0 mg/L); Butternut Creek (481%, 2.7 to 15.7 mg/L), Cowaselon Creek (Site CW2)(278%, 14.3 to 54.3 mg/L), Clockville Creek (297%, 3.7 to 14.7 mg/L), Oneida Creek (115%, 21.7 to 46.7 mg/L), Chittenango Creek (site CH1)(>135%, 10.3 to 24.3 mg/L), Canaseraga Creek (51%, 22.0 to 33.3 mg/L), Chittenango Creek (site CH2)(28%, 14 to 18 mg/L), and Canastota Creek (28%, 8 to 10.2 mg/L). These results suggest that large amounts of soil were lost from the watershed during events.

Nitrogen – Ammonia, Nitrate, Nitrite and Total Kjeldahl Nitrogen (TKN) (Table 2):

Nitrate is found in fertilizer, while total Kjeldahl (TKN) nitrogen represents the organic nitrogen plus ammonia present. Organic nitrogen would occur from sources such as sewage and animal manure, while nitrate is often a major component of fertilizer and is lost from sewage treatment plants. Except for Sites CH2 and LS2 at the base of Limestone and Chittenango Creeks, nitrates concentration increased an average of 127% (range 49 to 273%) during events. The largest percent increase was observed at Butternut Creek where average baseline concentrations rose from 0.51 to 1.90 mg/L during events (Fig. 2).

Generally, nitrite is not found in surface waters in large amounts as it is converted quickly to nitrate by bacteria. Measurable nitrite (values were less than 0.2 mg NO_2-N/L) was observed at all sample sites on 28 September 1999. The fact that nitrite was not observed on any other sampling dates and was present at low concentrations suggests that these results were apparent and may be an artifact of the sampling or analytical approach.

Ammonia, which generally occurs as the result of deamination of organic nitrogen-containing compounds and by hydrolysis of urea, was observed on the 19 May sample in Oneida (0.042 mg NH_3/L) and Cowaselon (0.052 mg NH_3/L) Creeks. Both these tributaries have sewage treatment plants present in the watershed. At some water treatment plants, ammonia is added to react with chlorine to form a combined chlorine residual.

As with nitrate, TKN increased slightly in all tributaries during storm events (average= 21%, range= 3 to 64%), except Chittenango Creek (CH1) and Canastota Creek (Fig. 4). Site CW1, (Cowaselon Creek at Gee Road) experienced the largest increase (64%) in TKN concentration during an event (557 µg/L to 913 µg/l). Highest baseflow concentrations (687 µg/L) of TKN were observed in Canastota Creek. The high loss of TKN from site CW1 during events suggests a source in the watershed.

Watershed Loss of Materials and Nutrients

Instantaneous Measurements

Although concentration of analytes provides useful information, the actual quantified loss of nutrients or materials from a watershed or loading is a better measurement of a watershed's impact to a downstream system. The loading estimate is a better indicator because it considers the volume of water being lost from a watershed, in addition to the concentration of the nutrient in that water. For example, a stream with a high concentration of a nutrient but a low discharge will have less of an impact on downstream systems than a stream with high discharge and a moderate concentration of a nutrient. Tables 3 and 4 present the average event and nonevent loss of total phosphorus, total Kjeldahl nitrogen, nitrate, total suspended solids and chloride.

The current sampling scheme provides a "snapshot" for an instant in time based on a single "grab" sample of water and a single measurement of discharge at a moment in time. . We have six snapshots (i.e. sample dates) or instances in time where samples were taken. Because flow or discharge was not monitored continuously, time trend analysis within the study period or into the future is not possible. However, prioritization of subwatersheds based on the amount of nutrients and materials lost from a subwatershed is possible and has been done below. It should be noted that these rankings will most likely change as more sampling dates are added to the data base. From a statistical point of view, confidence in these results will increase with more sampling dates. Direct comparisons of watersheds using areal losses (loss per watershed area) are used in this report (Table 4), although non-weighted nutrient losses are presented in Table 3. By calculating the loss per unit area of watershed, we normalize the results so that subwatersheds of different areas can be effectively compared. A watershed with a high loss of nutrients per unit area compared to another would suggest that a nonpoint or point source of nutrients exists in this watershed. Also by considering areal loading, prioritization or ranking of watersheds for remedial action is possible.

The results based on six sampling dates are presented in a series of comparative bar graphs (Figs. 5-7). Each bar graph in this series represents the nutrient or material losses from a tributary and its associated watershed normalized by the size of the watershed to allow direct comparison of each tributary - sometimes termed loading to the lake.

Discharge (Table 3)

For the six sampling dates, the average highest baseline (884,213 m^3/day) and event (8,847,141 m^3/day) flows were observed at Chittenango Creek (CH2). The lowest flows were observed at Canastota (baseline: 29,435 m^3/day, event: 93,031 m^3/day) and Clockville Creeks (baseline: 29,839 m^3/day, event: 305,149 m^3/day). Except for Canastota (CT1) and Chittenango Creeks (CH1), where flow increased by only 216% and 363%, respectively, from baseline conditions, all the other sampling locations experienced significantly higher event flows ranging as high as 2,587% (Cowaselon Creek, CW1) and 1,382 % (Limestone Creek (LS1) over baseflow (Table 3).

Phosphorus (Tables 3 and 4):

The loss of total phosphorus during events from the southern Oneida Lake subwatersheds was always higher than baseline losses. Baseline losses from each subwatershed were variable (0.1 to 1.8 g/ha/day), but not as variable as event losses (3.2 to 31.3 g/ha/day). Considering daily areal loading, Cowaselon Creek at Gee Road (site CW1) delivered more phosphorus (31.3 g P/ha) to downstream habitats than any other watershed during events (Fig. 5). Limestone Creek at Rt. 5 (site LS1), Canaseraga Creek (site CN1), Cowaselon Creek (site CW2), and Oneida Creek (site ON1) had high event losses of total phosphorus relative to other southern Oneida Lake subwatersheds. Total phosphorus loading was highly correlated with total suspended solid loss from Oneida Lake watersheds during events (r^2= 0.94). This suggests that the phosphorus in the particulate form (soil) was being washed off the landscape or eroded from stream banks.

By considering the total loading of a subwatershed (not normalized by area of the subwatershed), we perhaps have a better sense of the amounts of phosphorus being delivered into Oneida Lake by a subwatershed. For example, Cowaselon Creek (site CW1), which had the highest areal loading to Oneida Lake, was delivering ~1,278 lbs of phosphorus per storm event day.

Baseline loss of the dissolved fraction of phosphorus from the various subwatersheds was not as variable between subwatersheds as TP losses (range= 0.1 to 0.7 g/ha/day) (Fig. 5). Event dissolved phosphorus loss was highest from Oneida Creek (6.3 g/ha/day) followed closely by Cowaselon Creek at Gee Road (site CW1: 4.6 g/ha/day), Canaseraga Creek (3.9 g/ha/day) and Butternut Creek (3.7 g/ha/day). Interestingly, dissolved phosphorus made up over 90% of the total phosphorus in the Butternut Creek subwatershed. This suggests a different source of phosphorus in this subwatershed compared to other southern Oneida Lake tributaries.

Since phosphorus is generally considered to be the limiting nutrient of phytoplankton growth in freshwater lakes, any remedial program to protect the water quality of Oneida Lake should address these five watersheds: Limestone Creek, Canaseraga Creek, Cowaselon Creek, Oneida Creek and Chittenango Creek.

Nitrate (Tables 3 and 4)

Nitrate is a measure of the soluble forms of nitrogen that are used readily by plants for growth. Figure 7 depicts annual event and non-event losses of nitrate from the watersheds. The six watersheds that were contributing the largest amount of nitrate to downstream habitats during events in descending order were, Cowaselon Creek (site CW1)(343 g/ha/day), Canaseraga Creek

(332 g/ha/day), Cowaselon Creek (site CW2) (287 g/ha/day), Clockville Creek (274 g/ha/day), Limestone Creek (site LS1) (263 g/ha/ day) and Oneida Creek 237 g/ha/ day). Except for Clockville Creek, the same five subwatersheds had a very high loss of total and dissolved phosphorus from the upstream watershed.

Total Kjeldahl Nitrogen (Tables 3 and 4)

Total Kjeldahl nitrogen (TKN) is a measure of the organic nitrogen loss from the watershed. For example, cow manure would contain a large amount of organic nitrogen. Concentrations of TKN were higher in events than during non-events suggesting that organic material was being swept off the watershed during precipitation. In descending order, the greatest areal loss of total Kjeldahl nitrogen from the watershed to downstream systems occurred in: Cowaselon Creek (CW1), Canaseraga Creek (CN1), Cowaselon Creek (CW2), Limestone Creek (LS1), Chittenango Creek (CH2) and Oneida Creek (ON1) (Fig. 6). These losses appeared to be associated with land use. Over 40% of the land is in some form of agriculture in Cowaselon and Oneida Creeks. Similarly, the Chittenango Creek subwatershed was heavily used in agriculture with over 60 farms in operation. Total Kjeldahl nitrogen loading was highly correlated with total suspended solid loss from Oneida Lake watersheds during events (r^2= 0.86). This suggests that nitrogen, in the particulate from, is being washed off the landscape. These losses would suggest a source of nitrogen such as cow manure. Many of the farms in the Oneida Creek (34) and Cowaselon (59) watersheds are dairy farms.

Total Suspended Solids (Tables 3 and 4)

The loss of suspended solids is a measurement of the loss of soil and other materials suspended in the water from a watershed and can be used as a measure of soil erosion. Stream bank erosion can be a major source of soil loss. In general, soil erosion is one of the major sources of nutrient loss from watersheds and was positively correlated with total phosphorus and TKN loss in the southern Oneida Lake tributaries. Several watersheds were losing suspended materials at higher levels compared to other watersheds. Cowaselon Creek (site CW1 and CW 2), Limestone Creek (site LS1), Canaseraga Creek, and Oneida Creek were delivering in excess of 6000 g/ha/day of suspended solids to Oneida Lake during events (Figure 6). These are roughly the same four subwatersheds that were losing large amounts of phosphorus, nitrate and TKN.

Another way of gauging the impact of a watershed is to consider the total loading from the watershed - that is not normalizing the data for area. For Cowaselon Creek, about 256 tons of soil per storm event day was washed into the lake. In contrast, Canastota Creek was delivering about 1.2 tons of soil per event per day. These results agreed reasonably well with the 1999 Streambank Characterization of Erosion reported on by Hallock (1999). Portions of Canaseraga, Cowaselon, Canastota and Chittenango Creeks were walked and assessed for stream bank erosion by methods developed by the Soil and Water Conservation Service personnel. In this report, both Canaseraga and Cowaselon Creeks were estimated to have twice the loss of soil compared to Canastota and Chittenango Creeks. Although the magnitude of the loss of soil is not directly comparable, it is clear that different methodologies agreed that considerably more soil was being lost from Canaseraga and Cowaselon Creeks than from Canastota and Chittenango Creeks. A similar approach on Oneida Creek indicated that streambank erosion generated the largest amount of sediment (OCSWCD 1995).

Chloride (Table 3 and 4)

Chloride is a component of deicing salt. Unlike the other chemical analytes discussed where the highest concentration often occurred during hydrometeorologic events, concentrations of chloride were often highest during non-events (Table 2). Because discharge was considered during the calculation of loading, loss of salt during events was greater than during baseline flows. Cowaselon Creek (sites CW1 and CW2), followed by Canaseraga (site CN1), Chittenango (site CH2), and Limestone Creek (LS1 and LS2), delivered the highest amount of salt to downstream systems on an areal basis (Fig. 7). Chittenango Creek and site LS2 of Limestone Creek were not ranked in the top five watersheds losing materials for other analytes. The high loading of salt from Cowaselon Creek was most likely associated with the Town of Canastota and deicing salt used on city streets.

Unusual Results:

<u>Total suspended solids on the upper portion of Chittenango Creek</u> (Table 3): Sites LS1 and BN1 are upstream of site LS2 (Fig. 1). As a general rule, we would expect the load of suspended

solids a tributary carries to increase toward a lake as more material is eroded and swept off the landscape during a hydrometeorologic event. For example on Cowaselon Creek, the upstream site (CW2) is moving ~115,000 kg of soil per storm day (Table 3). Downstream of this site at CW1, the load being carried increased to ~233,000 kg soil per event day. This did not happen in the primary tributaries of Chittenango Creek. At site LS1 in Limestone Creek, a tributary of Chittenango Creek, the load carried was ~239,000 kg of soil per event day plus another 18,000 kg of soil per event day from Butternut Creek – another tributary of Chittenango Creek. At site LS2 on Limestone Creek before it enters Chittenango Creek, the load carried by the stream decreased to ~86,000 kg of soil per event day. Where did the suspended solids go? We have no way to resolve this question with the data available. The result may be accurate and represent a situation where the stream flows over its bank into a swamp during an event. The decrease in water velocity would allow suspended soil particles to settle out decreasing the load carried by the stream. However, other possible explanations are:

1. Inaccurate measurements of TSS. This does not seem likely with the quality control instituted by the analytical laboratory.
2. There is a dam that slows the velocity of the water allowing suspended solids to settle out. We do not know of any dams on this stream.
3. Site LS2 was sampled almost seven hours prior to sites BN1 and LS1. "Event or flood peaks" travel through a tributary. It is possible that site LS2 was sampled while it was raining. However, it is also possible that the soil-laden storm event water had not reached this site which was sampled from 5 to 7 hours prior to sites LS1 and BN1.

<u>Discharges in the Chittenango Watershed</u> (Table 3): Average discharge during events at site LS2 on Limestone, a tributary of Chittenango Creek was $3.1\text{x}10^6$ m^3/day. Event discharge at CH1, another tributary of Chittenango Creek, was $1.1\text{x}10^6$ m^3/day. Site CH2, which is below the confluence of sites CH1 and LS2, had a discharge of $8.8\text{x}10^6$ m^3/day. Discharge had doubled in a few miles of the creek. Although discharge should increase moving downward toward a lake, it is unlikely to have such an increase from normal surface runoff. Either there is another major source of water in this watershed that is not accounted for or there is a problem(s) in the velocity or discharge measurements. Some possibilities are:

1. During some events only one velocity measurement was taken. This is probably not a representative measurement of stream velocity.

2. Problems were encountered with keeping the Global velocity meter properly positioned in the stream. Many meters have to be positioned horizontal to the surface of the water to operate properly.
3. Cross-sectional areas of the stream bed are inaccurate.

Continuous Measurements

Oneida Creek: Loading Based on Continuous Discharge and Composite Analyte sampling during Hydrometeorological Events

On three dates (18 January, 24 February, and 18 May, 2000), loss of soil as total suspended solids and nutrients were calculated using the continuous discharge data from the USGS flow monitoring station and using water samples taken every 15 minutes with an automated sampler. These estimates are superior than the measurements taken based on one water sample and an average velocity measurement at one point in time. First, the storm hydrograph (Fig. 8) typically rising limb and ascending limb for discharge. This provides a much better estimate of discharge from a watershed than a single estimate of discharge at one point in time. For Oneida Creek, a comparison of discharge based on an average velocity measurement at one point in time versus continuous measurements indicates that the single measurement over estimates discharge by greater than 100% (Table 5). This is quite typical and not unique to Oneida Creek. Second, during precipitation events concentration generally increases from baseline discharges with the ascending portion of the hydrograph (e.g., Table 6). By taking measurements of nutrients and suspended solids during the ascending and descending portions of the curve a better estimate of nutrient and sediment concentration is possible than with a single measurement as was done with the non-continuous monitoring potion of this study.

The range of nutrient loads estimated using continuous discharge measurements versus a single measurement of discharge are present in Table 7. Although there is some overlap in the calculated loads of nutrients and suspended solids, it evident that the loads calculated based on a single measurement of discharge exceed loads, calculated from continuous measurements of discharge and automated water sampling of the storm hydrograph - often by an order of magnitude. These higher loads are undoubtedly due to the overestimation of discharge as shown in Table 5.

Comparison to Other Watersheds

The various creeks of the Irondequoit Bay watershed (Monroe County, NY.) have been identified as grossly polluted prior to remedial action (O'Brien and Gere 1983). Similarly, Northrup Creek (central Monroe County), which receives effluent from a sewage treatment plant, is known to be polluted and to possess a higher loading of phosphorus than creeks in the Irondequoit Bay watershed (Makarewicz 1988). A comparison of Oneida Lake tributaries to other creeks in western and central New York State has been made (Table 8). The loss of phosphorus from watersheds presented in Table 8 represent an average annual daily loss from selected watersheds that consider both event and nonevent losses based on continuous discharge measurements. For the Oneida Lake tributaries, annual daily average was not possible with the current data. Instead, we compared averages for three nonevents and three events for Oneida Lake tributaries to the annual daily averages from several tributaries. Although made, these comparisons should be viewed with considerable caution for several reasons. The event losses are likely to be high since they do not include the nonevent component as the rest of the data in Table 8.

By comparison to watersheds with various land uses in western and central New York, phosphorus loss from tributaries in the Oneida Lake watershed appeared very high during events (Table 8). For example, prior to diversion of the effluent from a sewer treatment facility, Irondequoit Creek near Rochester, NY, released 5.6 g P/ha/d (Table8). Sheldon Creek in Oswego County drains muckland fields with losses of 27 g P/ha/day. The subwatersheds of Oneida Lake having comparable losses of phosphorus were Cowaselon Creek (site CW1: 31.3 g P/ha/day), Limestone Creek at Rt. 5 (site LS1: 24.6 g P/ha/day), Canaseraga Creek (site CN1: 24.8 g P/ha/day), Cowaselon Creek (site CW2: 18.8 g P/ha/day), Oneida Creek (site ON1: 14.4 g P/ha/day) and Chittenango Creek (site CH2: 9.0 g P/ha/day). **We would expect these losses of phosphorus from Oneida Lake subwatersheds to decrease when annualized to consider discharge from events and nonevents.** Nevertheless, these comparisons do suggest that several subwatersheds in the southern Oneida Lake watershed were delivering substantial loads of phosphorus to Oneida Lake during events.

Monitoring of Other Chemicals

This report has focused on the loss of nutrients and total suspended solids from a watershed. They have a major impact on water quality, fish spawning, etc. However, the industrial and agricultural land use within the watershed suggests that other contaminants may exist. In 1997, NYSDEC and the USGS began a cooperative effort to monitor pesticides in New York State surface water. A statewide analysis of 64 streams and rivers for 47 pesticides across New York State revealed that the most commonly detected pesticides were the herbicides that are frequently applied to cornfields. The herbicides atrazine, deethylatrazine and metolachlor were detected in 80% of the streams (USGS 1998). Similarly, Makarewicz (2001) has demonstrated that atrazine loss from cornfields in the Sodus Bay watershed is substantial during the spring and later in the winter. Two other insecticides, carbaryl and diazinon were also detected in 20 and 14%, respectively, of the samples analysed.

The Rotating Intensive Basin Studies program (Myers et al. 1999) has sampled in several of the Oneida Lake tributaries including Oneida Creek, Canasera Creek and Chittenango Creek. Overall RIBS water quality rating for these three sites were fair – a value indicating some deterioration. Water column parameters of concern included iron, lead, and dissolved solids while bottom sediment parameters of concern were copper, iron, manganese and zinc.

Models

Lake and watershed managers are being asked on an increasing basis to evaluate the impact of man's activity on lake water quality. One popular method of evaluating impacts is through the use of mathematical models. A model is a simplified representation of a real object, process, concept or system (Reckhow and Charpra 1983). The vast majority of lake models used today can be described as empirical or deterministic. Empirical models are developed from statistical analyses of lake and watershed monitoring data. They are often called "black box" models which use statistical methods to describe the input/output relationship of a system. Deterministic models are inherently based on physical laws whereby the most efficient use of data is made to compensate for the uncertainty of fitting equations to natural processes. Such models use numerous mathematical equations to describe the system process and tend to be more input data intensive than empirical models.

There are several models available. The Wisconsin Lake Model Spreadsheet (WILMS) use empirical models and was developed as a lake management planning tool. The model is not intended to provide daily or monthly simulation results. WILMS estimates annual nutrient loading and in-lake phosphorus concentration to be used for planning and goal setting purposes. WILMS is a lotus 1-2-3 TM spreadsheet that couples 10 empirical lake response models with an export-driven watershed loading model, an uncertainty analysis module, parameter range module watershed load back calculation module, a lake condition module and a phosphorus steady state response time module. PHOSMOD (Chapra and Canale 1991) is another model that assesses the impact of phosphorus loading on stratified lakes. It is designed for interactive implementation. Appendix 5 lists required input parameters

The previous models looked at the relationship between watershed loading and its effects on a lake. A model whose objective is to predict discharge and nutrient and soil losses from a watershed is the Generalized Watershed Loading Function (GWLF) model (Haith 1990). Previous work with the GWLF model on three watersheds produced mixed results. The model was successful in the large 85,000 hectare west branch Delaware River watershed (Haith and Shoemaker 1987) predicting 90% of the observed monthly variation in nitrogen and phosphorus fluxes. In contrast, the model explained only 42% of the monthly variation in nutrient fluxes on the 4500 hectare Kendig Creek watershed near Seneca Lake (Haith 1992, 1975). Similarly, a field test of this model at Sodus Creek east (Glenmark Creek) by Brown (1993) was disappointing. The model explained only 44% of the total monthly variability in discharge underestimating discharge by 74%. for PHOSMOD.

Summary and Recommendations

The foundation for evaluating nutrient and soil losses from subwatersheds of Oneida Lake has been laid by the Central New York Regional Planning and Development Board. During storm events several watersheds (Cowaselon Creek, Limestone Creek (site LS1), Canaseraga Creek, Oneida Creek and Chittenango Creek) appeared to have high losses of nutrients and materials. Even though Oneida Lake is eutrophic and has likely been eutrophic since at least the 1600s (Greeson and Meyer 1969), the high event loss of nutrients, especially phosphorus, and total suspended solids (soil) from the various subwatersheds further enhance the productivity of

Oneida Lake and continue to contribute to siltation of fish spawning grounds. However, it is important to stress that the data presented are suggestive but are not conclusive at this time. There are simply too few data points.

For the southern subwatersheds, more sampling dates, event and nonevent, that are spread out over the entire year are required. Better information is required on discharge, which requires more frequent and consistent velocity measurement with a meter that works under event conditions. Cross-sectional areas of the stream beds need to be carefully measured. Sampling within a subwatershed (e.g., Chittenango Creek) has to be timely, preferably within one or two hours. To effectively evaluate and prioritize stream loading to Oneida Lake, the sampling effort should be expanded to include the entire watershed. These suggestions and others are expanded on below. All of these need to be evaluated in the context of time, funding and goals.

- Consideration should be given to increasing the number of samples taken during the year. The larger the number of samples the better the estimate of nutrient and soil loss from the watershed. The better the estimate, the greater the confidence in the prioritization of the watersheds. As an example, baseline samples are taken monthly and hydrometeological events are monitored six times during one annual cycle in the Canandaigua Lake watershed.

- All baseline (or nonevent) monitoring was completed during a two month period in late summer and early fall, while all event samples were taken during the winter and early spring. A better representation of the subwatersheds would be obtained by sampling during all four seasons of the year.

- Stream cross-sectional profiles should be accurately constructed for each site sampled. This would allow more accurate measurements of discharge.

- The construction of a rating curve (discharge versus stream depth) would allow more efficient estimates of discharge. Once established, a simple measurement of depth would allow an estimate of discharge.

- Velocity measurements need to be standardized for each site and measured on all sampling dates – especially during high flows. Equipment should be secured allowing measurements during high flows. In most creeks in western New York, over 60% of the loss of materials and nutrients occur during hydrometeorological events. The current Global Flow meter should be calibrated to confirm units of measurement.

- Several USGS gauging station are continuously monitoring discharge in the Oneida Lake watershed. Predictive equations could be developed that allow predictions of discharge on all creeks from a few. Once established, this would allow annual measures of loading comparable to other locations in New York State. This would also provide the most accurate measurements of nutrient and material losses from the watershed. Continuous discharge estimates from the USGS monitoring sites on Oneida Creek indicate an order of magnitude error in estimates based on average single measurement at one moment in time.

- Scheduling of stream sampling should be timely within a watershed. The lower portion of the Chittenango Creek watershed was sampled five to seven hours prior to tributaries in the upper portion of the watershed. This may lead to an invalid comparison. For example, an "event peak" carrying silt-laden water may be sampled at an upper tributary site that had simply not "arrived" at a sampling site in the lower portion of a watershed. It takes time for an "event peak" to travel through a watershed. Also, the policy of "...sampling one day after the rain event… to insure that the runnoff water had a chance to move through the watershed to streams" should be reconsidered. There is some evidence that hydrometeorological events on two occasions were not sampled; that is, event water had already passed through the subwatershed.

- An attempt should be made to investigate why soil losses from the upper tributaries of Chittenango Creek is not transported to the lower portion of the watershed.

- Chemistry samples are currently composited. This may not be necessary as streams are generally well mixed.

- If the goal is to evaluate nutrient and soil loss and cost is a concern, the measurement of nitrite, ammonia, dissolved oxygen, specific conductance and perhaps temperature could be dropped. This should be discussed with the parties involved.

- Depending on the goals, it may not be necessary to monitor the upstream portion of the subwatersheds until a ranking of the subwatersheds is completed.

- Some discussion on monitoring other potential pollutants should be considered. For example, the use of herbicides, such as atrazine is likely occurring in land planted in corn. Loss of atrazine to down stream systems is likely. Several other metals are of concern including lead, manganese, copper, etc.

- With improvements in data collection, it will be possible to prioritize or rank the subwatersheds according to loading from the watershed to the lake. Once completed for the entire Oneida Lake watershed, segment analysis on individual subwatersheds is suggested. In watersheds with high phosphorus and soil losses, sources could be identified. Stressed stream analysis or segment analysis is a technique that identifies the sources of pollutants within a watershed by subdividing the impacted watershed into small distinct geographical units (Makarewicz and Lewis, 1999). Samples are taken at the beginning and end of each stream unit to determine if a nutrient (or other contaminant) source occurs within that reach. We have found this technique very useful in identifying point and non-point sources that are not always obvious. Identified sources can then be targeted for remediation and best management practices. At present, it would be premature to suggest candidate watersheds with the current data from Oneida Lake.

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Table 2. Average concentrations in selected Oneida Lake tributaries during events and nonevents. B+E refers to the average for hydrometeorological events and baseline (non-events) conditions. Values are the average (± standard error). TP = total phosphorus, TSS = total suspended solids, TKN = total Kjeldahl nitrogen, DO = dissolved oxygen, SC = specific conductance. SRP= dissolved phosphorus.

Code	Creek	Mean	SRP (mg/L)	TP (mg/L)	TSS (mg/L)	TKN (mg/L)	Chloride (mg/L)	Nitrate (mg/L)	DO (mg/L)	SC (µS/cm)	pH
CH1	Chittenango Creek	Baseline	0.050 (.006)	0.076 (.035)	10.3 (4.6)	0.480 (.076)	30.7 (5.7)	0.78 (.11)	9.6 (.88)	879 (156)	7.82 (.20)
	(McGraw Road)	Event	0.026 (.019)	0.080 (.017)	24.3 (8.4)	0.463 (.058)	21.0 (4.0)	1.16 (.24)	11.97(1.29)	465 (27)	8.33 (.34)
		B+E	0.038	0.078	17.3	0.472	25.8	0.97	10.55	672	8.07
CH2	Chittenango Creek	Baseline	0.035 (.007)	0.063 (.035)	14.0 (2.5)	0.493 (.048)	55.7 (6.8)	1.11 (.14)	8.16 (1.11)	979 (91)	7.68 (.16)
	(Rt 31)	Event	0.015 (.013)	0.076 (.012)	18.0 (3.1)	0.553 (.086)	37.7 (5.2)	1.15 (.19)	10.01 (1.58)	527 (86)	8.11 (.29)
		B+E	0.025	0.070	16.0	0.523	46.7	1.13	8.90	798	7.9
LS2	Limestone Creek	Baseline	0.059 (.025)	0.104 (.042)	37.7 (19.0)	0.520 (.065)	63.0 (8.5)	1.57 (.35)	8.45 (0.90)	1036 (86)	7.95 (.21)
	(North Manlius Road)	Event	0.022 (.008)	0.089 (.032)	29.0 (10.5)	0.533 (.080)	44.3 (6.9)	1.36 (.27)	10.88 (1.39)	596 (40)	8.29 (.27)
		B+E	0.041	0.097	33.3	0.527	53.7	1.46	9.42	816	8.12
LS1	Limestone Creek	Baseline	0.011 (.002)	0.013 (.003)	5.0 (3.0)	0.307 (.020)	42.3 (8.4)	0.66 (.06)	10.99 (.47)	940 (147)	8.00 (.20)
	(Rt.5)	Event	0.017 (.016)	0.093 (.069)	42.0 (27.5)	0.440 (.110)	22.7 (5.8)	1.85 (.72)	12.13 (.85)	509 (23)	8.44 (.29)
		B+E	0.014	0.053	23.5	0.373	32.5	1.26	11.45	725	8.22
BN1	Butternut Creek	Baseline	0.012 (.005)	0.017 (.005)	2.7 (.7)	0.353 (.044)	67.3 (21.3)	0.51 (.06)	10.03 (.70)	1036 (168)	8.10 (.16)
		Event	0.038 (.019)	0.037 (.015)	15.7 (5.2)	0.377 (.052)	25.7 (5.6)	1.90 (.68)	12.05 (1.04)	529 (37)	8.60 (.31)
		B+E	0.025	0.027	9.2	0.365	46.5	1.20	10.84	782	8.35
CW1	Cowaselon Creek	Baseline	0.021 (.004)	0.042 (.017)	9.3 (4.1)	0.557 (.05)	49.7 (2.7)	1.42 (.44)	10.62 (.61)	1455 (.61)	7.56 (.12)
	(Gee Rd.)	Event	0.025 (.019)	0.159 (.067)	62.0 (26.5)	0.913 (.094)	33.7 (6.1)	2.50 (.50)	10.94 (1.03)	771 (51)	8.15 (.34)
		B+E	0.023	0.100	35.7	0.735	41.7	1.96	10.74	1113	7.86
CW2	Cowaselon Creek	Baseline	0.016 (.007)	0.062 (.026)	14.3 (5.2)	0.500 (.131)	43.7 (12)	0.92 (.29)	8.95 (.29)	1461 (35)	8.27 (.21)
	(Ditch Bank Road)	Event	0.018 (.016)	0.094 (.043)	54.3 (26.2)	0.620 (.152)	30.0 (5.3)	1.93 (.34)	11.54 (.89)	796 (50)	8.47 (.21)
		B+E	0.017	0.078	34.3	0.560	36.8	1.43	9.98	1129	8.37
CT1	Canastota Creek	Baseline	0.055 (.021)	0.091 (.024)	8.0 (1.5)	0.687 (.083)	52.7 (2.3)	1.23 (.19)	9.98 (.22)	1511 (56)	7.94 (.14)
		Event	0.042 (.021)	0.079 (.021)	10.2 (6.1)	0.413 (.075)	32.0 (6.4)	2.53 (.35)	12.38 (.59)	934 (55)	8.46 (.32)
		B+E	0.049	0.085	9.1	0.550	42.3	1.88	10.94	1222	8.20
CN1	Canaseraga Creek	Baseline	0.035 (.01)	0.077 (.033)	22.0 (5.5)	0.493 (.136)	44.0 (2.3)	0.91 (.25)	9.01 (.76)	1312 (34)	7.57 (.16)
		Event	0.023 (.018)	0.084 (.031)	33.3 (14.1)	0.527 (.095)	22.0 (4.7)	1.87 (.35)	11.25 (1.34)	670 (57)	8.16 (.36)
		B+E	0.029	0.081	27.7	0.510	33.0	1.39	9.91	991	7.87
CK1	Clockville Creek	Baseline	0.023 (.003)	0.078 (.066)	3.7 (1.7)	0.267 (.027)	23.0 (0.6)	1.33 (.09)	10.31 (.53)	1353 (130)	7.83 (.21)
		Event	0.018 (.016)	0.027 (.009)	14.7 (6.6)	0.320 (.060)	15.3 (1.5)	2.57 (.32)	12.02 (.49)	745 (36)	8.40 (.37)
		B+E	0.021	0.052	9.2	0.293	19.2	1.95	10.99	1049	8.12
ON1	Oneida Creek	Baseline	0.136 (.057)	0.164 (.081	21.7 (15.8	0.513 (.127	40.7 (2.7	1.03 (.44)	11.25 (.70)	1142 (39)	7.89 (.15)
		Event	0.049 (.023)	0.130 (.025)	46.7 (20.9)	0.567 (.107)	19.7 (3.8)	2.57 (.52)	11.95 (1.22)	592 (45)	8.44 (.33)
		B+E	0.093	0.147	34.2	0.540	30.2	1.80	11.53	867	8.16

Table 3. Average daily loss (kg/day) of nutrients and materials from selected subwatersheds into Oneida Lake. B+E refers to the average for hydrometeorological events and baseline (non-events) conditions. TP = total phosphorus, TSS = total suspended solids, TKN = total Kjeldahl nitrogen. SRP = dissolved phosphorus.

Creek Code	Subwatershed	Mean	Discharge (m^3/day)	SRP (kg P/day)	TP (kg P/day)	TSS (kg/day)	TKN (kg N/day)	Chloride (kg/day)
CH2	Chittenango	Baseline	884,213	33	49	11,599	431	47,049
	Creek (Rt 31)	Event	8,847,141	219	716	161,937	5,276	301,514
		B+E	4,865,677	126	383	86,768	2,853	174,281
CH1	Chittenango	Baseline	240,247	11	16	2,515	107	6,721
	Creek	Event	1,111,549	31	97	31,441	544	22,010
	(McGraw Road)	B+E	675,898	21	56	16,978	325	14,365
LS2	Limestone	Baseline	335,785	19	34	13,682	172	21,308
	Creek	Event	3,056,284	85	278	85,466	1,636	130,017
		B+E	1,696,035	52	156	49,574	904	75,663
LS1	Limestone Creek	Baseline	250,378	3	3	1,351	77	10,391
	(Rt.5)	Event	3,709,874	58	547	238,646	1,968	72,480
		B+E	1,980,126	30	275	119,998	1,023	41,435
BN1	Butternut Creek	Baseline	133,337	2	2	323	48	7,921
		Event	1,182,454	52	54	18,257	475	32,167
		B+E	657,896	27	28	9,290	261	20,044
CW1	Cowaselon	Baseline	105,865	2	5	1,186	59	5,167
	Creek (Gee Rd.)	Event	2,844,154	85	581	232,893	2,744	82,653
		B+E	1,475,010	43	293	117,040	1,401	43,910
CW2	Cowaselon	Baseline	98,087	2	6	1,319	47	4,335
	Creek	Event	1,555,276	30	197	114,811	1,118	40,532
		B+E	826,682	16	101	58,065	582	22,433
CT1	Canastota	Baseline	29,435	1	3	208	20	1,619
	Creek	Event	93,031	4	8	1,121	40	2,800
		B+E	61,233	3	5	664	30	2,209
CN1	Canaseraga	Baseline	133,268	4	10	3,208	56	5,703
	Creek	Event	1,183,298	21	136	53,971	739	21,297
		B+E	658,283	13	73	28,590	397	13,500
CK1	Clockville	Baseline	29,839	1	2	115	8	685
	Creek	Event	305,149	7	9	5,484	107	4,516
		B+E	167,494	4	6	2,799	57	2,601
ON1	Oneida Creek	Baseline	204,874	20	30	6,299	87	8,004
		Event	2,966,635	187	426	181,670	1,880	50,127
		B+E	1,585,754	103	228	93,984	983	29,065

Table 4. Average daily areal (g/ha/day) loss of nutrients and materials from selected subwatersheds into Oneida Lake. SRP=dissolved phosphorus, TP = total phosphorus, TSS = total suspended solids, TKN = total Kjeldahl nitrogen.

Creek		Mean	SRP	TP	TSS (g/ha/day)	TKN	Chloride	Nitrate
CH2	Chittenango Creek (Rt 31)	Baseline	0.4	0.6	146	5	593	12
		Event	2.8	9.0	2,040	66	3,799	139
CH1	Chittenango Creek (McGraw Road)	Baseline	0.6	0.8	125	5	335	9
		Event	1.6	4.8	1,567	27	1,097	64
LS2	Limestone Creek	Baseline	0.4	0.7	297	4	462	11
		Event	1.9	6.0	1,854	35	2,821	98
LS1	Limestone Creek (Rt.5)	Baseline	0.1	0.1	61	3	467	7
		Event	2.6	24.6	10,733	89	3,260	263
BN1	Butternut Creek	Baseline	0.1	0.1	23	3	558	5
		Event	3.7	3.8	1,287	33	2,268	124
CW1	Cowaselon Creek (Gee Rd.)	Baseline	0.1	0.3	64	3	278	7
		Event	4.6	31.3	12,540	148	4,451	343
CW2	Cowaselon Creek	Baseline	0.2	0.5	126	4	414	9
		Event	2.9	18.8	10,962	107	3,870	287
CT1	Canastota Creek	Baseline	0.5	1.2	95	9	740	19
		Event	1.9	3.6	512	19	1,280	104
CN1	Canaseraga Creek	Baseline	0.7	1.8	586	10	1,042	25
		Event	3.9	24.8	9,863	135	3,892	332
CK1	Clockville Creek	Baseline	0.2	0.6	39	3	230	13
		Event	2.5	3.2	1,840	36	1,515	274
ON1	Oneida Creek	Baseline	0.7	1.0	213	3	271	9
		Event	6.3	14.4	6,153	64	1,698	237

Table 5. Comparison of Oneida Creek discharge estimates based on the continuous recording USGS station (#04243500) and instantaneous discharge estimates based on a velocity measurement at a single time.

	USGS Measurements m^3/day	Single Measurement m^3/day
26 October 1999	122,256	199,103
6 January 2000	508,585	946, 969
1 March 2000	1,449,956	3,195,962
19 May 2000	1,711,584	4, 756, 973

Table 6. Comparison of nutrient and suspended solids concentrations during different phases of an event hydrograph from Oneida Creek, 18-19 may 2000.

	SRP	TSS	TKN
Baseline	<.002	43	.65
Rising Limb	.015	170	1.1
Peak	.030	540	2.6
Descending Limb	<.002	85	1.4
Final Sample	<.002	200	.78

Table 7. Loss of suspended solids (TSS) and nutrients during three meteorological events in Oneida Creek based on continuous measurements of discharge and composite sampling of water. Discharge is provisional data from USGS Station #04243500 on Oneida Creek. "Grab" samples are the range of loading values calculated from single discharge and analyte measurements during three monitoring events

	18-Jan-00 kg/day	24-Feb-00 kg/day	18-May-00 Kg/day	Range of "Grab"Samples kg/day
TP	49.2	119	5.97	104.2 - 856.3
TSS	75,282	73,539	18,295	16,098 – 413, 857
TKN	581	500	155	426 – 3,710
Nitrate	1,025	846	211	2,556 – 10,866
Chloride	11,343	11,198	1,804	24,621 – 63,919
SRP	2.90	24.4	1.01	3.8 – 294.9
Discharge(m^3/day)	440,335	287,525	123,400	594,957 – 1,444,772

Table 8. Comparison of phosphorus loading in subbasins of the Irondequoit Bay watershed, other Monroe County creeks, tributaries of Sodus and Port Bays, and Lake Neatahwanta tributaries. Irondequoit basin data are from 1980-81 (O'Brien and Gere 1983). Data from other Monroe County creeks are from 1987-88 (Makarewicz 1988). Wayne County creek data from 1991-93 are from Makarewicz et al. 1991, 1992, and1993. Orleans and Oswego data are from Makarewicz and Lewis (1998a, 1998b, 1999), while Canandaigua Lake data are from Makarewicz and Lewis (1998c) All data, except the Oneida Lake data, represents an annual period considering both events and nonevents (i.e., mean annual daily loading). Oneida Lake data represents the average for events (n=3) and nonevents (n=3).

Subbasin or Creek	**Watershed**	**Land Use**	**Total Phosphorus Loading (g P/ha/d) Annual Daily Average**	
Sucker Brook	Canandaigua Lake	Agriculture/Urban	7.66	
Irondequoit Creek (pre-diversion)	Irondequoit Bay	Several Sewage Plants	5.60	
1978-79 (post-diversion)	Irondequoit Bay		2.00	
Larkin	Lake Ontario	Suburban	0.70	
Buttonwood	Lake Ontario	Suburban	1.58	
Lower Northrup	Long Pond	Sewage Plant	6.64	
Upper Northrup	Long Pond	Urban	3.23	
First	Sodus Bay	Forested	0.11	
Clark	Sodus Bay	Forested	0.22	
Sodus East	Sodus Bay	Agriculture	8.57	
Wolcott	Port Bay	Agriculture	5.01	
Bobolink	Port Bay	Forested	0.02	
Sheldon	Lake Neatahwanta	Muckland	27.41	
Summerville	Lake Neatahwanta	Suburban	5.47	
			Two-Year Range	
Oak Orchard	Lake Ontario		3.48	2.86
Johnson	Lake Ontario		1.81	1.17
Sandy	Lake Ontario		0.98	0.77
Twelvemile Creek East	Lake Ontario	Agriculture	0.5	0.26
			Average Daily	
			Baseline	**Event**
Chittenango Creek (CH2)	Oneida Lake	Agriculture	0.6	9.0
Chittenango Creek(CH1)	Oneida Lake	Agriculture	0.8	4.8
Limestone Creek (LS2)	Oneida Lake	?	0.7	6.0
Limestone Creek (LS1)	Oneida Lake	?	0.1	24.6
Butternut Creek (BN1)	Oneida Lake	Urban?	0.1	3.8
Cowaselon Creek (CW1)	Oneida Lake	Agriculture, STP	0.3	31.3
Cowaselon Creek (CW2)	Oneida Lake	Agriculture, STP	0.5	18.8
Canastota Creek (CT1)	Oneida Lake	?	1.2	3.6
Canaseraga Creek (CN1)	Oneida Lake	?	1.8	24.8
Clockville Creek (CK1)	Oneida Lake	?	0.6	3.2
Oneida Creek (ON1)	Oneida Lake	Agriculture, STP	1.0	14.4

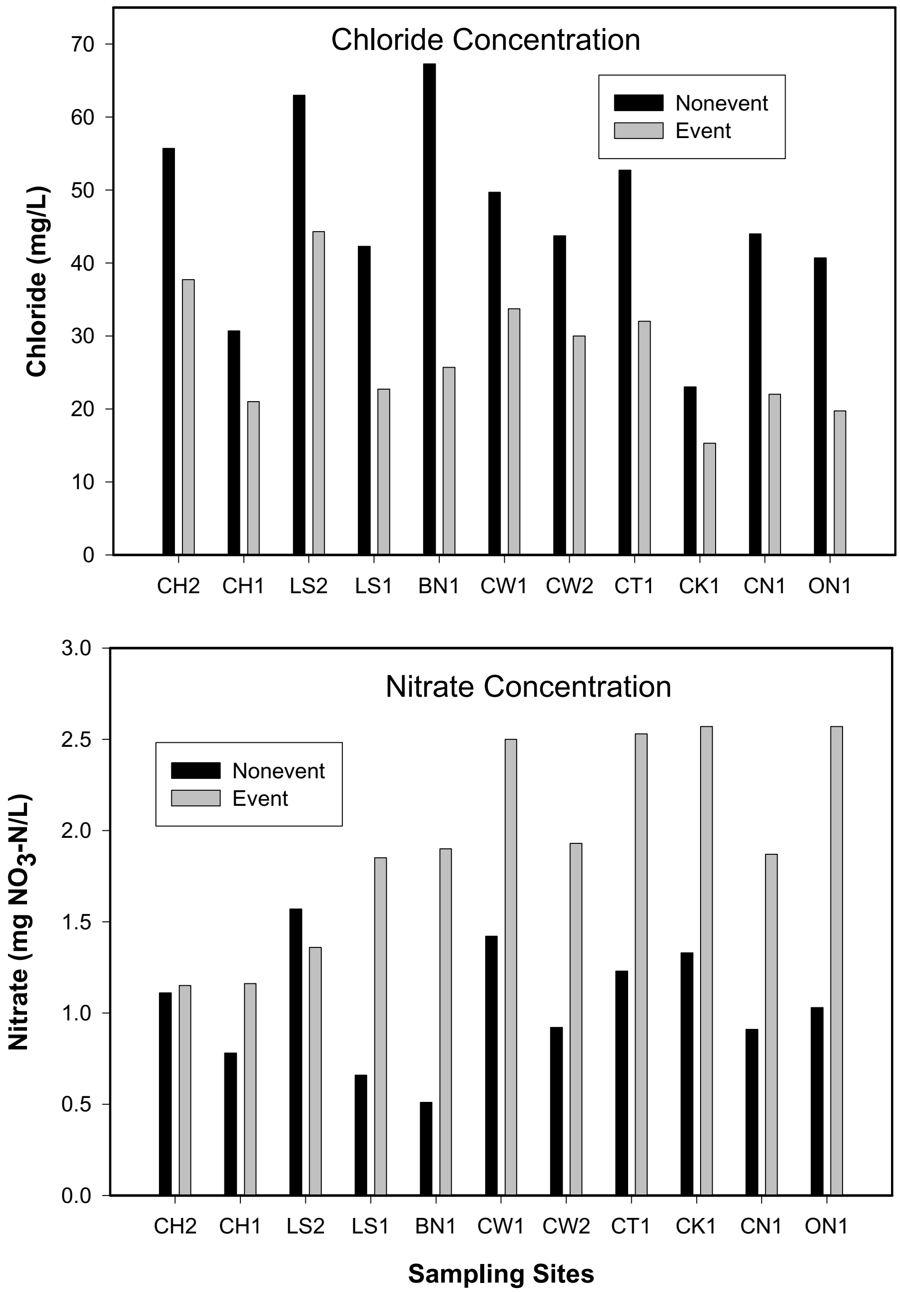


Figure 2. Average event and nonevent nitrate and chloride concentrations in southern Oneida Lake tributaries. CH1 (Chittenango Creek at McGraw Rd.), CH2 (Chittenango Creek at Rt. 31), LS2 (Limestone Creek), LS1 (Limestone Creek at Rt. 5), BN1 (Butternut Creek), CW1 (Cowaselon Creek at Gee Rd.), CW2 (Cowaselon Creek), CT1 (Canastota Creek), CK1 (Clockville Creek), CN1 (Canaseraga Creek), ON1 (Oneida Creek).

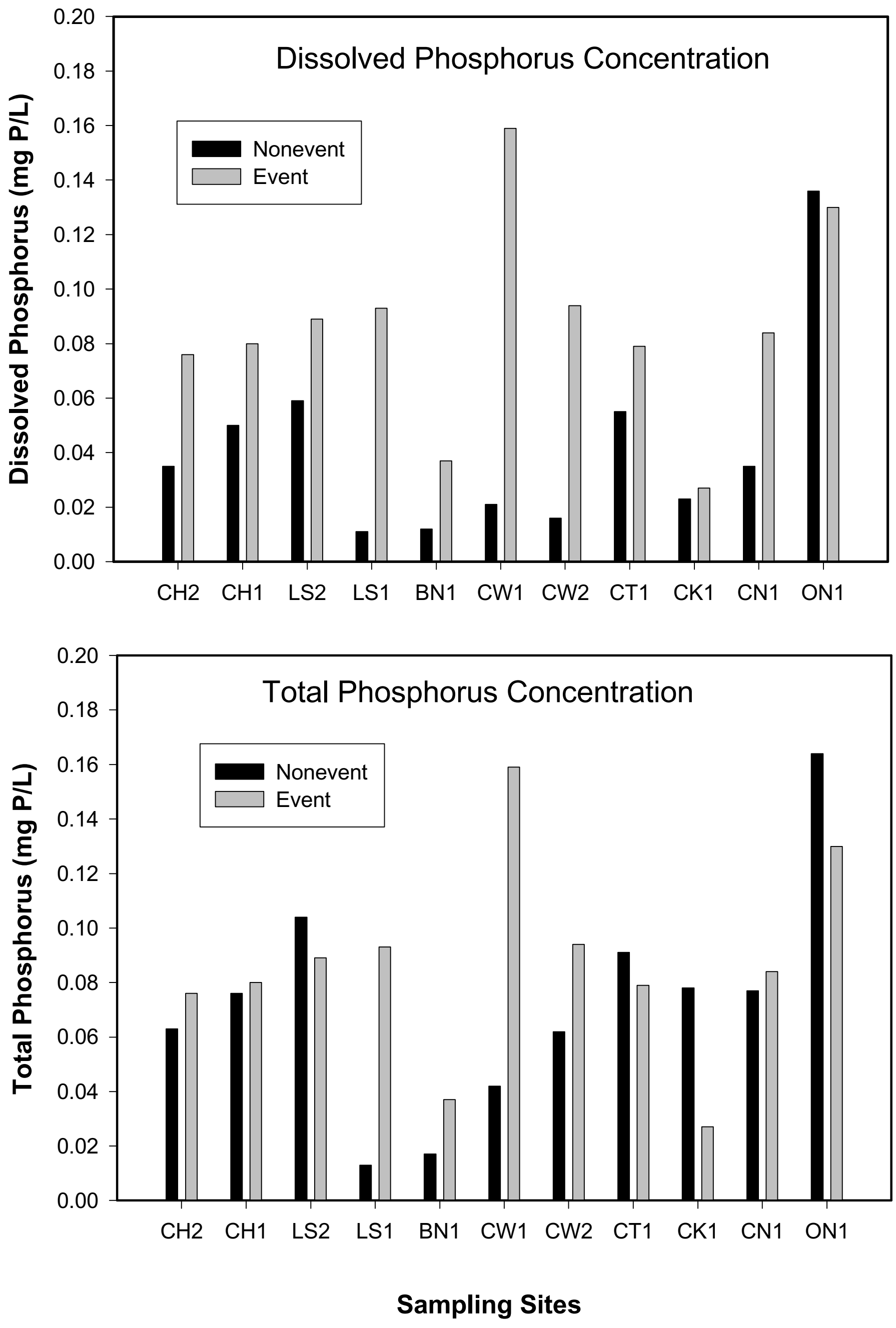
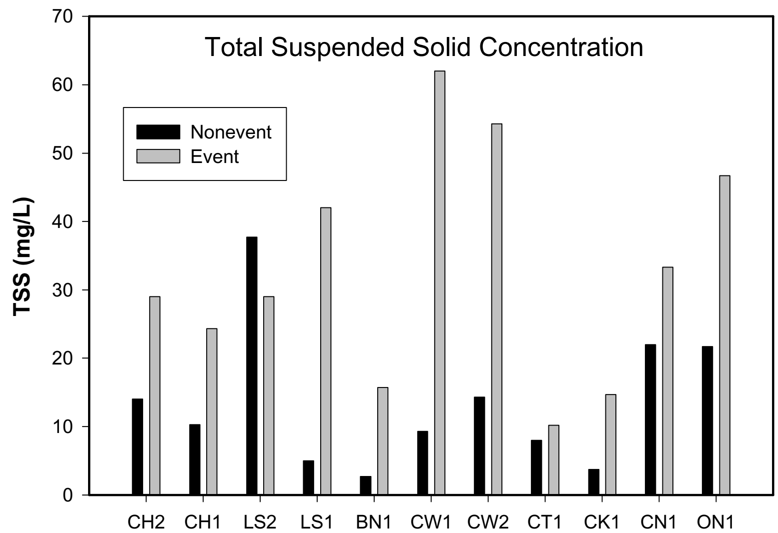


Figure 3. Average event and nonevent dissolved and total phosphorus concentrations in southern Oneida Lake tributaries. CH1 (Chittenango Creek at McGraw Rd.), CH2 (Chittenango Creek at Rt. 31), LS2 (Limestone Creek), LS1 (Limestone Creek at Rt. 5), BN1 (Butternut Creek), CW1 (Cowaselon Creek at Gee Rd.), CW2 (Cowaselon Creek), CT1 (Canastota Creek), CK1 (Clockville Creek), CN1 (Canaseraga Creek), ON1 (Oneida Creek).



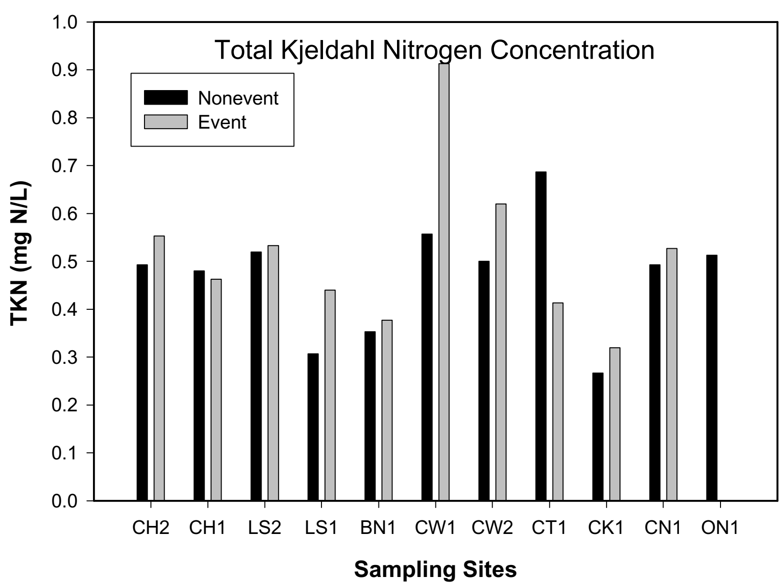


Figure 4. Average event and nonevent total suspended solids and total Kjeldahl nitrogen concentrations in southern Oneida Lake tributaries. CH1 (Chittenango Creek at McGraw Rd.), CH2 (Chittenango Creek at Rt. 31), LS2 (Limestone Creek), LS1 (Limestone Creek at Rt. 5), BN1 (Butternut Creek), CW1 (Cowaselon Creek at Gee Rd.), CW2 (Cowaselon Creek), CT1 (Canastota Creek), CK1 (Clockville Creek), CN1 (Canaseraga Creek), ON1 (Oneida Creek).

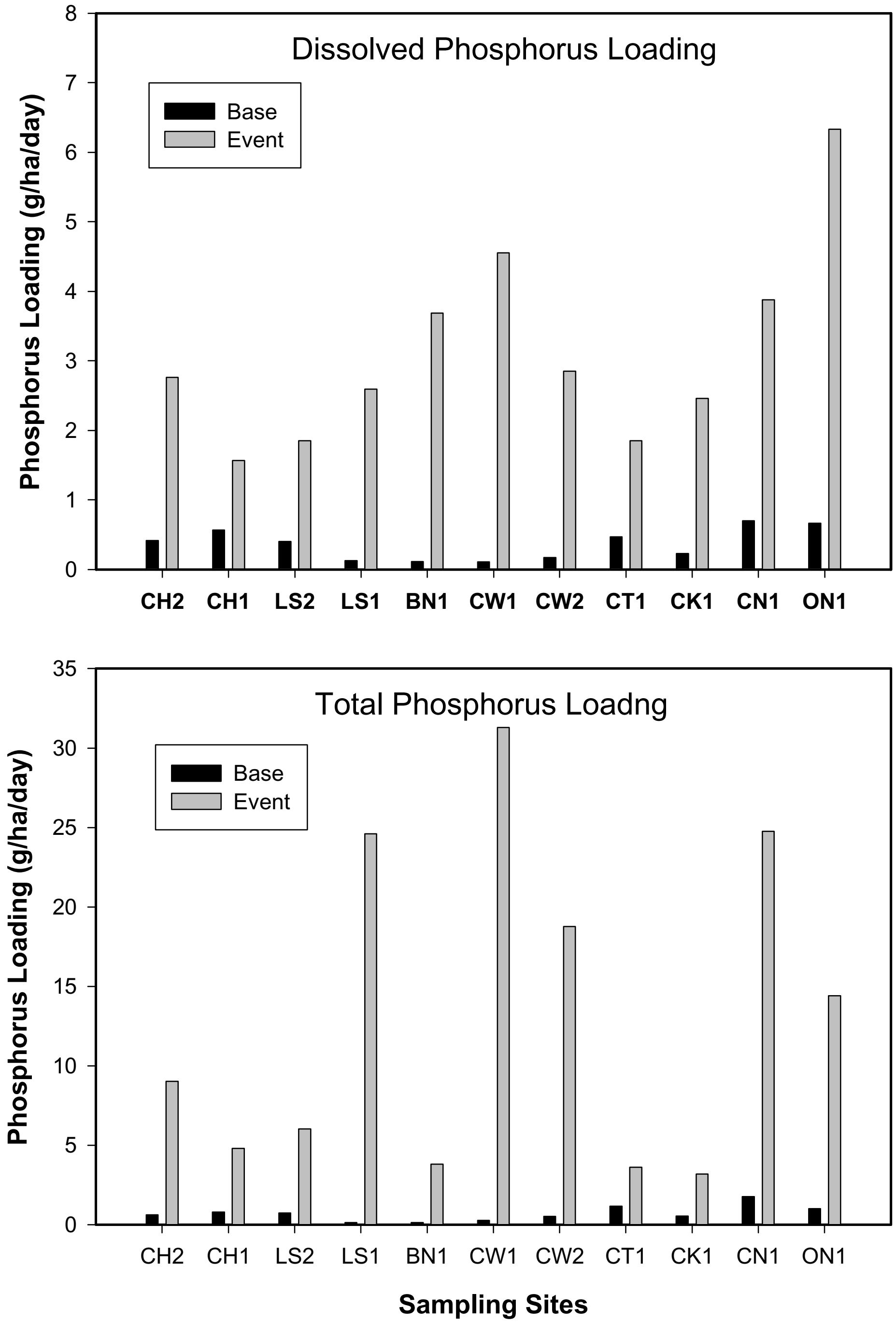


Figure 5. Average event and nonevent loading of dissolved phosphorus and total phosphorus from southern Oneida Lake tributaries. CH1 (Chittenango Creek at McGraw Rd.), CH2 (Chittenango Creek at Rt. 31), LS2 (Limestone Creek), LS1 (Limestone Creek at Rt. 5), BN1 (Butternut Creek), CW1 (Cowaselon Creek at Gee Rd.), CW2 (Cowaselon Creek), CT1 (Canastota Creek), CK1 (Clockville Creek), CN1 (Canaseraga Creek), ON1 (Oneida Creek).

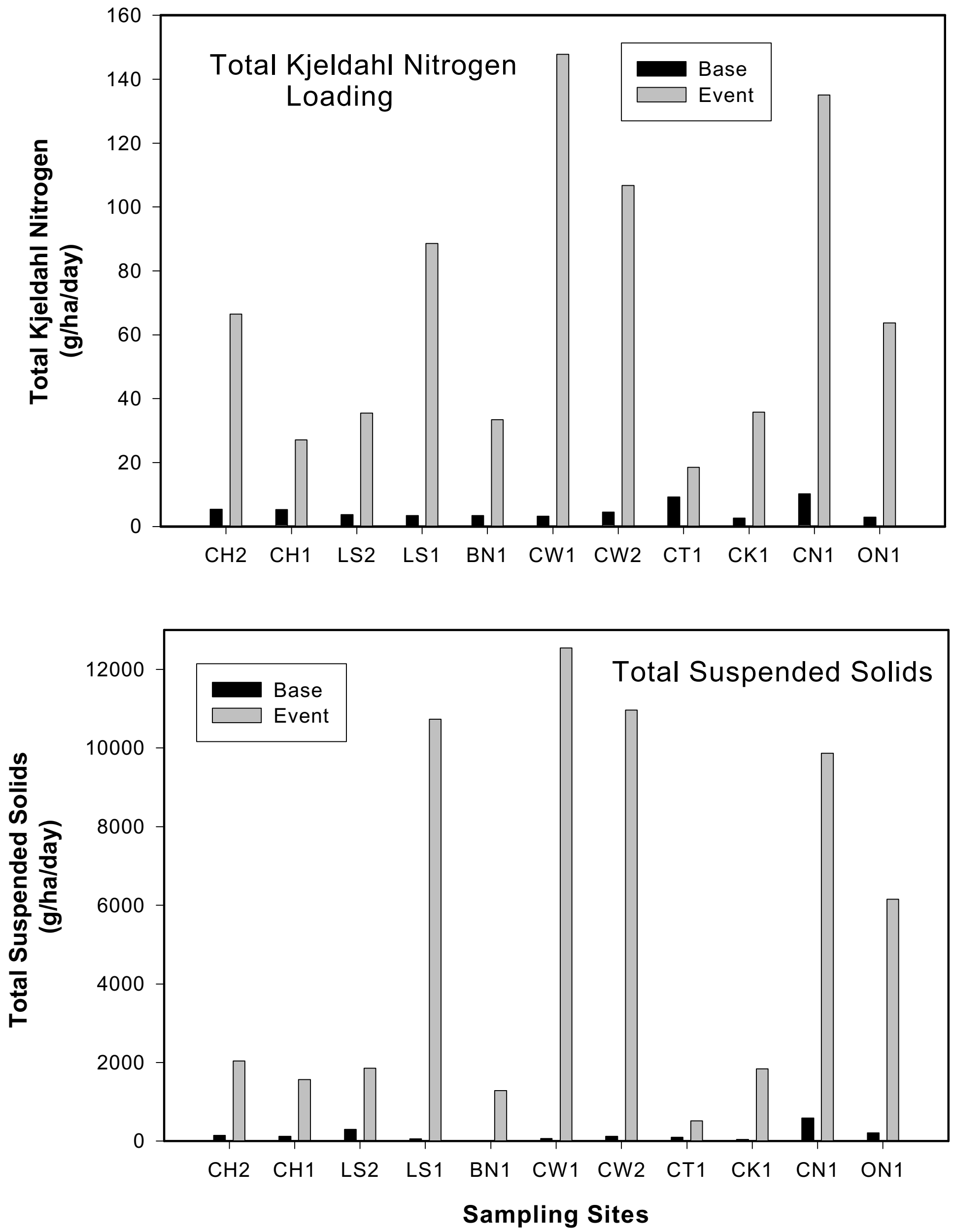


Figure 6. Average event and nonevent loading of total Kjeldahl nitrogen and total suspended solids from southern Oneida Lake tributaries. CH1 (Chittenango Creek at McGraw Rd.), CH2 (Chittenango Creek at Rt. 31), LS2 (Limestone Creek), LS1 (Limestone Creek at Rt. 5), BN1 (Butternut Creek), CW1 (Cowaselon Creek at Gee Rd.), CW2 (Cowaselon Creek), CT1 (Canastota Creek), CK1 (Clockville Creek), CN1 (Canaseraga Creek), ON1 (Oneida Creek).

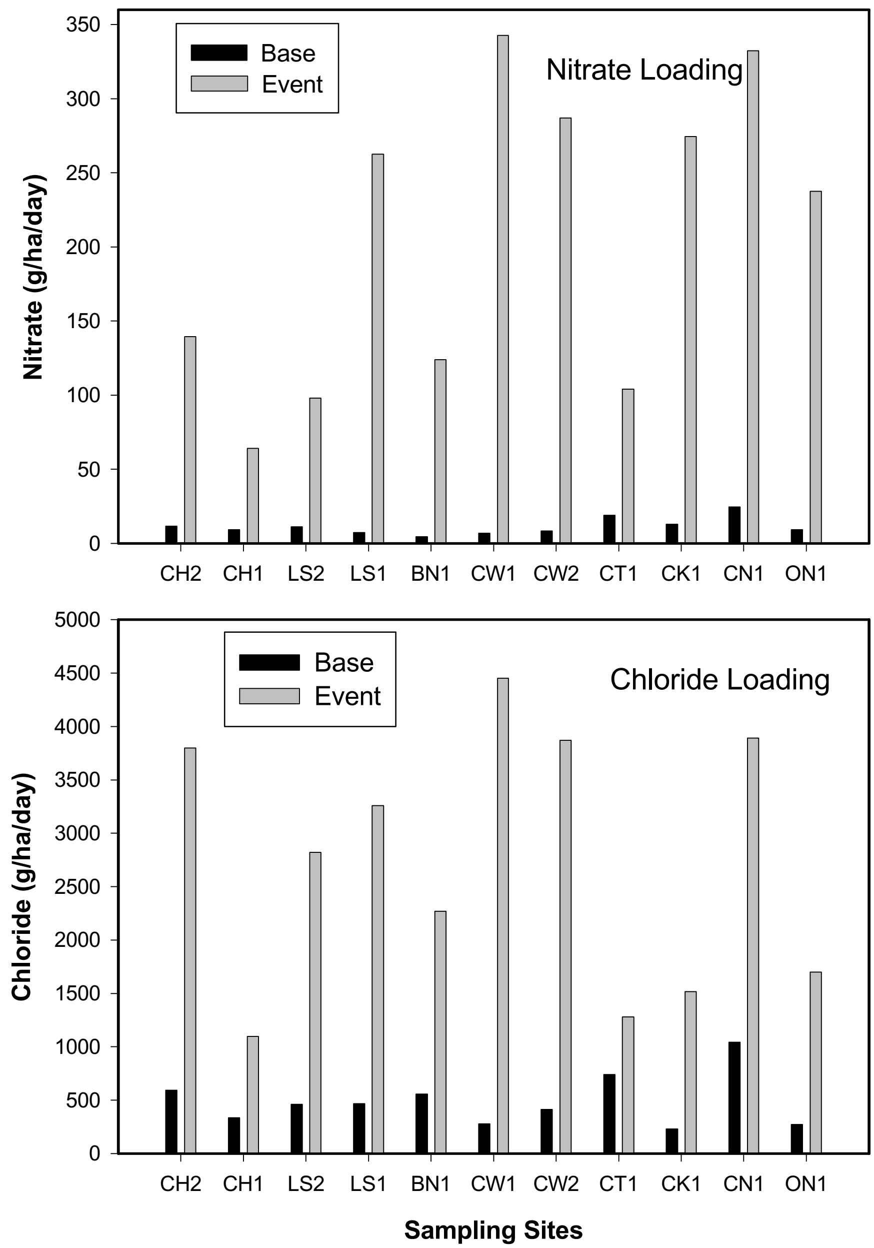


Figure 7. Average event and nonevent loading of total Kjeldahl nitrogen and total suspended solids from southern Oneida Lake tributaries. CH1 (Chittenango Creek at McGraw Rd.), CH2 (Chittenango Creek at Rt. 31), LS2 (Limestone Creek), LS1 (Limestone Creek at Rt. 5), BN1 (Butternut Creek), CW1 (Cowaselon Creek at Gee Rd.), CW2 (Cowaselon Creek), CT1 (Canastota Creek), CK1 (Clockville Creek), CN1 (Canaseraga Creek), ON1 (Oneida Creek).

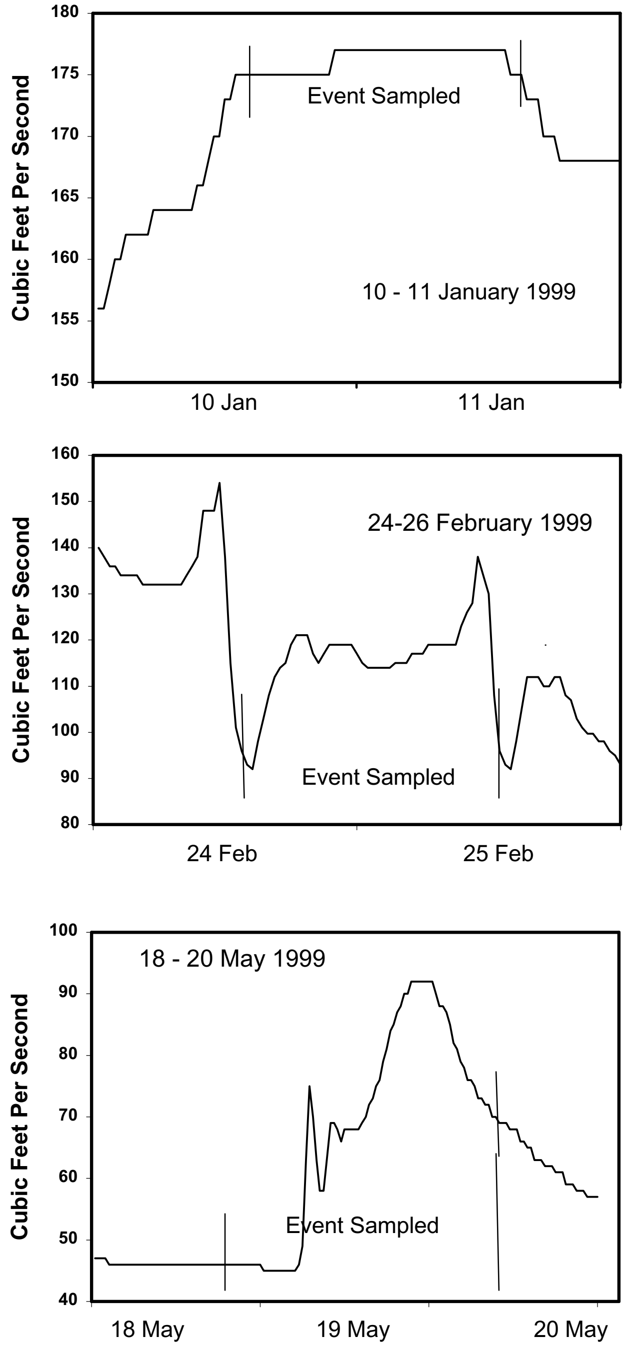
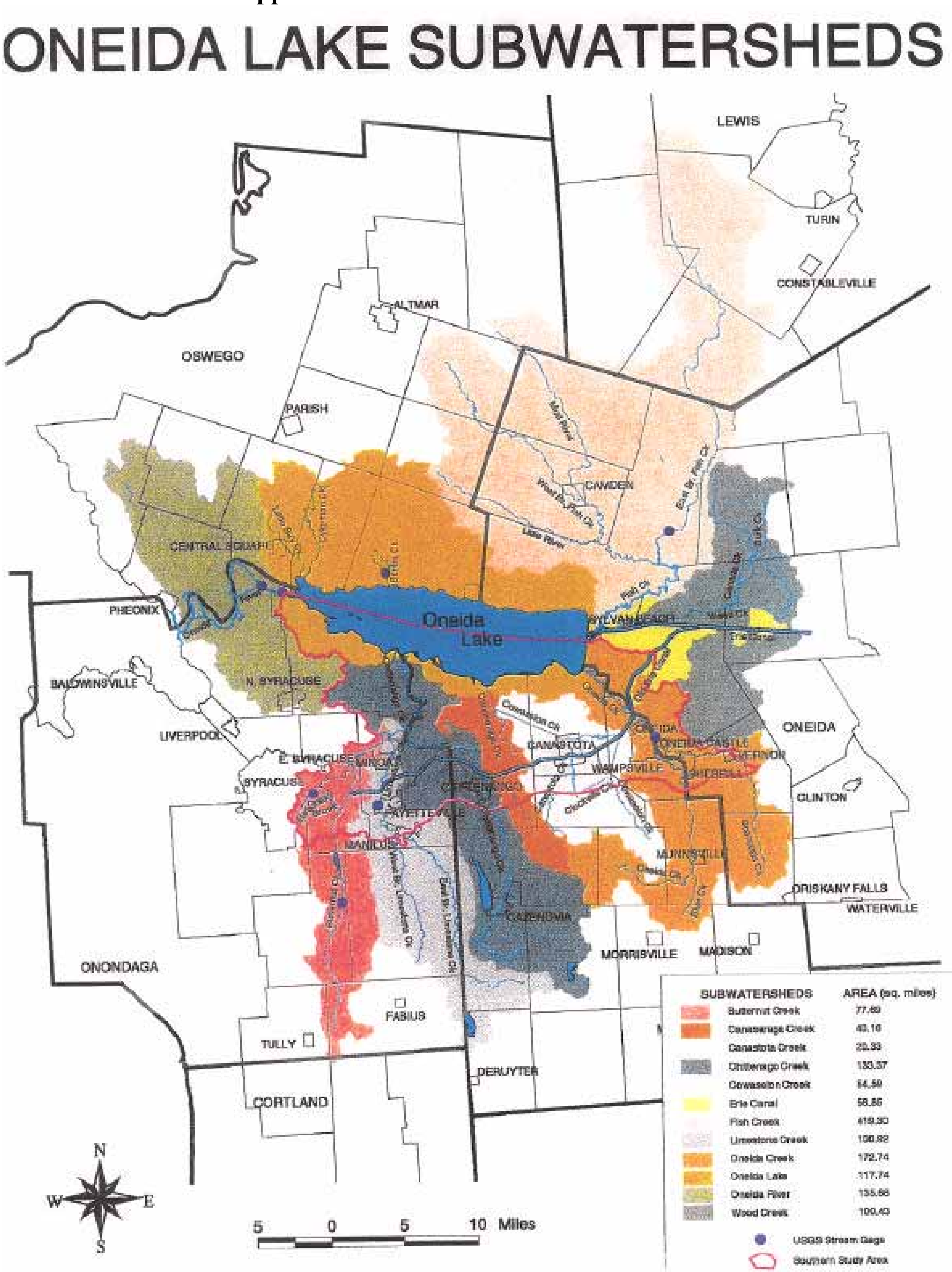


Figure 8. Event hydrograph for three dates on Oneida Creek . Data from the USGS.

Appendix 1. Oneida Lake Subwatersheds



Appendix 2: Subwatershed discharge on all sampling dates. [1]Sampling dates designated as baseline or nonevents because of low discharge. CH1 (Chittenango Creek at McGraw Rd.), CH2 (Chittenango Creek at Rt. 31), LS2 (Limestone Creek), LS1 (Limestone Creek at Rt. 5), BN1 (Butternut Creek), CW1 (Cowaselon Creek at Gee Rd.), CW2 (Cowaselon Creek), CT1 (Canastota Creek), CK1 (Clockville Creek), CN1 (Canaseraga Creek), ON1 (Oneida Creek).

Site	Date	Type of Flow	Discharge (m^3/s)	Site	Date	Type of Flow	Discharge (m^3/s)
CH1	04-Aug-99	Baseline	1.44	LS1	04-Aug-99	Baseline	2.63
	23-Sep-99	Baseline[1]	3.60		23-Sep-99	Baseline[1]	2.79
	26-Oct-99	Baseline[1]	3.30		26-Oct-99	Baseline[1]	3.28
	06-Jan-00	Event	6.89		06-Jan-00	Event	14.79
	01-Mar-00	Event	14.99		01-Mar-00	Event	38.18
	19-May-00	Event	16.72		19-May-00	Event	75.85
CH2	04-Aug-99	Baseline	9.18	LS2	04-Aug-99	Baseline	3.45
	23-Sep-99	Baseline[1]l	7.57		23-Sep-99	Baseline[1]	4.55
	26-Oct-99	Baseline[1]	13.95		26-Oct-99	Baseline[1]	3.66
	06-Jan-00	Event	33.88		06-Jan-00	Event	13.04
	01-Mar-00	Event	176.37		01-Mar-00	Event	61.98
	19-May-00	Event	96.94		19-May-00	Event	31.11
CN1	04-Aug-99	Baseline	0.53	CW1	04-Aug-99	Baseline	0.90
	23-Sep-99	Baseline[1]	2.17		23-Sep-99	Baseline[1]	1.94
	26-Oct-99	Baseline[1]	1.93		26-Oct-99	Baseline[1]	0.83
	06-Jan-00	Event	5.17		06-Jan-00	Event	9.72
	01-Mar-00	Event	8.10		01-Mar-00	Event	36.96
	19-May-00	Event	27.82		19-May-00	Event	52.07
CT1	04-Aug-99	Baseline	0.08	CW2	04-Aug-99	Baseline	0.82
	23-Sep-99	Baseline[1]	0.67		23-Sep-99	Baseline[1]	1.09
	26-Oct-99	Baseline[1]	0.27		26-Oct-99	Baseline[1]	1.49
	06-Jan-00	Event	0.91		06-Jan-00	Event	5.43
	01-Mar-00	Event	0.91		01-Mar-00	Event	20.25
	19-May-00	Event	1.42		19-May-00	Event	28.32
ON1	04-Aug-99	Baseline	0.95	CK1	04-Aug-99	Baseline	0.23
	23-Sep-99	Baseline[1]	3.86		23-Sep-99	Baseline[1]	0.38
	26-Oct-99	Baseline[1]	2.30		26-Oct-99	Baseline[1]	0.42
	06-Jan-00	Event	10.96		06-Jan-00	Event	1.85
	01-Mar-00	Event	36.99		01-Mar-00	Event	4.90
	19-May-00	Event	55.06		19-May-00	Event	3.84

Appendix 3: Directions* to and Descriptions of
Stream Sampling Sites for CNYRP DB
Southern Watershed of Oneida Lake

Carrie Wafer
15 December, 1999

Chittenango Creek 2 (CH2)(N43 9.295' W75 58.294')
Directions: Go to the bridge on Rt. 31 in Bridgeport; park in the BP gas station parking lot; sample from the downstream side of the bridge

Description: The stream is about 30 m wide at the bridge. The immediate riparian zone is well vegetated, but the slope of that zone is fairly steep. Development (i.e. parking lots, houses, lawns, etc.) begins as soon as the slope lessens. There are houses along a majority of this segment of stream. Sections of riparian vegetation and soil near the bridge were removed as a result of the bridge construction this summer.

There are islands in the stream, which provide good wildlife habitat. Except during high flow periods, the water at this section of stream is relatively shallow (no more than knee deep, approximately 2 feet deep in deep channels). The terrain is flat away from the immediate riparian zone.

Limestone Creek 2 (LS2)(N43 6.258' W75 58.767')
Directions: take Rt. 298 south out of Bridgeport; left on North Manlius Road (at intersection by gas station); sample at the bridge after the white house that looks abandoned, with a big yard; sample from the upstream side of the bridge (8 minutes)

Description: The riparian zone is vegetated. Downstream, the riparian zone is steeply sloped for the first couple of meters, then it flattens out. The upstream riparian zone is relatively flat. There is no development visible in the riparian zone or floodplain. It appears that agriculture or some similar land use historically occurred along the left side of the downstream section.

Large pieces of woody debris are in the upstream section. The upstream section is well shaded during the growing season, but the downstream side is more open. The stream appears to be deep across its width (depth between 28 and 68 inches). The terrain is flat away from the immediate riparian zone.

*Directions to the sites are in the order in which the sites are sampled, starting from Cornell's Biological Field Station at Shackelton Point.

Chittenango Creek 1 (CH1)(N43 4.41' W75 52.95')
Directions: take first left after Myers Rd, onto Fyler Road; go to Bolivar Rd; turn left onto McGraw Rd; sample at the first bridge; park in the entrance to the corn field before the bridge; sample on the upstream side (10 minutes)

Description: This stream is approximately 10 m wide. The immediate riparian zone is vegetated for 5 to 10 meters from the stream. The immediate riparian zone is steeply sloped for about 3 to 5 meters. Active corn fields are on the other side of the vegetated zones.

Large woody debris lay in the upstream portion of the stream. The downstream portion has some woody debris near the edges. There is a lot of garbage (old sink, fish tank, etc.) in the downstream segment. The upstream segment is well shaded during the growing season. The downstream segment is shaded, but it is more open. During low flow periods, the stream is shallow with lots of riffles. The terrain is flat away from the immediate riparian zone.

Canaseraga Creek 1 (CN1)(N43 5.898' W75 51.057')
Directions: continue down McGraw; take left onto Lakeport Rd.; right onto Tag Rd. (after the bridge); park on left after bridge in the little paved area (after second stream; first stream is really a ditch); sample on downstream side (5 minutes)

Description: This stream is lest than 10 m wide. The immediate riparian zone is vegetated to 10 to 15 meters from the stream. The immediate riparian zone is steeply sloped for about 5 to 8 meters. Active hay and corn fields are on the other side of the vegetated zones.

The up and downstream segments are shaded during the growing season, except for a few open spots on the downstream segment. Woody debris lay in the downstream segment. The upstream segment appears to be dammed up. The water is smooth, with no riffles. The downstream side is very shallow. The samples are collected from an area with a concrete bottom that is part of the culvert. The water in the downstream side of the bridge is rapidly flowing because of the gradient built up by the dammed water on the upstream side. The terrain is flat away from the immediate riparian zone.

Cowaselon Creek 1 (CW1)(N43 7.038' W75 49.829')
Directions: continue down Tag Rd; take second left onto Gee Rd; sample at second bridge on Ditch Bank Rd., park on the other side of the bridge in the left hand turn or park on right side of road before bridge; sample from upstream side (4 minutes)

Description: This stream is about 10 m wide. The immediate riparian zone is vegetated for 10 to 15 meters from the stream. The immediate riparian zone is steeply sloped for about 5 to 8 meters. Active farm fields are on the opposite side of some of the vegetation. There is a dirt road running along the south side of the stream.

The stream is not shaded. It appears to be used as a drainage ditch. There are no riffles and the water is deep across the width of the stream. The terrain is flat away from the immediate riparian zone.

Cowaselon Creek 2 (CW2)(N43 5.828’ W75 45.621’)
Directions: continue north on Gee Rd; take first right onto Pine Ridge Road; take right onto North Main St; stream should be fourth one immediately before sewage treatment plant; park on near side of bridge; sample on downstream side of bridge (8 minutes)

Description: This stream is about 15 m wide. The immediate riparian zone is vegetated at least 10 to 15 meters from the stream. The immediate riparian zone is steeply sloped for about 5 to 8 meters. Active farm fields are on the right-hand side of the downstream segment. The sewage treatment plant is on the left-hand side. I think the upstream sides are wooded.

The upstream segment is mostly pool habitat. The downstream has more riffles. The upstream is shaded in the growing season and downstream is not. The depth at the downstream sampling area is shallow (8 to 14 inches) during low flow periods. The terrain is flat away from the immediate riparian zone.

Canastota Creek 1 (CT1) (N43 5.334’ W75 45.343’)
Directions: continue south on North Main Street; park at entrance to the park near the diner; sample on downstream side (2 minutes)

Description: This stream is about 5 meters wide. Upstream riparian areas are vegetated. Portions of the downstream riparian area are vegetated and other portions are concrete. Away from the immediate riparian area, the upstream riparian areas are mowed or relatively inactive. The downstream areas have a road, parking lot, and park along one side and a concrete wall and probably inactive land on the other.

The up and downstream segments are predominantly riffle habitat. Both segments are shaded. The depth at the downstream sampling location is extremely shallow. The terrain is flat away from the immediate riparian zone.

Oneida Creek 1 (ON1)(N43 5.864 W75 38.397’)
Directions: continue south on North Main St.; take first left; take right onto Rt. 13; take Rt. 13 to Rt. 5; go west on Rt. 5 to Wampsville; take left onto 365A in Wampsville; take left onto 365; take left onto Sconondoa; less than ½ mi. down on left; pull in @ green shed with gauge station; sample from upstream side of bridge (30 minutes)

Description: This stream is about 25 meters wide. Upstream riparian areas are vegetated. Portions of the downstream riparian area are vegetated and other portions are rock. The upstream riparian areas immediately along the stream are not too steep and appear to be wooded for at least 20 m from the stream. Portions of the downstream riparian areas are mowed and there is a rock wall. The remaining downstream riparian areas are wooded.

The up and downstream segments are riffle habitat with some pools in the deeper channels. Both segments farther away from the bridge are shaded. There are a lot of houses in the vicinity of the stream. The terrain is flat away from the immediate riparian zone.

Clockville Creek 1 (CK1)(N43 3.397' W75 42.371')
Directions: back track to Rt. 5; take right (go west) onto Rt. 5 to Wampsville; take left at light to Lenox; go past a 4 way intersection and a left turn; sample at bridge before next left turn, there is a right hand dirt road immediately before the bridge, park on the side of the road before the bridge; sample on the downstream side of the stream (18 minutes)

Description: This stream is about 5 meters wide. Upstream riparian areas are predominantly vegetated, but there is a section of the road that abuts the stream. The upstream riparian areas immediately along the stream are not too steep and appear are partially wooded. The downstream riparian areas are vegetated for at least 5 meters, but part of the vegetation is a mowed lawn. There is a house about 5 meters from the stream on the right-hand side of the downstream segment near the bridge. The remaining downstream riparian areas are wooded.

The up and downstream segments have riffle habitat with some pools. Both segments farther away from the bridge are shaded. There are houses and a farm in the vicinity of the stream. The terrain is flat away from the immediate riparian zone, but large hills begin between 100 to 300 meters from the stream.

Limestone Creek 1 (LS1)(N43 1.754' W76 0.782')
Directions: get back to Rt. 5; head west; turn right before large bridge in Fayetteville into area with little shops; park wherever possible; sample from downstream side of bridge (25 minutes)

Description: The stream is about 30 m wide at the bridge. The immediate riparian zone is poorly vegetated, and the slope of that zone is fairly steep. There are a lot of logs and pavement near the stream. Development (i.e. parking lots, houses, lawns, etc.) begins as soon as the slope lessens. There is a lot of pavement in this area with large roads, parking lots, and business.

The stream is poorly shaded, except for the left-hand side downstream portion. The upstream segment has a lot of riffles, but the downstream segment has more pool habitat. The water is deep on the downstream sampling side (128-145 in deep). The terrain is gently sloped away from the immediate riparian zone.

Butternut Creek 1 (BN1)(N43 0.743 W76 4.481')
Directions: get back on Rt. 5; go to Rt. 481; get onto 481 in Dewitt and head south; get off @ Jamesville; turn left after off-ramp; on right look for dirt parking area, park there; sample off of cement culvert (upstream side) (18 minutes)

Description: This stream is about 20 meters wide. Upstream riparian areas are vegetated. The upstream riparian areas immediately along the stream are not too steep and are wooded. The downstream riparian areas are vegetated for at least 5 meters, but a lot of the area within 10 meters of the stream is road.

The up and downstream segments are riffled with some pools near the bridge. The upstream segment is partially shaded. The terrain is sloped away from the immediate riparian zone, but large hills begin between 100 to 300 meters from the stream.

Appendix 4.

Data and notes of Kevin Angel on event sampling of Oneida Creek

Sampling of 10 and 11 January 2000:

General Observations: Significant rainfall had occurred within the previous week with heavy rains from 3 to 4 January 2000.

10 January: No frost in the ground, no snow, saturated soils, muddy conditions.

- 1pm Light rain started to fall
- 2pm Started automated sampler. Water level at 2.4’
- 3pm Water level began to rise. Heavy steady rain throughout the afternoon.
- 8-10pm Fastest rise in water level from 3.2’ to 4.4’.
- 2am Peak water level at 5.3’
- 2pm Sampler off. Water level at 3.84’

Table A. Sample times and analyte concentrations during the rain event of 10-11 January 2000.

Sample				TP	SRP	TSS	TKN	NO_3	Cl	NH_3	NO_2
#1	Start	1/10/00	2:15-3pm	.004	.025	23	.39	2.6	29	<.03	<.1
#2	Composite	1/10-1/11	3:15pm-1am	.13	.01	270	1.8	2.2	29	<.03	<.1
#3	Peak Flow	1/11	1:15am-2am	.11	.005	100	1.0	2.5	24	<.03	<.1
#4	Composite	1/11	2:15am-1pm	.028	.004	68	.71	2.6	25	<.03	<.1
#5	End	1/11	1:15pm-2pm	.14	.12	210	2.3	2.7	46	<.03	<.1

Sampling of 24 and 25 February 2000:

General Observations: Warm temperatures started on 2/22; first rain started on 9am on 2/25; Heavy rains throughout day of 2/25; peak flows occurred after the sampling was completed; No ice on the creek.

2pm	Started automated sampler. Water level at 4.65’
11:30am	USGS technician changed hydrograph paper. Water level at 5.5’.
2 pm	Sampler off; water level at 6’ and rising.
8 pm	Water level at 6.75’.
9:40pm	Samples delivered

Table B. Sample times and analyte concentrations during the rain event of 24-25 February 2000.

Sample				TP	SRP	TSS	TKN	NO_3	Cl	NH_3	NO_2
#1	Start	2/24	2-3pm	.14	.12	210	2.3	2.7	46	<.03	<.1
#2	Composite	2/24-2/25	3pm-2am	.46	.12	250	1.9	2.9	42	<.03	<.1
#3	Peak Flow	2/25	2-3am	.44	.016	250	1.4	3.0	38	<.03	<.1
#4	Composite	2/25	3am-1pm	.42	.058	260	1.6	3.1	37	<.03	<.1
#5	End	2/25	1-2pm	.080	.035	460	2.0	3.1	35	<.03	<.1

Sampling of 18 and 19 May 2000:

General Observations: Very wet weather since first week of May, significant agricultural activity prior to rains (soil erosion, leaching of starter fertilizer and herbicides), no rainfall from13 to17 May 2000.

10:30 am Started automated sampler. Water level at 3.2’
2:30pm- 10:45pm Steep rise in water levels. Water levels at 5.75’ at 10:45.
10:30 Sampler off; water level at 4.2.

Table C. Sample times and analyte concentrations during the rain event of 18-19 May 2000.

Sample				TP	SRP	TSS	TKN	NO_3	Cl	NH_3	NO_2
#1	Start	5/18	10:30-11:30 am	.035	<.002	43	.65	2.1	17	<.03	<.1
#2	Compo-site	5/18	11:30am-10:30pm	.096	.015	170	1.1	2.0	1.7	<.03	<.1
#3	Peak Flow	5/18	10:30-11:30pm	.150	.030	540	2.6	1.7	14	<.03	.14
#4	Compo-site	5/18-19	11:30pm-9:30am	.120	<.002	85	1.4	1.5	13	<.03	<.1
#5	End	5/19	9:30am-10:30am	.036	<.002	200	.78	1.5	14	<.03	<.1

Appendix 5. Required input parameters for PHOSMOD.

Model 1: PHOSMOD

Data Requirement
Morphometry – Depth, surface area, sediment thickness, sediment area, hypolimnion depth
Initial Conditions – Lake total phosphorus, sediment P content, sediment porosity, sediment density

Rate Functions - Settling velocity, burial velocity, summer and winter recycle velocity, Summer and winter hypolimnion temperatures, start date of spring mixing, start date of summer stratification, start date of fall mixing, start of winter stratification, initial summer dissolved oxygen and initial winter dissolved oxygen.

Loading – hypothetical loading to estimate effect on lake.