THE WILDERNESS PRESERVATION

COMMITTEE OF ONTARIO

Lake Nipissing

Silver Beach, Lake Nipissing

Water Quality Study/2000
In Partnership

THE WATER QUALITY OF LAKE NIPISSING AND THE CONTRIBUTING WATERSHED

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EXECUTIVE SUMMARY

During the summer of 2000, a comprehensive water quality monitoring study was conducted on Lake Nipissing and the contributing watershed. A primary objective of this study was to evaluate the current ecological health of Lake Nipissing in comparison to 1988-1990 conditions. The study also focused on the following discharge sources, located within the contributing watershed:

- Chretian Drain and MacPherson Creek;
- Merrick Landfill site;
- Cross Lake; and
- eight major watercourses.

The 2000 Lake Nipissing water chemistry results indicated that the Cache Bay area had the highest chlorophyll-a, phosphorus, TKN, chloride, iron and pH levels. Callander Bay generally had the second highest levels of these same parameters.

The Lake Nipissing comparison study determined that the TKN and chlorophyll-a concentrations had increased at all thirteen sample stations since the 1988-1990 study was completed. There were also increases in pH at nine of the thirteen stations, with one station slightly exceeding the PWQO. In contrast, sulfate concentrations have decreased at all thirteen sample stations since 1988-1990.

The benthic macroinvertebrate evaluations determined that the contributing watercourses located along the eastern shoreline had the best water quality. The watercourses located along the northern and western shorelines had the poorest water quality.

The Chretian Drain and MacPherson Creek water quality evaluation determined that all six sample stations had exceeded the PWQO for phosphorus. Although there was an obvious increase in nutrient, turbidity and TSS levels at the Chretian Drain, the downstream concentrations did not steadily decrease with distance from the Drain.

The Merrick Landfill surface water quality evaluation determined that all six sample stations had exceeded the PWQO limits for iron and aluminum, but were below the PWQO limit for lead. Five of the six stations exceeded the cobalt PWQO. There were obvious concentration peaks of iron lead, cobalt, TKN and BOD closest to the landfill, which steadily declined with distance from the site.

All of the Cross Lake water quality samples exceeded the PWQO limits for total phosphorus. The lake was found to be slightly alkaline, with two of the four water samples slightly exceeding the PWQO for pH. All of the Cross Lake samples were within the PWQO for iron and un-ionized ammonia.

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THE WATER QUALITY OF LAKE NIPISSING AND THE CONTRIBUTING WATERSHED

1.0 INTRODUCTION

Lake Nipissing is located in northeastern Ontario, and is bordered by the City of North Bay along the northeastern shoreline (see Figure 1). The Lake is an important recreational resource in northeastern Ontario, serving thousands of cottagers and providing the revenue base for many commercial establishments.

Lake Nipissing has been the subject of previous intensive field monitoring studies conducted by the Ministry of the Environment (MOE) in 1971-1974 and 1988-1990. The primary objective of this recent 2000 study was to evaluate the current ecological health of Lake Nipissing in comparison to earlier conditions. In order to accomplish this goal, a comprehensive monitoring study was conducted during June, July and August of 2000. While this recent study continued with the earlier Lake Nipissing sampling regime, it was also expanded to include key features of the contributing watershed as well. For example, benthic macroinvertebrate evaluations were conducted on eight major watercourses in order to identify impaired water quality conditions. The issue of agricultural runoff impacts was addressed through a detailed study of the Chretian agricultural drainage system. The issue of leachate contamination was also addressed through a water quality evaluation of the Little Sturgeon River, located next to the Merrick Landfill. Two additional water quality stations were also established on Cross Lake, which ultimately discharges through the Amateewakea River to Lake Nipissing.

The methodologies and results of these individual studies are presented in the following report. When combined, they provide new and valuable insights pertaining to the changing ecological health of Lake Nipissing and the contributing watershed.

2.0 LAKE NIPISSING AND WATERSHED DESCRIPTION

Lake Nipissing is a remnant of glacial Lake Algonquin, and lies in an area of Precambrian bedrock, covered by extensive glacial sand and clay deposits. It has the distinction of being the fourth largest inland lake in Ontario, with an approximate surface area of 87,400 hectares. The contributing watershed covers an area of 13,100 km^2, and includes twelve major rivers (see Figure 1) and many smaller tributaries.

Most of the Lake Nipissing basin is relatively shallow, with depths ranging from 0-20 meters. However one area located at the French River outlet is 40 meters deep. The large fetch (a measure of the continuous extent of a lake exposed to wind), causes the water to be mixed by waves and wind to a substantial effect. The lake also has four enclosed embayments (Cache Bay, Callander Bay, West Bay and South Bay).

Although large sections of the watershed currently remain in their natural state, some areas have been altered by a variety of different land uses. The northeastern section is highly urbanized, including residential, recreational and commercial developments. In contrast, the northwestern portion is primarily agricultural, while the northern and southern areas are mainly unaltered.

Figure 1: General site map

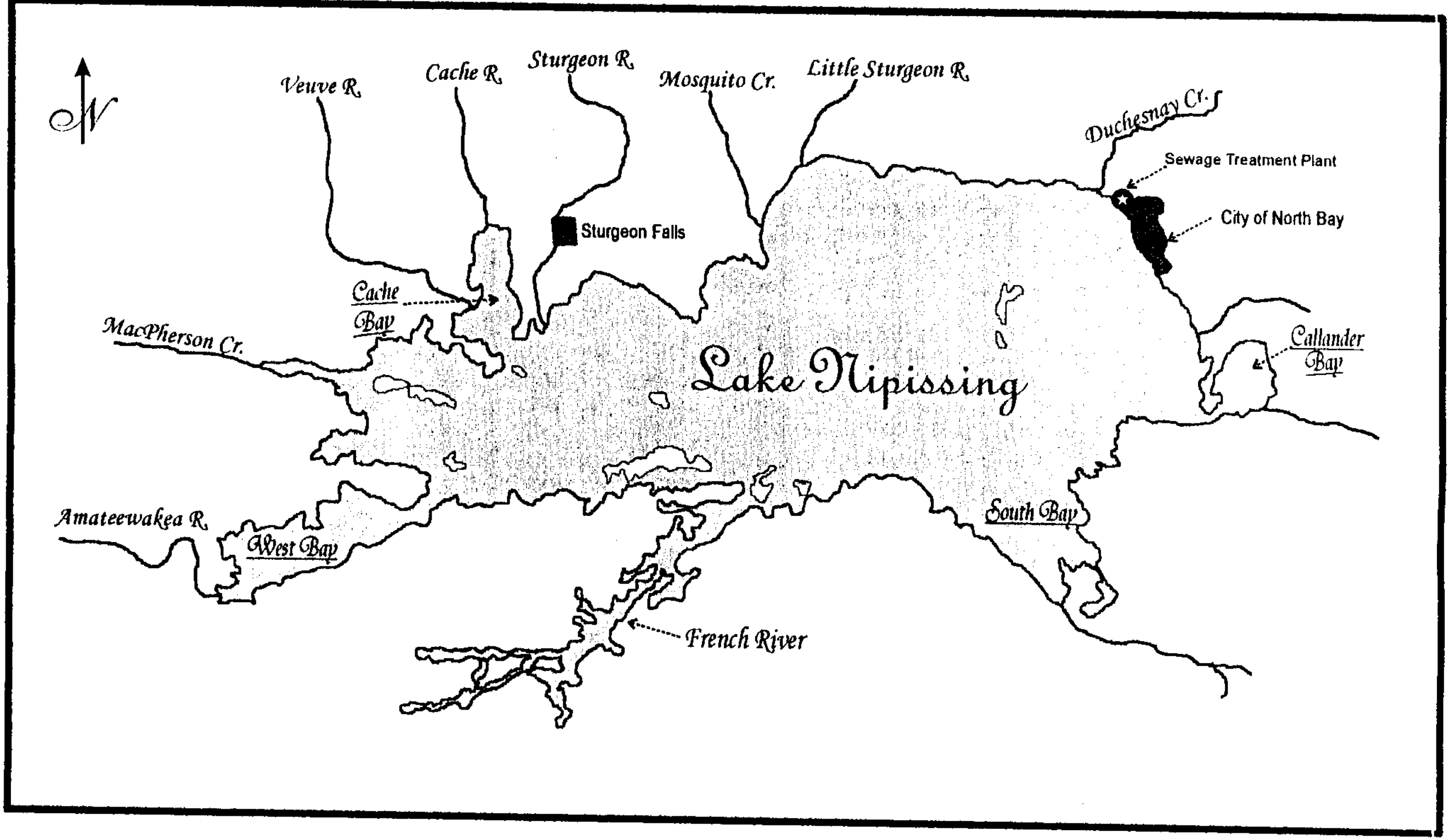
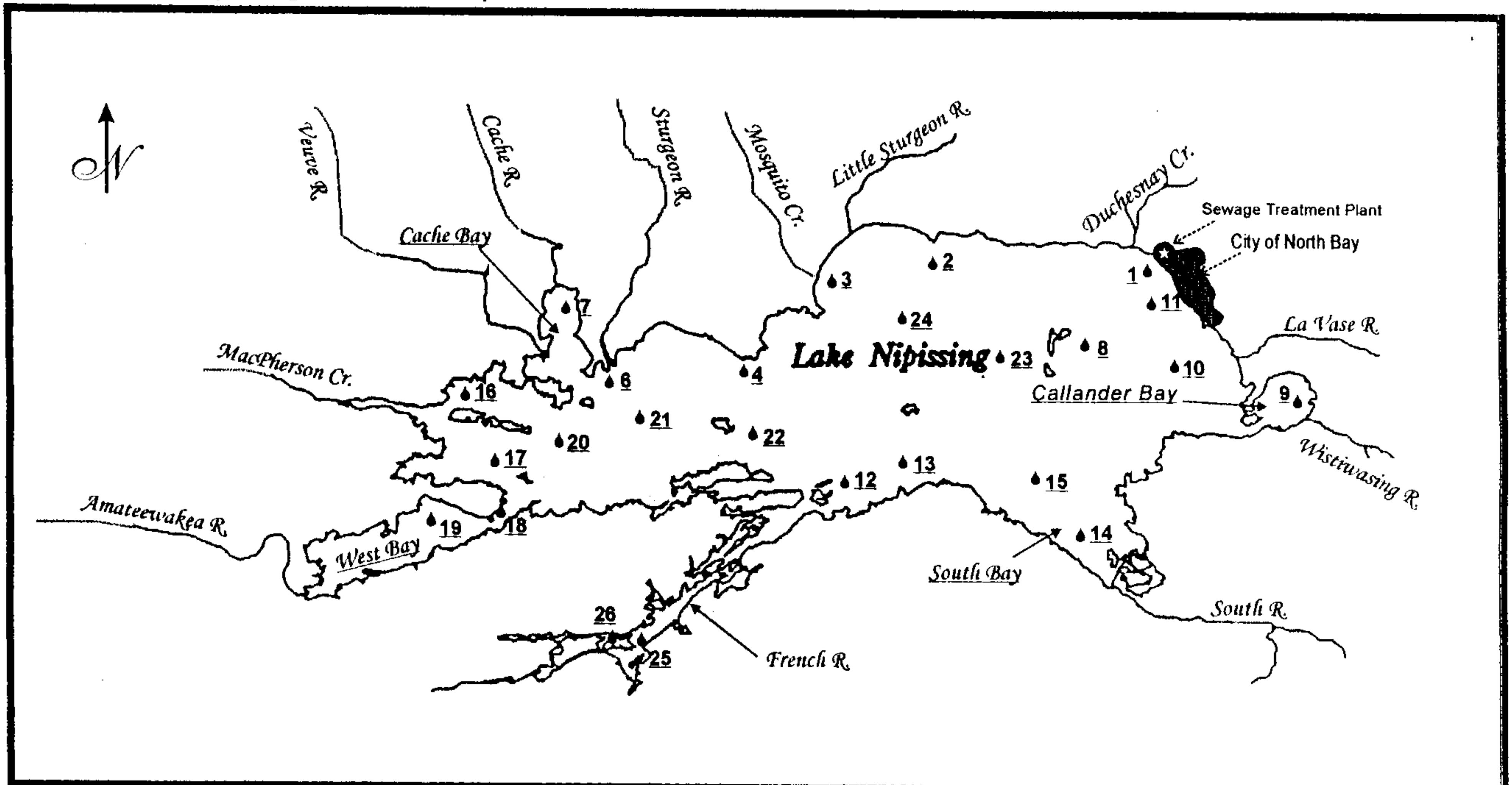


Figure 2: Lake Nipissing 1988-1990 sample stations



♦# - 1988-1990 water quality sample stations

3.0 STUDY METHODOLOGY

3.1 BACKGROUND INFORMATION REVIEW

Information was compiled from the following materials, for the purpose of gaining a more comprehensive knowledge of the study area and related issues:

i) *The Chemical Water Quality of Lake Nipissing, 1988-1990* (Neary, 1992).
ii) *BioMAP: Bioassessment of Water Quality* (Griffiths, 1999)
iii) *Fisheries Guidelines for the Review of Agricultural Drain Maintenance Proposals* (Smith, 1992).
iv) *Ministry of Natural Resources Class 2 electrofishing manual* (Carl, 2000).
v) *Stream Assessment Protocol for Ontario—V2.1 (Jones, 1998)*
vi) *Water Management: Policies, Guidelines, Provincial Water Quality Objectives*, (MOEE, 1994)
vii) Topographic maps
viii) Aerial photographs

3.2 2000 FIELD MONITORING ACTIVITIES

i) Lake Nipissing Comparative Water Quality Evaluation:

Field evaluations and water quality sampling of Lake Nipissing were completed in order to detect water quality changes that may have occurred since the last study was conducted in 1988-1990 (see Section 4.0).

ii) Contributing Watercourse Benthic Macroinvertebrate Evaluations:

Benthic macroinvertebrate samples were evaluated as water quality indicators for eight major watercourses that discharge to Lake Nipissing (see Section 5.0).

iii) MacPherson Creek/Chretian Drain Water Quality, Watercourse and Electrofishing Evaluation:

The Chretian Drain discharges agricultural runoff to MacPherson Creek, which ultimately discharges to Lake Nipissing. Water quality sampling, watercourse assessments and electrofishing activities were conducted in both the Creek and the Drain in order to evaluate the potential effects of these discharges on Lake Nipissing (see Section 6.0).

iv) Merrick Landfill/Little Sturgeon River Water Quality Evaluation:

Merrick Landfill leachate migrates toward the Little Sturgeon River, which ultimately discharges to Lake Nipissing. Water quality sampling of the Little Sturgeon River was conducted for the purpose of evaluating the potential effects of landfill leachate on Lake Nipissing (see Section 7.0).

iv) Cross Lake (West Arm) Water Quality Evaluation:

Two water quality sample stations were established on Cross Lake, which discharges through the Amateewakea River, located approximately 15 km upstream of Lake Nipissing. The Cross Lake water quality was therefore evaluated as a contributor to Lake Nipissing (see Section 8.0).

3.3 STUDY RESULTS EVALUATION

The study results were evaluated and conclusions made by representatives of the following:

i) Ontario Ministry of the Environment;
ii) Ontario Ministry of Natural Resources;
iii) Ontario Ministry of Agriculture, Food and Rural Affairs;
iv) The Wilderness Preservation Committee of Ontario; and
v) the author of the BioMAP evaluation system.

4.0 <u>LAKE NIPISSING COMPARATIVE WATER QUALITY EVALUATION</u>

4.1 1988-1990 LAKE NIPISSING WATER QUALITY STUDY SUMMARY (Taken directly from *The Chemical Water Quality of Lake Nipissing, 1988-1990 report*. See Appendix A for the complete document)

4.1.1 <u>1988-1990 Study Objective</u>

Previous chemical sampling of Lake Nipissing was conducted by the Ministry of the Environment during the early 1970's. A subsequent study was also conducted in 1988-1991 for the purpose of updating the lake's nutrient status, and to estimate urban and agricultural runoff impacts. The study results were also used to update the water chemistry database of major inland lakes within the Province of Ontario, as part of the *Inland Lakes Program*.

4.1.2 <u>1988-1990 Study Methods</u>

i) Field Measurements and Water Quality Sampling

The 1988-1990 sampling program was conducted monthly during open water conditions at twenty-six stations located throughout Lake Nipissing (see Figure 2). Water quality sampling was attempted monthly during ice-free conditions, and once during ice cover in March, 1990. On some occasions, weather conditions prevented sampling, but each site was visited a total of seventeen times.

The water quality sampling locations were selected with two criteria in mind:

1) Coincidence with sampling stations used in the 1975 assessment; and

2) representation of areas of the lake felt to be distinct; for example, embayments or areas close to point sources of nutrients such as the North Bay sewage treatment plant diffuser.

Water column composite samples were collected from 0 to 5 m, or to within I m of the lake bottom in the case of shallow stations. Station 12 was exceptionally deep (40 m) and was therefore the only one to be studied for monthly oxygen depth profiles in 1990. Water samples were collected from the entire depth of the 40 m water column, and submitted for laboratory analysis of the dissolved oxygen concentrations.

ii) Water Chemistry Analysis

All of the Lake Nipissing water samples were analyzed for the following parameters:

- <u>General</u>: alkalinity, chlorophyll-a, dissolved organic carbon (D.O.C.), dissolved oxygen (D.O.) and pH

- Ions: calcium, chloride, magnesium, potassium, sodium and sulfate
- Trace metals: iron and manganese
- Nutrients: ammonia, nitrate, nitrite, total kjeldahl nitrogen (TKN), organic TKN and total phosphorus

Major nutrients and ions were analyzed at BEAK Analytical Laboratories in Toronto, Ontario. Station 12 oxygen profile samples and all chlorophyll-*a* samples were analyzed at the Ontario Ministry of the Environment laboratory in Dorset, Ontario. Iron and manganese samples were analyzed at the Ministry of the Environment laboratory in Rexdale, Ontario.

iii) Data Analysis

The water chemistry results were presented in three different ways. Several parameters (alkalinity, calcium, chloride, conductivity, pH and sodium), showed minimal temporal variations but did vary spatially throughout the Lake. Consequently, each parameter was mapped as a three-year average across the Lake. Those parameters that were seasonally variable (total phosphorus, total inorganic nitrogen, total organic nitrogen, chlorophyll-*a* and secchi depth) were presented as monthly maps, showing the three-year average spatial and seasonal variations.

With the exception of the secchi depth and D.O. measurements, all raw, monthly, and annually averaged data were also listed in table format in the report (see Appendix A). Secchi depth readings were shown in map format only. The single D.O. readings taken under ice cover were shown in table format for every station except Station 12. Although the Station 12 oxygen depth profiles were plotted as an isopleth diagram, the raw data were not included in the final report. As a result, direct comparisons between the 1988-1990 and 2000 water quality data have been made for all the parameters, except secchi depth and D.O. concentrations.

4.1.3 1988-1990 Field Observations and Water Chemistry Results (Taken directly from *The Chemical Water Quality of Lake Nipissing, 1988-1990* report. See Appendix A for detailed data tables)

i) Major Ions

Station 7 (Cache Bay at the Cache River outlet) showed the highest average conductivity and calcium values of 134.63 umhos/cm and 15.14 mg/L respectively. Stations 18 (West Bay outlet) and 19 (lower West Bay) showed the lowest average conductivity values of 69.59 umhos/cm and 69.21 umhos/cm respectively. The lowest average calcium concentrations of 6.88 mg/L and 6.89 mg/L were also observed at Stations 18 and 19 respectively. There were additional areas of slightly elevated conductivity in the northeasterly portion of the Lake, including Stations 1(82.56 umhos/cm), 8(80.62 umhos/cm), 9(82.23 umhos/cm), 10(80.89 umhos/cm) and 11(85.84 umhos/cm). These areas clearly showed evidence of road salt input. While this is likely the result of anthropogenic activities, there are no known adverse effects of salt enrichment at these levels. Toxic effects of high chloride concentrations have been reported for several freshwater aquatic organisms, but the lowest recorded level of adverse impact is ten to twenty times the concentrations seen in the eastern end of Lake Nipissing.

The Lake pH and alkalinity levels were neutral to slightly basic, with the highest levels occurring at Stations 7 and 16(northeast of MacPherson Creek outlet). Station 7 had average pH and alkalinity levels of 8.57 and 49.01, respectively. The average pH and alkalinity levels of 7.61 and 23.35 occurred at Station 16 respectively. These relatively higher levels are associated with bicarbonate production in the highly productive macrophyte

(aquatic plant) beds in that portion of the lake. This is in addition to the elevated calcium levels being contributed to that end of the Lake through the Cache River.

Magnesium, potassium and sulfate levels were not outside the range of values that would be considered typical of an Ontario lake.

ii) Nutrients and Related Measurements

There were major spatial and seasonal differences in the total phosphorus concentrations occurring throughout the Lake. During the months of May to November of 1988, 1989 and 1990, most of the total phosphorus concentrations were below the total phosphorus PWQO of 0.02 mg/L. However, several exceedences did occur at Stations 7, 16, 4 (northcentral shoreline) and 9(Callender Bay at the Wistiwasing River outlet). Station 7 was the only location to exceed the PWQO during every sample month except for September. The average total phosphorus concentrations at Station 7 ranged from 0.021 mg/L in September, to 0.037 mg/L in May. Station 16 also exceeded the PWQO with average concentrations of 0.029 mg/L in May and 0.050 mg/L in November. Station 4 exceeded the PWQO in November with an average concentration of 0.025 mg/L. Station 9 exceeded the PWQO in August and September with respective concentrations of 0.026 mg/L and 0.034 mg/L.

The general seasonal trends indicated that most of the total phosphorus concentrations were within the 0.010-0.015 mg/L range during the month of May. Callander Bay and the northwest end of the lake did however have higher concentrations at that time. By mid summer, large portions of the lake had lower phosphorus concentrations due to the uptake of available phosphorus by algae and subsequent loss from the water column. In August and September, the east end of the lake showed considerable phosphorus enrichment. By November the highest concentrations were found in the Cache Bay portion of the lake. The most likely source of this phosphorus was the decay of the extensive macrophyte beds found in that portion of the lake.

iii) Total Inorganic Nitrogen

Although nitrogen compounds do not typically limit algal growth, they are essential plant nutrients, and can influence the lake type. As the inorganic nitrogen decreases during the algal growing season, the total nitrogen component of the lake was dominated by organic nitrogen compounds. The total inorganic nitrogen concentrations showed a general decline throughout the year.

In May and June, enrichment associated with urban and agricultural runoff, as well as nitrogen contributed from the North Bay sewage treatment plant was evident in the eastern portion of the lake (Stations 1, 9 and 11). The total inorganic nitrogen concentrations at these stations ranged from 0.137-0.150 mg/L. Since nitrate is a principal component of treated sewage effluent, these results were not surprising.

The total inorganic nitrogen was relatively lower throughout the lake during July and August. The average concentrations ranged from 0.011-0.067 mg/L. Most of the stations decreased to below 0.02 mg/L during September, October and November. However, Station 7 increased to 0.196 mg/L and 0.140 in October and November respectively. The Station 9 concentration increased to 0.148 mg/L in September.

iv) Chlorophyll-a

Chlorophyll-a is the principal plant pigment used in photosynthesis, and is responsible for the green coloration in most plants. In water, the concentration of chlorophyll-a is a

surrogate measure of the concentration of planktonic algae. Algal concentrations are determined by the availability of plant nutrients, particularly phosphorus.

Relatively high chlorophyll-a concentrations, generally in excess of 0.005 mg/L, were common in Cache Bay (Station 7) throughout the year. The average concentrations at this station ranged from 0.0036 mg/L in July and September, to 0.038 mg/L in October. The highest concentrations of chlorophyll-a, however, were observed in Callander Bay (Station 9). The average concentrations at this station ranged from 0.0041 mg/L in June, to 0.024 mg/L in August. These chlorophyll-*a* concentrations present aesthetic problems and render the waters of the bay less suitable for recreational water-contact. The lowest chlorophyll-a concentrations were consistently measured at Station 6, which was in the vicinity of the Sturgeon River outlet. These concentrations ranged from 0.0011 mg/L in September and October, to 0.002 mg/L in May. This pattern was likely attributable to the high flow conditions near the Sturgeon River mouth.

v) Secchi Depth

Secchi Depth is a crude measure of water clarity, which is highly affected by the presence of humic substances such as dissolved or suspended sediments, and algal concentrations. This study identified obvious differences in water transparency throughout the year. Periods of poor transparency throughout the lake were primarily attributed to the resuspension of particulates from the lake bottom during windy conditions. However, elevated chlorophyll-a concentrations in Cache Bay (Station 7) and Callander Bay (Station 9) were considered to be the main cause of low water clarity in those areas. During fall sampling, particles of decaying plants from the extensive macrophyte beds in the western end of the lake (Stations 17 and 19) also contributed to low water clarity.

vi) Oxygen

In productive lakes, algae and macrophytes can contribute large amounts of organic material to the sediment at the end of the summer. Bacteria decompose this material in a process that consumes oxygen. In very productive lakes, this process can result in the depletion of oxygen concentrations under the ice during the winter, as well as during the summer stratification period. The main source of oxygen to lakes is from the atmosphere, and during the ice-cover period, this source is effectively eliminated over most of the surface of the lake. There is, in addition, some algal and plant production in most lakes even under ice, and although photosynthesis can provide another source of daytime oxygen, plant and algal respiration can deplete oxygen supplies. A survey of the lake was conducted during March 1990, in order to determine the status of oxygen concentrations under the ice. The results of the survey indicated that there was no sign of oxygen depletion thoughout most of the lake.

Station 12 had a depth of 40m, and was therefore the only station that was deep enough to stratify. Lake conditions permitting, vertical oxygen profiles were measured at that station on each sampling run. There was clear evidence of oxygen depletion at this site during the summer, as well as under ice. The site turned over each spring and fall, but the decay of organic matter caused a continual consumption of oxygen during the summer. This is to be expected given the mesotrophic nature of the lake, the large area of production, and the small volume of the stratified area. It is important to note that the affected area represented a tiny fraction of the total lake area.

4.1.4 1988-1991 Study Conclusions

In general, the chemical water quality of Lake Nipissing typified a mesotrophic lake with acceptable levels of all of the parameters measured. The nutrient levels were high enough to sustain a productive warmwater fishery, while nuisance levels of algae were mostly absent in the main body of the lake. Eutrophic conditions prevailed in sheltered embayments receiving inflows from watersheds with significant agricultural activity.

The calcium concentrations were of particular interest from two standpoints: lake acidification and the probability of a zebra mussel invasion. Lake Nipissing is situated relatively close to Sudbury, Ontario, which was a major source of sulfur deposition and widespread regional lake acidification. The Lake Nipissing pH levels varied from neutral to slightly basic, and were well above that of any recorded acidification effects. This was thought to be due to sufficiently high calcium concentrations and the associated anion bicarbonate, which provided an adequate buffer against the negative effects of acidification.

In comparison however, high calcium levels can make a lake susceptible to zebra mussel (*Dreissena polymorpha*) invasions. As a relatively new phenomenon, the zebra mussel environmental survival and proliferation requirements were uncertain. Experimental studies in Europe indicated that the mussel larva could not thrive in systems containing less than 12 mg/L calcium (Sprung, 1987). Surveys in European lakes also found an absence of the mussels in lakes with less than 28 mg/L calcium (Ramcharan et al., 1991). Cache Bay (Station 7) was the only area to exceed 12 mg/L, with an average calcium concentration of 15 mg/L. These data led to the conclusion that unless the zebra mussel showed considerable capability to adapt to lower calcium levels, Lake Nipissing would likely be spared.

i) 1988-1990 Trophic Status

Lake Nipissing has always been a productive lake. The 1988-1990 phosphorus levels indicated that Lake Nipissing was mesotrophic (moderately enriched with nutrients), and capable of supporting a healthy warmwater fishery. The algae levels contributed to the productive fishery, and did not appear to be causing aesthetic problems or nuisance algae blooms over the majority of the lake area. Of greater concern were the tributaries flowing into these bays from areas of agricultural activity.

The dissolved oxygen survey indicated that Lake Nipissing was well oxygenated throughout the year, with the exception of a small area of deep water near the mouth of the French River (Station 12). It was likely that oxygen depletion of this area occurred historically, since there was such a large volume of productive water, which could contribute organic material to this small, stratified area. Oxygen depletion in this area was also noted in surveys conducted in 1934 and 1935. In the absence of a coldwater fishery, the oxygen depletion of this small area was not a concern.

The shallow depth of most of the lake, coupled with its long fetch, enables the wind to mix the water throughout the water column, sustaining high levels of dissolved oxygen. Eutrophic conditions and periodic algae blooms were observed in two relatively sheltered embayments: Callander Bay and Cache Bay. Agricultural activity in the watersheds of the rivers flowing into these embayments was thought to be the likely source of the eutrophication. Phosphorus concentrations in these bays exceeded the Provincial Water Quality Objectives. Vertical and horizontal mixing in the main body of the lake reduced the impact of nutrient discharges from urban runoff and the North Bay sewage treatment plant.

ii) Comparison of the 1971-1974 and 1988-1991 Studies

The primary goal of the 1988-1991 study was to evaluate the trophic status of Lake Nipissing in comparison to the data collected between 1971-1974. The earlier surveys of Lake Nipissing showed that the lake was very productive, with high levels of nutrients compared to other lakes in the area. The data suggested that there had been significant increases in chlorophyll-a and decreases in phosphorus levels. However, the 1988-1990 study questioned the validity of these results because they could only have occurred if there had been a dramatic alteration in the lake's food web structure. This was thought to be highly improbable since a 1990 fisheries evaluation indicated that the structure of the fishery had been fairly stable since 1970. Further comparison of the two studies indicated that the variations were likely due to improved analytical methods used in the more recent 1988-1991study. It was therefore not possible to state conclusively whether there has been a significant deterioration or improvement in the trophic status of Lake Nipissing since the mid-1970s. It is interesting to note however, that paleolimnology techniques indicated that there had not been a significant change in the trophic status of the lake between 1975 and 1991.

4.2 2000 LAKE NIPISSING WATER QUALITY STUDY

4.2.1 <u>2000 Lake Nipissing Water Quality Study Objective</u>

As discussed in Section 1.0 of this report, a primary objective of this study was to compare the existing nutrient status of Lake Nipissing to the conditions that existed during the 1988-1990 study.

4.2.2 <u>2000 Lake Nipissing Water Quality Study Methods</u>

i) Sample Station Locations

The 2000 sample regime included a total of fourteen water quality stations located along the Lake Nipissing shoreline (see Figure 3). The identification numbers and locations of the following eleven sample stations were the same in both the 1992 and 2000 reports: 2, 3, 6, 7, 9, 11, 12, 14, 16, 17, and 25. The 2000 study also supplemented the 1988-1991 sample regime with three additional stations (2a, 6a and 14a), respectively located at the northeast, northwest and southeast borders of the lake.

ii) Field Measurements and Water Quality Sampling

All of the stations were monitored and sampled three times during the months of June, July and August, 2000. Each station was accessed by boat and the locations were confirmed through the use of a Geographical Positioning System (GPS). Temperature, D.O. and secchi depth readings were also recorded during each sample event. The following discussion describes how Station 12 was evaluated differently from the other thirteen stations.

Single temperature and D.O. measurements were taken at each station, with the exception of Station 12, which was the subject of a more detailed profiling exercise. Station 12 is located at the deepest point in the lake, with an approximate depth of <u>40m</u>. A dissolved oxygen and temperature meter was used to take readings at 1 m intervals to a maximum depth of 8 m (the full length of the meter probe). The results of these readings are presented in Table 1 (Section 4.2.3) of this report.

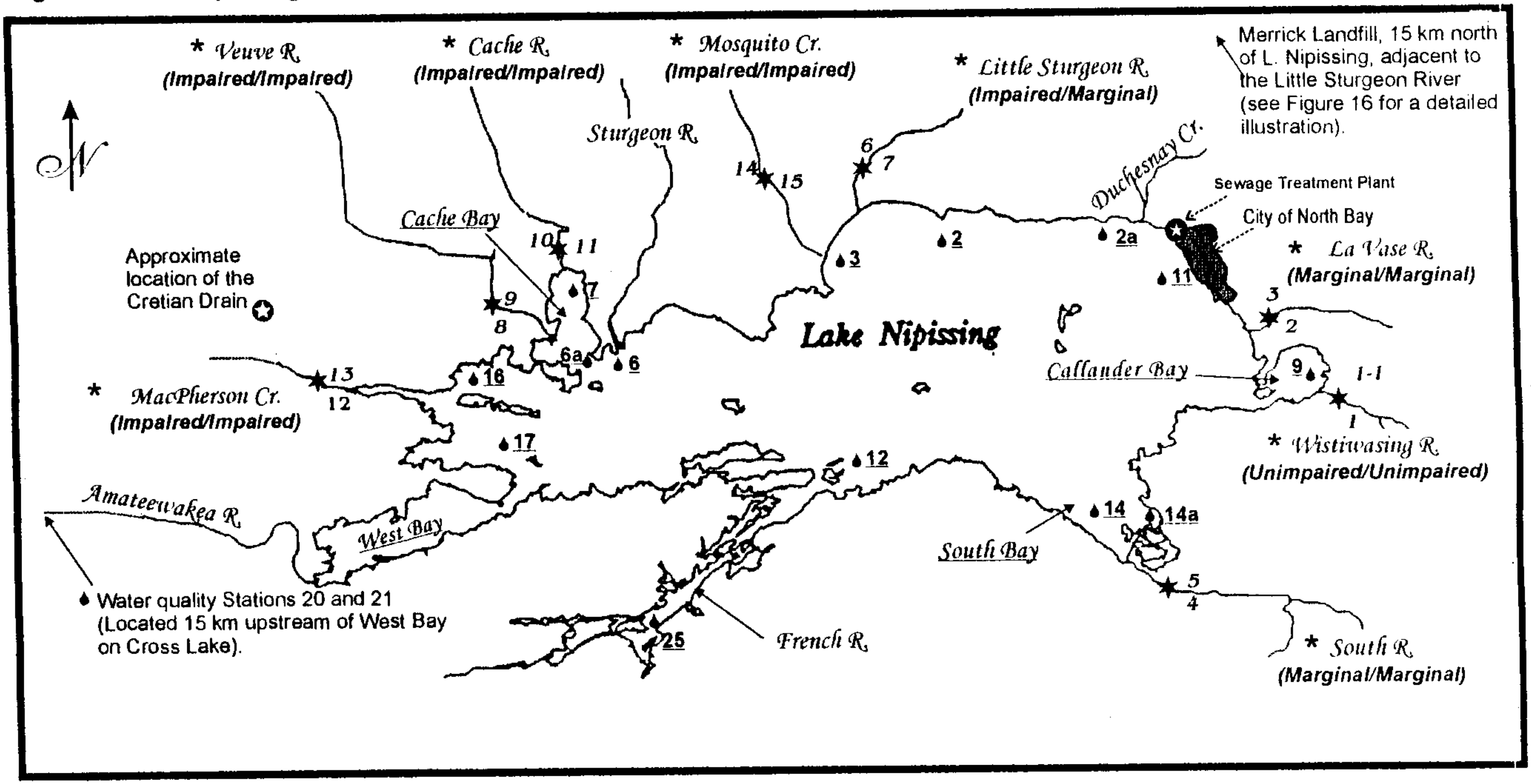
Single temperature and D.O. measurements were taken at the remaining thirteen stations by lowering a D.O./temperature probe to within 1 m of the lake bottom at each station. Water clarity measurements were taken by lowering a secchi disk over the unshaded side of the boat while recording the depth at which the contrasting black and white sections of the disk became visually obscured.

iii) Water Chemistry Analysis

Water column composite samples were collected from 0 to 5 m, or to within 1 m of the lake bottom in the case of shallow stations. All of the samples were submitted to Near North Laboratories in North Bay, Ontario, for analysis of the following parameters:

- <u>General</u>: alkalinity, chlorophyll-a, D.O.C. and pH
- <u>Ions</u>: calcium, chloride, magnesium, potassium, sodium and sulfate
- <u>Trace metals</u>: iron and manganese
- <u>Nutrients</u>: ammonia, nitrate, nitrite, total kjeldahl nitrogen (TKN), organic TKN and total phosphorus

Figure 3: Lake Nipissing and surrounding watershed 2000 sample stations



★8 9 - Watercourse benthic invertebrate sample stations. Lower numbers (e.g. 8) are upstream and higher numbers (e.g. 9) are downstream (see Section 5).

*Veuve River (Impaired/Impaired) - Refers to the BioMAP benthic invertebrate water quality study results (see Section 5.5).

upstream station — downstream station

♦# - Water quality sample stations (Sampled in 1988-1990 and 2000)

♦#a - Water quality sample stations (Sampled only in 2000)

✪ - Approximate location of the Cretian Drain. See Figure 14, for detailed drawing.

Each chlorophyll-a sample was collected in a 1L clear glass bottle, wrapped in aluminum foil and preserved with 20 drops of $MgCO_3$. The D.O.C. and nutrient samples were collected in two 500 mL amber glass bottles, and the remaining parameters were collected in three 500 mL plastic bottles. One 250 mL amber glass traveling blank air sample was also taken for the duration of each event.

iv) Data Analysis

All of the Lake Nipissing field evaluation and laboratory results were compiled into Appendix B-1 of this report. Where applicable, the results were compared to the Provincial Water Quality Objectives (PWQO) and all exceedences were highlighted. A more detailed analysis of chloride, iron, chlorophyll-a, secchi depths, total phosphorus and TKN was then completed, with specific trends illustrated in graph format (see Section 4.2.3).

The sample results for Stations 2, 3, 6, 7, 9, 11, 12, 14, 16, 17 and 25 were then compared to the 1988-1990 results. The differences between the past and present conditions were then calculated in Appendix B-2 of this report.

Comparisons of the data collected in 1988-1990 and 2000 are also presented in graph format in Section 4.2.3 of this report. The compared parameters included: calcium, conductivity, sodium, chloride, pH, alkalinity, total phosphorus, nitrogen and chlorophyll-a. It should be noted that secchi depth comparisons were not possible because the raw data for 1988-1990 was not available for this study.

The 2000 chemistry results also indicated obvious changes in iron and sulfate concentrations, which had occurred since the 1988-1990 study was completed. These changing trends are graphed in Section 4.2.3 of this report.

4.2.3 2000 Lake Nipissing Field Observations and Water Chemistry Results

As discussed in the above section, the complete list of 2000 chemistry results are presented in Appendix B-1 of this report. The following selected parameters of interest, are primarily reported as average concentrations.

i) General

Station 7 (Cache Bay at Cache River outlet) and Station 16 (Northeast of MacPherson Creek outlet) were the only stations to have one or more samples in exceedence of the PWQO for pH of 6.5-8.5. The Station 7 pH levels ranged from 9.7-10.2 with an average of 9.9. Station 16 ranged from 7.7-9.2 with an average of 8.5. The remaining twelve stations were within the pH range of 6.5-8.5 (see Figure 4).

The highest average alkalinity levels of 43 mg/L and 50 mg/L were measured at Stations 6 (at Sturgeon River outlet) and Station 7. The remaining twelve stations were within the alkalinity range of 19-25 mg/L (see Figure 5).

Station 9 (Callander Bay at Wistiwasing River outlet), had the highest average chlorophyll-a concentration of 0.01 mg/L. The remaining thirteen stations were within the range of 0.004-0.007 mg/L. (see Figure 6).

The deepest secchi readings were measured at Stations 12 (French River outlet), 25 (upper French River) and Station 16, with respective average measurements of 2.5m, 2.6m and 2.2m. The shallowest average readings of 1.2 m and 1.1 m were measured at Stations 6 and 6a (Cache Bay outlet) respectively. The remaining nine stations were within the range of 1.1-1.9 m (see Figure 7).

Figure 4: Lake Nipissing 2000 Average pH Measurements

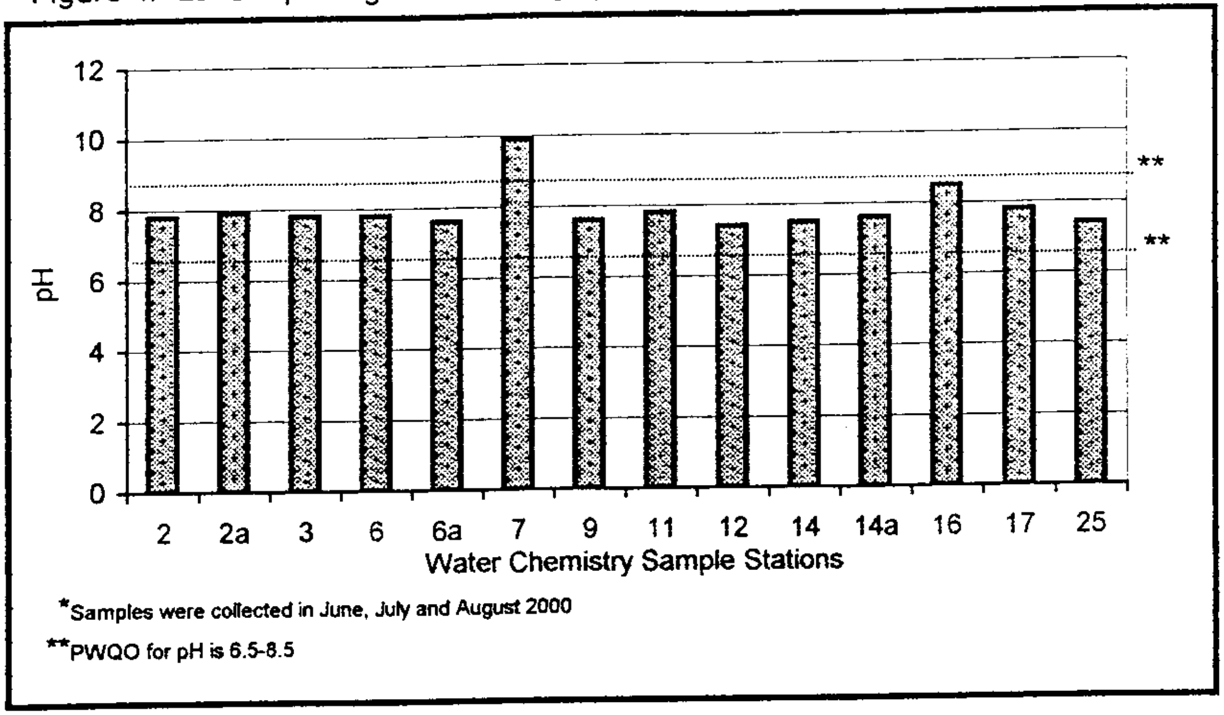


Figure 5: Lake Nipissing 2000 Average Alkalinity Measurements

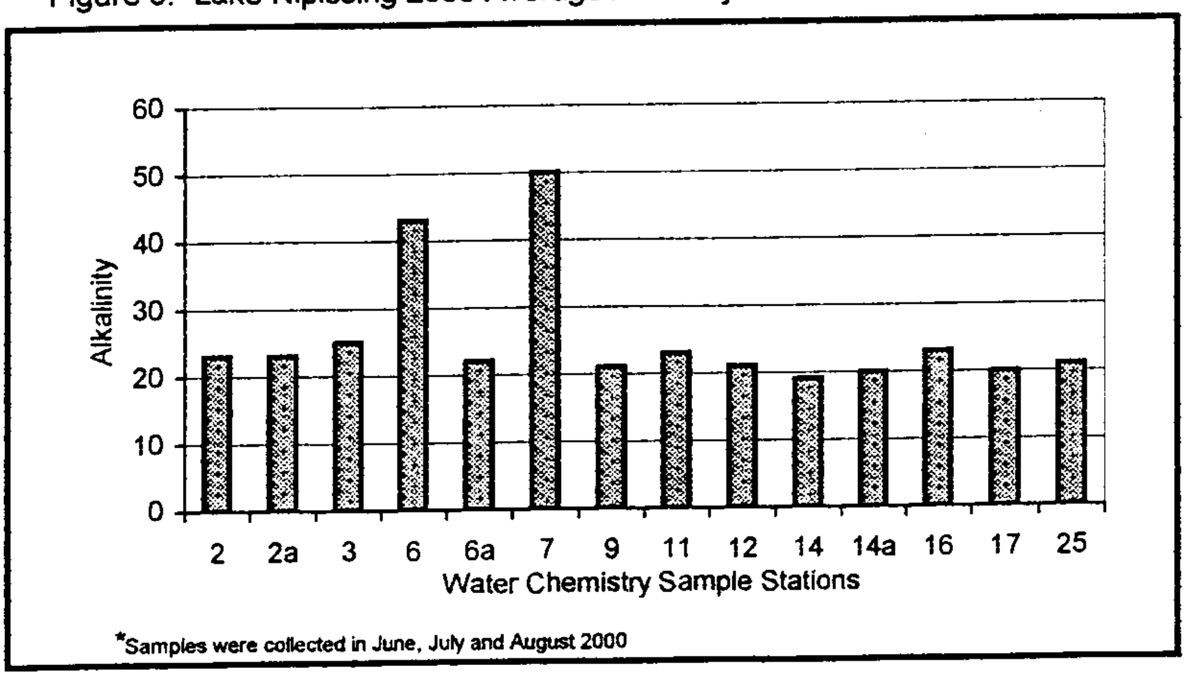


Figure 6: Lake Nipissing 2000 Average Chlorophyll-a Concentrations

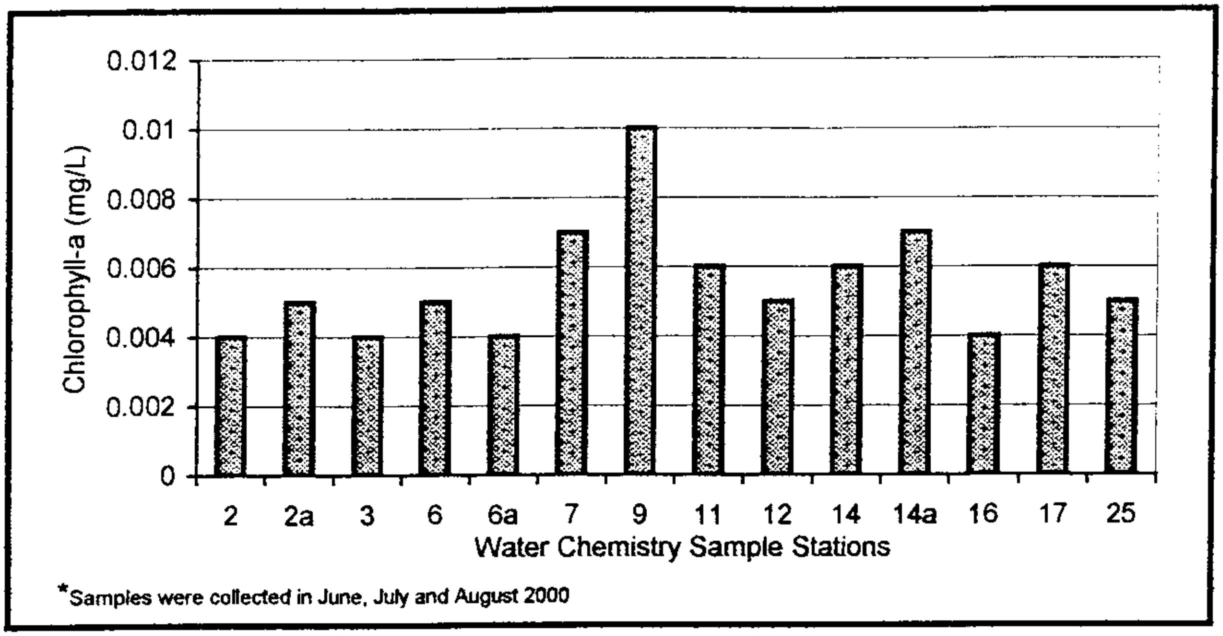
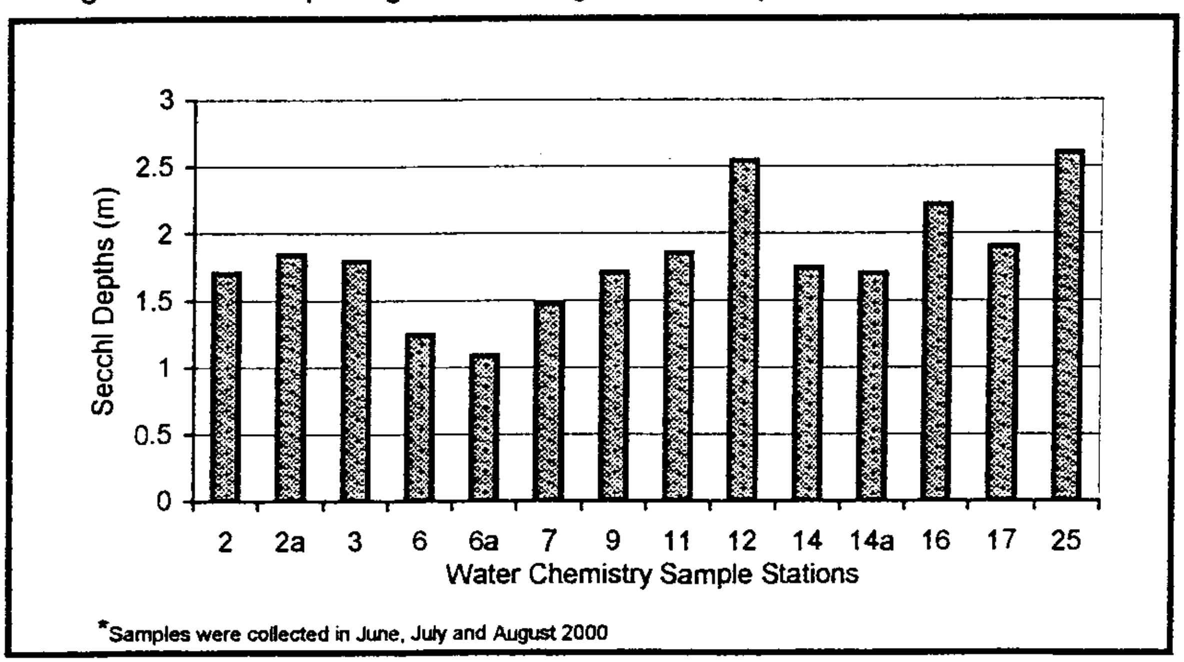


Figure 7: Lake Nipissing 2000 Average Secchi Depth Measurements



ii) Nutrients

The PWQO of 0.02 mg/L for total phosphorus was exceeded at Stations 6, 7, 9 and 12, with respective averages of 0.029mg/L, 0.025mg/L, 0.022mg/L and 0.021mg/L. The lowest average phosphorus concentrations of 0.003 mg/L and 0.004 mg/L were present at Stations 16 and 17 (Southeast of MacPherson Creek outlet) respectively. The remaining eight stations were within the range of 0.003-0.016 mg/L (see Figure 8).

The highest average TKN concentrations of 0.94 mg/l and 0.85 mg/L were found at Stations 6 and 7 respectively. The remaining twelve stations ranged from 0.44-0.66 mg/L (see Figure 9).

iii) Ions

The highest average chloride levels of 8.5 mg/L, 9.3 mg/L and 8.1 mg/L were detected at Stations 6 and 7 and 9 respectively. The lowest average concentration of 4.19 mg/L occurred at Station 6a (Cache Bay outlet). The remaining ten stations were within the range of 5.1-6.64 mg/L (see Figure 10).

iv) Metals

The PWQO of 0.3 mg/L for iron was consistently exceeded at Station 6 with an average concentration of 0.5 mg/L. The remaining thirteen stations were within the PWQO, with average concentrations ranging from of 0.15-0.20 mg/L (see Figure 11).

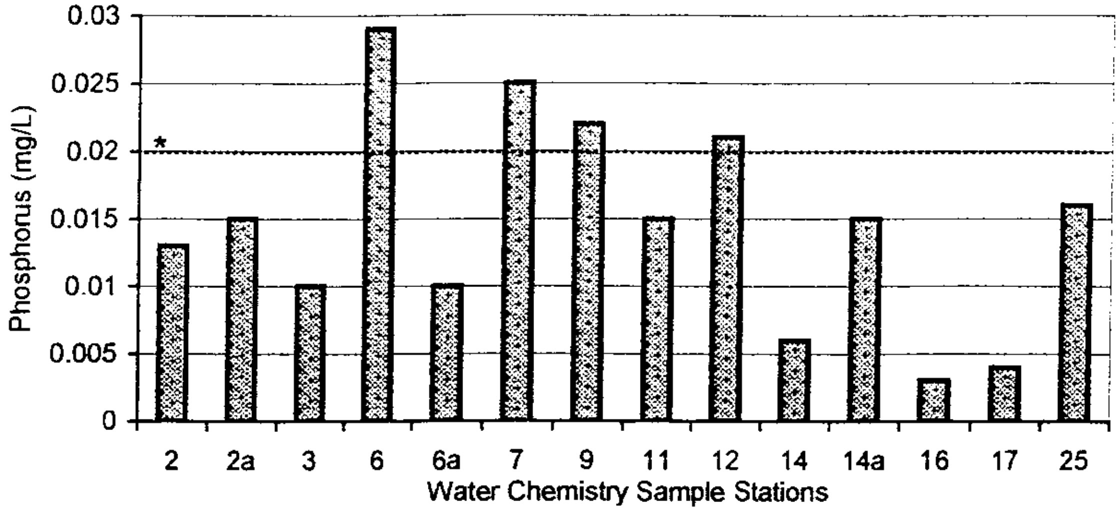
v) Station 12 Water Temperature and Dissolved Oxygen Profiles

Station 12 water temperature and dissolved oxygen profiles were recorded at 1 m intervals, to a total depth of 8 m. The temperatures remained between 18.7-19.8 ^{0}C throughout the field season, while the D.O. readings ranged from 8.24-8.52 mg/L (see Table 1).

Table 1: Lake Nipissing, Station 12 water temperature and dissolved oxygen profiles for 2000 field season

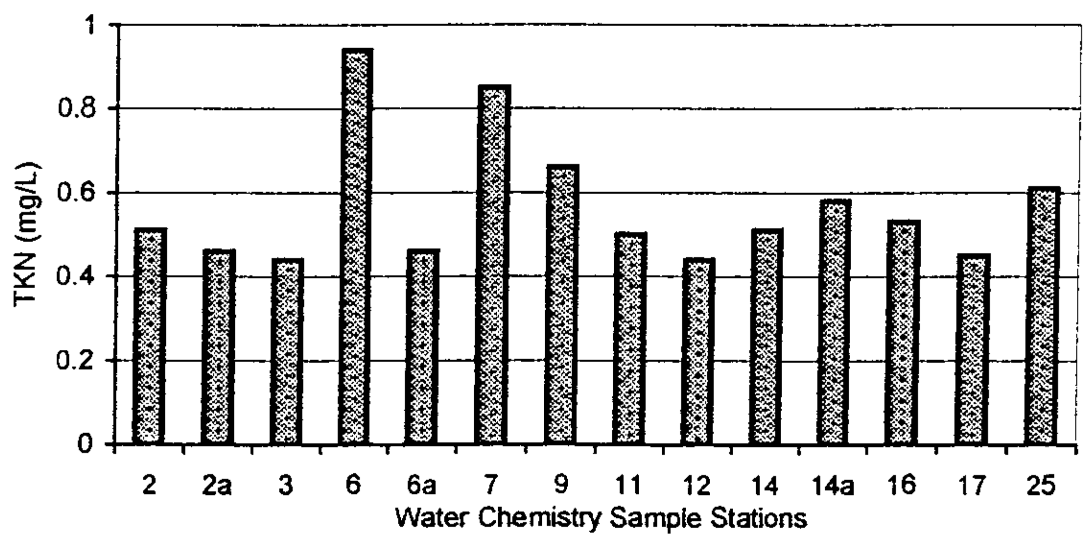
Depth (m)	June		July		August	
	Temperature (^{0}C)	D.O. (mg/L)	Temperature (^{0}C)	D.O. (mg/L)	Temperature (^{0}C)	D.O. (mg/L)
1	19.8	8.38	19.7	8.32	19.8	8.39
2	19.8	8.24	19.6	8.34	19.8	8.41
3	19.7	8.35	19.6	8.36	19.8	8.44
4	19.5	8.33	19.6	8.35	19.8	8.44
5	19.4	8.33	19.6	8.39	19.8	8.45
6	19.1	8.28	19.6	8.36	19.8	8.45
7	18.7	8.30	19.6	8.36	19.8	8.48
8	18.7	8.25	19.6	8.36	19.8	8.52

Figure 8: 2000 Lake Nipissing Average Phosphorus Concentrations



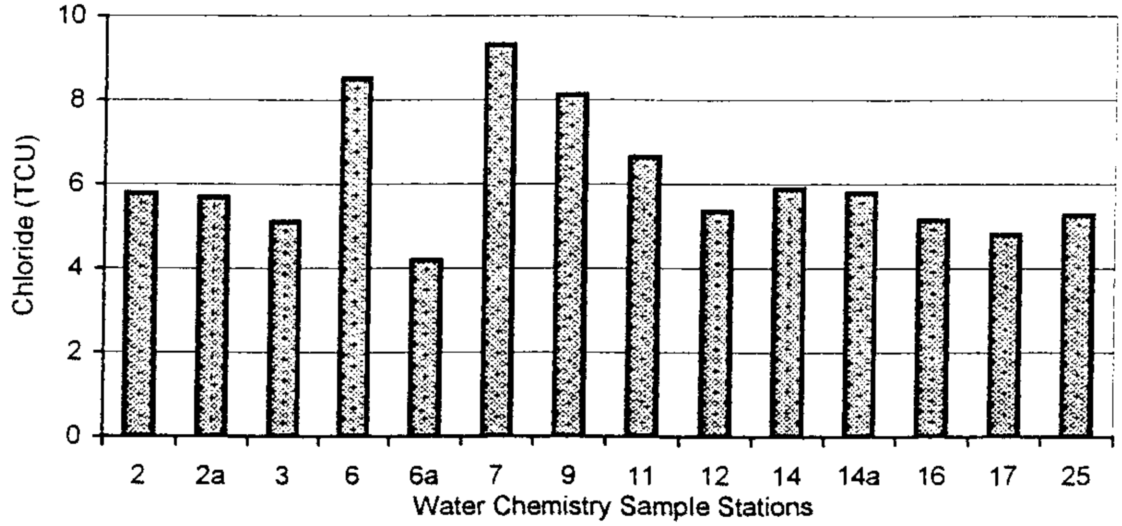
* ············ Provincial Water Quality Objective for phosphorus in lakes is 0.02 mg/L.
**Samples were collected in June, July and August 2000

Figure 9: 2000 Lake Nipissing TKN Average Concentrations



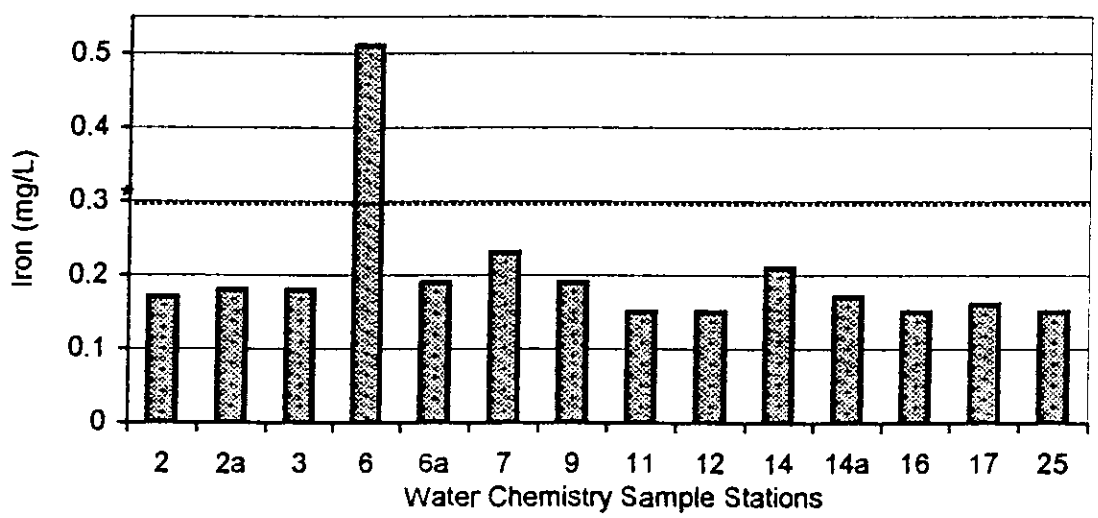
**Samples were collected in June, July and August 2000

Figure 10: 2000 Lake Nipissing Average Chloride Concentrations



*Samples were collected in June, July and August 2000

Figure 11: 2000 Lake Nipissing Average Iron Concentrations



* .... Provincial Water Quality Objective for iron is 0.3 mg/L

** Samples were collected in June, July and August 2000

4.3 Comparison of 1988-1990 and 2000 Lake Nipissing Water Quality Results

As discussed in the above section, a detailed comparison table of the 1988-1990 and 2000 chemistry results is presented in Appendix B-2 of this report. The following selected parameters of interest are reported as average concentrations.

i) pH and Alkalinity

The 2000 study results indicate that the average pH levels increased by a range of 1%-14% at nine of the eleven comparison sample stations (see Figure 12). Station 7 (Cache Bay at the Cache River outlet) was the only location to exceed the PWQO pH objective of 8.5 during both studies, with average pH levels of 8.6 in 1988-1990 and 9.9 in 2000. Station 7 also had the greatest pH increase of 14%, while Stations 12 (French River outlet) and 25 (upper French River), had the lowest changes of 0% and 1% respectively.

Ten of the eleven comparison stations indicated moderate increases in the 2000 alkalinity levels, by a range of 2%-22% (see Figure 13). The greatest increase of 63% however, occurred at Station 6 (Sturgeon River outlet). Although Station 6 had an intermediate average alkalinity level of 16.0 mg/L in 1988-1990, it increased to the second highest level of 43 mg/L in 2000. Station 7 had the highest alkalinity levels in both studies, measuring 49 mg/L in 1988-1990 and 50 mg/L in 2000.

ii) Chlorophyll-a

The average chlorophyll-a concentrations increased by a range of 25%- 90% at every station, except for Stations 7, 16 (MacPherson Creek outlet) and 9 (Callander Bay) (see Figure 14). Stations 7 and 16 had 0% changes, with the respective concentrations remaining at 0.007 mg/L and 0.004 mg/L in 2000. Station 9 however, had a 20% decrease, from 0.015 to 0.012 mg/L in 2000.

iii) Phosphorus and TKN

Phosphorus was the only parameter to demonstrate highly variable differences between past and present conditions throughout the entire study area (see Figure 15). The greatest increase of 50% occurred at Station 6. The average concentrations increased from 0.015 mg/L in 1988-1990, to 0.03 mg/L in 2000, which exceeds the PWQO of 0.02 mg/L. The Station 12 concentrations of 0.012 mg/L were well below the PWQO in 1988-1990, but increased by 44% to 0.020 mg/L in 2000. While the phosphorus concentrations at Stations 2 (east of Little Sturgeon River), 9, and 25 increased by a range of 5%-19%, they were all within the PWQO.

The greatest decrease in phosphorus concentrations occurred at Stations 16 and 17 (West Bay outlet), with reductions of 77% and 66%, respectively. The status of these stations was also changed from having relatively high average phosphorus concentrations of 0.021 mg/L and 0.018 mg/L in 1988-1990, to having the lowest concentrations of 0.007 mg/L and 0.008 mg/L in 2000. The remaining five Stations 3(Mosquito Creek outlet), 7, 9, 11(City of North Bay shoreline) and 14(South Bay), decreased by a range of 16% to 50%. It is worth noting that Station 7 was the only station to exceed the PWQO during both studies, with concentrations of 0.030 mg/L and 0.025 mg/L in 1988-1990 and 2000 respectively.

The TKN concentrations increased at every sample station, with the greatest increase of 65% occurring at Station 6 (see Figure 16). The Station 6 average concentrations increased from 0.33 mg/L in 1988-1990, to 0.94 mg/L in 2000. The lowest increase of 15% occurred at Station 11, with concentrations of 0.41 mg/L in 1988-1990 and 0.50 mg/L in 2000. The remaining nine stations increased by a range of 18% to 30%.

Figure 12: Lake Nipissing Average pH Levels - comparison of 1988-1990 to 2000 data

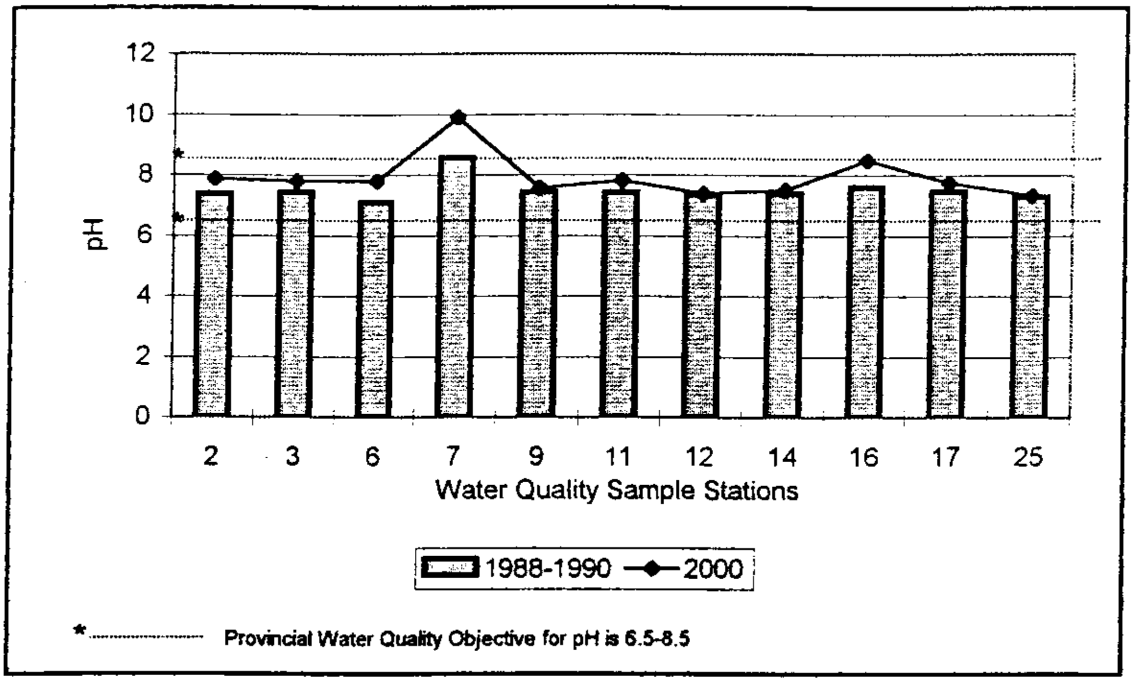
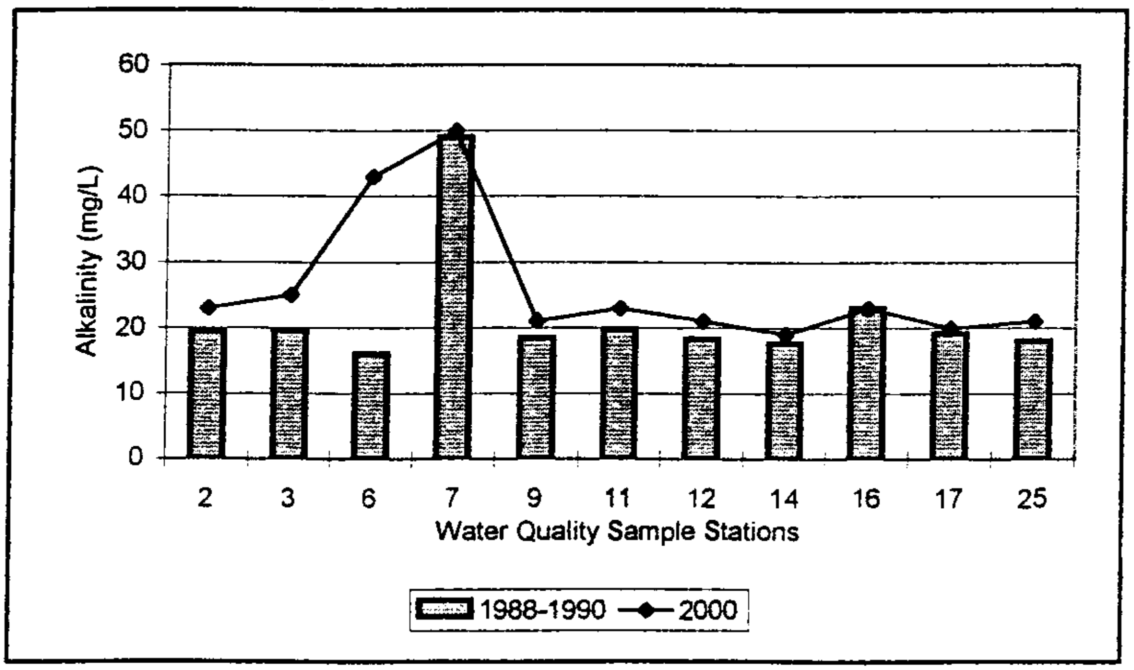
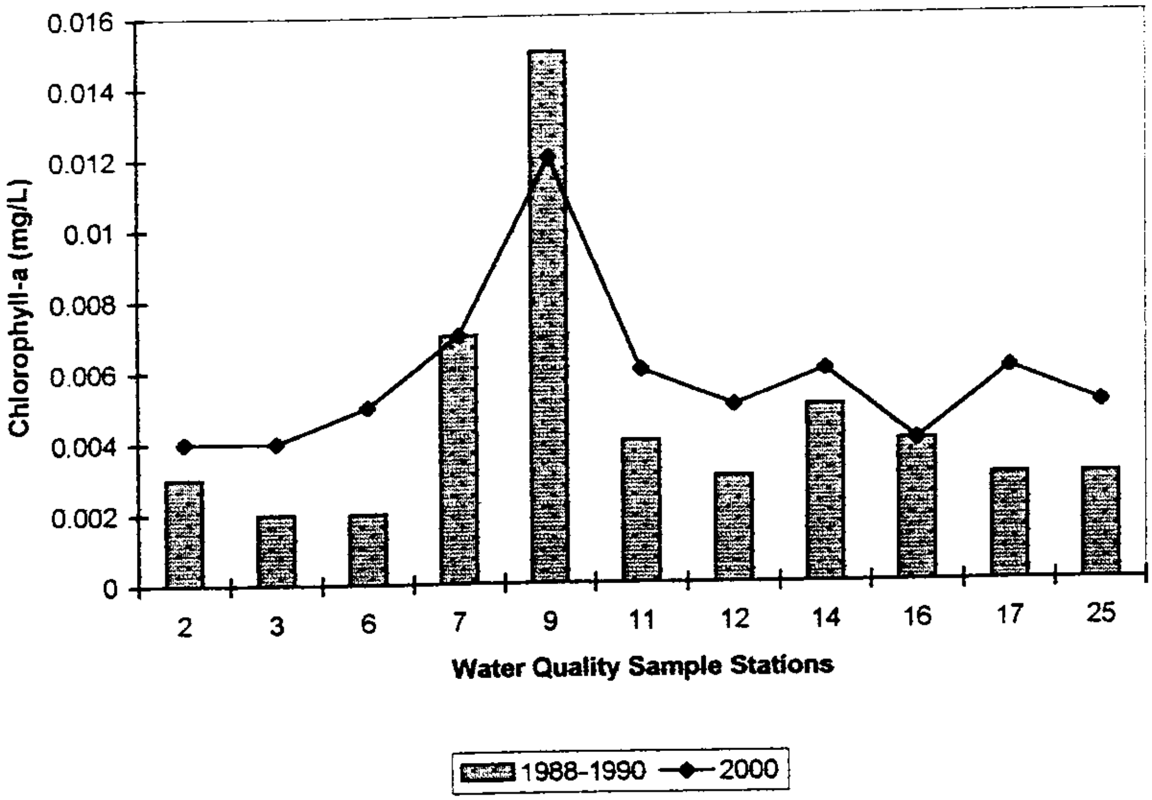


Figure 13: Lake Nipissing Average Alkalinity Levels - comparison of 1988-1990 to 2000 data



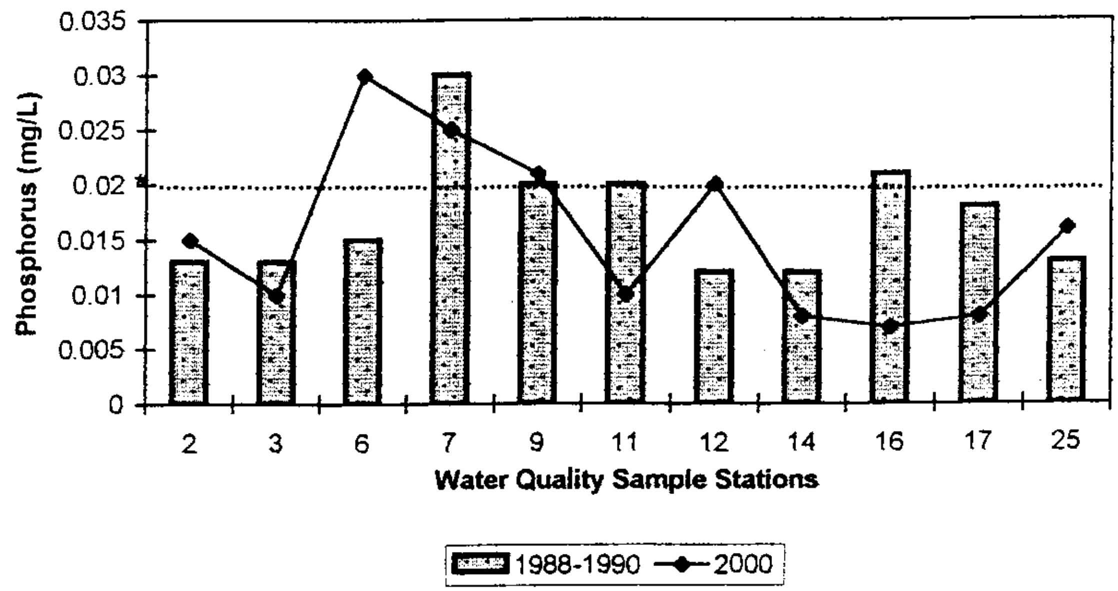
** 1988-1990 samples collected monthly during all seasons, 2000 samples collected during June, July and August.

Figure 14: Lake Nipissing Average Chlorophyll-a Concentrations - comparison of 1988-1990 to 2000 data



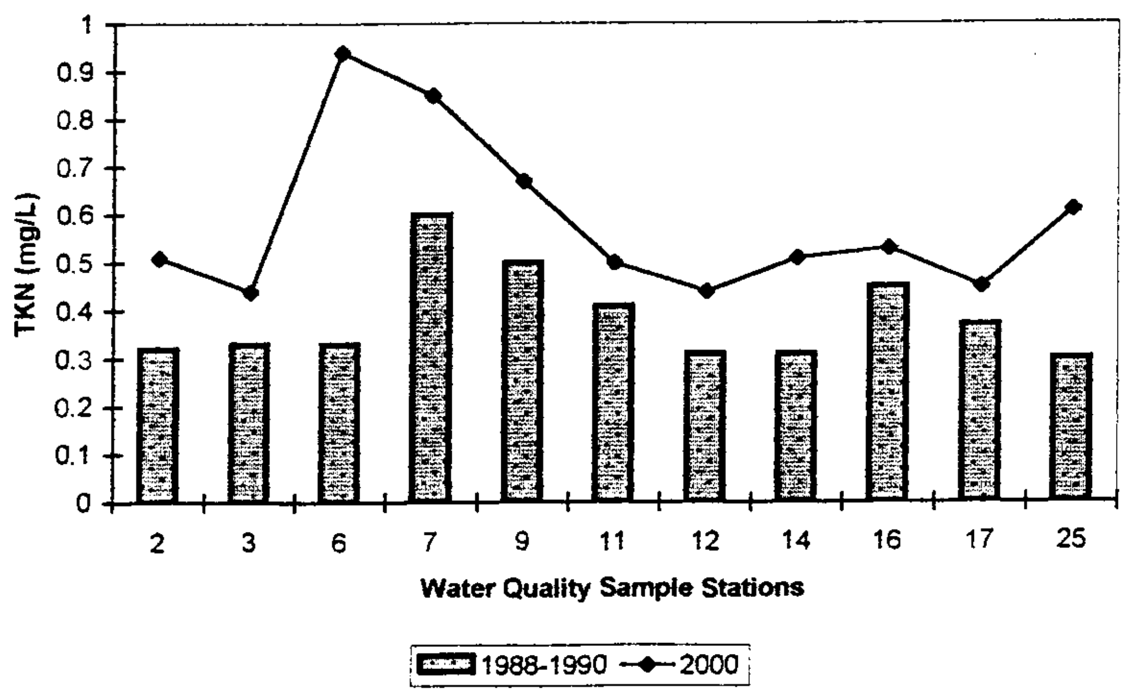
* All samples were collected in the months of June, July and August

Figure 15: Lake Nipissing Average Total Phosphorus Concentrations - comparison of 1988-1990 to 2000 data



* .... Provincial Water Quality Objective for phosphorus is 0.02 mg/L for the elimination of nuisance plant growth in lakes.

Figure 16: Lake Nipissing Average TKN Concentrations - comparison of 1988-1990 to 2000 data



*TKN = Total Kjeldhal Nitrogen (no Provincial Water Quality Objective)

* All samples were collected in the months of June, July and August

iv) Sodium and Chloride

With the exception of Stations 6 and 7, the minimal changes in sodium concentrations ranged from decreases of 1% to increases of 15% (see Figure 17). Station 6 increased by 57%, changing it's status from having the lowest average sodium concentration of 2.46 mg/L in 1988-1990, to the having the highest concentration of 5.75 mg/L in 2000. Station 7 increased by 32%, with a moderate concentration of 3.35 mg/L in 1988-1990, to the second highest concentration of 4.92 mg/L in 2000.

The chloride concentrations were greater at every sample station, ranging from 25% to 81% increases throughout the entire study area (see Figure 18). The greatest increases of 81% and 51% occurred at Station 6 and 7 respectively. The Station 6 average concentrations increased from 1.62 TCU in 1988-1990, to 8.50 TCU in 2000. The Station 7 average concentrations increased from 4.51 TCU in 1988-1990, to 9.3 TCU in 2000. The remaining nine stations increased by a range of 25%-45%.

v) Iron

Iron concentrations increased by a range of 6%-77% at nine of the eleven sample stations, with 6% decreases occurring at Stations 16 and 17 (see Figure 19). The average concentrations at these stations respectively decreased from 0.16 mg/L and 0.17 mg/L in 1988-1998, to 0.15 mg/L and 0.16 mg/L in 2000. The PWQO of 0.3 mg/L was exceedence only at Station 6, which increased from 0.19 mg/L in 1988-1990 to 0.51 mg/L in 2000.

vi) Sulfate

Sulfate was the only parameter to decrease at all eleven sample stations by a range of 30%-88% (see Figure 20). The largest decreases of 81% and 88% occurred at Stations 6 and Station 7, respectively. The average concentrations at these stations decreased from 11.1 mg/L and 8.58 mg/L in 1988-1990, to 8.58 mg/L and 1.9 mg/L in 2000. The smallest decreases of 30% and 44% occurred at Stations 2 and 11. The average concentrations at these stations respectively decreased from 10.57 mg/L and 10.64 mg/L in 1988-1990, to 7.5 mg/L and 6.0 mg/L in 2000.

4.4 REVIEWER COMMENTARY

4.4.1 Wilderness Preservation Committee of Ontario

- *With the limited data, there do not seem to be significant differences in the 1988 to 2000 data. It may therefore be wise not to state that there are significant differences in the report since this is not conclusive.*

- *Information should be included on land use changes that have occurred since the previous 1988-1990 report. Are there concerns for future development on the lake? In light of these uncertainties, it cannot be conclusively stated that the water quality has not changed since the earlier study was completed.*

- *Baseline or trend monitoring points should be situated where mixing is ensured. The report states that "the 1988-90 sampling locations were close to point sources." These should not be used for trend monitoring since they show local effects or source changes. This adds to the total variably of the data at a site since the source has many dependant variables such as wind, rainfall, the flow patterns and flow loadings. But they can be good to highlight potential areas of concern for further work.*

Figure 17: Lake Nipissing Sodium Concentrations - comparison of 1988-1990 to 2000 Data

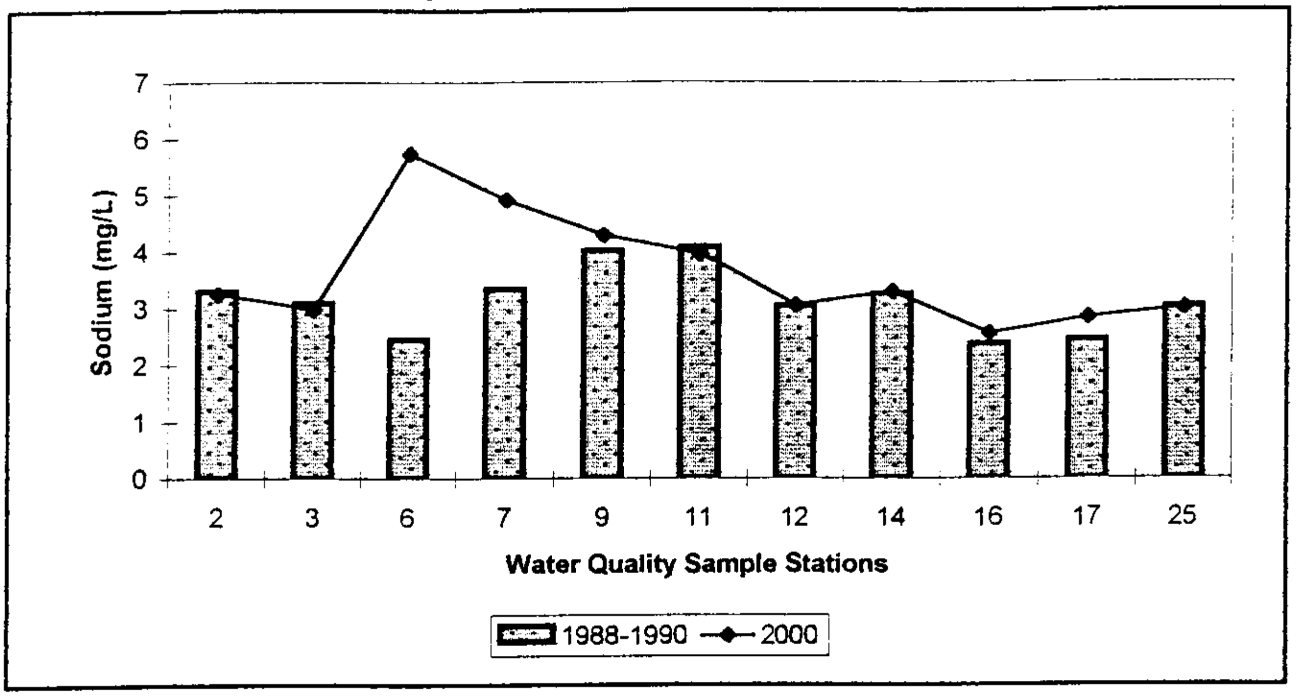
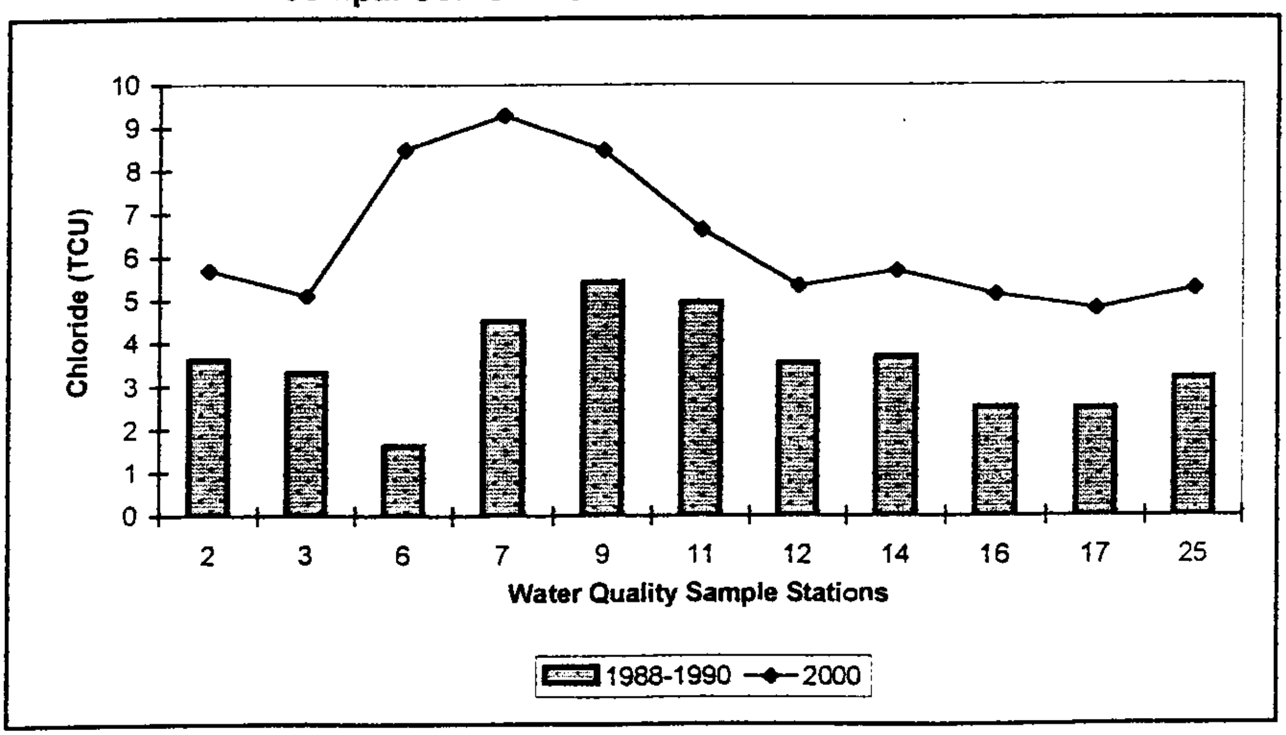


Figure 18: Lake Nipissing Average Chloride Concentrations - comparison of 1988-1990 to 2000 data



* 1988-1990 samples collected monthly during all seasons, 2000 samples collected during June, July and August.

Figure 19: Lake Nipissing Average Iron Concentrations - comparison of 1988-1990 and 2000 data

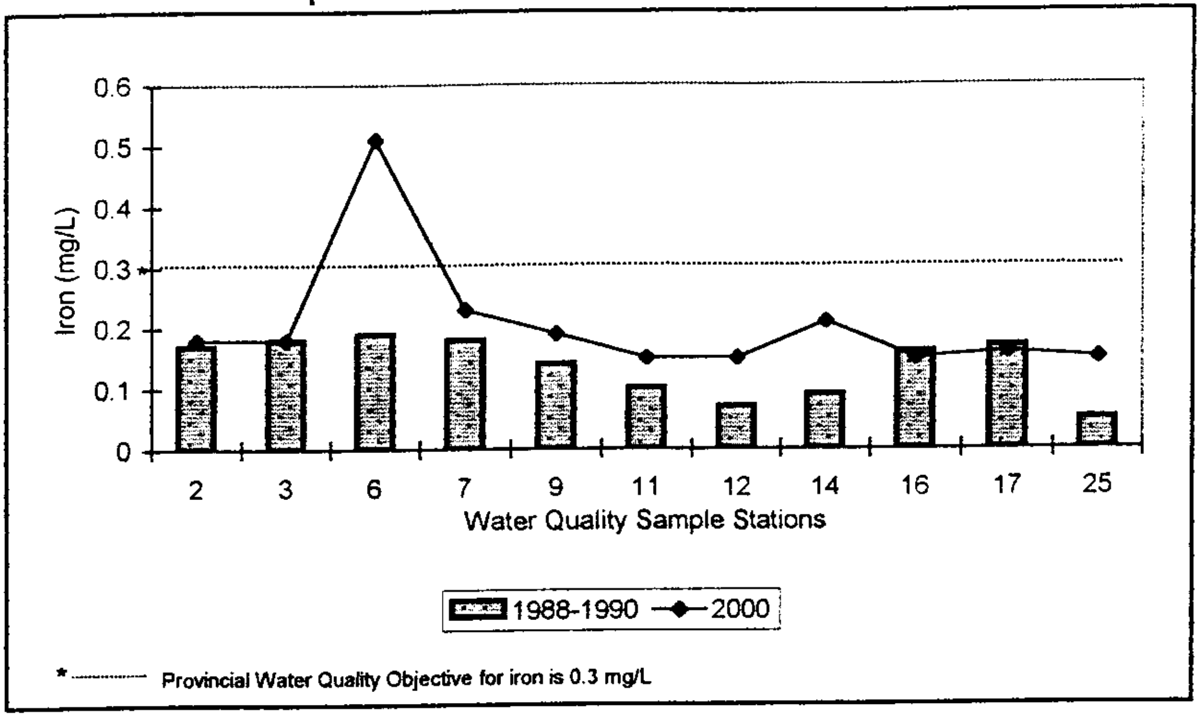
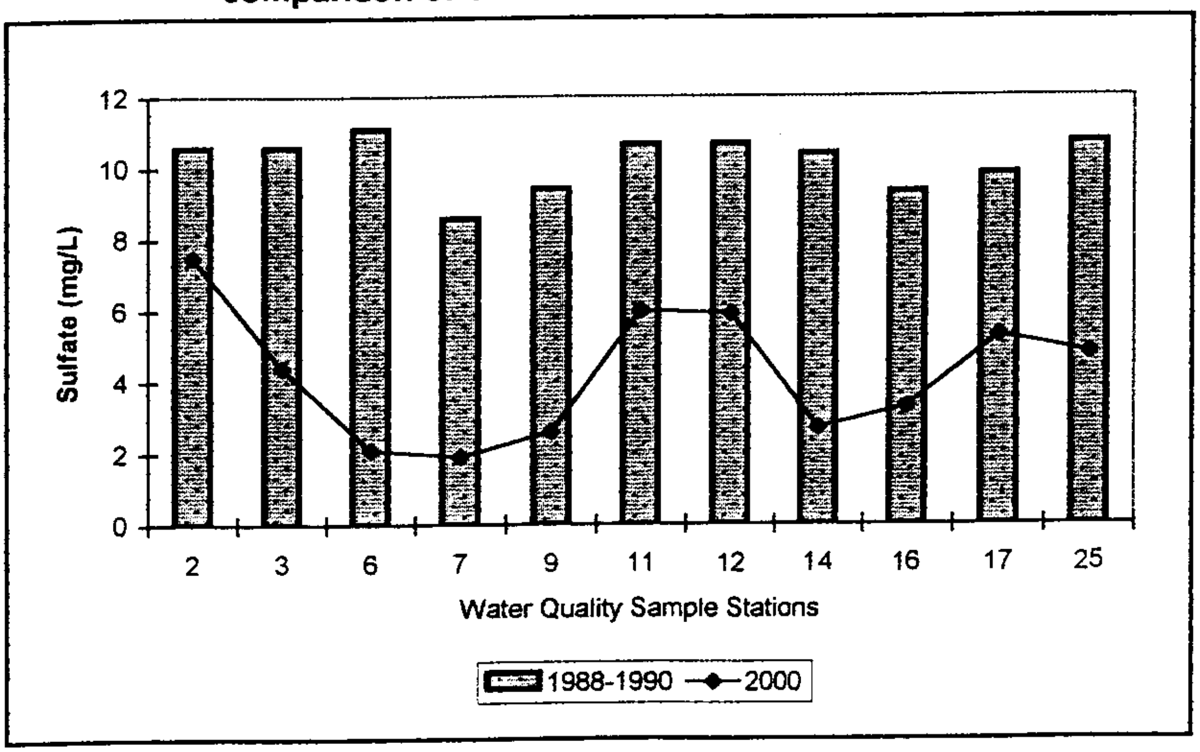


Figure 20: Lake Nipissing Average Sulfate Concentrations - comparison of 1988-1990 and 2000 data



*1988-1990 samples collected monthly during all seasons. 2000 samples collected during June, July and August.

- *Algae problems & high chlorophyll-a levels were documented in 1988 & 2000 but nothing is discussed about possible nutrient sources, lack of circulation, changes in flow, depth, water temperature, all of which affect the growth of algae. To evaluate what can be done to reduce the algae, this information will need to be collected. Future studies should also include the identification of algae types.*

- *Station 6, located near the Sturgeon Creek outlet to Lake Nipissing, shows increased levels of many parameters. (>conductivity, >D.O.C., <D.O., >TKN, >TP,>iron). Considering it was a wet year, it is likely that this sample point has been affected by stormwater runoff. Perhaps this should be further investigated. Information should also be collected on land uses and possible pollution sources.*

- *The deep secchi disk reading at 12 would indicate that if the area was stratified, it would likely be at >8m. The relatively greater clarity may possibly be due to the presence of larger amphipod populations at this station.*

- *Future studies should utilize a longer D.O. probe to ensure that data collection occurs below the thermocline.*

- *With the limited data, there does not seem to be significant differences in 1988 to 2000 data. It would therefore be wise to not conclusively state that there are significant differences in the final report.*

- *Algae problems & high chlorophyll-a were documented in 1988 & 2000, but possible sources of nutrients, lack of circulation, changes in flow, depth or water temperature are not identified. This information should be collected, and algae types should be identified in order to evaluate what can be done to reduce these algae levels.*

4.4.2 Ministry of the Environment

- *There do not seem to be any significant differences between the 1988-1990 and 2000 data. Minor variability may be a result of temporal variations in sampling. 1988-1990 data also included a May sampling event, which is often higher in total phosphorus, particularly in the lake samples. In contrast, the 2000 sampling occurred in late June, which is often lower in total phosphorus.*

5.0 CONTRIBUTING WATERCOURSE BENTHIC MACROINVERTEBRATE BIOMAP EVALUATIONS

5.1 WATERCOURSE EVALUATION OBJECTIVES

The **Bio**logical **M**onitoring and **A**ssessment **P**rogram (BioMAP) was applied to this study in order to evaluate the long-term water quality conditions of eight major watercourses that flow into Lake Nipissing (see Figure 3).

5.2 BioMAP DESCRIPTION

Benthic macroinvertebrates include those larger invertebrates that crawl over, or within aquatic substrates (e.g. sediments, stones, vegetation) for at least part of their life cycle. Several common examples of benthic macroinvertebrates include: mayflies, caddisflies, beetles, crayfishes, snails, clams and worms.

The BioMAP system is used to evaluate benthic macroinvertebrate communities as water quality indicators. This is possible because benthic macroinvertebrates have specific habitat requirements and restricted mobility, and are therefore continuously exposed to the constant and/or changing environmental conditions of localized areas. As a result, their responses to environmental stresses (e.g. chemical pollution, siltation, channelization, etc.) can provide important insights into the ecological health of aquatic systems.

BioMAP determines if specific aquatic habitats maintain unimpaired or impaired water quality conditions. "Unimpaired" water quality is defined as being unaltered by human activity, while "impaired" water quality is altered by human activity. When an aquatic habitat becomes degraded by pollution, the existing aquatic community may be replaced by a different, "out of place" community that is more suited to the new environmental conditions. For example, an existing pollution sensitive, coldwater community may be replaced by a more pollution tolerant, warm water community.

"Impaired" water quality is therefore identified by the presence of benthic macroinvertebrate species whose environmental requirements do not match those expected at that site (e.g. cold water habitats are dominated by warm water species). Conversely, "unimpaired" water quality is identified by the presence of benthic macroinvertebrate species whose environmental requirements are matched to those expected at that site (e.g. cold water habitats are dominated by cold water species, while warm water habitats are dominated by warm water species).

5.3 BioMAP EVALUATION METHODOLOGIES

The eight watercourses were evaluated according to BioMAP methods, as outlined in: *BioMAP: bioassessment of water quality* (Griffiths, 1999). The BioMAP water quality evaluations were determined through the following activities:

Step #1: Aquatic Habitat Classifications

Visual observations and physical measurements recorded at each station were used to develop the following habitat designations, as outlined in the BioMAP user manual:

a) *creeks:*
- headwaters of a riverine system (upper rhithron)
- bankfull width of <4 m
- principally first and second order systems
- closed tree canopy over water
- cold or cool summer temperatures

b) *streams:*
- lower stretch of the rhithron
- bankfull width of 4-16 m
- principally third and fourth order systems
- partially open tree canopy
- cold, cool or warm summer water temperatures

c) *rivers:*
- upper stretch of potamon
- bankfull width 16-64 m
- principally fifth and sixth order systems
- open tree canopy; sunlight reaches water surface
- cool and warm summer water temperatures

Step #2 Benthic Macroinvertebrate Collection

Two benthic macroinvertebrate evaluation stations were established approximately 50 paces apart, at each of the eight watercourses, for a total of sixteen stations. The benthic macroinvertebrate collection procedure utilized an artificial substrate consisting of cube-shaped wire baskets lined with a cobble-sized substrate. During the last week of June 2000, three baskets were placed in each of the sixteen stations, secured with stakes and marked with flagging tape. The field crew returned in late August to remove the baskets from each station.

The invertebrate collection procedure required that nets be used to manually sweep under the baskets as they were removed in order to catch any fleeing macroinvertebrates. The purpose of this quantitative sampling was to estimate the population density of each species located within a defined area.

The following habitat conditions were also recorded at the time of the invertebrate basket collections:

- Water temperature, D.O., pH, color, clarity, odor, watercourse width, watercourse depth, substrate type, macrophytes and bank vegetation.

Step #3 Macroinvertebrate Processing Methodology

The benthic macroinvertebrate samples were preserved in 10% buffered formalin solution within 24 hours of collection, in order to prevent them from degrading due to die-off and decay. The samples were then poured into a stack of three sieves containing 4 mm, 2 mm and 500 µm mesh. Water was then poured over the entire area of the top sieve and the stack was gently shaken to drain off as much water as possible. This was continued until the drained water was clear. The contents of each sieve were then placed in separate white enamel trays. The benthic macroinvertebrates were then removed from each tray using tweezers, and preserved in sample bottles containing an 80% ethanol solution.

Step #4 Benthic Macroinvertebrate Species Identification and Sensitivity Ranking

The processed samples were submitted to a taxonomic expert for quantification and identification to the species level. Using the BioMAP manual (Griffiths, 1999), sensitivity values ranging from 4 (most sensitive) to 0 (least sensitive), were recorded for each species.

Step #5 Water Quality Index Calculation

The macroinvertebrate numbers and sensitivity values for each species were used in the following BioMAP (d) quantitative water quality calculation:

$$WQI = [\sum^{n} (e^{Sv_i} * \ln(x_i + 1))] \div [\sum \ln(x_i + 1)]$$

where, Sv_i is the sensitivity value of the i^{th} ranked taxon,
xi is the density of the ith taxon,
n is the number of taxa in the sample,
in is the natural logarithm, and
e is the number 2.718.

Step #6 Water Quality Classification

Habitat classifications and water quality index values for all sixteen stations were referenced with Table 2, and designated as either "impaired" or "unimpaired".

TABLE 2: BioMAP (d) water quality index classifications based on habitat types

HABITAT CLASSIFICATION	WATER QUALITY CLASSIFICATION	
	Unimpaired	Impaired
Streams	>12	<10
Rivers	>9	<7

5.4 BioMAP DATA ANALYSIS

The benthic macroinvertebrate samples were identified by Ronald Griffiths (BioMAP author) and given individual sensitivity values. These values were then applied to the BioMAP water quality index calculation for each station, as described in Section 5.3 of this report. The values were then compiled in Table 3, and each station was designated as either "unimpaired" or "impaired".

5.5 WATERCOURSE EVALUATION RESULTS

Figure 3 identifies the impaired watercourses located along the northern and western shorelines, while the unimpaired and marginal watercourses were primarily located along the eastern shoreline. The detailed benthic macroinvertebrate species list is included in Appendix B-3 of this report.

Of the eight evaluated watercourses, only one (Wistiwasing River) received an "unimpaired" water quality designation. Two watercourses (South River and La Vase River) had marginal water quality. Four watercourses (MacPherson Creek, Veuve River, Cache River and Mosquito Creek) received "impaired" water quality designations. The eighth watercourse (Little Sturgeon River) was impaired at the upstream Station 6, but marginal at the downstream Station 7.

5.6 REVIEWER COMMENTARY

5.6.1 Wilderness Preservation Committee of Ontario

- *The Wistiwasing River is classified as an unimpaired river that enters Calendar Bay. Is it therefore assumed that the river is not a contributing source of the Bay's algal problems? Direct observations suggest that stormwater discharges to the bay, lack of circulation, depth, and water temperature may be the major problems.*

5.6.2 BioMAP Author

- *The Wistiwasing River is clearly the best watercourse. The remaining watercourses are similar to each other, with marginal to impaired water quality.*

- *The causes of impairment cannot be conclusively determined without further investigation (e.g. identification of possible point discharge sources, surrounding land use mapping, etc.).*

Table 3: Lake Nipissing watershed benthic invertebrate monitoring and water quality evaluation

Watercourse	Habitat Type	Calculated BioMAP (d) WQ Value	BioMAP WQ Designation
Wistiwasing River (upstream)	Stream	16	>12 ∴ **Unimpaired**
Wistiwasing River (downstream)	Stream	18	>12 ∴ **Unimpaired**
LaVase River (upstream)	River	7	<9, =7 ∴ **Marginal**
LaVase River (downstream)	River	7	<9, =7 ∴ **Marginal**
South River (upstream)	River	8	<9, >7 ∴ **Marginal**
South River (downstream)	River	7	<9, =7 ∴ **Marginal**
Little Sturgeon River (upstream)	River	6	<7 ∴ **Impaired**
Little Sturgeon River (downstream)	River	8	<9, >7 ∴ **Marginal**
Veuve River (upstream)	River	6	<7 ∴ **Impaired**
Veuve River (downstream)	River	6	<7 ∴ **Impaired**
Cache River (upstream)	Stream	8	<10 ∴ **Impaired**
Cache River (downstream)	Stream	6	<10 ∴ **Impaired**
MacPherson Creek (upstream)	River	6	<7 ∴ **Impaired**
MacPherson Creek (downstream)	Stream	7	<10 ∴ **Impaired**
Mosquito Creek (upstream)	Stream	4	<10 ∴ **Impaired**
Mosquito Creek (downstream)	Stream	5	<10 ∴ **Impaired**

*BioMAP = Biological Monitoring and Assessment Program
*WQ = water quality
*See Figure 3 for watercourse locations

6.0 <u>CHRETIAN DRAIN AND MACPHERSON CREEK</u>: Water Quality, Fisheries and Watercourse Evaluations

6.1 STUDY OBJECTIVES

The Chretian Drain discharges agricultural runoff to MacPherson Creek, which ultimately flows into Lake Nipissing. Water quality sampling, electrofishing and watercourse assessment activities were conducted on both the creek and the drain in order to characterize the existing contrasting conditions of each channel. The results of this study will be entered into a new database, to be updated through follow-up studies.

6.2 STUDY SITE LOCATION AND DESCRIPTION

The MacPherson Creek headwaters begin in Kirkpatrick Township and flow southward through MacPherson Township, located 20 km west of Sturgeon Falls. The creek flows through both natural and agricultural lands before entering Bear Lake, which ultimately discharges to the western shore of Lake Nipissing (see Figures 3 and 21). The Chretian Drain is an engineered channel that extends 3 km through an agricultural field before discharging to MacPherson Creek. The drain converges with MacPherson Creek midway between the creek headwaters and Bear Lake, within MacPherson Township.

6.3 STUDY METHODS (*author: Derrick Smith*)

6.3.1 <u>Field Evaluation</u>

The MacPherson Creek and Chretian Drain were initially traversed by canoe and foot in order to gain a better understanding of the topography, access routes, sampling stations, and flow dynamics. A greater familiarity of the site was also gained by viewing the Verner 41-1/8, Ed. 4, topographic map and aerial photographs of the MacPherson Creek and the Chretian Drain.

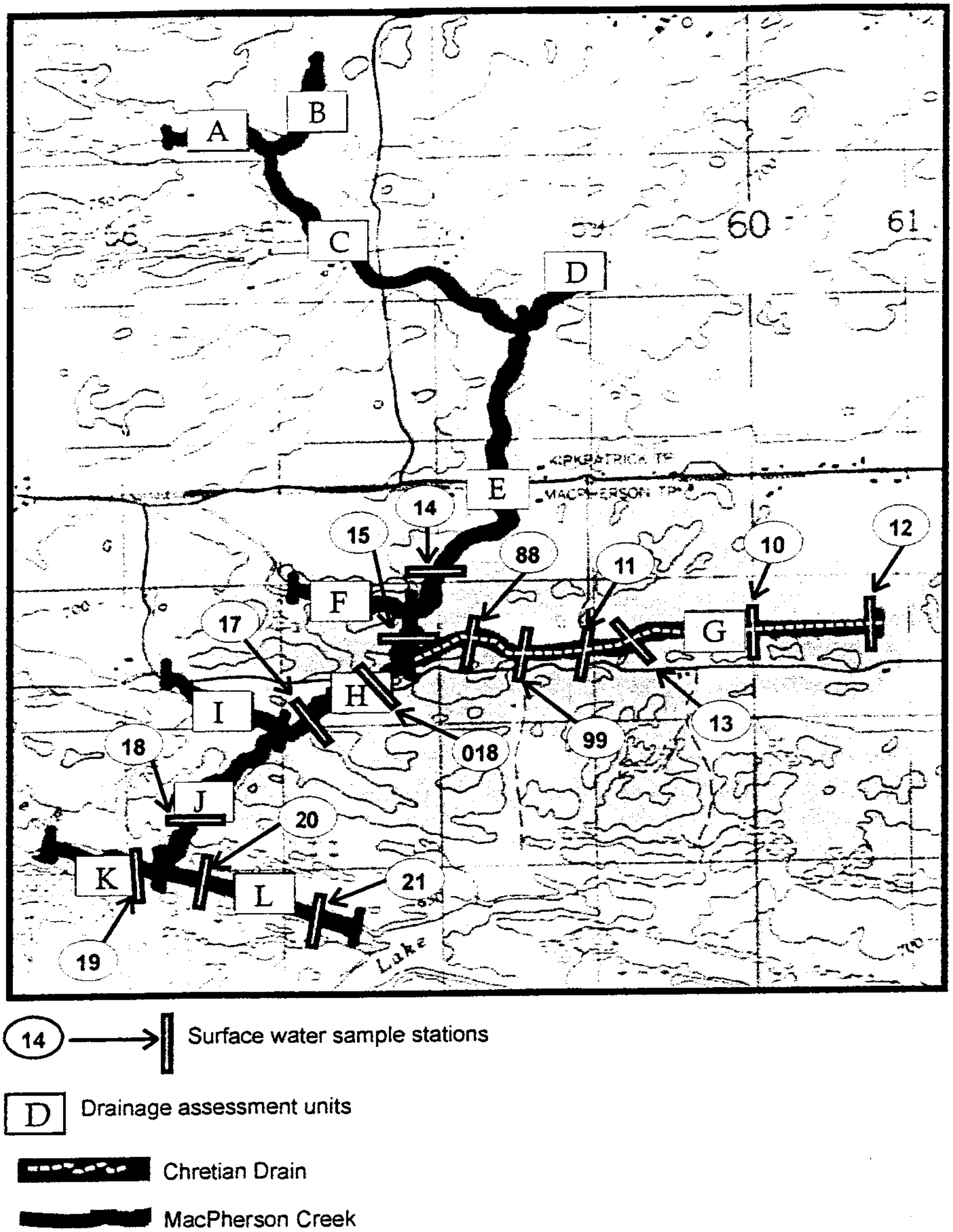
The drain is not illustrated on the topographic map, and was therefore mapped through the use of a Garmin 12 Geographical Positioning System (GPS). The field crew walked the drain and designated waypoints for each major meander point. Waypoints were also given to significant features such as: tributaries, outfalls, and culvert crossings. General descriptions of each waypoint are included in Appendix C-1 of this report.

6.3.2 <u>Water Chemistry</u>

A total of fifteen water quality sample stations were established along the Chretian Drain and MacPherson Creek (see Figure 14). Each sample station was located at selected tributary junctions, with one upstream and one downstream sample collected at each junction. Sites were also chosen with regard to what type of land the tributary passed through (e.g. crop fields). The purpose of this was to attain a sample that was representative of the area the water passed through, as well as to identify any significant changes in water quality. For example, samples that were taken close to Bear Lake, were representative of several tributaries upstream, while samples taken at unit C only represent conditions upstream of unit C.

Flow within this system varied as a direct result of precipitation, with levels fluctuating 1m after rain events. The highly fluctuating water levels resulted in only one session of water samples being taken. Once at a station, the current and previous weather conditions, time of day, the date, GPS coordinates, flow rates, sample procedures, and descriptions of the surrounding landscape were recorded. Each site was also flagged and given an identification number starting with AA11, AA22, and so on (See Figure 21).

Figure 21: MacPherson Creek and Chretian Drain sample stations and assessment units.



Each sample was submitted for analysis of the following parameters:

- General: alkalinity, pH, hardness, turbidity, total suspended solids, D.O.C. and B.O.D.
- Nutrients: ammonia, nitrate, nitrite, TKN and phosphorus

At each station, six water samples were collected using a 1.5 m sampling pole at ¾ the depth of the stream (stream depth varied significantly). One 250 ml air sample was also taken for the duration of the sample period. All parameters, except phosphorus and B.O.D., were bottled in four 500ml pet bottles. The phosphorus and B.O.D. samples were bottled in 250 ml and 500 ml brown glass bottles respectively. All samples were delivered to Near North Laboratories in North Bay, Ontario.

6.3.3 Watercourse Assessment

The purpose of the watercourse assessment was to produce a quantitative inventory of the landscape by visual interpretation and measurements. In this case, the assessment was conducted in context with both the *Stream Assessment Protocol for Ontario—V2.1* and the MNR *Fisheries Guidelines for the Review of Agricultural Drain Maintenance Proposals* (Smith, 1992).

The entire drainage system was initially divided into sub-units (see Figure 21), which made it easier to discuss as well as organize the system assessment into smaller, more detailed sections. Starting at the headwater (section A), the assessment traversed from upstream to downstream. Each subunit was sub-divided into 100m portions using flagging and measuring tape, which constituted a section. To increase efficiency, the GPS was used in relatively straight stream segments by marking a point and walking 100 m away from that point. Efficiency was also increased by the use of two crews working towards each other, with one moving downstream, and the other moving upstream. At every 500 m (five sections), a stake was driven and marked, which constituted a sub-unit. Each sub-unit was referenced (if not visible) using a GPS and etched on a copied map of the area, which included significant observations and locations. One should only have to mark the start of the unit with the GPS and travel from that mark by 100 m increments to produce the same results next season.

With one investigator on each stream bank and the other in the stream, each 100 m section was walked and observed in context with the assessment methodology (Appendix C-1). At the end of each section, both investigators discussed the stream habitat with regards to the protocol and established a value on a Form 1 assessment sheet. Some of the parameters listed on the form one concern the streambed. This is why one of the two investigators must be in the water during the observations in order to determine the stream substrate. In areas where the water level is too high, a canoe can be used to probe the bottom with a paddle or staff. The shoreline can also be walked to the maximum height of the waiters.

Once the Form 1 sheets are collected for each section and subunit, the forms can be further condensed onto a summary Form 2 sheet, and finally a Form 3 sheet (Appendix D). In this case, a Form 3 will be completed once all Form 2 sheets have been summarized.

6.3.4 Watercourse Cross Sections and Velocity Measurements

This procedure can be conducted while doing the stream survey to limit the number of field visits. The following is the equipment need for the survey:

- GPS
- Two stakes
- Level
- Mallet or axe
- 20 m rope
- Metre stick or a weighted measuring tape
- Waiters
- Canoe with relevant boating equipment such as paddles and safety gear (if needed)

A watercourse cross section was taken at the end of each unit. For example, only one cross section was needed at the end of Units A, B, C, etc. At each site, a stake was driven at the top of each bank. A rope previously marked with 10 cm intervals was tied from one stake to the other at the stake/ground interface, and subsequently leveled. A weighted tape (preferred since most depths exceeded 1 m), was used to take vertical measurements at each 10 cm interval. Each measurement was taken at the height of the rope, and not the water level, which fluctuated and was therefore not representative of the total channel depth. The velocity was also measured at each cross section. This was done simply by holding a meter stick parallel to the flow and dropping a leaf into the water at the top of the stick, while recording the time taken to reach the end.

6.3.5 Electrofishing and fish inventory

A general fish inventory was conducted at the following waypoints:

- Unit C 17T 0558238 5135749—start of 100 m section and divided in 25m segments.
- Unit G 17T 0558316 5133425—start of 100 m section and divided in 25m segments.

Electrofishing was conducted in accordance with the MNR Class 2 electrofishing manual, and was supervised by an MNR Management Biologist. Equipment and practice of this assessment was attained and conducted with permission of the MNR. The field procedures also followed the guidelines outlined in the MNR Class 2 electrofishing manual. Each fish was identified, weighed, and measured for length. The electrofishing results are presented in Appendix C-3 of this report.

6.4 DATA ANALYSIS

6.4.1 Water Quality

A total of sixteen sample stations were studied along the MacPherson Creek and the Chretian Drain. The water chemistry data for each of these stations were entered into Appendix B-4, and all PWQO exceedences were highlighted.

A more detailed analysis was also conducted on the following six sample stations: 14, 15, 88, 17, 18 and 21. These stations were specifically chosen for the purpose of identifying changes that may have occurred in the MacPherson Creek water quality, upstream and downstream of the Chretian Drain outlet. The MacPherson Creek background conditions were evaluated at Stations 14 and 15, which were located 500 m and 150 m (respectively) upstream of the Chretian Drain outlet. The Chretian Drain water quality was evaluated at Station 88, located 250 m upstream of the outlet to MacPherson Creek. The MacPherson Creek downstream conditions were evaluated at Stations 17, 18 and 21, located 750 m, 1.75 km, and 3.6 km (respectively) below the Chretian Drain outlet.

The Chretian Drain receives agricultural runoff, which typically includes associated fertilizer constituents (e.g. phosphorus and TKN) and soil particles (measured as turbidity and TSS). The relationships between phosphorus & TKN and turbidity & TSS are graphed in Section 6.5.2.

6.4.2 Fisheries

The electrofishing results were evaluated by an MNR fisheries, who made relevant comments and recommendations (see Section 6.6).

6.4.3 Watercourse Evaluations

The watercourse evaluation results were compiled into an extensive collection of approximately 150 observation sheets. The quantity of information collected from the watercourse evaluations is beyond the scope of this report, and will therefore be included in a separate report at a later date.

6.5 RESULTS

6.5.1 Field Observations (author: Derrick Smith)

Several observations were made during the period of June to September 2000. Firstly, in section E, a large beaver dam was removed, which lowered the water level within the area by more than 1.5 m. This resulted in a large flush of debris, sediment, biota, and water downstream. This dam removal is significant since it is still assumed that the system cannot be disturbed by agricultural practices. The result of such a rapid change in the system would also disturb aquatic and shoreline habitat to the extent that adaptation may not be plausible.

Secondly, this system is also very active with wildlife, such as birds, reptiles, amphibians, and mammals (e.g. bear, fox, raccoon, etc.). This is significant because the amount of agriculture is much less than the total amount of natural lands and vegetation within the system.

Finally, the Chretian Drainage system is a very rapid flowing system after a storm event. With this, large amounts of suspended solids are carried downstream. The result is obvious sediment deposition along the shoreline and on vegetation. This suggests that the system is a high energy environment, which is susceptible to rapid change (e.g. water chemistry and water level fluctuation).

6.5.2 Water Chemistry Results

As discussed in the above section, the complete water chemistry data set is presented in Appendix B-4 of this report. The following selected parameters are reported as average concentrations.

i) Phosphorus and TKN

Figure 22 illustrates that all six sample stations exceeded the 0.03 mg/L PWQO for phosphorus. The highest phosphorus and TKN concentrations of 0.423 mg/L and 2.57 mg/L, were detected at the MacPherson Creek background Station 14. Both phosphorus and TKN dropped sharply at the downstream Station 15, with respective concentrations of 0.05 mg/L and 1.29 mg/L. Both parameters rose to 0.071 mg/L and 1.81 mg/L at the Chretian Drain Station 88. Phosphorus increased slightly to 0.068 mg/L at the downstream Stations 17, increased further to 0.088 mg/L at Station 18 and dropped again at Station 21 to 0.048 mg/L. In contrast however, the TKN levels at Station 17 dropped to 0.95 mg/L, increased to 1.32 mg/L at Station 18 and dropped to 0.48 mg/L at Station 21.

ii) TSS and Turbidity

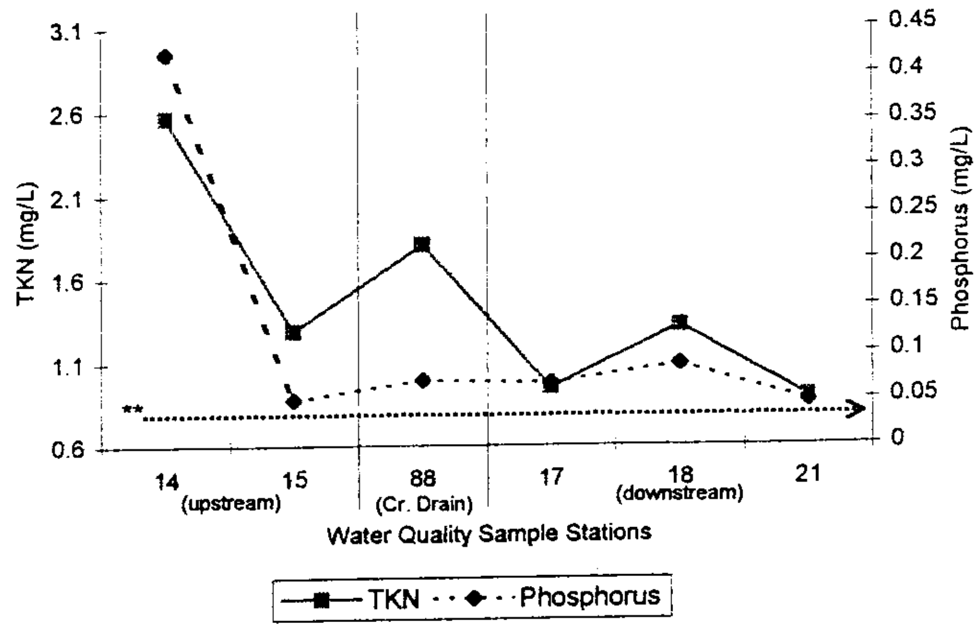
The TSS levels were highest at the background Station 14, with concentrations of 3 mg/L. TSS sharply dropped to 5 mg/L at the downstream Station 15 (see Figure 23). The level then increased to 9 mg/L at the Chretian Drain Station 88, and decreased to 3 mg/L at the downstream Station 17. The levels then rose to 8 mg/L at Station 18 and decreased to 7 mg/L at Station 21.

In contrast to TSS, the turbidity levels were highest at the Chretian Drain Station 88 with a concentration of 13 NTU. However, the rise and fall patterns were similar between the two parameters with the turbidity levels dropping sharply from Station 14 to Station 15, with respective levels of 12.1 NTU and 2.3 NTU. The levels then rose at the Chretian Drain Station 88 and dropped to 2.8 NTU at the downstream Station 17. The turbidity levels increased to 7.2 NTU at Station 18 and increased further to 8.7 NTU at Station 21.

6.5.3 Fish Survey

The electrofishing results are presented in Appendix C-3 of this report.

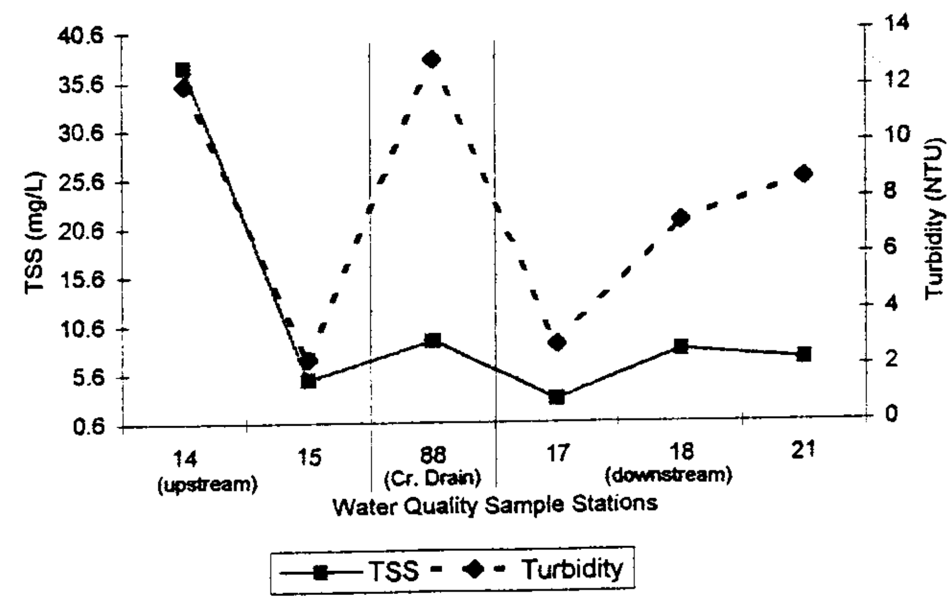
Figure 22: Chretian Drain and MacPherson Creek - TKN and Phosphorus Concentrations



* TKN = Total Kjeldahl Nitrogen

** .... Provincial Water Quality Objective for phosphorus in rivers is 0.03 mg/L.

Figure 23: Chretian Drain and MacPherson Creek - Turbidity and TSS Concentrations



*TSS = Total Suspended Solids

* See Figure 21 for sample station locations. Stations 14, 15, 17, 18 and 21 were sampled from MacPherson Creek, upstream and downtream of the Cretian Drain. Station 88 was sampled from the Drain itself.

6.6 REVIEWER COMMENTARY

6.6.1 Ministry of Agriculture, Food and Rural Affairs

- *The water quality data provided a good start to establishing a baseline but there is not enough information to draw any conclusions about the basic stream health and potential impacts. For example, the range of total phosphorus data from Stations 12, 10 and 13 indicate an anomaly. This may have been due to questionable quality control in the field (e.g. mislabeled bottles?), or the sample may not have been taken from the stream center where flow is integrated from within a tile drain or point source septic outlet. These questions cannot be answered without more information about the site at point of sample. Conclusions can also not be drawn on one time grab samples. Duplicate samples and sampling over time would be necessary to identify trends in quality.*

- *It would be helpful if the surrounding land use observations and flow measurement data were incorporated into this report. The flow data should be used to calculate nutrient loading to the receiving water body (ultimately more significant than individual concentrations).*

- *Future sample collections and water quality monitoring programs should include:*

  - *What were the drain conditions at each sampling point (e.g. had the drain been cleaned out in some areas at the time the samples were taken?),*
  - *Samples should be collected on same days and weather conditions.*
  - *The individuals located along the drain should set objectives for use and targets for quality within the drain. In doing so, they could set up an action plan to meet their targets.*
  - *A pro-active approach should be taken to implement best management practices for maintaining drains (see BMP manual "Fish and Wildlife Habitat Management" pages 74-75).*

6.6.2 Ministry of Natural Resources

- *The water quality data has provided us with high quality updated information on many water quality parameters. The electrofishing results are somewhat questionable, which may be due to several variables (e.g. limited sampling timeframe, fluctuating water levels, species identification expertise, etc.). It is therefore recommended that a more thorough study be completed in the 2001 field season. The new study should include a complete fish species inventory in addition to benthic invertebrate and vegetation surveys.*

- *In addition to work in the drain system, there are many drain inlets that discharge to Lake Nipissing which we know very little about with respect to water quality, fish habitat and species. Moreover, there are numerous other projects that would also be desirable to complete with appropriate human resources and funds:*

  - *Post-tournament mortality study of northern pike following the Cache Bay Pike Derby;*
  - *a lake sturgeon education project, including a live display in Sturgeon Falls as the final product;*
  - *more benthic basket work conducted in the many Lake Nipissing inlets, to obtain a true "big picture" in the quest to monitor the Lake Nipissing ecosystem.*

6.6.3 Wilderness Preservation Committee of Ontario

- *Future studies could be improved by placing greater effort on same-day water sample collections, and less effort on such extensive water velocity data collections.*

- *A level meter should ideally be used to collect continuous flow data. Another less expensive monitoring method includes the installation of temperature probes to detect rain events passing through a site with the changes in the daily temperature patterns.*

- *The study area has many field tile drains to compensate for naturally poor drainage conditions. Rain event discharges will make the watercourse velocities and water quality fluctuate even greater.*

- *Total phosphorus, TKN and SS concentrations were highest at Station 14 during wet weather events. Is this due to surrounding land uses?*

- *The decreased SS concentrations from 37 mg/L to 5 mg/L at Station 15 is likely due to settling at the pond (field notes).*

- *The sample stations were monitored on different days and weather conditions. We are therefore comparing a dry weather input of the drain on a wet weather data in the creek, which cannot accurately characterize water quality conditions between stations.*

- *If the MNR believes the electrofishing data to be suspect, it should not be used. In the future, the creeks should be inventoried on a priority basis. Possibly one criterion could be to protect areas from development or as part of an improvement plan.*

7.0 MERRICK LANDFILL SURFACE WATER QUALITY MONITORING

7.1 SITE LOCATION AND STUOY PURPOSE

The Merrick Landfill site is located approximately 20 km north of North Bay, just east of Highway 11 and north of Sand Dam Road (see Figure 24). The Little Sturgeon River runs along the western perimeter of the landfill, flowing in a southerly direction, ultimately discharging to the north shore of Lake Nipissing (see Figure 3). The purpose of this study was to determine if leachate was migrating from the Merrick Landfill to the Little Sturgeon River.

7.2 SAMPLE STATION LOCATIONS

Five water quality sample stations (SW-U, SW-M, SW-T, SW-P and MER1) were evaluated along the Little Sturgeon River at varying distances from the landfill (see Figure 24). "Channel A" begins at the eastern perimeter of the landfill, and flows directly to the river. Station SW-U was established approximately 1 km upstream of Channel A, for the purpose of monitoring background water quality conditions. Station SW-M was located approximately 150 m downstream of Channel A, at the southwest corner of the landfill site. Station SW-T was located on a secondary tributary, which flows 1 km downstream to the Little Sturgeon River, converging approximately 750 m downstream of Channel A. SW-P was located on the Little Sturgeon River, approximately 1.5 km downstream of Channel A. Station MER1 is located farther downstream, approximately 15 km upstream of the point that the Little Sturgeon River flows into Lake Nipissing.

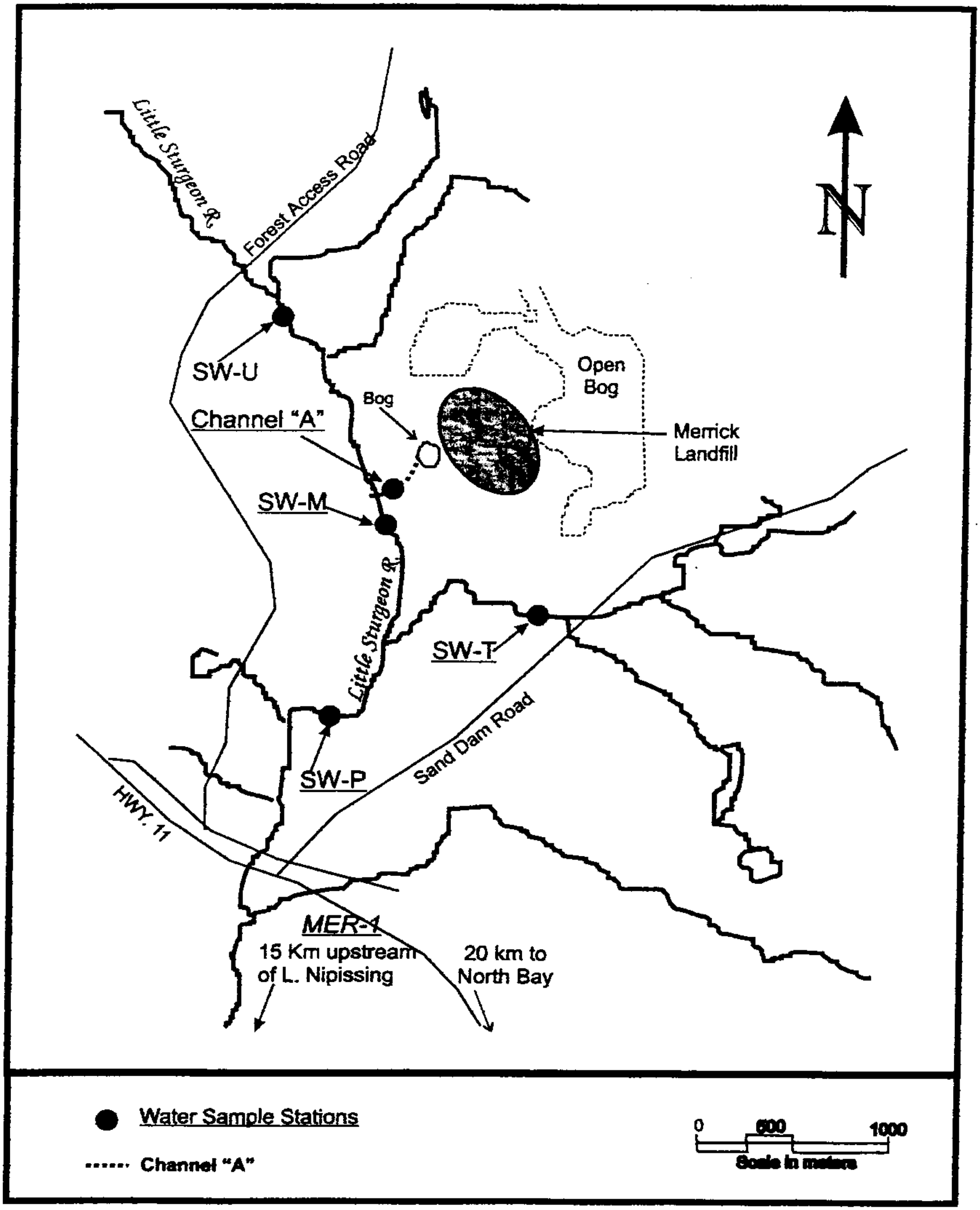
7.3 STUOY METHOOS

7.3.1. Water Chemistry Analysis

Water chemistry samples were collected from each of the five sample stations during two site visits, which occurred in July and August, 2000. Grab samples were collected from each station and submitted to the Ontario Ministry of Environment Central Laboratory for analysis of the following parameters:

- General: alkalinity, B.O.D., conductivity. pH, total suspended solids, total solids. dissolved solids
- Nutrients: ammonia, nitrate, nitrite, TKN, total phosphorus and phosphate
- Ions: calcium, chloride, sulfate and magnesium
- Trace Metals: aluminum, barium, beryllium. cadmium, cobalt, chromium copper, iron, lead, manganese, molybdenum, nickel, strontium, titanium, vanadium and zinc

Figure 24: Merrick landfill surface water sample station locations



7.3.2. Data Analysis

All five water quality sample stations (SW-U, SW-M, SW-T, SW-P and MER1) were evaluated for the purpose of identifying changes that may have occurred in the Little Sturgeon River, upstream and downstream of the Merrick Landfill. The water chemistry data for each of these stations were entered into Appendix B-5, and all PWQO exceedences were highlighted. A more detailed analysis of the following six landfill leachate indicators was also conducted: iron, lead, aluminum, cobalt, TKN and BOD. Two line charts were created to comparatively evaluate iron, lead, aluminum and cobalt concentrations and PWQO exceedences. A third comparative line chart was also created to evaluate the TKN and BOD concentrations (see Section 7.4). This chart does not include PWQO exceedences because they do not exist for TKN and BOD.

7.4 MERRICK LANDFILL SURFACE WATER QUALITY RESULTS

As discussed in the above section, the complete set of data is presented in Appendix B-5 of this report. The following selected parameters are reported as average concentrations.

7.4.1. Iron, Lead, Aluminum and Cobalt

Figure 25 illustrates that all five sample stations exceeded the iron PWQO of 0.3 mg/L. The second lowest iron concentration of 2.12 mg/L occurred at the background Station SW-U, and rose to the highest level of 8.3 mg/L at Station SW-M, located 15 m downstream of Channel A. The iron concentrations steadily declined at Stations SW-T (7.6 mg/L), SW-P (3.7 mg/L) and MER1 (1.8 mg/L).

In contrast to iron, all five sample stations were below the lead PWQO of 5 ug/L see (Figure 25). The lead distribution pattern was however similar to iron, with the lowest concentration of 0.3 ug/L occurring at the background Station SW-U. The concentration also rose to 1.11 ug/L at SW-M and fell to 1.0 ug/L and 0.2 ug/L at Stations SW-T and SW-P, respectively. However, Figure 17 illustrates that the lead concentrations increased to the highest level of 1.6 ug/L at the downstream Station MER1.

Figure 26 illustrates that all five sample stations exceeded the aluminum PWQO of 0.075 mg/L. The highest concentration of 0.474 mg/L occurred at the background Station SW-U, and dropped to 0.229 at Station SW-M. The levels then increased to 0.255 at SW-T, decreased to 0.133 at SW-P and rose again at MER1 to a level of 0.351.

Figure 26 also illustrates that four of the five stations exceeded the cobalt PWQO of 0.4 ug/L. The rise and fall pattern was similar to lead, with concentrations spiking from 0.487 ug/L at SW-U, to the highest level of 7.8 ug/L at SW-M. The concentrations decreased steadily at SW-T, SW-P and MER1 with respective levels of 6.87 ug/L, 2.71 ug/L and 0.39 ug/L.

7.4.2. TKN and BOD

Both the TKN and BOD concentrations of 1.09 mg/L and 1.6 mg/L rose sharply from the background Station SW-U, to the highest concentrations of 1.46 mg/L and 2.9 mg/L at Station SW-M (see Figure 27). TKN steadily declined with concentrations of 1.17 mg/L, 0.9 mg/L and 0.84 mg/L at Stations SW-T, SW-P and MER1. The BOD concentrations also decreased from Stations SW-T to SW-P with respective concentrations of 1.7 mg/L and 0.8 mg/L. The BOD level did however increase at Station MER 1, with a concentration of 1.0 mg/L.

7.5 REVIEWER COMMENTARY

7.5.1 <u>Ministry of the Environment</u>

- *There are noticeable impacts around the Merrick Landfill site.*

Figure 25: Merrick Landfill Surface Water Quality:
Average Iron and Lead Concentrations

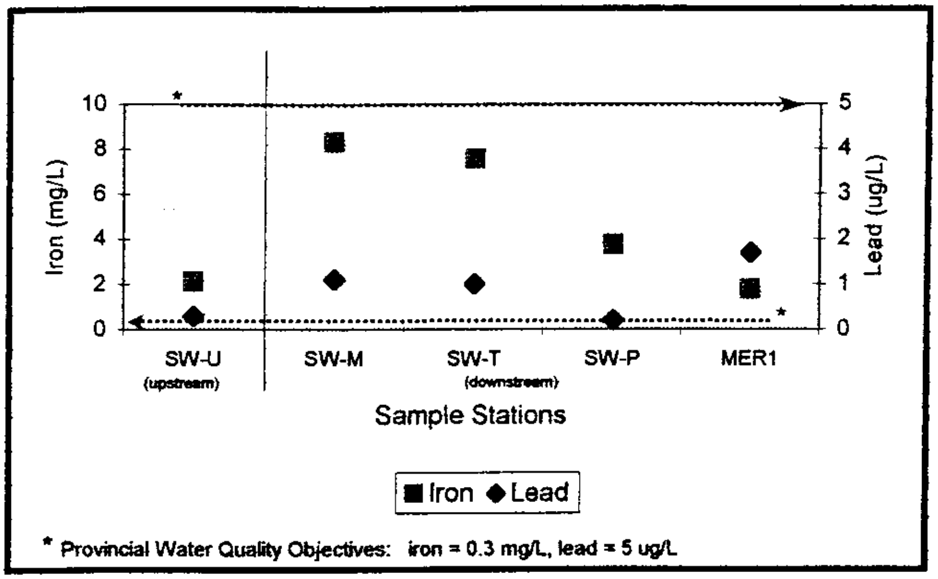
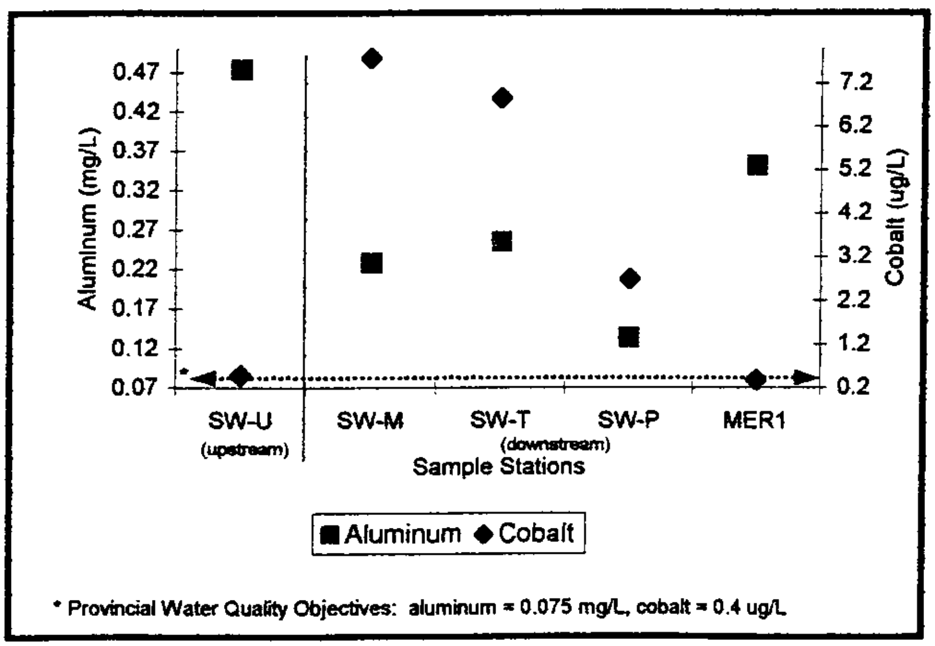
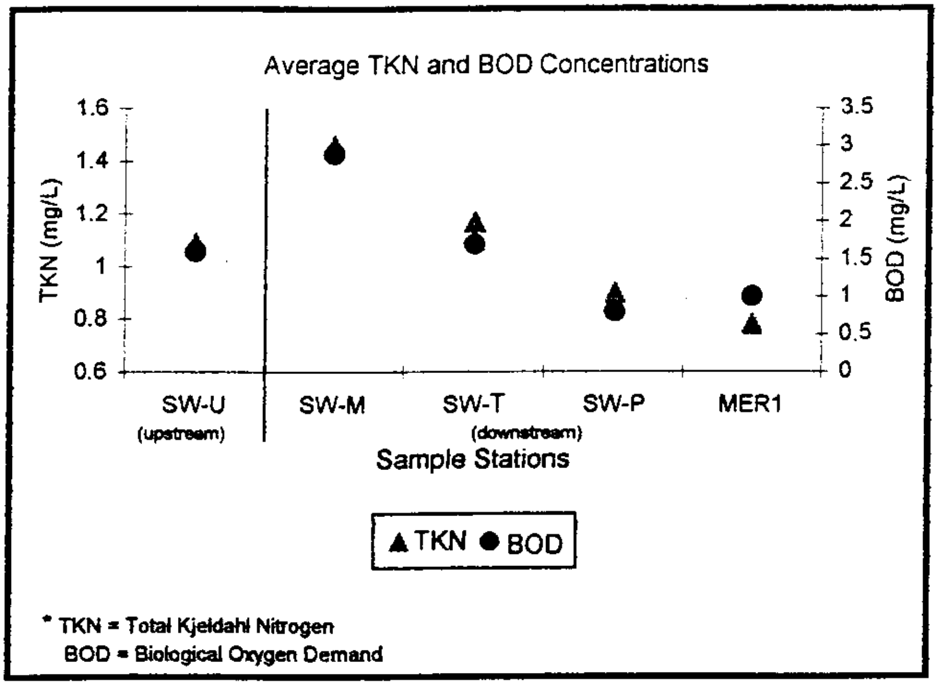


Figure 26: Merrick Landfill Surface Water Quality
- Average Aluminum and Cobalt Concentrations



* See Figure 24 for sample station locations upstream and downstream of Channel A.

Figure 27: Merrick Landfill Surface Water Quality:
TKN and BOD Concentrations



* See Figure 24, for sample station locations upstream and downstream of discharge channel.

7.5.2 Wilderness Preservation Committee of Ontario

- *Future studies should include surrounding land use mapping, detailed weather condition records, and increased water quality sample collections.*
- *The high cobalt concentrations at Stations SW-U and SW-T may indicate that landfill leachate is migrating in two different directions.*
- *Possible upstream sources of aluminum should be investigated.*
- *Station SW-T (tributary station) should be viewed as a contribution to MacPherson Creek. This station should be monitored to determine if landfill leachate is entering the tributary.*

8.0 CROSS LAKE (West Arm) WATER QUALITY EVALUATION

8.1 STUDY PURPOSE AND STATION LOCATIONS

The West Arm of Cross Lake discharges to the Amateewakea River, which is located at the west end of Lake Nipissing (see Figure 3). Two water quality sample stations were established on the West Arm of Cross Lake for the purpose of evaluating the contributions of pollutants to Lake Nipissing. Stations 20 and 21 were located approximately 15 km upstream of Lake Nipissing, at the following respective Verner 41-1/8, Ed. 4, topographic map coordinates: 497270 and 483263.

8.2 STUDY METHODS

Water quality samples and measurements were collected from Stations 20 and 21 on July 26 and August 29, 2000. Each station was accessed by boat and the locations were confirmed through the use of a Geographical Positioning System (GPS). Single temperature and D.O. measurements were taken at each station by lowering a D.O./temperature probe to within 1 m of the lake bottom at each station. Water clarity measurements were taken by lowering a secchi disk over the unshaded side of the boat and recording the depth at which the contrasting black and white sections of the disk became visually obscured.

8.2.1 Water Chemistry Analysis

Water column composite samples were collected from 0 to 5 m, or to within I m of the lake bottom in the case of shallow stations. All of the samples were submitted to Near North Laboratories in North Bay Ontario, for analysis of the following parameters:

- General: alkalinity, chlorophyll-*a*, D.O.C. and pH
- Ions: calcium, chloride, magnesium, potassium, sodium and sulfate
- Trace metals: iron and manganese
- Nutrients: ammonia, nitrate, nitrite, total kjeldahl nitrogen (TKN), organic TKN and phosphorus

Each chlorophyll-*a* sample was collected in a 1L clear glass bottle, wrapped in aluminum foil and preserved with 20 drops of $MgCO_3$. The D.O.C. and nutrient samples were collected in two 500 mL amber glass bottles, and the remaining parameters were collected in three 500 mL plastic bottles. One 250 mL amber glass traveling blank air sample was also taken for the duration of each event.

8.2.2 *Data Analysis*

All of the Cross Lake field evaluation and laboratory results were compiled into Appendix B-6 of this report. Where applicable, the results were compared to the Provincial Water Quality Objectives (PWQO) and all exceedences were highlighted. A more detailed analysis of pH, alkalinity, phosphorus, TKN, chloride, iron, chlorophyll-a and secchi depths, is discussed in the following Section 8.3 of this report.

8.3 Cross Lake Field Observations and Water Chemistry Results

As discussed in the above section, the complete list of chemistry results are presented in Appendix B-6 of this report. The following selected parameters of interest, are reported as concentration ranges.

8.3.1 pH and Alkalinity

The pH levels were generally within the PWQO of 6.5-8.5, with the exception of two slight exceedences at both Stations 20 and 21. The Station 20 pH levels were 7.7 in July, and 8.7 in August. The Station 21 levels were 8.0 in July and 8.7 in August.

The alkalinity levels at Station 20 were 30 mg/L in July and 32 mg/L in August. The Station 21 alkalinity levels were 34 mg/L in July and 33 mg/L in August.

8.3.2. Phosphorus and TKN

The Cross Lake water quality data indicates that every sample exceeded the 0.02 mg/L PWQO for total phosphorus at both Stations 20 and 21. The phosphorus concentrations at Station 20 ranged from 0.030 mg/L in July, to 0.032 mg/L in August. The Station 21 concentrations ranged from 0.034 mg/L in July, to 0.04 mg/L in August.

The Station 20 TKN concentrations ranged from 0.64 mg/L in July, to 1.43 mg/L in August. The Station 21 concentrations ranged from 0.94 mg/L in July, to 1.32 mg/L in August.

8.3.3. Chloride

The chloride concentrations at Station 20 ranged from 4.84 mg/L in July, to 5.0 mg/L in August. The concentrations at Station 21 ranged from 5.5 mg/L in July, to 6.0 mg/L in August.

8.3.4. Iron

All four water samples collected at Stations 20 and 21 were within the 0.3 mg/L PWQO for iron. The iron concentrations at Station 20 ranged from 0.2 mg/L in July, to 0.3 mg/L in August. The concentrations at Station 21 also ranged from 0.2 mg/L in July, to 0.3 mg/L in August.

8.3.5. Chlorophyll-a and Secchi Depth Readings

The chlorophyll-a concentrations at Station 20 ranged from 0.004 mg/L in July to 0.048 mg/L in August. The concentrations at Station 21 ranged from 0.005 mg/L in July, to 0.053 mg/L in August.

The secchi depth readings at Station 20 ranged from 2.0 m in July, to 0.7 m in August. The Station 21 readings ranged from 6.9 m in July, to 0.8 m in August.

8.4 REVIEWER COMMENTARY

8.4.1 Ministry of the Environment

- *The high total phosphorus concentrations at Station 21 may be of some concern.*

9.0 SUMMARY

9.1 Lake Nipissing Water Quality Evaluation

- *2000 Study*

  - The Cache Bay area (including Stations 6 and 7) generally had the highest chlorophyll-a, phosphorus, TKN, chloride, iron and pH levels. Callander Bay (Station 9) generally had the second highest levels of these same parameters.

- *1988-1990 and 2000 Comparison Study*

  - TKN and chlorophyll-a concentrations have increased at all thirteen sample stations since the 1988-1990 study was completed.

  - Sulfate concentrations have decreased at all thirteen sample stations since the 1988-1990 study was completed.

  - The largest increases in pH, chlorophyll-a, phosphorus, TKN, sodium, chloride, and sulfate, generally occurred in the Cache Bay area at Stations 6 and 7.

9.2 Contributing Watercourse Benthic Macroinvertebrate Evaluations

- The Wistiwasing River was the only one of eight watercourses to receive an "Unimpaired" water quality designation.
- The three watercourses located along the eastern shoreline (LaVase R., Wistiwasing R. and South R.) received "Marginal" to "Unimpaired" water quality designations.
- The Little Sturgeon River, located at the northeastern shoreline, received an "Impaired" to "Marginal" water quality designation.
- The remaining four watercourses (MacPherson Cr., Veuve R., Cache R. and Mosquito Cr.) located along the west and northwestern shorelines, received "Impaired" water quality designations.

9.3 Chretian Drain and MacPherson Creek Water Quality Evaluation

- All six sample stations exceeded the PWQO phosphorus limit.
- The water quality conditions at background Station 14, was generally poorer than the five downstream stations.
- There was an obvious increase in TKN, phosphorus, turbidity and TSS levels at the Chretian Drain Station 88. The downstream concentrations did not steadily decrease with distance from the Drain.

9.4 Merrick Landfill Surface Water Quality Evaluation

- All six stations exceeded the PWQO limits for iron and aluminum, but were below the PWQO limit for lead. Five of the six stations exceeded the cobalt PWQO.
- There were obvious concentration peaks of iron lead, cobalt, TKN and BOD at Station SW-M, located 15m downstream of Channel A. These same parameter concentrations steadily declined with distance from the landfill. Lead and BOD did however, increase at Station MER-1, located the farthest distance downstream of the landfill.

9.5 Cross Lake Water Quality Evaluation

- All four water samples collected from Cross Lake exceeded the PWQO limits for total phosphorus.
- The samples were found to be slightly alkaline, with two samples slightly exceeding the PWQO for pH.
- All of the Cross Lake water samples were within the PWQO for iron and un-ionized ammonia.

REFERENCES

Carl, L.M. and Straszynski, E.B. 2000. *Class one electrofishing certification course manual.* Prepared for: Ontario Ministry of Natural Resources and the Aquatic Ecosystems Section of the Watershed Science Centre. Peterborough, Ontario.

Griffiths, Ronald W. 1999. *BioMAP: bioassessment of water quality.* The Centre for Environmental Training, Niagara College, Glendale Campus, Niagara-on-the-Lake, Ontario. ISBN 0-9685921-0-4.

Jones, Mike et al. 1998. *Stream assessment protocol for Ontario.* Prepared for: Ontario Ministry of Natural Resources and Metro Region Conservation Authority, V.2.1. 20.

Neary, B.P. and Clark, B.J. 1992. *The chemical water quality of Lake Nipissing: 1988-1990.* Prepared for: Ontario Ministry of the Environment. Queen's Printer for Ontario. PIBS 1839. log 91-2345-085.

Ontario Ministry of the Environment and Energy. 1994. *Water management: policies, guidelines, provincial water quality objectives.* Queen's Printer for Ontario. PIBS 3303E. ISBN 0-7778-3494-4.

Ramcharan, C.W., D.K. Padilla, and S.I. Dodson. 1991. *Predicted population dynamics of Dreissena polymorpha in the Great Lakes based on analysis of European data.* Presented at the American Society of Limnology and Oceanography Conference, June 11. Halifax, Nova Scotia.

Smith, Norm and Wales, Donna et al. 1992. *Fisheries guideline for the review of agricultural drain maintenance proposals.* Prepared for: Ontario Ministry of Natural Resources.

Sprung, M. 1987. *Ecological requirements of developing Dreissena polymorpha eggs.* Arch. Hydrobiolo/Suppl. 79:69-86.

APPENDIX A

The Chemical Water Quality of Lake Nipissing: 1988-1990 (complete document)

APPENDIX B

Water Quality Tables

B-1: Lake Nipissing 2000 water quality data

B-1a: Lake Nipissing 2000 weather conditions

B-2: Comparison of Lake Nipissing 1988-1990 and 2000 water quality data

B-3: Benthic macroinvertebrate Biobasket species list

B-4: Chretian Drain and MacPherson Creek water quality data

B-5: Merrick Landfill surface water quality data

B-6: Circle Lake water quality data

Table B-1: Lake Nipissing 2000 Water Quality Data

Parameter	Units	PWQO	Station #2				Station #2a				Station #3			
			30-Jun	28-Jul	30-Aug	Average	30-Jun	28-Jul	30-Aug	Average	30-Jun	28-Jul	30-Aug	Average
GENERAL														
Alkalinity	mg/L	*	22	22	24	23	22	--	24	23	22	23	29	25
Chlorophyll-a	mg/L	*	0.004	--	0.006	0.005	0.002	--	0.006	0.004	0.003	--	<0.005	0.004
Conductivity	umhos/cm	*	75.5	--	84.0	79.8	74.1	--	84.0	79.1	74.4	--	85.0	79.7
DO	mg/L	*	8.0	8.8	7.9	8.2	7.7	8.6	8.2	8.2	7.8	8.3	8.1	8.0
DOC	mg/L	*	5.0	4.4	6.3	5.2	4.9	4.7	6.3	5.3	5.3	4.9	6.8	5.7
pH	no units	6.5-8.5	7.7	8.1	7.6	7.8	7.7	8.3	7.6	7.9	7.7	8.0	7.7	7.8
Secchi Disk (m)	meters	*	1.50	2.20	1.81	1.84	1.45	1.80	1.84	1.70	2.04	1.80	1.54	1.79
Temperature	^0C	*	19.4	23.9	20.0	21.1	19.1	24.3	20.4	21.3	19.1	24.5	20.2	21.3
NUTRIENTS														
Ammonia	mg/L	*	<0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	0.02	0.02	<0.02	<0.02	0.02
Ammonia (un-ionized)	mg/L	0.02	trace	trace	trace	trace	0.0003	trace	trace	0.0008	0.0002	trace	trace	0.0008
Nitrate	mg/L	*	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Nitrite	mg/L	*	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
TKN	mg/L	*	0.44	0.39	0.56	0.46	0.48	0.48	0.56	0.51	0.48	0.42	0.41	0.44
TKN Organic	mg/L	*	0.43	0.39	0.56	0.46	0.45	0.48	0.56	0.50	0.46	0.42	0.41	0.43
T. Phosphorus	mg/L	0.02	0.017	0.012	0.011	0.013	0.019	0.014	0.011	0.015	0.010	0.006	0.013	0.010
IONS														
Calcium	mg/L	*	6.75	7.84	8.41	7.67	6.63	7.49	8.41	7.51	6.70	7.81	9.14	7.88
Chloride	TCU	*	4.38	--	7.00	5.69	4.56	--	7.00	5.78	4.20	--	6.00	5.10
Magnesium	mg/L	*	2.34	2.44	2.50	2.43	2.33	2.32	2.50	2.38	2.21	2.44	2.73	2.46
Potassium	mg/L	*	0.6	--	0.6	0.6	0.5	--	0.6	0.6	0.6	--	0.7	0.7
Sodium	mg/L	*	2.59	--	3.80	3.20	2.71	--	3.80	3.26	2.58	--	3.40	2.99
Sulfate	mg/L	*	2.1	12.0	11.0	8.4	2.3	9.2	11.0	7.5	2.9	6.4	4.0	4.4
METALS														
Iron	mg/L	0.3	0.2	--	0.1	0.2	0.3	--	0.1	0.2	0.2	--	0.2	0.2
Manganese	mg/L	*	<0.01	--	<0.01	<0.01	<0.01	--	<0.01	<0.01	<0.01	--	<0.01	<0.01

- PWQO = Provincial Water Quality Objective
- ***0.3*** = PWQO exceedences
- * = No PWQO
- -- = No data
- DO = Dissolved Oxygen
- DOC = Dissolved Organic Carbon

Table B-1: Lake Nipissing 2000 Water Quality Data

Parameter	Units	PWQO	Station #6				Station #6a				Station #7			
			28-Jun	26-Jul	24-Aug	Average	30-Jun	28-Jul	30-Aug	Average	28-Jun	26-Jul	24-Aug	Average
GENERAL														
Alkalinity	mg/L	*	42	42	46	43	26	21	21	22	55	53	43	50
Chlorophyll-a	mg/L	*	0.005	0.005	0.005	0.005	0.004	--	<0.005	0.004	0.009	0.007	0.004	0.007
Conductivity	umhos/cm	*	116.0	129.0	127.0	124.0	78.4	--	78.0	78.2	131.0	123.0	127.0	127.0
DO	mg/L	*	9.5	6.1	6.9	7.5	8.8	8.8	7.6	8.4	13.0	--	11.8	12.4
DOC	mg/L	*	8.9	11.6	11.8	10.8	5.7	4.5	6.5	5.6	8.2	8.3	8.7	8.4
pH	no units	6.5-8.5	8.1	7.8	7.5	7.8	7.7	7.7	7.4	7.6	***9.7***	***10.2***	***9.8***	***9.9***
Secchi Disk (m)	meters	*	1.50	1.07	1.14	1.24	1.25	1.00	1.00	1.08	1.44	--	1.50	1.47
Temperature	^{o}C	*	20.5	19.7	18.6	19.6	20.5	23.8	19.6	21.3	20.9	--	18.4	19.7
NUTRIENTS														
Ammonia	mg/L	*	0.05	0.03	<0.02	0.03	0.05	<0.02	<0.02	0.07	<0.02	<0.02	<0.02	<0.02
Ammonia (un-ionized)	mg/L	0.02	0.0019	0.0011	trace	0.0011	0.0007	trace	trace	0.0009	trace	trace	trace	trace
Nitrate	mg/L	*	<0.03	0.08	<0.03	0.05	<0.03	0.03	<0.03	0.03	<0.03	<0.03	<0.03	<0.03
Nitrite	mg/L	*	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
TKN	mg/L	*	0.88	1.13	0.81	0.94	0.57	0.32	0.49	0.46	0.88	0.78	0.88	0.85
TKN Organic	mg/L	*	0.83	1.10	0.81	0.91	0.52	0.32	0.49	0.44	0.87	0.78	0.88	0.84
T. Phosphorus	mg/L	0.02	0.016	***0.039***	***0.031***	***0.029***	0.021	<0.006	0.011	0.011	***0.032***	***0.026***	0.016	***0.025***
IONS														
Calcium	mg/L	*	11.50	11.50	14.30	12.43	7.37	7.31	8.88	7.85	14.60	11.50	10.60	12.2
Chloride	TCU	*	7.00	10.50	8.00	8.50	4.38	--	4.00	4.19	9.00	9.91	9.00	9.30
Magnesium	mg/L	*	4.31	4.34	4.88	4.51	2.56	2.02	2.49	2.36	4.95	4.61	4.56	4.71
Potassium	mg/L	*	0.5	1.4	1.8	1.2	0.5	--	0.6	0.6	<0.4	1.0	1.5	1.3
Sodium	mg/L	*	4.35	7.40	5.50	5.75	2.61	--	2.60	2.61	4.9	4.6	5.3	4.9
Sulfate	mg/L	*	2.0	2.3	2.0	2.1	1.4	13.1	3.0	5.8	<1.0	2.7	2.0	1.9
METALS														
Iron	mg/L	0.3	***0.4***	***0.7***	***0.5***	***0.5***	0.2	--	0.2	0.2	0.2	0.2	0.3	0.2
Manganese	mg/L	*	0.05	0.04	0.03	0.04	0.02	--	<0.01	0.02	0.02	0.01	<0.01	0.01

Fout

- PWQO = Provincial Water Quality Objective
- ***0.3*** = PWQO exceedences
- * = No PWQO
- -- = No data
- DO = Dissolved Oxygen
- DOC = Dissolved Organic Carbon

Table B-1: Lake Nipissing 2000 Water Quality Data

Parameter	Units	PWQO	Station #9					Station #11				Station #12			
			29-Jun	20-Jul	28-Jul	28-Aug	Average	29-Jun	24-Jul	28-Aug	Average	4-Jul	21-Jul	29-Aug	Average
GENERAL															
Alkalinity	mg/L	*	21	20	19	23	21	25	22	23	23	20	20	22	21
Chlorophyll-a	mg/L	*	0.006	0.007	0.015	0.013	0.010	0.005	0.006	0.007	0.006	0.003	0.004	0.007	0.005
Conductivity	umhos/cm	*	80.0	80.9	79.9	81.0	80.5	82.0	78.7	85.0	81.9	72.7	74.6	78.0	75.1
DO	mg/L	*	7.8	8.8	7.7	8.2	8.1	7.8	7.9	8.5	8.1	8.4	8.4	8.5	8.4
DOC	mg/L	*	5.6	7.5	6.5	5.9	6.4	5.2	6.3	4.6	5.4	4.6	5.3	4.6	4.8
pH	no units	6.5-8.5	7.5	7.5	7.6	7.7	7.6	7.6	8.0	7.9	7.8	7.5	7.2	7.5	7.4
Secchi Disk (m)	meters	*	1.82	1.67	1.70	1.66	1.71	1.54	2.10	1.91	1.85	2.84	2.52	2.26	2.54
Temperature	^{0}C	*	19.6	20.2	20.1	20.2	20.0	20.0	19.5	20.0	19.8	18.7	19.6	19.8	19.4
NUTRIENTS															
Ammonia	mg/L	*	0.04	0.03	0.05	<0.02	0.04	0.04	0.01	<0.02	0.02	0.34	0.06	<0.02	0.14
Ammonia (un-ionized)	mg/L	0.02	0.0005	0.0004	0.0006	trace	0.0005	0.0005	0.0004	trace	0.0002	0.0039	0.0002	trace	0.0016
Nitrate	mg/L	*	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Nitrite	mg/L	*	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
TKN	mg/L	*	0.60	0.57	0.77	0.68	0.66	0.50	0.40	0.59	0.50	0.56	0.42	0.33	0.44
TKN Organic	mg/L	*	0.56	0.54	0.72	0.68	0.63	0.46	0.39	0.59	0.48	0.22	0.36	0.33	0.30
T. Phosphorus	mg/L	0.02	***0.025***	***0.026***	0.013	***0.025***	0.022	0.016	0.022	0.006	0.015	***0.033***	0.020	0.010	0.021
IONS															
Calcium	mg/L	*	6.42	6.73	5.03	7.59	6.44	6.97	7.65	8.37	7.66	6.40	6.80	5.64	6.28
Chloride	TCU	*	7.00	8.89	8.55	8.00	8.11	7.00	5.92	7.00	6.64	5.60	5.41	5.00	5.34
Magnesium	mg/L	*	2.17	2.42	2.10	2.32	2.25	2.30	2.44	2.55	2.43	2.14	2.40	1.98	2.17
Potassium	mg/L	*	0.8	0.8	<0.4	0.8	0.7	0.6	<0.4	1.1	0.7	0.6	0.7	<0.4	0.6
Sodium	mg/L	*	4.28	4.18	4.1	4.5	4.3	3.74	3.90	4.30	3.98	2.89	2.71	3.6	3.07
Sulfate	mg/L	*	2.0	2.5	2.3	3.0	2.4	2.0	5.0	11.0	6.0	2.8	5.0	10.0	5.9
METALS															
Iron	mg/L	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.1	0.1
Manganese	mg/L	*	0.02	0.05	<0.01	0.02	0.02	<0.01	<0.01	0.03	0.02	0.02	0.03	0.01	0.02

- PWQO = Provincial Water Quality Objective
- ***0.3*** = PWQO exceedences
- * = No PWQO
- – = No data
- DO = Dissolved Oxygen
- DOC = Dissolved Organic Carbon

Table B-1: Lake Nipissing 2000 Water Quality Data

Parameter	Units	PWQO	Station #14				Station #14a				Station #16			
			27-Jun	20-Jul	28-Aug	Average	27-Jun	20-Jul	28-Aug	Average	28-Jun	21-Jul	1-Sep	Average
GENERAL														
Alkalinity	mg/L	*	18	20	20	19	19	20	20	20	22	23	24	23
Chlorophyll-a	mg/L	*	0.005	0.007	0.007	0.006	0.005	0.012	<0.005	0.007	0.002	0.005	<0.005	0.004
Conductivity	umhos/cm	*	69.0	73.7	75.0	72.6	69.0	72.1	74.0	71.7	73.0	73.9	80.0	75.6
DO	mg/L	*	9.2	8.3	8.1	8.5	8.1	8.4	8.5	8.3	8.8	9.3	9.3	9.1
DOC	mg/L	*	5.4	5.0	5.4	5.3	4.8	6.9	5.0	5.6	5.8	5.6	5.4	5.6
pH	no units	6.5-8.5	7.6	7.5	7.5	7.5	7.5	7.6	7.7	7.6	7.7	8.5	***9.2***	8.5
Secchi Disk (m)	meters	*	1.50	1.90	1.81	1.74	1.61	1.50	2.00	1.70	2.18	2.210	2.25	2.21
Temperature	^{0}C	*	18.2	20.1	19.7	19.3	20.7	20.0	20.5	20.4	20.3	19.3	21.2	20.3
NUTRIENTS														
Ammonia	mg/L	*	<0.02	<0.02	<0.02	<0.02	<0.02	0.04	<0.02	0.03	<0.02	0.06	0.07	0.05
Ammonia (un-ionized)	mg/L	0.02	trace	trace	trace	trace	trace	0.0005	trace	0.0004	trace	0.0063	0.0209	0.0056
Nitrate	mg/L	*	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Nitrite	mg/L	*	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
TKN	mg/L	*	0.56	0.50	0.47	0.51	0.65	0.59	0.49	0.58	0.51	0.45	0.62	0.53
TKN Organic	mg/L	*	0.56	0.50	0.47	0.51	0.65	0.55	0.49	0.56	0.51	0.39	0.62	0.51
T. Phosphorus	mg/L	0.02	<0.006	0.008	0.011	0.006	0.009	***0.025***	0.011	0.015	<0.006	0.008	<0.006	0.003
IONS														
Calcium	mg/L	*	6.46	8.20	7.19	7.28	6.74	6.39	7.34	6.82	5.95	6.50	8.47	6.97
Chloride	TCU	*	5.00	6.65	6.00	5.88	5.00	6.38	6.00	5.79	4.00	5.41	6.00	5.14
Magnesium	mg/L	*	2.25	2.46	2.24	2.32	2.23	2.25	2.23	2.24	2.35	2.62	2.60	2.52
Potassium	mg/L	*	0.6	0.6	0.8	0.7	0.6	0.6	0.7	0.6	0.5	<0.4	0.6	0.5
Sodium	mg/L	*	3.31	2.90	3.70	3.30	3.19	2.93	3.50	3.21	2.62	2.09	3.00	2.57
Sulfate	mg/L	*	1.0	4.0	3.0	2.7	1.0	3.4	7.0	3.8	1.0	3.0	6.0	3.3
METALS														
Iron	mg/L	0.3	0.2	0.2	0.3	0.2	0.1	0.2	0.1	0.2	0.2	0.2	0.1	0.2
Manganese	mg/L	*	0.05	0.03	0.02	0.03	0.08	0.05	0.02	0.05	<0.01	0.04	<0.01	0.02

- PWQO = Provincial Water Quality Objective
- ***0.3*** = PWQO exceedences
- * = No PWQO
- -- = No data
- DO = Dissolved Oxygen
- DOC = Dissolved Organic Carbon

Table B-1: Lake Nipissing 2000 Water Quality Data

Parameter	Units	PWQO	Station #17				Station #25			
			28-Jun	21-Jul	1-Sep	Average	4-Jul	21-Jul	29-Aug	Average
GENERAL										
Alkalinity	mg/L	*	20	20	21	20	20	21	21	21
Chlorophyll-a	mg/L	*	0.003	<0.002	0.009	0.006	0.003	0.004	0.008	0.005
Conductivity	umhos/cm	*	71.0	72.2	73.0	72.1	70.0	72.3	75.0	72.4
DO	mg/L	*	8.6	8.5	8.9	8.7	8.3	8.1	8.2	8.2
DOC	mg/L	*	7.0	5.7	4.9	6	4.8	5.8	4.8	5.1
pH	no units	6.5-8.5	7.6	7.7	7.9	7.8	7.3	7.4	7.4	7.4
Secchi Disk (m)	meters	*	1.8	2.1	2.0	1.9	2.7	2.6	2.5	2.6
Temperature	^0C	*	19.8	19.5	20.9	20.1	18.3	20.0	19.9	19.4
NUTRIENTS										
Ammonia	mg/L	*	0.04	0.03	0.07	0.05	0.34	0.06	<0.02	0.14
Ammonia (un-ionized)	mg/L	0.02	0.0005	0.0004	0.0009	0.0006	0.0012	0.0007	trace	0.0016
Nitrate	mg/L	*	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Nitrite	mg/L	*	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
TKN	mg/L	*	0.36	0.42	0.58	0.45	0.45	0.34	1.05	0.61
TKN Organic	mg/L	*	0.32	0.39	0.58	0.43	0.11	0.28	1.05	0.48
T. Phosphorus	mg/L	0.02	<0.006	<0.006	0.011	0.004	0.011	***0.030***	0.007	0.016
IONS										
Calcium	mg/L	*	6.66	7.00	7.68	7.11	6.18	6.59	6.69	6.49
Chloride	TCU	*	4.00	5.41	5.00	4.80	5.37	5.41	5.00	5.26
Magnesium	mg/L	*	2.22	2.42	2.34	2.33	2.05	2.37	2.17	2.20
Potassium	mg/L	*	0.6	0.6	0.7	0.6	0.6	0.6	<0.4	0.50
Sodium	mg/L	*	2.83	2.43	3.30	2.85	2.82	2.74	3.5	3.0
Sulfate	mg/L	*	1.0	6.0	9.0	5.3	2.7	3.7	8.0	4.8
METALS										
Iron	mg/L	0.3	0.2	0.2	0.1	0.2	0.2	0.2	0.1	0.1
Manganese	mg/L	*	0.02	0.04	<0.01	0.02	0.02	0.04	0.01	0.02

- PWQO = Provincial Water Quality Objective
- ***0.3*** = PWQO exceedences
- * = No PWQO
- -- = No data
- DO = Dissolved Oxygen
- DOC = Dissolved Organic Carbon

Table B-1a: Lake Nipissing 2000 Weather Conditions

SAMPLE DATE	AIR TEMPERATURE	CLOUD COVER	WIND	WATER CONDITIONS
June 27/00	ND	Partially overcast	Strong, NW	Turbulent
June 28/00	ND	Partially overcast	Strong, NW	Turbulent
June 29/00	ND	Overcast, storm clouds	Strong, NW	Turbulent
June 30/00	ND	Clear and sunny	Breezy	Small waves
July 4/00	ND	Mainly sunny	Steady, NW	Small waves
July 20/00	16 °C	Partially overcast	10 km/hr	Small waves
July 21/00	24 °C	Partially overcast	4 km/hr	Small waves
July 24/00	14 °C	Mainly overcast	0 km/hr	Calm
July 26/00	24 °C	Overcast	11 km/hr SSE	Small waves
July 28/00	23 °C	Mainly sunny	17 km/hr SE	Turbulent
Aug 24/00	21 °C	Increasing clouds	15 km/hr SW	Turbulent
Aug 28/00	21 °C	Partially overcast	15 km/hr SE	Turbulent
Aug 29/00	21 °C	Isolated thunderstorms	15 km/hr SSW	Turbulent
Aug 30/00	22 °C	Mainly sunny	0 km/hr	Calm

ND = no data
S = south
N = north
E = east
W = west
km/hr = kilometers per hour

Table B-2: Comparison of Lake Nipissing 1988-1990 and 2000 water chemistry data

Parameter	Units	PWQO	Station 2			Station 3			Station 6			Station 7		
			'88-'91	'00	Difference	'88-'91	'00	Difference	'88-'91	'00	Difference	'88-'91	'00	Difference
# of samples			16	3	-13	16	3	-13	16	3	-13	16	3	-13
GENERAL														
Alkalinity	mg/L	*	19.3	23.0	+3.71	19.5	25.0	+5.5	16.0	43.0	+27.0	49.0	50.0	+1.0
Chlorophyll-a	mg/L	*	0.003	0.004	+0.001	0.002	0.004	+0.002	0.002	0.005	+0.003	0.007	0.007	0.000
Conductivity	umhos/cm	*	80.38	79	-1.38	80.09	80	-0.09	70.06	124	+53.94	134.63	127	-7.63
DOC	mg/L	*	5.5	5.3	-0.20	5.8	5.7	-0.10	7.4	10.8	+3.4	8.4	8.4	0.00
pH	no units	6.5-8.5	7.39	7.87	+0.48	7.44	7.81	+0.48	7.1	7.81	+0.71	***8.57***	***9.91***	+1.34
NUTRIENTS														
Nitrate	mg/L	*	0.02	<0.03	Nil	0.02	<0.03	Nil	0.04	0.05	+0.01	0.02	<0.03	Nil
T.Phosphorus	mg/L	0.02	0.013	0.015	+0.002	0.013	0.010	-0.003	0.015	***0.030***	+0.015	***0.030***	***0.025***	-0.01
TKN	mg/L	*	0.32	0.51	+0.19	0.33	0.44	+0.11	0.33	0.94	+0.61	0.60	0.85	+0.26
IONS														
Calcium	mg/L	*	7.73	7.51	-0.22	7.88	7.88	0.00	7.23	12.43	+5.20	15.14	12.2	-2.94
Chloride	TCU	*	3.61	5.69	+2.39	3.31	5.1	+1.69	1.62	8.5	+7.38	4.51	9.3	+4.49
Magnesium	mg/L	*	2.43	2.38	-0.05	2.48	2.46	-0.02	2.11	4.51	+2.40	4.66	4.71	+0.05
Potassium	mg/L	*	0.72	0.6	-0.12	0.69	0.7	0.01	0.64	1.2	+0.56	0.69	0.9	+0.21
Sodium	mg/L	*	3.31	3.26	-0.05	3.1	2.99	-0.11	2.46	5.75	+0.29	3.35	4.92	+1.57
Sulfate	mg/L	*	10.57	7.5	-3.07	10.57	4.4	-6.17	11.1	2.1	-9.00	8.58	1.9	-6.68
METALS														
Iron	mg/L	0.3	0.17	0.18	+0.0175	0.18	0.18	0.00	0.19	***0.51***	+0.32	0.18	0.23	+0.055
Manganese	mg/L	*	0.015	<0.01	-0.005	0.013	<0.01	-0.005	0.03	0.04	+0.01	0.015	0.010	-0.01

- Data are presented as average concentrations
- PWQO = Provincial Water Quality Objective
- ***0.14*** = PWQO exceedences
- * = No PWQO
- DOC = Dissolved Organic Carbon
- TKN = Total Kjeldahl Nitrogen

Table B-2: Comparison of Lake Nipissing 1988-1990 and 2000 water chemistry data

Parameter	Units	PWQO	Station 9			Station 11			Station 12		
			'88-'91	'00	Difference	'88-'91	'00	Difference	'88-'91	'00	Difference
# of samples			17	4	-13	17	3	-14	16	3	-13
GENERAL											
Alkalinity	mg/L	*	18.4	21.0	+2.6	19.7	23.0	+3.3	18.3	21.0	+2.7
Chlorophyll-a	mg/L	*	0.015	0.012	-0.003	0.004	0.006	+0.002	0.003	0.005	+0.002
Conductivity	umhos/cm	*	82.23	81.00	-1.23	85.84	82.00	-3.84	77.57	75.00	-2.57
DOC	mg/L	*	6.0	6.6	+0.6	5.2	5.4	+0.2	5.0	4.8	-0.2
pH	no units	6.5-8.5	7.43	7.57	+0.14	7.43	7.82	+0.39	7.36	7.40	+0.04
NUTRIENTS											
Nitrate	mg/L	*	0.03	<0.03	0.00	0.05	<0.03	-0.02	0.02	<0.03	Nil
T.Phosphorus	mg/L	0.02	0.020	0.021	+0.001	0.02	0.01	-0.01	0.012	0.020	+0.008
TKN	mg/L	*	0.50	0.67	+0.17	0.41	0.50	+0.09	0.31	0.44	+0.13
IONS											
Calcium	mg/L	*	7.45	6.45	-1.00	7.65	7.66	+0.01	6.98	6.28	-0.70
Chloride	TCU	*	5.41	8.48	+2.59	4.95	6.64	+2.05	3.53	5.34	+1.81
Magnesium	mg/L	*	2.37	2.28	-0.09	2.43	2.43	0.00	2.35	2.17	-0.18
Potassium	mg/L	*	0.93	0.70	-0.23	0.79	0.70	-0.09	0.70	0.60	-0.10
Sodium	mg/L	*	4.03	4.30	+0.27	4.09	3.98	-0.11	3.05	3.07	0.02
Sulfate	mg/L	*	9.41	2.60	-6.81	10.64	6.00	-4.64	10.66	5.90	-4.76
METALS											
Iron	mg/L	0.3	0.14	0.19	+0.50	0.10	0.15	+0.05	0.07	0.15	+0.08
Manganese	mg/L	*	0.030	0.030	+0.003	0.010	0.020	+0.010	0.013	0.020	+0.007

- Data are presented as average concentrations
- PWQO = Provincial Water Quality Objective
- ***0.14*** = PWQO exceedences
- * = No PWQO
- DOC = Dissolved Organic Carbon
- TKN = Total Kjeldahl Nitrogen

Table B-2: Comparison of Lake Nipissing 1988-1990 and 2000 water chemistry data

Parameter	Units	PWQO	Station 14			Station 16			Station 17			Station 25		
			'88-'91	'00	Difference	'88-'91	'00	Difference	'88-'91	'00	Difference	'88-'91	'00	Difference
# of samples			16	3	-13	16	3	-13	16	3	-13	16	3	-13
GENERAL														
Alkalinity	mg/L	*	17.6	19.0	+1.4	23.4	23.0	-0.4	19.2	20.0	+0.8	18.0	21.0	+3.0
Chlorophyll-a	mg/L	*	0.005	0.006	+0.001	0.004	0.004	0.000	0.003	0.006	+0.003	0.003	0.005	+0.002
Conductivity	umhos/cm	*	76.79	73.00	-3.79	81.14	76.00	-5.14	73.03	72.00	-1.03	77.25	72.00	-5.25
DOC	mg/L	*	5.0	5.3	+3.0	6.2	5.6	-0.6	5.7	6.0	+0.3	5.1	5.1	0.0
pH	no units	8.5-8.5	7.40	7.52	+0.12	7.61	8.49	+0.88	7.47	7.75	+0.28	7.30	7.35	+0.05
NUTRIENTS														
Nitrate	mg/L	*	0.02	<0.03	Nil	0.01	<0.03	Nil	0.01	<0.03	Nil	0.03	<0.03	0.00
T.Phosphorus	mg/L	0.02	0.012	0.008	-0.004	0.021	0.007	-0.014	0.018	0.008	-0.010	0.013	0.016	+0.003
TKN	mg/L	*	0.31	0.51	+0.20	0.45	0.53	+0.08	0.37	0.45	+0.08	0.30	0.61	+0.31
IONS														
Calcium	mg/L	*	7.16	7.28	+0.12	7.96	6.97	-0.99	7.32	7.11	-0.21	7.43	6.49	-0.94
Chloride	TCU	*	3.68	5.68	+2.00	2.51	5.14	+2.63	2.49	4.80	+2.31	3.19	5.26	+2.07
Magnesium	mg/L	*	2.27	2.32	+0.05	2.88	2.52	-0.36	2.43	2.33	-0.10	2.25	2.20	-0.05
Potassium	mg/L	*	0.73	0.70	-0.03	0.78	0.50	-0.28	0.70	0.60	-0.10	0.71	0.50	-0.21
Sodium	mg/L	*	3.26	3.30	+0.04	2.38	2.57	+0.19	2.45	2.85	+0.40	3.04	3.02	-0.02
Sulfate	mg/L	*	10.39	2.70	-7.69	9.32	3.30	-6.02	9.82	5.30	-4.52	10.71	4.80	-5.91
METALS														
Iron	mg/L	0.3	0.09	0.21	+0.13	0.16	0.15	-0.01	0.17	0.16	-0.01	0.05	0.15	+0.10
Manganese	mg/L	*	0.015	0.030	+0.020	0.014	0.020	+0.010	0.014	0.020	+0.010	0.020	0.020	0.00

- Data are presented as average concentrations
- PWQO = Provincial Water Quality Objective
- ***0.14*** = PWQO exceedences
- * = No PWQO
- DOC = Dissolved Organic Carbon
- TKN = Total Kjeldahl Nitrogen

Table B-3: Benthic invertebrate Biobasket species list - 6 week samples collected in August 2000 and evaluated according to BioMAP values.

Sensitivity Value	Species List	Wistiwasing River				LaVase River				South River			
		1*		1A*		2*		3*		4*		5*	
		1**	3**	1**	2**	1**	2**	1**	2**	2**	3**	2**	3**
	Insects:												
	ALDERFLIES:												
	Corydalidae:												
1	Chauloides												
3	Nigronia	15	4	2	13								
	Sialidae:												
2	Sialis					3							
	AQUATIC MOTHS:												
2	Pyralidae												
	BEETLES:												
	Elmidae:												
1	Dubiraphia minima												
2	Dubiraphia vittata												
2	Macronychus galbratus											2	
2	Stenelmis crenata	12	1										
	Haliplidae:												
1	Haliplus												
1	Peltodytes												
	Psephenidae:												
3	Psephenus	2	1	1									
	BUGS:												
	Belostomatidae:												
0	Belostoma												
	Corixidae:												
0	Sigara mullettensis												
0	Sigara variabilis												
	Hydrometridae:												
0	Hydrometra martini												
	Notonectidae:												
0	Notonecta												
	Pleidae:												
0	Neoplea												
	CADDISFLIES:												
	Dipseudopsidae:												
2	Phylocentropus					1	1	3	2				
	Glossosomatidae:												
4	Glossosoma			4									
	Hydroptilidae:												
1	Agraylea												
	Hydropsychidae:												
-	Cheumatopsyche	84	207	32	82	4	1	66					
3	Hydropsyche bronta	13	30	33	29								
2	Hydropsyche morosa				12								
3	Hydropsyche sparna	28	21	206	67								
	Leptoceridae:												
0	Leptocercus americanus												
1	Mystacides								1		3		
2	Oecetis					4	4	10	18				
1	Triaenodes												
	Limnephilidae:												

*Benthic sample station numbers

** - benthic macroinvertebrate sample basket number

Table B-3: Benthic invertebrate Biobasket species list - 6 week samples collected in August 2000 and evaluated according to BioMAP values.

Sensitivity Value	Species List	Wistiwasing River				LaVase River				South River			
		1*		1A*		2*		3*		4*		5*	
		1**	3**	1**	2**	1**	2**	1**	2**	2**	3**	2**	3**
3	Pycnopsyche												
	Molannidae:												
2	Molanna												
	Philopotamidae:												
3	Chimarra	16	13		166								
	Polycentropodidae:												
2	Neureclipsis												
-	Polycentropus	24	22			3	2	5	8	6	11	2	6
	DAMSELFLIES:												
	Calopterygidae:												
2	Calopteryx aequalis	4											
	Coenagrionidae:												
2	Argia modesta										5		2
2	Chromagrion conditum												
2	Enallagma antennatum					4	2	17	10	27	24	20	12
0	Enallagma ebrium												
0	Ischnura					30	22	32	25	2	5		1
	DRAGONFLIES:												
	Aeshnidae:												
2	Aeshna						1			1			
1	Basiaeschna					2		5	1	4	3	2	1
2	Boyeria	1	3		1								
	Corduliidae:												
1	Epitheca					2			1				1
3	Somatochlora												
	Gomphidae:												
2	Phanogomphus						1		1				
	MAYFLIES:												
	Baetidae:												
3	Acentrella turbida				4								
2	Baetis intercalaris			17	36								
4	Baetis tricaudatus				4								
3	Centroptilum						2	2					
3	Diphetor hageni		8		16								
2	Procloeon	4								11	2	4	12
	Caenidae:												
1	Caenis					2							
	Ephemerellidae:												
1	Eurylophella											2	
3	Serratella	16	4	4	4								
	Heptageniidae:												
3	Heptagenia			2									
4	Leucrocuta hebe	1	4		2								
2	Stenacron interpunctatum	42	30			15	41	45	88	32	29	35	47
1	Stenonema femoratum				4	5	1	35	18				1
2	Strenonema modestum		1										
3	Stenonema vicarium	26	19	7	6								
	Isonychiidae:												
2	Isonychia	48	115	100	281								
	Leptophlebiidae:												
3	Paraleptophlebia	12	4	4	4			2		2			

*Benthic sample station numbers

** - benthic macroinvertebrate sample basket number

Table B-3: Benthic invertebrate Biobasket species list - 6 week samples collected in August 2000 and evaluated according to BioMAP values.

Sensitivity Value	Species List	Wistiwasing River				LaVase River				South River			
		1*		1A*		2*		3*		4*		5*	
		1**	3**	1**	2**	1**	2**	1**	2**	2**	3**	2**	3**
	STONEFLIES:												
	Leuctridae:												
4	Leuctra	4											
	Perlidae:												
2	Acroneuria abnormis			3	4								
3	Acroneuria carolinensis	1	10										
2	Acroneuria lycorias				1								
3	Paragnetina media		1	18	24								
	TRUE FLIES:												
0	Ceratopogonidae					2		2					
	Chironomidae:												
2	Ablabesmyia		4								2		
0	Chironomus												
1	Clinotanypus					2	2						
2	Conchapelopia	12	4										
2	Corynoneuria		4										
0	Dicrotendipes												
0	Endochironomus							2					
3	Eukiefferiella			4									
0	Glyptotendipes								4				
1	Labrundinia												
2	Microtendipes		8		4								
3	Nanocladius												
3	Pagastia		4										
1	Parachironomus								2				
3	Parametriocnemus	4											
1	Paratanytarsus												
2	Polypedilum convictum												
1	Polypedilum scalaenum												
	Polypedilum sordens							1	2		2		
0	Procladius	4											
1	Pseudochironomus										2		
2	Stempellinella								2				
2	Tanytarsus	4									2		
1	Tribelos	4				1							
2	Simuliidae												
	Tipulidae:												
-	Tipula												
	Crustaceans:												
	AMPHIPODS:												
	Gammaridae:												
2	Crangonyx					18	8	12	40				
	Hyalellidae:												
2	Hyalella					4	5	2	4	2	6		2
	CRAYFISHES:												
	Cambaridae:												
2	Orconectes propinquus					3	1	2	1				1
	ISOPODS:												
	Asellidae:												
1	Caecidotea												

*Benthic sample station numbers

** - benthic macroinvertebrate sample basket number

Table B-3: Benthic invertebrate Biobasket species list - 6 week samples collected in August 2000 and evaluated according to BioMAP values.

Sensitivity Value	Species List	Wistiwasing River				LaVase River				South River			
		1*		1A*		2*		3*		4*		5*	
		1**	3**	1**	2**	1**	2**	1**	2**	2**	3**	2**	3**
2	Lirceus												
	Molluscs:												
	BIVALVES:												
	Sphaeridae:												
1	Musculium securis							1	4				
	Pisidium					1							
	SNAILS:												
	Hydrobiidae:												
2	Amnicola					3	2	1					
	Physidae:												
0	Physella									1			
	Planorbidae:												
1	Gyraulus						3						
1	Helisoma anceps							1				1	
0	Planorbella campanulatum					2							
	Valvatidae:												
2	Valvata tricarnata												
	Annelids:												
	LEECHES:												
	Erpobdellidae:												
1	Erpobdella punctata												
2	Nephelopsis obscura												
	Glossiphonidae:												
	Batracobdella phalera								1				
2	Helobdella stagnalis												
1	Placobdella montifera												
1	Placobdella ornata												
	WORMS:												
	Tubificidae:												
0	immature, no hair chaete												
0	immature, hair chaete						2						
	Platyhelminthes:												
	FLATWORMS:												
3	Tricladida			8		10	8	6	4	4	8		6
	NUMBER TAXA	23	23	15	20	21	19	21	21	11	14	8	12
	NUMBER ORGANISMS	366	518	443	751	118	109	252	237	92	104	68	92
	BioMAP(d) WQI	15.4	16.0	18.4	17.0	6.1	7.4	6.9	6.0	8.3	7.3	6.3	8.0

*Benthic sample station numbers

** - benthic macroinvertebrate sample basket number

Table B-3: Benthic invertebrate Biobasket species list - 6 week samples collected in August 2000 and evaluated according to BioMAP values.

Sensitivity Value	Species List	Little Sturgeon R.				Veuve River				Little Cash River			
		6*		7*		8*		9*		10*		11*	
		1**	2**	2**	3**	1**	3**	1**	2**	2**	3**	1**	2**
	Insects:												
	ALDERFLIES:												
	Corydalidae:												
1	Chauloides												
3	Nigronia												
	Sialidae:												
2	Sialis	3									2		
	AQUATIC MOTHS:												
2	Pyralidae						2						
	BEETLES:												
	Elmidae:												
1	Dubiraphia minima												
2	Dubiraphia vittata											37	
2	Macronychus galbratus												
2	Stenelmis crenata												
	Haliplidae:												
1	Haliplus				1			2					
1	Peltodytes										1	1	
	Psephenidae:												
3	Psephenus												
	BUGS:												
	Belostomatidae:												
0	Belostoma											1	
	Corixidae:										1		
0	Sigara mullettensis												1
0	Sigara variabilis												1
	Hydrometridae:												
0	Hydrometra martini												
	Notonectidae:												
0	Notonecta											5	
	Pleidae:												
0	Neoplea						1						
	CADDISFLIES:												
	Dipseudopsidae:												
2	Phylocentropus												
	Glossosomatidae:												
4	Glossosoma												
	Hydroptilidae:												
1	Agraylea												
	Hydropsychidae:												
-	Cheumatopsyche												
3	Hydropsyche bronta					2							
2	Hydropsyche morosa												
3	Hydropsyche sparna												
	Leptoceridae:												
0	Leptocercus americanus												
1	Mystacides												
2	Oecetis				4	16		2	4				
1	Triaenodes				1								
	Limnephilidae:												

*Benthic sample station numbers
** - benthic macroinvertebrate sample basket number

Table B-3: Benthic invertebrate Biobasket species list - 6 week samples collected in August 2000 and evaluated according to BioMAP values.

Sensitivity Value	Species List	Little Sturgeon R.				Veuve River				Little Cash River			
		6*		7*		8*		9*		10*		11*	
		1**	2**	2**	3**	1**	3**	1**	2**	2**	3**	1**	2**
3	Pycnopsyche												
	Molannidae:												
2	Molanna		1										
	Philopotamidae:												
3	Chimarra												
	Polycentropodidae:												
2	Neureclipsis		1										
-	Polycentropus	2	1	2	1	6	4	2	8	39	44	14	8
	DAMSELFLIES:												
	Calopterygidae:												
2	Calopteryx aequalis				1								
	Coenagrionidae:												
2	Argia modesta												
2	Chromagrion conditum	3	2	1									
2	Enallagma antennatum	7	4		2						1		
0	Enallagma ebrium							2	8				
0	Ischnura	2			1	16	7	47	22	5	2	87	37
	DRAGONFLIES:												
	Aeshnidae:												
2	Aeshna	1											
1	Basiaeschna	1			1			1				2	3
2	Boyeria												
	Corduliidae:												
1	Epitheca				3		2	1	2				
3	Somatochlora							2					
	Gomphidae:												
2	Phanogomphus												
	MAYFLIES:												
	Baetidae:												
3	Acentrella turbida												
2	Baetis intercalaris												
4	Baetis tricaudatus												
3	Centroptilum									1			
3	Diphetor hageni												
2	Procloeon												
	Caenidae:												
1	Caenis				1		1			2	2		
	Ephemerellidae:												
1	Eurylophella	5			1								
3	Serratella												
	Heptageniidae:												
3	Heptagenia												
4	Leucrocuta hebe												
2	Stenacron interpunctatum	6		1	2	2	2	9	6	2	10		
1	Stenonema femoratum						1			13	27		1
2	Strenonema modestum												
3	Stenonema vicarium												
	Isonychiidae:												
2	Isonychia												
	Leptophlebiidae:												
3	Paraleptophlebia	2		2						2	2		

*Benthic sample station numbers

** - benthic macroinvertebrate sample basket number

Table B-3: Benthic invertebrate Biobasket species list - 6 week samples collected in August 2000 and evaluated according to BioMAP values.

Sensitivity Value	Species List	Little Sturgeon R.				Veuve River				Little Cash River			
		6*		7*		8*		9*		10*		11*	
		1**	2**	2**	3**	1**	3**	1**	2**	2**	3**	1**	2**
	STONEFLIES:												
	Leuctridae:												
4	Leuctra												
	Perlidae:												
2	Acroneuria abnormis												
3	Acroneuria carolinensis												
2	Acroneuria lycorias												
3	Paragnetina media												
	TRUE FLIES:												
0	Ceratopogonidae												
	Chironomidae:												
2	Ablabesmyia		1		1					8			8
0	Chironomus												
1	Clinotanypus												
2	Conchapelopia										2		
2	Corynoneuria												
0	Dicrotendipes					2				3			
0	Endochironomus												
3	Eukiefferiella												
0	Glyptotendipes												
1	Labrundinia												
2	Microtendipes								2		3	1	
3	Nanocladius												
3	Pagastia												
1	Parachironomus												
3	Parametriocnemus												
1	Paratanytarsus												
2	Polypedilum convictum											1	
1	Polypedilum scalaenum												
	Polypedilum sordens												
0	Procladius							2					
1	Pseudochironomus												
2	Stempellinella												
2	Tanytarsus						1						
1	Tribelos												
2	Simuliidae												
	Tipulidae:												
-	Tipula												
	Crustaceans:												
	AMPHIPODS:												
	Gammaridae:												
2	Crangonyx					9	6		4				
	Hyalellidae:												
2	Hyalella					108	21	22	32	97	24	309	100
	CRAYFISHES:												
	Cambaridae:												
2	Orconectes propinquus	1	1			2	4	5	3	1		2	3
	ISOPODS:												
	Asellidae:												
1	Caecidotea	1									4	4	12

*Benthic sample station numbers

** - benthic macroinvertebrate sample basket number

Table B-3: Benthic invertebrate Biobasket species list - 6 week samples collected in August 2000 and evaluated according to BioMAP values.

Sensitivity Value	Species List	Little Sturgeon R.				Veuve River				Little Cash River			
		6*		7*		8*		9*		10*		11*	
		1**	2**	2**	3**	1**	3**	1**	2**	2**	3**	1**	2**
2	Lirceus							2	2				
	Molluscs:												
	BIVALVES:												
	Sphaeridae:												
1	Musculium securis				1								
	Pisidium	1											1
	SNAILS:												
	Hydrobiidae:												
2	Amnicola	3		8	29	133	142	158	140				6
	Physidae:												
0	Physella	2	2		2	3	3		2				
	Planorbidae:												
1	Gyraulus								4				
1	Helisoma anceps												
0	Planorbella campanulatum												
	Valvatidae:												
2	Valvata tricarnata							1					
	Annelids:												
	LEECHES:												
	Erpobdellidae:												
1	Erpobdella punctata											1	
2	Nephelopsis obscura												
	Glossiphonidae:												
	Batracobdella phalera							2	4				
2	Helobdella stagnalis					2							
1	Placobdella montifera						1						
1	Placobdella omata												
	WORMS:												
	Tubificidae:												
0	immature, no hair chaete												
0	immature, hair chaete												
	Platyhelminthes:												
	FLATWORMS:												
3	Tricladida							4	2	44	12		84
	NUMBER TAXA	14	8	5	16	12	14	17	16	12	14	13	13
	NUMBER ORGANISMS	37	13	14	52	301	196	264	245	217	135	465	265
	BioMAP(d) WQI	6.4	6.3	10.4	5.0	6.6	5.4	6.8	5.9	9.0	7.8	4.6	7.5

*Benthic sample station numbers

** - benthic macroinvertebrate sample basket number

Table B-3: Benthic invertebrate Biobasket species list - 6 week samples collected in August 2000 and evaluated according to BioMAP values.

Sensitivity Value	Species List	MacPherson Creek				Mosquito Creek			
		12*		13*		14*		15*	
		1**	2**	1**	2**	2**	3**	1**	2**
	Insects:								
	ALDERFLIES:								
	Corydalidae:								
1	Chauloides			1					
3	Nigronia								
	Sialidae:								
2	Sialis						1		
	AQUATIC MOTHS:								
2	Pyralidae								
	BEETLES:								
	Elmidae:								
1	Dubiraphia minima					1		10	4
2	Dubiraphia vittata								
2	Macronychus galbratus								
2	Stenelmis crenata	1							
	Haliplidae:								
1	Haliplus								
1	Peltodytes								
	Psephenidae:								
3	Psephenus								
	BUGS:								
	Belostomatidae:								
0	Belostoma								
	Corixidae:								
0	Sigara mullettensis								
0	Sigara variabilis								
	Hydrometridae:								
0	Hydrometra martini				4				
	Notonectidae:								
0	Notonecta								
	Pleidae:								
0	Neoplea								
	CADDISFLIES:								
	Dipseudopsidae:								
2	Phylocentropus								
	Glossosomatidae:								
4	Glossosoma								
	Hydroptilidae:								
1	Agraylea	7							
	Hydropsychidae:								
-	Cheumatopsyche	921	636						
3	Hydropsyche bronta								
2	Hydropsyche morosa								
3	Hydropsyche sparna								
	Leptoceridae:								
0	Leptocercus americanus		4	28	52				
1	Mystacides								
2	Oecetis	5							
1	Triaenodes			4					
	Limnephilidae:								

*Benthic sample station numbers

** - benthic macroinvertebrate sample basket number

Table B-3: Benthic invertebrate Biobasket species list - 6 week samples collected in August 2000 and evaluated according to BioMAP values.

Sensitivity Value	Species List	MacPherson Creek				Mosquito Creek			
		12*		13*		14*		15*	
		1**	2**	1**	2**	2**	3**	1**	2**
3	Pycnopsyche			1					
	Molannidae:								
2	Molanna								
	Philopotamidae:								
3	Chimarra								
	Polycentropodidae:								
2	Neureclipsis								
-	Polycentropus	14	12	9	13				
	DAMSELFLIES:								
	Calopterygidae:								
2	Calopteryx aequalis								
	Coenagrionidae:								
2	Argia modesta								
2	Chromagrion conditum								
2	Enallagma antennatum								
0	Enallagma ebrium								
0	Ischnura			13	1				
	DRAGONFLIES:								
	Aeshnidae:								
2	Aeshna								
1	Basiaeschna		4		1				
2	Boyeria								
	Corduliidae:								
1	Epitheca			1	2				
3	Somatochlora								
	Gomphidae:								
2	Phanogomphus								
	MAYFLIES:								
	Baetidae:								
3	Acentrella turbida								
2	Baetis intercalaris								
4	Baetis tricaudatus								
3	Centroptilum								
3	Diphetor hageni								
2	Procloeon								
	Caenidae:								
1	Caenis								
	Ephemerellidae:								
1	Eurylophella								
3	Serratella								
	Heptageniidae:								
3	Heptagenia								
4	Leucrocuta hebe								
2	Stenacron interpunctatum			18	20				
1	Stenonema femoratum	1		10	12				
2	Strenonema modestum								
3	Stenonema vicarium								
	Isonychiidae:								
2	Isonychia								
	Leptophlebiidae:								
3	Paraleptophlebia							2	

*Benthic sample station numbers

** - benthic macroinvertebrate sample basket number

Table B-3: Benthic invertebrate Biobasket species list - 6 week samples collected in August 2000 and evaluated according to BioMAP values.

Sensitivity Value	Species List	MacPherson Creek				Mosquito Creek			
		12*		13*		14*		15*	
		1**	2**	1**	2**	2**	3**	1**	2**
	STONEFLIES:								
	Leuctridae:								
4	Leuctra								
	Perlidae:								
2	Acroneuria abnormis								
3	Acroneuria carolinensis								
2	Acroneuria lycorias								
3	Paragnetina media								
	TRUE FLIES:								
0	Ceratopogonidae								
	Chironomidae:								
2	Ablabesmyia	4		8			1	6	9
0	Chironomus							1	
1	Clinotanypus								
2	Conchapelopia	12							
2	Corynoneuria								
0	Dicrotendipes								
0	Endochironomus		4						
3	Eukiefferiella								
0	Glyptotendipes	1	4						
1	Labrundinia				4				
2	Microtendipes								
3	Nanocladius		8						
3	Pagastia								
1	Parachironomus	4							
3	Parametriocnemus								
1	Paratanytarsus	1						1	3
2	Polypedilum convictum								
1	Polypedilum scalaenum	78	84						
	Polypedilum sordens								
0	Procladius							3	
1	Pseudochironomus								
2	Stempellinella								
2	Tanytarsus		4	4				6	2
1	Tribelos								
2	Simuliidae							1	
	Tipulidae:								
-	Tipula		4						
	Crustaceans:								
	AMPHIPODS:								
	Gammaridae:								
2	Crangonyx						3	3	1
	Hyalellidae:								
2	Hyalella	179	28	121	88				
	CRAYFISHES:								
	Cambaridae:								
2	Orconectes propinquus				1				
	ISOPODS:								
	Asellidae:								
1	Caecidotea			4		2	1	12	3

*Benthic sample station numbers

** - benthic macroinvertebrate sample basket number

Table B-3: Benthic invertebrate Biobasket species list - 6 week samples collected in August 2000 and evaluated according to BioMAP values.

Sensitivity Value	Species List	MacPherson Creek				Mosquito Creek			
		12*		13*		14*		15*	
		1**	2**	1**	2**	2**	3**	1**	2**
2	Lirceus								
	Molluscs:								
	BIVALVES:								
	Sphaeridae:								
1	Musculium securis	3							
	Pisidium								
	SNAILS:								
	Hydrobiidae:								
2	Amnicola	1			14				
	Physidae:								
0	Physella	19	12		5				
	Planorbidae:								
1	Gyraulus								
1	Helisoma anceps								
0	Planorbella campanulatum				1				
	Valvatidae:								
2	Valvata tricarnata								
	Annelids:								
	LEECHES:								
	Erpobdellidae:								
1	Erpobdella punctata		8						
2	Nephelopsis obscura						2	1	1
	Glossiphonidae:								
	Batracobdella phalera								
2	Helobdella stagnalis					1		1	
1	Placobdella montifera								
1	Placobdella ornata					2	3	2	3
	WORMS:								
	Tubificidae:								
0	immature, no hair chaete					1			
0	immature, hair chaete								
	Platyhelminthes:								
	FLATWORMS:								
3	Tricladida	111	196	4	4				
	NUMBER TAXA	17	14	13	15	5	5	13	8
	NUMBER ORGANISMS	1362	1008	225	222	7	10	49	26
	BioMAP(d) WQI	6.9	7.7	5.9	5.1	3.2	5.5	5.6	4.8

*Benthic sample station numbers

** - benthic macroinvertebrate sample basket number

Table B-4: Chretian Drain and MacPherson Creek Water Quality Data

Parameter	Units	PWQO	Station 10		Station 11		Station 12	Station 13	Station 14	Station 15
			17 T 0560360		17 T 0556964		--	--	17 T 0558164	17 T 0557846
			UTM 5133748		UTM 5133348		--	--	UTM 5133518	UTM 5133500
			12-Jun	13-Jun	12-Jun	13-Jun	13-Jun	13-Jun	15-Jun	15-Jun
Alkalinity	mg/L	*	--	121	72	159	83	92	161	92
Ammonia	mg/L	*		<0.02	<0.02	<0.02	0.03	0.02	0.13	0.02
BOD	mg/L	*	--	10	--	9	7	7	12	9
Calcium	mg/L	*	--	49.20	4.77	59.90	49.70	48.80	59.40	22.40
Color	TCU	*	--	82	64	96	70	66	62	42
DOC	mg/L	*	--	22.0	--	27.2	21.4	20.0	20.4	15.0
Hardness	mg/L	*	--	174	63	208	175	175	213	88
Magnesium	mg/L	*	--	12.4	12.3	14.2	12.3	12.6	15.6	7.78
Nitrate	mg/L	*	--	<0.03	0.29	<0.03	0.07	0.16	<0.03	<0.03
Nitrite	mg/L	*	--	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
pH	no units	6.5-8.5	--	6.95	7.26	7.02	7.07	7.33	7.61	7.65
T.Phosphorus	mg/L	0.03	**0.119**	**0.066**	0.034	**0.082**	**0.040**	0.030	**0.423**	**0.050**
TKN	mg/L	*	--	1.52	1.63	2.15	1.70	1.51	2.57	1.29
TSS	mg/L	*	--	12	3	14	3	2	37	5
Turbidity	NTU	*	--	5.1	4.1	6.6	3.1	3.0	12.1	2.3

PWQO = Provincial Water Quality Objective

0.7 = PWQO exceedences

* = no PWQO

-- = no data

BOD = Biological Oxygen Demand
DOC = Dissolved Organic Carbon
TKN = Total Kjeldahl Nitrogen
TSS = Total Suspended Solids

<u>Field Conditions</u>

June 12 - Sunny, windy. Storm event on June 10.
June 13 - Sunny windy. Dry, low water levels.
June 15 - Overcast. Storm event on June 14.
June 17 - Sunny. Rain event June16

Table B-4: Chretian Drain and MacPherson Creek Water Quality Data

Parameter	Units	PWQO	Station 16	Station 17	Station 18	Station 19	Station 20	Station 21	Station 88
			17 T 0556996	17 T 0557014	17 T 0556743	17 T 0556213	17 T 0556296	17 T 0557478	17 T 0558118
			UTM 5132770	UTM 5132751	UTM 5132515	UTM 5131822	UTM 5131765	UTM 5131765	UTM 5133450
			17-Jun	17-Jun	17-Jun	17-Jun	17-Jun	17-Jun	12-Jun
Alkalinity	mg/L	*	72	95	83	51	54	30	73
Ammonia	mg/L	*	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
BOD	mg/L	*	2	3	3	3	2	3	--
Calcium	mg/L	*	17.20	23.30	21.40	13.50	14.30	8.43	26.60
Color	TCU	*	87	47	59	75	72	56	78
DOC	mg/L	*	16.2	16.8	16.3	17.7	17.5	13.8	--
Hardness	mg/L	*	71	92	85	56	58	36	102
Magnesium	mg/L	*	6.69	8.29	7.57	5.36	5.51	3.67	8.64
Nitrate	mg/L	*	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.22
Nitrite	mg/L	*	<0.03	<0.03	<0.03	0.05	0.04	<0.03	<0.03
pH	no units	6.5-8.5	7.48	7.32	7.25	7.25	7.26	7.49	7.28
T.Phosphorus	mg/L	0.03	**0.089**	**0.068**	**0.088**	**0.073**	**0.122**	**0.048**	**0.071**
TKN	mg/L	*	0.95	0.95	1.32	1.19	1.12	0.89	1.81
TSS	mg/L	*	11	3	8	6	6	7	9
Turbidity	NTU	*	18.4	2.8	7.2	10.3	9.9	8.7	13

PWQO = Provincial Water Quality Objective

0.7 = PWQO exceedences

* = no PWQO
-- = no data
BOD = Biological Oxygen Demand
DOC = Dissolved Organic Carbon
TKN = Total Kjeldahl Nitrogen
TSS = Total Suspended Solids

Field Conditions
June 12 - Sunny, windy. Storm event on June 10.
June 13 - Sunny windy. Dry, low water levels.
June 15 - Overcast. Storm event on June 14.
June 17 - Sunny. Rain event June16

Table B-4: Chretian Drain and MacPherson Creek Water Quality Data

Parameter	Units	PWQO	Station 99	Station 004	Station 018
			17 T 0558554 UTM 5133328	17 T 0558579 UTM 5133317	17 T 0557556 UTM 5133082
			12-Jun	12-Jun	12-Jun
Alkalinity	mg/L	*	--	69	90
Ammonia	mg/L	*	--	<0.02	<0.02
BOD	mg/L	*	--	--	--
Calcium	mg/L	*	--	25.40	23.10
Color	TCU	*	--	88	41
DOC	mg/L	*	--	--	--
Hardness	mg/L	*	--	98	162
Magnesium	mg/L	*	--	8.28	8.17
Nitrate	mg/L	*	--	0.14	<0.03
Nitrite	mg/L	*	--	<0.03	<0.03
pH	no units	6.5-8.5	--	7.50	7.40
T.Phosphorus	mg/L	0.03	**0.049**	--	--
TKN	mg/L	*	--	1.49	1.12
TSS	mg/L	*	--	5	5
Turbidity	NTU	*	--	6.5	4.0

PWQO = Provincial Water Quality Objective

0.7 = PWQO exceedences

* = no PWQO

-- = no data

BOD = Biological Oxygen Demand

DOC = Dissolved Organic Carbon

TKN = Total Kjeldahl Nitrogen

TSS = Total Suspended Solids

<u>Field Conditions</u>

June 12 - Sunny, windy. Storm event on June 10.

Juna 13 - Sunny windy. Dry, low water levels.

June 15 - Overcast. Storm event on June 14.

June 17 - Sunny. Rain event June16

Table B-5: Merrick landfill surface water quality data

PARAMETERS	Units	PWQO	SW-U 40m US of landfill		SW-M 15m DS of landfill		SW-T DS Tributary		SW-P 60m DS of landfill		MER1 15km DS of landfill	
			31/07/00	08/31/00	31/07/00	08/31/00	31/07/00	08/31/00	31/07/00	08/31/00	31/07/00	09/01/00
GENERAL												
Alkalinity	mg/L	--	2.5	2	58	5.5	5	44	20.5	21.5	4.5	5
BOD	mg/L	--	2.4	0.8	5.4	0.4	1.2	2.2	1	0.6	1.4	0.6
conductivity	uS/cm	--	17	17	176	125	130	142	139	140	60	74
pH	none	6.5-8.5	***4.99***	***5.08***	6.84	***6.41***	***6.18***	6.78	6.90	6.99	***6.69***	***5.96***
TSS	mg/L	--	15	7	42.5	6	15.5	25.5	6.5	5.5	3	4.5
total solids	mg/L	--	26	18	156	88	100	118	98	96	42	52
dissolved solids	mg/L	--	12	12	114	82	84	92	90	92	40	48
NUTRIENTS												
ammonia+ammonium	mg/L	--	0.03	0.032	1.56	0.008	0.076	0.974	0.504	0.382	0.024	0.04
nitrite	mg/L	--	0.025	0.012	0.03	0.001	0.009	0.016	0.013	0.008	0.019	0.012
nitrite+nitrate	mg/L	--	0.046	0.018	0.056	0.117	0.157	0.025	0.122	0.104	0.053	0.046
TKN	mg/L	--	1.28	0.9	2.56	0.36	0.6	1.74	0.98	0.82	24	0.72
phosphate	mg/L	--	0.005	0.004	0.003	0.002	0.002	0.005	0.0005	0.003	0.002	0.004
phosphorus, total	mg/L	0.03	***0.060***	***0.044***	***0.044***	0.024	0.026	0.028	0.028	0.016	0.032	0.028
IONS												
calcium	mg/L	--	1.24	1.11	12.6	3.98	4.08	10.9	7.88	8.14	2.82	3.41
chloride	mg/L	--	1.6	1.2	19	29.2	32	15.4	27.6	26.4	12.4	16.4
magnesium	mg/L	--	0.393	0.392	4.09	1.3	1.26	3.64	2.48	2.62	0.874	1.14
sulfata	mg/L	--	1	2	1	4	3.5	2	3	3	2	2.4
METALS												
aluminum	mg/L	0.075	***0.567***	***0.380***	***0.282***	***0.176***	***0.288***	***0.222***	***0.152***	***0.113***	***0.381***	***0.321***
barium	ug/L	--	15.7	12.3	126	37.6	41.6	97.5	64.5	61	16.6	16.6
beryllium	ug/L	--	0.0339	0.026	0.0225	0.0257	0.0349	0.0235	0.0229	0.0203	0.0339	0.0324
cadmium	ug/L	0.5	<0	0.113	0.14	0.332	0.144	0.262	0.297	0.0685	0.0477	0.168
cobalt	ug/L	0.4	***0.624***	0.349	***16.2***	***0.448***	0.332	***13.4***	***2.8***	***2.61***	***0.534***	0.244
chromium	ug/L	100	1.45	0.286	0.351	0.241	0.317	0.571	0.0439	0.196	0.989	1.15
copper	ug/L	5	0.937	0.138	0.568	0.0433	0.322	0.292	0.472	0.164	0.876	0.843
iron	mg/L	0.3	***2.55***	***1.68***	***14.6***	***2.0***	***3.66***	***11.5***	***3.94***	***3.54***	***1.75***	***1.76***
lead	ug/L	5	<0	0.60	2.02	0.20	<0	2.01	0.41	<0	3.10	0.21
manganese	ug/L	--	0.04	0.03	3.49	0.10	0.12	3.25	0.81	0.77	0.03	0.02
molybdenum	ug/L	10	1.13	0.25	1.81	0.394	1.55	0.246	1.21	0.617	1.47	0.126
nickel	ug/L	25	3.25	1.73	4.45	1.07	1.32	3.53	1.50	1.76	1.58	1.92
strontium	mg/L	--	0.013	0.012	0.098	0.040	0.040	0.087	0.075	0.078	0.035	0.043
titanium	ug/L	--	6.94	4.44	4.55	2.3	3.43	4	2.52	1.98	6.08	5.9
vanadium	ug/L	7	1.3	0.667	1.03	0.882	0.992	0.975	0.934	0.631	1.73	1.03
zinc	ug/L	20	5.97	4.72	3.08	3.45	6.69	28.4	2.55	2.53	5.07	4.25

*PWQO = Provincial Water quality Objective
*-- = No PWQO
****0.43*** = PWQO exceedences

*BOD = biological oxygen demand
*TKN = total kjeldahl nitrogen
*TSS = total suspended solids

Field Conditions
*July 31 - Scattered showers, 21 °C air temperature
*August 31 and September 1 - No data

Table B-6: Cross Lake Water Quality Data

Parameter	Units	PWQO	Station #20			Station #21		
			26-Jul	29-Aug	Average	26-Jul	29-Aug	Average
GENERAL								
Alkalinity	mg/L	*	30	32	31	34	33	33
Chlorophyll-*a*	mg/L	*	0.004	0.048	0.026	0.005	0.053	0.029
Conductivity	umhos/cm	*	83.8	87.0	85.4	81.4	94.0	87.7
DO	mg/L	*	5.3	8.2	6.7	1.8	8.9	5.3
DOC	mg/L	*	8.3	10.4	9.4	9.7	11.2	10.5
pH	none	6.5-8.5	7.7	***8.7***	8.2	8.0	***8.7***	8.3
Secchi Disk (m)	meters	*	2.0	0.7	1.4	6.9	0.8	3.8
Temperature	celcius	*	20.3	20.1	20.2	21.5	19.8	20.7
NUTRIENTS								
Ammonia	mg/L	*	<0.02	<0.02	<0.02	0.04	<0.02	0.03
Ammonia (un-ionized)	mg/L	0.02	trace	trace	trace	0.0016	trace	0.0012
Nitrate	mg/L	*	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Nitrite	mg/L	*	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
TKN	mg/L	*	0.64	1.43	1.04	0.94	1.32	1.13
TKN Organic	mg/L	*	0.64	1.43	1.04	0.90	1.32	1.09
T. Phosphorus	mg/L	0.02	***0.030***	***0.032***	***0.031***	***0.034***	***0.040***	***0.037***
IONS								
Calcium	mg/L	*	8.83	8.57	8.70	7.05	9.42	8.24
Chloride	TCU	*	4.84	5.00	4.92	5.50	6.00	5.75
Magnesium	mg/L	*	3.44	3.29	3.37	3.53	3.63	3.58
Potassium	mg/L	*	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Sodium	mg/L	*	3.30	3.00	3.15	3.1	3.3	3.2
Sulfate	mg/L	*	2.3	3.0	2.6	2.0	3.0	2.5
METALS								
Iron	mg/L	0.3	0.2	0.3	0.3	0.2	0.3	0.3
Manganese	mg/L	*	0.02	0.02	0.02	0.02	0.02	0.02

- PWQO = Provincial Water Quality Objective
- * = no PWQO
- $\boxed{\#}$ PWQO exceedences
- -- = no data
- DO = dissolved oxygen
- DOC = dissolved organic carbon
- July 26 weather: 24°C, overcast, 11km/hr SSE winds, small waves
- August 29 weather: 21°C, isolated thunderstorms, 15 km/hr SSW winds, turbulent conditions

APPENDIX C

Chretien Drain and MacPherson Creek Water Quality Tables

C-1: Waypoint descriptions and field notes

C-2: Watercourse cross sections

C-3: Electrofishing results

Cretian Drain Field Notes

Water quality parameters:

phosphates, hardness, alkalinity, pH, turbidity, total suspended solids, nitrate, nitrite, ammonia, total Kelijdal nitrogen, dissolved organic carbon, biological oxygen demand.

Sampling procedure:

Five water samples and one air sample was collected at each site using a 1.5m long sampling pole at 3/4 of the depth of the stream. All parameters except for phosphates were taken from four 1/2L P.E.T. bottles. Phosphates were taken in a 250mL brown glass bottle. The air sample was also taken in a 250mL glass bottle. All water sample bottles were rinsed three times, no preservatives were used. The air sample was previously filled with deionized water and sterilized by the lab. The air sample was left open during the start of the sampling procedure and capped after all samples had been collected.
The phosphate and air samples were numbered in multiples of five with "a" being phosphates and "b" being the air sample. Samples were delivered the same day to Near North labs for analysis.

June 12/00
-weather- overcast, heavy rain event on weekend. Sunny with constant wind by mid-afternoon.

Site AA11, Way point 001,10:22am
17 T 0558964
UTM 5133348
-Samples were collected and numbered 1-4, 5a and 5b
-Site was marked with flagging tape.
-Two road drains entered the stream from the north and south and there was a small tile outflow on the north bank.

Site AA22, Way point 002,10:43am
17 T 0558877
UTM 5133320
-small tile outflow into flowing drain.
-steady flow
-approximately 6" above the surface of the water in the drain. The drain is located on the north bank.
-no Samples were taken

Way point 003
17 T 0558663
UTM 5133304
-The drain is bridged by a culvert

Site AA33, Way point 004,10:58am
17 T 0558579
UTM 5133317
-two small tile outflows entering the drain, one on the north bank and one on the south bank.
-the drain on the north slope has a steady flow.
-another ditch enters the drain from the south side.-the ditch was flagged.

Site AA44,Way point 005,11:14am
17 T 0558481
UTM 5133351
-broken beaver dam
-the shape of the dam produces a small meander, possibly assisting in T.S.S. fall out.
-site flagged
-MNR mark 3+425 six paces south.

Site AA55,Way point 006,11:27am
17 T 0558405
UTM 5133389
-start of stream meander
-small 1 foot wide tributary input with a steady flow is present.
-a cloud of suspended solids was entering the stream via the clay bottomed tributary.

Site AA66,Way point 007,11:34am
17 T 0558397
UTM 5133423
-end of meander
-a small tributary is located on the west facing slope, steady flow.
-the main drain now headed south.

Way point 008, 11:44am
17 T 0558358
UTM 5133434
-meander

Way point 009, 11:49am
17 T 0558343
UTM 5133442
-meander

Way point 010,12:00pm
17 T 0558299
UTM 5133436
-bridge with culvert crosses drain
-culvert is damaged on top

Way point 011, 12:05pm
17 T 0558254
UTM 5133437
-meander

Way point 011-012
-Moose tracks spotted
-ground much more moist
-many birds spotted and heard
-drain becoming wider, roughly 2m

Way point 012, 12:10pm
17 T 0558149
UTM 5133458
-major meander
-another large tributary flowing from the north with a high sediment load meets the drain.
-drain headed west
-site roughly 20 paces from MNR mark W+000
-drain about to enter a large wetland area, roughly 40m wide

Site AA77,Way point 013, 12:15pm
17 T 0558008
UTM 5133396
-Ground continues to become more wet.

Site AA88,Way point 014, 12:20pm
17 T 0558118
UTM 5133450
-ground too wet, backtracked to MNR site W+000
-samples were taken-numbered6,7,8,9,10a,10b

Way point 015, 12:30pm
17 T 0558344
UTM 5133388
-MNR benchmark

Site AA99,Way point 016, 12:45pm
17 T 0558554
UTM 5133328
-sample site, 11,12,13,14,15a,15b
-swift moving current
-approxamitly 15 paces from way point 004
-site coincides with MNR site M+500

Way point 017, 1:00pm
17 T 0558950
UTM 5133340
-small tile outflow enters from south bank.

Way point 018, 1:37pm
17 T 0557556
UTM 5133082
-samples taken, 16,17,18,19,20a,20b
-bridge crossing
-tributary was slow moving, approxamitly 2.5m across and was the deepest sampling site of the day.

Way point 019, 2:10pm
17 T 0558414
UTM 5134451
-reference along bridge in road bordering Kirkpatrick and MacPherson Twp.

Date	Waypoint	Location	Sampling	Comments
Weather: sunny, with slight overcast. Slight breeze. No rain for several days producing low water level.				
June 13/00	022	N46°21.240 W80°13.853 **(Note** all lat. and long. Coordinates can be converted to UTM by using a GPS.)**	AA11 took four 500ml pet bottle water samples for pH, BOD, TSS, etc. and numbered them 36,37,38,39 Took one 250ml water sample for phosphates and numbered it 40a. Took one 250ml travelling blank air sample for the duration of the sample period and numbered it 40b.	Bridge crossing with culvert
June 13/00	023	N46°21.271 W80°13.853	none	Dried up tributary into the drain, active after a rain event.
June 13/00	024	N46°21.296 W80°13.866	none	None--reference
June 13/00	025	N46°21.300 W80°13.859	none	Removed beaver dam, heavily vegetated on either bank.
June 13/00	026	N46°21.332 W80°13.834	none	Meander to the northeast.
June 13/00	027	N46°21.341 W80°13.812	AA12 took four 500ml pet bottle water samples for pH, BOD, TSS, etc. and numbered them 31,32,33,34 Took one 250ml water sample for phosphates and numbered it 35a. Took one 250ml travelling blank air sample for the duration of the sample period and numbered it 35b.	Removed beaver dam, approximately 5m pool upstream. A bear cub was identified here. Evidence of reconstruction on dam by beavers. Stream has heavy sediment load.
June 13/00	028	N46°21.347 W80°13.798	none	Fork in drain. Evidence of maintenance on the field side of the drain. Maintenance consisted of natural vegetation on one side and cleared vegetation on the other.
June 13/00	029	N46°21.388 W80°13.636	none	Branch of drain ends. A small tile outfall drains into this tributary.
June 13/00	030	N46°21.361 W80°13.614	none	Opposite tributary from 030. Meander in drain. Water was a red and orange colour.
June 13/00	031	N46°21.359 W80°13.383	none	Dry tributary into the Chretien drain. Meander in drain.
June 13/00	032	N46°21.361 W80°13.315	none	Heavy macrophyte growth in drain. Vegetation consists primarily of tall grasses.
June 13/00	033	N46°21.372 W80°13.228	none	Branching tributary of the drain surrounded by both non-cultivated fields and natural vegetation.
June 13/00	034	N46°21.373	none	Bridge with culvert

		W80°13.197		
June 13/00	035	N46°21.385 W80°13.114	none	Active beaver dam with a large pool upstream (approx. 6m).
June 13/00	036	N46°21.393 W80°13.087	AA11 took four 500ml pet bottle water samples for pH, BOD, TSS, etc. and numbered them 26,27,28,29 Took one 250ml water sample for phosphates and numbered it 30a. Took one 250ml travelling blank air sample for the duration of the sample period and numbered it 30b.	Reference point
June 13/00	037	N46°21.392 W80°12.969	none	Active tributary draining both natural vegetation and hayfields.
June 13/00	038	N46°21.394 W80°12.927	AA10 took four 500ml pet bottle water samples for pH, BOD, TSS, etc. and numbered them 21,22,23,24. Took one 250ml water sample for phosphates and numbered it 25a. Took one 250ml travelling blank air sample for the duration of the sample period and numbered it 25b.	
Weather: cool and overcast with some periods of sun. High water level as a result of an intense rain on June 14/00.				
June 15/00	042	N46°21.283 W80°14.640	AA14 took four 500ml pet bottle water samples for pH, BOD, TSS, etc. and numbered them 41,42,43,44 Took one 250ml water sample for phosphates and numbered it 45a. Took one 250ml travelling blank air sample for the duration of the sample period and numbered it 45b.	Tributary in unit H had evidence of cleared beaver dam.
June 15/00	043	N46°21.274 W80°14.889	AA15 took four 500ml pet bottle water samples for pH, BOD, TSS, etc. and numbered them 46,47,48,49 Took one 250ml water sample for phosphates and numbered it 50a. Took one 250ml travelling blank air sample for the duration of the sample period and numbered it 50b.	Large open pond approximately 15m across surrounded by natural vegetation.
Weather: sunny and warm with some cloud cover. Rain the night before, producing high water levels.				
June 17/00	044	N46°20.884	AA16 took four 500ml pet	Grassy open wetland.

		W80°15.557	bottle water samples for pH, BOD, TSS, etc. and numbered them 51,52,53,54 Took one 250ml water sample for phosphates and numbered it 55a. Took one 250ml travelling blank air sample for the duration of the sample period and numbered it 55b.	
June 17/00	045	N46°20.847 W80°15.542	AA17 took four 500ml pet bottle water samples for pH, BOD, TSS, etc. and numbered them 56,57,58,59 Took one 250ml water sample for phosphates and numbered it 60a. Took one 250ml travelling blank air sample for the duration of the sample period and numbered it 60b.	
June 17/00	046	N46°20.751 W80°15.757	AA18 took four 500ml pet bottle water samples for pH, BOD, TSS, etc. and numbered them 61,62,63,64 Took one 250ml water sample for phosphates and numbered it 65a. Took one 250ml travelling blank air sample for the duration of the sample period and numbered it 65b.	
June 17/00	047	N46°20.636 W80°15.947	None	Beaver dam.
June 17/00	048	N46°20.503 W80°15.987	None	Bedrock channel.
June 17/00	049	N46°20.422 W80°16.110	None	Beaver dam and debris. Water dark brown in colour.
June 17/00	050	N46°20.375 W80°16.174	AA19 took four 500ml pet bottle water samples for pH, BOD, TSS, etc. and numbered them 66,67,68,69 Took one 250ml water sample for phosphates and numbered it 70a. Took one 250ml travelling blank air sample for the duration of the sample period and numbered it 70b.	Damaged beaver dam. Water is dark brown in colour.
June 17/00	051	N46°20.343 W80°16.111	AA20 took four 500ml pet bottle water samples for pH, BOD, TSS, etc. and numbered them 71,72,73,74 Took one 250ml water sample for phosphates and	Mixing of tributaries.

			numbered it 75a. Took one 250ml travelling blank air sample for the duration of the sample period and numbered it 75b.	
June 17/00	052	N46°22.696 W80°15.157	AA21 took four 500ml pet bottle water samples for pH, BOD, TSS, etc. and numbered them 76,77,78,79. Took one 250ml water sample for phosphates and numbered it 80a. Took one 250ml travelling blank air sample for the duration of the sample period and numbered it 80b.	

APPENDIX D

Agency Comments and Recommendations

D-1: Ministry of Agriculture, Food and Rural Affairs

D-2: Ministry of Natural Resources

D-3: Ministry of the Environment

Ministry of Agriculture, Food and Rural Affairs
3rd Floor
1 Stone Road West
Guelph, Ontario N1G 4Y2
Tel: (519) 826-3843
Fax: (519) 826-3259

Ministère de l'Agriculture, de l'Alimentation et des Affaires rurales
3e étage
1, rue Stone ouest
Guelph (Ontario) N1G 4Y2
Tél.: (519) 826-3843
Téléc.: (519) 826-3259

Ontario

Resources Management Branch
Environmental Management Unit

Date: January 8, 2001

To: Claude Peloquin
OMAFRA, Verner Regional Office

From: Julie Cayley
Rural Water Quality Program Coordinator

Subject: Request for comment on MacPherson Creek/Chretian Drain water quality survey

---

Claude,

I have reviewed the information you faxed to me January 3, 2001 regarding the water quality study of the agriculture drain in question including the copies of the Cretian Drain (spelled differently in the letters and on the data sheets, assuming same drain) water quality data. There is too much basic information missing to draw any conclusions as to basic stream health and potential impacts.

The water quality data presented is a good start to establishing a baseline to work from. I notice significant anomalies in the data. For example, the range in total phosphorus data from station AA 12, AA10 then AA13 is a significant anomaly. It indicates that there may have been questionable quality control in the field (ie. Bottles mislabeled) or that the sample may not have been from the stream center where flow is integrated but from within a tile drain or point source septic outlet. None of these questions can be answered without more information about the site at point of sample. Conclusions can also not be drawn on one time grab samples, duplicate samples and sampling over time would be necessary to note trends in quality. There is limited and/or no information on sample collection methodology, field and weather conditions, flow conditions, and surrounding land use. With so many variables and so much information missing it is not possible to have confidence in or draw conclusions from the water quality data presented.

There are several questions/issues I see as needing to be answered and included in future sample collection and water quality monitoring programs:

- Where are the tile drain outlets?
- What is the surrounding land use?

- What is the flow regime? Flow stations should be set up in order to calculate nutrient load to the receiving water body (ultimately more significant than individual concentrations)
- Are there beaver damns or other obstructions that may influence flow and quality? Where are they?
- What were the weather conditions prior to and day of sampling? Was this a storm event?
- What were the conditions of the drain at each sample point? Had the drain already been cleaned out in some areas at the time the samples were taken?
- Sample dates vary. Without flow data or information on weather or not the data was collected during baseflow, low flow, high flow after storm event it is impossible to make direct comparisons between sites where data was not collected on the same day under the same conditions.

By initiating this project the Wilderness Preservation Committee of Ontario has made a good start to establishing baseline data. The Provincial Water Quality objective for surface water quality for total phosphorus (baseflow) is 0.03 mg/l (refer to the "Water Management, Policies, Guidelines and Provincial Water Quality Objectives" available at (http://www.ene.gov.on.ca/envision/gp/index.htm#PartWater). I would suggest working with all the landowners/stakeholders within the drain watershed to set a target for water quality (may be to be at 0.03 mg/l total phosphorus at baseflow or may be to reduce phosphorus load from that drain by a certain percent). Collectively, the individuals along this drain should set objectives for use and targets for quality for the water within this drain. In doing so, they could set up an action plan to meet their targets.

Claude, you mentioned in our phone conversation that one objective is to have the entire drain "cleaned out". I would recommend that a pro-active approach be taken in implementing best management practices for maintaining drains (see BMP manual "Fish and Wildlife Habitat Management" pages 74-75). I would also recommend that you speak with Sid Vanderveen, OMAFRA Drainage Coordinator (519-826-3552).

Thank you for the opportunity to comment. If I can be of any further assistance please contact me at 519-826-3843 (julie.cayley@omafra.gov.on.ca).

Julie Cayley

Cc: S. Vanderveen

Ontario

Ministry of Natural Resources
Ministère des Richesses naturelles

3301 Trout Lake Road
North Bay On P1A 4L7

Ph: (705) 475-5550
Fx: (705) 475-5500

January 17, 2001

Peter Lee, Director
The Wilderness Preservation Committee of Ontario
49 Lebreche Drive
North Bay, ON P1A 3R3

Dear Peter:

SUBJECT: Lake Nipissing Water Quality and Fish Habitat Project 2000

I have finally reviewed the reports generated during the summer of 2000 by your summer students working on the Lake Nipissing water quality update and the fish habitat baseline study in MacPherson Creek (a.k.a. the Florent Chretien Drain).

The water quality study has provided us with high quality updated information on many water quality parameters. I am now in the process of relating these data to fish population dynamics. Last year was also a good start in collecting baseline biological data in the Florent-Chretien Drain system to monitor this system long term.

It is my hope that we can complete this baseline study during the 2001 field season. Specifically, we need to complete a fish species inventory on the system, as well as conduct aquatic invertebrate and vegetation surveys. In addition to work in the drain system, there are many inlets into Lake Nipissing which we know very little about with respect to water quality, fish habitat and fish species. Moreover, there are numerous other projects that would also be desirable to complete with appropriate human resources and funds. Some ideas include a post-tournament mortality study on northern pike following the Cache Bay pike derby; a lake sturgeon education project, with a live display in Sturgeon Falls as the final product. More benthic basket work in the many Inlets of Lake Nipissing would also help us achieve a true 'big picture' in our quest to monitor the Lake Nipissing ecosystem.

Please let me know your thoughts on continuing our fruitful summer student projects on Lake Nipissing for 2001. I would be interested in hearing your ideas in developing some of the above-mentioned projects further.

I look forward to hearing from you in the near future.

Yours truly,

Richard Rowe
Management Biologist
Tomiko/Wasi Area
North Bay District
705-475-5540

RR/

Subject: Lake Nippissing Water Quality Survey
Date: Wed, 03 Jan 2001 12:56:55 -0500
From: "Peggy Gale" <Peggy.Gale@ene.gov.on.ca>
To: Peter.Lee@ene.gov.on.ca

There does not seem to be any significant differences between the 88 and 00 data. Minor variability may be a result of temporal variation in sampling. 88-90 data included a May sampling which is often higher in TP, particularly in the lake samples. The '00 sampling was in late June.
Total phosphorus (TP) should be recorded to three decimal places in mg/L.
Table 1. Station 21 is high in TP. If it is the same as in 88-90, there may be some concern here.

There are noticeable impacts around the Merrick Landfill site.

Hope this helps for polishing the final report.

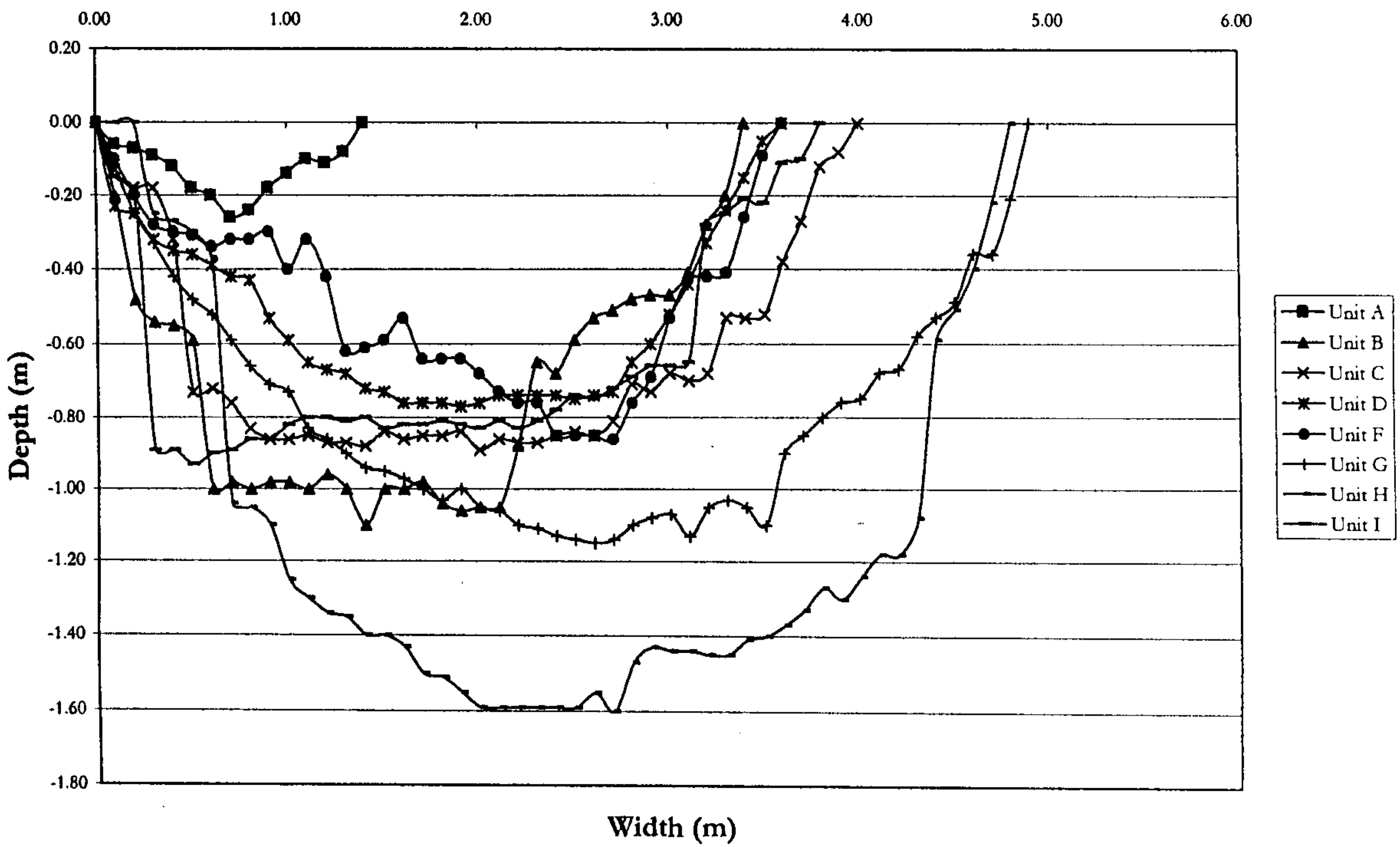
Date	Location	Crew Leader	Time	Section	Time Shocked (Sec)	Volts	Power Setting	Section Length (m)
08/04/00	McPherson Creek headwaters	Richard Rowe	11:00	1	418	600	I-2	25
08/04/00	McPherson Creek headwaters	Richard Rowe	11:00	1	418	600	I-2	25
08/04/00	McPherson Creek headwaters	Jan Latour	11:51	2	514	500	I-3	25
08/04/00	McPherson Creek headwaters	Jan Latour	11:51	2	514	500	I-3	25
08/04/00	McPherson Creek headwaters	Jan Latour	11:51	2	514	500	I-3	25
08/04/00	Flourent/Chrechen Drain	Derek Smith	14:14	1	769	600	I-2	25
08/04/00	Flourent/Chrechen Drain	Derek Smith	14:14	1	769	600	I-2	25
08/04/00	Flourent/Chrechen Drain	Derek Smith	14:14	1	769	600	I-2	25
08/04/00	Flourent/Chrechen Drain	Derek Smith	14:14	1	769	600	I-2	25
08/04/00	Flourent/Chrechen Drain	Derek Smith	14:14	1	769	600	I-2	25
08/04/00	Flourent/Chrechen Drain	Derek Smith	14:14	1	769	600	I-2	25
08/04/00	Flourent/Chrechen Drain	Kevin Esseltine	14:40	2	1876	600	I-2	25
08/04/00	Flourent/Chrechen Drain	Kevin Esseltine	14:40	2	1876	600	I-2	25
08/04/00	Flourent/Chrechen Drain	Kevin Esseltine	14:40	2	1876	600	I-2	25
08/04/00	Flourent/Chrechen Drain	Kevin Esseltine	14:40	2	1876	600	I-2	25
08/04/00	Flourent/Chrechen Drain	Kevin Esseltine	14:40	2	1876	600	I-2	25
08/04/00	Flourent/Chrechen Drain	Kevin Esseltine	14:40	2	1876	600	I-2	25
08/04/00	Flourent/Chrechen Drain	Kevin Esseltine	14:40	2	1876	600	I-2	25
08/04/00	Flourent/Chrechen Drain	Kevin Esseltine	14:40	2	1876	600	I-2	25
08/04/00	Flourent/Chrechen Drain	Dave McPherson	N/A	3	638	600	I-2	25
08/04/00	Flourent/Chrechen Drain	Dave McPherson	N/A	3	638	600	I-2	25
08/04/00	Flourent/Chrechen Drain	Dave McPherson	N/A	3	638	600	I-2	25
08/04/00	Flourent/Chrechen Drain	Dave McPherson	N/A	3	638	600	I-2	25
08/04/00	Flourent/Chrechen Drain	Dave McPherson	N/A	3	638	600	I-2	25
08/04/00	Flourent/Chrechen Drain	Dave McPherson	N/A	3	638	600	I-2	25
08/04/00	Flourent/Chrechen Drain	Dave McPherson	N/A	3	638	600	I-2	25

Common Name	Species Code	Total Number	Total Weight(g)	# of Minnows	Calculated Weight(g)
central mudminnow	141	56	121.45	27	4.50
brook stickleback	281	15	11.18	15	0.75
central mudminnow	141	24			
Brook Stickleback	281	11			
spottail shiner	201	1			
creek chub	212	20			
central mudminnow	141	23			
brook stickleback	281	3			
pearl dace	214	9			
common shiner	198	7			
while sucker	163	1			
creek chub	212	40			
central mudminnow	141	33			
brook stickleback	281	2			
pearl dace	214	20			
white sucker	163	2			
hornyhead chub	192	1			
northern redbelly dace	182	1			
rainbow darter	337	2			
creek chub	212	3			
brook stickleback	281	5			
central mudminnow	141	24			
white sucker	163	2			
pearl dace	214	5			
rainbow darter	337	2			
northern redbelly dace	182	1			

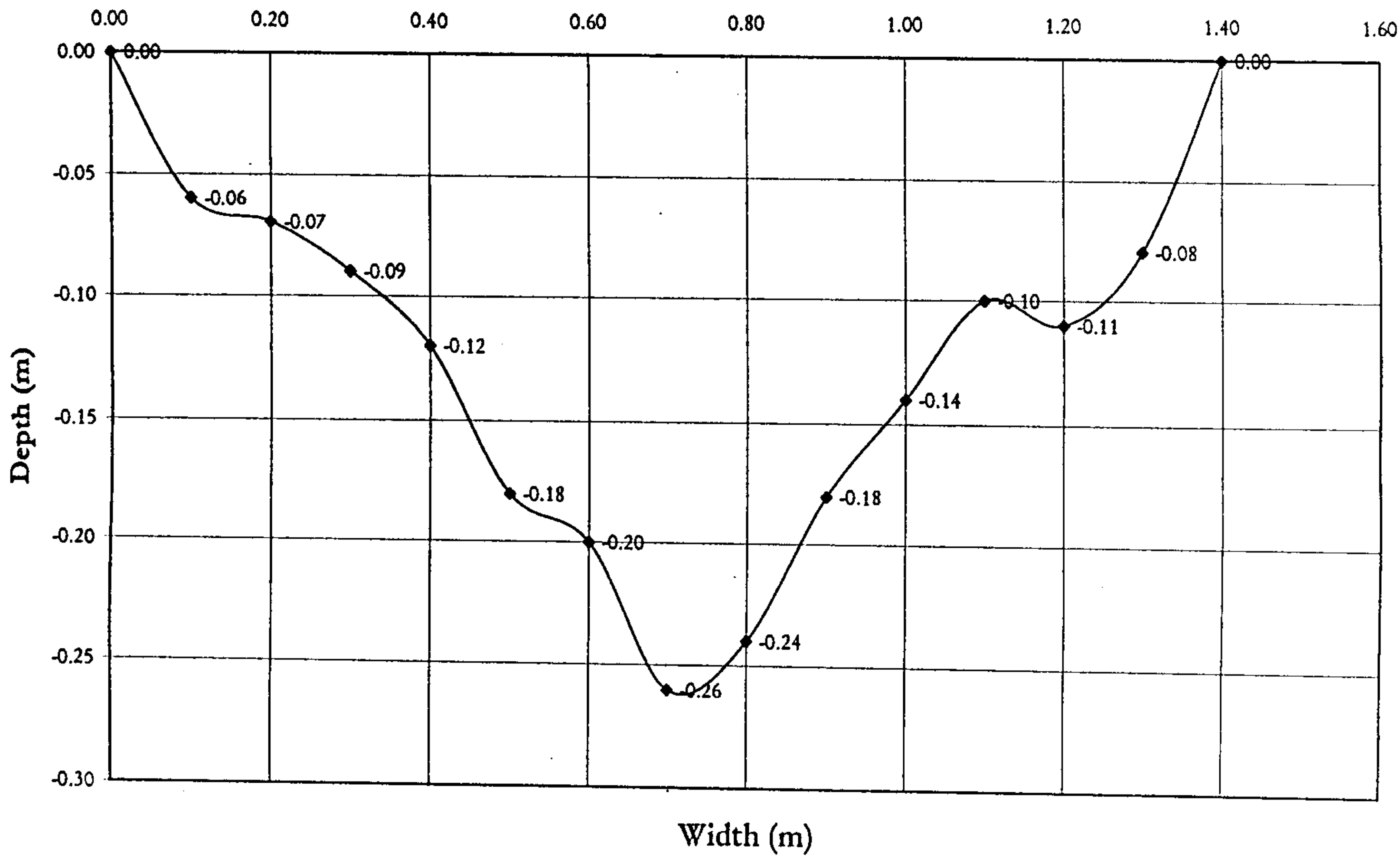
Date	Location	Section	Time	Time Shocked (Sec)	Volts	Power Setting	Length of Section
04/08/2000	McPherson Creek headwaters	1	11:00	418	600	I-2	25
04/08/2000	McPherson Creek headwaters	1	11:00	418	600	I-2	25
04/08/2000	McPherson Creek headwaters	1	11:00	418	600	I-2	25
04/08/2000	McPherson Creek headwaters	1	11:00	418	600	I-2	25
04/08/2000	McPherson Creek headwaters	1	11:00	418	600	I-2	25
04/08/2000	McPherson Creek headwaters	1	11:00	418	600	I-2	25
04/08/2000	McPherson Creek headwaters	1	11:00	418	600	I-2	25
04/08/2000	McPherson Creek headwaters	1	11:00	418	600	I-2	25
04/08/2000	McPherson Creek headwaters	1	11:00	418	600	I-2	25
04/08/2000	McPherson Creek headwaters	1	11:00	418	600	I-2	25
04/08/2000	McPherson Creek headwaters	1	11:00	418	600	I-2	25
04/08/2000	McPherson Creek headwaters	1	11:00	418	600	I-2	25
04/08/2000	McPherson Creek headwaters	1	11:00	418	600	I-2	25
04/08/2000	McPherson Creek headwaters	1	11:00	418	600	I-2	25
04/08/2000	McPherson Creek headwaters	1	11:00	418	600	I-2	25
04/08/2000	McPherson Creek headwaters	1	11:00	418	600	I-2	25
04/08/2000	McPherson Creek headwaters	1	11:00	418	600	I-2	25
04/08/2000	McPherson Creek headwaters	1	11:00	418	600	I-2	25
04/08/2000	McPherson Creek headwaters	1	11:00	418	600	I-2	25
04/08/2000	McPherson Creek headwaters	1	11:00	418	600	I-2	25

Species	Sample #	Total Length (mm)	Weight (g)
141	1	91	9.27
141	2	67	3.31
141	3	68	3.29
281	4	44	0.74
141	5	70	3.62
281	6	52	1.23
141	7	109	14.62
281	8	32	0.24
141	9	76	4.63
281	10	43	0.57
141	11	72	4.31
141	12	42	0.8
281	13	40	0.46
141	14	91	9.22
141	15	65	2.92
281	16	37	0.4
281	17	54	1.1
281	18	43	0.79
281	19	40	0.34
281	20	51	1.14

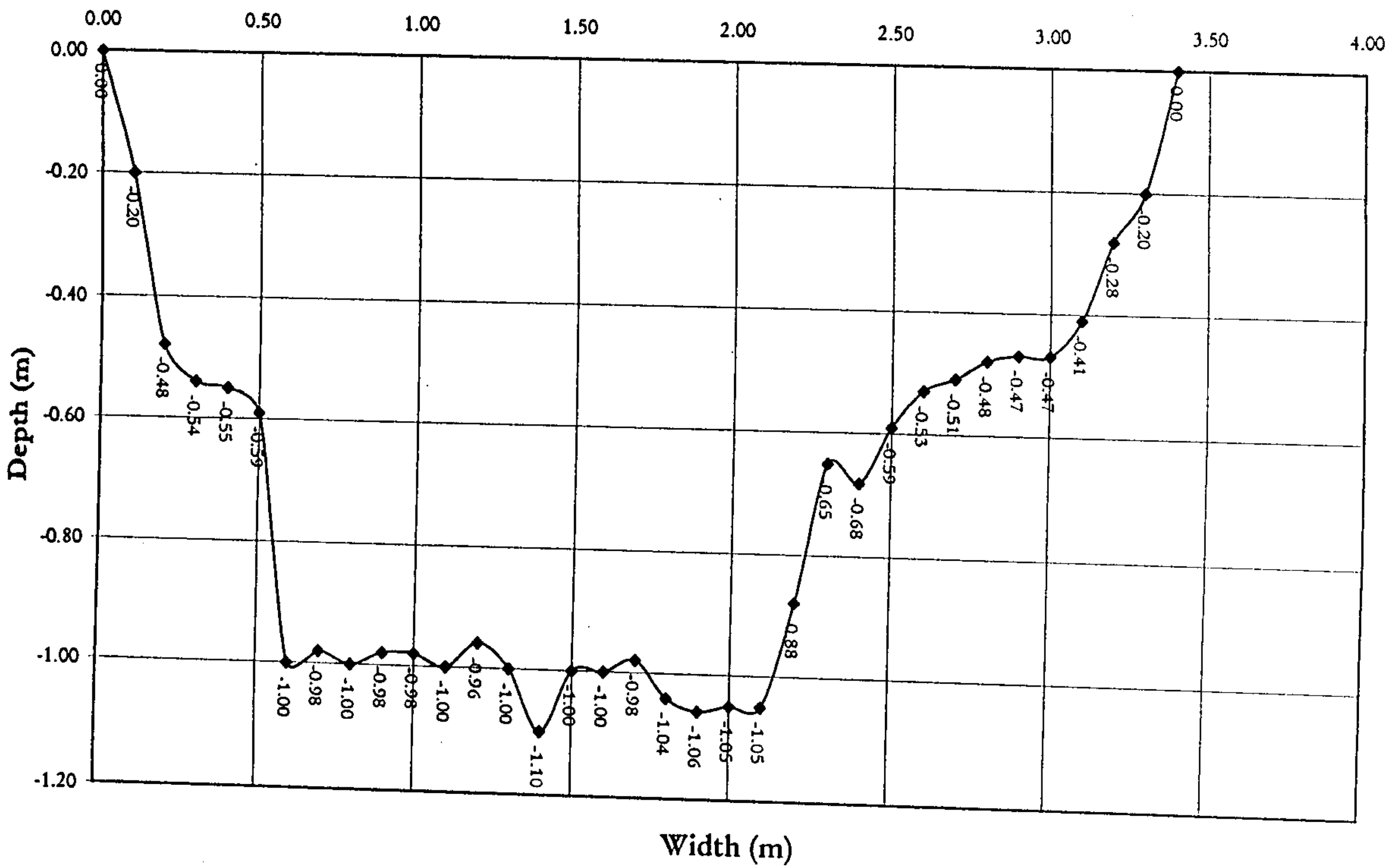
Cross Sections for Units (A) Throught (I)



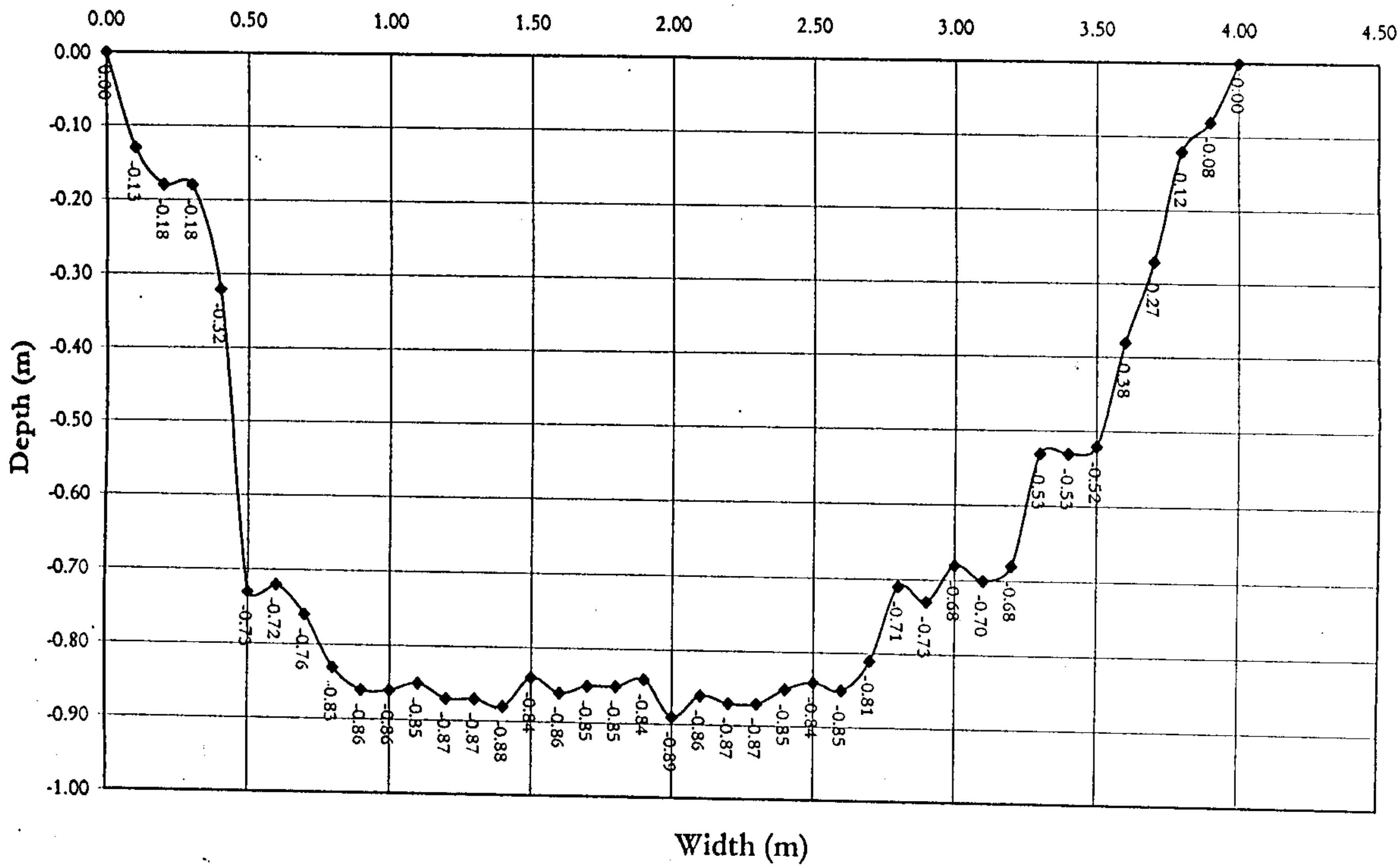
Cross Section for Unit A



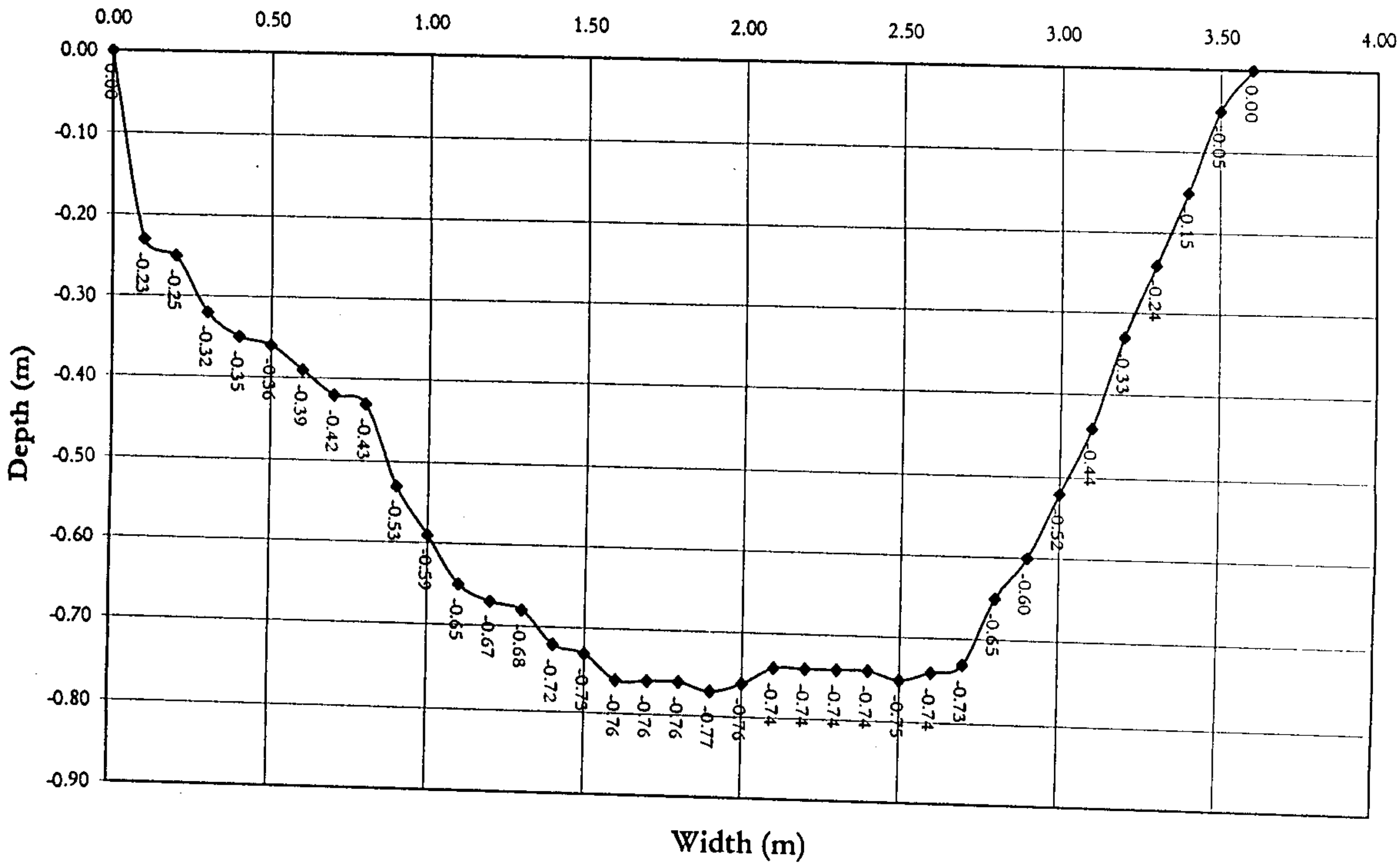
Cross Section for Unit B



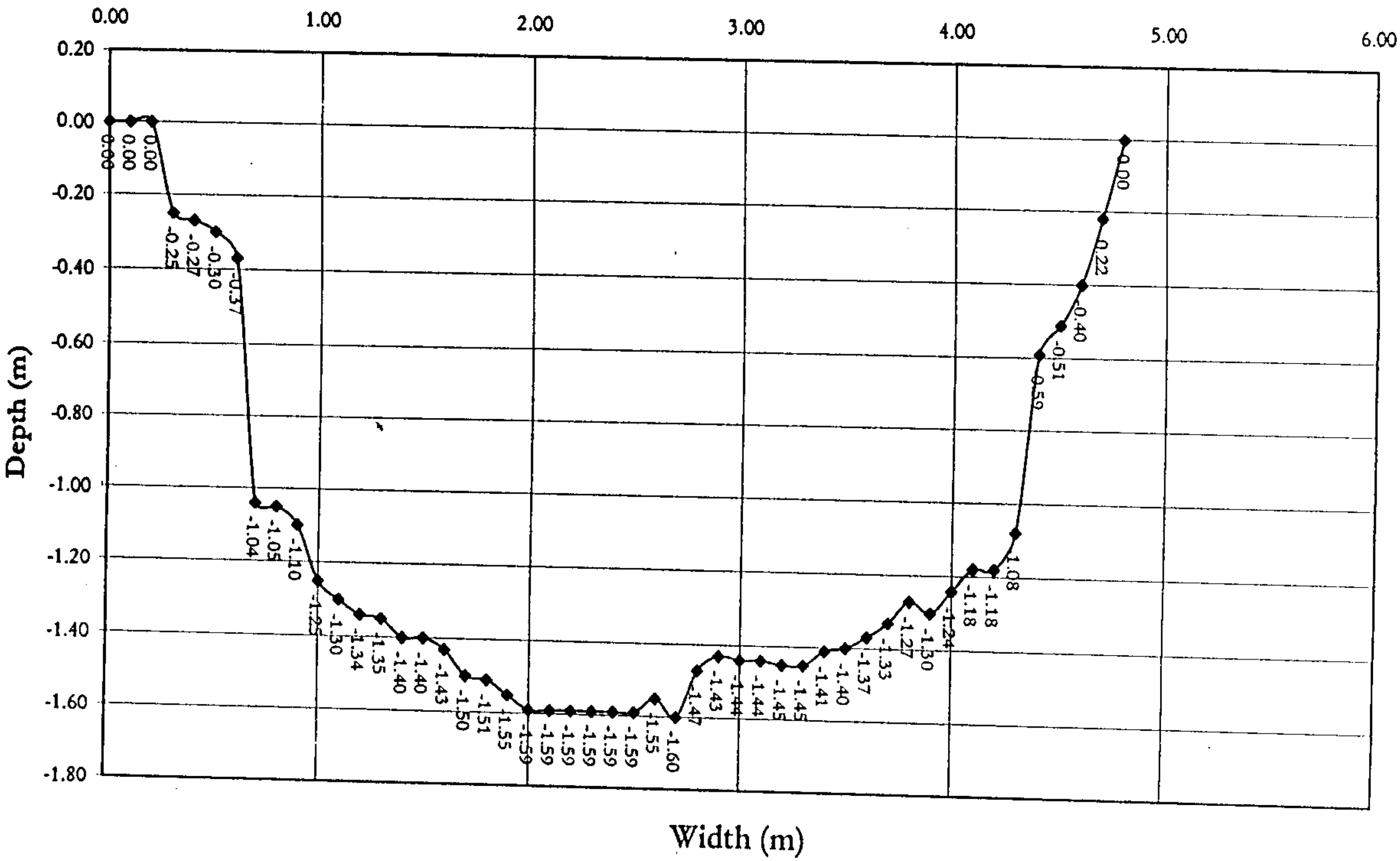
Cross Section for Unit C

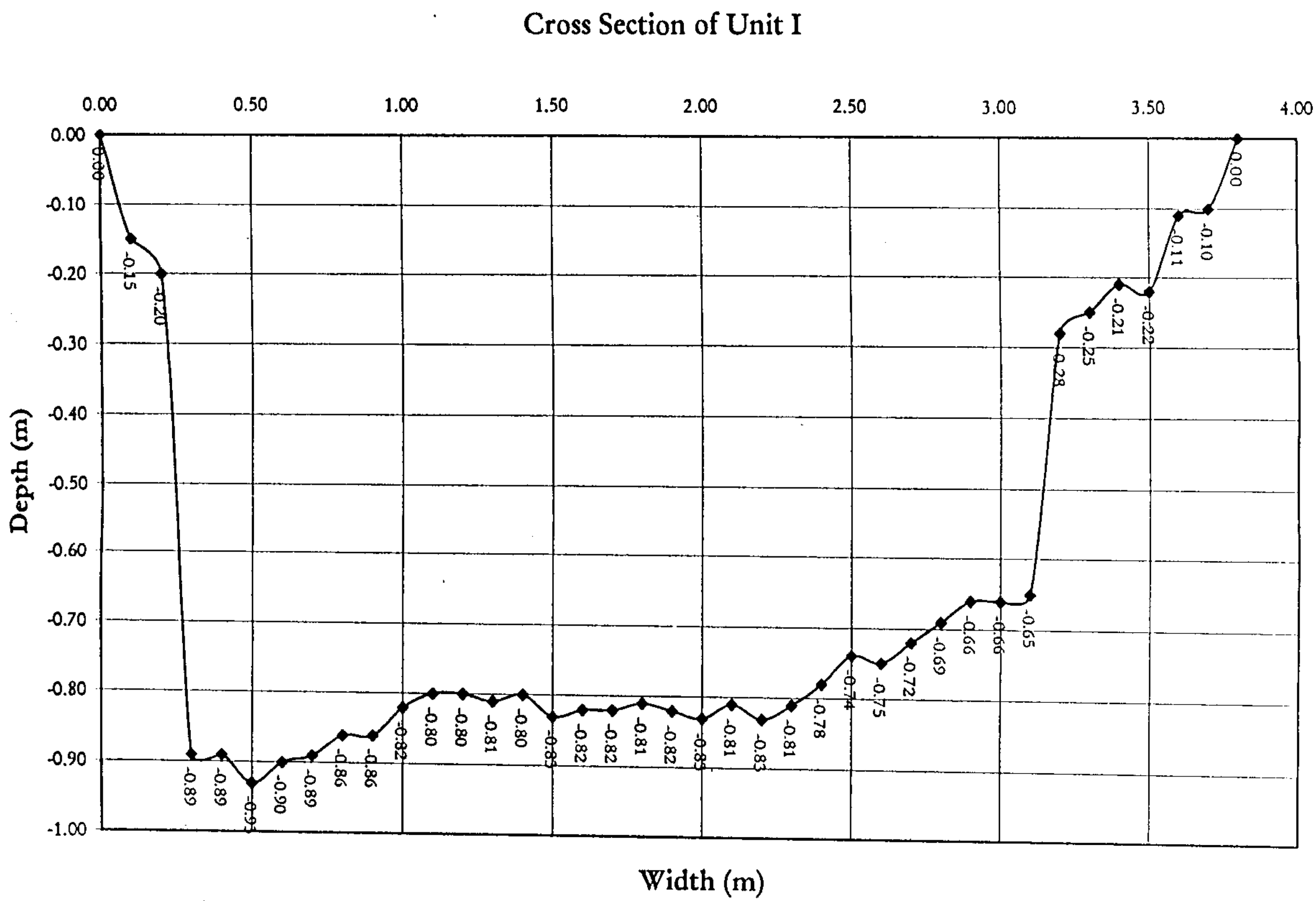


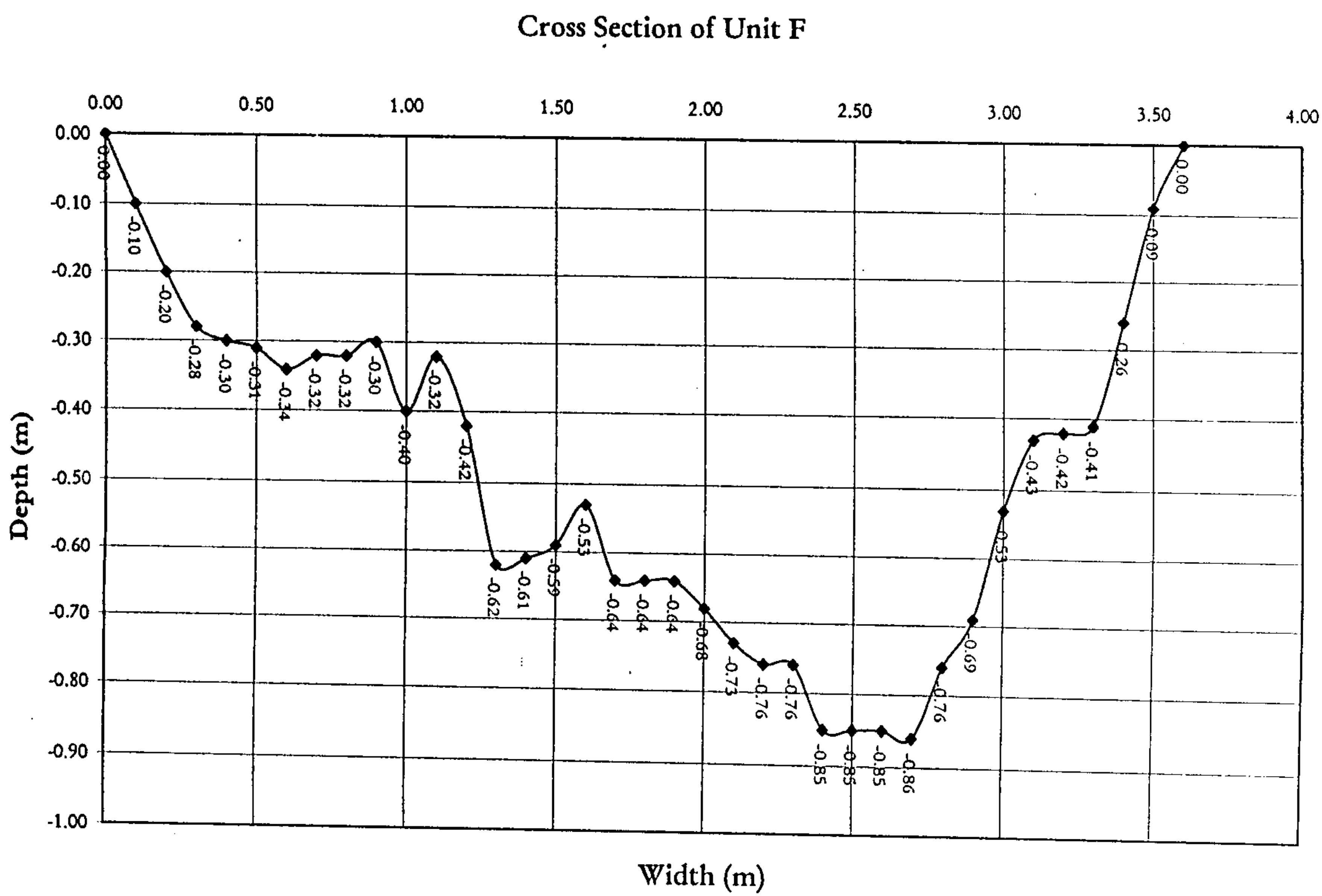
Cross Section for Unit D



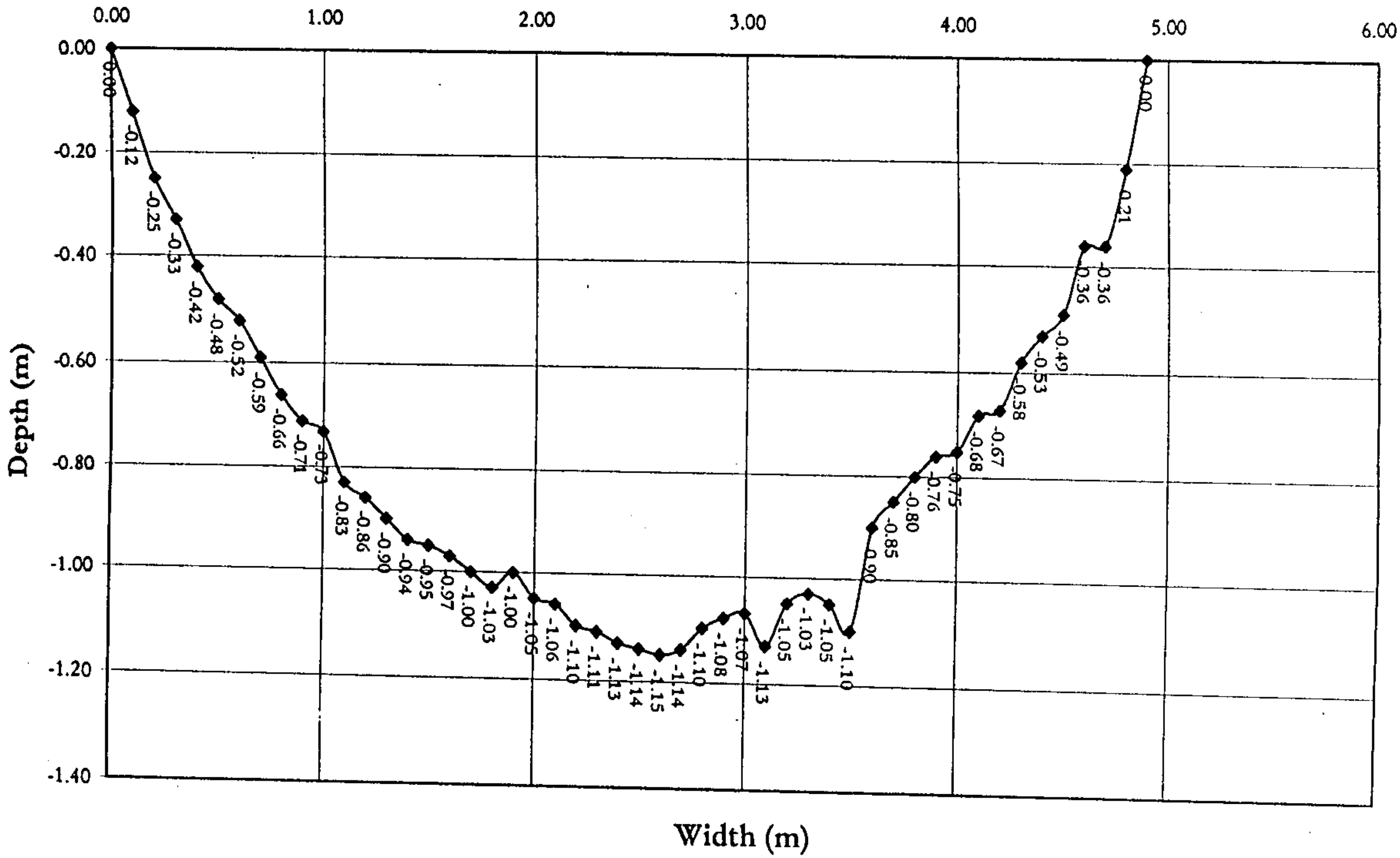
Cross Section of Unit H




Cross Section of Unit I
Depth (m)
Width (m)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00


Cross Section of Unit F
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
Depth (m)
Width (m)
0.00
-0.10
-0.20
-0.28
-0.30
-0.31
-0.34
-0.32
-0.32
-0.30
-0.40
-0.32
-0.42
-0.62
-0.61
-0.59
-0.53
-0.64
-0.64
-0.64
-0.68
-0.73
-0.76
-0.76
-0.85
-0.85
-0.85
-0.86
-0.76
-0.69
-0.53
-0.43
-0.42
-0.41
-0.26
-0.09
0.00

Cross Section of Unit G



Silver Beach, Lake Nipissing

To Encourage and Promote:

- Private and public initiatives in the protection of the wilderness areas
- Public education and awareness related to protecting air, land, water and natural habitats
- Production and distribution of educational materials
- Programs that enhance the ecosystem quality
- Research that increases knowledge in areas of ecosystem and watershed management
- Actions which facilitate the above activities

The Wilderness Preservation Committee of Ontario