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Nutrient and Soil Losses from the Eighteenmile Creek Watershed

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SUMMARY AND RECOMMENDATIONS

1. The headwaters of Eighteenmile Creek originate in the towns of Cambria, Lockport, and Royalton and the creek flows 13 miles to its discharge into Lake Ontario, approximately eighteen miles east of the mouth of the Niagara River. The creek's watershed is centrally located within the bounds of Niagara County. It is the largest drainage basin found in the county, covering an area of approximately 58,000 acres within the towns of Newfane, Hartland, Royalton, Lockport, Cambria and Wilson and the City of Lockport.

2. 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. Identifying the magnitude of soil and nutrient losses from this watershed will allow the determination of the health of the creek and its impact to Lake Ontario. This information will also assist with the development of a watershed management plan for Eighteenmile Creek.

3. In July 2003, the Niagara County Soil & Water Conservation District (NCSWCD), in conjunction with the Department of Environmental Science and Biology at SUNY Brockport, began a monitoring program for Eighteenmile Creek, located in Niagara County, New York. Eighteenmile Creek was monitored for two annual cycles from 1 August 2003 through 31 July 2005. The purpose of the monitoring program was to collect data needed to accurately characterize the water quality in the creek and to quantify the concentration and loading of nutrients and suspended sediments transported from Eighteenmile Creek to Lake Ontario.

4. A continuous monitoring station was deployed at Ide Road on Eighteenmile Creek where creek level was recorded continuously with an ISCO flow meter linked to an ISCO sequential sampler and creek discharge calculated. The sampler allowed for automated hourly stream sampling during significant runoff events. The monitoring also included manual weekly sampling of the creek and analysis of all water samples collected utilizing water chemistry techniques for total phosphorus (TP), nitrate + nitrite, total suspended solids (TSS), total Kjeldahl nitrogen (TKN), and sodium at SUNY Brockport's certified laboratory; Field measurement of various physical parameters such as water temperature, dissolved oxygen, conductivity and pH were also completed.

5. **Discharge:** The annual discharge from Eighteenmile Creek measured at Ide Road was 151,735,000 m^3 in year 1 (1 August 2003 to 31 July 2004) and 191,858,440 m^3 in year 2 (1 August 2004 to 31 July 2005). Nearly 70% of the annual discharge for the two years monitored occurred during the winter and spring seasons. Over the two year period, 56% of the discharge of Eighteenmile Creek occurred during

non-event conditions and 44% during event conditions.

6. **Total phosphorus:** The total phosphorus concentration of Eighteenmile Creek was 42% higher during hydrometerological events (244.7 µg P/L) versus non-event creek (171.9 µg P/L) conditions with a maximum concentration of 915.5 µg P/L that occurred during an event on 4 July 2004. The mean non-event total phosphorus concentration of Eighteenmile Creek (171.9 µg P/L) was compared to other watersheds in western and central New York. The Eighteenmile Creek value was eclipsed only by watersheds that had a heavy loss of phosphorus from agricultural muckland (Ley Creek in Oswego County at 270.8 µg P/L) and a watershed that receives discharge from a municipal sewage treatment plant (Lower Northrup Creek in Monroe County at 263.6 µg P/L). Eighteenmile Creek lost an annual average of 33 metric tones of total phosphorus during the two-year monitoring period. That rate translates to 90 kg of phosphorus lost per day or 3.83 g/ha/day on an areal basis. Seasonally, 41% of the total phosphorus was lost from the watershed in winter followed by the spring season where another 25% of TP was lost.

   The best way to compare different watersheds is to normalize the phosphorus losses for the size of the watershed (areal basis). When compared to a number of New York State watersheds with varied land usages Eighteenmile Creek (3.83 g P/ha/day) is at the middle to upper end of this comparison. In other words, the Eighteenmile Creek watershed is moderately to severely impacted in terms of phosphorus pollution. Eighteenmile Creek has similar areal phosphorus loadings to watersheds that are heavily in agriculture or have sewage treatment plant effluent discharged into them. Eighteenmile Creek's areal phosphorus loss is nearly six times that of Twelvemile Creek West (0.67 g P/ha/day) and over 12 times that of Twelvemile Creek East (0.30 g P/ha/day), which are both are Niagara County watersheds that are heavily in agriculture. Eighteenmile Creek is not as pristine as watersheds that are completely forested such as First (0.11 g P/ha/day) and Clark (0.22 g P/ha/day) Creeks in Wayne County. Eighteenmile Creek receives discharge from the City of Lockport's sewage treatment plant that does elevate the total phosphorus concentration of Eighteenmile Creek.

7. **Total Kjeldahl nitrogen:** The mean concentration for total Kjeldahl nitrogen during events was 931 µg N/L and 795 µg N/L during non-event conditions at Ide Road during the monitoring period. This represents a 17% increase in TKN concentrations during event conditions. Total Kjeldahl nitrogen, a measure of organic nitrogen, loss from the Eighteenmile Creek watershed was 148 metric tonnes (404 kg/day, 17.2 g/ha/day) for the 1 August 2003 to 31 July 2004 period and 194 metric tonnes (531 kg/day, 22.6 g/ha/day) during the 1 August 2004 to 31 July 2005 period. Over the two year monitoring period, 45% of the TKN loss occurred during the winter seasons.

8. **Nitrate:** The mean event nitrate concentration for Eighteenmile Creek was 1.95 mg N/L versus 2.00 mg N/L during non-event periods. Nitrate was lost from the

Eighteenmile Creek watershed at a rate of 874 kg/day (37.2 g/ha/day) with little variability over the two year period (301,618 kg [824 kg/day, 35.1 g/ha/day] lost during 1 August 2003 to 31 July 2004 and 337,456 kg [925 kg/day, 39.4 g/ha/day] lost during 1 August 2004 to 31 July 2005). The winter and spring seasons accounted for 69% of the nitrate loss from the Eighteenmile Creek watershed.

9. **Total suspended solids:** The mean total suspended solids event concentration (26.3 mg/L) was nearly double the mean TSS concentration during non-event conditions (15.0 mg/L) in Eighteenmile Creek. Total suspended solids or soil was lost from the Eighteenmile Creek watershed at a rate of 10,989 kg/day during the two year period encompassing 1 August 2003 to 31 July 2005. On an areal basis, TSS was lost at a rate of 369 g/ha/day during the period 1 August 2003 to 31 July 2004 and a rate of 567 from 1 August 2004 to 31 July 2005. Forty six percent of the TSS loss occurred during the winter seasons followed by spring (29%), summer (16%) and autumn (9%). Of all the parameters measured in Eighteenmile Creek, the loss of total suspended solids was the most affected by hydrometerological events. Seventy percent of total suspended solids loss occurred when Eighteenmile Creek was in event conditions. This is not surprising as the increased water flowing over land in the watershed erodes soil and picks up solids and carries them to the creek.

10. **Sodium:** The mean sodium concentration of Eighteenmile Creek was 19% higher during non-event creek conditions (50.43 mg/L for events, 59.79 mg/L for non-events). The Eighteenmile Creek watershed lost an average of 27,773 kg of sodium per day during the period from 1 August 2003 to 31 July 2005. When normalized for the Eighteenmile Creek watershed area, sodium loss occurred at a rate of 1,182 g/ha/day. As expected the majority of sodium was lost from the watershed during the winter (56%) and spring (23%) seasons when deicing salt, containing sodium, is being applied to road surfaces.

11. **Geographic analysis of the Eighteenmile Creek watershed:** Two sites were monitored in addition to the Ide Road site (Figure 1) to begin to geographically access the water quality of Eighteenmile Creek. The site at Stone Road represents a small percentage of the overall watershed (~5%) but includes discharge from the City of Lockport and effluent from its sewage treatment plant (STP) and additional water from the Erie Canal to dilute that effluent. Another site, below the Burt dam was added downstream from the main Ide Road site. This site was added to help determine the effect the dam and its resulting reservoir has on the water quality of Eighteenmile Creek and its loading to Lake Ontario.

12. The results of two annual cycles of water chemistry at the three sampling locations on Eighteenmile Creek showed that within each site there were no significant differences ($p>0.05$) between year 1 and year 2 for total phosphorus, nitrate, total suspended solids, total Kjeldahl nitrogen, sodium, temperature, conductivity or dissolved oxygen with the exception of pH which was

approximately 0.5 units higher in year 2.

13. **Effect of the City of Lockport's sewage treatment plant:** There is evidence that the City of Lockport's sewage treatment plant (STP) is having an impact on the water quality of Eighteenmile Creek. The Eighteenmile Creek site at Stone Road represents losses from only a small (~ 5%) percentage of the upper portion of the watershed but receives effluent from the sewage treatment plant as well as water from the Erie Canal that is used to dilute the effluent from the STP. Total phosphorus was significantly higher ($p = 0.000$) at Stone Road compared to Ide Road (240.9 µg P/L versus 181.3 µg P/L). Both pH ($p = 0.046$) and dissolved oxygen ($p = 0.018$) were significantly higher at Ide Road than at the Stone Road site. These differences in phosphorus, dissolved oxygen and pH are likely due to the effluent from the STP in Lockport discharged into this portion of the Creek. In addition, sodium ($p = 0.001$) and conductivity ($p = 0.000$) were significantly higher at Stone Road versus Ide Road. The loss of de-icing salt from urban portions of this watershed is the likely cause.

    In order to allow further evaluation of the impact of the Lockport STP and Erie Canal on Eighteenmile Creek, we estimated nutrient, soil losses and discharge for the Stone Road portion of the watershed based on continuous measurements of discharge at Ide Road. By using this approach, 46% of the discharge measured at Ide Road originated from the watershed above Stone Road. Similarly, 57% of the total phosphorus, 61% of nitrate, 33% of total suspended solids, 44% of total Kjeldahl nitrogen and 65% of the sodium loss measured at Ide Road originated upstream of Stone Road: the urban area portion of the watershed (5% of the total watershed area) that included the STP and Erie Canal effluent. The previous estimate was based on continuous measurements of discharge at Ide Road, regression derived continuous discharge at Stone Road and event chemistry at only the Ide Road site. Instantaneous loads of nutrients and suspended solids were also calculated based on actual sampling days. This approach suggested that the Stone Road segment of Eighteenmile Creek may account for over 70% of the discharge and over 85% of the nutrient load. Further discussion on the limitations of theses analyses is in the text.

14. **Effect of the Burt Dam:** The average total suspended solids concentration decreased significantly ($p = 0.038$) from 16.1 mg/L at Ide Road (above the Burt Dam) sampling location to 9.5 mg/L at the Below the Dam sampling location. This suggests that the Burt Dam and its resultant reservoir are a sink for sediments; that is sediments are being stored behind the dam from upstream sites.

INTRODUCTION

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. This process enhances the ability of concerned groups to obtain external funding for demonstration and remedial projects. In July 2003, the Niagara County Soil & Water Conservation District (NCSWCD), in conjunction with the Department of Environmental Sciences and Biology at SUNY Brockport, began a monitoring program for Eighteenmile Creek, located in Niagara County, New York. The purpose of the monitoring program was to collect water quality data to quantify the concentration and loading of nutrients and suspended sediments transported from Eighteenmile Creek to Lake Ontario and to evaluate the health of the creek and its impact on Lake Ontario. In addition, the data serve as a database to make informed water quality management decisions including the development of a watershed management plan, and as a benchmark of discharge and nutrient data to measure the success of future remediation efforts.

This report, prepared by SUNY Brockport and the Niagara County Soil and Water Conservation District, provides information on the nutrient/sediment monitoring program of Eighteenmile Creek. Included are methodologies, results of the monitoring including documentation on types and amounts of nutrients that may be adversely impacting water quality and the conditions which generate them. Lastly, the report serves as a mechanism of transmittal of results and conclusions to all concerned parties and stakeholders of the Eighteenmile Creek watershed.

Justification

Freshwater resources have historically played an instrumental role in community development and economic sustainability. The water resources in Niagara County play an important role in the economy, have aesthetic value and provide diverse opportunities for those who enjoy the resource directly. A major thrust of the County's tourism industry is predicated on the availability of high quality water resources and angling opportunities in nearshore Lake Ontario and its tributaries. Needless to say, agriculture also has a major economic impact in Niagara County and loss of important resources, such as soil and nutrients, from a watershed is of concern to the landowner and the Soil and Water Conservation District. Remediation and protection of these resources depend largely on the identification of both the cause and effect of elements likely to reduce their economic and social value (Makarewicz 2000).

Background - County Water Quality Issues

The International Joint Commission has identified Eighteenmile Creek and Olcott Harbor as an Area of Concern (AOC) due to high levels of conventional pollutants, heavy metals and organic pollutants in the water, sediments and biota. The creek has been intensively studied in the past to determine the extent of organic chemicals and trace metals in the

creek. Several reports and a Remedial Action Plan have been prepared detailing the industrial contamination in the Area of Concern Eighteenmile Creek is polluted by past industrial and municipal discharges, the disposal of waste and the use of pesticides. Fishing is impaired by PCBs and dioxins found in the flesh of various game fish. The health of the benthos is impaired by PCBs and metals in the creek sediments. Bird and animal health is likely impaired by PCBs, dioxins, DDT and its metabolites, and dieldrin found in fish flesh. Contaminated sediments in Eighteenmile Creek, inflow from the past discharge of contaminants into the NYS Barge Canal, and as yet to be determined source of PCBs between Olcott Street and North Transit Road, are sources of pollutants (Makarewicz 2000). Other sources have been identified as potential sources because the contaminants causing impairments are known to exist, but the link between the source and the impairment has not been clearly established. Because of these concerns, Eighteenmile Creek has been designated an Area of Concern for which a Remedial Action Plan (RAP) has been developed.

This project was funded through by FL-LOWPA. The identified water quality impairments to be addressed by the NCSWCD/FL-LOWPA program include non-point source pollution from nutrients and sediment. Priority waterbody list (PWL) sheets for creeks within Niagara County list nutrients, pesticides and silt/sediment as types of pollutants which occur in the watersheds. Sources of pollutants identified on the PWL's consist of contaminated sediments, storm sewers, agriculture, urban runoff, and stream bank erosion. In addition, information gathered through the AEM program has identified these impairments, as well as the Niagara County Soil and Water Conservation District's familiarity with county-wide water quality issues.

The Eighteenmile Creek monitoring program was the 1st phase in a comprehensive county wide effort initiated to assess water quality. Baseline and storm event sediment and nutrient loadings were investigated for Eighteenmile Creek as an initial step because of the creeks Area of Concern (AOC) designation and the increased interest sparked by a 2003 Streambank Stabilization and Habitat Restoration Project. This project directly complements current initiatives intended to manage and assist in the overall remediation of the Eighteenmile Creek AOC. This project along with a Soil & Water Assessment Tool (SWAT) model completed by Buffalo State College and the U.S. Army Corps of Engineers, has given AOC management necessary tools and information required for sound decision making.

Since the completion of this project, Niagara County has begun an investigation of 17 major creeks within the county for baseline and storm event sediment and nutrient loads as well as BOD and temperature. The results will be used to identify those creeks in need of further study, to provide scientific data to update the Priority Waterbodies List and to identify problems and prioritize local projects. Influenced by general accessibility and stream morphology, water samples are being taken as close to the receiving water body as possible. It is the goal of this comprehensive round of sampling to assess the 16 major streams on a watershed scale. Once priority watersheds have been identified, sub-watershed based sampling may be conducted in future sampling rounds to identify sources and trends.

Water Quality Coordinating Committee

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 Soil and Water Conservation District has formed a committee whose specific task is to address water quality issues. This committee has become known as the Niagara County Water Quality Coordinating Committee (WQCC). This committee provides the necessary foundation to effect changes in the reduction of non-point source pollution through the implementation of Best Management Practices (BMP's) and changes in land use regulations. With the combined expertise of the Water Quality Coordinating Committee and the availability of actual field data, progress towards healthier freshwater resources is underway. A recommendation of the WQCC was to move forward in prioritizing the major tributaries in terms of high nutrient losses from the watershed.

Definitions

Total Phosphorus (TP) - 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.

Nitrates + Nitrites- 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 (TKN)- 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 but does not include nitrate or nitrite. Manure, for example, contains a large amount of organic nitrogen.

Sodium- 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 (TSS) - 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.

Concentration – The amount of a chemical (e.g. phosphorus) present expressed as weight per unit volume of water (e.g., mg/L, µg/L).

Loading – The loss of material (nutrient, sediment) from a watershed to a downstream location. This measurement considers flow/discharge (m^3 or ft^3) of the stream and analyte concentration (mg/L). Loading is often expressed in kg/day lost from the watershed or may be normalized for the area of the watershed and expressed as g/ha/day

METHODS

General

The headwaters of Eighteenmile Creek originate in the towns of Cambria, Lockport, and Royalton. The creek flows 13 miles to its discharge into Lake Ontario, approximately eighteen miles east of the mouth of the Niagara River. The creek's watershed is centrally located within the bounds of Niagara County. It is the largest drainage basin found in the county, covering an area of approximately 58,000 acres within the towns of Newfane, Hartland, Royalton, Lockport, Cambria and Wilson and the City of Lockport. A map of the Eighteenmile Creek watershed with sampling locations, along with a similar map depicting land uses throughout the watershed are provided in Figures 1 and 2.

In July 2003, the Niagara County Soil & Water Conservation District (NCSWCD), in conjunction with the Department of Environmental Science and Biology at SUNY Brockport, began a monitoring program for Eighteenmile Creek. Eighteenmile Creek was monitored for two annual cycles from 1 August 2003 through 31 July 2005. This monitoring included weekly baseline sampling and hydrometerological event sampling of the creek; analysis of water samples for total phosphorus, nitrate + nitrite, total suspended solids, total Kjeldahl nitrogen, and dissolved sodium; and the determination of various physical parameters such as stream velocity, hourly level readings, water temperature, dissolved oxygen, conductivity and pH.

Sampling Sites

Three sampling sites were chosen on Eighteenmile Creek for this study. A base site (Ide Road), where discharge of the creek was monitored continuously, and two supplemental sites (Stone Road and below the Burt Dam), which provided less detailed data but added some additional geographic information about the water quality of Eighteenmile Creek, were located in the watershed. The routine non-event or baseline sampling involved the collection of stream water grab samples from the creek on a weekly basis at two sampling sites on the creek (Ide Road and Stone Road) and bi-weekly sampling at a third location (below the Burt Dam) by NCSWCD personnel. Hydrometerological event samples were collected automatically at the Ide Road site as they occurred. More detailed information on the three sampling sites on Eighteenmile Creek is listed below and a map of the sites is included in Figure 1.

Ide Road (43° 17.18'N, 78° 42.91'W): At the base site monitoring station at Ide Road, creek levels were recorded continuously with an ISCO flow meter linked to an ISCO sequential sampler. The sampler allowed for hourly stream sampling during significant runoff events. A rise in the stream level of one inch in a half hour signified an event and subsequently triggered the automatic sampler. If the event lasted longer than 24 hours, the 24-sample bottle set was removed from the sampler and replaced with a second set of bottles to accurately document the entire event. The hourly rise and fall samples were

composited into one rise and one fall sample for each event and analyzed at the State and Nationally certified water quality laboratory at SUNY Brockport.

Stone Road (43° 11.63'N, 78° 42.53'W): The Stone Road sampling location was geographically selected to determine the water quality for a small section of the watershed (an area of approximately 5% of the entire watershed) but which includes potentially important contributions from the City of Lockport's wastewater treatment plant and water from the Erie Canal which is used to dilute effluent water from the Plant. This site was sampled weekly.

Below the Dam at Burt, NY (43° 19.02'N, 78° 42.97'W): The below the Dam site is approximately 2 miles upstream from Lake Ontario and 0.3 miles downstream of the Burt Dam at the creek access road from Fisherman's park. This location was also approximately 2.7 miles downstream of the Ide Road sampling location. Due to budget constraints weekly sampling at this site was not feasible so bi-weekly sampling was done instead. The sample location was chosen because of its public access, its location above the influence of the lake, and most importantly, its location downstream of the dam and its resultant reservoir. The sampling was performed at this location to determine the effect the reservoir has on removing nutrients and sediment from the creek, and the ultimate nutrient and sediment load to the lake.

Statistical Analysis
Oneway analysis of variance with a Tukey LSD post-hoc test was utilized for all statistical comparisons using the SPSS statistical package.

Field Sampling
All sampling bottles were pre-coded to ensure exact identification of the particular sample. Sample bottles were coded with a designation as a rise, fall or baseline sample, the date of sampling, sample location and initials of the personnel collecting the samples. Containers were rinsed prior to sample collection with the water being collected. All sample water for dissolved nutrient analysis for nitrate + nitrite and sodium were filtered using .45 μm MCI Magma Nylon 66 membrane filters and were frozen or put on ice and held at 4°C until analysis. The filtration unit and other processing apparatus were cleaned routinely with phosphate-free RBS.

Weekly baseline and event samples were transported to SUNY Brockport for water chemistry analysis for total phosphorus (TP), total Kjeldahl nitrogen (TKN), nitrate + nitrite, sodium and total suspended solids (TSS).

Water Chemistry
Nitrate + Nitrite: Dissolved nitrate + nitrite nitrogen analyses were performed by the automated (Technicon Autoanalyser) cadmium reduction method (APHA 1999).

Sodium: Sodium was determined by atomic absorption spectrophotometry (Perkin-Elmer AAnalyst 100) (APHA 1999).

Total Phosphorus: The persulfate digestion procedure was used prior to analysis by the automated (Technicon Autoanalyser) colorimetric ascorbic acid method (APHA 1999).

Total Kjeldahl Nitrogen: Analysis was performed using EPA Method 351.2 with the substitution of copper for mercury as the catalyst as per APHA Method 4500-N_{org} B (EPA 1979, APHA 1999).

Total Suspended Solids: APHA (1999) Method 2540D was employed for this analysis.

Physical Measurements

Stream Water Depth

Eighteenmile Creek stream depths were monitored hourly at the Ide Road location utilizing an ISCO flow meter equipped with a bubbler sensor and weekly at the Stone Road location using a manual staff gauge installed on the wall of the bridge. Ide Road creek depths, as measured by the flow meter, were manually calibrated weekly using a staff gauge installed on the Ide Road culvert.

Some difficulties arose with the monitoring station over the two-year study period due to battery failure and vandalism. There were twenty-two instances where level data was missing or corrupt. Some of these gaps were simply a missing hour of data while others were of a more substantial duration. For example, during the late winter/spring of 2005 the monitoring station at Ide Road was vandalized which caused intermittent creek level readings for a period of about two months until the problem with a damaged air tube was discovered and replaced. In these instances where hourly level readings were lost, Eighteenmile Creek levels were interpolated from reliable flow meter readings and / or available manual staff gauge readings. For periods when the flow meter was not working the frequency of manual staff gauge readings by NCSWCD personnel was increased as warranted by changes in stream level.

Discharge Rating Curves, Stream Velocity and Cross-sectional Area

The cross-section of the bridge and culverts was manually surveyed with a laser plan rotary level by NCSWCD personnel and Figures of each structure are included as Figures 3 and 4. Point discharges used to build rating curves for Ide Road and Stone Road were performed by NCSWCD personnel following Rantz *et al*. (1982) using the conventional current meter measurement of discharge method. A current-meter measurement is the summation of the products of the subsection areas of the stream cross section and their respective average velocities (Rantz *et al*. 1982). Discharge was estimated on 22 dates at Ides Road (for 12 stream sections) and on 19 dates at Stone Road (for 17 stream sections) during the study period encompassing a wide range of creek levels. Velocity was measured utilizing a Gurley current meter equipped with two sizes of rotational buckets to accommodate the velocity range observed on Eighteenmile Creek. Eighteenmile Creek stream levels at Ide Road were referenced to the installed ISCO flow meter for the rating curve for that site (Figure 5) while the Stone Road rating curve is referenced to the staff gauge level readings (Appendix 1). Both predictive curves are second order polynomials

with an r^2 greater than 0.987. In addition, an Ide Road rating curve that is referenced to the staff gauge was also developed ($r^2 = 0.990$) for future measurements after the ISCO flow meter is removed (Appendix 2).

Eighteenmile Creek Discharge

Ide Road: The hourly stream level readings from the ISCO flow meter at the Ide Road location were converted to discharge using that site's rating curve (Figure 5). During hydrometerological events, hourly discharge was summed for both the rising and falling limbs of the event hydrograph. During nonevent periods, hourly discharge was summarized into a nonevent daily discharge.

Stone Road: Daily discharge at the Stone Road location was predicted from the daily discharge measured at the Ide Road monitoring station. A predictive curve was created from the manually determined discharge at the Stone Road and the measured discharge on that date at the Ide Road location for each date that Stone Road was measured. The plot of Ide Road discharge versus Stone Road discharge and the resulting curve is included as Figure 6 and the resultant second order polynomial gave an r^2 of 0.975.

Below the Dam: The discharge volume at Ide Road and below Burt Dam at Fisherman's Park is assumed to be identical for this report. This assumption must be viewed with caution in that there is undoubtedly some additional direct drainage downstream between the two sites that was very difficult to quantify.Another potential difficulty for this assumption is the fluctuations in discharge at the Burt Dam as well as changes in storage of water in the reservoir upstream of the dam.

Losses from the Watershed (Loading)

Ide Road: In general, nutrient and soil loss from the Eighteenmile Creek watershed is calculated by multiplying discharge by the concentration of the water quality constituent of that discharge. Losses from hydrometerological events and non-event conditions were handled differently due to the rapid changing of water quality during events. Better resolution of event data yields superior estimates of load and hourly resolution of discharge and water sampling was used for this report. For losses during hydrometerological events, the discharge from the rising and falling limbs of events was multiplied by their respective water chemistry concentrations. For periods during hydrometerological events of which there were no corresponding composite samples available, seasonal average event chemistry was applied to determine loading. During nonevent periods, baseline daily discharge was multiplied by that period's (weekly resolution) water chemistry concentrations to yield daily loading. The daily discharge and loadings from each date were summed to give nonevent (baseline) discharge and loadings for the entire monitoring period. Adding baseline discharges and loadings to event discharge and loadings yielded total discharge and loadings (Event + Non-Event). The total discharge and loadings were then divided by the number of days monitored to estimate the average daily discharge and loading.

Stone Road: Daily discharge from the Stone Road sampling location obtained by regression (Figure 6) was multiplied by the corresponding (weekly resolution) water chemistry concentrations to yield daily loading. The daily discharge and loadings from each day in the two-year monitoring period were summed to give discharge and loadings for the entire monitoring period. A single additional event water chemistry grab sample was taken on April of 2005 from this site and incorporated into the loading calculations.

Below the Dam: The Ide Road nutrient loading was compared to the data from the Below the Burt Dam sampling location to determine the effect the Burt Dam and reservoir had on water quality. Nutrient loading at the Below the Dam location was calculated by multiplying the daily discharge at the Ide Road location by the corresponding water chemistry concentrations (bi-weekly resolution) for the Below the Dam location.

Water Temperature, Dissolved Oxygen & Conductivity

Water temperature, dissolved oxygen and conductivity were all monitored weekly by NCSWCD personnel at the Ide and Stone Road sampling sites, and bi-monthly at the Below the Dam location utilizing a hand held YSI 85 meter. The YSI Model 85 was calibrated according to manufacturers instructions by field staff prior to sampling.

pH

pH was monitored on a weekly basis by NCSWCD personnel at the Ide and Stone Road sampling sites and bi-monthly at the Below the Dam location, utilizing a HANNA pH pocket tester. The HANNA pH pocket tester is equipped with an automatic calibration feature. The pocket tester was calibrated monthly by placing the pH electrode cartridge into a set of memorized calibration solutions (pH 4.01/7.01) Once the Pocket tester reading equaled the calibration coefficient, the instrument was considered calibrated and ready for sampling.

Watershed Area

The watershed area for Eighteenmile Creek was calculated using a geographical information system (GIS) delineation based upon the watershed boundaries developed from the topographical mapping of the area by NCSWCD. The total calculated area is 58,056 acres.

External Quality Control

The Water Chemistry Laboratory at SUNY Brockport is State and Nationally certified through the National Environmental Laboratory Accreditation Conference (NELAC – EPA Lab Code # 01449) and New York State Department of Health's Environmental Laboratory Approval Program (ELAP - # 11439). This program includes biannual proficiency audits, annual inspections and good laboratory practices documentation of all samples, reagents and equipment. Table 1 is a summary of the SUNY Brockport Water

Chemistry Laboratory's last proficiency audit.

RESULTS AND DISCUSSION

Ide Road Monitoring Station:

Water chemistry (Concentration):

The results of water chemistry analysisfrom the Ide Road site on Eighteenmile Creek from 1 August 2003 to 31 July 2005 are presented in Table 2. This site was continuously monitored for discharge and event samples were collected with an automated sampler that was triggered by an increase in the creek's level, in addition to the manual weekly samples collected by NCSWCD personnel. The concentrations of total phosphorus, nitrate, total Kjeldahl nitrogen, total suspended solids and sodium are separated into event and non-event stream conditions. The chemical parameters that are associated with particulate matter (TP, TKN and TSS) being swept off the watershed are higher during events versus non-event conditions. Total phosphorus and total Kjeldahl nitrogen samples are digested and represent a bound fraction of the nutrient in addition to the soluble form while total suspended solids is the measure of solids carried in the water.

Total phosphorus was 42% higher during events (244.7 µg P/L) versus non-event creek (171.9 µg P/L) conditions (Table 2) with a maximum concentration of 915.5 µg P/L that occurred during an event on 4 July 2004. The mean concentration for total Kjeldahl nitrogen during events was 931 µg N/L and 795 µg N/L during non-event conditions at Ide Road during the monitoring period. This represents a 17% increase in TKN concentrations during event conditions. The mean total suspended solids event concentration (26.3 mg/L) was nearly double the mean TSS concentration during non-event conditions (15.0 mg/L) in Eighteenmile Creek (Table 2). The soluble chemical fractions may get diluted during event conditions as the mean event nitrate concentration was 1.95 mg N/L versus 2.00 mg N/L during non-event periods. Similarly, the mean sodium concentration was 19% higher during non-event creek conditions (50.43 mg/L for events, 59.79 mg/L for non-events) (Table 2).

Discharge:

The annual discharge from Eighteenmile Creek measured at Ide Road was 151,735,000 m^3 in year 1 (1 August 2003 to 31 July 2004) and 191,858,440 m^3 in year 2 (1 August 2004 to 31 July 2005) (Table 3). For the two annual cycles at Ide Road, the mean annual discharge of Eighteenmile Creek was 171,796,720 m^3/year. Nearly 70% of the annual discharge for the two years monitored occurred during the winter and spring seasons (Figure 7). Over the two year period, 56% of the discharge of Eighteenmile Creek occurred during non-event conditions and 44% during event conditions (Figure 8).

Nutrients:

A nutrient loading summary is presented for each year and the 2-year combined period for Eighteenmile Creek at the Ide Road monitoring site (Table 3).

Eighteenmile Creek lost an annual average of 33 metric tonnes (metric tonne = 1000 kg) of total phosphorus (TP) during the two-year monitoring period. That rate translates to 90 kg of phosphorus lost per day or 3.83 g/ha/day on an areal basis (Table 4). Seasonally, 41% of the total phosphorus was lost from the watershed in winter followed by the spring season where another 25% of TP was lost (Figure 9).

Nitrate was lost from the Eighteenmile Creek watershed at a rate of 874 kg/day (37.2 g/ha/day) with little variability over the two year period (301,618 kg [302 metric tonnes, 824 kg/day, 35.1 g/ha/day] lost during 1 August 2003 to 31 July 2004 and 337,456 kg [337 metric tonne, 925 kg/day, 39.4 g/ha/day] lost during 1 August 2004 to 31 July 2005) (Tables 3 and 4). Similar to phosphorus, the winter and spring seasons accounted for 69% of the nitrate loss from the Eighteenmile Creek watershed (Figure 10).

Total Kjeldahl nitrogen, a measure of organic nitrogen, loss from the Eighteenmile Creek watershed was 148 metric tonnes (404 kg/day, 17.2 g/ha/day) for the 1 August 2003 to 31 July 2004 period and 194 metric tonnes (531 kg/day, 22.6 g/ha/day) during the 1 August 2004 to 31 July 2005 period (Tables 3 and 4). Over the two-year monitoring period, 45% of the TKN loss occurred during the winter seasons (Figure 11).

Soil loss as measured by total suspended solids:
Total suspended solids were lost from the Eighteenmile Creek watershed at a rate of 10,989 kg/day (annual average of 4,016 metric tonnes) during the two-year period encompassing 1 August 2003 to 31 July 2005 (Table 4). On an areal basis, TSS was lost at a rate of 369 g/ha/day during the period 1 August 2003 to 31 July 2004 and a rate of 567 from 1 August 2004 to 31 July 2005 (Table 4). Forty six percent of the TSS loss occurred during the winter seasons followed by spring (29%), summer (16%) and autumn (9%) (Figure 12). Of all the parameters measured in Eighteenmile Creek, the loss of total suspended solids was the most affected by hydrometerological events. Seventy percent of total suspended solids loss occurred when Eighteenmile Creek was in event conditions (Figure 8). This is not surprising as the increased water flowing over land in the watershed erodes soil and picks up solids and carries them to the creek.

Sodium:
The Eighteenmile Creek watershed lost an average of 27,773 kg of sodium per day (annual average of 10,151 metric tonnes) during the period from 1 August 2003 to 31 July 2005 (Table 4). When normalized for the Eighteenmile Creek watershed area, sodium loss occurred at a rate of 1,182 g/ha/day. As expected the majority of sodium was lost from the watershed during the winter (56%) and spring (23%) seasons when deicing salt, containing sodium, is being applied to road surfaces (Figure 13).

Comparisons to other watersheds:

It is illustrative to compare the concentrations and areal losses of phosphorus from watersheds in the same geographic area. This data can be used to assess the relative condition and quality of the creek and the watershed it drains. Two tables have been prepared from data collected using similar methods as those used in this study upon which comparisons can be drawn. Table 5 represents non-event total phosphorus concentrations over a wide range of watershed sizes, land use and geography. Eighteenmile Creek has the third highest non-event TP concentration of the watersheds monitored in Central and Western New York (Table 5). The mean non-event total phosphorus concentration of Eighteenmile Creek was 171.9 µg P/L, this value was eclipsed only by watersheds that had a heavy loss of phosphorus from agricultural muckland (Ley Creek in Oswego County at 270.8 µg P/L) and a watershed that receives discharge from a municipal sewage treatment plant (Lower Northrup Creek in Monroe County at 263.6 µg P/L). Eighteenmile Creek receives discharge from the City of Lockport's sewage treatment plant that appears to elevate the total phosphorus concentration of Eighteenmile Creek. This point will be explored further in the next section of this report that deals with three geographic sampling sites in the Eighteenmile Creek watershed.

Perhaps the best way to compare losses from different watersheds is to normalize the phosphorus losses for the size of the watershed (areal basis). Table 6 presents an areal comparison of total phosphorus losses from a number of New York State watersheds with varied land usages. The mean areal total phosphorus loss from Eighteenmile Creek was 3.83 g P/ha/day. Eighteenmile Creek is at the middle to upper end of this comparison meaning that the watershed is moderately to severely impacted in terms of phosphorus pollution. Eighteenmile Creek has similar areal phosphorus loadings to watersheds that are heavily in agriculture or have sewage treatment plant effluent discharged into them (Table 6). Eighteenmile Creek's areal phosphorus loss is nearly six times that of Twelvemile Creek West (0.67 g P/ha/day) and over 12 times that of Twelvemile Creek East (0.30 g P/ha/day), which are both are Niagara County watersheds that are heavily in agriculture (Makarewicz and Lewis 2000 and 2003). Eighteenmile Creek is not as pristine as watersheds that are completely forested such as First (0.11 g P/ha/day) and Clark (0.22 g P/ha/day) Creeks in Ontario County (Table 6).

Geographic analysis within the Eighteenmile Creek watershed:

Stone Road versus Ide Road: Two sites were monitored in addition to the Ide Road site (Figure 1). The site at Stone Road represents a small percentage of the overall watershed (~5%) but includes discharge from the City of Lockport and effluent from its sewage treatment plant (STP) and additional water from the Erie Canal to dilute that effluent. Downstream from the main Ide Road station, another site was monitored below Burt Dam. This site was added to help determine the effect that the dam and its resulting reservoir has on the water quality of Eighteenmile Creek and it's loading to Lake Ontario.

The results of two annual cycles of water chemistry at the three sampling locations on

Eighteenmile Creek are presented in Table 7. Temporally within each site, there were no significant differences ($p>0.05$) in total phosphorus, nitrate, total suspended solids, total Kjeldahl nitrogen, sodium, temperature conductivity or dissolved oxygen between year 1 versus year 2 with the exception of pH which was approximately 0.5 units higher in year 2.

There is evidence that the City of Lockport's sewage treatment plant (STP) is having an impact on the water quality of Eighteenmile Creek. The Eighteenmile Creek site at Stone Road represents losses from only a small percentage (~ 5%) of the upper portion of the watershed but receives effluent from the sewage treatment plant as well as water from the Erie Canal that is used to dilute the effluent from the STP. Total phosphorus was significantly higher ($p = 0.000$) at Stone Road compared to Ide Road (240.9 µg P/L versus 181.3 µg P/L). Both pH ($p = 0.046$) and dissolved oxygen ($p = 0.018$) were significantly higher at Ide Road than at the Stone Road site. These differences in phosphorus, dissolved oxygen and pH are likely due to the effluent from the STP in Lockport discharged into this portion of the Creek. In addition, sodium ($p = 0.001$) and conductivity ($p = 0.000$) were significantly higher at Stone Road versus Ide Road. The loss of de-icing salt from urban portions of this watershed is the likely cause.

In order to allow further evaluation of the impact of the Lockport STP and Erie Canal on Eighteenmile Creek, we estimated nutrient, soil losses and discharge for the Stone Road portion of the watershed based on continuous measurements of discharge at Ide Road (Table 8). By using this approach, 46% of the discharge measured at Ide Road originated from the watershed above Stone Road. Similarly, 57% of the total phosphorus, 61% of nitrate, 33% of total suspended solids, 44% of total Kjeldahl nitrogen and 65% of the sodium loss measured at Ide Road originated upstream of Stone Road: the urban area portion of the watershed (5% of the total watershed area) that included the STP and Erie Canal effluent. The previous estimate was based on continuous measurements of discharge at Ide Road, regression derived continuous discharge at Stone Road and event chemistry at only the Ide Road site. Instantaneous loads of nutrients and suspended solids were also calculated based on actual sampling days. This approach suggested that the Stone Road segment of Eighteenmile Creek may account for over 70% of the discharge and over 85% of the nutrient load. This second approach suffered from the lack of event discharge and event chemistry data. What can be concluded is that input from the urban area upstream of Stone Road accounted for a significant portion of the nutrient loss from the entire Eighteenmile Creek watershed. This information should be used with caution. The former analysis compared data where one site (Ide Road) included automated event condition samples for chemistry and the other (Stone Road) did not and is, therefore, a conservative estimate while the latter analysis used only single point weekly readings sacrificing a great deal of data resolution. An appropriate analysis would include automated discharge estimates and event chemistry at both sites.

Burt Dam versus Ide Road: The average total suspended solids concentration decreased significantly ($p = 0.038$) from 16.1 mg/L at Ide Road (above the Burt Dam) sampling location to 9.5 mg/L at the Below the Dam sampling location. This suggests that the Burt Dam and its resultant reservoir are a sink for sediments; that is sediments are being stored

behind the dam from upstream sites.

Nutrient and soil losses were estimated for the below the Dam sites using the grab routine samples that were taken (Table 8) at the request of NCSWCD. The data do suggest that particulate forms (TP, TKN, TSS) are being retained in the sediment behind the dam while dissolved fractions (nitrate and sodium) are not. There was a 19% reduction in TKN, a 22% reduction in TP and a 51% reduction in TSS loading between the Ide Road site and the below the Dam site. However, the values provided in Table 8 below the Burt Dam must be viewed with considerable caution. The estimates below the dam do not include all event samples as the Ide Road base site. Due to the limited number of event samples that were taken as part of the routine biweekly sampling, these reductions in sediment, TP, and TKN are probably overestimated.

A more accurate depiction of the geographic differences in discharge and losses from the watershed can only be accomplished by installing similar automated continuous monitoring stations at all locations.

CONCLUSIONS

Eighteenmile Creek is moderately to severely impacted with respect to phosphorus loss from its watershed when compared, on an areal basis, with other watersheds in western and central New York State. Within Niagara County, Eighteenmile Creek's areal phosphorus loss is nearly six times that of Twelvemile Creek West and over 12 times that of Twelvemile Creek East. Eighteenmile Creek is not as pristine as watersheds that are completely forested such as First and Clark Creeks in Wayne County (Table 6). The non-event total phosphorus concentration was also very high when compared to other watersheds that have a very heavy agricultural presence or receive discharge from a sewage treatment plant.

The City of Lockport's sewage treatment plant and the Erie Canal are having an impact on the water quality of Eighteenmile Creek. The STP is contributing a large amount of phosphorus to the creek and creating a biochemical oxygen demand that is lowering the pH and dissolved oxygen in that portion of the watershed. Non-event loadings of total phosphorus, nitrate, total Kjeldahl nitrogen, and sodium are nearly equal to or greater than event loadings, most likely due to the continuous input from the STP.

As expected the dam at Burt, NY is slowing down the Creek's flow allowing solids to settle out resulting in a significant decrease in total suspended solids concentrations below the dam versus the sampling sites above the dam.

A summation of the conclusions and a consolidation of the results from this study can be found on page 3 of this report.

Acknowledgements

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Table 1. Results of the semi-annual New York State Environmental Laboratory Assurance Program (ELAP # 11439, SUNY Brockport) Non-Potable Water Chemistry Proficiency Test.

WADSWORTH CENTER
NEW YORK STATE DEPARTMENT OF HEALTH
ENVIRONMENTAL LABORATORY APPROVAL PROGRAM

Proficiency Test Report

Lab 11439 SUNY BROCKPORT
WATER LAB LENNON HALL
BROCKPORT, NY 14420
USA

EPA Lab Id NY01449

Shipment: 290 Non Potable Water Chemistry
Shipment Date: 24-Jan-2006

Analyte	Sample ID	Result	Mean/Target	Satisfactory Limits	Method	Score
Approval Category : **Non Potable Water**						
Sample: **Residue**						
Solids, Total Suspended 244 passed out of 254 reported results.	9002	76.0	77.2	62.8 – 86.2	SM18-20 2540D	Satisfactory
Sample: **Organic Nutrients**						
Kjeldahl Nitrogen, Total 93 passed out of 103 reported results.	9004	2.65	2.60	1.82 – 3.57	EPA 351.2	Satisfactory
Phosphorus, Total 99 passed out of 110 reported results.	9004	7.05	6.98	5.76 – 8.27	SM18-20 4500-PF	Satisfactory
Sample: **Inorganic Nutrients**						
Nitrate (as N) 118 passed out of 123 reported results.	9007	17.78	18.6	14.5 – 22.4	SM18-20 4500-NO3 F	Satisfactory
Orthophosphate (as P) 107 passed out of 118 reported results.	9007	3.00	3.01	2.46 – 3.59	SM18-20 4500-PF	Satisfactory
Sample: **Minerals II**						
Sodium, Total 78 passed out of 93 reported results.	9037	81.56	78.0	66.2 – 89.4	SM 18-19 3111B	Satisfactory
Sample: **Nitrite**						
Nitrite as N 98 passed out of 105 reported results.	9041	2.29	2.28	1.92 – 2.64	SM 18-20 4500-NO3 F	Satisfactory

Table 2. Average concentrations ± S.E. (range) of water chemistry parameters for the Event and Non-Event conditions at the Ide Road sampling site on Eighteenmile Creek for the time period between 1 August 2003 and 31 July 2005. TP = Total Phosphorus, Nitrate = Nitrate + Nitrite, TKN = Total Kjeldahl Nitrogen, TSS = Total Suspended Solids.

	Event	Non-Event
TP (µg P/L)	244.7 ± 25.6 (97.9 - 915.5)	171.9 ± 6.8 (7.6 - 440.0)
Nitrate (mg N/L)	1.95 ± 0.13 (0.93 – 4.99)	2.00 ± 0.07 (0.47 - 4.50)
TKN (µg N/L)	931 ± 69 (210 - 2080)	795 ± 61 (75 - 3630)
TSS (mg/L)	26.3 ± 4.5 (0.3 – 121.0)	15.0 ± 2.2 (1.5 - 150.0)
Sodium (mg/L)	50.43 ± 2.98 (14.16 - 120.30)	59.79 ± 2.39 (29.23 - 145.22)

Table 3. Discharge and loadings for the Ide Road sampling site on Eighteenmile Creek under Event + Non-Event, Non-Event, and Event conditions. The Year 1 time period refers to discharge and loading occurring between 1 August 2003 and 31 July 2004; the Year 2 time period refers to discharge and loading occurring between 1 August 2004 and 31 July 2005; the Both Year time period refers to the mean annual discharge and loading occurring between 1 August 2003 and 31 July 2005.

Nonevent + Event

Time Period	Discharge (m^3)	TP (kg)	Nitrate (kg)	TSS (kg)	TKN (kg)	Sodium (kg)
Year 1	151,735,000	28,582	304,978	3,170,942	147,926	9,043,848
Year 2	191,858,440	37,154	337,456	4,861,845	193,902	11,258,455
2 Year Mean	171,796,720	32,868	321,217	4,016,394	170,914	10,151,152

Nonevent

Time Period	Discharge (m^3)	TP (kg)	Nitrate (kg)	TSS (kg)	TKN (kg)	Sodium (kg)
Year 1	80,251,839	12,910	180,560	857,911	74,481	5,642,579
Year 2	110,455,909	17,110	214,548	1,547,022	77,915	8,128,952
2 Year Mean	95,353,874	15,010	197,554	1,202,467	76,198	6,885,766

Event

Time Period	Discharge (m^3)	TP (kg)	Nitrate (kg)	TSS (kg)	TKN (kg)	Sodium (kg)
Year 1	71,483,161	15,672	124,419	2,313,031	73,445	3,401,269
Year 2	81,402,531	20,045	122,908	3,314,823	115,987	3,129,503
2 Year Mean	76,442,846	17,858	123,664	2,813,927	94,716	3,265,386

Table 4. Event + Non-Event daily discharge, loadings and areal loading for the Ide Road sampling site on Eighteenmile Creek. The Year 1 time period refers to discharge and loading occurring between 1 August 2003 and 31 July 2004; the Year 2 time period refers to discharge and loading occurring between 1 August 2004 and 31 July 2005; the Both Year time period refers to discharge and loading occurring between 1 August 2003 and 31 July 2005.

Time Period	Discharge (m^3/day)	TP (kg/day)	Nitrate (kg/day)	TSS (kg/day)	TKN (kg/day)	Sodium (kg/day)
Both Years	470,032	90	874	10,989	468	27,773
Year 1	414,577	78	824	8,664	404	24,710
Year 2	525,640	102	925	13,320	531	30,845

Time Period	Discharge (m^3/day)	TP (g/ha/day)	Nitrate (g/ha/day)	TSS (g/ha/day)	TKN (g/ha/day)	Sodium (g/ha/day)
Both Years	470,032	3.83	37.2	468	19.9	1,182
Year 1	414,577	3.32	35.1	369	17.2	1,052
Year 2	525,640	4.33	39.4	567	22.6	1,313

Table 5. Nonevent (baseline) total phosphorus concentrations and watershed areas from creeks in central and western New York. Data is from Makarewicz 1988, Makarewicz and Lewis 1996, 1998, 1998a, 1999, 2000, 2003 Makarewicz *et al*.1991a, 1992.

Creek	Total phosphorus (μg P/L)	Watershed Area (ha)	Land Use
Canandaigua Lake Watershed 1997			
Fall Brook	**19.4**	**1343**	**Agriculture /suburban**
Deep Run Gully	**7.4**	**525**	**Agriculture**
Vine Valley	**28.4**	**1115**	**Agriculture**
Clark Gully	**9.1**	**325**	**Forested**
Naples Creek	**5.5**	**8143**	**Agriculture / Suburban**
Sucker Brook	**97.5**	**1759**	**Urban / Agriculture**
Seneca Point	**94.8**	**1048**	
Oswego County 1997			
Sheldon	**92.0**	**1357**	**Muckland**
Summerville	**108.1**	**409**	**Suburban**
Ley	**270.8**	**632**	**Muckland / Agriculture**
Wayne County 1991-92			
Sodus	**46.3**	**3065**	**Agriculture**
Wolcott	**115.6**	**4416**	**Agriculture**
Second	**31.3**	**2610**	
Orleans County 1997-98			
Oak Orchard	**126.4**	**36989**	**Agriculture**
Johnson	**88.3**	**25530**	**Agriculture**
Sandy	**96.9**	**23056**	**Agriculture / Suburban**
Orleans County 1998-99			
Oak Orchard	**103.5**	**36989**	**Agriculture**
Johnson	**95.8**	**25530**	**Agriculture**
Sandy	**123.7**	**23056**	**Agriculture / Suburban**
Seneca County 1990-94			
Kendig Creek	**143.0**	**5149**	**Agriculture**
Livingston County 1990-91			
Hanna's	**74.6**	**718**	**Agriculture / Suburban**
Conesus Inlet	**28.2**	**4475**	**Wetlands / Agriculture**
South McMillan	**30.6**	**2687**	**Agriculture**
Monroe County 1987-88			
Upper Northrup	**68.60**	**1049**	**Suburban**
Lower Northrup	**263.60**	**1862**	**Suburban / Sewage Plant**
Niagara County 1998 - 2002			
Twelvemile Creek East	**46.0**	**16372**	**Agriculture / Suburban**
Twelvemile Creek West	**68.1**	**9321**	**Agriculture / Suburban**
Niagara County 2003 – 2005			
Eighteen Mile Creek - Ide Road	**171.9**	**23494**	**Urban / Agriculture**

Table 6. 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, 1993 Makarewicz and Lewis 1998, 1998a, 1999, 2000, 2003. All data is for an annual period (i.e., mean annual daily loading).

Subbasin or Creek	Land Use	Total Phosphorus Loading (g P/ha/d) Annual
Sucker Brook	Agriculture/Urban	7.66
Irondequoit Creek at Browncroft Blvd. 1975-77 (pre-diversion)	Several Sewage Plants	5.60
1978-79 (post-diversion)		2.00
Larkin	Suburban	0.70
Buttonwood	Suburban	1.58
Lower Northrup	Sewage Plant	6.64
Upper Northrup	Urban	3.23
First	Forested	0.11
Clark	Forested	0.22
Sodus East	Agriculture	8.57
Wolcott	Agriculture	5.01
Bobolink	Forested	0.02
Sheldon	Muckland	27.41
Summerville	Suburban	5.47
		1997-98 / 1998-99
Oak Orchard		3.48 / 2.86
Johnson		1.81 / 1.17
Sandy		0.98 / 0.77
		1998-99 / 1999-00
		1998-2002
Twelvemile Creek East	Agriculture	0.30
		1999-2002
Twelvemile Creek West	Agriculture	0.67
		2003-2005
Eighteenmile Creek	Urban/Agriculture	3.83

Table 7. Average values ± S.E. (range) of the routine grab samples for various chemical and physical properties for the Ide Road, Stone Road, and Below the Dam sampling sites on Eighteenmile Creek. The Ide Road and Stone Road sites were sampled weekly, the Below the Dam site was sampled bi-weekly. The Year 1 time period refers to sampling dates between 1 August 2003 and 31 July 2004; the Year 2 time period refers to sampling dates between 1 August 2004 and 31 July 2005; the Both Year time period refers to sampling dates between 1 August 2003 and 31 July 2005.

	Time Period	Total Phosphorus (µg P/L)	Nitrate + Nitrite (mg N/L)	Total Suspended Solids (mg/L)	Total Kjeldahl Nitrogen (µg N/L)	Dissolved Sodium (mg/L)	Water Temperature (°F)	Temperature Corrected Conductivity (µS/cm^2)	pH	Dissolved Oxygen (mg/L)
Ide Road	Both Years	181.3 ± 10.1 (7.6 - 915.5)	2.00 ± 0.07 (0.47 - 4.50)	16.1 ± 2.4 (1.5 - 150.0)	803 ± 60 (75 - 3630)	59.41 ± 2.36 (29.23 - 145.22)	51 ± 1 (32 - 78)	629 ± 16 (322 - 1107)	8.3 ± 0.1 (7.0 - 10.6)	9.87 ± 0.41 (0.70 - 17.78)
	Year 1	186.4 ± 17.3 (7.6 - 915.5)	2.15 ± 0.11 (0.47 - 4.50)	15.8 ± 3.4 (2.0 - 132.1)	795 ± 64 (200 - 2810)	59.93 ± 3.41 (29.23 - 145.22)	51 ± 2 (32 - 74)	661 ± 26 (420 - 1107)	8.0 ± 0.1 (7.0 - 10.6)	10.01 ± 0.69 (0.70 - 17.78)
	Year 2	176.3 ± 10.6 (73.5 - 440.0)	1.86 ± 0.07 (0.86 - 3.74)	16.4 ± 3.3 (1.5 - 150.0)	810 ± 102 (75 - 3630)	58.89 ± 3.28 (31.30 - 135.12)	51 ± 2 (32 - 78)	602 ± 19 (322 - 971)	8.5 ± 0.1 (7.8 - 10.0)	9.73 ± 0.44 (5.06 - 14.73)
Stone Road	Both Years	240.9 ± 11.8 (52.9 - 778.4)	2.56 ± 0.13 (0.35 - 8.27)	16.6 ± 1.6 (0.1 - 87.3)	956 ± 91 (75 - 7160)	77.11 ± 3.94 (30.17 - 229.45)	52 ± 1 (33 - 76)	719 ± 24 (413 - 1822)	8.1 ± 0.1 (6.6 - 9.8)	8.61 ± 0.33 (1.46 - 15.30)
	Year 1	254.6 ± 20.6 (52.9 - 778.4)	2.52 ± 0.18 (0.35 - 8.27)	16.6 ± 2.3 (2.5 - 75.6)	909 ± 54 (75 - 1860)	76.95 ± 5.50 (31.64 - 224.07)	52 ± 2 (33 - 74)	765 ± 41 (440 - 1822)	7.7 ± 0.1 (6.6 - 8.2)	8.42 ± 0.54 (1.46 - 15.30)
	Year 2	227.0 ± 11.3 (80.6 - 516.5)	2.61 ± 0.18 (1.11 - 7.66)	16.5 ± 2.2 (0.1 - 87.3)	1004 ± 177 (290 - 7160)	77.27 ± 5.70 (30.17 - 229.45)	52 ± 2 (33 - 76)	677 ± 27 (413 - 1393)	8.5 ± 0.1 (7.7 - 9.8)	8.81 ± 0.36 (4.90 - 12.88)
Below The Dam	Both Years	164.3 ± 10.8 (15.6 - 559.7)	1.93 ± 0.15 (0.59 - 8.65)	9.5 ± 1.5 (0.2 - 59.5)	826 ± 70 (200 - 3230)	56.53 ± 2.83 (29.16 - 128.10)	52 ± 2 (32 - 77)	612 ± 15 (380 - 896)	8.0 ± 0.1 (6.8 - 8.9)	9.11 ± 0.55 (1.32 - 16.28)
	Year 1	177.4 ± 17.9 (15.6 - 559.7)	1.93 ± 0.13 (0.59 - 3.59)	9.6 ± 2.1 (0.2 - 51.7)	835 ± 77 (200 - 1800)	56.91 ± 4.55 (31.70 - 128.10)	52 ± 3 (32 - 74)	622 ± 21 (430 - 828)	7.8 ± 0.1 (6.8 - 8.7)	8.90 ± 0.89 (1.32 - 16.28)
	Year 2	151.3 ± 11.7 (21.3 - 353.2)	1.93 ± 0.27 (1.00 - 8.65)	9.4 ± 2.1 (2.2 - 59.5)	817 ± 117 (320 - 3230)	56.15 ± 3.46 (29.16 - 109.22)	53 ± 3 (32 - 77)	602 ± 22 (380 - 896)	8.2 ± 0.1 (6.8 - 8.9)	9.33 ± 0.64 (4.20 - 14.15)

Table 8. Daily discharge and loadings for the Ide Road, Stone Road, and Below the Dam sampling sites on Eighteenmile Creek for the period 1 August 2003 and 31 July 2005. Discharge is assumed to be the same for both the Ide Road and Below the Dam sampling sites.

Site	Discharge (m^3/day)	TP (kg/day)	Nitrate (kg/day)	TSS (kg/day)	TKN (kg/day)	Sodium (kg/day)
Ide Road	470,032	90	874	10,989	468	27,773
Stone Road	217,212	51	533	3,635	205	17,997
Below the Dam	470,032	70	908	5,370	378	29,582

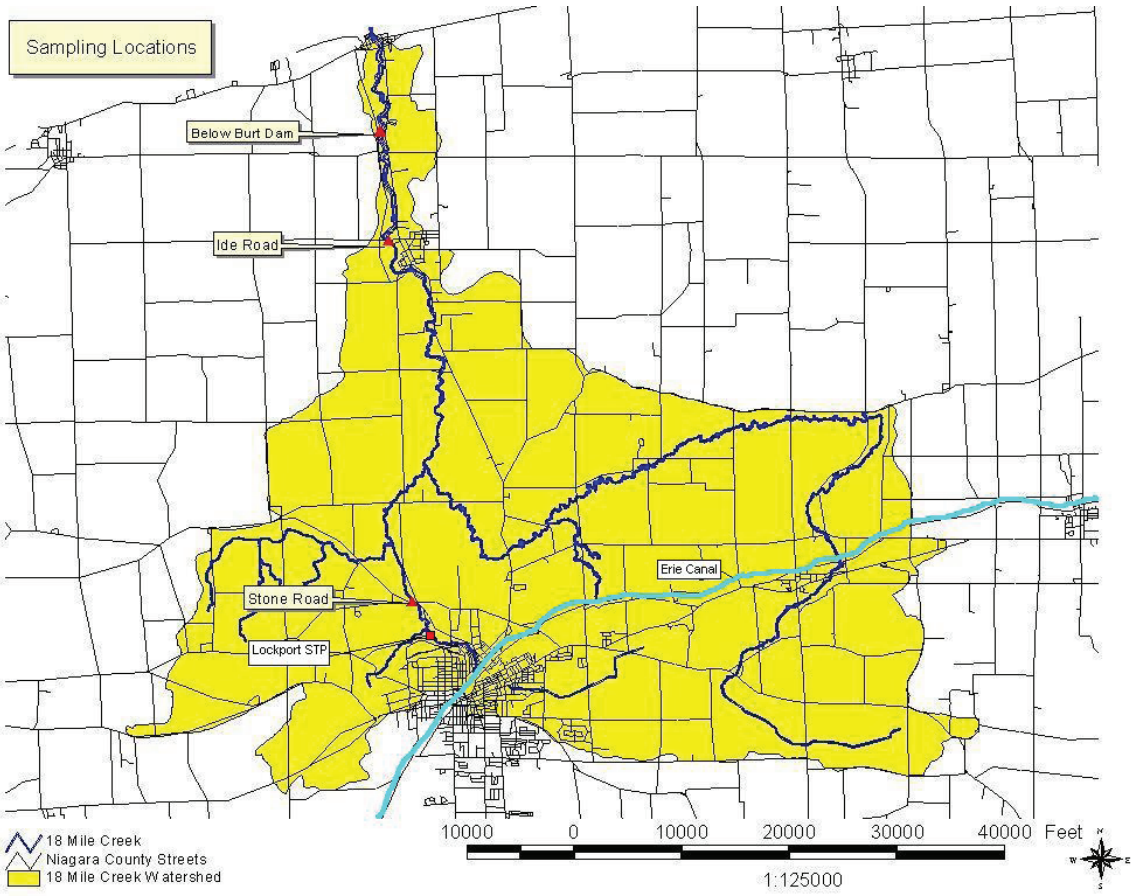


Figure 1. Map of Eighteenmile Creek showing the location of sampling stations at Ide Road in the Town of Newfane, Stone Road in the Town of Lockport and Below Burt Dam at Fisherman's park in the Town of Newfane. The map also shows the location of the City of Lockport's sewage treatment plant (STP) and the Erie Canal. The map was provided by the Niagara County Soil and Water Conservation District.

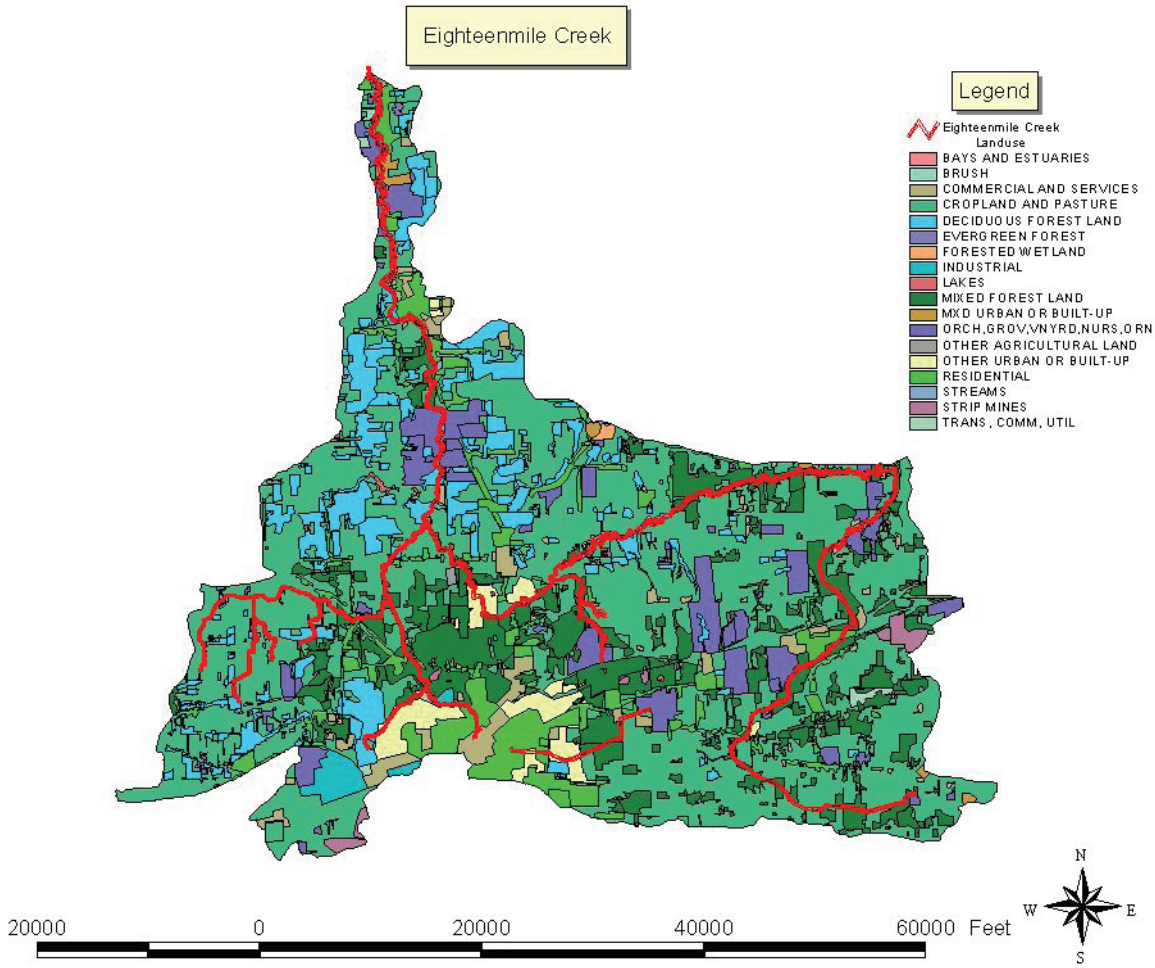


Figure 2. Map of the Eighteenmile Creek watershed showing the land use within its boundaries. The map was provided by the Niagara County Soil and Water Conservation District. Land use data is based upon 2002 Aerial photos, completed by Buffalo State College in 2004.

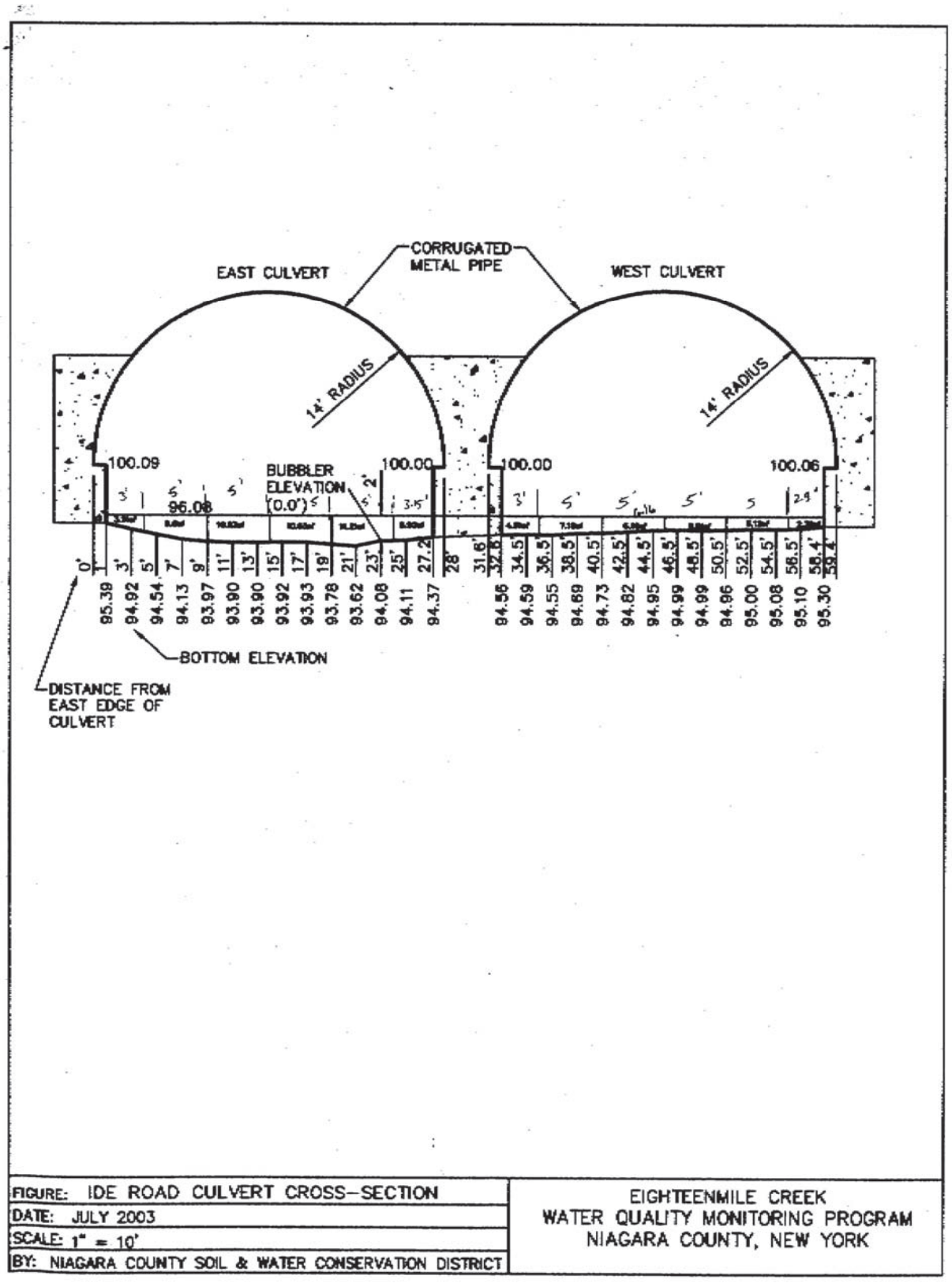


Figure 3. Survey of the Ide Road Culverts on Eighteenmile Creek performed by NCSWCD.

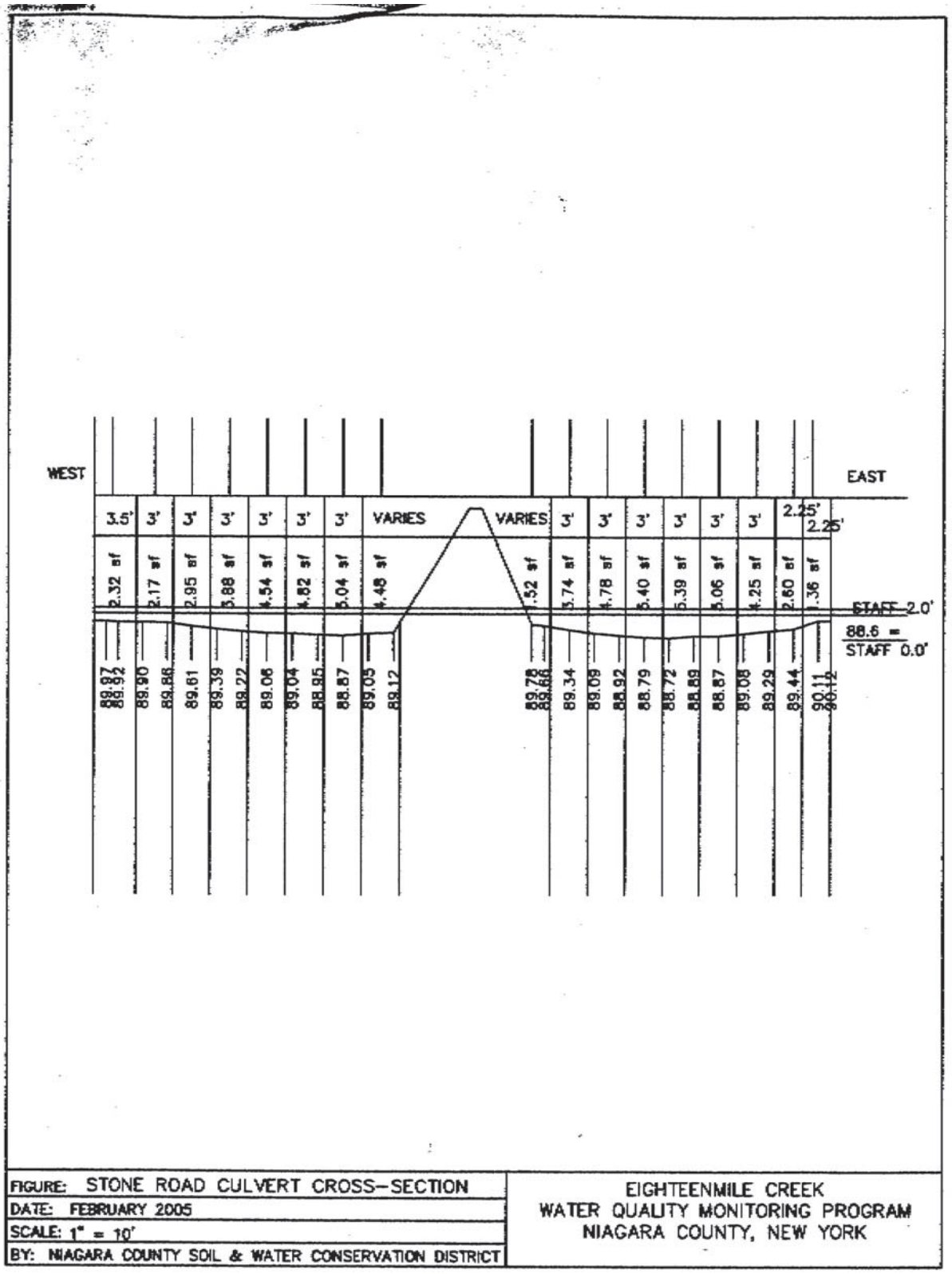


Figure 4. Survey of the Stone Road Culvert on Eighteenmile Creek performed by NCSWCD.

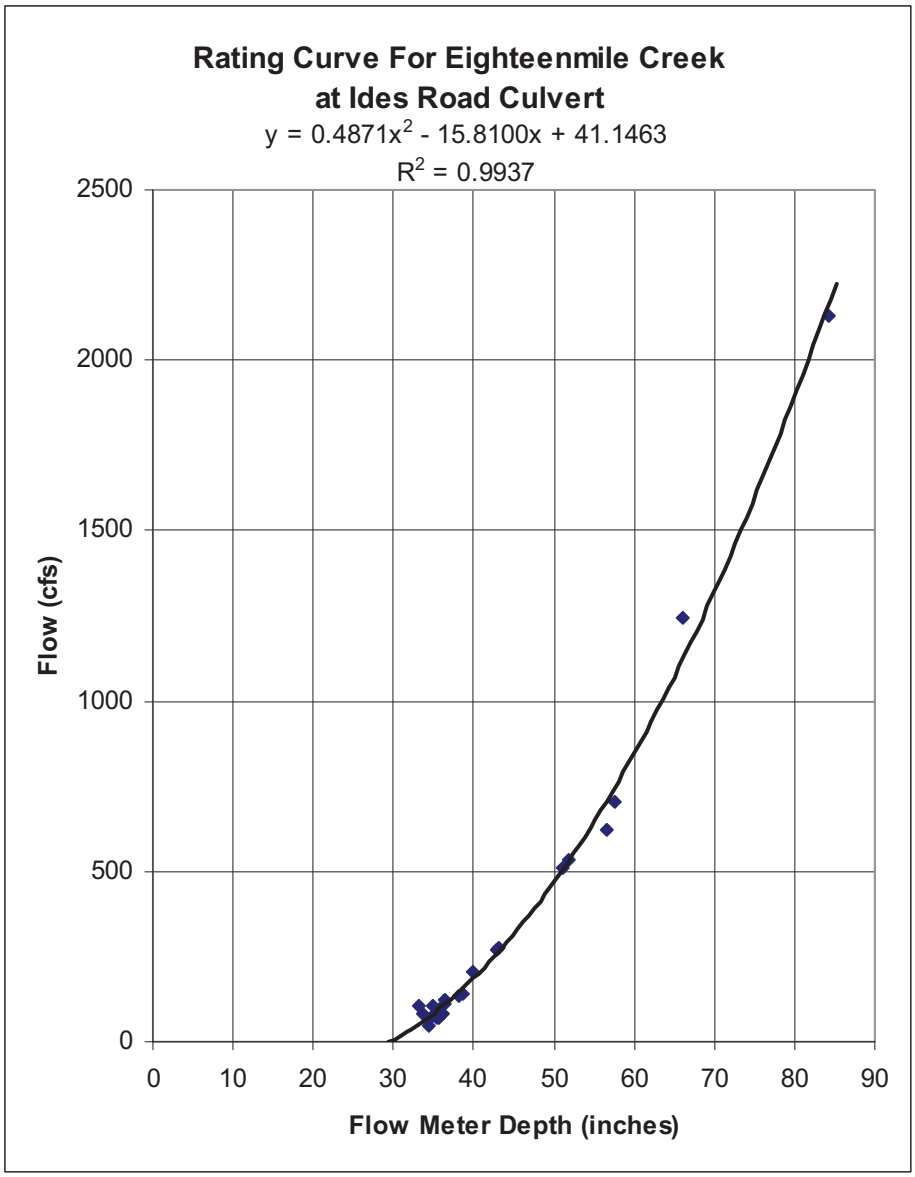


Figure 5. Eighteenmile Creek rating curve for the Ide Road monitoring station.

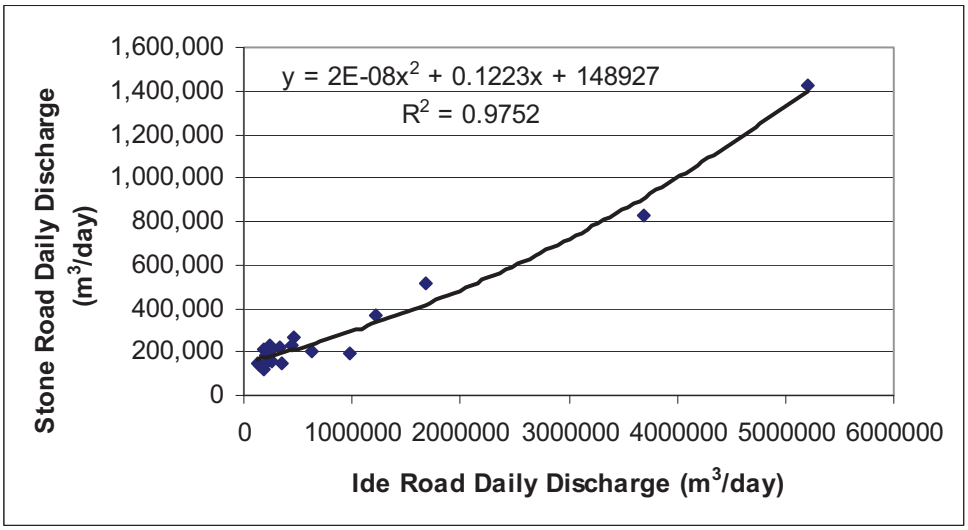


Figure 6. Plot of Ide Road daily discharge versus the Stone Road daily discharge. The equation of the trendline was used to predict daily discharge at the Stone Road sampling site on Eighteenmile Creek from daily discharge at the Ide Road sampling site on Eighteenmile Creek.

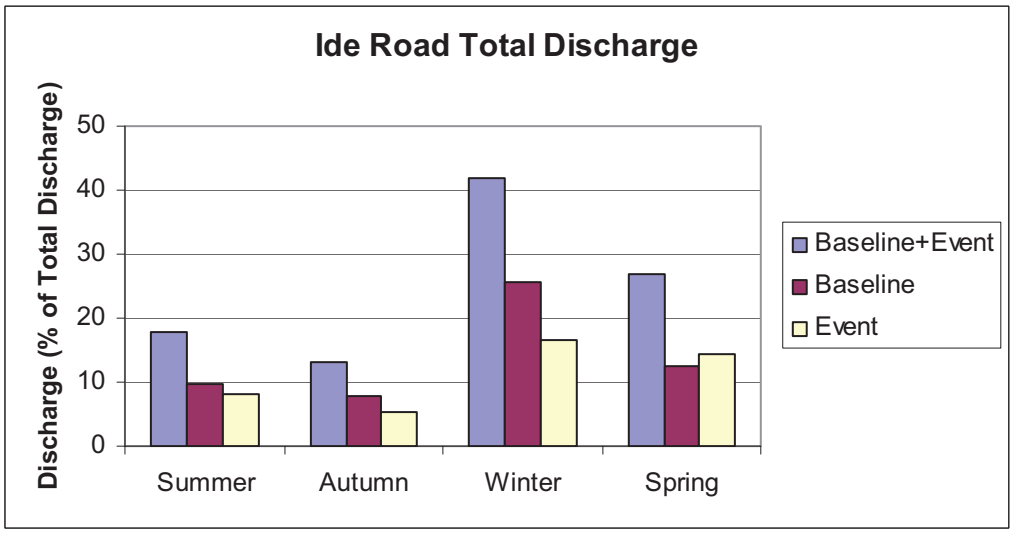


Figure 7. Seasonal discharge as a percent of the total discharge for the Ide Road sampling site on Eighteenmile Creek from 1 August 2003 to 31 July 2005.

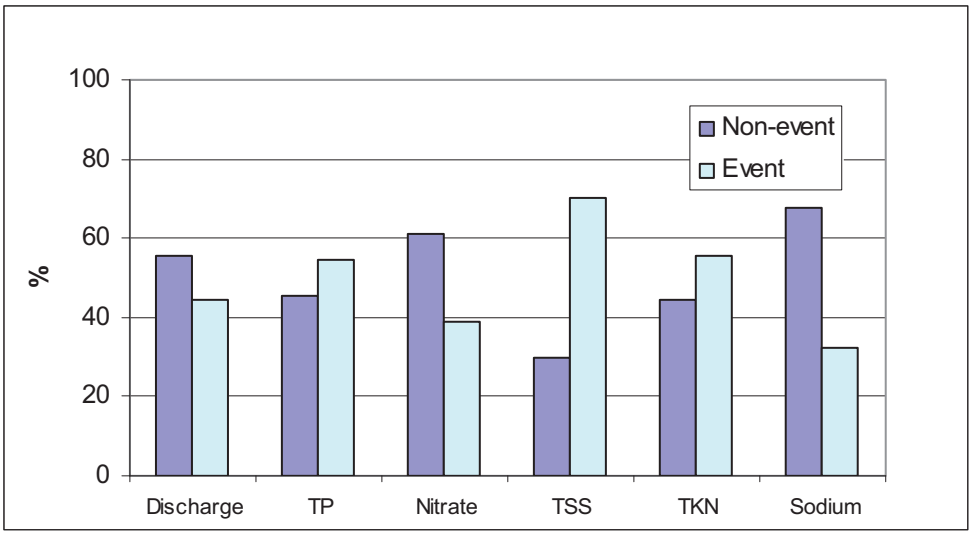


Figure 8. Percent of discharge and loss of material from the Eighteenmile Creek watershed (loading to Lake Ontario) during nonevent and hydrometerological event creek conditions between 1 August 2003 and 31 July 2005 at the Ide Road sampling site.

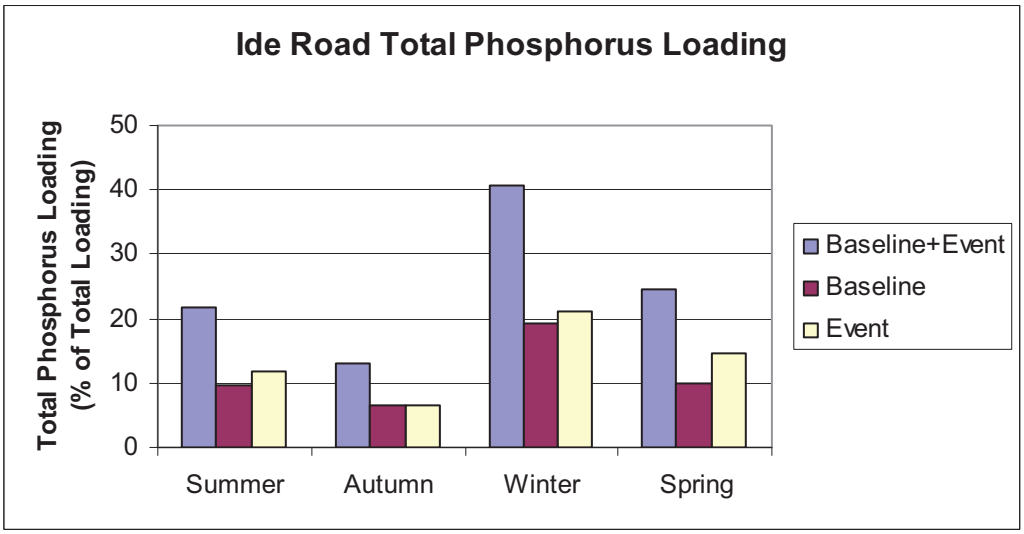


Figure 9. Seasonal total phosphorus (TP) loading as a percent of the total TP loading for the Ide Road sampling site on Eighteenmile Creek from 1 August 2003 to 31 July 2005.

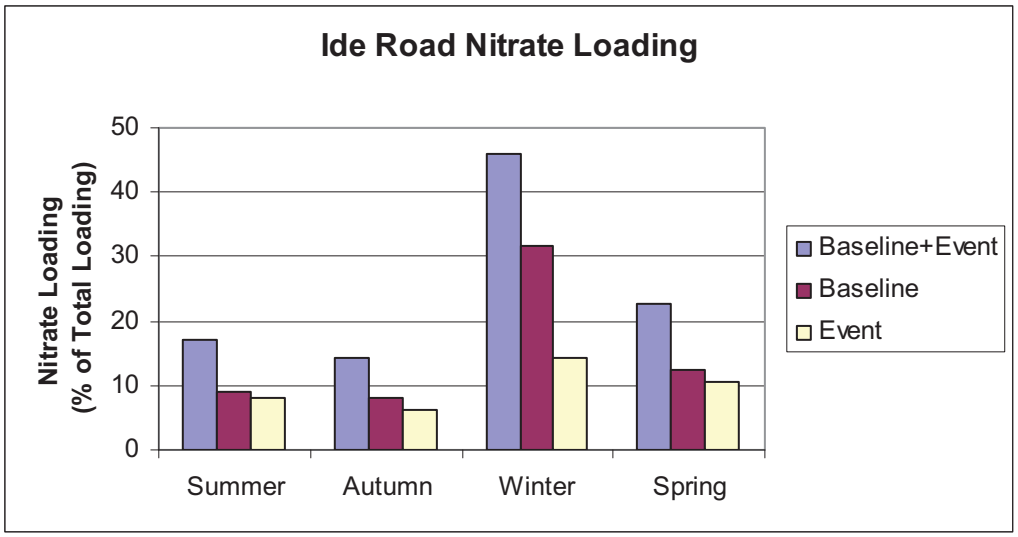


Figure 10. Seasonal nitrate loading as a percent of the total nitrate loading for the Ide Road sampling site on Eighteenmile Creek from 1 August 2003 to 31 July 2005.

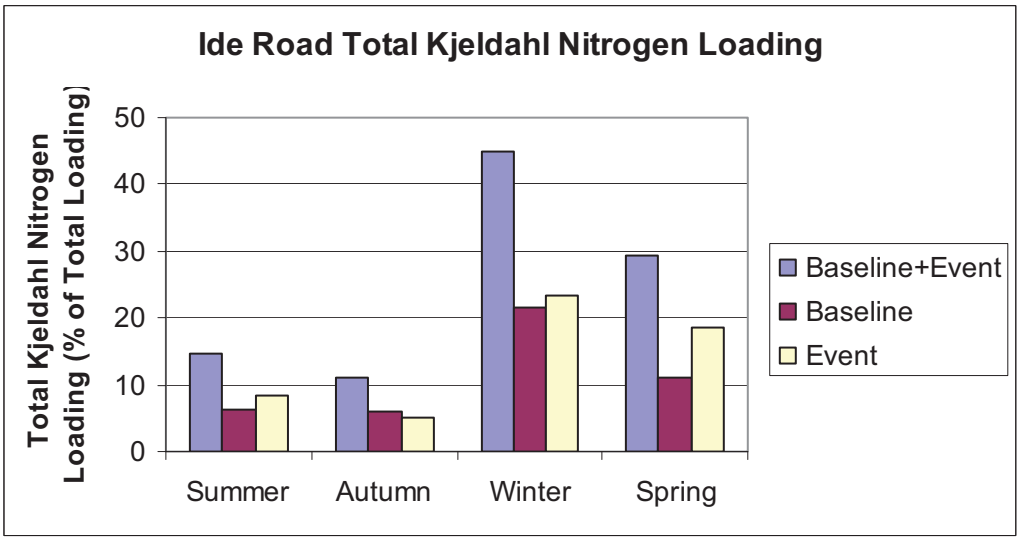


Figure 11. Seasonal total Kjeldahl nitrogen (TKN) loading as a percent of the total TKN loading for the Ide Road sampling site on Eighteenmile Creek from 1 August 2003 to 31 July 2005.

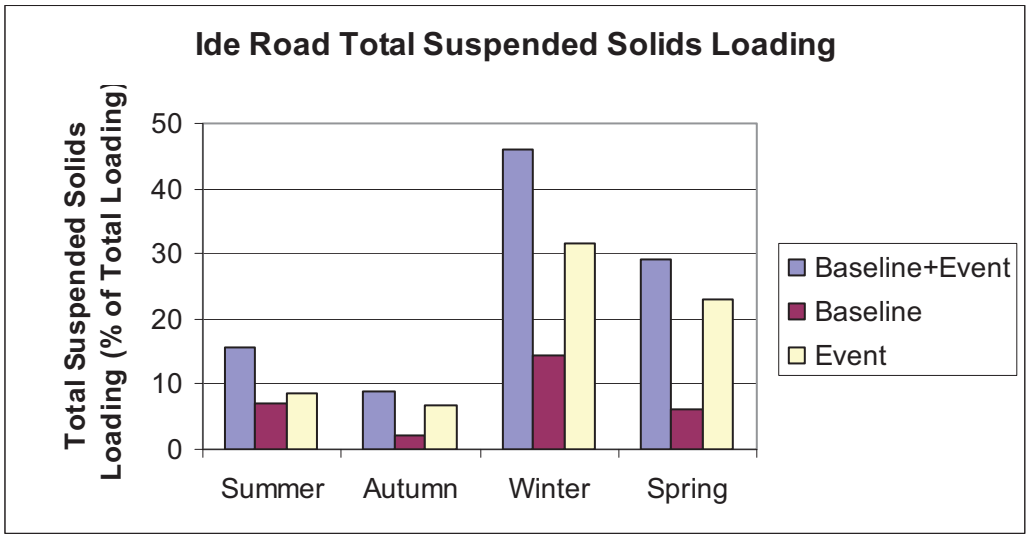


Figure 12. Seasonal total suspended solids (TSS) loading as a percent of the total TSS loading for the Ide Road sampling site on Eighteenmile Creek from 1 August 2003 to 31 July 2005.

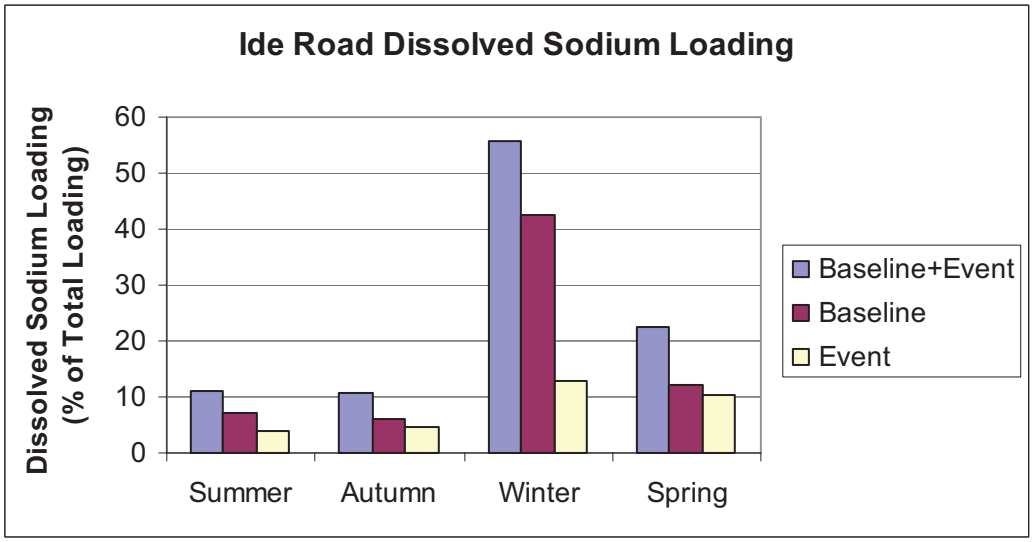
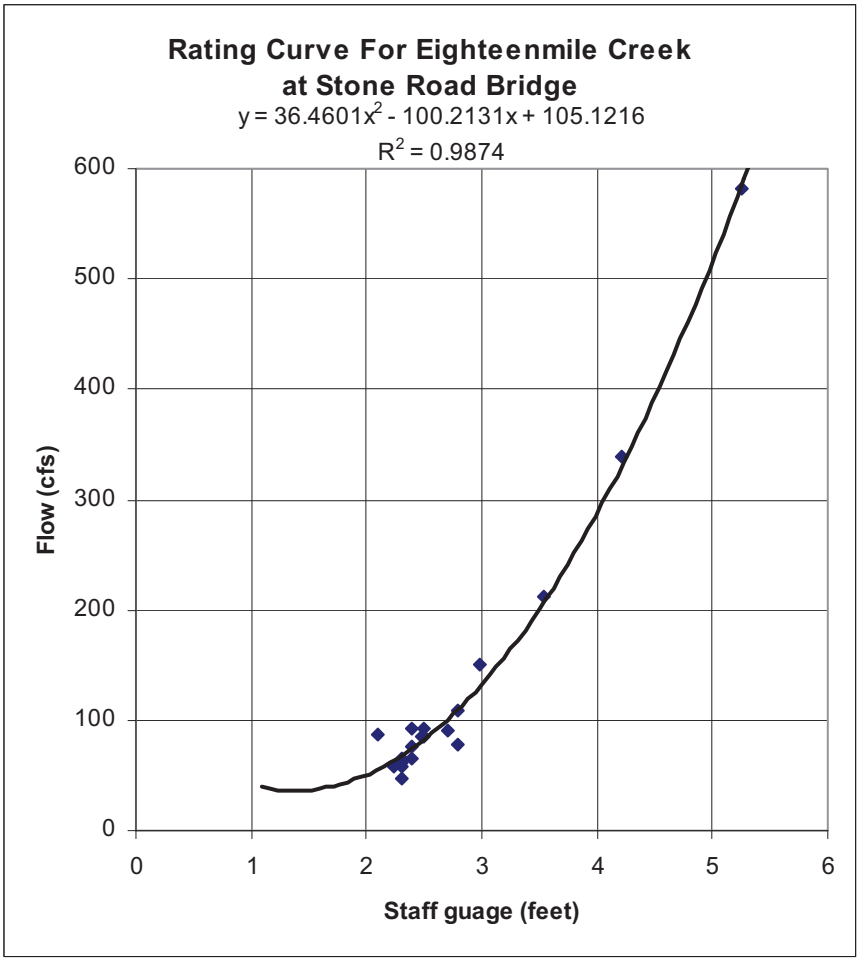
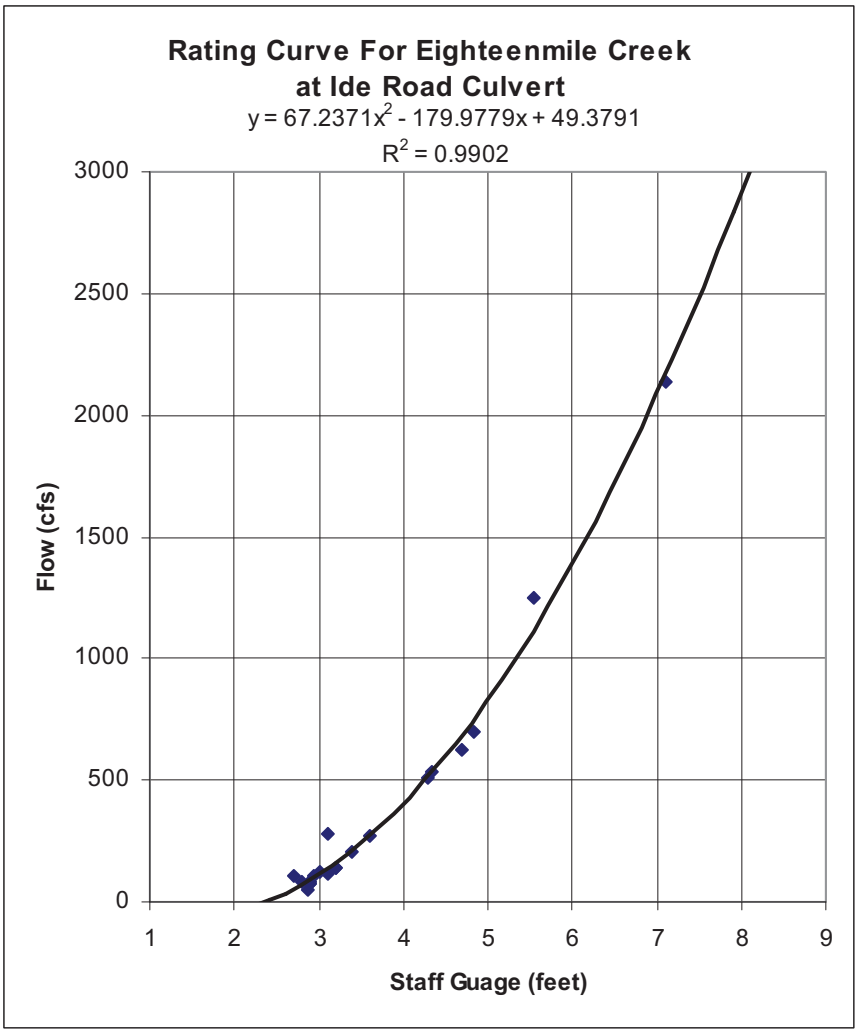


Figure 13. Seasonal sodium loading as a percent of the total sodium loading for the Ide Road sampling site on Eighteenmile Creek from 1 August 2003 to 31 July 2005.



Appendix 1. Rating curve for the Eighteenmile Creek site at Stone Road. The predictive discharge curve references the staff gauge installed on the bridge culvert.



Appendix 2. Rating curve for the Eighteenmile Creek site at Ide Road. The predictive discharge curve references the staff gauge installed on the culvert.