Environmental Impact Assessment and Stressed Stream Analysis Report

Prepared as part of the NSF-sponsored
Stressed Stream Analysis Workshop
at SUNY Brockport

May 31 – June 22, 1997

by
Blue Team Members:

Michel Boudrias
Larry Kolenbrander
Janet MacFall
Cynthia Moulton
Yangdon Pan

Sewage Treatment Plant Expansion, Northrup Creek, Spencerport NY
Environmental Impact Analysis
CAASA/NSF Stressed Stream Analysis Program

Project Description

The Village of Spencerport is proposing to double the capacity of its Sewage Treatment Plant (STP) to further residential and commercial development in the community. As the population in the Village of Spencerport continues to increase, the need for more sewage treatment capacity is eminent. In addition, the Lead Recycling Group, Ltd. (LRG) plans to build a facility in Spencerport to recycle lead from car batteries and expects to discharge about 2 kg of lead per day to the STP. The SAASA/NSF Stressed Stream Analysis participants have been contracted by the Village of Spencerport to prepare an Environmental Impact Assessment for the proposed STP expansion. A separate consulting firm has been hired to conduct the EIS on the proposed lead recycling facility.

Environmental Setting

Currently, the STP is located along Northrup Creek, a Class C stream (NYSDEC 1991) in the Village of Spencerport (Figure1). The creek is a second order stream with headwaters south and southwest of the village and extends under the Erie Canal continuing northeast mainly through agricultural land, suburban residences, and woodland to Long Pond (Table1 and 2). Stream discharge for Northrup Creek varied from 0.18 m^3/s to 0.25 m^3/s during the 1997 study period. Mean monthly discharges and daily maximum discharge for Northrup Creek for water years 1984 through 1993 are shown in Figure 2 and Table 3. The STP facility has a current capacity to receive flows of 1,000,000 gal/day, but averages 750, 000 gal/day. After secondary treatment, the STP discharges an average of 600,00 gal/day (range = 200,000 - 2,000,000 gal/day) effluent to the Creek northeast of the Village off Big Ridge Road (Haynes Project Information, 1997). Raw sewage overflows, usually following storm events, are rare. Sludge created at the plant is transported to Monroe County's Northwest Quadrant WWTP on Lake Ontario where it is processed and burned. The SPDES (1986) permit for the Spencerport STP requires daily monitoring for ammonia, BOD, coliform bacteria, pH and suspended and settleable solids. Flocculation procedures to reduce phosphorus began in 1996 because of concerns about eutrophication in Long Pond. Annual monitoring for metals, including lead, is also required but lead has not been identified above the limits of detection.

Currently, the watershed displays a mix of rural and suburban land uses with a substantial growth potential related to industrial areas of Rochester located about 25 miles to the east. The expansion of Highway 531 has been integral in the westward trend of development from Rochester towards Spencerport (Joe Makarewicz, pers. Com.). From 1980 to 1990 growth in the surrounding towns has ranged from 5 to 15% (SSA Green Monster, 1997) and is expected to continue and potentially increase in the future. Census data (1990) revealed that 3,606 persons reside in the Village of Spencerport with 1,302 households (1990 Census Lookup, http://venus.census.gov/cdrom/lookup/866734514).

Table 1. Areas in Land Use Types above Big Ridge Road Sampling Site*

Land Use Type	**Area (hectares)**	**Percent**
Woodland	386.12	29.48
Shrubland	51.87	3.96
Cropland	338.48	25.83
Pasture	62.48	4.77
Orchard	2.88	0.22
Residential	288.24	22.00
Municipal	109.34	8.34
Industrial	0	0
Wetlands	18.44	1.41
Gravel Pit	16.63	1.26
Ponds	5.97	0.45
Barge Canal	8.83	0.67
NY 531	20.64	1.16
Total	1309	100.

*(Karl Korfmacher, 1997)

Table 2. Areas in Land Use Types above Dean Road Sampling Site*

Land Use Type	**Area (hectares)**	**Percent**
Woodland	538.82	28.99
Shrubland	118.02	6.35
Cropland	427.45	23.00
Pasture	161.62	8.69
Orchard	2.88	0.15
Residential	402.09	21.64
Municipal	124.59	6.70
Industrial	26.69	1.43
Wetlands	18.34	0.98
Gravel Pit	8.40	0.45
Ponds	8.83	0.45
Barge Canal	8.82	0.47
NY 531	20.64	1.19
Total	1858.4	100

*(Karl Korfmacher, 1997)

Anticipated Project Impacts

Positive Impacts

The following positive impacts could result from the doubling of the Spencerport STP:

(A) Economic Development
(B) Reduction of Non-point source pollution from septic systems
(C) STP effluent could add carbon to the currently carbon limited stream ecosystem
(D) Change stream habitat and enhance community dynamics

Economic Development. At this time the Spencerport STP is near capacity and no further residential development may connect into this system (Jim Haynes, pers com.). By doubling the capacity of the STP, the Village of Spencerport will, in effect, be able to manage and plan ahead for subsequent residential and commercial development. Most towns and cities do not have this benefit and thus deal with increased service needs such as waste removal and treatment after the population has already exceeded the standards set for processing. By acknowledging that this growth is not only inevitable but advantageous in terms of tax base, conspicuous consumption, economic progress, and employment potential in the surrounding areas, Spencerport can establish a planned community and preserve its rural charm while supporting the basic service needs of its citizens. The increased capacity of the STP could also entice new businesses to establish themselves and encourage existing businesses and industries to relocate to Spencerport, further enhancing the village's tax base and employment possibilities.

Reduction of Non-point Source Pollution. The Spencerport STP which has been operating since 1931 (Berg 1983) does not exceed any criteria in its NPDES permit and appears to be adequately purifying its effluent discharge (especially since the new phosphorus flocculation procedures - See Appendix I). An increased capacity of sewage treatment would allow existing households and developments with septic systems to essentially hook into the established Spencerport system. The Northrup Creek watershed consists of relatively deep, fine-grained, till plains and sandy lake and shoreline sediments. The two major soil types found in the watershed, Madrid-Messina and Colonie-Elnora-Minoa soil associations support poor drainage and have moderate to severe erosion hazard limitations (see Appendix I). Although the soil type does not prohibit the use of septic systems, they are limited and require additional (and sometimes costly) engineered solutions in septic design. Some houses have old septic systems that were built before the limitations of these systems were realized and do not adequately support the capacity of the household. In other situations, leaking or overflowing septic systems can result in discharges of raw sewage into wetland habitats, usually containing biologically hazardous materials such as fecal coliforms and associated bacteriaphages. Thus far, in addition to effectively removing the inorganic nutrients, the Spencerport STP has been eliminating much of the microbiological organisms and organic carbon (see Appendix I) before discharging effluent into Northrup Creek. If the STP continues to do so, effluent discharge could actually be of higher quality than the water flowing in the stream. This could help to dilute the non-point source pollution and excess nutrients while enhancing the overall water quality in the northern part the stream and Long Pond.

Negative Impacts

The proposed doubling of the Spencerport Sewage treatment Plant (STP) accompanied by a connection to a battery recycling plant producing lead waste could potentially have many serious negative impacts to Northrup Creek, the surrounding watershed, and as far away as Lake Ontario. The negative impacts can be seen in changes in air quality, water quality, and landscape quality on a regional scale. There are even some potential international implications from this proposed project.

Air Quality. Increased smell from STP and potentially from associated lead recycling plant.
Mitigation: sludge removal could be done in low wind conditions and lead plant should have strong scrubbers.

Water Quality. Increased lead concentration and loading in the stream and adjoining watershed may result in problems with lead seeping into groundwater supplies, may increase the number and seriousness of macroinvertebrate mouthpart deformities, and may result in biological magnification of heavy metal contamination in fish feeding on stream macroinvertebrates. Increased phosphate and nitrate concentrations in the stream and adjoining watershed may lead to potential microbial and algal blooms and to continued eutrophication of the watershed. Increased incorporation of lead and phosphorous in the sediments could result in to potential problems in the benthic communities of macroinvertebrates and fish. These chemical features per se would not be a problem but their effect on the habitat will lead to reduced health of the communities.
Mitigation: Increased flocculation of solid phosphorus and tertiary treatment of sewage.

Organics. A increased availability of organic carbon because of the doubling of the capacity of the STP and the increased demand on the STP resulting in less efficient removal of organic carbon. This would remove the major carbon limitation and lead to increases in microbial and viral abundance and activity.
Mitigation: increased efficiency of secondary treatment or move to tertiary treatment.

Aesthetics. Increased nutrients could result in large algal blooms as well as increased aquatic vegetation changing the aesthetic of the stream
Mitigation: Increased efficiency of secondary treatment or move to tertiary treatment.

Land. Increased development will continue the change in land use toward a more commercial and residential landscape. More hard surfaces will lead to more runoff from land, less retention of soils and chemicals, and additional non-point source pollution to the watershed. More development will also lead to more automobile traffic, more noise, and more emissions affecting air quality.
Mitigation: unknown.

International Effects. Increased lead and nutrient loading to the stream and adjoining watershed will eventually affect Long Pond and Lake Ontario. Canadian fisherman could potentially gather contaminated fish that have been affected by the increases in heavy metals and associated bacterial numbers.
Mitigation: Close monitoring of the physical/chemical inputs, and continuous assessment of the fish populations is essential to avoid a potentially major international incident.

Direct and Indirect Consequences:
(A) Human health concerns with the potential of lead contamination in drinking water because of groundwater seepage and surface wells.
(B) Potential of higher bacterial and viral counts in drinking water and in ponds and lake with the potential for recreational activities.
(C) Human health concern with feeding on large invertebrates, like crayfish, which may show signs of contamination from excess lead.
(D) Human health concerns in feeding on contaminated fish in stream, Long Pond, and lake Ontario. Will exacerbate an already serious problem.
(E) Socioeconomic problem because of people who depend on fish as a major part of their diet. Excess lead and higher bacterial and viral counts could lead to contaminated fish, fish with lesions or tumors, or even reduce fish abundance. This is a particularly serious problem for people in lower tier of the socioeconomic class structure.

Unavoidable Adverse Impacts
1. Increased lead
2. Increased phosphorus and nitrogen
3. Increased development and land use change
4. Continued hyper-eutrophication of Long Pond and Lake Ontario

The two major unavoidable negative impacts are increased levels of nutrients and increased development and land use change around Spencerport.

Increased Nutrient Load. The Sewage Treatment Plant (STP) is already contributing high phosphate and high nitrate loading to the Northrup Creek and the adjoining watershed (See Appendix I). Even without a change in the effluent discharge, Northrup Creek has been deteriorating over time and contributing to the eutrophication of Long Pond and Lake Ontario (see Appendix I). The proposed project would increase lead loading to the watershed and increase phosphorus and nitrate loads as well. This may accelerate the deterioration of this stream and watershed. Even increased flocculation which has substantially reduced the phosphate concentrations in the stream from 1995 to 1997 (See Appendix I) will not be enough to mitigate the increased concentrations of nutrients in the watershed. Dissolved lead levels were generally quite low in 1997 (See Appendix I) but data from the MAPb (Mothers Against Lead) from other streams (See Appendix I) and projected lead loading levels (See Appendix I) for Northrup Creek show excess lead in the water which will lead to detrimental ecological effects. Even if the Village of Spencerport connects to the main sewage line in order to reduce its input to the watershed, the increased development in the area may lead to increase runoff and more non-point source pollution.

Increased development and land use change. The area around Spencerport is growing rapidly (J. Makarewicz, pers. comm.) and new developments are being built near the existing STP (pers. obs.). Though many homes in the area use septic tank systems, continuing development may saturate the existing soil allocations for septic systems or may cause more non-point source overflows. The demands of new developments on the existing sewage treatment operation will continue to increase and may reduce the efficiency of the Spencerport STP. This will result in more nutrients in the stream, the potential for more lead if the project is approved, and the potential for more organic matter. The increased runoff from all the new homes and associated commercial enterprises may also increase nutrient load, heavy metal and hydrocarbon contaminants, pesticides, fertilizers, and possibly organic matter due to defective septic systems. The potential increase in organic matter may lead to increases in bacteria, viruses, and algae. These ecological changes would have dire consequences on the stream and the watershed. Even without the project or any of its alternatives, the increase in new homes and the potential for more non-point source pollution events may be inevitable.

Description of Alternatives

Three alternatives have been considered in the environmental impact analysis of the Spencerport's proposed treatment plant expansion. Alternative one is designated as the "No Project" alternative. Alternative two is the proposed expansion of the Spencerport Wastewater Treatment Plant (SWWTP). Alternative three is defined as the attachment of existing and future wastewater collection systems to the regional wastewater treatment system with treatment to occur at the Monroe County Northwest Quadrant Waste Water Treatment facility.

Alternative one, or the "No Project" alternative would provide a future condition in which there would be no changes in the current sizing (1 MGD) or operation of the SWWTP. The plant would continue to operate under its current discharge permit and effluent standards. This alternative would have the effect of limiting future growth in the Spencerport area due to existing restrictions on the use of "on site" septic disposal systems(J. M. Haynes, pers. Comm.)

Alternative two would provide a wastewater treatment facility with double the current capacity (2 MGD). The facility would be sized to accommodate the additional discharge expected from the lead recycling factory proposed to be built by the Lead Recycling Group, Ltd. (approximately 200,000 gallons per day) and to provide excess capacity for future growth in population in the Spencerport treatment collection area. The expanded treatment facility would be located at the site of the present SWWTP and would require approximately twice the current land area. The operation of the plant would meet New York State SPDES standards for discharge into class "C" receiving waters. Additional standards and testing would be required in order to ensure compliance with aquatic organism propagation standards (NYSDEC, 1991) which are calculated to reach a maximum concentration of 6.5 ppb (Makarewicz, 1989) in the receiving waters of Northrup Creek.

Alternative three is defined as the attachment of all existing and future wastewater collection systems to the regional Monroe County Northwest Quadrant Wastewater Plant. Under this alternative all wastewater generated within the Spencerport area would be collected by a regional collection system and would be transported to the Monroe County facility for treatment.

Impact Assessment of Alternatives

Negative Impacts of Alternative One:
1. Continued discharge of nutrients into Northrup Creek and ongoing negative effects on Long Pond which is already hypereutrophic (Makarewicz, J.C., et. al, 1990).
2. Limits on future growth in the Spencerport area.

Positive impacts of Alternative One:
1. Limits on future growth in the Spencerport area

Negative impacts of Alternative Two:
1. Land disturbance related to construction.
2. Continued discharge of nutrients (nitrogen and phosphates) into Northrup Creek that will add to the already hypereutrophic trophic state of the ultimate receiving waters of Long Pond.
3. The addition of 130 grams of lead per day into the Northrup Creek and Long Pond ecosystems.
4. Allows continued growth in the Spencerport area with attendant problems of increased air pollution, water pollution from home herbicide, fertilizer and pesticide use.
5. Costs associated with the expansion will likely result in increased taxes or monthly treatment charges to homeowners.
6. Does not solve the problem of existing on-site septic systems that may be contributing to groundwater pollution and migration of pollutants into the surface stream systems

Positive impacts from Alternative two:
1. Allows for the continued growth and development in the Spencerport area. With increases in local tax base.
2. Continued reduction in Agricultural land uses that may be contributing substantial nutrient loadings to streams from non-point sources.
3. Increased employment in local area which may reduce traffic congestion and attendant impacts from travel to Rochester area.

Negative impacts from Alternative three:
1. Allows continued growth in Spencerport area with attendant problems
2. High costs ($40 Million) will cause increases in taxes or monthly treatment costs to homeowners.

Positive impacts from alternative three:
1. Allows for continued growth in Spencerport area with increases in local tax base

2. Reduction in nutrient loads in Northrup Creek and Long Pond.
3. Potential reduction in non-point nutrient loads from reduction in agriculture as lands are converted to residential use.

Nutrient Loading to Northrup Creek with Proposed Plant Expansion

The Village of Spencerport within the Town of Ogden has proposed expansion of the currently existing wastewater treatment plant to accommodate a local increase in population and industry. To support this development, they have proposed 1) increasing the capacity of the plant from 1 MGD (3788 m^3) to 2 MGD discharge into adjacent Northrup Creek. Discharges of water under present and proposed future conditions are shown in Table 3.

Table 3. Average Measured Daily Discharge and Predicted Discharge from the Plant and Northrup Creek.

Discharge Site	Discharge (m^3/day)
Northrup Creek above STP	18,432
Discharge from STP (daily mean)	2,271
Current Max. allowable from STP	3,788
Proposed Max. allowable from STP	7,576
Northrup Creek below STP	20,703
Northrup Creek below STP at current capacity	22,220
Northrup Creek Below STP at proposed maximum	26,008

Based on current and present water discharges, predicted discharges for phosphate, nitrate and lead and concentrations for these compounds and elements were calculated (Table 4).

Table 4. Nutrient Discharge and Concentrations in Northrup Creek under Present STP and Proposed STP Expansion.

Source	PO_4 Discharge (g/day)	NO_2 Discharge (g/day)	PO_4 Conc. (µg/L)	NO_2 Conc. (µg/L)
Present Northrup Creek	1830	19,394	88	936
Northrup Creek at max. allowable discharge	3037	32,194	136	1448
Northrup Creek proposed max. allowable discharge	6039	64,000	232	2461

Under the New York State Standards (NYSDEC 1991), neither phosphate (1 mg/L) nor nitrate (1 - 2 mg/L is considered good) would exceed state recommended standards when the plant is running at full capacity under both present conditions and with expansion.

For lead, however, under current conditions lead levels in Northrup Creek do not exceed the state recommended allowable concentration of 6.5 µg/L (Table 5). However, the proposed expansion has been requested to support construction of a manufacturing plant expected to discharge lead contaminated effluent for treatment by the Spencerport Wastewater Treatment Plant. Although the proposed plant will include facilities for recycling of lead in the waste stream, they still expect to discharge an additional 0.2 MGD (757 m^3/day) containing 0.75 mg/L of lead. This calculates to a discharge of 568 g/day of lead. Assuming that there are no additional modifications to the facility to improve removal of lead from the effluent, if this lead is discharged to Northrup Creek, the predicted concentration of lead in the creek downstream of the waste water plant would be 21.8 mg/L. This concentration is in excess of the guidelines recommended by the state of 6.5 mg/L.

Table 5. Microbial analyses for total coliforms in Colony Forming Units (CFU) /100 ml, fecal coliforms in Colony Forming Units (CFU) /100 ml, coliphage in Plaque Forming Units (PFU)/100 ml, and Assimilable Organic Carbon (AOC) in µg/liter from samples of Northrup Creek water on June 3, 1997.

Sampling sites	**Colilert**		**Membrane filtration**		**Coliphage**	**AOC**
	Total	**E. coli**	**Total col.**	**Fecal col.**		
Big Ridge Rd	+	+	230	210	4	129
Upstream STP	+	+	350	159	1	178
Downstream STP	+	+	310	160	4	118
Dean Road	+	+	1200	120	0	147

There are two options available to the manufacturing facility for reducing the lead waste stream. The first is to reduce the volume of discharge from 758 m^3/day to 173 m^3/day, assuming the concentration of lead in the effluent water remains the same. Alternatively, they can reduce the concentration of lead in the effluent stream from 0.75 mg/L to 0.17 mg/L, effectively reducing the loading rate to the waste water plant to 130 g/day. Exceeding this discharge rate would cause the concentrations of lead in Northrup Creek to exceed recommended standards.

Figure 1. Map of Northrup Creek showing study sites, June 1997.

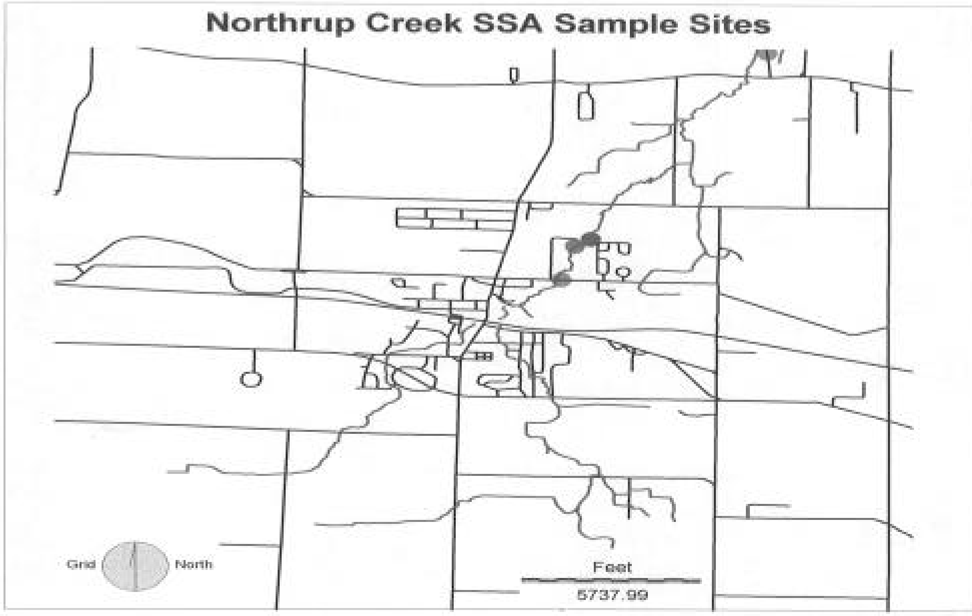
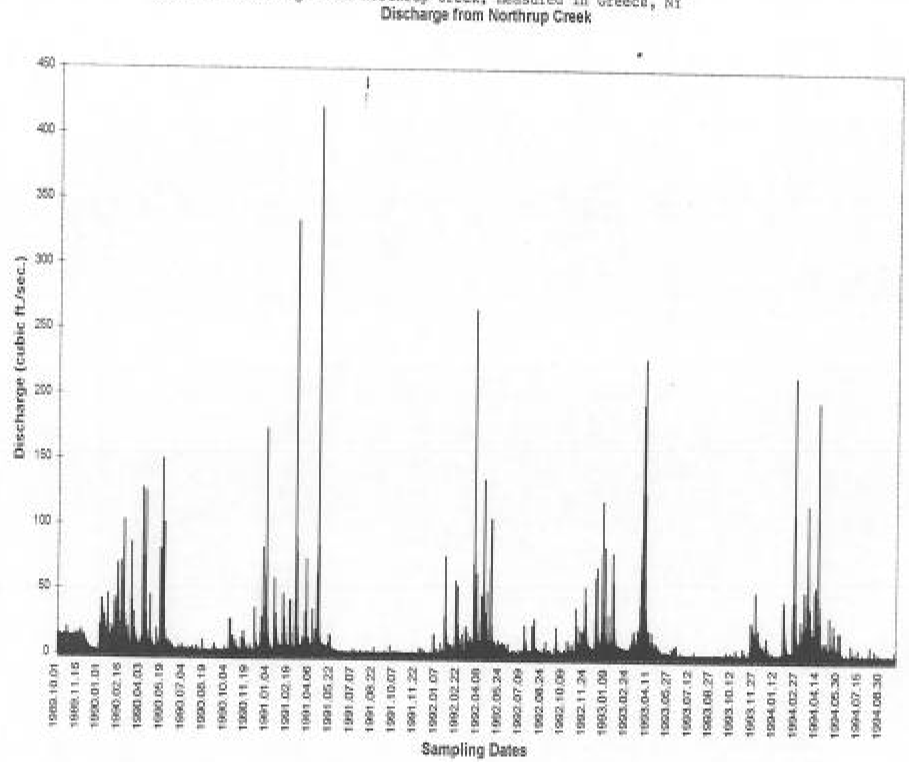


Figure 2 Discharge from Northrup Creek, measured in Greece, NY



Appendix I

Stressed Stream Analysis Report

Prepared as part of the NSF sponsored
Stressed Stream Analysis Workshop
SUNY Brockport

May 31-June 22, 1997

By
Blue Team Members:

Michel Boudrias
Larry Kolenbrander
Janet MacFall
Cynthia Moulton
Yangdong Pan

Introduction

The Stressed Stream Analysis 1997 program is the third incarnation of a program designed to provide faculty with the opportunity to learn new field and laboratory techniques in the context of stream ecology. The program is designed as an integrated view of a particular stream within a large watershed. A group of 20 faculty were divided into 4 working groups each responsible for analyzing a portion of Northrup Creek, a second order stream in northwestern New York. Three groups were clustered around the Spencerport Sewage Treatment Plant (STP) along a South to North transect while a fourth group focused on a site further down Northrup Creek in order to provide us all with a perspective on watershed effects. All four teams cooperated on the collection of the data with the purpose of producing a Stressed Stream Analysis report and a separate Environmental Impact Statement (EIS). The main objectives of the SSA were:

1. to characterize each site
2. to assess water quality (Soluble Reactive Phosphorus, Nitrate, Dissolved Lead)
3. to measure biotic indices (Microbial, Macroinvertebrates, Fish)
4. to develop landscape scale maps of the watershed
5. to integrate the data over spatial and temporal scales

The major emphasis of the Stressed Stream Analysis concept is an integrated approach to stream ecology. Following our objectives, we learned to use a suite of field and laboratory techniques to gather a matrix of data. By combining physical and chemical characterization of the Northrup Creek with several biological indicators of potential stress, we could attempt to determine the natural conditions in the stream and the potential effect of the Sewage Treatment Plant. The goal of this report is to compare the various stress indicators we have measured, to integrate the physical and biological data, and to place our data within the larger landscape of the watershed. This report will also serve as the scientific backbone to our EIS addressing the potential effects of a lead battery processing plant.

The BLUE team was assigned the task of characterizing the site downstream of the STP. Using the data we collected at our sampling site as well as the data at the three other sites (Big Ridge Road, Upstream of the STP, and Dean Road), we have integrated the physical, chemical, and biological data to provide some evidence on the potential state of health of Northrup Creek. The framework of this report follows three major themes: (1) a general description of individual analyses and data for the sites along Northrup Creek; (2) a comparison of the integrated physical, chemical, and biological data for sites above the STP (the natural or background stream characteristics) and those below the STP (sites presumably affected by the effluent); and (3) a temporal comparison of the integrated data for all sites for the years 1993, 1995, and 1997. The report will have individual analysis components and a common discussion and recommendation section.

General Watershed Description

The 1997 Stressed Stream analysis was performed in the southern portion of the Northrup Creek Watershed south of West Ridge Road (Fig. 1). Surficial geology of the study area is a result of Wisconsinan Glaciation and consists of relatively deep, fine-grained, till plains and more sandy lake and shoreline sediments. The Madrid-Messina soil association consists of deep, fine grained sediments that are poorly drained and have moderate to severe erosion hazard limitations. The Colonie-Elnora-Minoa soil association consists of medium to fine grained lake sediments that are excessively to poorly drained and have severe erosion hazard for disturbed soils. These deposits have weathered into soils ranging from fine sandy loams to silt loams to very fine silt loams (U.S. Soil Conservation Service, 1973).

The watershed area currently displays a mix of rural and suburban land uses (Fig. 2, Tables 1 and 2). This area is exhibiting substantial growth related to the industrial areas of Rochester located about 25 miles to the east. Population growth in the surrounding area from 1980 to 1990 ranges from about 5% for the city of Spencerport, to 11.4% for Greece, 12.6% for Parma, and 15% for Ogden (Haynes et al., 1997). The opening of New York highway 531 has been a major impetus for growth west of Rochester (Makarewicz, Personal communication) and these growth rates can certainly be expected to continue into the future.

Northrup Creek is a second order stream with headwaters south and southwest of the town of Spencerport. Mean monthly discharge and daily maximum discharge for Northrup Creek for water years 1984 through 1993 are shown in Figure 3. Stream discharge for Northrup Creek varied from 0.18 M^3/sec to 0.28 M^3/sec during the 1997 period of study. Watershed areas above the Big Ridge Road site and the Dean Road site are 1309 hectares and 1858 hectares respectively.

Water Quality Assessment

Methods. To assess water quality, we collected two water samples in the flowing portion of the stream at each of four sampling sites on June 4, 10, and 13, 1997 (Fig. 1). Samples were filtered with 0.45 μm filter membrane in the field. The sample for Pb analysis was acidified by adding 2 drops of concentrated HNO_3 in the field. All water samples were placed on ice in the field and kept at 4 ^{0}C prior to analysis.

Water chemistry analysis was performed using a Technicon AutoAnalyser II. Soluble reactive phosphate (SRP) was analyzed by ascorbic acid method (APHA 1995). NO_3/NO_2 was measured with the cadmium reduction method (APHA 1995). Pb was analyzed using double beam atomic absorption spectrophotometer with granphite furnace (APHA 1995).

To estimate the stream discharge, a cross sectional area of the culvert at Big Ridge Road was measured and calculated. Stream current velocity was measured at 6/10 depth with a current meter across a transect (every 50 cm). Discharge was estimated by multiplication of the current velocity and cross sectional area. Daily nutrient loading was calculated by multiplication of the averaged nutrient concentration and discharge. The average discharge of effluent from STP was 2271 m^3/day.

Results and Discussion. Nutrient concentrations in the sites below the STP were higher than the sites above STP (Fig.4, Table 4) Average SRP concentration in the two sites below STP were approximately four times higher than those above the STP (34.7 and 33.43 μg/L). Average SRP concentration at the STP effluent pipe was as 805 μg/L, approximately 23 times higher than the concentration in above STP sites. NO_3 concentrations at sites below the STP were almost double that of sites above the STP. Average NO_3 concentration at the STP effluent pipe was 8.54 mg/L, approximately ten times higher than at sites above the STP. This pattern was observed consistently among three different sampling dates from June 4 to June 13. Pb concentration was generally low (average<1 μg/L) with no recognizable patterns between the sites above and below the STP.

A similar pattern for SRP and NO_3 was observed in daily nutrient loading (Table 4). Non-point source SRP daily loading, estimated from the two sites above the STP, was 647.9 g P/day. Point source SRP from the STP, estimated from SRP concentration from the effluent pipe, was 1,829.97 g P/day, almost three times higher than non-point source P loading. The ratio of non-point source and point source loading for SRP was 0.34, suggesting the STP was the major source of SRP. Average daily SRP loading below the STP was 2,546.4 g P/day, approximately four times higher than the non-point source loading. A similar pattern was observed with daily NO_3 loading. Non-point source N loading was approximately 16,105 g NO_3/day. Though daily loading from the STP effluent pipe was high (19,394 g NO_3/day), the ratio of non-point source and point source N loading was 0.8.

Our data suggest that the STP may significantly contribute to elevation of nutrient levels in Northrup Creek . Our data indicated that the effluent from the STP is nutrient rich and is responsible for elevated nutrient levels in Northrup Creek below the STP. Nutrient concentration from our two reference sites (above the STP sites) was similar. The nutrient levels in the reference sites may reflect non-point source nutrient input from agriculture dominated watershed. However, average SRP concentrations in the two sites below the STP were approximately four times higher than the reference sites above the STP. The results from the samples collected directly from the effluent pipe of STP showed that SRP concentration in the effluent was 23 times higher than the concentrations in the reference sites. Daily SRP loading from STP was averaged 1,829.97 g P/day, approximately three times higher than the daily loading of SRP in the reference sites (e.g. from non-point source). A similar pattern was also observed in our nitrate data. Our data clearly suggest that the STP is a major point source of nutrients, especially SRP, to Northrup Creek.

Stream Habitat Integrity Index

Methods. Habitat quality parameters were scored for each site using the qualitative Biological and Habitat Survey Protocols for Wadable Streams and Rivers (Michigan

Department of Natural Resources, Proc. #51, 1991). This procedure considers three principle categories, (1) substrate and in-stream cover, (2) channel morphology, and (3) riparian and bank structure. These categories, and scoring levels are based on the degree of importance each has to the fish communities inhabiting a stream. Usually the total metric points of a site are compared to one or more reference sites within the study. We considered the upstream sites reference sites since our goal was to determine if the STP impacts ecological conditions in the stream.

Results and Discussion. Habitat scoring values for Big Ridge Road and upstream STP were 83.5 and 69.5, respectively (mean = 85.5). Downstream from the STP, habitat scoring values were 75, and at Dean Road scoring values were 102 (mean = 79). The average values for upstream versus downstream sites are within 10% of each other indicating comparable habitat quality between the sites. The creek as a whole exhibited poor to good quality habitat, with bank stability and vegetation receiving "good" scores and substrate embeddedness/siltation being substantial, or "poor" at the sites just above and below the STP. However, substrate and in-stream cover may have more impact on fish communities (Michigan DNR Proc. #51, 1991). The poor to fair values for this category, i.e. silty conditions, reported at the two sites closest to the Spencerport STP probably reflect long-term construction conditions (pre-1993 to present) occurring immediately across from the plant rather than from the plant itself.

Microbial Indicators

Methods. In an effort to collect more complete biological data, we collected water samples for microbial analysis. Three different field sampling methods were employed: (1) collection of raw water samples for laboratory analysis of coliforms; (2) large volume sampling (1000 liters) with a pump and filter for coliphage; and (3) collection of raw water samples in nitric and sulfuric acid-cleaned bottles (carbon-free) for assimilable organic carbon (AOC) analysis. Field samples were only done on June 3, 1997.

We performed four microbial analyses in the laboratory. Coliforms were measured using both the rapid Colilert technique and by membrane filtration and plating. Both techniques allowed us to determine total coliforms and fecal coliforms. Coliphage were determined in the lab using a combination of resuspension and reconcentration methods. All samples were plated as replicates using a serial dilution sequence to ensure measurable results. Samples were incubated overnight. Assimilable Organic Carbon (AOC) samples were counted over time to allow the microbial colonies to reach equilibrium. Replicate AOC samples were counted on day 3, day 9, and day 10.

Results and Discussion. The data did not vary much from site to site for any of the microbial analyses (Table 5). Total coliforms and fecal coliforms were detected at all sites using the Colilert test (Table 5). The membrane filtration data also did not show any major trends, although the Dean Road sample for total coliforms was unusually high. Fecal coliforms at all four sites did not differ in any discernible way. The only apparent change from site to site in fecal coliforms was the proportion of fecal to total which decreased from a high of 91% at Big Ridge Road to a medium value of 48.5 % near the Sewage Treatment Plant to a low of 10% at Dean Road. The Dean Road value may be skewed due to the extremely high total coliforms. The coliphage data show no apparent trends and exhibit very low viral activity overall (Table 5). Finally, the equilibrium values of AOC averaged over days 9 and 10 exhibited no trend among the sites above and below the STP.

The microbial data do not exhibit any differences along Northrup Creek. There are no discernible sources of bacteria or viruses and no differences between the areas upstream of the STP and downstream of the STP. The spatial and temporal trends in dissolved ortho-phosphate, nitrate/nitrite, and lead do not seem to influence bacterial abundance. The only large discrepancy in bacterial abundance occurs at Dean Road with one value for total coliforms exceeding all others by a factor of four. With only one replicate, we can not distinguish analytical error from a potential point source event. This unusually high total coliform value also affects the percentage of fecal to total coliforms. This apparent decrease in the percentage of fecal coliform is difficult to interpret without more confidence and replicates for total and fecal coliforms. The Colilert test did not provide any additional evidence to support any consistent decreases. The sites around the STP show no increase in any of the major microbial indices compared to either spatial extreme.

The lack of trends in microbial abundance or activity along Northrup creek, and especially at the sites close to the STP, suggests that the Spencerport Sewage Treatment Plant seems to be efficient in cleaning water with respect to bacteria and possibly even coliphage viruses. The low microbial abundance and the lack of relationship between bacteria and the dissolved chemistry of the stream may indicate that suspended bacteria are not good indicators of a stressed stream system. Surface-dwelling bacteria in the streambed and nutrients adsorbed to streambed particles could show a stronger correlation between water chemistry, effluent effects, and bacterial abundance and activity.

Though the Assimilable Organic Carbon (AOC) data do not show any trends in relation to spatial or chemical parameters, they are uniformly low (Table 5). In a typical freshwater stream ecosystem, the ratio of Carbon, Nitrogen, and Phosphorus (C:N:P) should approach 100:10:1. At our study sites, the ratios never approach the standards (Table 6). It is clear that this system is severely limited in carbon. This large reduction in available carbon may be the result of efficient sewage treatment at the STP which would remove a large portion of the organic matter available for bacteria. The low numbers of bacteria in the stream above the STP may be the result of carbon limitation and its affect on growth. The low bacterial abundance below the STP may also be due to low available carbon which could either severely impact the growth of bacteria from the sewage effluent or simply reflect low abundance overall.

In summary, the microbial analyses do not indicate any effect of the sewage treatment plant. All our microbial data are within the low range of abundance which may be connected to the low values of AOC. However, without replicate temporal samples in one sampling season at all sites we can not accurately gauge the validity of our data. Furthermore, only dissolved chemistry and suspended particles and associated bacteria were sampled so we can not determine the abundance, activity, or effect of the sewage treatment plant on the microbial benthic community. We recommend raw water samples at each site on each sampling date to improve repeatability of the data and possibly a chemical and microbial analysis of the sediments to determine the benthic component of the microbial equation. Finally water samples at the effluent could also be analyzed for bacteria as a corollary to the effluent water chemistry.

Macroinvertebrates Indices and Morphological Deformity

Biological indicators such as macroinvertebrates within an aquatic ecosystem may provide a measure of water quality within a specific drainage basin. Macroinvertebrates are larger-than-microscopic invertebrate animals that inhabit stream bottoms, including aquatic insects, worms, clams, snails and crustaceans. Analysis of macroinvertebrate communities is a reliable and cost-effective approach to water quality monitoring because: 1) they are sensitive to environmental impacts, 2) they are less mobile than fish, and thus cannot avoid discharges, 3) they can indicate effects of spills, intermittent discharges, and lapses in treatment, 4) they are indicators of overall, integrated water quality, including synergistic effects and substances in concentrations lower than detectable limits, 5) they are often in high abundance, 6) they are relative easy and inexpensive to sample, 7) they can often provide an on-site estimate of water quality without additional laboratory analysis, 9) they potentially bioaccumulate many contaminants, so that analysis of their tissue may be a good monitor of toxic substances in the aquatic food chain, and 10) they provide an endpoint in defining water quality objectives (Bode et al., 1996).

Methods. Analysis of macroinvertebrates was used to assess biological impairment to Northrup Creek due to discharge from the Spencerport STP. Two sites upstream of the discharge site served as control sites for comparison with two sites sampled below the point of discharge. Four sites were selected fitting the criteria for sampling of macroinvertebrates. At these sites, the creek had a riffle current underlain with rock, rubble, gravel and/or sand, depth was less than one meter, and the current speed did not exceed 0.4 meters per second. The physical and chemical parameters of each site were assessed to establish comparability between sites (Bode et al., 1996). Results of this Habitat Comparability Survey are shown in Table 7.

Invertebrates were sampled at each site by kick sampling along three 5 m transects placed diagonally across the creek. Rocks and bottom sediment were dislodged upstream of a D-net placed along the transect line. The net was moved against the current, with vigorous agitation of the bottom, rocks and debris in front of the net. Sampling progressed for a period of two minutes along each transect. Following sampling, large rocks and sticks were gently washed to remove attached invertebrates. The net was washed free of organisms and the contents of the net and pan were rinsed through a U.S. No. 30 standard sieve. The contents were washed into a jar filled with 95% ethanol containing 125 mg/l rose bengal stain.

Immediately following return to the laboratory, sample populations were washed from the ethanol and placed into a gridded enamel pan. Sections from the grid were randomly selected and all invertebrates removed. Organisms were removed from additional sections until 100 organisms were sampled from each transect. These were sorted and identified to Order in all cases and to Family and Genus where possible or needed. Populations of invertebrates were rated using the Percent Model Affinity, Hilsenhoff Biological Index, Species Richness Index, and the EPT (Ephemeroptera, Plectoptera, Tricoptera) Richness Index. These indices reflect impact to the water quality of surface waters in a specific drainage inhabited by the target invertebrates. Indices were calculated for each sample site and a score was assigned indicating the environmental impact on water quality (Bode et al., 1996).

In addition, Chironomids were examined for deformities of the head capsule, focusing on the mouthparts. Chironomids frequently inhabit the bottom sediments, contacting compounds which are potentially toxic or teratogenic. Heads were surgically removed and mounted in CMC Mounting Media on glass slides for subsequent microscopic examination. Twenty specimens were examined from each site.

Results and Discussion. None of the indices measured for macroinvertebrate organisms at any of the sites showed that the sites were unimpacted with respect to water quality. Indices were assigned ratings ranging from unimpacted (= a rating of 4), to slight (= a rating of 3), moderate (= a rating of 2), and severe (= a rating of 1) impacts. The Hilsenhoff Biogical Index showed that just above the sampling site water quality was least impacted and was only moderately impacted at the remaining sites. There was no indication from any of the indices that the wastewater treatment plant created a further negative impact to the quality of water in Northrup Creek (Figs. 5 and 6). A survey of the biological indices from invertebrates sampled in 1993 and 1995 showed similar trends of no negative impact below the plant compared to sites sampled upstream of the plant.

One trend that persisted throughout all four indices was that the Dean Road site was slightly less impacted than the other three sites. This may be a reflection of a slightly different physical environment at Dean Road compared to the other three sites. The phi value was -3.8, compared with values ranging from -2.3 to 2.3 at the other sites. This suggests a rockier bottom, which would be expected to support a more diverse and healthy invertebrate community.

The survey of deformities within the chironomid community showed two sites to be negatively impacted (Fig. 7). Under non-toxic conditions, the frequency of would be expected to be 0 - 15%. There were two sites where frequency of deformities exceeded this level. At the Big Ridge Road site, 35% of the heads examined showed deformities, suggesting moderately toxic conditions. The frequency of deformities at Dean Road also exceeded 15%, suggesting slightly toxic conditions. The observations at the Dean Road site are in contrast to the invertebrate indices discussed above, which indicated that the Dean Road site is the least impacted with respect to water quality. However, they are consistent with observations made in 1995 of high frequencies of deformities at the Dean Road site (Fig. 7).

The Big Ridge Road site is an area with high traffic, potentially harboring toxic washing from the road surface. It has been a past site of high lead concentrations within the stream, likely from fuel burned by passing traffic before restrictions against using leaded gasoline. In addition, there is the possibility of the introduction of toxic substances from BOCES, located directly adjacent to the water sampling site.

In summary, use of macroinvertebrates as biological indicators of environmental impact on the water quality in Northrup Creek does not suggest that there is a negative impact from discharge by the Spencerport STP into the creek. The creek has been negatively impacted throughout the length of the reach sampled. None of the indices showed the site sampled immediately below the wastewater plant to be either more or less impacted than both sites upstream. However, construction in the adjacent area is likely impairing water quality at the site immediately upstream. This may make comparison between these two sites difficult. Nevertheless, these results indicate that discharge from the STP has not contributed additional negative impacts to the quality of water within the creek immediately below the point of discharge.

Fish Index of Biological Integrity

Methods. Using fish as indicators of stream ecosystem integrity (Karr et al. 1986) we compared ecological conditions at two sites upstream and two sites downstream of the STP (Fig. 1). “Site” refers to a precise location (approximately 75 m) where a fish sample was taken. Our data include three sampling events, one each in June 1993, 1995 and 1997. In 1993 and 1997, all sites were seined with seine nets (mesh size = 3/16ths in.) and electrofished. In 1995, fish were electroshocked at all 4 sites but seined only at Big Ridge Road and Dean Road. Habitat quality parameters were assessed for each of the four sites in June 1997.

We calculated an Index of Biotic integrity for each site based on the Ohio EPA’s Biological criteria for the protection of aquatic life (Ohio EPA Doc. 0048e/0014e, 1988). Although no standards exist for this criterion in the New York or federal regulations, simply measuring the available nutrients and physical water characteristics will not predict the quality of a system’s wholeness (Karr et al. 1986). Assessing a stream’s capability to support and maintain a balanced and diverse community of organisms is an important component of stream “health”.

Results and Discussion**.** Fish sampling data from 1997 revealed little difference in overall fish communities from each site (Table 8). The species richness between sites ranged from 8 native species captured at Dean Road (the northern most site) to 10 native species found at Above the STP to 12 native species captured at both the Big Ridge Road and Below the STP sites. Creek chubs seemed to dominate the catches at all sites except for Dean Road. However, the Dean Road site contained Hornyhead and Creek chubs predominantly, with an undetermined amount of interbreeding between the two species (pers. Comm. Ann Throckmorton). The IBI scores indicate that Big Ridge Road maintains a “*fair*” rating in terms of overall integrity while all of the other sites sustain "*poor*" ratings (Table 9). The presence of numerous tolerant species (mainly Creek chubs), and low numbers of darters and top carnivores negatively affected the total IBI scores for each site**.** However, all sites contained at least one sensitive species and a diverse array of omnivores, insectivores, and simple lithophils. The similar IBI values between sites above and below the STP do not necessarily indicate similar ecological conditions. The fish assemblages may be affected by the habitat quality associated with this stream more than water quality.

According to Karr (1991) the attributes of *poor* reflect systems "dominated by omnivores, tolerant forms, and habitat generalists; few top carnivores; growth rates and condition factors commonly depressed; hybrids and diseased fish often present". Although we found numerous tolerant species and few top carnivores, our sites were not dominated by omnivores. The discrepancy may be due to differences in the fish communities in New York as compared to Ohio. We recommend that New York DNR modify of the Ohio IBI for future assessments of stream communities in this state.

On a temporal scale, IBI scores are not dramatically different (Table 9). In fact, the current year data suggest improvements in stream integrity over all the sites. This may be an artifact of sampling differences or it could be a real improvement in stream quality in terms of both nutrient and silt loading. The sewage treatment plant began flocculation of phosphorus in 1996 which greatly reduced the amount of ortho-phosphorus. And, major road and house construction activities have declined in the region of our study since 1995. The number of native species ranged from 8 to 12 in 1993, from 4 to 11 in 1995, and from 8 to 12 in 1997. The number of species captured varied only slightly between the three sampling events; 15 species were identified in 1993, 18 species were identified in 1995, and 16 species were found in 1997. Initially, it appeared that higher numbers of individuals were captured in the 1993 and 1994 sampling events. But in these years, fish were sampled by seines and electrofishing on two separate occasions in the same week whereas in 1997, seining and electrofishing were conducted on the same day. Creek chubs and tolerant species in general, have prevailed in this ecosystem.

Conclusions

Multiple lines of evidence indicated that Northrup Creek is a stressed stream. The creek is impacted by both point and non-point source pollution. Water quality data clearly indicated that the STP is the major point source of SRP and nitrate to Northrup Creek. Located in an agriculture-dominated watershed, Northrup Creek is also impacted by non-point source pollution such as nutrients and siltation. Excessive nutrient and silt inputs degrade both water quality and stream habitat quality, and thus consequently biological integrity in Northrup Creek.

Table 1. Areas in Land Use Types above Big Ridge Road Sampling Site*

Land Use Type	**Area (hectares)**	**Percent**
Woodland	386.12	29.48
Shrubland	51.87	3.96
Cropland	338.48	25.83
Pasture	62.48	4.77
Orchard	2.88	0.22
Residential	288.24	22.00
Municipal	109.34	8.34
Industrial	0	0
Wetlands	18.44	1.41
Gravel Pit	16.63	1.26
Ponds	5.97	0.45
Barge Canal	8.83	0.67
NY 531	20.64	1.16
Total	1309	100.

*(Karl Korfmacher, 1997)

Table 2. Areas in Land Use Types above Dean Road Sampling Site*

Land Use Type	**Area (hectares)**	**Percent**
Woodland	538.82	28.99
Shrubland	118.02	6.35
Cropland	427.45	23.00
Pasture	161.62	8.69
Orchard	2.88	0.15
Residential	402.09	21.64
Municipal	124.59	6.70
Industrial	26.69	1.43
Wetlands	18.34	0.98
Gravel Pit	8.40	0.45
Ponds	8.83	0.45
Barge Canal	8.82	0.47
NY 531	20.64	1.19
Total	1858.4	100

*(Karl Korfmacher, 1997)

Table 3. Percent Land Use Changes by type - 1966 to 1994

Land Use Type	Percent in 1966	Percent in 1994	Change
Forest	16.9	13.4	- 3.5
Shrub - Old field	18.1	25.2	7.1
Pasture	4.7	1.5	- 3.2
Orchard	1.9	0.0	- 1.9
Cropland	50.8	31.7	- 19.1
Urban Residential	13.7	23.3	9.6
Urban Commercial	2.6	4.0	1.4
Wetland	0.9	0.6	-0.3

Table 4. The mean concentrations and daily loading rates of SRP, nitrate, and lead in Northrup Creek (average of 3 sampling dates).

Site	Concentration (μg/L)			Loading rate (g/day)		
	SRP	NO_3	Pb	SRP	NO_3	Pb
BRR	34.7	820	1.30	639.6	15114	24.0
Above STP	33.4	870	0.71	616.2	16097	13.1
Effluent pipe	805.8	8540	0.88	1830.0	19394	2.0
Below STP	120.3	1640	0.98	2216.8	30167	18.0
Dean Rd.	156.1	1760	0.42	2876.1	32378	7.8

Table 5. Microbial analyses for total coliforms in Colony Forming Units (CFU) /100 ml, fecal coliforms in Colony Forming Units (CFU) /100 ml, coliphage in Plaque Forming Units (PFU)/100 ml, and Assimilable Organic Carbon (AOC) in μg/liter from samples of Northrup Creek water on June 3, 1997.

Sampling sites	**Colilert**		**Membrane filtration**		**Coliphage**	**AOC**
	Total	**E. coli**	**Total col.**	**Fecal col.**		
Big Ridge Rd	+	+	230	210	4	129
Upstream STP	+	+	350	159	1	178
Downstream STP	+	+	310	160	4	118
Dean Road	+	+	1200	120	0	147

Table 6. Carbon, Nitrogen, and Phosphorus ratios (C:N:P) for all sites based on Assimilable Organic Carbon (AOC), nitrate concentrations, and ortho-phosphate data. AOC values from samples on June 3, 1997, and nitrate and phosphorus mean values in Northrup Creek.

Sampling sites	**Carbon: Nitrogen: Phosphorus**
Big Ridge Rd	11 : 13 : 0.4
Upstream STP	15 : 14 : 0.4
Downstream STP	10 : 26 : 1
Dean Road	12 : 28 : 2

Table 7. Habitat comparability among 4 sites.

Parameter	Big Ridge Road	Above STP	Below STP	Dean Road
Width (m)	2.4	5.35	3.7	4.5
Depth (m)	0.17	0.16	0.20	0.22
Velocity (m/sec)	0.89	0.40	0.53	0.59
Bank Description	weeds and undercut roots	steep, shrubby slope	steep, banks about 30cm from water	60% veg. Coverage, rocks
Canopy (%)	20	15	5	20
Embeddedness (%)	50	50	36	60
Substrate (phi)	-2.3	2.3	-1.6	-3.8
Aquatic Vegetation	some algae	scattered	18% covered with aquatic veg.	25% Cladophora & cress
Water Temperature (^{o}C)	20	22	21	19
Dissolved Oxygen (mg/L)	8.4	9.7	7.9	8.4
pH	7.8	8	7.7	7.8
Conductivity mmho/cm	600	600	600	600
Time Sampled (est)	0930	1130	1100	1000

Table 8. Characteristics fish communities from four sites along Northrup Creek. Fish sampled via seines and electrofishing in June 1997, 1995, and 1993.

1997	**Big Ridge Rd**	**Above STP**	**Below STP**	**Dean Rd**
Native spp.	12	10	12	8
Sensitive spp.	1	1	1	1
Tolerant spp.	5	4	6	4
% Tolerant spp.	55%	66%	70%	36%
% Omnivores	5%	23%	15%	13%
% Insectivores	39%	29%	33%	55%
%Pioneering	55%	55%	78%	31%
# Inds. /300 m	396	492	612	412
# Simple Lith.	2	1	2	1
% DELTs	0%	<1%	3%	0%

1995	**Big Ridge Rd**	**Above STP**	**Below STP**	**Dean Rd**
Native spp.	8	11	7	4
Sensitive spp.	1	1	1	0
Tolerant spp.	4	6	4	3
% Tolerant spp.	66%	74%	81%	79%
% Omnivores	8%	27%	81%	7%
% Insectivores	18%	22%	3%	0%
%Pioneering	54%	61%	23%	73%
# Inds. /300 m	996	1576	424	1362
# Simple Lith.	2	2	1	1
% DELTs	0%	1.52%	0%	%

1993	**Big Ridge Rd**	**Above STP**	**Below STP**	**Dean Rd**
Native spp.	10	12	8	8
Sensitive spp.	1	1	1	1
Tolerant spp.	5	5	4	3
% Tolerant spp.	68%	68%	73%	70%
% Omnivores	7%	13%	22%	24%
% Insectivores	28%	29%	27%	29%
%Pioneering	61%	60%	79%	49%
# Inds. /300 m	808	1840	321	740
# Simple Lith.	3	2	2	3
% DELTs	5%	5%	3%	2%

Table 9. Total Index of Biotic Integrity (IBI) scores and integrity classes for fish assemblages in four sites along Northrup Creek, New York. Fish sampled via seines and electrofishing in June 1993, 1995, and 1997.

Site	IBI 1993	IBI 1995	IBI 1997	Integrity Class of Site
Blue Ridge Road	30	36	42	Fair
Above the STP	32	24	28	Poor
Below the STP	28	24	30	Poor
Dean Road	28	24	30	Poor

References

APHA. 1992. Standard methods for the examination of water and wastewater, 18th ed. American Public Health Assoc. Washington, D.C.

Bode, R.W., Novak, M.A., and Abele, L.E. 1996. Quality assurance work plan for biological stream monitoring in New York State. NYS Dept. of Environmental Conservation, Stream Biomonitoring Unit, Bureau of Monitoring and Assessment, Division of Water. Albany, NY.

Haynes, J. (editor). 1997. Stressed Stream Analysis Workbook. Center for Applied Aquatic Science and Aquaculture. SUNY at Brockport, N.Y.

Karr, J.R. 1991. Biological integrity: A long-neglected aspect of water resource management. Ecological Applications 1(1): 66-84.

Karr, J.R., Fausch, K.D., Angermeier, P.L., Yant, P.R., and Schlosser, I.J. 1986. Assessing biological integrity in running water: A method and its rationale. Illinois Natural History Survey Special Publication 5.

Makarewicz, J.C. 1989. Chemical analysis of water from Buttonwood, Larkin, Round Pond and Northrup Creeks, Lake Ontario Basin West, May 1987-May 1988. Final Report to the Monroe County Department of Health by the Center for Applied Aquatic Science and Aquaculture, SUNY at Brockport, NY.

Makarewicz, J.C., T.W. Lewis, A. Brooks, and R. Burton. 1990. Chemical analysis and nutrient loading of: Salmon Creek, Otis Creek, Black Creek, Spencerport Sewage Treatment Plant, precipitation falling in western Monroe County, with a discussion on the trophic status of Long Pond and stressed stream analysis of Northrup and Buttonwood Creeks. Prepared for the Monroe County Department of Health by the Center for Applied Aquatic Science and Aquaculture, SUNY at Brockport, NY.

Michigan DNR. 1991. Biological and habitat survey protocols for wadeable streams and rivers. Michigan Dept. of Natural Resources, Proc. #51, Lansing, MI.

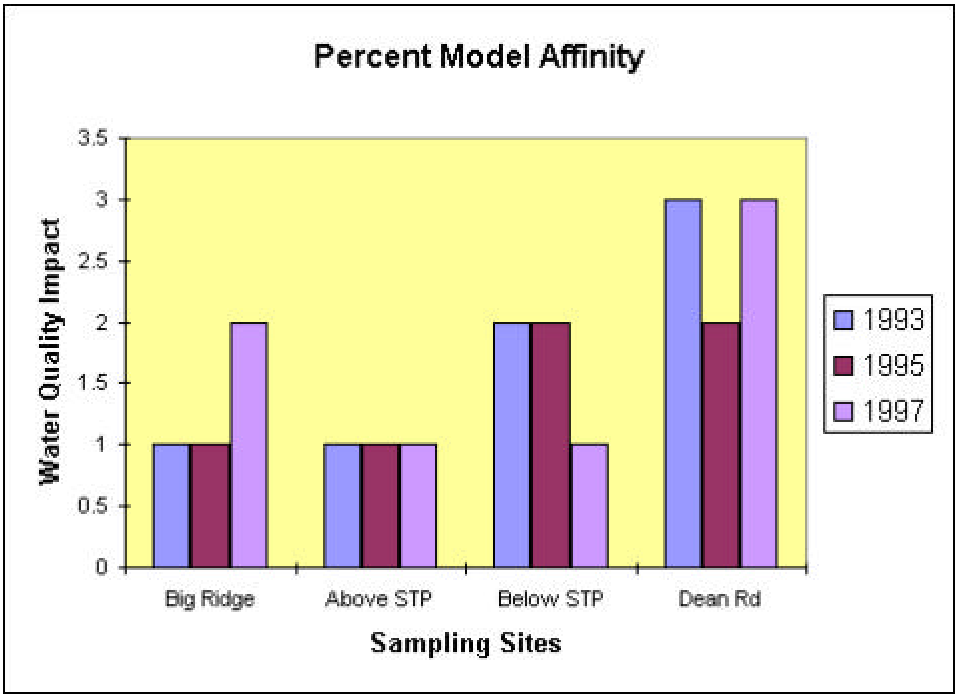
NYSDEC. 1991. Water quality regulations: surface and groundwater classifications and standards. NYCRR Title 6, Chapter X, Parts 700-705. NYS Dept. of Environmental Conservation. Albany, NY.

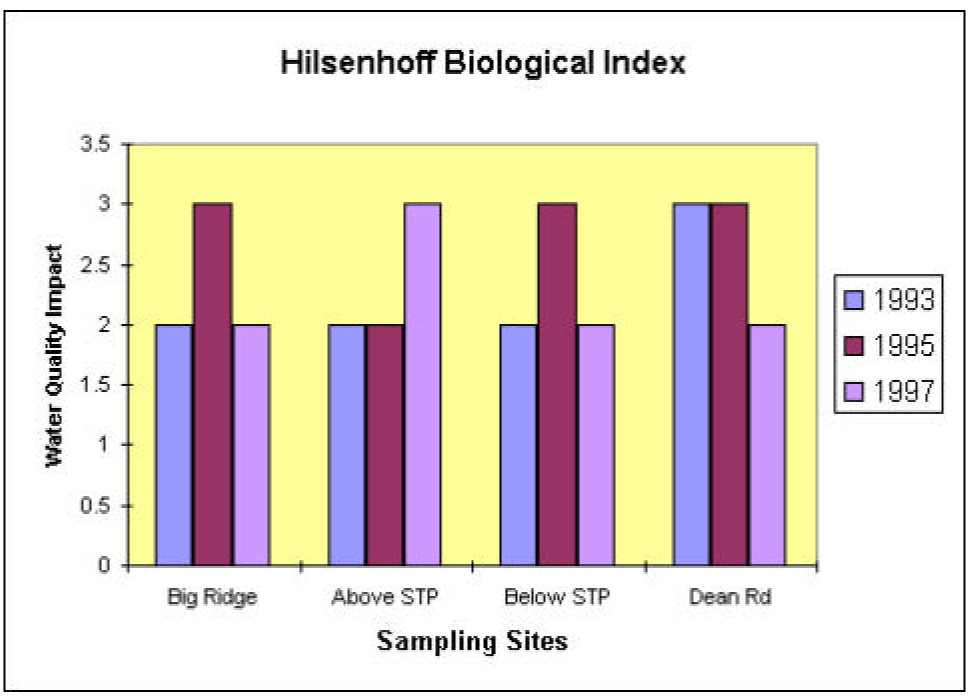
Ohio EPA. 1988. Biological criteria for the protection of aquatic life. Ohio Environmental Protection Agency, Division of Water Quality Monitoring and Assessment, Surface Water Section. Columbus, OH.

SPDES. 1986. Final effluent limitations and monitoring requirements for the Spencerport STP. NYS Dept. of Environmental Conservaation. Avon, NY. 4p. (mimeo).

U.S. Soil Conservation Service. 1973. Soil survey for Monroe County, New York. U.S. Department of Agriculture, Soil Conservation Service. Washington, D.C.

Figure 5. Biotic Indices of Macroinvertebrates





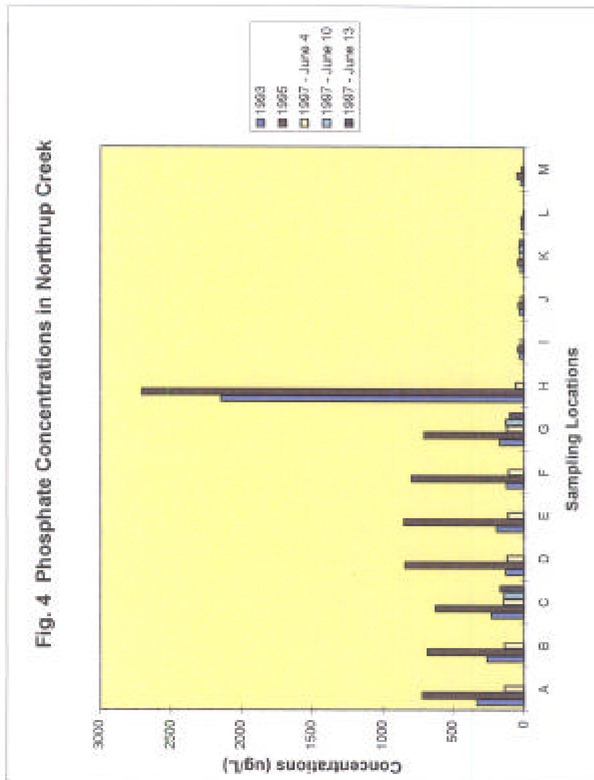
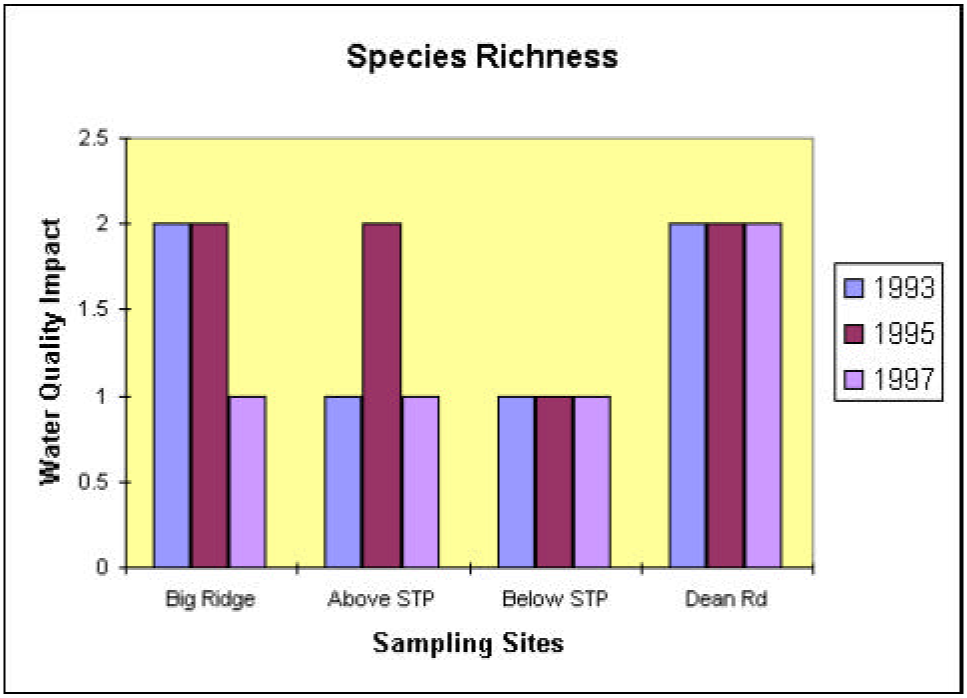


Fig. 4 Phosphate Concentrations in Northrup Creek

Figure 6. Biotic Index for Invertebrates



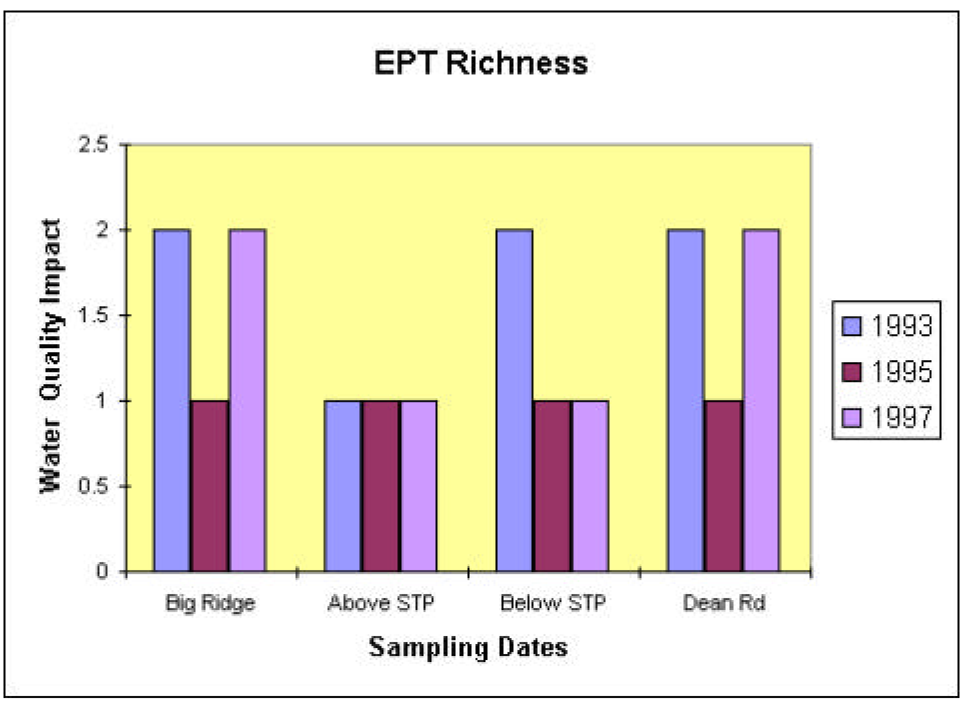


Figure 7. Percentage of Chironomid Larvae with Deformities