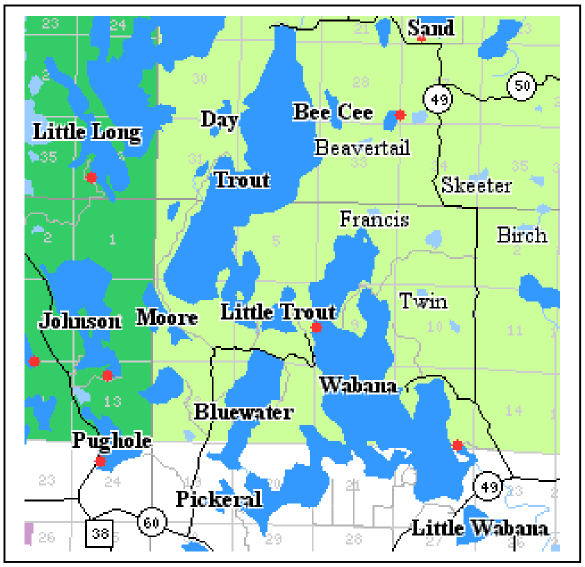
Water Quality Update and Trend Monitoring in Itasca County

(Lakes: Little Wabana, Wabana, Bluewater and Trout)

2000



Minnesota Pollution Control Agency

Environmental Outcomes Division

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MPCA Lake and Trend Monitoring for 2000
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Summary

During the summer of 2000 the Minnesota Pollution Control Agency (MPCA) monitored four lakes in Itasca County as a part of our lake and trend monitoring efforts. This monitoring effort is intended to supplement and complement data gathered through the Citizen Lake-Monitoring Program (CLMP), Lake Assessment Program (LAP), and Clean Water Partnership (CWP) Program. The intent of this lake sampling effort is to: provide baseline water quality data, provide data for potential LAP and CWP lakes, characterize lake condition in different regions of the state, examine year-to-year variability in ecoregion-reference lakes, and provide additional trophic status data for lakes exhibiting trends in Secchi transparency. In the latter case, we attempt to determine if the trends in Secchi transparency are "real," i.e., do supporting trophic status data substantiate whether a change in trophic status has occurred. This effort also provides a means to respond to citizen concerns about protecting or improving the lake in cases where no data exists to evaluate the quality of the lake. To make for efficient sampling we tend to select geographic clusters of lakes (e.g., focus on a specific county) whenever possible.

In 2000, the MPCA monitored the following four lakes in Itasca County: Little Wabana, Wabana, Bluewater, and Trout. Samples were collected monthly from May through September at most lakes. A summary of data from 2000 and available historical data follows. This summary will include data from 2000 as well as any data available in STORET, U.S. EPA's national water quality data bank (Appendix). Summer-mean epilimnetic (upper well-mixed layer) concentrations for each lake are compared to the "typical" range for ecoregion-reference lakes in the Northern Lakes and Forests Ecoregion (Figure 1 and Table 2). This provides a basis for placing data from these lakes in perspective relative to one another as well as other lakes in the same ecoregion. The Wabana Chain was sampled during the summer of 2000 by the Minnesota Pollution Control Agency (MPCA) staff and citizens from the Wabana Chain of Lakes Association (Association). The water quality parameters sampled (total phosphorus, chlorophyll a and Secchi transparency) help to characterize the trophic status of a lake. These measures indicate *mesotrophic* – conditions for the Wabana Chain.

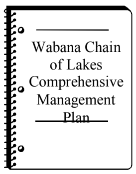
A good historical data base is available for assessing trends in the transparency of Wabana, Bluewater and Trout Lakes (Little Wabana had not previously been monitored before 2000). These data include 12 – 15 years of Secchi data but very limited water chemistry data for the three lakes. Based on an analysis of 12 – 15 years of CLMP and MPCA Secchi transparency data, the Wabana Chain exhibited no distinct trend in transparency over time. A fair amount of year-to-year variability (± 1 – 2 ft) is evidenced in the data; although this amount of variation is typical for Minnesota lakes.

Two lake water quality models were used to estimate the water quality of the Wabana Chain based on morphometry and watershed characteristics. These models provide a means to compare the measured water quality of the lake relative to the predicted water quality. The first model, MINLEAP, predicted a summer-mean phosphorus (P) concentration of 11 µg/L; which is slightly lower, than the observed summer-mean of 14.7 µg/L for Little Wabana Lake. This model also estimated a phosphorus loading of ~ 15 kg P/year and a water residence time of about 17.6 years. A regression model within MINLEAP, Vighi and Chiaudani (1985), predicted a background P concentration of 15.3 µg/L for Little Wabana, which is comparable to the 2000 summer-mean P of 14.7 µg/L. For modeling purposes, the lakes in the Wabana Chain of Lakes (WCOL) were treated as a large, single lake. MINLEAP predicted a summer-mean P concentration of 11 ± 4 µg/L, which is very comparable to the observed summer-mean P of 9 µg/L for the WCOL. It also estimated phosphorus loading at 901 kg P/yr, and a water residence time of 13.5 years for the WCOL.

The second model, Reckhow and Simpson, estimated in-lake water quality based on precipitation, land use data, and runoff coefficients. [Note: This does not include water and nutrient contributions from groundwater to the lakes; which can be an important part of the water and nutrient budget for some lakes.] Predicted P for Little Wabana Lake was estimated at 14 – 17 µg/L, which is not significantly different than the observed P for 2000 (14.7 µg/L). The P-loading rate from the model was estimated at 22 - 31 kg P/yr. The "estimated" relative contributions to the P-loading rate are as follows: runoff from the watershed: 42 – 45 %, precipitation on the lake: 29 – 41 %, and septic systems: 14 – 29 %. For the WCOL, Reckhow and Simpson predicted P concentrations of 12 – 13 µg/L, which is slightly higher, but not significantly different than the observed combined average for 2000 (9 µg/L). The P-loading rate from the model was estimated at 933 – 1,011 kg P/yr. The "estimated" relative contributions to the P-loading rate are as follows: runoff from the watershed: 59 – 61 %, precipitation on the lake: 34 – 37 %, and septic systems: 2 – 7 %. The contribution from septic systems was *estimated* based on the number of residences around the lake, standard per-capita loading rates, and an estimated soil retention of 70 – 90 percent. The relative contribution (loading rates) could be higher or lower, depending on the efficiency and maintenance of on-site systems and soils in the shoreland area. For example, well-maintained and up-to-code systems on good soils will retain a high percentage of P loaded to the system while poorly-maintained systems on water-logged soils will retain a low percentage of P.

The following recommendations are based on the study of Wabana Chain:

The 2000 water quality of the Wabana Chain was very good compared to other lakes in the NLF ecoregion. The lakes could exhibit declines in transparency and increases in the amount of algae with increases in in-lake total phosphorus. The Wabana Chain would be sensitive to change in trophic status with increases in the nutrient loading from watershed or in-lake sources, as is evidenced from the historical data. These sources would increase the in-lake phosphorus concentration which can degrade the lakes. It is essential, therefore, that the lake protection efforts be conveyed by all local government groups with land use/zoning authorities for Itasca County. The Association should be commended for their efforts to date, which include interacting with Itasca County, MDNR, and participating in the Citizen Lake-Monitoring Program (CLMP).



a) **The Association should develop a plan for protecting the water quality of the chain of lakes**. This plan, referred to as a *Lake Management Plan*, should incorporate a series of activities in a prioritized fashion; which will aid in the long-term protection and improvement of the lake. The plan should be developed cooperatively by a committee consisting of representatives from state agencies (e.g., the Minnesota Department of Natural Resources [MDNR], Minnesota Board Water and Soil Resources, MPCA), local units of government, and association members. Following are some activities could be included in the plan:

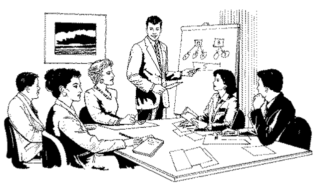
b) **The Association should continue to participate in the CLMP and related monitoring programs**. Data from this program provides an excellent basis for assessing long-term and year-to-year variations in algal productivity, i.e., trophic status of the lakes. At a minimum, measurements should be taken weekly during the summer at consistent sites on the lakes.

c) **Further development or land use change in the watershed should occur in a manner that minimizes water quality impacts on the lakes.**

- In the shoreland areas, setback provisions should be strictly followed. MDNR and County shoreland regulations will be important in this regard.
- Stormwater regulations should be adhered to during and following any major construction/development activities in the watershed.
- Limiting the amount of impervious surfaces can have beneficial affects as well, in terms of reduced runoff and P loading.
- Activities in the total watershed that change drainage patterns, such as wetland removal or major alterations in lake usage, should be discouraged unless they are carefully planned and adequately controlled. Restoring or improving wetlands in the watershed may also be beneficial for reducing the amount of nutrients or sediments which reach Wabana Chain. The U.S. Fish and Wildlife Service at Fort Snelling may be able to provide technical and financial assistance for these activities.
- The Association should continue to seek representation on boards or commissions that address land management activities so that their impact can be minimized. The booklet, Protecting Minnesota's Waters: The Land-Use Connection, may be a useful educational tool in this area.

d) **On-site septic systems are a *potential* source of nutrients to Wabana Chain**. Given the low levels of phosphorus in the chain, poorly functioning on-site systems could *potentially* be an important source of nutrient loading to Wabana Chain. The Association and Itasca County should continue to educate homeowners on proper maintenance of their systems and encourage all homeowners with non-code systems to bring their systems up to code. The Association may want to facilitate a lake-wide schedule for pumping systems.

g) **An examination of land use practices in the watershed and identification of possible nutrient sources such as lawn fertilizer, the effects of ditching and draining of wetlands, and agricultural practices etc., may aid the Association in determining areas where best management practices may be needed**. For example, recent studies indicated that a majority of lawns in the Twin Cities metro area do not need additional phosphorus – this may be true for lawns in Itasca County as well. The Association, together with Itasca County, should encourage the use of P-free fertilizers on lawns in the watershed. The Association could work with the county to consider the feasibility of developing ordinances which require the use of P-free fertilizers, as other municipalities like Minneapolis, St. Paul, Shoreview and Plymouth have done. Likewise, there may be opportunities to implement/promote Best Management Practices (BMP's) that may reduce nutrient loading from other sources in the watershed.



h) **The MPCA's Clean Water Partnership Program (CWP) is also an option for further assessing and dealing with nonpoint sources of nutrients in the watershed**. It may be in the best interest of the Association and Wabana Chain to continue to work with Itasca County, and local officials to do as much as possible to protect the condition of the lakes by means of local ordinances and education of shoreland residents since the competition for CWP funding can be very extensive. If these steps prove to be inadequate or lake conditions worsen (as evidenced by significant declines in Secchi transparency measurements), application to CWP may then be appropriate. *One indication of a declining trend in water quality would be if summer-mean transparency remained consistently below the current long-term means for each lake (Figures 29 – 31).*

INTRODUCTION

The Wabana Chain of Lakes was sampled by the Minnesota Pollution Control Agency (MPCA) during the summer of 2000 as a part of the Lake Assessment Program (LAP) and on-going trend monitoring work. This program is designed to assist lake associations or municipalities in the collection and analysis of baseline water quality data in order to assess the trophic status of their lakes. The general work plan for LAP includes Association participation in the Citizen Lake-Monitoring Program (CLMP), cooperative examination of land use and drainage patterns in the watershed of the lake, and an assessment of the data collected by MPCA staff.

This study was conducted at the request of the Association. Wabana Lake was originally studied as a LAP in 1991. The current study, which includes the other lakes in the chain, was conducted in order to assess any changes in water quality which might have occurred since that time. The Wabana Chain was sampled on five occasions during the spring and summer of 2000. Participants in this effort included Jennifer Klang, Steve Heiskary, Stephanie Johnson, and Jesse Anderson from the MPCA and David Lick, from the Association. CLMP measurements were taken by Duane Amundson, Susan Lick, and Kenneth Zimmer (Wabana Lake); Nancy Ellsworth and George Klacan (Bluewater Lake); and William Berg and Betty Unger (Trout Lake). Land-use and watershed information for the Wabana Chain was assembled by Noel Griese, Itasca County SWCD. David Lick coordinated the Association's efforts on this study. Phytoplankton analysis was conducted by Dr. Howard Markus, MPCA.

<u>BACKGROUND:</u> Watershed, Soils, and Land Use

The Wabana Chain is located in Itasca County, approximately thirteen miles north of Grand Rapids, Minnesota. Little Wabana Lake is in the upper twenty-five percent of lakes in the state in terms of size (105 acres) and has a maximum depth of 57 feet. Bluewater Lake is in the upper ten percent of lakes in the state in terms of size (370 acres) and has a maximum depth of 100 feet. Wabana and Trout Lakes are in the upper five percent of lakes in terms of their size (2,133 and 1,659 acres, respectively) and have maximum depths of 115 and 160 feet, respectively.

The Wabana Chain lakes were formed from ice-block basins (or pits) in glacial till from the Des Moines Lobe, the most recent glacial lobe (Goebel and Walton, 1979 and Zumberge, 1952). Soils near the lakes consist of the Nebish-Rockwood series soils (Arneman, 1963). This area is gently rolling to hilly area. These soils tend to be light colored and well drained. They are formed from loam (Nebish) and sandy load (Rockwood) calcareous buff-colored glacial till (Arneman, 1963).

Since land use affects water quality, it has proven helpful to divide the state into regions where land use and water resources are similar. Minnesota is divided into seven regions, referred to as ecoregions, as defined by soils, land surface form, natural vegetation and current land use. Data gathered from representative, minimally-impacted (reference) lakes within each ecoregion serve as a basis for comparing the water quality and characteristics of other lakes. The Wabana Chain is located in the *Northern Lakes and Forest ecoregion* (Figure 1).

Figure 1. Minnesota's Seven Ecoregions as Mapped by U.S. EPA

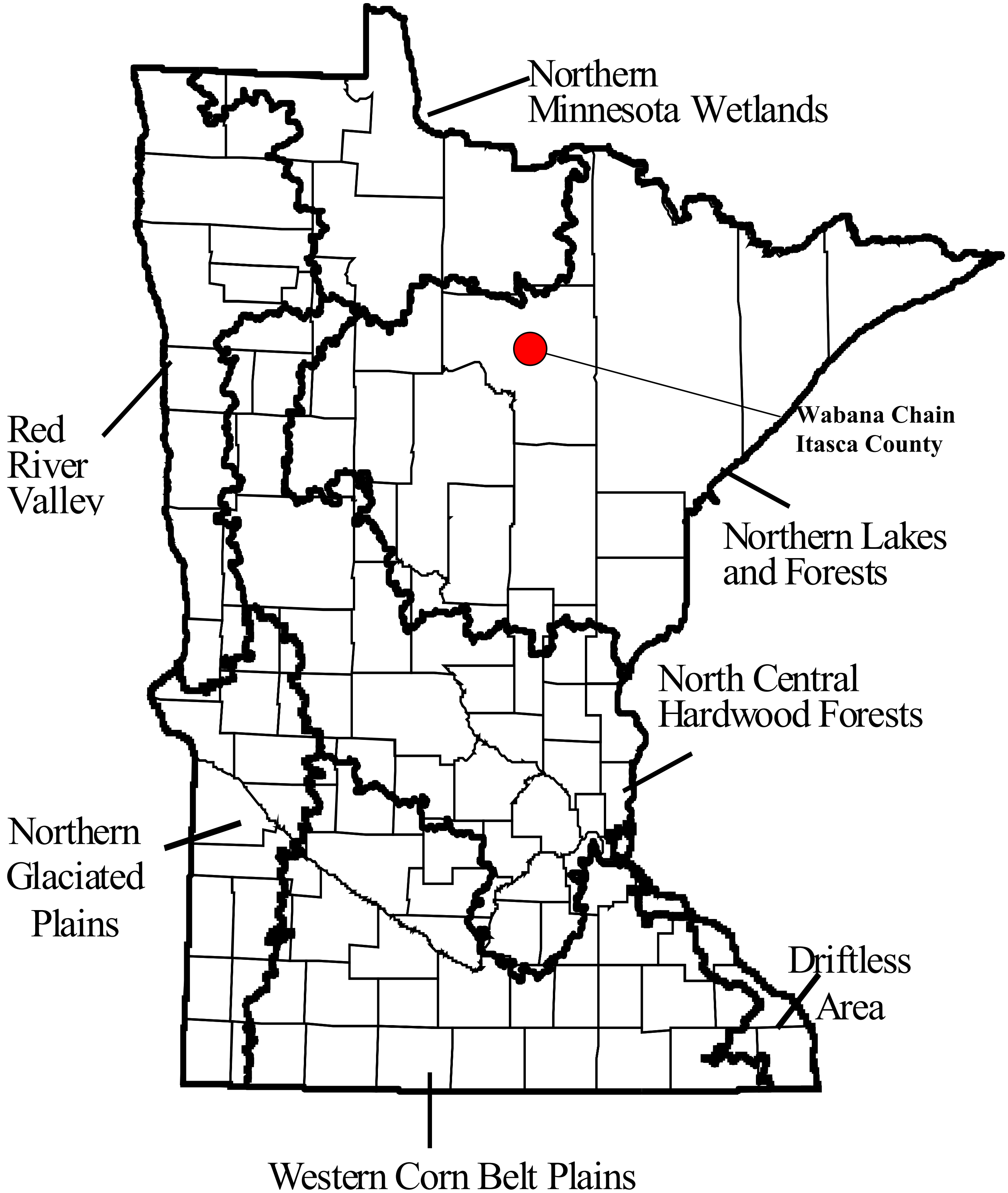


Table 1. Morphometric & Watershed Characteristics for Wabana Chain of Lakes 2000.

Characteristic	Little Wabana	Wabana	Bluewater	Trout
Area: acres (hectares)	105 (43)	2,133 (864)	376 (152)	1,752 (709)
Mean Depth: feet (meters)	29.9 (9.1)	27.2 (8.3)	60.4 (18.4)	45.1 (13.7)
Maximum Depth: feet (meters)	57 (17.4)	115 (35)	120 (36.6)	160 (48.8)
Littoral: acres (Percent)	31 (30)	785 (37)	72 (19.5)	386 (23)
Volume: acre-feet (cubic hectometers)	3,152 (3.9)	58,018 (71.5)	22,706 (28)	79,083 (97.5)
Watershed Area: acres (hectares)	180 (73)	10,351 (4,190)	467 (189)	2,437 (987)
Watershed:Lakes Ratio	2:1	5:1	1:1	1.5:1
Est. Residence Time	17.6 Years	6.7 Years	44.2 Years	30.4 Years
Public Access	1	2	0	1
Inlets	0	2	1	2
Outlets	0	2	0	1
Shoreland Zoning	Natural Environmental	Recreational Development	Recreational Development	Recreational Development
Schupp's Classification	23	22	23	22
Permanent Residences*	10	37	10	3
Seasonal Residences*	5	78	29	7

*Values do not represent resorts

Table 2. Average Summer Water Quality and Trophic Status Indicators - Itasca County Lakes Monitored in 2000. Based on 2000 epilimnetic data.

Parameters	Little Wabana	Wabana	Bluewater	Trout	Typical Range: NLF Ecoregion
Total Phosphorus (µg/L)	14.7	10.6	6.8	8.8	**14 - 27**
Chlorophyll a (µg/L)[2]	-	-	-	-	**-**
Mean	3.8	3.1	1.5	1.6	**< 10**
Maximum	4.6	5.9	2.6	2.7	**< 15**
Secchi disk (feet)	12.1	12.1	13.5	13.8	**8 – 15**
Total Kjeldahl Nitrogen (mg/l)	0.6	0.4	0.3	0.3	**< 0.75**
Nitrite + Nitrate-N (mg/l)	-	-	-	-	**< 0.01**
Alkalinity (mg/l)	77	117	-	-	**40 – 140**
Color (Pt-Co Units)	6.3	6.7	-	-	**10 – 35**
pH (SU)	9.1	8.8	8.7	8.6	**7.2 – 8.3**
Chloride (mg/l)	3.3	1.2	-	-	**< 2**
Total Suspended Solids (mg/l)	2.1	2	-	-	**< 1 – 2**
Total Sus. Inorganic Solids	1.8	1.5	-	-	**< 1 – 2**
Turbidity (NTU)	-	-	-	-	**< 2**
Conductivity (µmhos/cm)	133	204	244	221	**50 – 250**
Calcium Carbonate (mg/L)	48.3	69.5	82.3	-	**-**
TN:TP Ratio	41:1	38:1	44:1	34:1	**25:1-35:1**

Trophic Status Indicators: 2000

	Little Wabana	Wabana	Bluewater	Trout
TP TSIP =	43	38	32	36
Chl a TSIC =	44	42	35	35
Secchi TSIS =	41	41	40	39
OVERALL TSI	43	40	36	37

[1] Derived from Heiskary and Wilson (1990).
[2] Chlorophyll a measurements have been corrected for pheophytin.

Figure 2. Carlson's Trophic State Index
R.E. Carlson

TSI < 30 Classical Oligotrophy: Clear water, oxygen throughout the year in the hypolimnion, salmonid fisheries in deep lakes.

TSI 30 - 40 Deeper lakes still exhibit classical oligotrophy, but some shallower lakes will become anoxic in the hypolimnion during the summer.

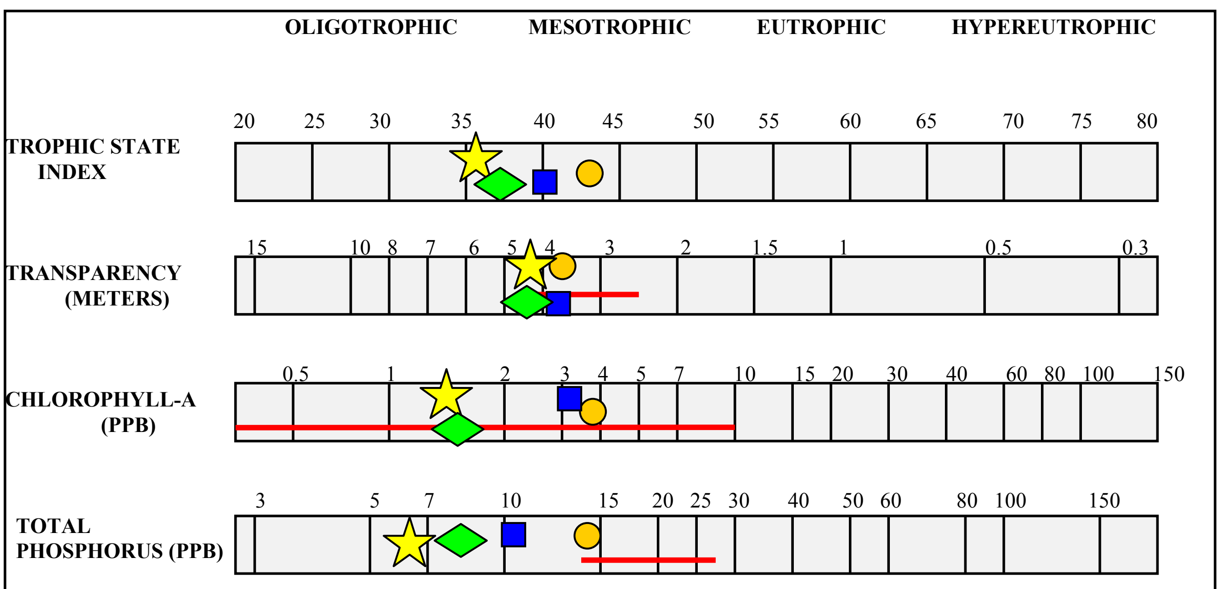
TSI 40 - 50 Water moderately clear, but increasing probability of anoxia in hypolimnion during summer.

TSI 50 - 60 Lower boundary of classical eutrophy: Decreased transparency, anoxic hypolimnia during the summer, macrophyte problems evident, warm-water fisheries only.

TSI 60 - 70 Dominance of blue-green algae, algal scums probable, extensive macrophyte problems.

TSI 70 - 80 Heavy algal blooms possible throughout the summer, dense macrophyte beds, but extent limited by light penetration. Often would be classified as hypereutrophic.

TSI > 80 Algal scums, summer fish kills, few macrophytes, dominance of rough fish.



After Moore, l. and K. Thornton, [Ed.]1988. Lake and Reservoir Restoration Guidance Manual. USEPA>EPA 440/5-88-002.

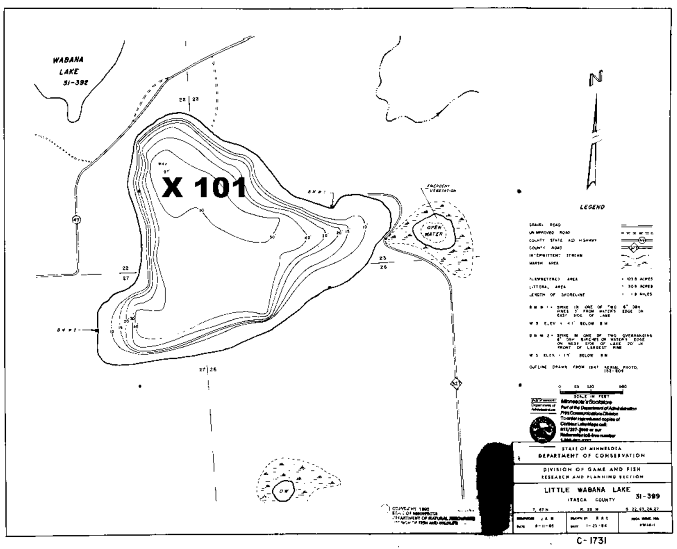
NLF Ecoregion Range: Little Wabana: Wabana: Bluewater: Trout:

CURRENT CONDITIONS

1. Little Wabana (ID# 31-0399)

Little Wabana Lake, located 12 miles north of Grand Rapids, Minnesota, was sampled at the request of lakeshore residents and the Wabana Chain of Lakes Association, which had concerns over the water quality of the lake. The fact that no historic data was available in STORET for this lake and that additional sampling was already planned for that area, we were able to accommodate the request. Little Wabana is about 105 acres in size with a maximum depth of about 57 feet. There are no known inlets or outlets for this lake. Samples were taken in May, June, July, August and September at Site 101 (Figure 3) over the site of maximum depth on the northwest end of the lake.

Figure 3. Little Wabana Lake Bathymetric Map & Sampling Locations



Little Wabana Lake was thermally stratified at this site during the summer of 2000 as evidenced by the dissolved oxygen and temperature measurements (Figure 4). Summer-mean TP, total Kjeldahl nitrogen, chlorophyll-a, and Secchi transparency values compare favorably with the ecoregion reference values (Table 2). The TN:TP ratio is about 41:1 which suggests that TP is the nutrient which limits algal growth in the lake. The Carlson Trophic State Index (TSI) values based on TP, chlorophyll-a and Secchi were 43, 44, and 41 respectively, and indicate mesotrophic conditions for the lake (Figure 2). The three TSI values correspond to one another quite well and thus indicate that Secchi transparency should provide a good indication of trophic status and trends for the lake.

Based on the 2000 data Little Wabana's epilimnion (surface) TP concentrations ranged from 13 μg/L in May and August to 16 μg/L in September and averaged 14.7 μg/L; while hypolimnion (bottom) concentrations ranged from 31 μg/L in August to 46 μg/L in July (Figure 4). No June data was used because the samples were contaminated. These values are well within the range of values exhibited by reference lakes in this ecoregion.

Figure 4. Little Wabana Lake Dissolved Oxygen and Temperature Profiles

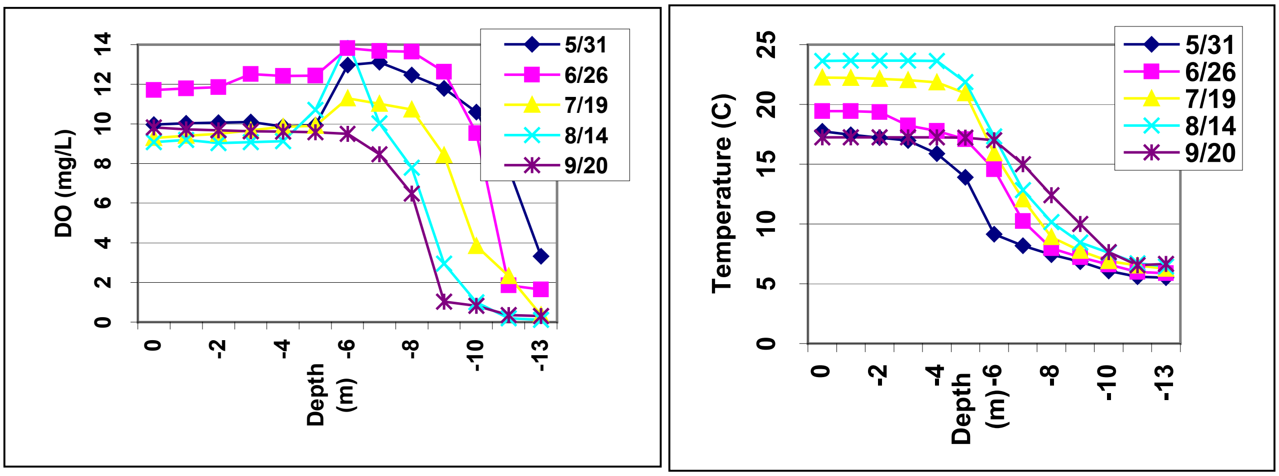
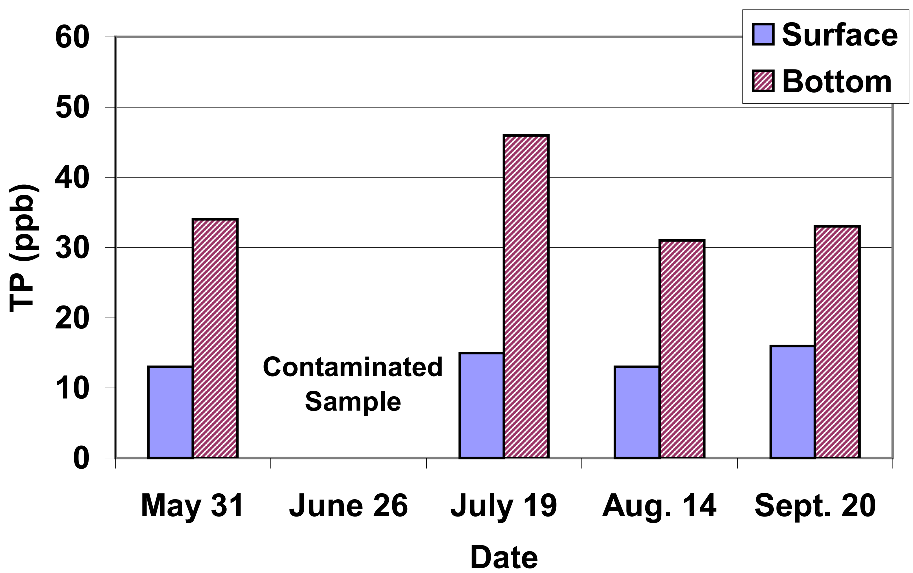
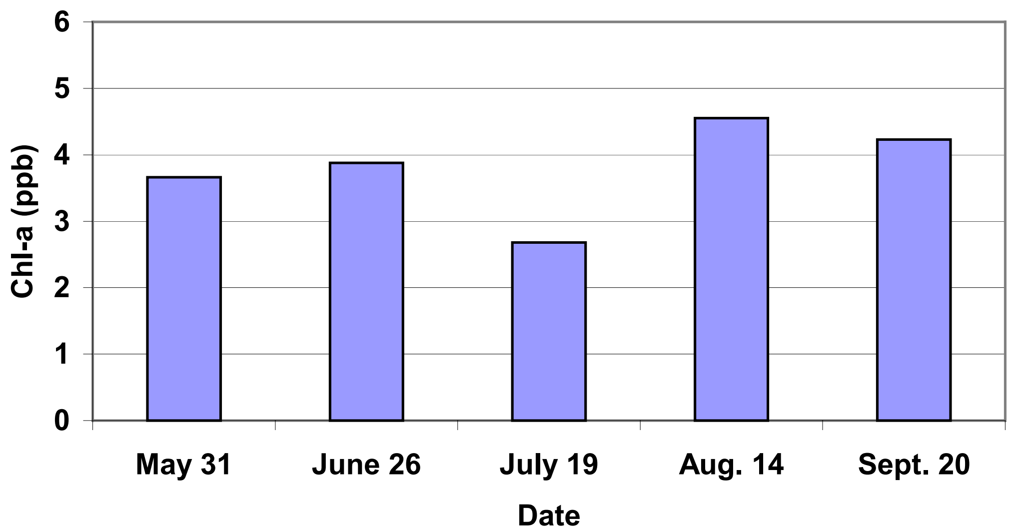


Figure 5. Little Wabana Lake Total Phosphorus Concentrations



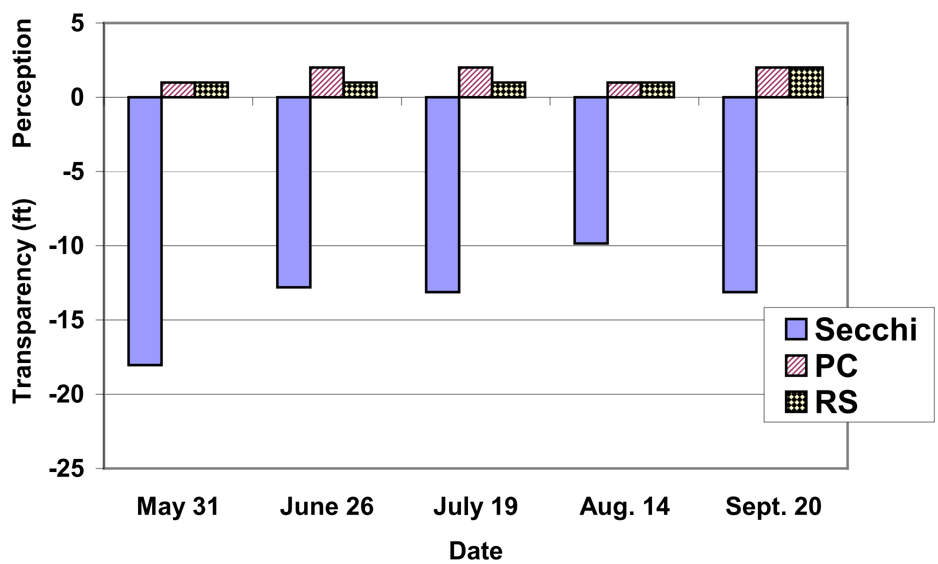
Chlorophyll-a concentrations for Little Wabana Lake ranged from 2.7 μg/L in July to 4.6 μg/L in August and averaged 3.8 μg/L, based on the 2000 data (Figure 6). These values are well within the expected range for reference lakes in the NLF ecoregion. No nuisance (chl-a > 20 μg/L) or severe nuisance (chl-a > 30 μg/L) blooms were observed on Little Wabana Lake in 2000.

Figure 6. Little Wabana Lake Chlorophyll-a Concentrations



Secchi transparency for Little Wabana Lake ranged from 18 feet (5.5 m) in May to 9.8 feet (3 m) in August and averaged 12.1 feet (3.7 m), based on the 2000 data (Figure 7). These values are also well within the range of expected values for this area. Along with Secchi transparency measurements, subjective measures of the lake's "physical appearance" and "recreational suitability" were made by MPCA staff. Physical appearance ratings range from "crystal clear" (Class 1) ... to "dense algal blooms, odor, etc." (Class 5) and recreational suitability ratings range from "beautiful, could not be any nicer" (Class 1) ... to "no recreation possible" (Class 5) in this user perception rating system (Heiskary and Wilson, 1988). Physical condition ratings for Little Wabana Lake were generally characterized as "crystal clear" (Class 1) and "not quite crystal clear" (Class 2) for most of the summer. Recreational suitability ratings were generally characterized as "beautiful" (Class 1) for most of the summer.

Figure 7. Little Wabana Lake Secchi Transparency & User Perceptions

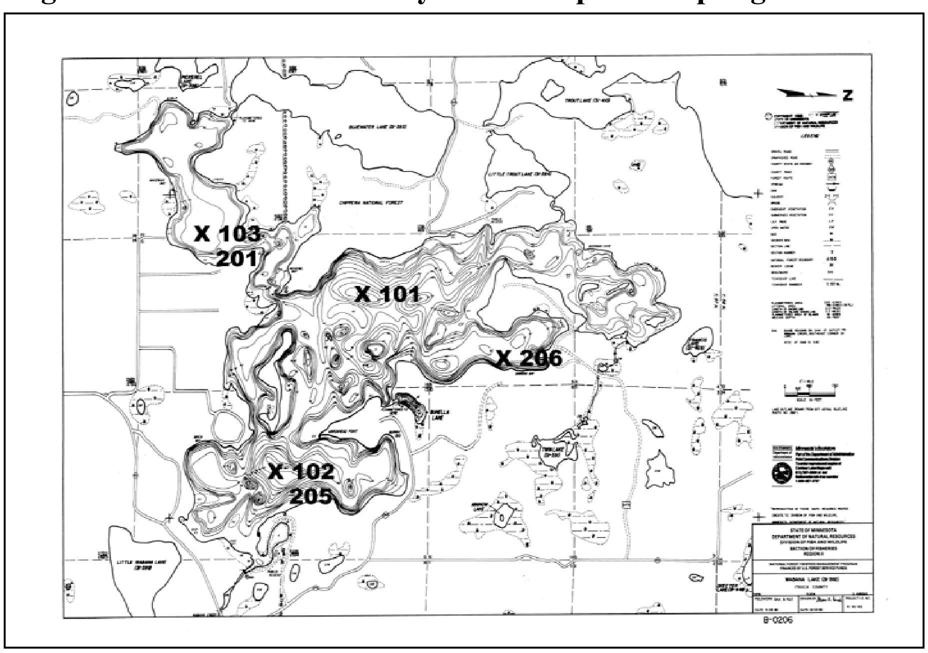


Because of its low nutrient concentrations and lack of a surface outlet, which would allow for flushing, Little Wabana would be very susceptible to increased eutrophication with an increase in TP loading. Every effort should be made to minimize TP loading to the lake whenever possible. Also it would be very important to monitor the lake to assess trends over time. The CLMP is the least expensive and perhaps the best opportunity for trend assessment. Any lakeshore residents or other persons who routinely use the lake are encouraged to participate in the CLMP.

2. Lake Wabana (ID # 31-0392)

Wabana Lake, located six miles northwest of Coleraine, Minnesota, was sampled five times during the 2000 sampling season. This study was conducted at the request of the Association. Wabana Lake was originally studied as a LAP in 1991. The current study, which includes the other lakes in the chain, was conducted in order to assess any changes in water quality, which might have occurred since that time. Wabana Lake is about 2,133 acres in size with a maximum depth of about 115 feet. There are two inlets and two outlets for this lake. Samples were taken in May, June, July, August and September at Sites 101, 102 and 103 (Figure 8).

Figure 8. Lake Wabana Bathymetric Map & Sampling Locations



Wabana Lake was thermally stratified at sites 101 and 102 during the summer of 2000; however, site 103 was well-mixed on all sampling occasions. (Figures 9, 10, & 11). Conditions were too windy to get good profile readings during the June and September sampling dates at site 102. Summer-mean TP, total Kjeldahl nitrogen, chlorophyll-a, and Secchi transparency values compare favorably with the ecoregion reference values (Table 2). The TN:TP ratio is about 38:1 which suggests that TP is the nutrient which limits algal growth in the lake. The Carlson Trophic State

Index (TSI) values based on TP, chlorophyll-a and Secchi were 38, 42, and 41 respectively, and indicate mesotrophic conditions for the lake (Figure 2). The three TSI values correspond to one another well and as such, indicate that Secchi transparency should provide a good indication of trophic status and trends for the lake.

Based on the 2000 data, Wabana's epilimnion TP concentrations ranged from 8 µg/L to 17 µg/L and averaged 10.6 µg/L; while hypolimnion concentrations ranged from 8 µg/L to 22 µg/L in (Figure 12). These values are well within the range of values exhibited by reference lakes in this ecoregion (Table 2) and very comparable to the TP data collected in 1991 (10.2 µg/L, Table 3).

Chlorophyll-a concentrations for Wabana Lake ranged from 1.5 µg/L to 5.9 µg/L and averaged 3.1 µg/L, based on the 2000 data (Figure 13). No nuisance (chl-a > 20 µg/L) or severe nuisance (chl-a > 30 µg/L) blooms were observed on Wabana Lake in 2000. These values are well within the expected range for reference lakes in the NLF ecoregion and very similar to the chlorophyll data collected in 1991 (3.3 µg/L, Table 3).

The composition of the phytoplankton (algae) population of Wabana Lake, collected at site 102, is presented in Figure 14. Data are presented in terms of algal type, although most sampling occasions found sparse to very sparse overall populations. Yellow-brown populations were the dominant form found on most sampling occasions with the form, Dinobryon, being most common. A seasonal transition in algal types from diatoms to greens to blue-green is more typical for mesotrophic and eutrophic lakes in Minnesota.

Secchi transparency for Wabana Lake ranged from 8.2 feet (2.5 m) to 15.4 feet (4.7 m) and averaged 12.1 feet (3.7 m), based on the 2000 MPCA data (Figure 15). These values are well within the range of expected values for this area and slightly less than the 1991 mean of 16 feet (4.9 m). Along with Secchi transparency measurements, subjective measures of the lake's "physical appearance" and "recreational suitability" were made by MPCA staff. Physical appearance ratings range from "crystal clear" (Class 1) ... to "dense algal blooms, odor, etc." (Class 5) and recreational suitability ratings range from "beautiful, could not be any nicer" (Class 1) ... to "no recreation possible" (Class 5) in this user perception rating system (Heiskary and Wilson, 1988). Physical condition ratings for Wabana Lake were generally characterized as "crystal clear" (Class 1) and "not quite crystal clear" (Class 2) for most of the summer. Recreational suitability ratings were generally characterized as "beautiful" (Class 1) and "minor aesthetic problems" (Class 2) for most of the summer (Appendix).

Citizen Lake-Monitoring Program (CLMP) volunteers (Duane Amundson, Susan Lick, and Ken Zimmer) also monitored Secchi transparency for Wabana Lake at sites 201, 205, and 206 (Figure 8). These values ranged from 11 feet (3.4 m) to 21 feet (6.4 m) (Figure 16). Subjective measures of Wabana Lake's "physical appearance" and "recreational suitability" were made by CLMP observers. Physical condition ratings for Wabana Lake were generally characterized as "crystal clear" (Class 1) and "not quite crystal clear" (Class 2) for most of the summer. Recreational suitability ratings were generally characterized as "beautiful" (Class 1) and "minor aesthetic problems" (Class 2) for most of the summer (Appendix).

Figure 9. Wabana Lake Dissolved Oxygen & Temperature Profiles, Site 101

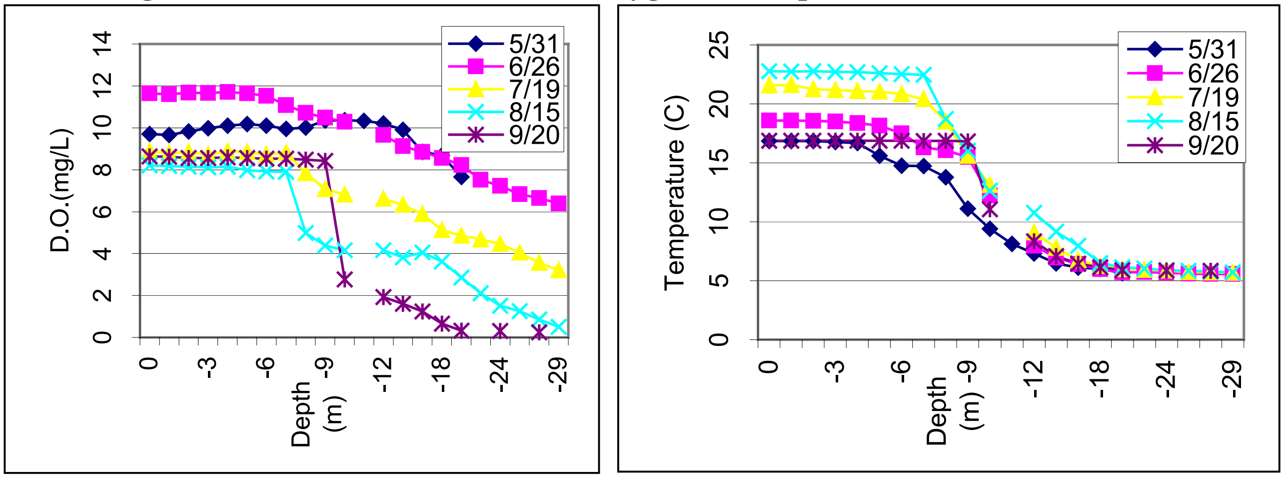


Figure 10. Wabana Lake Dissolved Oxygen & Temperature Profiles, Site 102

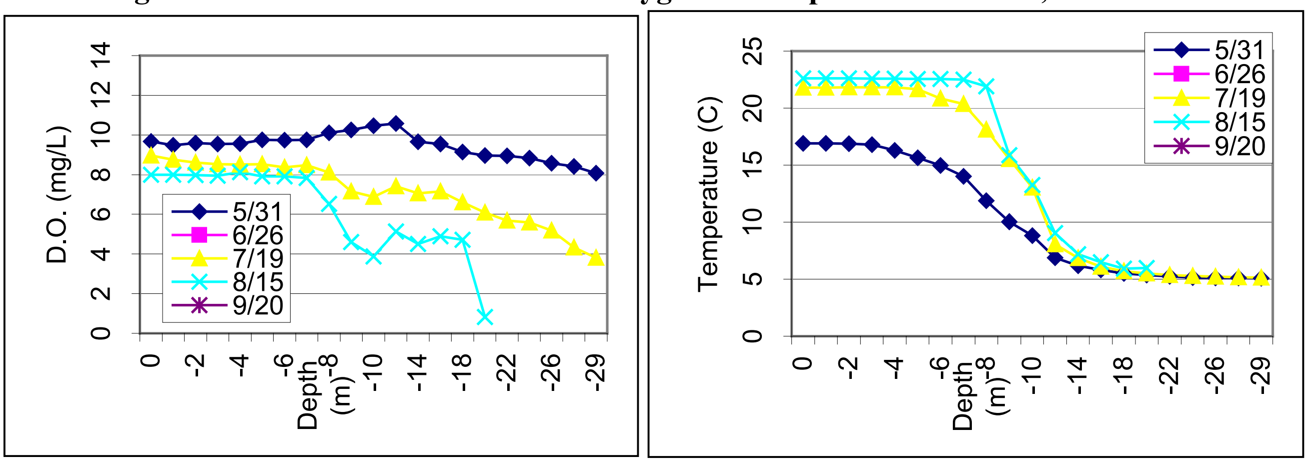


Figure 11. Wabana Lake Dissolved Oxygen & Temperature Profiles, Site 103

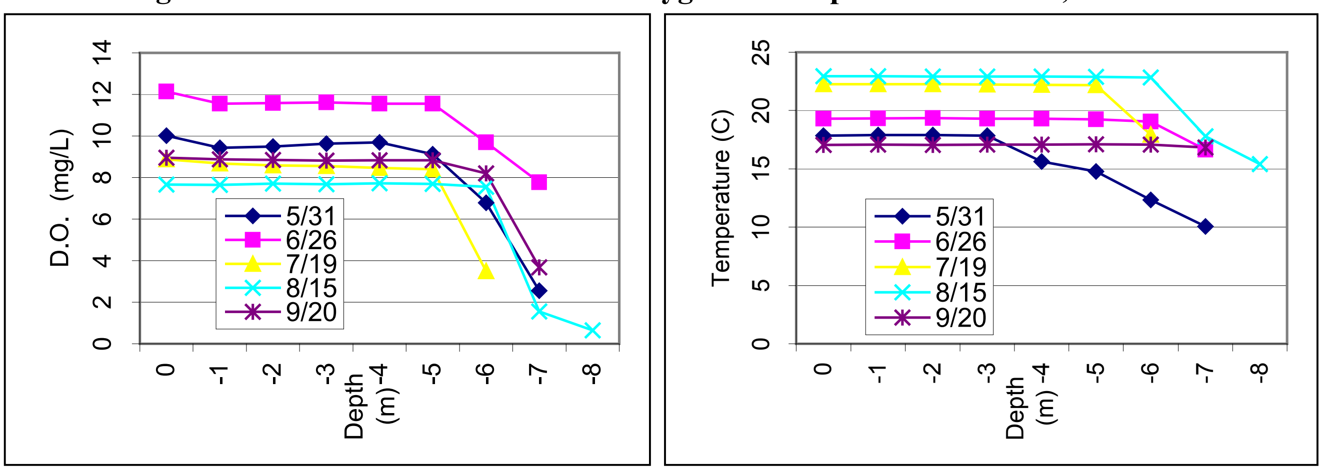


Figure 12. Wabana Lake Total Phosphorus Concentrations for 2000.

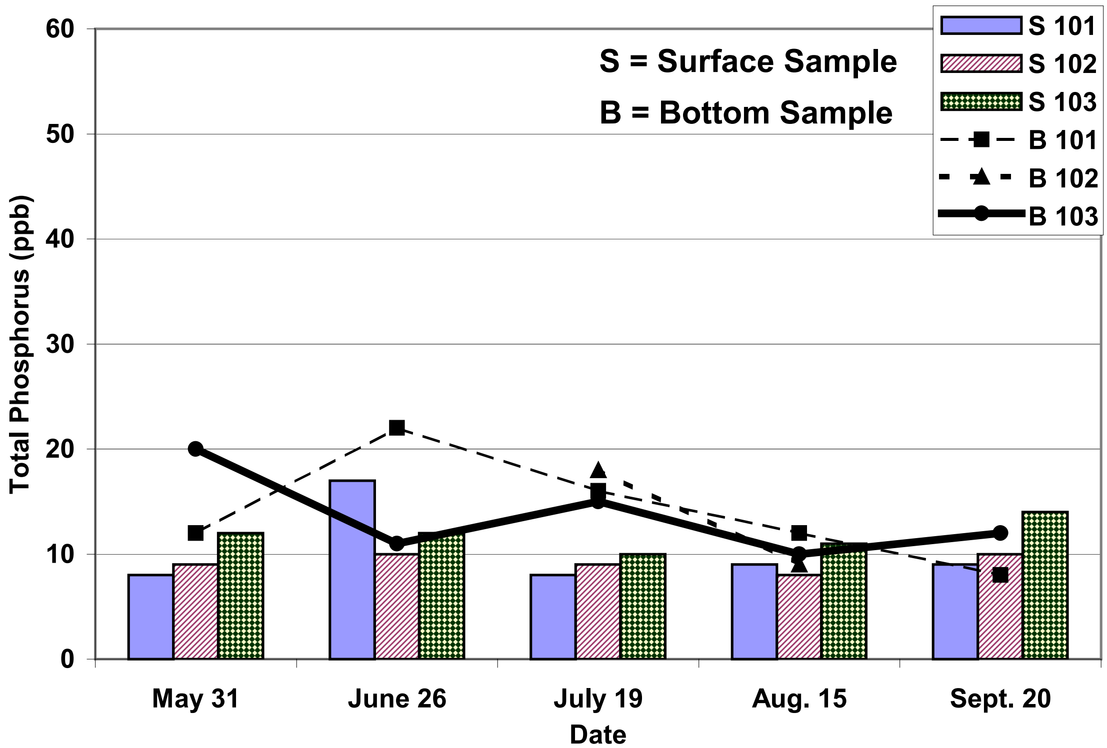


Table 3. 1991 and 2000 Average Summer Water Quality Data for Wabana Lake

Parameters	Wabana 1991	Wabana 2000	Typical Range: NLF Ecoregion
Total Phosphorus (µg/L)	10.2	10.6	**14 - 27**
Chlorophyll a (µg/L)[3]	-	-	**-**
Mean	3.4	3.1	**< 10**
Maximum	11	5.9	**< 15**
Secchi disk (feet)	16	12.1	**8 – 15**
Total Kjeldahl Nitrogen (mg/l)	0.3	0.4	**< 0.75**
Nitrite + Nitrate-N (mg/l)	0.02	-	**< 0.01**
Alkalinity (mg/l)	117.5	117	**40 – 140**
Color (Pt-Co Units)	8.8	6.7	**10 – 35**
pH (SU)	8.2	8.8	**7.2 – 8.3**
Chloride (mg/l)	0.8	1.2	**< 2**
Total Suspended Solids (mg/l)	1.5	2	**< 1 – 2**
Total Sus. Inorganic Solids	0.5	1.5	**< 1 – 2**
Turbidity (NTU)	0.9	-	**< 2**
Conductivity (µmhos/cm)	201	204	**50 – 250**
Calcium Carbonate (mg/L)	-	69.5	**-**
TN:TP Ratio	33:1	38:1	**25:1-35:1**

Figure 13. Wabana Lake Chlorophyll-a Concentrations for 2000.

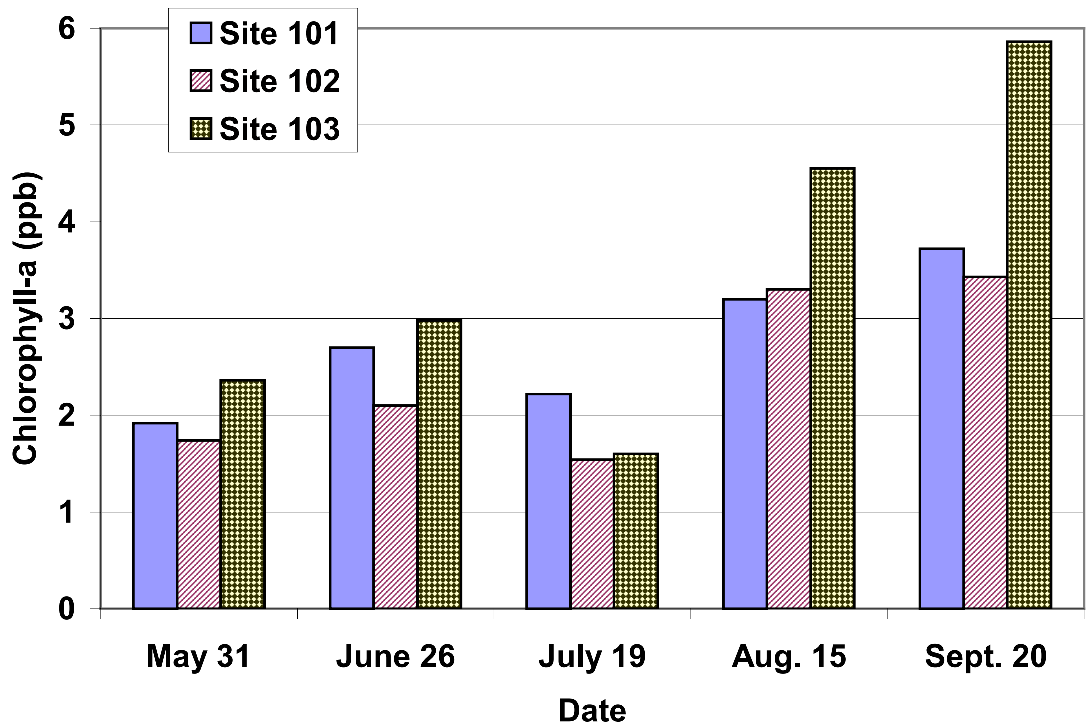


Figure 14. Wabana Lake Phytoplankton Composition for 2000

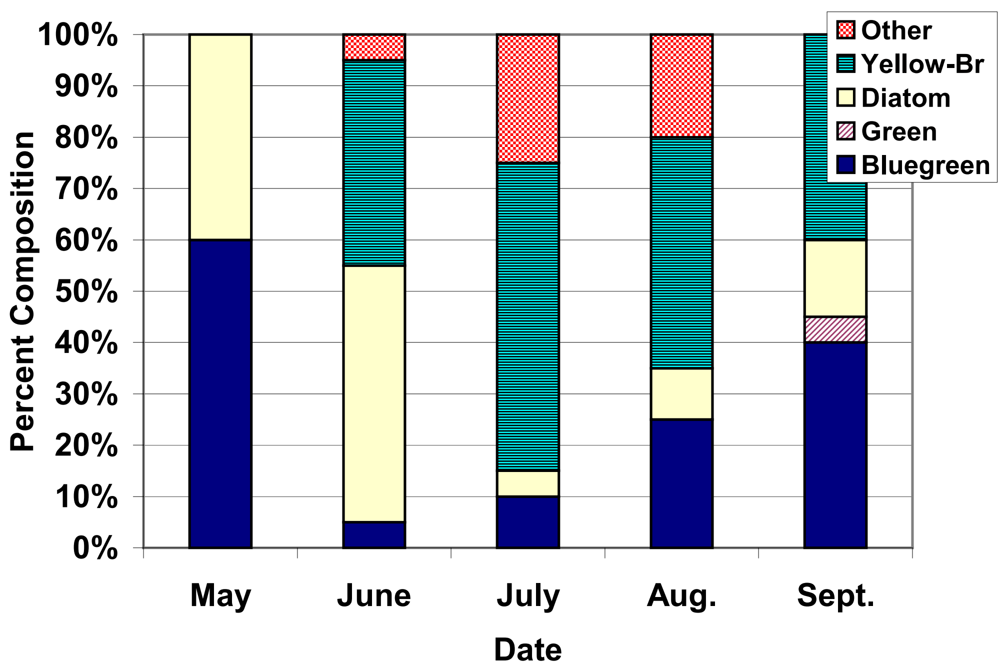


Figure 15. Wabana Lake MPCA Secchi Transparency

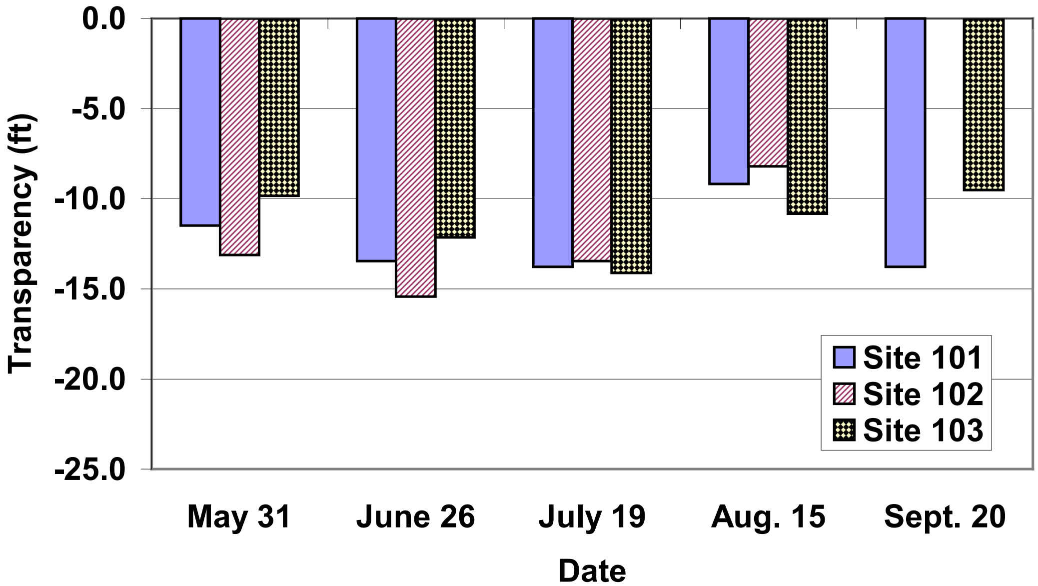
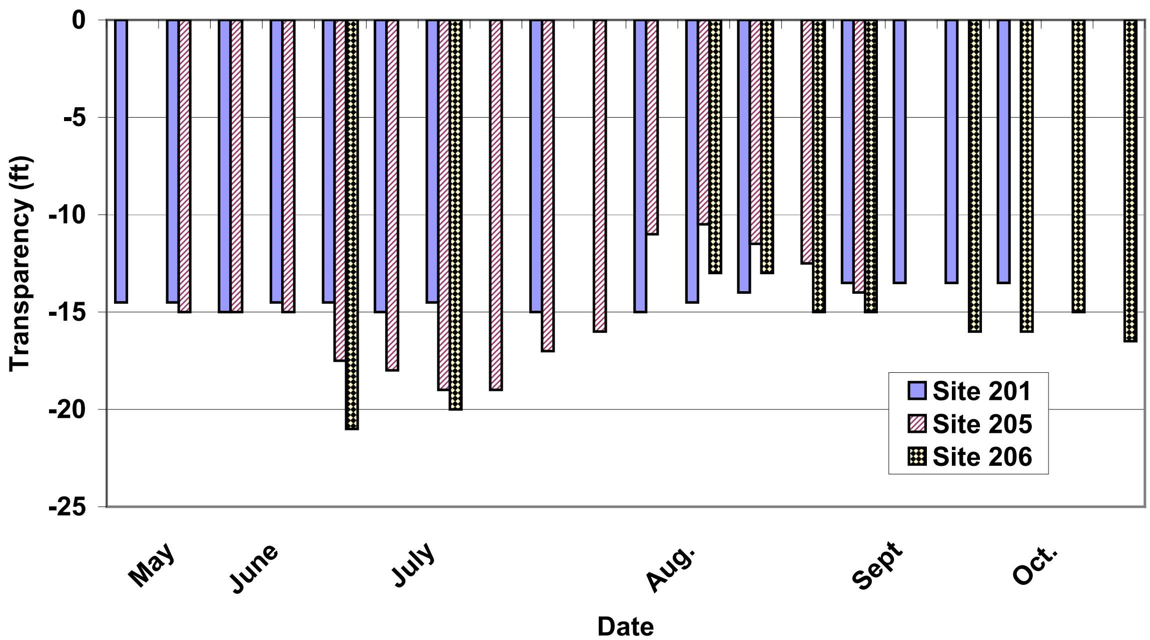


Figure 16. Wabana Lake CLMP Secchi Transparency for 2000

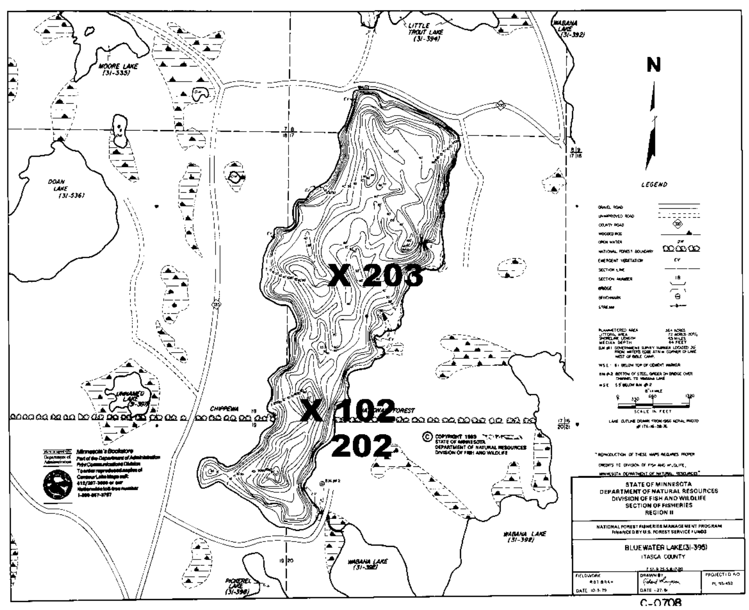


Because of its low nutrient concentrations and moderate-sized watershed, Wabana Lake would be very susceptible to increased eutrophication with an increase in TP loading. Every effort should be made to minimize TP loading to the lake whenever possible. Also it would be very important to monitor the lake to assess trends over time. The CLMP is the least expensive and perhaps the best opportunity for trend assessment. Continued participation in the CLMP by lakeshore residents or other persons who routinely use the lake is recommended.

3. Bluewater Lake (ID# 31-0395)

Bluewater Lake, located 13 miles north of Grand Rapids, Minnesota, was sampled five times during the 2000 sampling season. This lake was included as part of study of the Wabana Chain of Lakes at the request of the Association. Bluewater Lake is about 376 acres in size with a maximum depth of about 120 feet. There is one outlet (to Wabana Lake) and no inlets for this lake. Samples were taken in May, June, July, August and September at Site 102 (Figure 17).

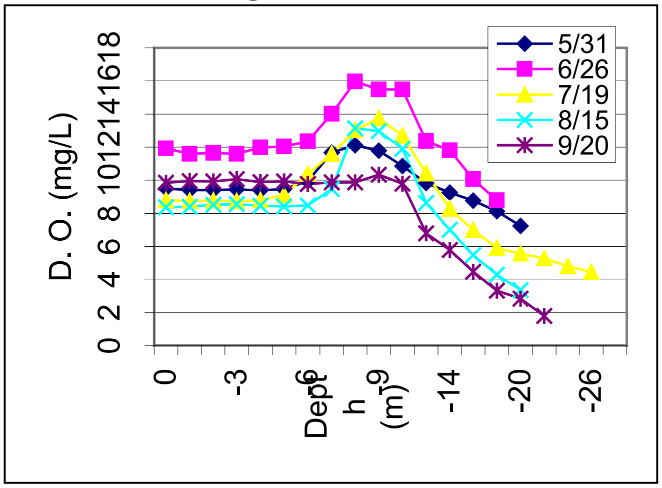
Figure 17. Bluewater Lake Bathymetric Map and Sampling Locations

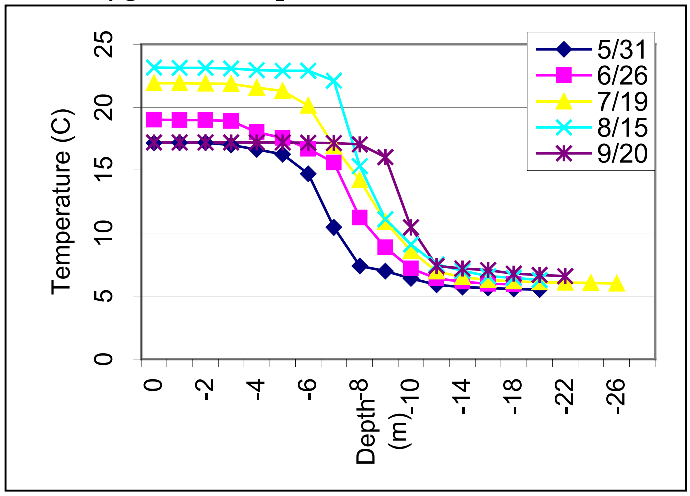


Bluewater Lake was thermally stratified during all sampling visits at site 102 during the summer of 2000 (Figure 18). Oxygen levels actually increased near the thermocline (7-10 meters), and then rapidly dropped off to below 5 mg/L on all sampling occasions. This phenomenon, where the oxygen levels increase near the thermocline (metalimnion), is referred to as *metalimnetic oxygen maxima*. In those lakes that experience metalimnetic maxima, typically they are found between 3 – 10 meters (~10 – 33) feet. The maxima are most often the result of oxygen produced by algae populations (typically blue green algae) growing in this lower layer. These algae are typically well adapted to this lower temperature range and light intensity (Wetzel, 1975). This phenomenon can be quite common in deep and highly transparent lakes.

Summer-mean TP, total Kjeldahl nitrogen, chlorophyll-a, and Secchi transparency values compare favorably with the ecoregion reference values (Table 2). The TN:TP ratio is about 44:1 which suggests that TP is the nutrient which limits algal growth in the lake. The Carlson Trophic State Index (TSI) values based on TP, chlorophyll-a and Secchi were 32, 35, and 40 respectively, and indicate mesotrophic conditions for the lake (Figure 2). The TP and chla TSI values correspond to one another well; while the Secchi transparency TSI is slightly higher. Bluewater Lake, with its

Figure 18. Bluewater Lake Dissolved Oxygen & Temperature Profiles

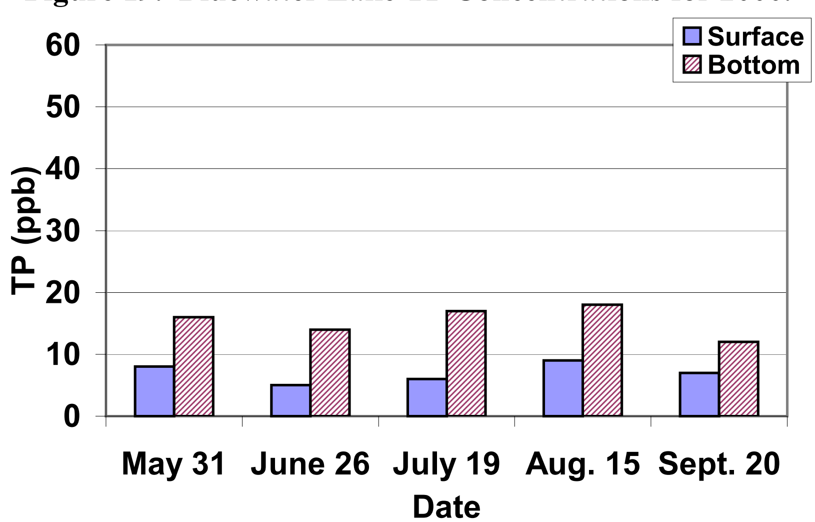




extreme turquoise coloring, would be referred to as a "marl lake." These lakes typically have sediments consisting of marl, a mixture of clay, sand and limestone that tends to be soft in texture. These lakes also tend to be hard-water lakes (higher concentrations of calcium, magnesium and bicarbonate). As the pH of the lake becomes more basic and gets above 8 (7 is neutral), the calcium carbonate starts to precipitate out of the water column forming a white floc (cloudy white particles suspended in the water). The floc will eventually settle out of the water column and deposit in the lake sediments. This floc may have an influence on the transparency, but overall, Secchi transparency should provide a good indication of trophic status and trends for the lake.

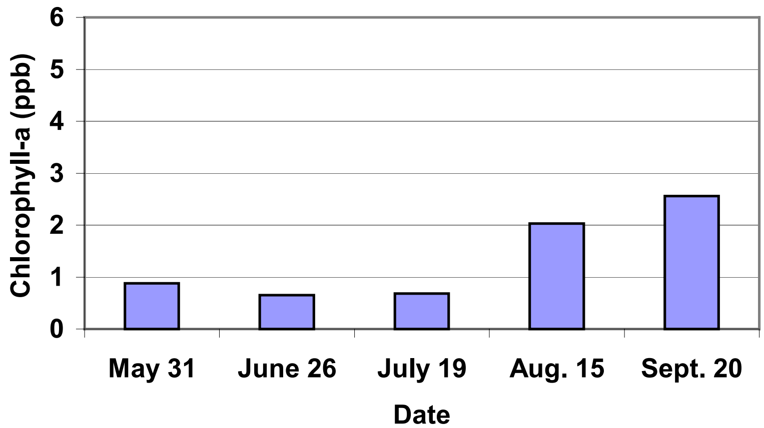
Based on the 2000 data, Bluewater's epilimnion TP concentrations ranged from 5 µg/L to 9 µg/L and averaged 6.8 µg/L; while hypolimnion concentrations ranged from 12 µg/L to 18 µg/L in (Figure 19). These values are well within the range of values exhibited by reference lakes in this ecoregion (Table 2).

Figure 19. Bluewater Lake TP Concentrations for 2000.



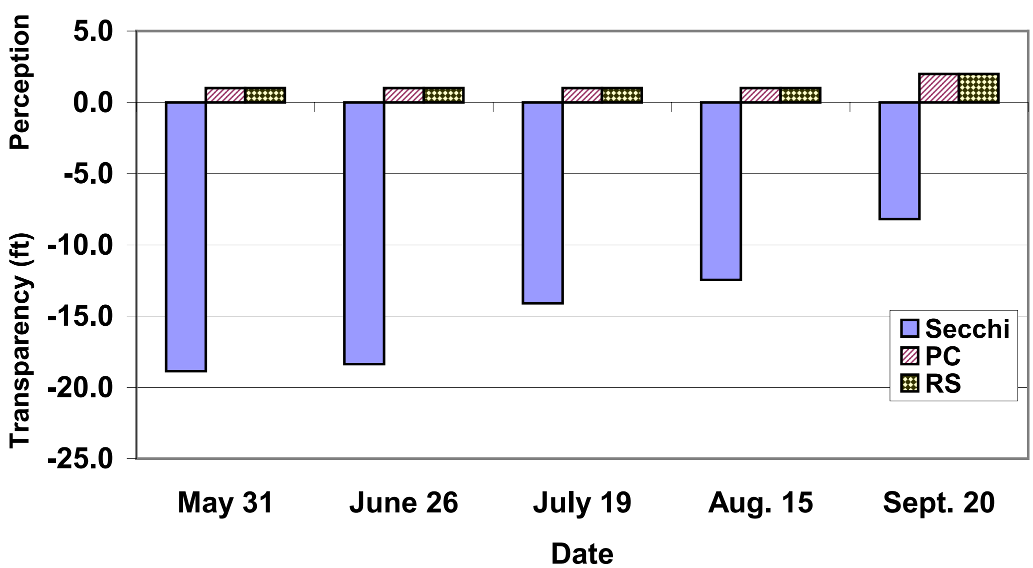
Chlorophyll-a concentrations for Bluewater Lake ranged from 0.7 µg/L to 2.6 µg/L and averaged 1.5 µg/L, based on the 2000 data (Figure 20). No nuisance (chl-a > 20 µg/L) or severe nuisance (chl-a > 30 µg/L) were observed on Bluewater Lake in 2000. These values are better than the expected range for reference lakes in the NLF (Table 2).

Figure 20. Bluewater Lake Chlorophyll-a Concentrations for 2000.



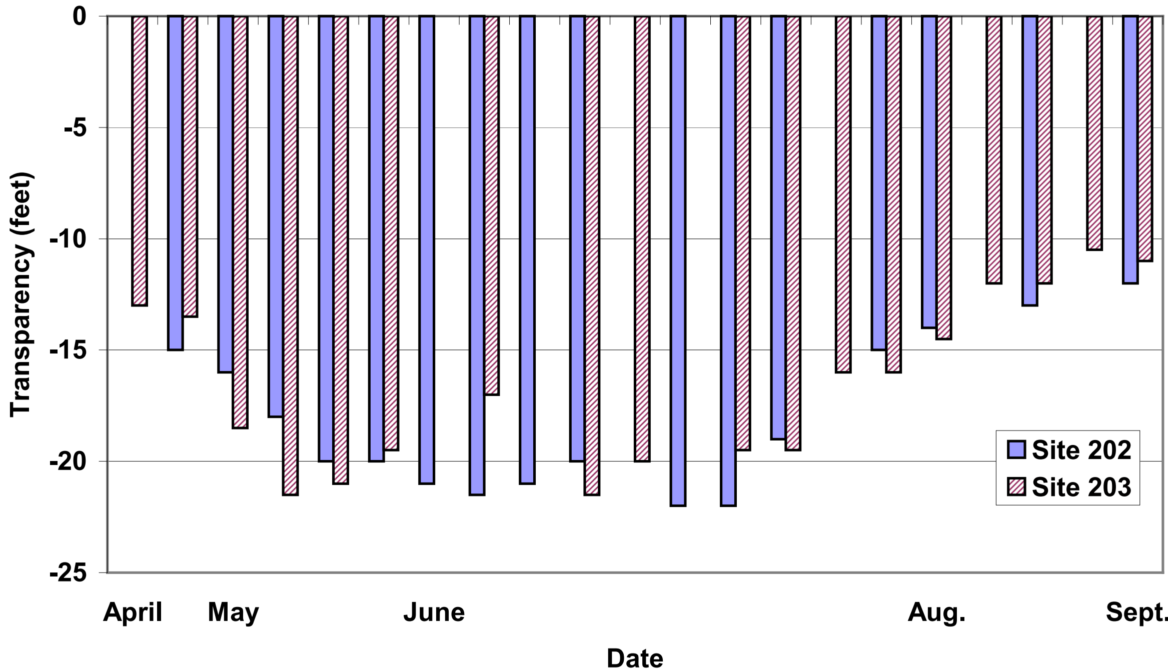
Secchi transparency for Bluewater Lake ranged from 8.2 feet (2.5 m) to 18.9 feet (5.8 m) and averaged 13.5 feet (4.1 m), based on the 2000 MPCA data (Figure 21). Along with Secchi transparency measurements, subjective measures of the lake's "physical appearance" and "recreational suitability" were made by MPCA staff. Physical condition ratings for Bluewater Lake were generally characterized as "crystal clear" (Class 1) for most of the summer and recreational suitability ratings were generally characterized as "beautiful" (Class 1) for most of the summer as well.

Figure 21. Bluewater Lake Secchi Transparency & User Perceptions for 2000.



CLMP volunteers (Nancy Ellsworth & George Klacan) also monitored Secchi transparency for Bluewater Lake at sites 202 and 203 (Figure 22). These values ranged from 10.5 feet (3.2 m) to 22 feet (6.7 m). No subjective measures of Bluewater Lake's "physical appearance" and "recreational suitability" were made by CLMP observers.

Figure 22. Bluewater Lake CLMP Secchi Transparency

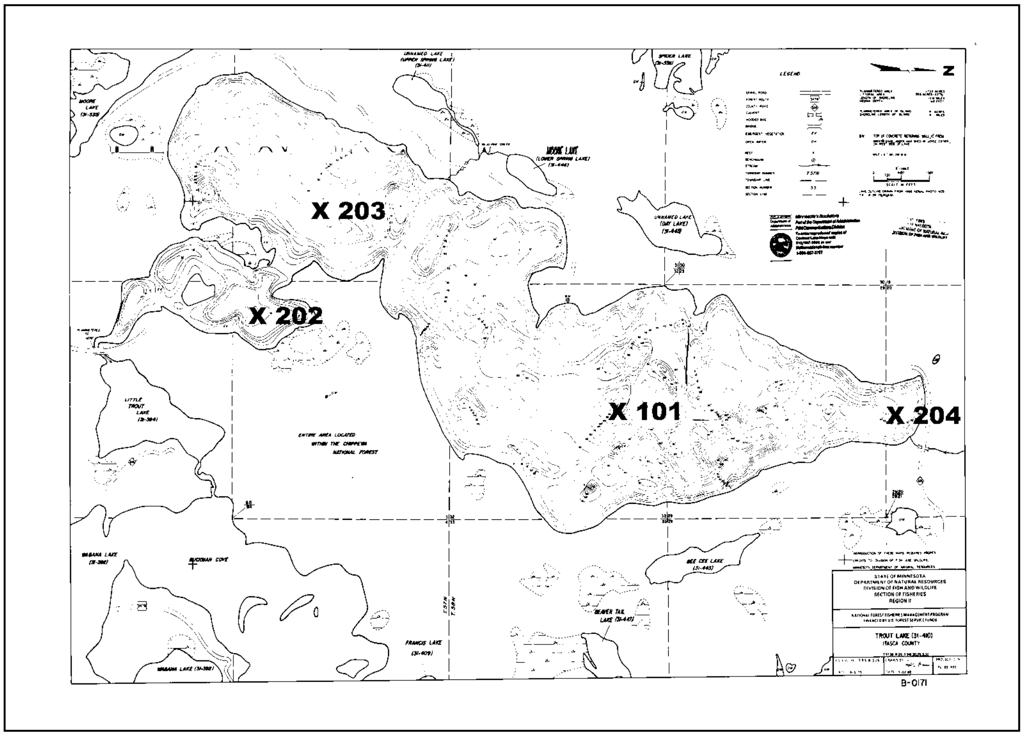


Bluewater Lake would also be very susceptible to increased eutrophication with an increase in TP loading; therefore, every effort should be made to minimize TP loading to the lake whenever possible. Secchi transparency offers the best database for assessing trends for this lake. Continued participation in the CLMP by volunteer lake monitors for Bluewater Lake is recommended.

4. Trout Lake (ID # 31-0410)

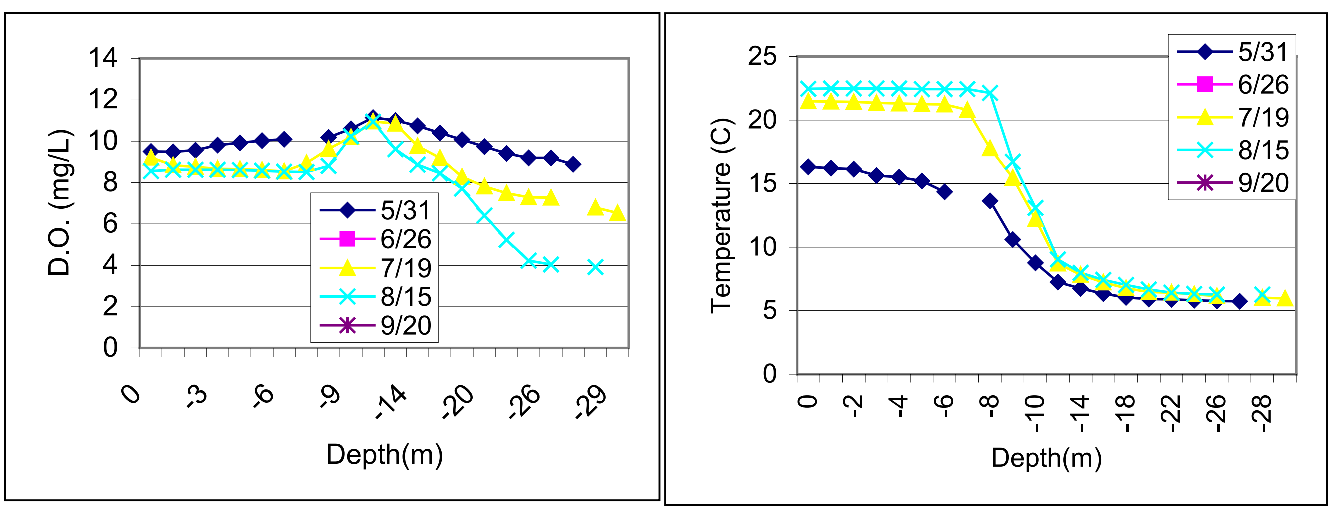
Trout Lake, located 16 miles north of Grand Rapids, Minnesota, was sampled five times during the 2000 sampling season. This lake was included as part of study of the Wabana Chain of Lakes at the request of the Association. Trout Lake is the second largest lake in the chain of lakes, covering about 1,752 acres in size; and is the deepest lake in the chain with a maximum depth of about 160 feet. There are two inlets, one outlet, and one public access for this lake. Samples were taken in May, June, July, August and September at Site 101 (Figure 23).

Figure 23. Trout Lake Bathymetric Map and Sampling Locations



Trout Lake was thermally stratified during all sampling visits at site 101 during the summer of 2000 (Figure 24); however, conditions were too windy to get good profile readings for the June and September sampling occasions. As in Bluewater Lake, oxygen levels increased near the thermocline (8 – 12 meters) creating a *metalimnetic oxygen maxima*.

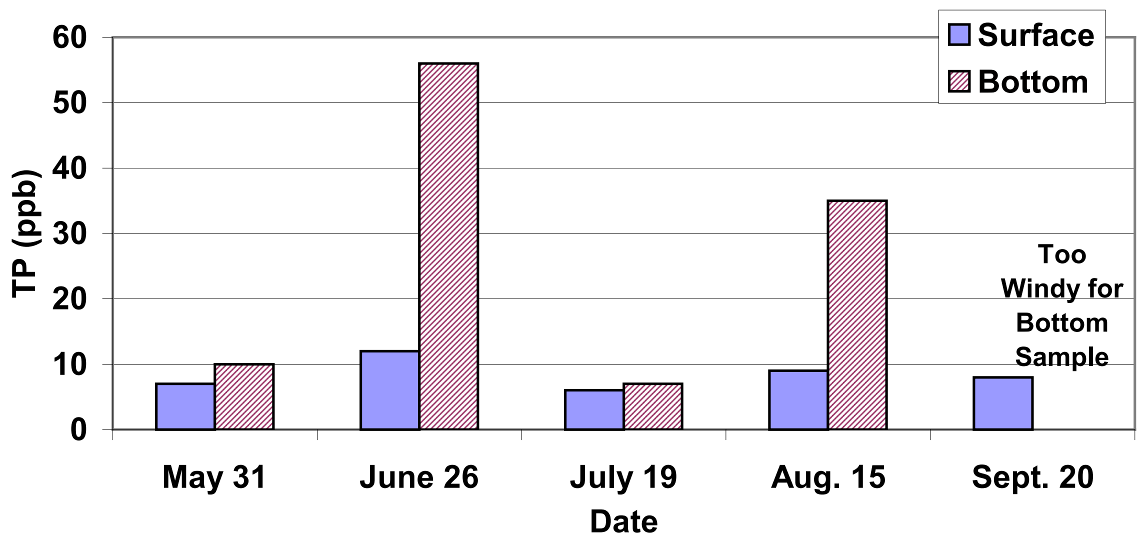
Figure 24. Trout Lake Dissolved Oxygen and Temperature Profiles



Summer-mean TP, total Kjeldahl nitrogen, chlorophyll-a, and Secchi transparency values for Trout Lake compare favorably with the ecoregion reference values (Table 2). The TN:TP ratio is about 34:1 which suggests that TP is the nutrient which limits algal growth in the lake. The Carlson Trophic State Index (TSI) values based on TP, chlorophyll-a and Secchi were 36, 35, and 39 respectively, and indicate mesotrophic conditions for the lake (Figure 2). The TP and chla TSI values correspond to one another well; while the Secchi transparency TSI is slightly higher. Trout Lake, like Bluewater Lake, would be referred to as a "marl lake." The floc from the calcuim carbonate precipitate may have an influence on the transparency, but overall, Secchi transparency should provide a good indication of trophic status and trends for the lake.

Based on the 2000 data, Trout Lake's epilimnion TP concentrations ranged from 6 μg/L to 12 μg/L and averaged 8.8 μg/L; while hypolimnion concentrations ranged from 7 μg/L to 56 μg/L in (Figure 25). These values are well within the range of values exhibited by reference lakes in this ecoregion (Table 2).

Figure 25. Trout Lake TP Concentrations for 2000.



Chlorophyll-a concentrations for Trout Lake ranged from 0.9 μg/L to 2.7 μg/L and averaged 1.6 μg/L, based on the 2000 data (Figure 26). No nuisance (chl-a > 20 μg/L) or severe nuisance (chl-a > 30 μg/L) were observed on Trout Lake in 2000. These values are better than the expected range for reference lakes in the NLF (Table 2).

Secchi transparency for Trout Lake ranged from 10.8 feet (3.3 m) to 20 feet (6.1 m) and averaged 13.8 feet (4.2 m), based on the 2000 MPCA data (Figure 27). Along with Secchi transparency measurements, subjective measures of the Trout Lake's "physical appearance" and "recreational suitability" were made by MPCA staff. Physical condition ratings for Trout Lake were generally characterized as "crystal clear" (Class 1) for most of the summer and recreational suitability ratings were generally characterized as "beautiful" (Class 1) for most of the summer as well.

Figure 26. Trout Lake Chlorophyll-a Concentrations for 2000.

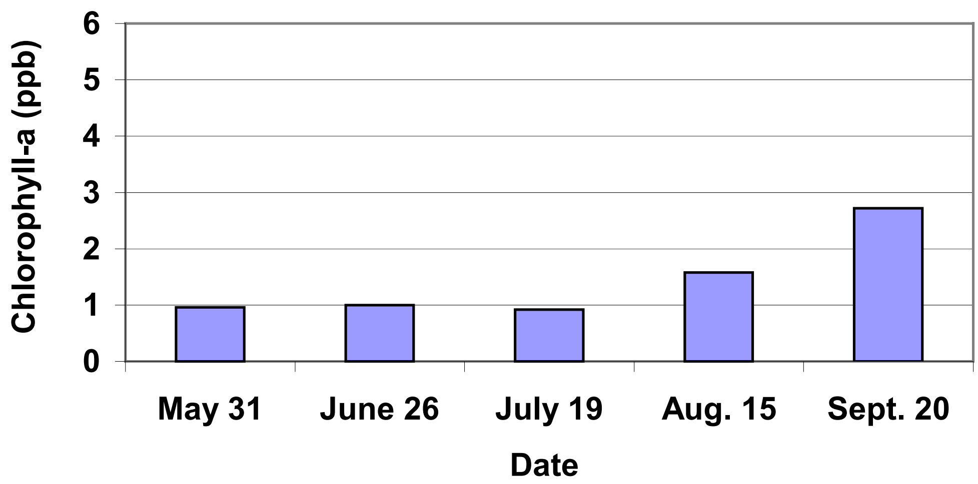
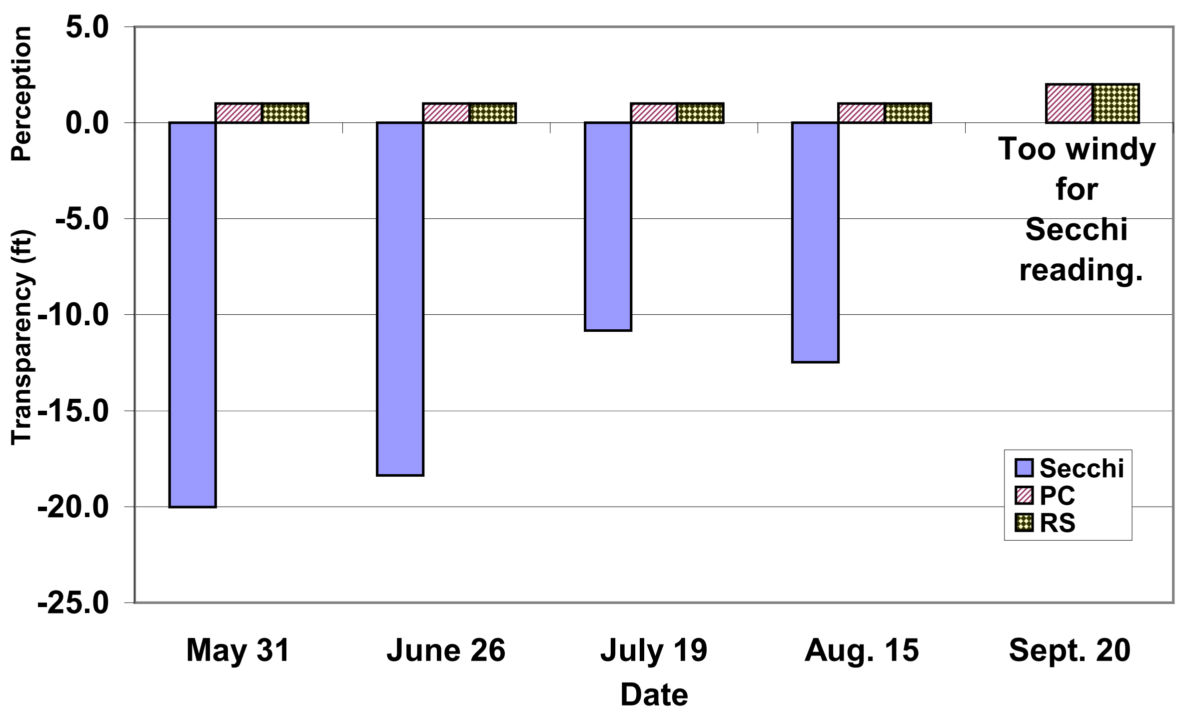
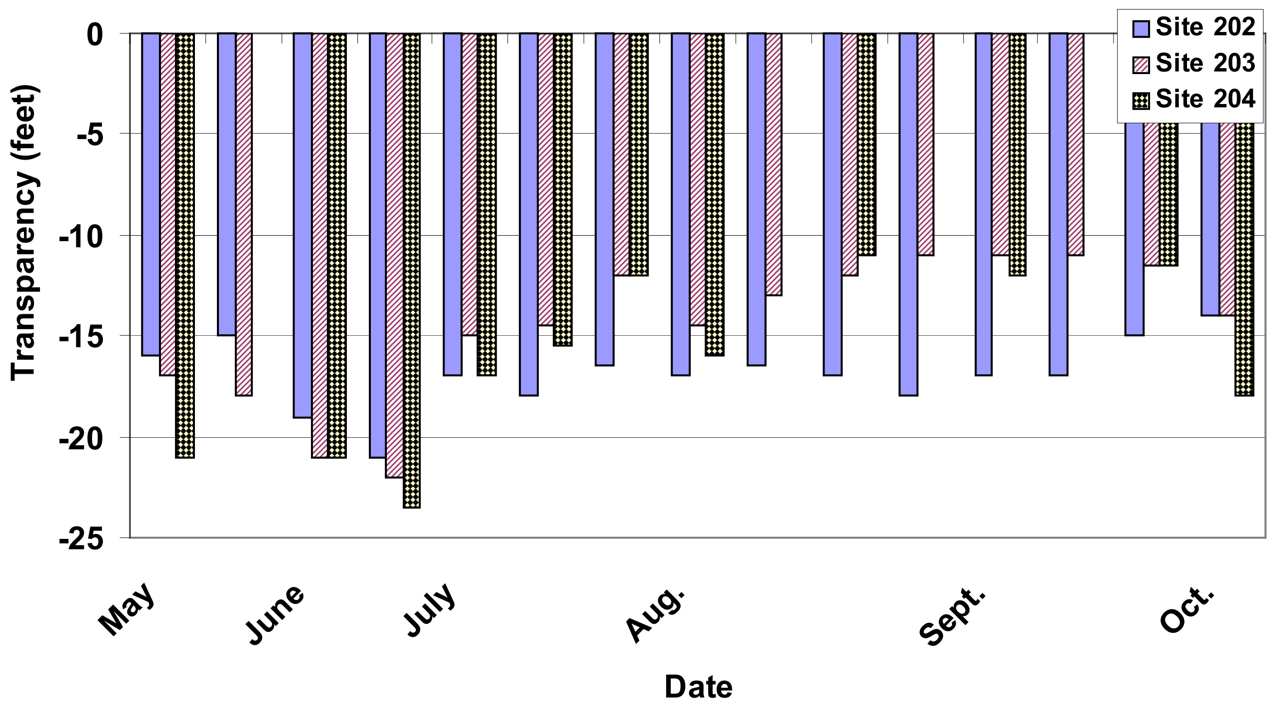


Figure 27. Trout Lake Secchi Transparency & User Perceptions for 2000.



CLMP volunteers (Betty Unger & William Berg) also monitored Secchi transparency for Trout Lake at sites 202, 203 and 204 (Figure 28). These values ranged from 11 feet (3.4 m) to 23.5 feet (7.2 m). Physical condition ratings by the volunteers for Trout Lake were generally characterized as "crystal clear" (Class 1) for most of the summer and recreational suitability ratings were generally characterized as "beautiful" (Class 1) for most of the summer as well.

Figure 28. Trout Lake CLMP Secchi Transparency

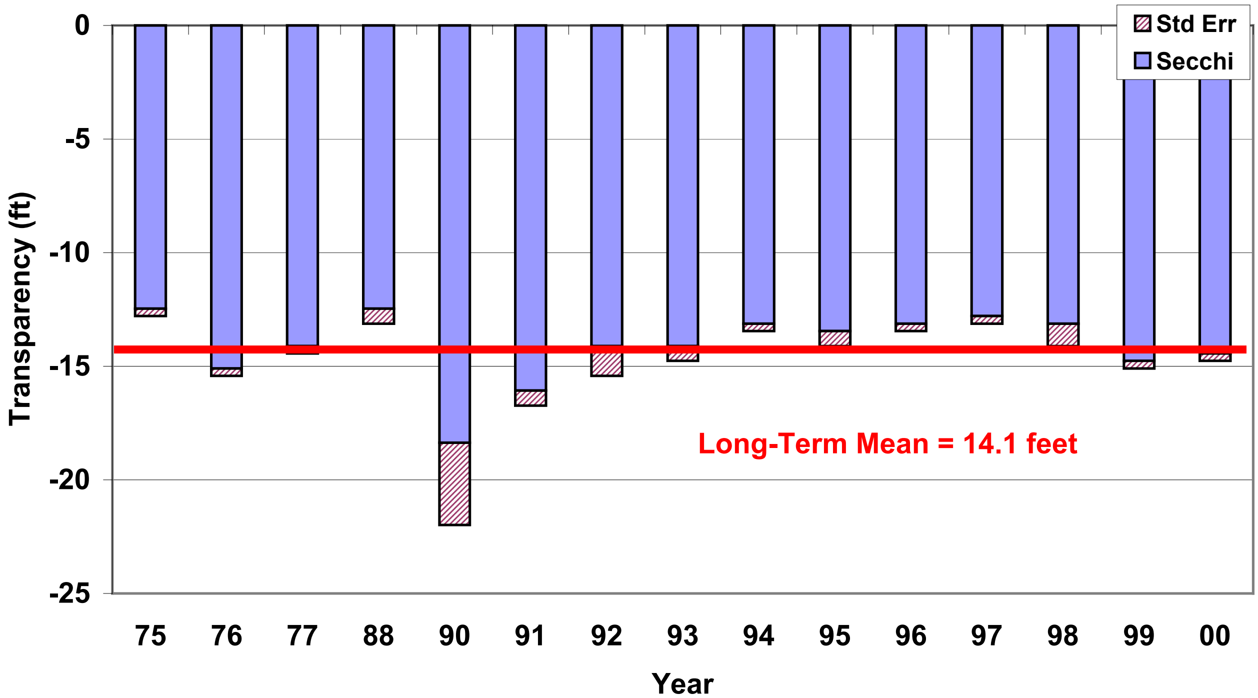


Because of its low nutrient concentrations and connnection to the Wabana Chain, Trout Lake would be very susceptible to increased eutrophication with an increase in TP loading. Every effort should be made to minimize TP loading to this lake as well. The least expensive and best opportunity for monitoring the lake to assess trends over time would be thorugh the CLMP. Current CLMP volunteers are encouraged to continue their participation.

WATER QUALITY TRENDS

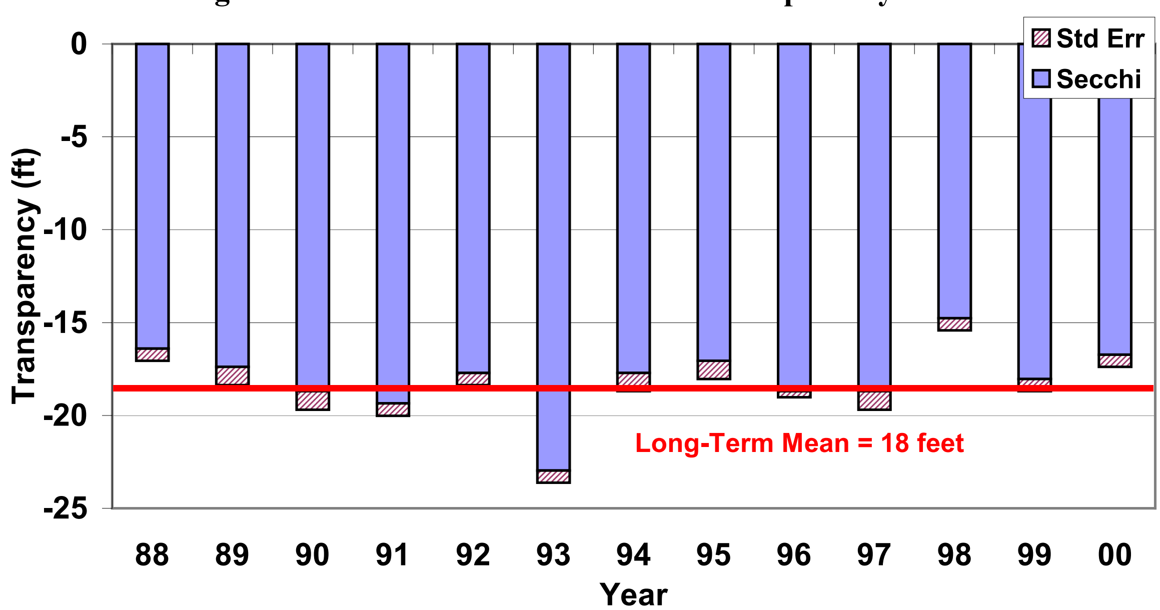
One of the primary purposes of this assessment was to evaluate possible trends in the quality of Wabana Lake over time. The best source of data for this purpose is the CLMP Secchi transparency data collected by volunteer lake monitors. A good historical data base is available for assessing trends in the transparency of Wabana, Bluewater and Trout Lakes. For Wabana Lake, these data include 15 years of Secchi data but very limited water chemistry data. Based on an analysis of 15 years of CLMP and MPCA Secchi transparency data, Wabana Lake exhibits no trend in transparency over time. Summer-mean Secchi transparency ranged from 12.5 feet (3.8 m) in 1977 to 18.4 feet (5.6 m) in 1990 and 13.5 feet (4.1 m) in 1995 to 16 feet (4.9 m) in 1991 (Figure 29). For Wabana Lake, very little year-to-year variability (± 1 – 2 ft) is evidenced in the data. This amount of variation is typical for Minnesota lakes with no distinct long-term trend at this time.

Figure 29. Wabana Lake Historic Secchi Transparency Data



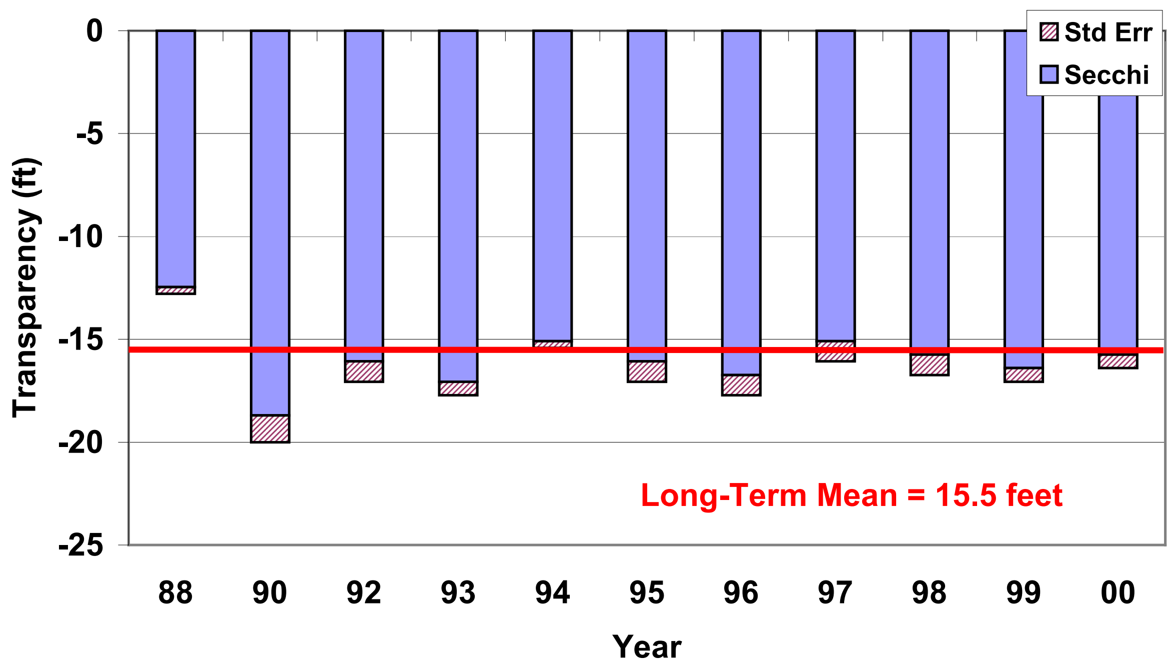
For Bluewater Lake, these data include 13 years of Secchi data and very limited water chemistry data. Based on available CLMP and MPCA Secchi transparency data, Bluewater Lake exhibits no trend in transparency over time. Summer-mean Secchi transparency ranged from 23 feet (7 m) in 1993 to 14.8 feet (4.5 m) in 1998 (Figure 30). For Bluewater Lake, some year-to-year variability (± 1 – 2 ft) is evidenced in the data. This amount of variation is typical for Minnesota lakes.

Figure 30. Bluewater Historic Secchi Transparency Data



For Trout Lake, these data include 11 years of Secchi data and very limited water chemistry data. Based on available CLMP and MPCA Secchi transparency data, Trout Lake exhibits no trend in transparency over time. Summer-mean Secchi transparency ranged from 18.7 feet (5.7 m) in 1990 to 12 feet (3.7 m) in 1988 (Figure 31). For Trout Lake, minimal year-to-year variability (± 1 – 2 ft) is evidenced in the data. This amount of variation is typical for Minnesota lakes exhibiting no trend.

Figure 31. Trout Historic Secchi Transparency Data



MODELING

Two lake water quality models were used to estimate the water quality of the Wabana Chain based on morphometry and watershed characteristics. These models provide a means to compare the measured water quality of the lake relative to the predicted water quality. The first model, MINLEAP, predicted a summer-mean phosphorus (P) concentration of 11 µg/L; which is slightly lower, than the observed summer-mean of 14.7 µg/L for Little Wabana Lake (Table 4). This model also estimated a phosphorus loading of ~ 15 kg P/year and a water residence time of about 17.6 years. A regression model within MINLEAP, Vighi and Chiaudani (1985), predicted a background P concentration of 15.3 µg/L for Little Wabana, which is comparable to the 2000 summer-mean P of 14.7 µg/L. We treated the Wabana Chain of Lakes (WCOL) as a large, single lake for modeling purposes. MINLEAP predicted a summer-mean P concentration of 11 µg/L for the WCOL; while Vighi and Chiaudani predicted 16 µg/L (Table 4). Both model results are quite comparable to the observed results for the chain; which suggests that the WCOL is near background conditions. MINLEAP also estimated phosphorus loading at 901 kg P/yr, and a water residence time of 13.5 years for the chain.

Table 4. MINLEAP MODEL RESULTS

Parameter	Little Wabana (Observed)	Little Wabana (Predicted)	Wabana Chain (Obs)	Wabana Chain (Pred)
TP (μg/L)	14.7 ± 1.5	11 ± 4	9 ± 1	11 ± 4
chl-a (μg/L)	3.8 ± 0.8	2.1 ± 1.5	2.1 ± 0.5	2.3 ± 1.6
% chl-a >20 μg/L	0	0	0	0
% chl-a >30 μg/L	0	0	0	0
Secchi (meters)	3.7 ± 1.5	5 ± 2.2	4 ± 0.2	4.7 ± 2.1
P loading (kgP/yr)	-	15	-	901
P retention (%)	-	84	-	81
P inflow conc.(μg/L)	-	68	-	62
water load (m/yr)	-	0.52	-	0.85
outflow vol. (hm^3/yr)	-	0.22	-	14.58
background P (μg/L)	-	15.3	-	16.3
residence time (yrs)	-	17.6	-	13.5

Reckhow-Simpson model was used to estimate the water quality of Little Wabana Lake and the WCOL. For Reckhow-Simpson modeling, estimates of precipitation, runoff and evaporation for the watersheds were used. P-loading to the lake was estimated based on land use composition (Appendix 4), as provided by the Itasca Soil and Water Conservation District (SWCD) and export coefficients. The Reckhow and Simpson model provides a basis for estimating water and nutrient budgets for the lakes using a combination of runoff and P export coefficients based on land use in the watershed. Estimates for P and water loading were made as follows:

1. *P export coefficients* - standard coefficients based on the literature and past experience were used.
2. *Precipitation* - was estimated based on 2000 water year data and runoff was estimated from statewide isopleth maps.
3. *Atmospheric coefficients* – estimated at 20 kg/km^2/yr.
4. *Septic Systems* – based on the number of seasonal and annual residences, standard per capita loading rate, and a soil retention coefficient of 70 (low) – 90 (high) percent.

The "low" range of P export coefficients provided the best estimate of in-lake P for Little Wabana Lake (14 μg/L predicted vs. 14.7 μg/L observed, Table 5). This yielded an estimated P-loading rate of 22 – 31 kg P/yr. Based on a P-loading rate of 22 – 31 kg P/yr, the model estimates that watershed sources could potentially contribute about 42 – 45 percent; precipitation on the lake could contribute about 29 – 41 percent; and septic systems could *potentially* contribute about 14 – 29 percent (Table 6). The predicted loading rate seems to be a reasonable estimate of the P-loading generated from this watershed. As is common for lakes with small, forested watersheds, precipitation on the lake is an important source of P. For Little Wabana, it is roughly equivalent to the P-load from the watershed. In this small watershed, P-loading from septic systems can be a significant but manageable source of P to the lake. The validity of these estimates is somewhat contingent on the model accurately predicting the in-lake P concentration of the lake.

Table 5. Reckhow-Simpson Model Comparisons for L. Wabana and the WCOL

2000 Observed L. Wabana	"LOW" Reckhow-Simpson (L. Wabana)	"HIGH" Reckhow-Simpson (L. Wabana)	2000 Observed WCOL	"LOW" Reckhow-Simpson (WCOL)	"HIGH" Reckhow-Simpson (WCOL)
14.7 ± 1.5 µg/L	14 µg/L	17 µg/L	9 ± 1 µg/L	12 µg/L	13 µg/L

Table 6. Potential P-Loading Sources % Contribution for Little Wabana and the WCOL

Potential Source	Estimated Relative Percent Contribution L. WABANA	Estimated Relative Percent Contribution WABANA CHAIN
Watershed	**42 – 45**	**59 – 61**
Precipitation	**29 – 41**	**34 – 37**
Septics	**14 – 29**	**2 – 7**

The "low" range of P export coefficients also provided the best estimate of in-lake P for the WCOL (12 µg/L predicted vs. 9 µg/L observed, Table 5). This yielded an estimated P- loading rate of 933 – 1,011 kg P/yr. Based on this P-loading rate, the model estimates that watershed sources could potentially contribute about 59 – 61 percent; precipitation on the lake could contribute about 34 – 37 percent; and septic systems could *potentially* contribute about 2 – 7 percent (Table 6). The predicted loading rate seems to be a reasonable estimate of the P-loading generated from this watershed. This assumes that the majority of septic systems are up to code, properly maintained with a soil/system retention of 90 percent. If this is not the case, the relative contribution may be greater. Because of the large surface area of the combined chain of lakes, atmospheric deposition and precipitation are a large potential source of P-loading to the chain.

Overall comparisons between the various models suggests that the Little Wabana Lake and the WCOL are producing as much algae as expected based on the available nutrients and potential nutrient sources. For Little Wabana and the WCOL, Vighi and Chiaudani model comparisons suggest that both systems are near background conditions. Watershed and precipitation sources are nearly equivalent in their overall relative potential for P-loading contribution. Septic systems are a *potential* but manageable source of P-loading.

Appendix

1. **Glossary**

2. **Water Quality Abbreviations, Units, and Data**

3. **Lake Level Data**

4. **Watershed and Land Use Information**

Appendix 1. Glossary

Acid Rain: Rain with a higher than normal acid range (low pH). Caused when polluted air mixes with cloud moisture. Can make lakes devoid of fish.

Algal Bloom: An unusual or excessive abundance of algae.

Alkalinity: Capacity of a lake to neutralize acid.

Bioaccumulation: Build-up of toxic substances in fish flesh. Toxic effects may be passed on to humans eating the fish.

Biomanipulation: Adjusting the fish species composition in a lake as a restoration technique.

Dimictic: Lakes which thermally stratify and mix (turnover) once in spring and fall.

Ecoregion: Areas of relative homogeneity. EPA ecoregions have been defined for Minnesota based on land use, soils, landform, and potential natural vegetation.

Ecosystem: A community of interaction among animals, plants, and microorganisms, and the physical and chemical environment in which they live.

Epilimnion: Most lakes form three distinct layers of water during summertime weather. The epilimnion is the upper layer and is characterized by warmer and lighter water.

Eutrophication: The aging process by which lakes are fertilized with nutrients. *Natural eutrophication* will very gradually change the character of a lake. *Cultural eutrophication* is the accelerated aging of a lake as a result of human activities.

Eutrophic Lake: A nutrient-rich lake – usually shallow, "green" and with limited oxygen in the bottom layer of water.

Fall Turnover: Cooling surface waters, activated by wind action, sink to mix with lower levels of water. As in spring turnover, all water is now at the same temperature.

Hypolimnion: The bottom layer of lake water during the summer months. The water in the hypolimnion is denser and much colder than the water in the upper two layers.

Lake Management: A process that involves study, assessment of problems, and decisions on how to maintain a lake as a thriving ecosystem.

Lake Restoration: Actions directed toward improving the quality of a lake.

Lake Stewardship: An attitude that recognizes the vulnerability of lakes and the need for citizens, both individually and collectively, to assume responsibility for their care.

Limnetic Community: The area of open water in a lake providing the habitat for phytoplankton, zooplankton and fish.

Littoral Community: The shallow areas around a lake's shoreline, dominated by aquatic plants. The plants produce oxygen and provide food and shelter for animal life.

Mesotrophic Lake: Midway in nutrient levels between the eutrophic and oligotrophic lakes

Nonpoint Source: Polluted runoff – nutrients and pollution sources not discharged from a single point: e.g. runoff from agricultural fields or feedlots.

Oligotrophic Lake: A relatively nutrient- poor lake, it is clear and deep with bottom waters high in dissolved oxygen.

pH Scale: A measure of acidity.

Photosynthesis: The process by which green plants produce oxygen from sunlight, water and carbon dioxide.

Phytoplankton: Algae – the base of the lake's food chain, it also produces oxygen.

Point Sources: Specific sources of nutrient or polluted discharge to a lake: e.g. stormwater outlets.

Polymictic: A lake which does not thermally stratify in the summer. Tends to mix periodically throughout summer via wind and wave action.

Profundal Community: The area below the limnetic zone where light does not penetrate. This area roughly corresponds to the hypolimnion layer of water and is home to organisms that break down or consume organic matter.

Respiration: Oxygen consumption

Secchi Disk: A device measuring the depth of light penetration in water.

Sedimentation: The addition of soils to lakes, a part of the natural aging process, makes lakes shallower. The process can be greatly accelerated by human activities.

Spring Turnover: After ice melts in spring, warming surface water sinks to mix with deeper water. At this time of year, all water is the same temperature.

Thermocline: During summertime, the middle layer of lake water. Lying below the epilimnion, this water rapidly loses warmth.

Trophic Status: The level of growth or productivity of a lake as measured by phosphorus content, algae abundance, and depth of light penetration.

Turbidity: Particles in solution (e.g. soil or algae) which scatter light and reduce transparency.

Water Density: Water is most dense at 39 degrees F (4 degrees C) and expands (becomes less dense) at both higher and lower temperatures.

Watershed: The surrounding land area that drains into a lake, river or river system.

Zooplankton: Microscopic animals

Appendix 2. Water Quality Abbreviations, Units, and Data

DATE= yr-mo-da
SITE= sampling site ID, 100 series=MPCA, 200=CLMP, etc.
DM= sample depth in meters(0=0-2 m integrated)
TP= total phosphorus in mg/l(decimal) or ug/L as whole number
OP= total ortho-phosphorus in mg/l
DP= dissolved phosphorus in mg/l
TKN= total Kjeldahl nitrogen in mg/l
N2N3= nitrite+nitrate N in mg/l
NH4= ammonia-N in mg/l
TNTP=TN:TP ratio
PH= pH in SU (F=field, L or _=lab)
ALK= alkalinity in mg/l (lab)
TSS= total suspended solids in mg/l
TSV= total suspended volatile solids in mg/l
TSIN= total suspended inorganic solids in mg/l
TURB= turbidity in NTU (F=field)
CON= conductivity in umhos/cm (F=field, L=lab)
CL= chloride in mg/l
SI= total silica in mg/L
DO= dissolved oxygen in mg/l
TEMP= temperature in degrees centigrade
SD= Secchi disk in meters (SDF=feet)
CHLA= chlorophyll-a in ug/l
TSI= Carlson's TSI (P=TP, S=Secchi, C=Chla)
PHEO= pheophytin in ug/l
PHYS= physical appearance rating (classes=1 to 5)
REC= recreational suitability rating (classes=1 to 5)
RTP, RN2N3...= remark code; k=less than, Q=exceeded holding time

Commonly used statistical abbreviations in data printouts
NTP, NSD,....= number of observations
MTP, MSD,....= mean TP, Secchi, etc.(typically June-Sept. mean)
STP, SSD, ...= standard error of the mean for TP, Secchi, etc.
[std err = std deviation/square root of number of observations]
TPCV, SDCV, .= coefficient of variation of mean for TP, Secchi, etc.
[CV=(100*std deviation)/mean]; and is expressed as a % of the mean]

Little Wabana Lake (31-0399)

Date	Site	DEPTH	TP PPB	CHL-A PPB	PHEO PPB	TKN mg/L	CL mg/L	ALK mg/L	COLOR CU	SV SOL mg/L	SUS SOL mg/L	CACO3 mg/L	Secchi m	PC 1-5	RS 1-5	pH SU	Cond umhos/cm
5/31/00	101	0	13	3.66	0.22	0.84	1.1	70	5	1.2	1.6		5.5	1	1	8.51	133
5/31/00	101	12	34														
6/26/00	101	0		3.88	0.99	0.56	1.2	70	5	2	2.4	52	3.9	2	1	9.15	138
6/26/00	101	12															
7/19/00	101	0	15	2.68	0.92	0.55	10	78	5	1.6	1.6	48	4	2	1	8.98	137
7/19/00	101	13	46														
8/14/00	101	0	13	4.55	0.74	0.56	1.1	78	10	2	2.8	46	3	1	1	9.1	138
8/14/00	101	12	31														
9/20/00	101	0	16	4.23	< 0.32	0.59	< 1.0	82	5	1.6	1.6	47	4	2	2	9.1	121
9/20/00	101	12.5	33														

Dissolved Oxygen (mg/L)

Depth	May	June	July	Aug.	Sept.
0	9.96	11.71	9.29	9.07	9.82
-1	10.02	11.78	9.39	9.19	9.72
-2	10.06	11.86	9.5	9.02	9.68
-3	10.09	12.52	9.67	9.07	9.62
-4	9.87	12.42	9.85	9.12	9.61
-5	9.93	12.43	9.9	10.71	9.58
-6	12.96	13.82	11.28	14.16	9.5
-7	13.11	13.68	11.01	10.02	8.46
-8	12.46	13.64	10.73	7.78	6.48
-9	11.79	12.62	8.42	2.95	1.03
-10	10.6	9.53	3.85	1	0.82
-12	7.73	1.86	2.33	0.2	0.36
-13	3.33	1.64	0.36	0.12	0.3

Temperature (°C)

Depth	May	June	July	Aug.	Sept.
0	17.75	19.45	22.25	23.64	17.24
-1	17.47	19.43	22.23	23.66	17.24
-2	17.21	19.36	22.13	23.66	17.24
-3	16.98	18.23	22.03	23.65	17.24
-4	15.89	17.79	21.85	23.64	17.24
-5	13.9	17.08	20.94	21.86	17.23
-6	9.14	14.56	15.91	17.32	17
-7	8.18	10.23	12.07	12.84	15.01
-8	7.42	7.97	8.91	10.17	12.41
-9	6.84	7.22	7.75	8.44	9.99
-10	6.07	6.61	6.89	7.6	7.64
-12	5.58	5.99	6.52	6.72	6.56
-13	5.51	5.87	6.25	6.45	6.65

Wabana Lake (31-0392)

Date	**Site**	**DEPTH**	**TP PPB**	**CHL-A PPB**	**PHEO PPB**	**TKN mg/L**	**CL mg/L**	**ALK mg/L**	**COLOR CU**	**SV SOL mg/L**	**SUS SOL mg/L**	**CACO3 mg/L**	**Secchi m**	**PC 1-5**	**RS 1-5**	**pH SU**	**Cond umhos/cm**
5/31/00	101	0	8	1.92	< 0.20	0.38							3.5	1	1	8.23	213
5/31/00	101	18	12														
6/26/00	101	0	17	2.7	< 0.20	0.37							4.1	2	1	8.91	209
6/26/00	101	28	22														
7/19/00	101	0	8	2.22	0.69	0.33							4.2	2	1	8.83	204
7/19/00	101	30	16														
8/15/00	101	0	9	3.2	0.45	0.38							2.8	1	1	8.53	198
8/15/00	101	28	12														
9/20/00	101	0	9	3.72	< 0.32	0.34							4.2	2	2	8.69	196
9/20/00	101	30	8														
5/31/00	102	0	9	1.74	0.21	0.38							4	1	1	8.51	213
5/31/00	102	11															
6/26/00	102	0	10	2.1	< 0.2	0.27	1.4	110	5	1.2	1.2	79	4.7	2	1	8.92	208
7/19/00	102	0	9	1.54	1.21	0.33	1.2	110	5	1.6	1.6	68	4.1	2	2	9.01	202
7/19/00	102	30	18														
8/15/00	102	0	8	3.3	0.34	0.34	1.1	130	10	1.6	3.2	64	2.5	1	1	8.59	195
8/15/00	102	17	9														
9/20/00	102	0	< 10	3.43	0.34	0.36						67		2	2		
5/31/00	103	0	12	2.36	< 0.2	0.5							3	1	1	8.55	219
5/31/00	103	6	20														
6/26/00	103	0	12	2.98	< 0.2	0.32							3.7	2	1	8.94	212

Wabana Lake Continued.

Date	Site	DEPTH	TP PPB	CHL-A PPB	PHEO PPB	TKN mg/L	CL mg/L	ALK mg/L	COLOR CU	SV SOL mg/L	SUS SOL mg/L	CACO3 mg/L	Secchi m	PC 1-5	RS 1-5	pH SU	Cond umhos/cm
6/26/00	103	6	11														
7/19/00	103	0	10	1.6	0.25	0.44							4.3	2	2	8.96	208
7/19/00	103	6	15														
8/15/00	103	0	11	4.55	< 0.20	0.39							3.3	1	1	8.46	204
8/15/00	103	6	10														
9/20/00	103	0	14	5.86	0.35	0.38							2.9	2	2	8.65	204
9/20/00	103	5	12														

Dissolved Oxygen (mg/L) Site 101

Depth	May 31	June 26	July 19	Aug. 15	Sept. 20
0	9.71	11.65	8.89	8.22	8.64
-1	9.66	11.61	8.8	8.19	8.63
-2	9.83	11.68	8.86	8.15	8.56
-3	9.99	11.66	8.74	8.12	8.56
-4	10.1	11.71	8.88	8.15	8.59
-5	10.18	11.65	8.85	7.98	8.56
-6	10.1	11.52	8.74	7.93	8.54
-7	9.96	11.08	8.82	7.91	8.53
-8	10.01	10.72	7.85	4.99	8.49
-9	10.35	10.49	7.09	4.4	8.43
-10	10.37	10.29	6.82	4.17	2.76
-11	10.33				
-12	10.22	9.66	6.63	4.17	1.93
-14	9.91	9.13	6.33	3.81	1.61
-16	8.86	8.85	5.89	4.06	1.23
-18	8.69	8.56	5.13	3.62	0.66
-20	7.67	8.23	4.87	2.85	0.32
-22		7.52	4.68	2.1	
-24		7.24	4.47	1.51	0.31
-26		6.84	4.04	1.25	
-28		6.66	3.56	0.85	0.25
-29		6.39	3.2	0.51	

Temperature (^oC)

Depth	May 31	June 26	July 19	Aug. 15	Sept. 20
0	16.85	18.58	21.58	22.76	16.88
-1	16.86	18.59	21.6	22.75	16.88
-2	16.84	18.55	21.26	22.77	16.88
-3	16.76	18.51	21.17	22.71	16.88
-4	16.69	18.36	21.1	22.69	16.87
-5	15.59	18.15	21.03	22.6	16.87
-6	14.76	17.5	20.84	22.54	16.87
-7	14.73	16.31	20.4	22.48	16.86
-8	13.77	16.05	18.5	18.73	16.88
-9	11.11	15.5	15.61	16.04	16.82
-10	9.4	12.23	13.12	12.64	11.05
-11	8.13				
-12	7.32	7.96	9.09	10.75	8.33
-14	6.46	6.96	7.81	9.16	7.1
-16	6.11	6.41	6.73	7.97	6.43
-18	6.01	5.99	6.25	6.5	6.14
-20	5.66	5.72	5.99	6.15	5.89
-22		5.74	5.93	6.02	
-24		5.69	5.87	5.89	5.87
-26		5.59	5.74	5.83	
-28		5.57	5.71	5.77	5.84
-29		5.56	5.68	5.72	

Dissolved Oxygen (mg/L) Site 102

Depth	May 31	June 26	July 19	Aug. 15	Sept. 20
0	9.68		8.96	7.99	
-1	9.48		8.76	7.99	
-2	9.59		8.6	7.98	
-3	9.55		8.53	7.94	
-4	9.56		8.51	8.12	
-5	9.76		8.53	7.92	
-6	9.73		8.36	7.91	
-7	9.75		8.48	7.83	
-8	10.11		8.11	6.53	
-9	10.26		7.16	4.6	
-10	10.46		6.88	3.87	
-12	10.58		7.41	5.13	
-14	9.66		7.06	4.5	
-16	9.55		7.16	4.89	

Temperature (^oC)

Depth	May 31	June 26	July 19	Aug. 15	Sept. 20
0	16.9		21.79	22.6	
-1	16.91		21.8	22.6	
-2	16.87		21.81	22.6	
-3	16.79		21.82	22.58	
-4	16.27		21.81	22.57	
-5	15.64		21.64	22.55	
-6	14.96		20.85	22.54	
-7	14		20.36	22.5	
-8	11.86		18.1	21.9	
-9	10.05		15.52	15.87	
-10	8.83		13.01	13.25	
-12	6.89		8.08	9.05	
-14	6.2		6.85	7.19	
-16	5.83		6.11	6.49	

Dissolved Oxygen (mg/L) Site 102

Depth	May 31	June 26	July 19	Aug. 15	Sept. 20
-18	9.14		6.6	4.72	
-20	8.97		6.08	0.82	
-22	8.94		5.68		
-24	8.83		5.58		
-26	8.58		5.18		
-28	8.42		4.33		
-29	8.08		3.81		

Temperature (^oC) Continued.

Depth	May 31	June 26	July 19	Aug. 15	Sept. 20
-18	5.52		5.71	5.93	
-20	5.36		5.5	6	
-22	5.27		5.37		
-24	5.16		5.28		
-26	5.11		5.23		
-28	5.12		5.18		
-29	5.08		5.16		

Dissolved Oxygen (mg/L) Site 103

Depth	May 31	June 26	July 19	Aug. 15	Sept. 20
0	10.01	12.14	8.87	7.66	8.95
-1	9.43	11.56	8.68	7.65	8.87
-2	9.49	11.58	8.59	7.71	8.85
-3	9.63	11.62	8.55	7.68	8.81
-4	9.69	11.55	8.46	7.72	8.83
-5	9.12	11.56	8.4	7.69	8.83
-6	6.78	9.7	3.5	7.56	8.2
-7	2.56	7.77		1.55	3.68
-8				0.65	

Temperature (^oC)

Depth	May 31	June 26	July 19	Aug. 15	Sept. 20
0	17.84	19.31	22.25	22.95	17.05
-1	17.89	19.32	22.27	22.95	17.07
-2	17.89	19.34	22.25	22.93	17.06
-3	17.85	19.31	22.22	22.92	17.08
-4	15.63	19.3	22.21	22.91	17.08
-5	14.78	19.23	22.17	22.88	17.1
-6	12.33	19.06	17.92	22.83	17.09
-7	10.07	16.64		17.79	16.83
-8				15.41	

Wabana CLMP Data Site 201

Date	Time	Secchi (ft)	PC	RS
5/12/00	0001	14.5	2	1
5/23/00	0001	14.5	2	1
6/4/00	0001	15	2	1
6/23/00	0001	14.5	2	1
6/30/00	0001	14.5	2	1
7/6/00	0001	15	2	1
7/14/00	0001	14.5	2	1
7/21/00	0001	15	3	1
8/3/00	0001	15	3	1
8/12/00	0001	14.5	2	1
8/20/00	0001	14	3	1
9/3/00	0001	13.5	3	1
9/14/00	0001	13.5	3	1
9/21/00	0001	13.5	3	1
9/29/00	0001	13.5	3	1

Wabana CLMP Data Site 205

Date	Time	Secchi (ft)	PC	RS
5/21/00	1500	15	2	2
6/11/00	1300	15	2	2
6/19/00	1245	15	2	2
6/24/00	1400	17.5	2	2

Wabana CLMP Data Site 205 Continued.

Date	Time	Secchi (ft)	PC	RS
7/3/00	1430	18	2	2
7/10/00	1430	19	2	2
7/17/00	1300	19	2	2
7/24/00	1300	17	2	2
7/31/00	1100	16	2	2
8/8/00	1130	11	2	2
8/16/00	1130	10.5	2	2
8/23/00	1300	11.5	2	2
8/29/00	1300	12.5	2	2
9/4/00	1400	14	2	2

Wabana CLMP Data Site 206

Date	Time	Secchi (ft)	PC	RS
6/30/00	1030	21	1	1
7/9/00	1115	20	1	1
8/10/00	1005	13	1	1
8/22/00	1115	13	1	1
8/29/00	1030	15	1	1
9/4/00	1030	15	1	1
9/21/00	1100	16	1	1
9/25/00	1045	16	1	1
10/10/00	1030	15	1	1
10/19/00	1400	16.5	1	1

Wabana Historical Data

LAKEID	YR	TP	STP	NTP	SDM	SSD	NS	CHLA	SCHLA	NC	CHLANC	NCNC	TKN	N2N3	CL	MTSIP	MTSIS	MTSIC	MTSI
31-0392	75	.	.	0	3.8	0.1	17	.	.	0	.	0	.	.	.	.	41	.	41
31-0392	76	.	.	0	4.6	0.1	17	.	.	0	.	0	.	.	.	.	38	.	38
31-0392	77	.	.	0	4.3	0.1	17	.	.	0	.	0	.	.	.	.	39	.	39
31-0392	88	16	3	9	3.8	0.2	12	3.6	1	9	.	0	0.4	0	0.9	43	41	40	41
31-0392	90	.	.	0	5.6	1.1	2	.	.	0	.	0	.	.	.	.	35	.	35
31-0392	91	10	4	15	4.9	0.2	15	3.4	0.7	14	.	0	0.3	0	0.8	26	37	41	34
31-0392	92	.	.	0	4.3	0.4	14	.	.	0	.	0	.	.	.	.	39	.	39
31-0392	93	.	.	0	4.3	0.2	12	.	.	0	.	0	.	.	.	.	39	.	39
31-0392	94	.	.	0	4	0.1	13	.	.	0	.	0	.	.	.	.	40	.	40
31-0392	95	.	.	0	4.1	0.2	8	.	.	0	.	0	.	.	.	.	40	.	40
31-0392	96	.	.	0	4	0.1	9	.	.	0	.	0	.	.	.	.	40	.	40
31-0392	97	.	.	0	3.9	0.1	9	.	.	0	.	0	.	.	.	.	41	.	41
31-0392	98	.	.	0	4	0.3	8	.	.	0	.	0	.	.	.	.	40	.	40
31-0392	99	.	.	0	4.5	0.1	25	.	.	.	.	.	.	.	.	.	38	.	38
31-0392	00	10.6	0.7	14	4.4	0.1	45	3.1	0.3	14	.	.	0.4	.	1.2	38	39	42	40

Bluewater Lake (31-0395)

Date	Site	DEPTH	TP PPB	CHL-A PPB	PHEO PPB	TKN mg/L	CACO3 mg/L	Secchi m	PC 1-5	RS 1-5	pH SU	Cond umhos/cm
5/31/00	102	0	8	0.88	< 0.20	0.38		5.75	1	1	8.46	258
5/31/00	102	19	16									
6/26/00	102	0	5	0.65	< 0.23	0.24	95	5.6	1	1	8.93	255
6/26/00	102	17	14									
7/19/00	102	0	6	0.68	0.31	0.28	82	4.3	1	1	8.82	247
7/19/00	102	30	17									
8/15/00	102	0	9	2.03	< 0.23	0.27	77	3.8	1	1	8.41	246
8/15/00	102	19	18									
9/20/00	102	0	7	2.56	< 0.32	0.26	75	2.5	2	2	8.78	229
9/20/00	102	20	12									

Dissolved Oxygen (mg/L) Site 102

Depth	May 31	June 26	July 19	Aug. 15	Sept. 20
0	9.5	11.93	8.78	8.37	9.86
-1	9.4	11.6	8.74	8.4	9.94
-2	9.4	11.66	8.77	8.52	9.92
-3	9.45	11.59	8.73	8.56	10.07
-4	9.38	11.99	8.79	8.45	9.9
-5	9.47	12.04	9.12	8.41	9.93
-6	9.94	12.35	10.37	8.48	9.78
-7	11.68	14.02	11.6	9.47	9.87
-8	12.11	15.96	13.03	13.14	9.88
-9	11.79	15.49	13.74	12.96	10.34
-10	10.85	15.48	12.69	11.91	9.79
-12	9.84	12.36	10.41	8.64	6.79
-14	9.26	11.81	8.29	7	5.78
-16	8.76	10.06	6.98	5.47	4.46
-18	8.12	8.79	5.9	4.28	3.31
-20	7.23		5.55	3.35	2.82
-22			5.27		1.79
-24			4.79		
-26			4.43		
-28					

Temperature (^oC)

Depth	May 31	June 26	July 19	Aug. 15	Sept. 20
0	17.14	18.99	21.89	23.14	17.18
-1	17.17	18.98	21.9	23.13	17.18
-2	17.17	18.97	21.88	23.11	17.19
-3	16.99	18.9	21.84	23.07	17.19
-4	16.64	18.01	21.55	22.94	17.19
-5	16.24	17.54	21.29	22.9	17.18
-6	14.69	16.69	20.12	22.9	17.17
-7	10.45	15.6	16.91	22.11	17.14
-8	7.39	11.22	14.19	15.31	17.03
-9	7	8.87	10.89	11.09	16.01
-10	6.41	7.21	8.6	9.1	10.46
-12	5.91	6.42	6.98	7.54	7.39
-14	5.71	6.15	6.5	7.01	7.2
-16	5.64	5.97	6.27	6.59	7.07
-18	5.57	5.94	6.18	6.45	6.8
-20	5.51		6.1	6.29	6.7
-22			6.07		6.58
-24			6.05		
-26			6.01		
-28					

CLMP Data for Site 202

Date	Time	Secchi (ft)
5/15/00	1400	15
5/16/00	1300	16
5/20/00	1230	18
5/29/00	1300	20
6/5/00	1430	20
6/11/00	1330	21
6/20/00	1200	21.5
6/24/00	1330	21
6/30/00	1130	20
7/12/00	1200	22

CLMP Data for Site 202 Continued.

Date	Time	Secchi (ft)
7/18/00	1400	22
7/26/00	1230	19
8/9/00	1300	15
8/15/00	1330	14
8/26/00	1230	13
9/8/00	1400	12

CLMP Data for Site 203 Continued.

Date	Time	Secchi (ft)
4/25/00	1000	13
5/4/00	1500	13.5
5/19/00	1015	18.5
5/25/00	1015	21.5
5/29/00	1500	21
6/8/00	1145	19.5
6/18/00	1100	17
6/29/00	1100	21.5
7/3/00	1300	20
7/21/00	1130	19.5
7/26/00	1500	19.5
8/3/00	1500	16
8/8/00	1000	16
8/12/00	1330	14.5
8/19/00	1000	12
8/25/00	1500	12
9/2/00	1100	10.5
9/13/00	1100	11

Bluewater Historical Data

LAKEID	YR	TP	STP	NTP	SDM	SSD	NS	CHLA	SCHLA	NC	CHLANC	NCNC	TKN	N2N3	CL	MTSIP	MTSIS	MTSIC	MTSI
31-0395	88	15	3	6	5	0.2	19	1.6	0.4	6	.	0	0.3	0	0.7	42	37	31	36
31-0395	89	.	.	0	5.3	0.3	13	.	.	0	.	0	.	.	.	.	36	.	36
31-0395	90	.	.	0	5.7	0.3	11	.	.	0	.	0	.	.	.	.	35	.	35
31-0395	91	2	0	2	5.9	0.2	14	0.6	0.1	2	.	0	0.3	.	.	14	34	25	33
31-0395	92	.	.	0	5.4	0.2	20	.	.	0	.	0	.	.	.	.	36	.	36
31-0395	93	.	.	0	7	0.2	18	.	.	0	.	0	.	.	.	.	32	.	32
31-0395	94	.	.	0	5.4	0.3	15	.	.	0	.	0	.	.	.	.	36	.	36
31-0395	95	.	.	0	5.2	0.3	12	.	.	0	.	0	.	.	.	.	37	.	37
31-0395	96	.	.	0	5.7	0.1	12	.	.	0	.	0	.	.	.	.	35	.	35
31-0395	97	.	.	0	5.7	0.3	10	.	.	0	.	0	.	.	.	.	35	.	35
31-0395	98	.	.	0	4.5	0.2	14	.	.	0	.	0	.	.	.	.	38	.	38
31-0395	99	.	.	0	5.5	0.2	26	.	.	0	.	0	.	.	.	.	35	.	35
31-0395	00	7	0.9	4	5.1	0.2	29	1.5	0.5	4	.	0	0.3	.	.	32	37	35	35

Trout Lake (31-0410)

Date	Site	DEPTH	TP PPB	CHL-A PPB	PHEO PPB	TKN mg/L	Secchi m	PC 1-5	RS 1-5	pH SU	Cond umhos/cm
5/31/00	101	0	7	0.96	< 0.2	0.28	6.1	1	1	8.23	231
5/31/00	101	25	10								
6/26/00	101	0	12	1	< 0.2	0.28	5.6	1	1	8.81	229
6/26/00	101	20	56								
7/19/00	101	0	6	0.92	< 0.2	0.24	3.3	1	1	8.64	222
7/19/00	101	30	7								
8/15/00	101	0	9	1.58	0.41	0.26	3.8	1	1	8.47	213
8/15/00	101	27	35								
9/20/00	101	0	8	2.72	< 0.32	0.27	too windy	2	2	too windy	too windy

Dissolved Oxygen (mg/L) Site 103

Depth	May 31	June 26	July 19	Aug. 15	Sept. 20
0	9.51		9.21	8.56	
-1	9.49		8.84	8.62	
-2	9.56		8.76	8.62	
-3	9.81		8.66	8.62	
-4	9.92		8.65	8.6	
-5	10.03		8.6	8.57	
-6	10.09		8.54	8.53	
-7			8.94	8.51	
-8	10.19		9.63	8.81	
-9	10.6		10.2	10.23	
-10	11.14		10.96	10.95	
-12	11.01		10.86	9.61	
-14	10.74		9.77	8.87	
-16	10.4		9.19	8.45	
-18	10.07		8.28	7.7	
-20	9.73		7.81	6.41	
-22	9.41		7.49	5.23	
-24	9.2		7.29	4.23	
-26	9.19		7.27	4.05	
-27	8.89				
-28			6.79	3.92	
-29			6.52		

Temperature (^{o}C)

Depth	May 31	June 26	July 19	Aug. 15	Sept. 20
0	16.32		21.48	22.46	
-1	16.21		21.45	22.49	
-2	16.14		21.42	22.48	
-3	15.63		21.35	22.47	
-4	15.52		21.31	22.47	
-5	15.2		21.26	22.44	
-6	14.35		21.22	22.43	
-7			20.79	22.43	
-8	13.65		17.78	22.13	
-9	10.6		15.45	16.71	
-10	8.76		12.21	13.1	
-12	7.25		8.7	9.05	
-14	6.75		7.83	7.99	
-16	6.34		7.23	7.42	
-18	6.04		6.76	7.02	
-20	5.92		6.48	6.66	
-22	5.88		6.41	6.42	
-24	5.81		6.29	6.31	
-26	5.76		6.14	6.26	
-27	5.73				
-28			6.01	6.26	
-29			5.97		

CLMP Data for Site 202

Date	Time	Secchi (ft)	PC	RS
5/16/00	1115	16	1	1
6/4/00	1045	15	1	1
6/25/00	1445	19	1	1
7/3/00	1115	21	1	1
7/15/00	1115	17	1	1
7/22/00	1030	18	1	1
8/5/00	1030	16.5	1	1
8/13/00	1100	17	1	1
8/21/00	1115	16.5	1	1

CLMP Data for Site 202 Continued.

Date	Time	Secchi (ft)	PC	RS
8/27/00	1115	17	1	1
9/4/00	1515	18	1	1
9/11/00	1115	17	1	1
9/18/00	1115	17	1	1
9/28/00	1230	15	1	1
10/16/00	1400	14	1	1

CLMP Data for Site 203

Date	Time	Secchi (ft)	PC	RS
5/16/00	1130	17	1	1
6/4/00	1145	18	1	1
6/25/00	1500	21	1	1
7/3/00	1100	22	1	1
7/15/00	1100	15	1	1
7/22/00	1045	14.5	1	1
8/5/00	1045	12	1	1
8/13/00	1115	14.5	1	1
8/21/00	1100	13	1	1
8/27/00	1130	12	1	1
9/4/00	1530	11	1	1
9/11/00	1130	11	1	1
9/18/00	1130	11	1	1
9/28/00	1300	11.5	1	1
10/16/00	1415	14	1	1

CLMP Data for Site 204

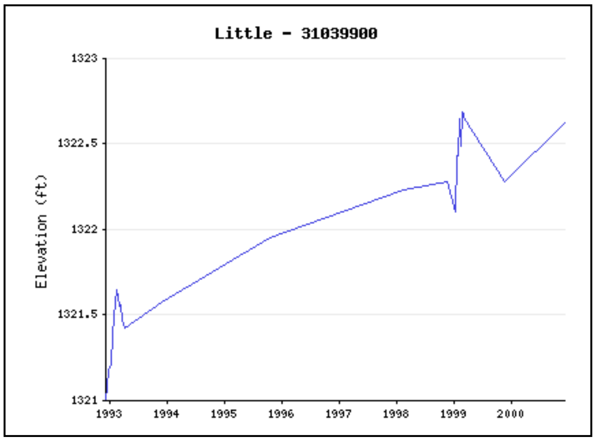
Date	Time	Secchi (ft)	PC	RS
5/14/00	1315	21	1	2
6/11/00	1322	21	1	2
7/3/00	1231	23.5	1	2
7/23/00	1331	17	1	2
7/30/00	1200	15.5	2	2
8/6/00	1347	12	2	2
8/12/00	1230	16	2	2
8/27/00	1243	11	2	2
9/14/00	1310	12	2	2
10/7/00	1245	11.5	2	2
10/20/00	1320	18	1	2

Trout Lake Historical Data

LAKEID	YR	TP	STP	NTP	SDM	SSD	NS	CHLA	SCHLA	NC	CHLANC	NCNC	TKN	N2N3	CL	MTSIP	MTSIS	MTSIC	MTSI
31-0410	88	13	2	6	3.8	0.1	15	2	0.5	6	.	0	0.3	0	0.7	40	41	36	40
31-0410	90	.	.	0	5.7	0.4	5	.	.	0	.	0	.	.	.	.	35	.	35
31-0410	91	5	.	1	3.3	.	1	1.1	.	1	.	0	0.3	.	.	27	43	32	34
31-0410	92	.	.	0	4.9	0.3	13	.	.	0	.	0	.	.	.	.	37	.	37
31-0410	93	.	.	0	5.2	0.2	28	.	.	0	.	0	.	.	.	.	37	.	37
31-0410	94	.	.	0	4.6	0.1	29	.	.	0	.	0	.	.	.	.	38	.	38
31-0410	95	.	.	0	4.9	0.3	16	.	.	0	.	0	.	.	.	.	37	.	37
31-0410	96	.	.	0	5.1	0.3	14	.	.	0	.	0	.	.	.	.	37	.	37
31-0410	97	.	.	0	4.6	0.3	16	.	.	0	.	0	.	.	.	.	39	.	39
31-0410	98	.	.	0	4.8	0.3	17	.	.	0	.	0	.	.	.	.	38	.	38
31-0410	99	.	.	0	5.0	0.2	33	.	.	0	.	0	.	.	.	.	37	.	37
31-0410	00	8.8	1.3	4	4.8	0.2	37	1.6	0.4	4	.	0	0.3	.	.	36	37	35	36

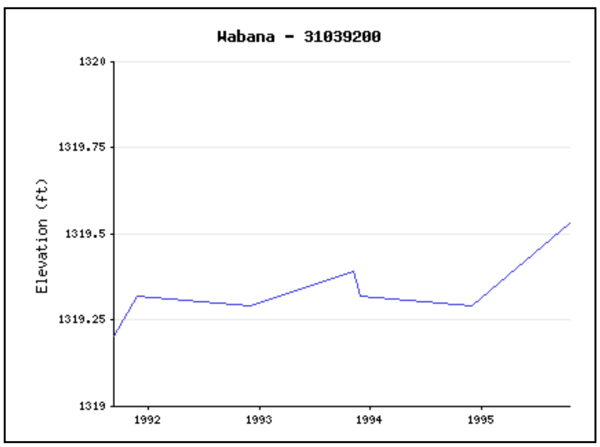
Appendix 3. Lake Level Data

Little Wabana Lake Levels



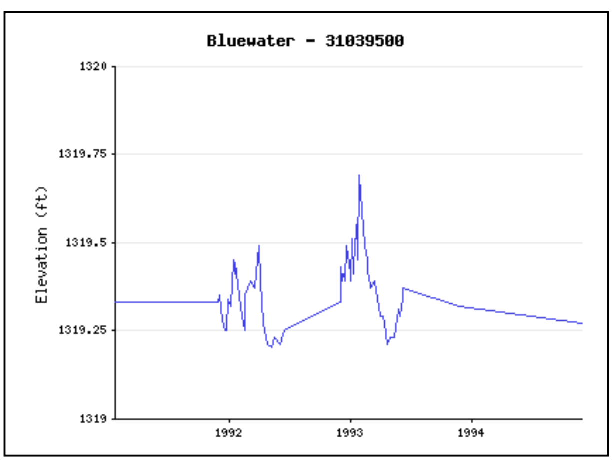
Period of Record:	5/20/93 – 5/11/00
# Readings:	25
Highest Level:	1321.95 ft (4/4/96)
Lowest Level:	96.18 ft (5/20/93)
Average Level:	146.14 ft
Recorded Range:	1225.77 ft
OHW Elevation:	None Given

Wabana Lake Levels



Period of Record:	5/30/72 – 4/4/96
# Readings:	63
Highest Level:	1319.74 ft (5/14/85)
Lowest Level:	1318.42 ft (6/8/89)
Average Level:	1319.33 ft
Recorded Range:	1.32 ft
OHW Elevation:	1320 ft (in 1929)

Bluewater Lake Levels



Period of Record:	7/9/91 – 5/19/95
# Readings:	67
Highest Level:	1319.69 ft (7/16/93)
Lowest Level:	1319.2 ft (10/25/92)
Average Level:	1319.37 ft
Recorded Range:	0.49 ft
OHW Elevation:	1320 ft (in 1929)

Trout Lake: OHW: 1320 (in 1991), Water Surface on 7/11/91 was 1319.5 ft.

Appendix 4. Watershed & Land Use Information