LAKE ASSESSMENT PROGRAM

1991

Green Lake

(I.D. #30-0136)

Isanti County, Minnesota

Minnesota Pollution Control Agency
Water Quality Division
Roger Ramthun
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SUMMARY AND RECOMMENDATIONS

Green Lake is located 10.5 miles west of Cambridge in Isanti County. The lake is basically oval shaped and has a surface area of about 800.8 acres. Land use in the watershed is primarily characterized by wetlands (~53 percent) and agriculture (~27 percent). The watershed is relatively small (19 sq. miles) compared to the surface area of the lake (15.2:1 ratio). The land use composition is fairly typical for the lakes in this region of the state - North Central Hardwood Forests ecoregion. A number of wetlands and a significant forest percentage (~9 percent) exists in the watershed which can serve to trap nutrients and sediments arising from the watershed.

Green Lake was sampled during the summer of 1991 by Minnesota Pollution Control Agency (MPCA) staff and citizens from the Green Lake Improvement Association (Association). Water quality data collected during the study indicates the lake is eutrophic with a mean total phosphorus concentration of 43 µg/L, mean chlorophyll a of 25.3 µg/L and new Secchi transparency of 4.9 feet. The total phosphorus value is on the upper range of values found in representative minimally impacted lakes in the North Central Hardwood Forests ecoregion. The chlorophyll a concentration is slightly higher than expected based on the phosphorus concentration. This may be related to the higher than normal precipitation for 1991. Higher precipitation means more runoff and higher phosphorus loading which can contribute to increased algae growth and lower Secchi transparency.

A comparison of total phosphorus, chlorophyll a and Secchi transparency from previous monitoring efforts on Green Lake suggest that total phosphorus is the limiting factor for plant growth in Green Lake.

Historical Citizen Lake Monitoring Program (CLMP) Secchi transparency reveal fluctuations in transparency from year to year. For example, the average summer transparency in 1973 was 4.1 feet, which is significantly lower than the summer average transparency measured in 1989 (5.8 feet). The 1974 water year (October 1973 - September 1974) was characterized by above normal precipitation and runoff, whereas 1989 was below the long-term norm for this part of the state. This suggests that nutrient loading (which would accompany the high runoff) from the watershed strongly influences the quality of Green Lake and the condition of the lake may be quite variable from year to year dependent on precipitation and runoff.

Two lake water quality models were used to estimate the water quality of Green Lake based on its 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 - (Table 3) predicted a total phosphorus concentration essentially equivalent to the measured concentration (43 µg/L) in Green Lake in 1991. The second model - Reckhow and Simpson - predicted a slightly lower phosphorus concentration (39 µg/L) than was measured in 1991. This model used the estimated precipitation and runoff for 1991. The low to average export values tend to bracket the 1991 TP concentration (39-51 µg/l vs. 43 measured). The loading rates from Reckhow and Simpson (998 - 1455 Kg P/yr) compare favorably to the phosphorus load predicted by MINLEAP (1,044 Kg P/yr).

Based on this study, it appears that the quality of Green Lake will vary from year to year as a function of changes in the amount of precipitation and runoff. It will be important to reduce the amount of nutrients which enter the lake from the watershed if conditions observed in a year with low precipitation and runoff are to be attained in years of average to high precipitation and runoff.

The in lake phosphorus goal for Green Lake should be less than or equal to 40 µg/l. With in lake phosphorus levels in that proximity, a mean chlorophyll a of approximately 16 µg/l should be expected. Given these conditions, nuisance algae blooms (chlorophyll a greater than 30 µg/l) would likely occur less than 10 percent of the summer, in contrast to about 25 percent of the time during the summer of 1991.

The following recommendations are based on the 1991 Lake Assessment Program (LAP) study of Green Lake.

1. It is important to note that Green Lake is sensitive to change in trophic status because it presently has relatively medium to high phosphorus and high chlorophyll a concentrations. Relatively minor increases in nutrient loading rates from the watershed or in-lake sources which would increase the in-lake phosphorus concentration can further degrade the lake (Figure 8). It is essential, therefore, that lake protection efforts be conveyed by all local government groups with land use/zoning authorities for Green Lake. The Association should be commended for their efforts to date, which include interacting with the Isanti County Soil and Water Conservation District (SWCD), conducting a septic system survey by mail,

and participating in the CLMP and in DNR's lake level program. To complement these efforts, the Association should develop a plan for protecting the water quality of the lake. The following activities could be included in the plan:

a. The Association should continue to participate in the Citizen Lake-Monitoring Program (CLMP). 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 lake. At a minimum, measurements should be taken weekly during the summer at the deepest site in each basin, e.g., site 101 in the southeastern basin, and site 102 in the west-northwest basin.

b. The Association should follow-up on the evaluation of all on-site septic systems around the lake (if this has not already been completed. The survey which was conducted had a 63 percent response rate. Of these, about 40 percent either did not respond to the question on pumping, pump at intervals of 10 years or longer or do not pump their system. Any existing system which does not meet the minimum requirements as a conforming system, as outlined in Minn. Rules ch. 7080.0600, must be upgraded to a system which meets all the current code requirements. In addition, new home construction or upgrading of a non conforming system must meet the current 7080 standards, i.e. be a code system. These steps may require assistance from Isanti County planning and zoning. See appendix #9 for an explanation of the Code System/Conforming System differences. Education of homeowners around the lake with respect to septic systems, lawn maintenance and shoreline protection will also be beneficial. Staff from the MPCA and the Minnesota Department of Natural Resources (MDNR), along with county officials, such as staff from the Agricultural Extension Office, and the Isanti County Soil and Water Conservation District and Planning and Zoning could provide assistance in this area. A Citizens' Guide to Lake Protection, a booklet, and turfgrass, fertilizer, and pesticide management fact sheets and videos are available from the MPCA WQ Division, Nonpoint Source Section, St. Paul. These materials will be a useful educational tool for the Association. The fact sheets can be copied and distributed by the Lake Association.

c. Further development in the immediate watershed of the lake should occur in such a manner as to minimize water quality impacts on the lake. Considerations such as setback provisions and septic tank regulations should be understood and strictly followed. MDNR's shoreland regulations will also be important in this regard. Also, activities in the total watershed that change drainage patterns, such as wetland removal or major alterations in lake use, should be discouraged unless they are carefully planned and adequately controlled. The Association should continue to seek representation on boards or commissions, e.g. watershed management organizations, that address land management activities so that their impact can be minimized.

The booklet, Protecting Minnesota's Waters: The Land-Use Connection, (available from the MPCA WQ Division, Nonpoint Source Section, St. Paul) may be a useful education tool in this area.

d. A more detailed examination of the possible nutrient sources such as wetland run-off, agricultural run-off, septic systems, lawn fertilizers, and the effects of ditching and draining of wetlands, etc., may aid the Association in determining areas where improvement is needed. Some of the county offices mentioned above and the MPCA Clean Lakes project will be of help in this regard.

2. The 1991 water quality of Green Lake was fair relative to other lakes in the ecoregion. It could, however, exhibit a measurable decline in transparency, increases in the amount of algae and possibly increases in the amount of rooted vegetation with a fairly small increase in in-lake total phosphorus. Changing land-use practices in the watershed provide the greatest likelihood for changes in phosphorus loading. However, internal loading of phosphorus from the lake's sediments could be an additional source of phosphorus. Excessive use of herbicides to reduce the amount of rooted vegetation may also result in some additional phosphorus for alage growth as the weeds decompose.

   Conversely, a reduction of the amount of nutrients that enter the lake may result in improved transparency and a reduction in algal concentrations. One means of reducing nutrient input is by implementing best management practices (BMPs) in the watershed (land management activities used to control nonpoint source pollution). Technical assistance in BMP implementation may be available through local resource management agencies. The Association should continue to work with the Isanti SWCD to examine land use practices in the watershed and develop strategies for reducing the transport of nutrients to the lake.

The MPCA's Clean Lakes Grant recently awarded to Isanti County for Green Lake is an opportunity for further assessment and delineation of nonpoint source nutrient contributions to the lake from the watershed. It may be in the best interest of the Association and Green Lake to continue concurrent work with the Isanti SWCD, DNR and the local townships to do as much as possible to protect the condition of the lake by means of local ordinances and education of shoreland residents in conjunction with the Clean Lakes Program efforts.

3. This LAP report serves as a foundation upon which further studies and assessments may be based. The water and nutrient income-outgo summaries were estimated based on limited amounts of monitoring data and should be considered best approximations. The next step will be to define water and nutrient sources to the lake in a much more detailed fashion via the Clean Lakes Program grant and build further upon the 1989 WRM survey, the January 21, 1985 EM, P.A. "Preliminary Report on Water Levels on Green Lake," and the other information now available. A more accurate measurement of the lake's surface area, mean depth and volume would also be required. This should be accomplished prior to implementation of in-lake restoration techniques. These detailed studies would allow the reasonably accurate estimation of total phosphorus (and ortho-phosphorus), total nitrogen (and inorganic nitrogen) and water income-outgo summaries.

LAKE ASSESSMENT PROGRAM: 1991

Green Lake

(I.D. #30-0136)

INTRODUCTION

Green Lake was sampled by the Minnesota Pollution Control Agency (MPCA) during the summer of 1991 as a part of the Lake Assessment Program (LAP). This program was 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), a cooperative examination of land use and drainage patterns in the watershed of the lake, and an assessment of the data collected by MPCA staff.

Green Lake was sampled on five occasions during the spring and summer of 1991. Participants in this effort included Steve Heiskary and Roger Ramthun from the MPCA and members of the Green Lake Improvement Association (Association). Association participants in the sampling included Bill Torkildson and Claudia Bomier. CLMP measurements were collected by Bill Torkildson and Claudia Bomier during the summer of 1991. Lake water level measurements were taken by Bill Torkildson. Rainfall data was collected by Bill Torkildson and Glenn Okan.

Land-use information for the lake's watershed was assembled by Mark Demouth from Isanti County Soil and Water Conservation District.

This study was conducted at the request of the Association, whose members were interested in identifying sources of pollution to the lake, characterizing the quality of the lake, and developing a program to assist in lake management. Data was available for Green Lake from previous MPCA surveys (during 1988 and 1989), the 1989 WRM survey, and the EM, P.A. "preliminary Report on Water Levels on Green Lake" 1985. These data and CLMP data from previous years provided a basis for assessing year-to-year fluctuations in the quality of Green Lake. The Association also conducted a septic system survey by mail. A copy of the survey form and summary of findings is included in Appendix 8.

BACKGROUND

Green Lake is located in Isanti County about 10.5 miles west of Cambridge. It has a surface area of 800.8[4] acres and a drainage area of 19 square miles[1]. The lake is basically oval shaped, has a maximum width of 6,600 feet, a maximum depth of 28 feet, and has about 23,000 feet of shoreline[1]. The littoral area (area of the lake less than 15 feet deep) is approximately 44 percent[1]. The lake has a gently sloping, sandy shoreline. Over half of the shoreline is sand ridges up to 40 feet high, the remaining shoreline ranges up to 10 feet above normal lake level[1].

Land use in the watershed is primarily characterized by wetlands (~53 percent), agricultural (~27 percent), urban (~10 percent), forest (~9 percent), and water (~1 percent). The watershed terrain varies in elevation from 920 (lake level) to 980 feet. Surface runoff is probably low because of the relatively flat terrain and pervious sandy surface soils(1). The lake has two major tributaries, Wyanett Creek on the southwest side and North Brook on the north side. The lake outlet is on the southeast side where Green Lake Brook drains to the Rum River.

Green Lake is the lowest point in the area, hence early settlers drained a lot of their wetlands to the lake and thus they were able to plant more crops. It is alleged that for over 100 years Green Lake has had agricultural runoff coming into it(3).

In the early 50's people started buying strips of land which farmers could not use. After the nicer property sold, the land in the low areas was filled in to build cabins, not realizing that Green Lake is a relief valve for the Rum River. Green Lake is only two feet above the Rum River. When the Rum River rises, and it will rise as much as nine feet, the septic systems in the low areas (about ½ of all of the shoreland property) may leach into the lake(3).

Green Lake water levels are affected by two water control structures on Green Lake Brook. A combination bridge and stoplog control structure is located at County Road 7 on the southeast shore of the lake. A box culvert equipped with a timber flap gate is located approximately three miles downstream at Minnesota Highway 47, just upstream from the Rum River. The hinged timergate is installed on the downstream side of the structure to prevent backflow from the Run River (the Rum River can rise nine feet), enter Green Lake Brook and subsequently raise lake levels(1).

In October 1991, MPCA staff was monitoring in the area and a local alleged that someone stole the stoplogs from the County Road 7 lake level control structure, and that it has been a recurring problem. The stoplog removal relates to local lake level disagreements: lakeshore owners with low property want low lake levels and those with higher property want higher lake levels. On October 27, 1984, Green Lake headwater was 922.29. There was no flow in Green Lake Brook due to no slope between Green Lake and the Rum River.

There is evidence that ground water inflow to the lake is high. However, the rate of inflow is low with respect to other factors. Consequently, ground water may be significant in maintaining minimum water levels during times of low precipitation, while having little effect on high lake stages[1].

Green Lake is located in the southeast portion of the Rum River Watershed Unit. (The minor watershed is the Green Lake Brook Watershed.) The Green Lake Watershed drains an area of 19 square miles in east-central Minnesota. Green Lake's 19 square mile watershed is relatively small compared to its surface area (~15.2:1 watershed: lake surface area).

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. Green Lake is located in the North Central Hardwood Forests ecoregion (Figure 1).

The land uses observed in the watershed of Green Lake has considerably more marsh and water acreage and less agricultural acreage compared to the typical range for this ecoregion (Table 1). Agricultural uses account for about 27 percent of the land use in this watershed. A number of wetlands and marshes are present in the Green Lake watershed (~ 53 percent). Marshes and wetlands will allow pollutants in runoff to settle out and serve to slow the flows which enter Green Lake during periods of high precipitation and runoff. Wetlands, however, can be a source of nutrients when they become anoxic (without oxygen) during the hot summer months. Then wetlands can release phosphorus to the lake, hence becoming a phosphorus contributor rather than a phosphorus sink.

The primary inlets to Green Lake are Wayanett Creek and North Brook (Figure 3). Besides these, there are three other tributaries which drain the remainder of the watershed into Green Lake. Green Lake Brook is the only outlet for the lake. The watershed of Green Lake is about nineteen square miles.

Precipitation in the Isanti County area was about eight inches above normal (Appendix 4) for the 1991 water year (October 1990 - September 1991). According to rainfall records kept by one member of the Association, 16.7 inches of precipitation was recorded near Green Lake between May 22 and September 8. Another member measured 19.3 inches from May 17 through September 9, 1991. The heaviest precipitation occurred in July with almost 5.4 inches. The normal precipitation for the period from May to September is on the order of 15.5 inches and the annual normal is on the order of 28 inches for this part of the state. Evaporation typically exceeds precipitation in this part of the state and averages about 39 inches per year (Gundard, 1985). (For the St. Paul pan evaporation totals (23 year average) see Appendix 4). Runoff averages about 3.9 inches with 1 in 10 year low and high values of 0.8 inches and 5.9 inches respectively for this area (Gunard, 1985).

FIGURE 1. GREEN LAKE LOCATION MAP

Minnesota's ecoregions noted

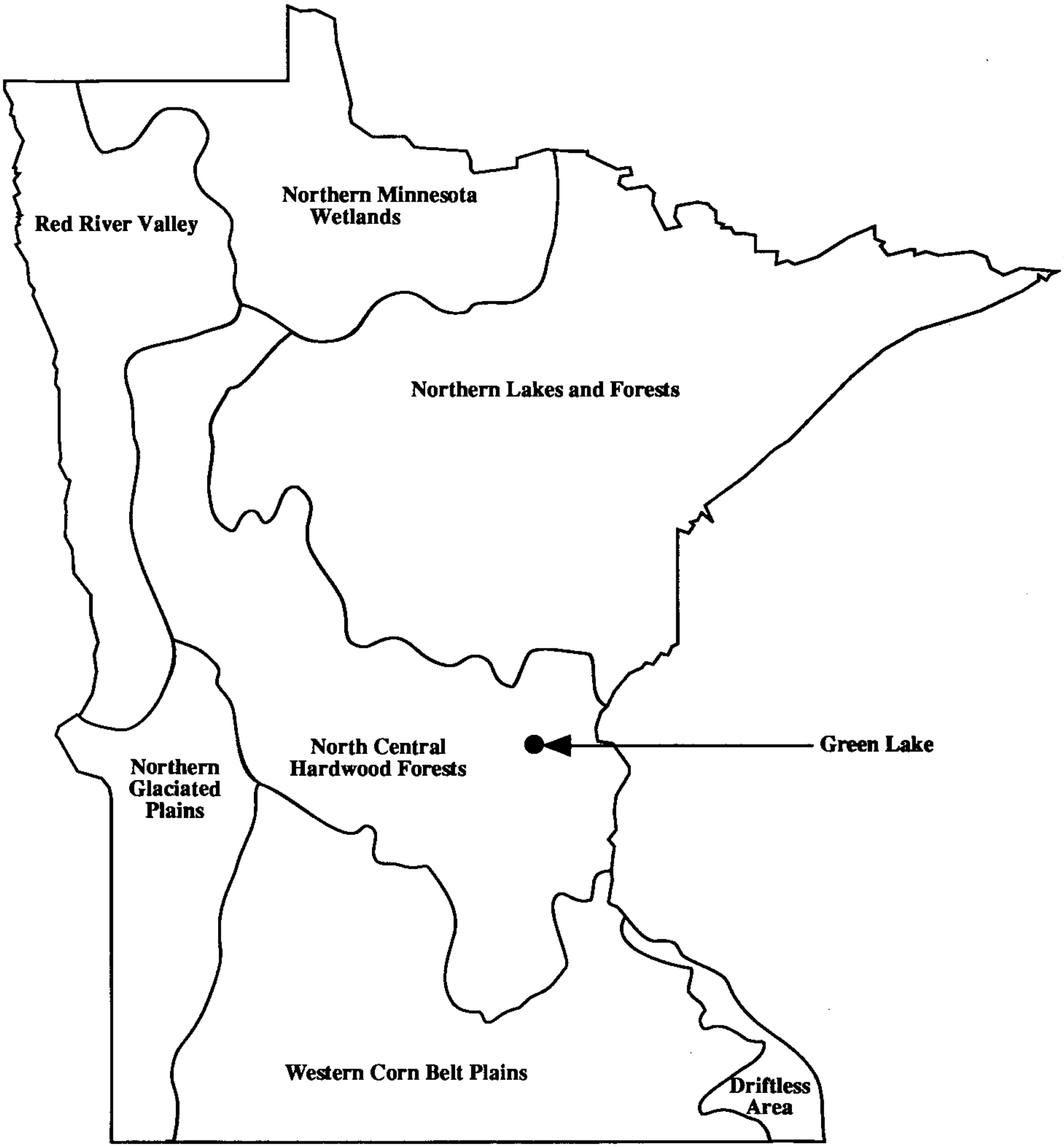


TABLE 1. GREEN LAKE MORPHOMETRIC, WATERSHED AND FISHERY CHARACTERISTICS

Lake Name: Green
MDNR I.D. #30-0136

Area (lake)[5]	800.8 acres (324.08 ha)[1]
Mean depth	16.1 feet (4.9 m)
Maximum depth	28 feet (8.5 m)
Volume	12,926 acre-feet (15.95 HM3) acre-feet x 1, 234.0 = cubic meters
Littoral area	45%[4], 44%[2]
Fetch[5]	Max. length (E-W) = 8,360' Max. width (N-S) = 6,600'
Watershed area[8]	12,160 acres (4921.09 ha) WRM (89)
Watershed: lake surface ratio	15.19:1
Estimated average water residence time	2-2.5 years

Fisheries	- Ecological Classification	Centrachid - Walleye
	- Management Classification	Walleye - Centrachid

Public accesses (#)[7]: 1 state owned
Inlets: 2 major Outlets: 1
3 minor

Land Use (percentage/area):

	Forest	Water	Marsh	Pasture	Cultivated	Urban -Res.	Agri- cultural
Project (percent)[2]	9%	1	53%	?	?	10%	27%
(acre)	(1094 acre)	(121.6)	(6444.8)	?	?	(1216)	(3283.2)
Ecoregion (percent)[3]	6-25%	14-30%		11-25%	22-50%	2-9%	33-75%

Shoreland zoning: natural, recreational or general

Development (homes)	Seasonal	Permanent	Total
1967[7]	105	43	148
1982[7]	85	79	164
Current (1989)(2)	88	78	166

Foot notes:
1. Pertinent conversions: acres divided by 2.47 = hectare; feet divided by 3.28 = meters; acre-feet divided by 811 = HM3.
2. Information from 1989 Water Quality Monitoring WRM, Inc. Oct. 5, 1989.
3. Derived from Heiskary and Wilson (1988 or 1990) Minnesota Lake Water Quality Assessment Report Table 6.
4. DNR or Land Management Information Center records.
5. Planimetered by MPCA from MDNR bathymetric map.
6. Green Lake Improvement Association septic survey.
7. SWIM Database, State Planning Agency, Information Center, St. Paul, MN.
8. EM, P.A. 1985

A septic system survey form was sent out to 162 property owners around Green Lake by the Association. A copy of the form and a summary of the results is included in Appendix 9. The purpose of this survey is to provide the Association with some basic information regarding the type of systems on the lake, age of the systems, type of dwelling and the frequency of pumping. This information should assist the Association in determining whether more education is needed with respect to design and maintenance of on-site systems and whether assistance from Isanti County is needed, e.g., education, inspections, etc.

Of the 162 surveys distributed, 102 (63 percent) were returned. This is a rather high percentage return rate. Based on the form that was submitted, the following types of systems were noted: septic tank-drainfield - 64 percent; septic tank-drywell - seven percent; septic tank-drywell (seepage) - seven percent; cesspool (open bottom) - 11 percent; outhouse - 1 percent; direct discharge to body of water - one percent; holding tank - seven percent; and mound system - 10 percent. The majority of these systems (54 percent) were 10 years old or less, while 31 percent were greater than 20 years of age or unknown. About 57 percent of the respondents pump their systems at least once per 1 to 5 years, four percent pump every 5-10 years, 16 percent did not respond, and 20 percent do not pump or only pump their systems once every ten years or longer. Minnesota Extension Service recommends pumping every one to three years for a 1,000 gallon tank serving a three bedroom house and four occupants (assumes year round use). Based on the results of the survey, it appears that more work on septic tank maintenance (education and inspection) may be appropriate.

Figure 2.
Green Lake Bathymetric Map

Sampling Sites Noted.

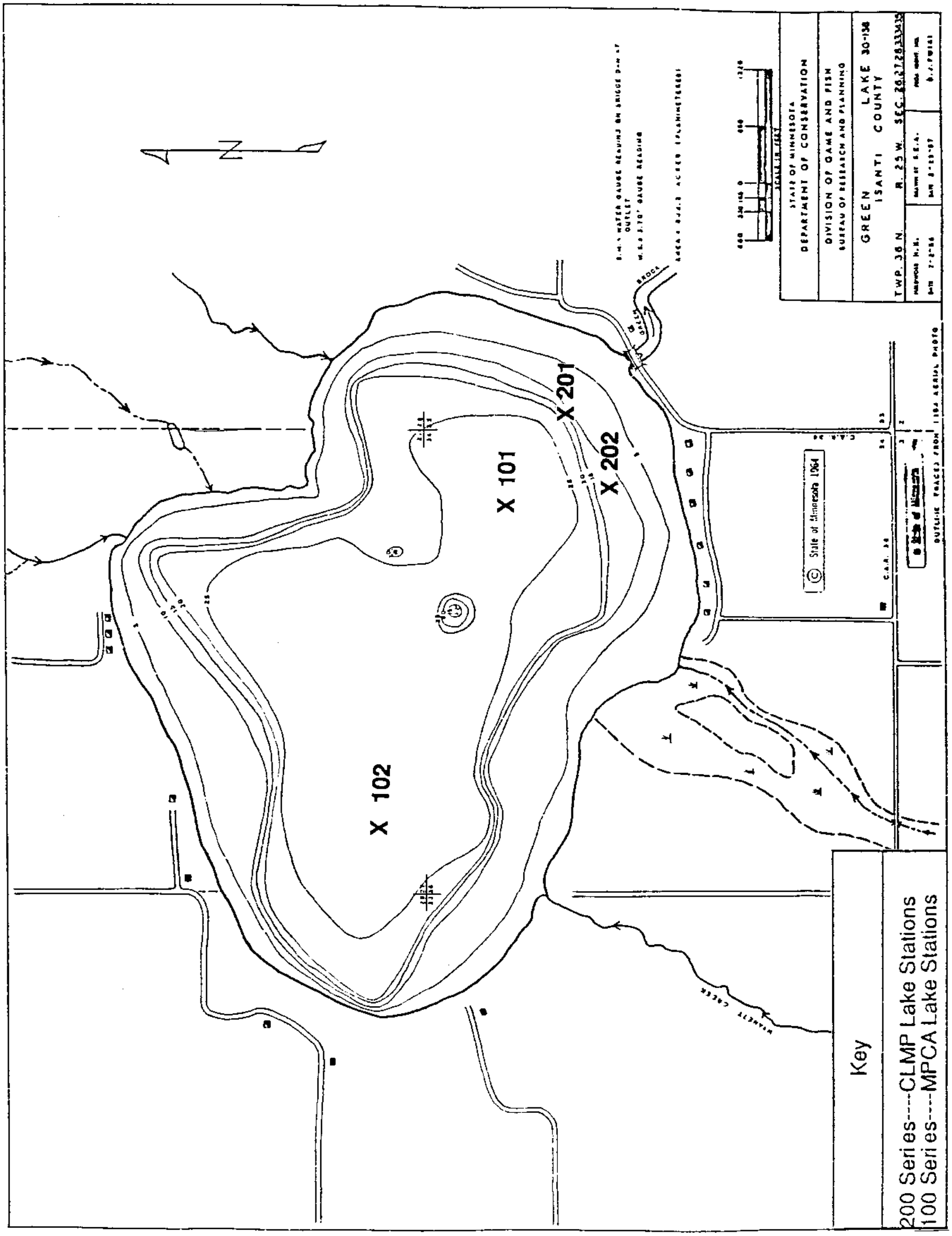
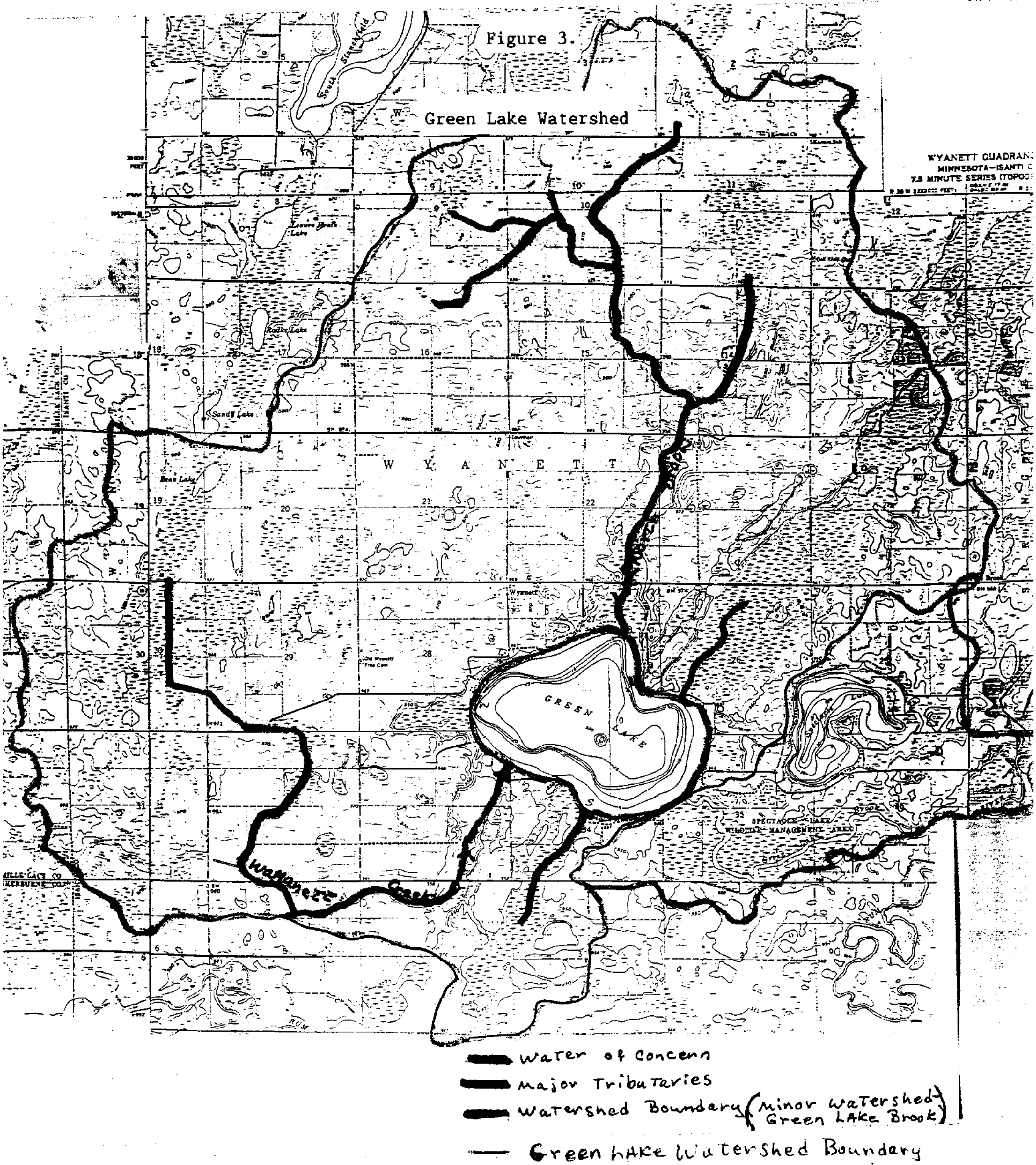
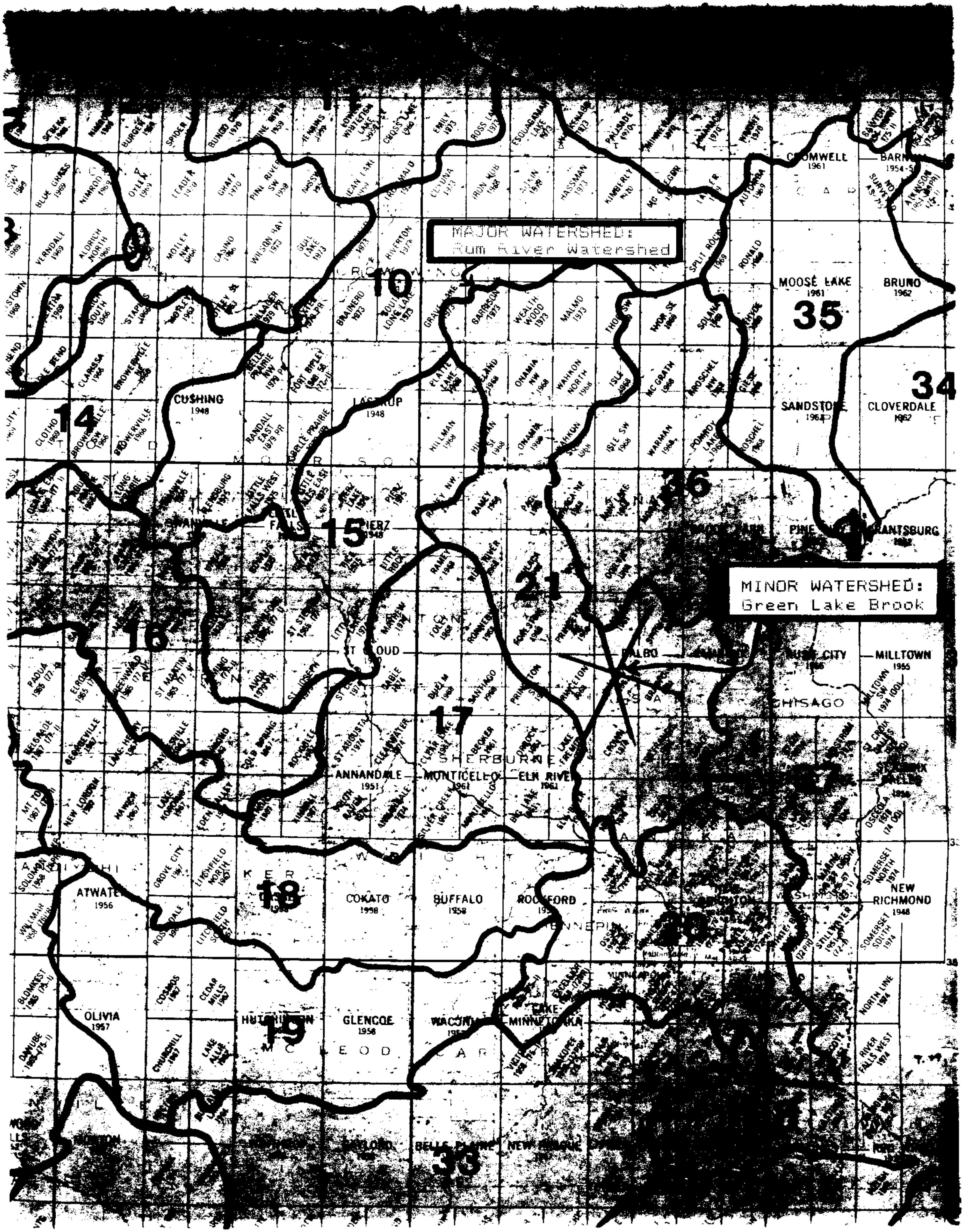


Figure 3.

Green Lake Watershed




MAJOR WATERSHED:
Rum River Watershed
MINOR WATERSHED:
Green Lake Brook
CROMWELL 1961
MOOSE LAKE 1961
BRUNO 1962
SANDSTONE 1964
CLOVERDALE 1962
CUSHING 1948
LASTRUP 1948
PIERZ 1948
ST CLOUD
ANNANDALE 1951
MONTICELLO 1961
ELK RIVER 1961
RUSH CITY 1966
MILLTOWN 1965
CHISAGO
SHERBURNE
ATWATER 1956
COKATO 1958
BUFFALO 1958
ROCKFORD
NEW RICHMOND 1948
OLIVIA 1957
GLENCOE 1958
LAKE MINNETONKA
MCLEOD
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36

RESULTS AND DISCUSSION

Water quality data was collected by the MPCA on April 29, June 3, July 1, August 5 and September 10, 1991, in Green Lake. Two sites were used primarily: Site 101 and 102 over the two areas of maximum depth (Figure 2). Lake surface samples were collected with an integrated sampler, which is a PVC tube 6.6 feet (2 meters) in length with an inside diameter of 1.25 inches (3.2 centimeters). Near-bottom samples were collected with either a two-liter PVC Kemmerer or Van Dorn sampler. In addition, phytoplankton (algae) samples were taken at site 101 with an integrated sampler. Four sites had Secchi disk monitoring (sites 101, 102, 201, 202, Figure 2).

Sampling procedures were employed as described in the MPCA Quality Control Manual. Laboratory analyses were performed by the laboratory of the Minnesota Department of Health using U.S. Environmental Protection Agency (EPA)-approved methods. Samples were analyzed for nutrients, color, solids, pH, alkalinity, turbidity, conductivity, chloride, and chlorophyll (Table 2). Temperature and dissolved oxygen profiles and Secchi disk transparency measurements were also taken (Figure 4). CLMP Secchi disk measurements from previous years were available for comparison. All data was stored in STORET, the EPA's national water quality data bank. The following discussion assumes that the reader is familiar with basic water quality terminology as used in the Citizens' Guide to Lake Protection.

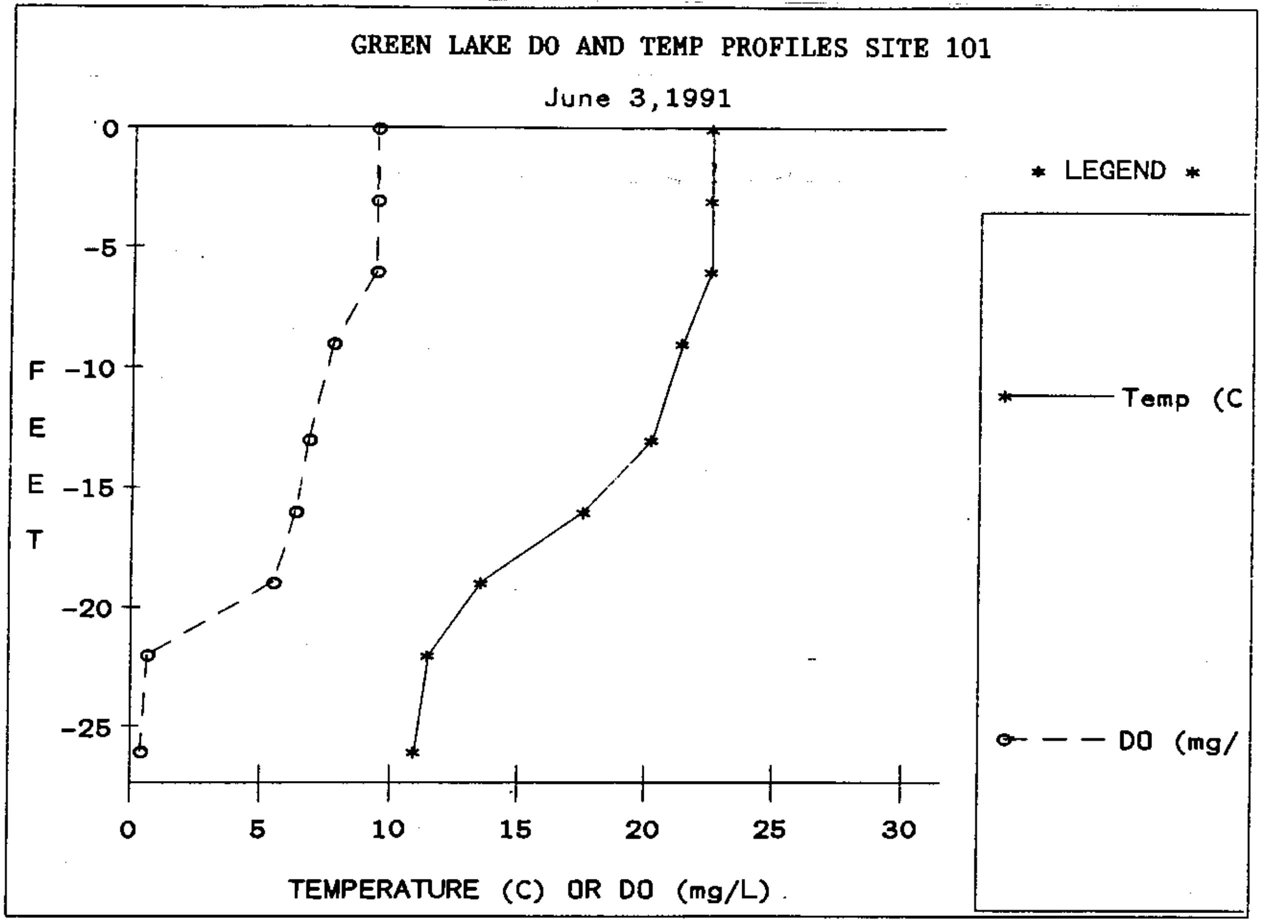
<u>In-lake Conditions</u>: 1991

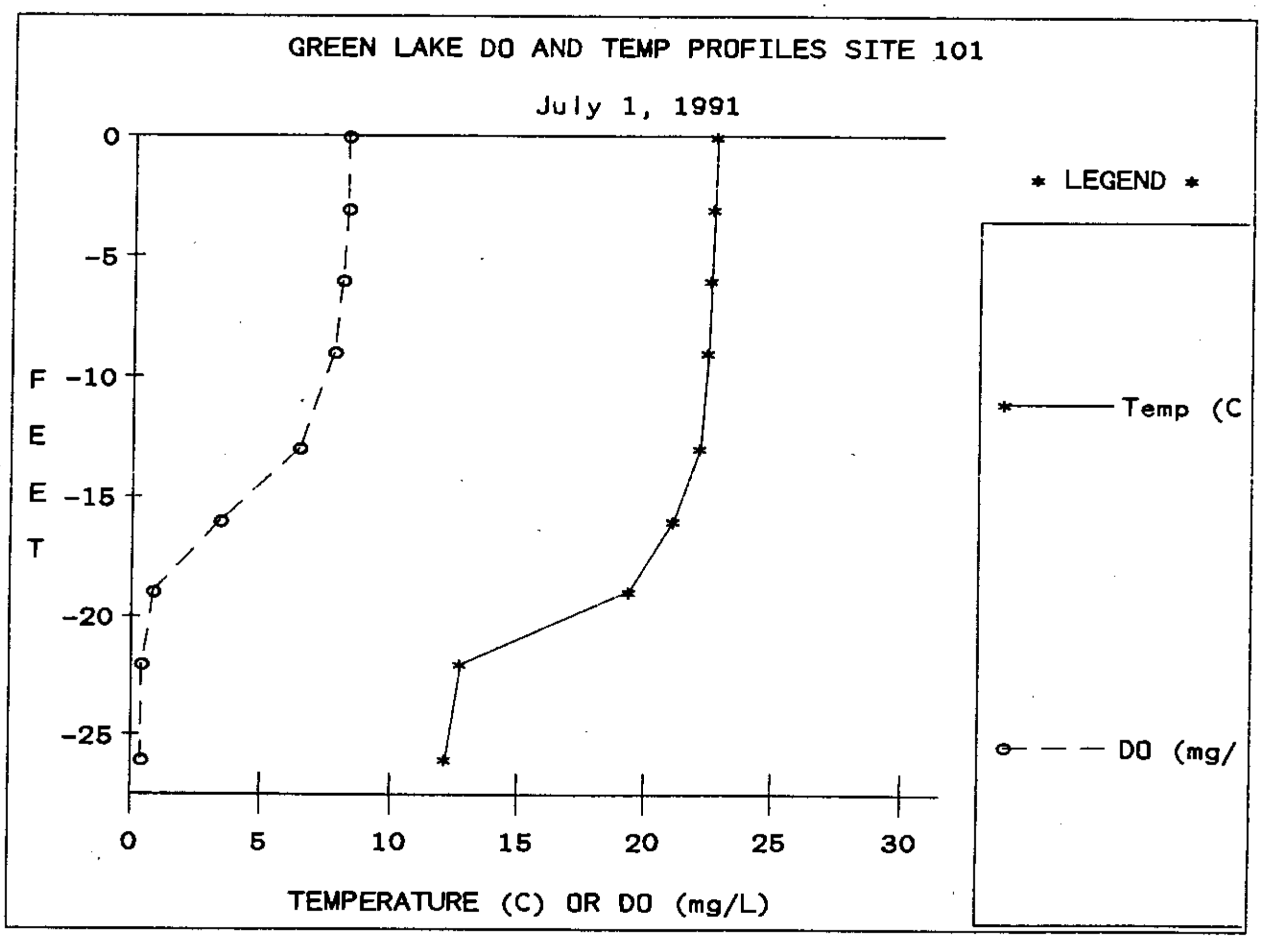
The dissolved oxygen and temperature profiles were taken at the point of maximum depth in each basin of Green Lake sites 101 and 102. Dissolved oxygen and temperature profiles were plotted for the two sites (Figure 4). Site 101 represented a deepest water site (2 feet) in the southeast basin, and site 102 represented a west northwest deepest water (28 feet) basin see Figure 2 (sampling site location).

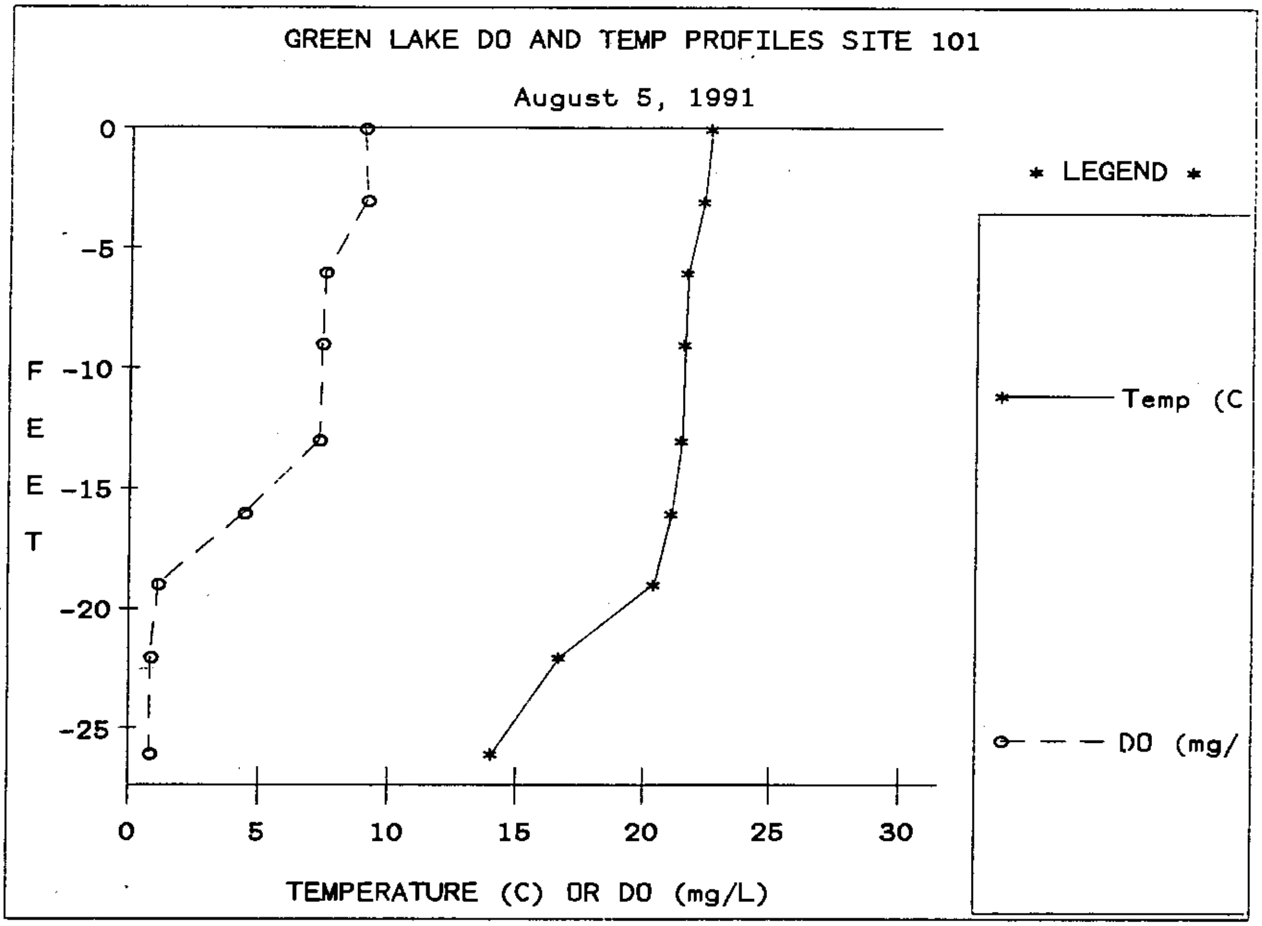
The April 29, 1991 dissolved oxygen and temperature profiles for site 101 indicated well-mixed conditions down to the bottom (Figure 4). By the June sample date, thermal stratification was evident, with surface water temperatures of 22.5°C and bottom water temperatures of about 11.0°C. The lake was anoxic (lacked oxygen) below 22 feet at this site. By the September sampling date, fall mixing had occurred at site 101 and relative isothermal (same water temperature top to bottom) conditions were noted. The bottom waters at site 101 were oxygenated at that time. Sites 101 and 102 exhibited similar profiles during the September sampling with the exception that the site 102 thermocline was at $\simeq$ 22 feet and conditions were anoxic below 22 feet.

Dissolved oxygen concentrations remained above 5 mg/L (milligrams per liter or parts per million) throughout the summer in the epilimnion (upper warmer layer). However, dissolved oxygen concentrations in the thermocline and hypolimnion (lower, cooler layer) were well below 5 mg/L, which is generally too low to support game fish. This reduction of oxygen in the hypolimnion indicates that the sediments of the lake exert a significant oxygen demand on the water. The oxygen is depleted as it is used in the decomposition of

Figure 4. Dissolved Oxygen and Temperatures for Green Lake






GREEN LAKE DO AND TEMP PROFILES SITE 101
August 5, 1991
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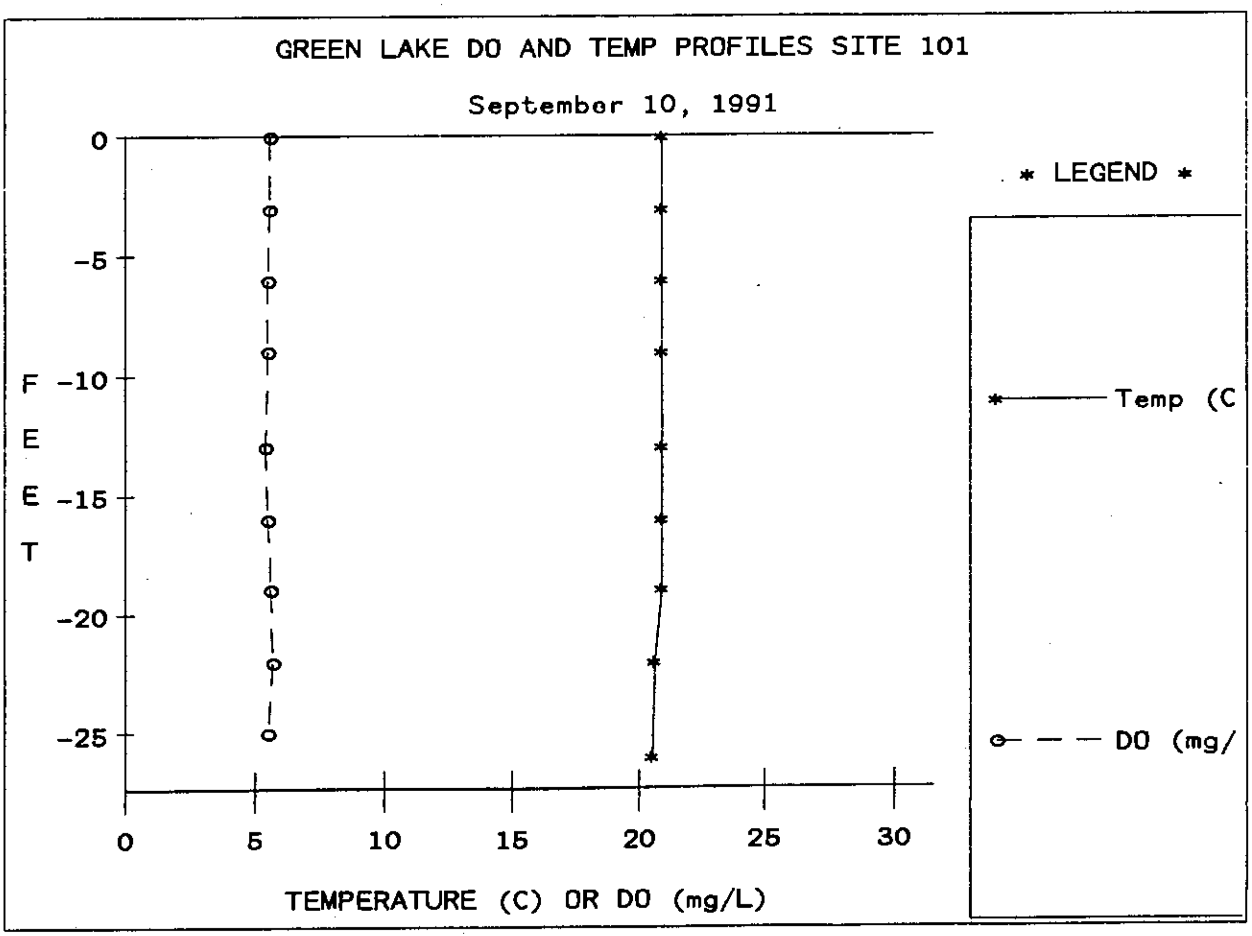
GREEN LAKE DO AND TEMP PROFILES SITE 101
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organic matter in the sediments. Its effects are most pronounced during periods of stratification, when there is little or no oxygen produced in the hypolimnion. This is a common occurrence in Minnesota lakes.

Total phosphorus (TP) concentrations (an important nutrient for plant growth) averaged approximately 43 µg/L (micrograms per liter or parts per billion) in the epilimnion (Table 2) during the summer of 1991. This value is slightly greater than concentrations found in a set of representative minimally impacted lakes in the North Central Hardwood Forests ecoregion (Table 2). Epilimnetic phosphorus concentrations in Green Lake generally ranged between 29-95 µg/L. Concentrations were in the 50-64 µg/L range in May, after spring turnover, and declined to the 42 µg/L range by September. Concentrations increased to 42 µg/L in September after the onset of fall mixing. There was no significant difference between the summer average TP concentrations between the two sampling locations.

Measurements of hypolimnetic (1 meter off the bottom) phosphorus were taken on all five sampling dates at site 101. Elevated concentrations were noted in the July and August sampling at site 101. The hypolimnion was anoxic at these sites at that time.

Phosphorus (site 101) concentrations in the hypolimnion ranged from 57 µg/L in the spring to 721 µg/l by August. Phosphorus is released by the sediments under anoxic (void of oxygen) conditions. This was the case from June through August at site 101. Although this phosphorus is effectively trapped in the hypolimnion under stratified condition, it will be mixed into the water column when stratification breaks down (due to cooling of the water and wind mixing) in the fall. This probably occurred in September based on the temperature profiles (Figure 4) and the in-lake phosphorus measures.

Total nitrogen (TN) concentrations, which consists of total Kjeldahl nitrogen plus nitrite and nitrate-N, averaged .291 mg/L over the summer. This concentration is within that typically observed for minimally impacted lakes in this region. Nitrite and nitrate-N concentrations were less than 0.07 mg/L, which is a little higher than minimally impacted lakes in this ecoregion.

The ratio of TN:TP can give an indication as to which nutrient is limiting the production of algae in the lake. For Green Lake, the TN:TP ratio is about 30:1. This suggests that phosphorus is the limiting nutrient in Green Lake. Generally, phosphorus is the least abundant nutrient and therefore is the limiting nutrient for biological productivity in a lake. The TN:TP ratio is well within the typical range for North Central Hardwood Forests ecoregion (26-35:1) Table 2.

Chlorophyll a concentrations provide an estimate of the amount of algal production in a lake. During the summer of 1991, chlorophyll a concentrations ranged from 19.0 µg/L to 32.5 µg/L with an average of 25.3 µg/L. Concentrations from 10-20 µg/L would be perceived as a mild algal bloom, while concentrations greater than 30 µg/L would be perceived as a severe nuisance (Heiskary and Walker, 1988). The average chlorophyll a concentration for Green Lake is higher than the average value for this region. No significant difference was noted in the chlorophyll a concentrations between sites 101 and 102.

TABLE 2. GREEN LAKE: AVERAGE SUMMER WATER QUALITY AND TROPHIC STATUS INDICATORS. Based on 1991 epilimnetic data.

Parameter	Mean	Typical Range for NCHF Ecoregion[1]
Total Phosphorus (µg/L)	43.0	23 - 50
Chlorophyll a (µg/L)		
Mean	25.3	5 - 22
Maximum	32.5	7 - 37
Secchi disk (feet)	4.9 ft. (1.5 m)	4.9 - 10.5 (1.5 - 3.2 m)
Total Kjeldahl Nitrogen (mg/l)	1.22	<0.60 - 1.2
Nitrite + Nitrate-N (mg/l)	0.07	<0.01
Alkalinity (mg/l)	125	75 - 150
Color (Pt-Co Units)	22.5	10 - 20
pH (SU)	8.47	8.6 - 8.8
Chloride (mg/l)	5.7	4 - 10
Total Suspended Solids (mg/l)	7.55	2 - 6
Total Suspended Inorganic Solids	2.75	1 - 2
Turbidity (NTU)	5.8	1 - 2
Conductivity (µmhos/cm)	239	300 - 400
TN:TP Ratio	30:1	25 - 35:1

Trophic Status Indicators: 1991

Carlson Trophic State Index Values		Percentile[2] NCHF Ecoregion
TP	TSIP = 58	-
Chl a	TSIC = 62	-
Secchi	TSIS = 55	-
Mean (All)	TSI = 58	54th

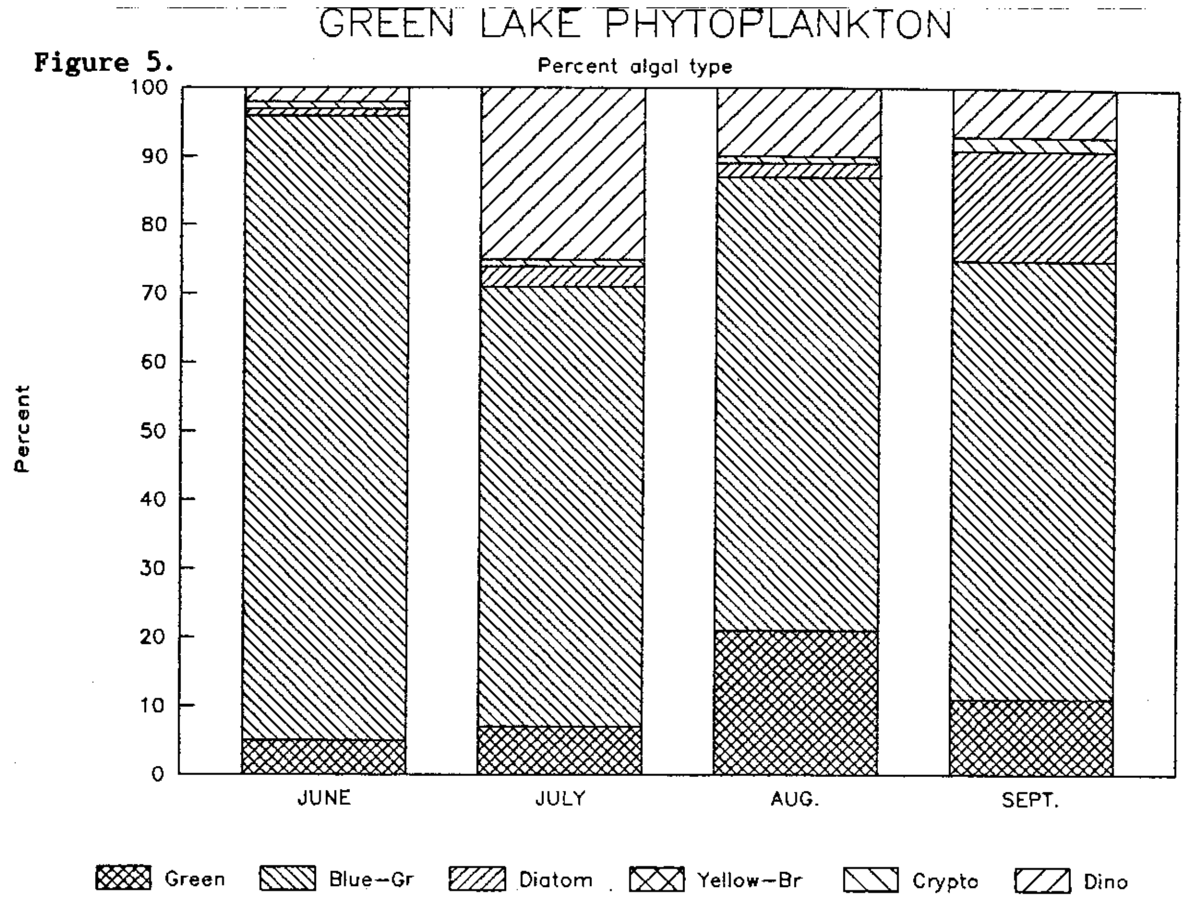
[1]Derived from Heiskary and Wilson (1990).

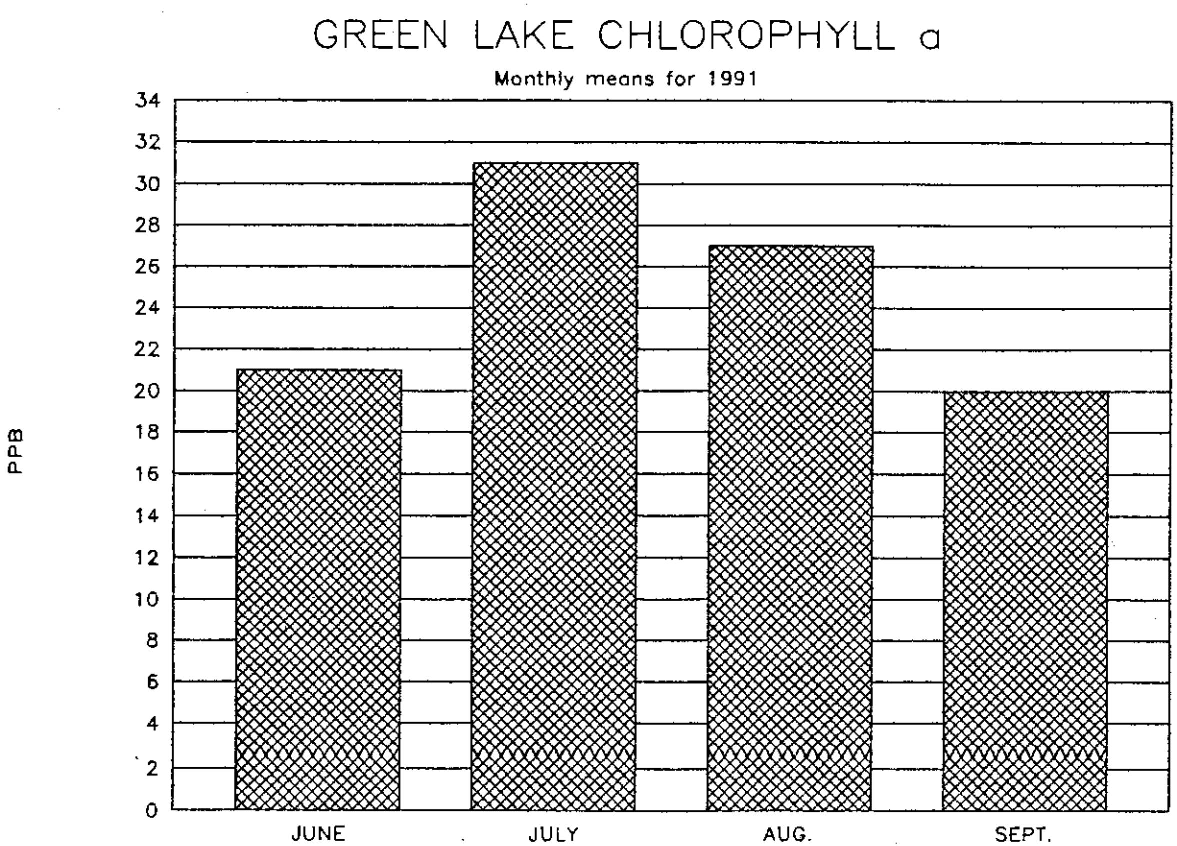
[2]Relative to approximately 530 assessed lakes in North Central Hardwood Forests Ecoregion, whereby the lower the trophic state (TSI), the higher the percentile ranking (100 percent level implies lowest TP or deepest Secchi disk for that ecoregion).

The composition of the phytoplankton (algae) population of Green Lake is presented in Figure 5. Data are presented in terms of algal type. Samples were collected at site 101. The June sample was dominated by the Division Cyanophyta (Blue-Green Algae) - 91 percent: (Aphanizomenon flos-aguae - 87 percent and Gomphosphaeria - three percent) and the green-algae - five percent. By July, the blue-green algae were less prominent (64 percent), while the Dionflaggelletes (25 percent) and green algae (seven percent) increased in dominance. The blue-green forms - Gomphosphaeria Naegelianum (25 percent) and Aphanizomanon flos-aguae (25 percent) became more dominant. In August and September, the blue greens (66 percent and 64 percent, respectively) were still the dominant forms; the genera Aphanizomanon flos-aguae will appear as clumps of "grass clippings" at the surface of the water and along with other blue-greens may form surface scums. Chlorophyll a concentrations in July, August and September would be equated with mild blooms. The seasonal transition in the algae from diatoms to greens to blue-green is rather typical for mesotrophic and eutrophic lakes in Minnesota. This transition began early in the year for Green Lake.

Secchi disk transparency is generally a function of the amount of algae in the water. Suspended sediments or color due to dissolved organics may also reduce water transparency. Color, as measured at site 101 in the southeast basin averaged 22.5 PT-Co Units which is slightly above the typical range for the North Central Hardwood Forests ecoregion. Color may vary, however, depending on the amount of runoff from the surrounding wetlands. Total suspended solids averaged 7.55 mg/L over the summer. The total suspended solids value is slightly high for this region. These levels of color and total suspended solids should not appreciably limit water transparency in Green Lake. Secchi

Figure 5.


GREEN LAKE PHYTOPLANKTON
Percent algal type
Percent
100
90
80
70
60
50
40
30
20
10
0
JUNE
JULY
AUG.
SEPT.
Green
Blue-Gr
Diatom
Yellow-Br
Crypto
Dino


GREEN LAKE CHLOROPHYLL a
Monthly means for 1991
PPB
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
JUNE
JULY
AUG.
SEPT.

disk transparency ranged from 3.3 to 6.6 feet (1.0 to 2.0 m) and averaged 4.9 feet (1.5 m) during the summer of 1991. These transparency measures are on the low side of the typical range for minimally impacted lakes in the North Central Hardwood Forests ecoregion.

Along with the CLMP transparency measurements, subjective measures of Green Lake's "physical appearance" and "recreational suitability" were made by the CLMP observers (Table 6). 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 rating system (Heiskary and Wilson, 1988). Transparency, physical appearance and recreational suitability for CLMP site 202 are presented in Figure 6.

Secchi transparency was measured via CLMP on only five dates in 1991 (Figure 6). These data indicate that transparency was high in June (seven feet) and declined through the summer to a minimum of three feet in July. "Physical appearance" was rated as (2) "a little algae visible" in June and changed to (4) "high algae levels" in July and August. The "recreational suitability" went from (1) "beautiful" to (3) "swimming impaired" in July and August, as transparency fell below five feet.

One means to evaluate the trophic status of a lake and to interpret the relationship between total phosphorus, chlorophyll a and Secchi disk readings is Carlson's Trophic State Index (TSI, Carlson 1977). This index was developed from the interrelationships of summer Secchi disk transparency and the concentrations of surface water chlorophyll a and total phosphorus. TSI values are calculated as follows:

Figure 6. Green Lake Secchi Transparency

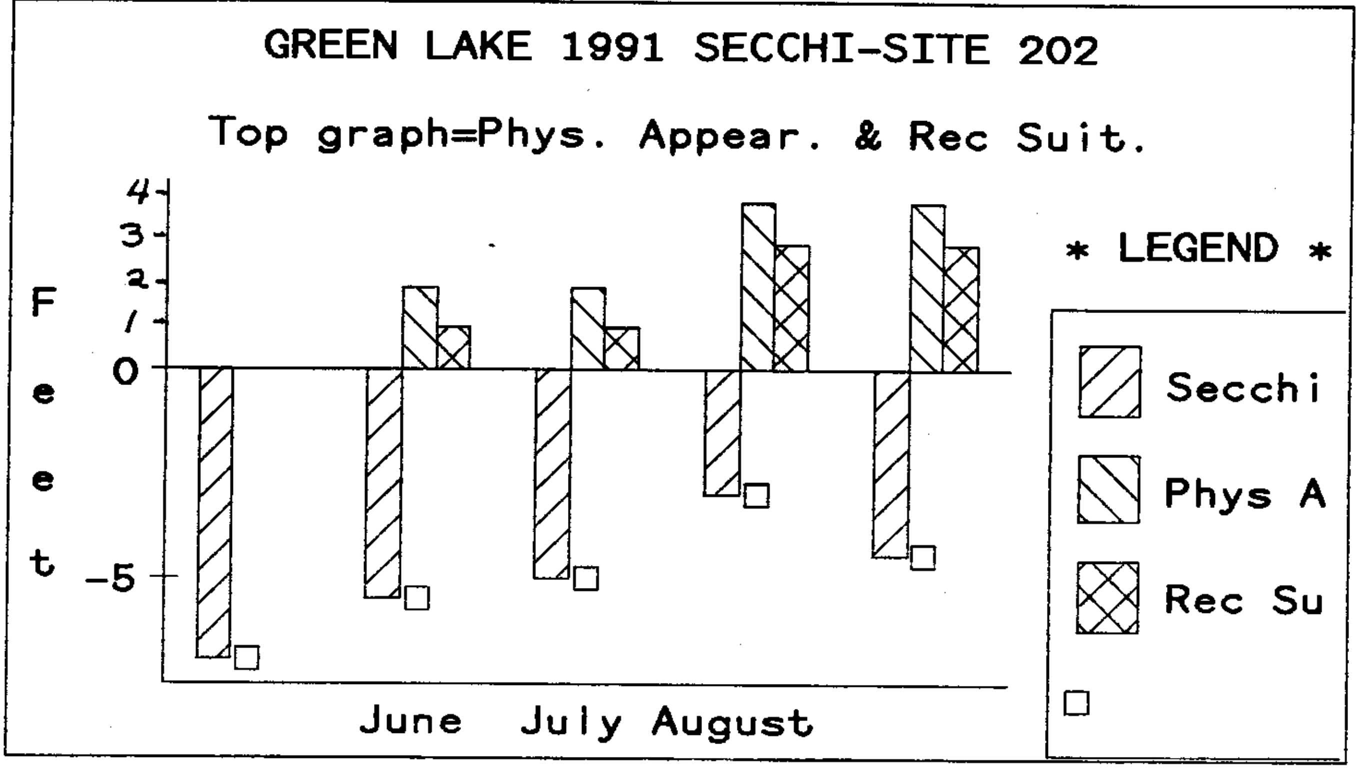


Table 2.—Lake observer survey.

A. Please circle the one number that best describes the physical condition of the lake water today:

1. Crystal clear water.
2. Not quite crystal clear, a little algae present/visible.
3. Definite algal green, yellow, or brown color apparent.
4. High algal levels with limited clarity and/or mild odor apparent.
5. Severely high algal levels with one or more of the following: massive floating scums on lake or washed up on shore, strong foul odor, or fish kill.

B. Please circle the one number that best describes your opinion on how suitable the lake water is for recreation and aesthetic enjoyment today:

1. Beautiful, could not be any nicer.
2. Very minor aesthetic problems; excellent for swimming, boating, enjoyment.
3. Swimming and aesthetic enjoyment slightly impaired because of algal levels.
4. Desire to swim and level of enjoyment of the lake substantially reduced because of algal levels (would not swim, but boating is okay).
5. Swimming and aesthetic enjoyment of the lake nearly impossible because of algal levels.

Total phosphorus TSI (TSIP) = 14.42 ln (TP) + 4.15

Chlorophyll a TSI (TSIC) = 9.81 ln (Chl a) + 30.6

Secchi disk TSI (TSIS) = 60 - 14.41 ln (SD)

TP and chlorophyll a are in µg/L and Secchi disk transparency is in meters. TSI values range from 0 (ultra-oligotrophic) to 100 (hypereutrophic). In this index, each increase of 10 units represents a doubling of algal biomass.

Average values for trophic variables in Green Lake and respective TSIs are presented in Figure 7. Based on these values, Green Lake would be considered eutrophic in condition. The mean TSI of 58 would rank Green Lake at the 54th percentile relative to 800 other lakes in the North Central Hardwood Forests ecoregion. In other words, its TSI value is lower (less eutrophic) than 46 percent of the lakes assessed in this region. The individual TSI values suggest that the transparency of Green Lake is slightly higher than would be expected based on the chlorophyll a and TP measurements that were taken.

Another means for comparing these three variables is graphically on scatterplots. Values for Green Lake are noted in Figure 8. In general, we note that total phosphorus-chlorophyll a-Secchi transparency relationships in Green Lake are quite comparable to those observed in other Minnesota lakes.

Water Quality Trends

Very little data is available for determining long-term trends in the quality of Green Lake. The best source of data, CLMP data, date back to 1973 and 1974 for two consecutive years. Then commencing again in 1988 and continuing

Figure 7. CARLSON'S TROPHIC STATE INDEX VALUES FOR GREEN LAKE
TSI Relationships based on mean summer data for 1991.

Changes in the Biological Condition of Lakes With Changes in Trophic State

R.E. Carlson

TSI < 30 Classical oligotrophy: Clear water, oxygen throughout the year in 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.

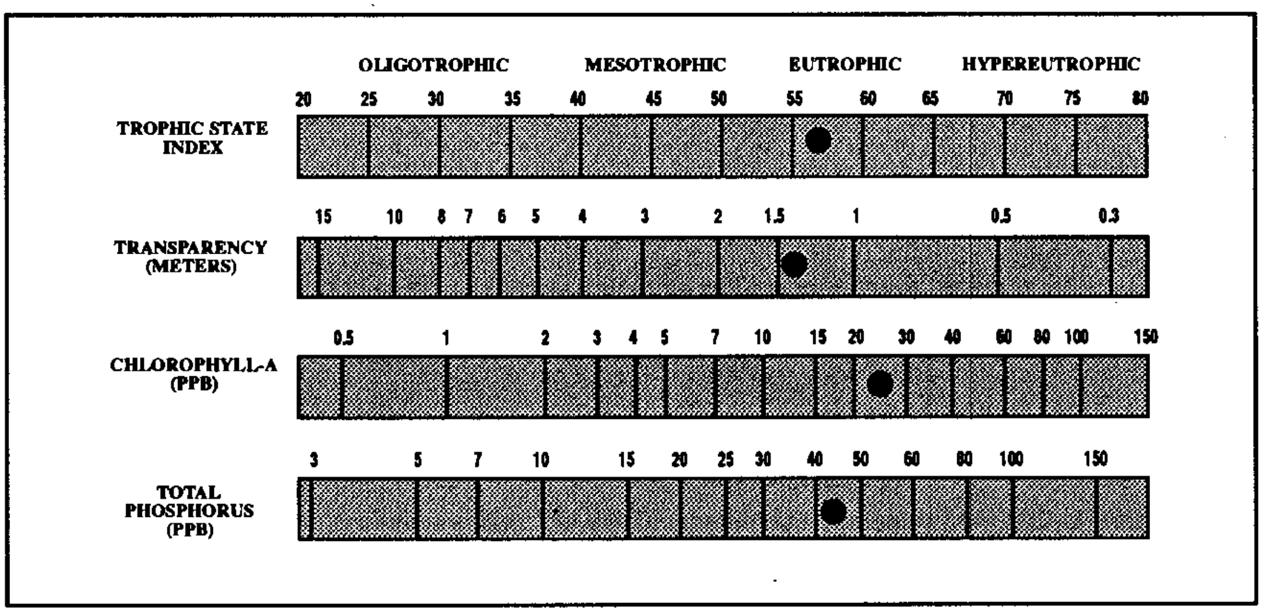
TSI 40 - 50 Water moderately clear, but increasing probability of anoxia in hypolimnion during summer..

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.

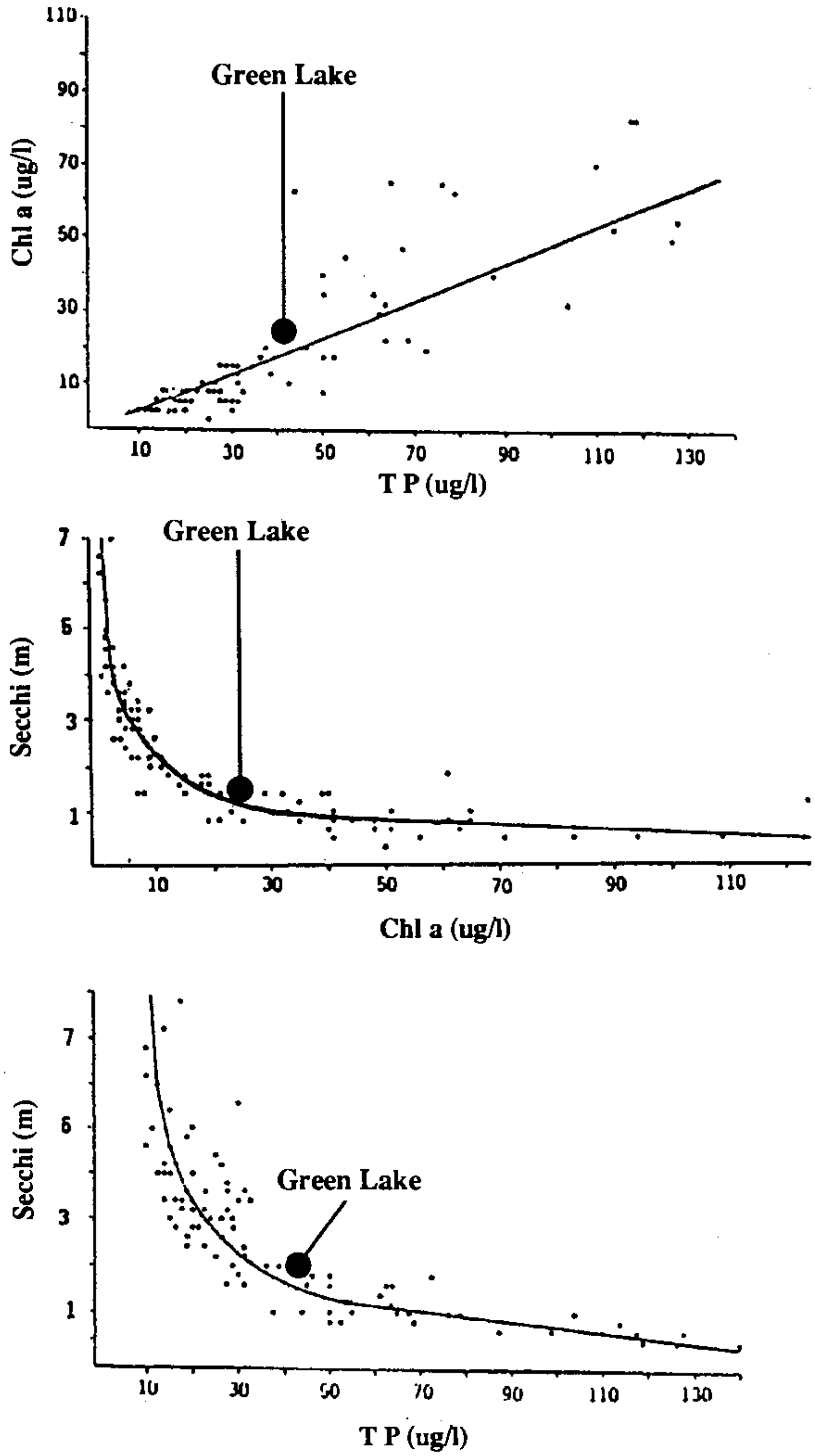
TSI 70 - 80 Heavy algal blooms possible throughout the summer, dense macrophyte beds, but extent limited by light penetration. Often would be classified as hypertrophic..

TSI > 80 Algal scums, summerfish 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..

Figure 8. SCATTERPLOTS OF CHLOROPHYL-a, TOTAL PHOSPHORUS AND SECCHI TRANSPARENCY. Based on summer data from a set of representative lakes from four ecoregions in Minnesota. Values for Green Lake noted:



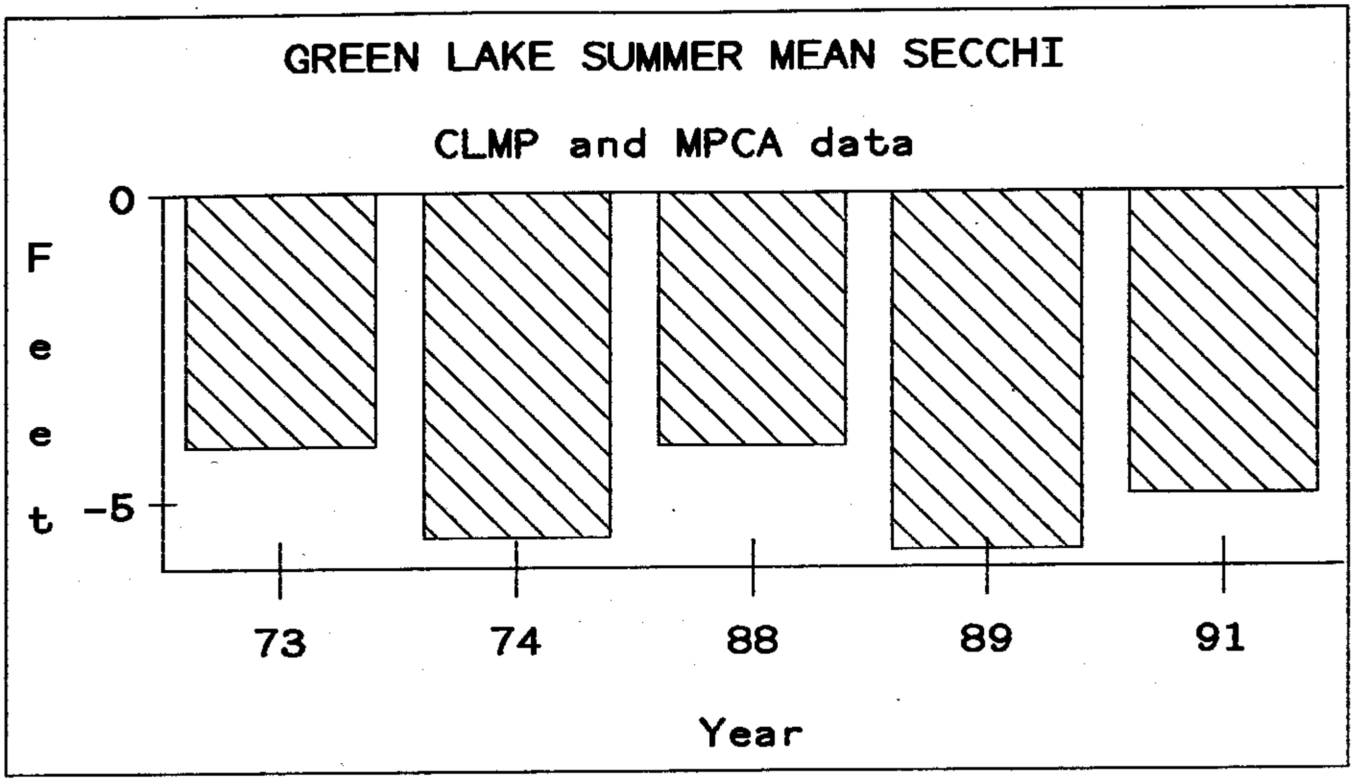
through the present. These data do not reveal any long-term trends, but do indicate that the transparency may be quite variable from year to year, with summer averages between about 2.5 feet to 5.5 feet (Figure 9). The year-to-year fluctuations in transparency are probably related to the differing amounts of runoff (nutrient loading) which enters the lake in each of these years and the resulting changes in the amount of algae which are produced.

The mean total phosphorus of 43 µg/l compared very well to the mean total phosphorus for 1988 and 1989 at 44 and 37 µg/l, respectively. The mean chlorophyll a for 91 (25.3 µg/l) compared favorably with the 1988 chlorophyll a mean (24.5 µg/l).

Modeling Summary

Numerous complex mathematical models are available for estimating nutrient and water budgets for lakes. These models can be used to relate the flow of water and nutrients from a lake's watershed to observed conditions in the lake. Alternatively, they may also be used for estimating changes in the quality of the lake as a result of altering nutrient inputs to the lake (e.g., changing land uses in the watershed) or altering the amount of water that enters the lake. To analyze the 1991 quality of Green Lake, the models of Reckhow and Simpson (1980) and the Minnesota Lake Eutrophication Analysis Procedures (MINLEAP) model (Wilson, 1988) were used. Reckhow and Simpson's model is used extensively for assessing lake water quality. The more recently developed model, the MINLEAP model, was developed by MPCA staff based on an analysis of data collected from a set of representative minimally impacted lakes for each ecoregion. It is intended to be used as a screening tool for estimating lake

Figure 9. Summer Mean Secchi Transparency



conditions with minimal input data and is described in greater detail in Wilson and Walker (1988) and Heiskary and Wilson (1988).

No actual measure of water flow into or out of the lake or measures of nutrient concentrations into or out of the lake were made. Rather, published runoff coefficients, precipitation and evaporation data, and nutrient export coefficients were used in this modeling. Precipitation and evaporation data were derived from Gunnard (1985) and preliminary data from the State Climatology Office (1991).

Results from the MINLEAP modeling compared fairly well with observed conditions in Green Lake in 1991 with the exception of Chlorophyll a (Table 3). Chlorophyll a measured was higher than that predicted by MINLEAP. Based on MINLEAP, the water residence time (average time it would take to replace the entire volume of the lake) for Green Lake is on the order of 2.4 years. Green Lake retains approximately 73 percent of the phosphorus that enters the lake.

The results from MINLEAP should be viewed with caution, since average precipitation and runoff were used in the model. In contrast, 1991 was quite wet and precipitation was approximately eight to 12 inches above normal (Appendix 4 and 5) and runoff to the lake was above normal. Also, the surface area used for the modeling of Green Lake was the planimetered area from a 1955 contour map, i.e. 800.8 acres (324.1 ha). Water levels were somewhat higher in 1991. Thus, the actual surface area and mean depth may have been greater than that reported here.

TABLE 3. MINLEAP Model Results for Green Lake

Minnesota Lake Eutrophication Analysis Procedure
ENTER INPUT VARIABLES
LAKE NAME ? Green
ECOREGION NUMBER 1=NLF,2=CHF,3=WCP,4=NGP ? 2
WATERSHED AREA (HA) ? 4921
LAKE SURFACE AREA (HA) ? 324
LAKE MEAN DEPTH (M) ? 4.9
OBSERVED MEAN LAKE TP (UG/L) ? 43
OBSERVED MEAN CHL-A (UG/L) ? 25
OBSERVED MEAN SECCHI (M) ? 1.5

INPUT DATA:
LAKE NAME =Green ECOREGION=CHF
LAKE AREA = 324 HA
WATERSHED AREA (EXCLUDING LAKE) = 4921 HA
MEAN DEPTH = 4.9 METERS
OBSERVED MEAN TP = 43 UG/L
OBSERVED MEAN CHL-A = 25 UG/L
OBSERVED MEAN SECCHI = 1.5 METERS

<press ENTER to view results>

LAKE = Green ECOREGION = CHF
AVERAGE INFLOW TP = 159.9535 UG/L TOTAL P LOAD = 1044 KG/YR
LAKE OUTFLOW = 6.5269 HM3/YR AREAL WATER LOAD = 2.014475 M/YR
RESIDENCE TIME = 2.432395 YRS P RETENTION COEF = .728279

VARIABLE	UNITS	OBSERVED	PREDICTED	STD ERROR	RESIDUAL	T-TEST
TOTAL P	(UG/L)	43.00	43.46	15.42	-0.00	-0.03
CHL-A	(UG/L)	25.00	16.29	10.23	0.19	0.63
SECCHI	(METERS)	1.50	1.50	0.63	0.00	0.01

NOTE: RESIDUAL = LOG10(OBSERVED/PREDICTED)
T-TEST FOR SIGNIFICANT DIFFERENCE BETWEEN OBS. AND PREDICTED

CHLOROPHYLL-A INTERVAL FREQUENCIES (%)

CHL-A PPB	OBSERVED	PREDICTED CASE A	PREDICTED CASE B	PREDICTED CASE C
10	95.25	78.15	76.35	67.66
20	58.95	25.18	26.84	34.66
30	26.73	6.51	8.12	18.64
60	1.95	0.16	0.32	4.08

CASE A = WITHIN-YEAR VARIATION CONSIDERED
CASE B = WITHIN-YEAR + YEAR-TO-YEAR VARIATION CONSIDERED
CASE C = CASE B + MODEL ERROR CONSIDERED
Ok

The Reckhow and Simpson modeling utilized estimates of precipitation, runoff and evaporation for the 1991 water year. Land use composition for the watershed was supplied by Isanti SWCD based on the most recent survey for the county. The number of seasonal and permanent residences were taken from information provided by the Association. Phosphorus export coefficients were taken from the literature and/or were calculated based on equations presented by Prairie and Kalff (1986). Their premise is that in large agricultural watersheds, much of the phosphorus exported by the various land uses is retained in the watershed. This is probably realistic in watersheds where the drainage is not heavily channelized and there exists a number of lakes or wetlands which may act as sinks for phosphorus. This would seem to be the case for Green Lake's watershed. These calculated coefficients are often lower than those in the literature. Estimates of agricultural acreage (27 percent) were made by Mark Demouth, Isanti SWCD. The soil retention coefficient is a means for estimating the soil's ability to trap phosphorus which may leach from watershed soils and septic tanks and potentially reach the lake. A high retention coefficient (in the case of this model) can reflect a high degree of trapping by the soils and/or well maintained septic systems.

The in-lake phosphorus concentration predicted by Reckhow-Simpson was 39 µg/L for Green Lake in 1991 (Table 4). The estimated chlorophyll and Secchi transparency (see D, Table 4) for the "low" value also agree fairly well with the observed conditions in Green Lake.

Reckhow-Simpson used estimated precipitation and runoff for 1991. The low to average export values tend to bracket the measured '91' TP: * predicted 39 µg - 51 µg/l vs. 43 µg/l measured. TP load rate (flux) 998 - 1455 Kg/yr (MINLEAP $\simeq$ 1044 Kg/yr) → good agreement with models. This model also provides the opportunity to assess the relative importance of sources of phosphorus to Green Lake. Based on these estimates, agricultural land uses generate the majority (about 45 percent) of the phosphorus load to the lake with 27 percent of the land use. In contrast, forested lands generate about 3 percent of the total phosphorus flux to the lake with nine percent of the land use. Urban land uses (i.e., shoreland residences), represent about 10 percent of the total land area in the watershed and would be predicted to generate approximately 230 kg/yr or about 23 percent of the total phosphorus load to the lake. Based on this modeling, septic systems would be predicted to contribute about 28 Kg P/yr to the lake or about three percent. This assumes, however, that systems are well maintained and minimal export of phosphorus from these systems reach the lake. It does not take into account any near shore effects, e.g., excess weed or attached algae growth that may be caused from septic tank effluents which reach the lake.

Goal Setting

The water quality observed in Green Lake in 1991 compared very favorably to the typical range of concentrations for minimally-impacted lakes in the North Central Hardwood Forests ecoregion. However, the 1991 water year was characterized by above average precipitation and runoff for this part of the state. Data from 1989, a lower precipitation and runoff year, indicate somewhat better water quality - based on the higher transparency (Figure 9) as compared to 1988 or 1991. This suggests that nutrient loading from the watershed of Green Lake will strongly influence the quality observed in the lake.

Based on the results from 1991 and previous efforts, it will be desirable to maintain 1989 water quality conditions. In years of higher precipitation and runoff, this will require a reduction in the phosphorus load. At a phosphorus concentration of 40 µg/L (whole lake average), "nuisance algal blooms" (chlorophyll a >20 µg/L) would be expected to occur about 25 percent of the summer (Table 3). Secchi transparency should remain at or above five feet for about 50 percent of the summer. Based on responses of CLMP volunteers in 1991, transparencies below five feet were associated with "high algae levels and impaired swimming."

In comparison, if summer average phosphorus concentrations increase to the 50 µg/L range, nuisance algal blooms would be predicted to occur between 40-50 percent of the summer and Secchi transparency would likely remain below three feet about 30 percent of the summer.

Based on this study, it appears that it may be necessary to reduce the amount of nutrients which enter Green Lake from its watershed if the proposed phosphorus goals are to be attained in years of average or above average precipitation and runoff. Further study may be necessary to determine where efforts should be targeted. However, obvious sources of nutrients near the lake should probably be addressed first. The effects of nutrient sources further away from the lake will likely be minimized by the numerous lakes and wetlands in the watershed.

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TABLE 4

RECKHOW-SIMPSON MODELING SUMMARY

8d	Name	Green				
	Watershed Area (ha)	4921			8365738.	=EST Q
	Lake Area (ha)	324			2.58	=EST qs
	Water Runoff (m)	0.17 *			NOTE: 1HM3 = 1,000,000 M3	
	Precipitation(m)	1 *			0.043	=Observed TP (mg/l)
	Evaporation(m)	0.88 (mean)			0.012	=Observed TP StDev
	Volume (HM3)	15.8			9	=N
	County capitas/cabin	2.8			25	=Observed Chla (ug/l)
	Number Seasonal Cabi	88			1.5	=Observed Secchi (m)
	Number Perm. Cabins	78				
		Before	After	Delta		
	Forest Area (ha)	414	414	0	1.9	=Water Residence (year)
	Agric Area (ha)	1241	1241	0		
	Urban Area (ha)	460	460	0		
	Wetland Area (ha)	2436	2436	0		
	Pasture/Open (ha)	0	0	0		

* estimated for 1991

Export Values		Low	Average	High
Forest P Export		0.08	0.1	0.15
Agric P Export		0.36	0.45	0.63
Urban P Export		0.5	1	1.25
Wetland P Export		0.08	0.1	0.1
Pasture/open Export		0.2	0.3	0.4
Atmospheric Export		0.2	0.3	0.4
Soil Retention Coef		0.9	0.8	0.7
Point Source Before	kg/yr	0	0	0
Point Source After	kg/yr	0	0	0
Delta Point Source	kg/yr	0	0	0
Capita Years		276.9	276.9	276.9

**** P EXPORT R E F E R E N C E ****

****

Prairie & Kalff (1986) \Wilson & Walker (1989)
"Effect of Catchment Size... \Development of Lake Assessment...

Use	Ha	P export	\Ecoreg.	Dominant Landuse	Net** P Export
Forest	414	0.08	\NCHF	Cul+Mixed	0.19
Ag-mix	1241	0.65	\NLF	For (75%)	0.12
Ag-row++	600	0.36	\NGP	Cul (83%)	0.76
Ag-nonrow++	641	0.63	\WCBP	Cul (84%)	0.74
Pasture	0	ERR	** Of all landuse values.		

Wat.Res.Bull 22:465-470 \ Lake Res.Man.5:11-22.
++Fill in this estimated landuse data

Low	Average	High	
33	41	62	=Forested Flux =
447	558	782	=Ag flux =
230	460	575	=Urban flux =
195	244	244	=Wetland flux =
0	0	0	=Pasture/Open flux=
65	97	130	=Ppt flux =
28	55	83	=Septic flux =
0	0	0	=Point Souce =
998	1455	1876	=Total P Flux =
308	449	579	= P LOAD =
119	174	224	= Inflow P ug/l
0.021	0.031	0.039	=PREDICTED TP =
	-1.50863		=LOG Pml =
	0.011		= + MODEL ERROR =
	-0.008		= - MODEL ERROR =
	0.004		= + LOADING ERROR =
	0.005		= - LOADING ERROR =
	0.012		=TOTAL + UNCERTAIN
	0.009		=TOTAL - UNCERTAIN
22	31	43	55% CONFIDENCE LIMITS
13	31	55	90% CONFIDENCE LIMITS
39	51	60	CANFIELD/BACHMANN

		Observed	(low) Predicted	(average)	(high) Predicted
			Fill-in from above (Canfield/Bachmann) or insert other values.		
LAKE TP	mg/l	0.043	0.039	0.051	0.06
LAKE CHLA	ug/l	25	13.9	20.6	26.1
LAKE SECCHI	m	1.5	1.6	1.3	1.1
TSI TP		58.4	57	60.8	
TSI CHLA		62.2	56.4	60.3	
TSI SD		54.2	53.2	56.2	

APPENDIX 1

MPCA Water Quality Data

GREEN LAKE WATER QUALITY DATA (LAKEID=30-0136). Includes all MPCA data in STORET.

DATE	SITE	D	TP	RTP	TKN	N2N3	RN2N3	TSS	TSIN	ALK	PHF	CL	CONF	TURB	COLOR	CHLA	PHEO	SDF
880517	101	0	.040		1.02	0.30		4.2	1.9	130	.	5.2	.	1.5	10	4.96	1.65	10.2
880628	101	0	.029		0.74	0.01	K	3.8	1.2	120	.	5.0	.	3.5	20	8.33	1.92	4.6
880628	101	19	.042		1.03	.		.	.	.	.	.	.	.	.	.	.	.
880628	102	0	.028		0.63	.		.	.	.	.	.	.	.	.	7.36	0.96	4.6
880727	101	0	.032		0.80	0.01	K	5.0	2.8	110	.	6.2	.	3.0	10	10.40	4.00	4.3
880727	101	21	.036		0.91	.		.	.	.	.	.	.	.	.	.	.	.
880727	102	0	.028		0.80	.		.	.	.	.	.	.	.	.	12.80	3.20	4.3
880830	101	0	.080		1.32	0.01	K	11.0	4.0	120	.	5.8	.	6.0	10	64.10	2.40	2.6
880830	101	19	.070		1.15	.		.	.	.	.	.	.	.	.	.	.	.
880830	102	0	.068		1.15	.		.	.	.	.	.	.	.	.	44.10	3.20	3.0
890516	101	0	.030		0.75	0.12		0.5	-0.3	120	.	7.0	235	0.9	10	6.09	1.92	5.6
890516	101	22	.049		1.07	0.24		.	.	.	.	.	.	.	.	.	.	.
890516	102	0	.026		0.84	0.11		.	.	.	.	.	235	.	.	5.13	1.92	4.9
890809	101	0	.037		0.75	0.01		3.6	1.4	110	.	7.5	220	1.7	20	7.37	0.64	9.5
890809	101	19	.026		0.76	.		.	.	.	.	.	.	.	.	.	.	.
910429	101	0	.057		1.06	0.38		9.2	4.2	140	8.6	5.3	250	2.0	40	33.60	1.60	4.9
910429	101	19	.066		1.01	.		.	.	.	.	.	.	.	.	.	.	.
910603	101	0	.052		1.17	0.21		5.6	1.6	130	.	5.8	230	3.5	20	23.20	0.16	5.9
910603	101	19	.092		1.79	.		.	.	.	.	.	.	.	.	.	.	.
910603	102	0	.064		1.25	.		.	.	.	.	.	235	.	.	20.30	0.16	6.6
910701	101	0	.029		1.36	0.03		12.0	6.2	110	8.8	7.7	230	0.5	20	30.10	0.43	3.3
910701	101	26	.213		2.98	.		.	.	.	.	.	.	.	.	.	.	.
910701	102	0	.029		1.47	.		.	.	.	8.8	.	230	.	.	32.50	0.21	3.3
910701	102	26	.095		.	.		.	.	.	.	.	.	.	.	.	0.21	.
910805	101	0			0.96	0.01	K	7.2	1.2	130	8.8	5.2	235	4.3	30	28.80	0.21	4.9
910805	101	26	.721		5.00	.		.	.	.	.	.	.	.	.	.	.	.
910805	102	0			1.10	.		.	.	.	8.8	.	230	.	.	26.60	0.19	4.9
910910	101	0			1.26	0.03		5.4	2.0	130	7.8	5.2	262	15	20	21.70	1.52	4.9
910910	101	25	.064		1.41	.		.	.	.	.	.	.	.	.	.	.	.
910910	102	0	.042		1.20	.		.	.	.	7.9	.	260	.	.	19.00	1.37	5.6

Abbreviations and Units

SITE= sampling site ID
DM= sample depth in meters(0=0-2 m integrated)
D= sample depth in feet
TP= total phosphorus in mg/l
TKN= total Kjeldahl nitrogen in mg/l
N2N3= nitrite+nitrate N in mg/l
PH= pH in SU (field)
PHL= pH in SU (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
COND= conductivity in umhos/cm (l=lab)
CONF= conductivity (field)
CL= chloride in mg/l
DO= dissolved oxygen in mg/l
TEMP= temperature in degrees centigrade
SD= Secchi disk in meters
SDF= Secchi disk in feet
CHLA= chlorophyll-a in ug/l
PHEO= pheophytin in ug/l
PHYS= physical appearance rating
REC= recreational suitability rating
RTP, RN2N3...= remark code; k=less than

GREEN LAKE DISSOLVED OXYGEN AND TEMPERATURE MEASUREMENTS (LAKEID=30-0136)

SITE	DATE	D	DO	TEMP	TP
101	910429	0	12.1000	11.3000	0.05700
101	910429	3	12.0000	11.3000	.
101	910429	6	12.0000	11.3000	.
101	910429	9	11.9000	11.3000	.
101	910429	13	11.8000	11.2000	.
101	910429	16	11.5000	11.1000	.
101	910429	19	11.1000	11.0000	0.06600
101	910429	22	11.0000	11.0000	.
101	910603	0	9.4000	22.5000	0.05200
101	910603	3	9.4000	22.5000	.
101	910603	6	9.4000	22.5000	.
101	910603	9	7.7000	21.4000	.
101	910603	13	6.8000	20.2000	.
101	910603	16	6.3000	17.6000	.
101	910603	19	5.5000	13.6000	0.09200
101	910603	22	0.6000	11.5000	.
101	910603	26	0.4000	11.0000	.
101	910701	0	8.2000	22.7000	0.09500
101	910701	3	8.2000	22.6000	.
101	910701	6	8.0000	22.5000	.
101	910701	9	7.7000	22.4000	.
101	910701	13	6.4000	22.1000	.
101	910701	16	3.4000	21.1000	.
101	910701	19	0.8000	19.4000	.
101	910701	22	0.4000	12.8000	.
101	910701	26	0.4000	12.2000	0.21300
101	910805	0	9.0000	22.6000	
101	910805	3	9.1000	22.3000	.
101	910805	6	7.5000	21.7000	.
101	910805	9	7.4000	21.6000	.
101	910805	13	7.3000	21.5000	.
101	910805	16	4.4000	21.1000	.
101	910805	19	1.1000	20.4000	.
101	910805	22	0.8000	16.7000	.
101	910805	26	0.8000	14.1000	0.72100
101	910910	0	5.6000	20.9000	
101	910910	3	5.6000	20.9000	.
101	910910	6	5.5000	20.9000	.
101	910910	9	5.5000	20.9000	.
101	910910	13	5.4000	20.9000	.
101	910910	16	5.5000	20.9000	.
101	910910	19	5.6000	20.9000	.
101	910910	22	5.7000	20.6000	.
101	910910	25	5.5000	20.5000	0.06400
102	910603	0	9.2000	24.1000	0.06400
102	910603	3	9.2000	24.1000	.
102	910603	6	9.2000	24.0000	.
102	910603	9	9.3000	23.5000	.
102	910603	13	8.6000	21.8000	.
102	910603	16	6.0000	17.3000	.
102	910603	19	4.0000	14.1000	.
102	910603	22	1.9000	12.2000	.
102	910603	26	0.5000	11.2000	.

LAKEID=30-0136
(continued)

SITE	DATE	D	DO	TEMP	TP
102	910701	0	8.3000	23.0000	0.02900
102	910701	3	8.10000	22.8000	.
102	910701	6	7.80000	22.5000	.
102	910701	9	7.90000	22.5000	.
102	910701	13	7.70000	22.5000	.
102	910701	16	5.80000	21.2000	.
102	910701	19	0.30000	19.1000	.
102	910701	22	0.30000	13.5000	.
102	910701	26	0.30000	11.9000	0.029000
102	910805	0	9.40000	23.1000	
102	910805	3	9.50000	23.0000	.
102	910805	6	9.60000	22.6000	.
102	910805	9	8.70000	22.0000	.
102	910805	13	7.00000	21.7000	.
102	910805	16	5.10000	21.4000	.
102	910805	19	0.80000	20.3000	.
102	910805	22	0.70000	16.3000	.
102	910805	26	0.60000	13.9000	.
102	910910	0	4.80000	20.9000	0.042000
102	910910	3	4.70000	20.9000	.
102	910910	6	4.60000	20.9000	.
102	910910	9	4.60000	20.9000	.
102	910910	13	4.70000	20.9000	.
102	910910	16	4.60000	20.9000	.
102	910910	19	4.50000	20.9000	.
102	910910	22	0.60000	19.5000	.
102	910910	25	0.50000	16.7000	.

Minnesota Pollution Control Agency
Citizen Lake-Monitoring Program

LAKEID: 30-0136

LAT.LON.: 453427 932624
LAKE: GREEN
LOCATION: 8 MI E OF PRINCETON
COUNTY: ISANTI
AREA: 802 acres
MAXDEPTH: 28 feet

DATE	TIME	D	00029 SITE	*00078 SECCHI FEET	84141 PHYSCON 1-5	84142 RECSUIT 1-5
910603		0	202	7.00	-	-
910609	1300	0	"	5.50	2	1
910623	1200	0	"	5.00	2	1
910706	1300	0	"	3.00	4	3
910810	1200	0	"	4.50	4	3

Table 2.—Lake observer survey.

A. Please circle the one number that best describes the physical condition of the lake water today:

1. Crystal clear water.
2. Not quite crystal clear, a little algae present/visible.
3. Definite algal green, yellow, or brown color apparent.
4. High algal levels with limited clarity and/or mild odor apparent.
5. Severely high algal levels with one or more of the following: massive floating scums on lake or washed up on shore, strong foul odor, or fish kill.

B. Please circle the one number that best describes your opinion on how suitable the lake water is for recreation and aesthetic enjoyment today:

1. Beautiful, could not be any nicer.
2. Very minor aesthetic problems; excellent for swimming, boating, enjoyment.
3. Swimming and aesthetic enjoyment slightly impaired because of algal levels.
4. Desire to swim and level of enjoyment of the lake substantially reduced because of algal levels (would not swim, but boating is okay).
5. Swimming and aesthetic enjoyment of the lake nearly impossible because of algal levels.

SITE=101 MO=04

Variable	N	Mean	Std Dev	Minimum	Maximum
SDF	1	4.9000000	.	4.9000000	4.9000000
SD	1	1.5000000	.	1.5000000	1.5000000
PHYSN	1	2.0000000	.	2.0000000	2.0000000
RECN	1	2.0000000	.	2.0000000	2.0000000

SITE=101 MO=06

Variable	N	Mean	Std Dev	Minimum	Maximum
SDF	1	5.9000000	.	5.9000000	5.9000000
SD	1	1.7999992	.	1.7999992	1.7999992
PHYSN	1	2.0000000	.	2.0000000	2.0000000
RECN	1	2.0000000	.	2.0000000	2.0000000

SITE=101 MO=07

Variable	N	Mean	Std Dev	Minimum	Maximum
SDF	1	3.3000000	.	3.3000000	3.3000000
SD	1	1.0000000	.	1.0000000	1.0000000
PHYSN	1	3.0000000	.	3.0000000	3.0000000
RECN	1	3.0000000	.	3.0000000	3.0000000

SITE=101 MO=08

Variable	N	Mean	Std Dev	Minimum	Maximum
SDF	1	4.9000000	.	4.9000000	4.9000000
SD	1	1.5000000	.	1.5000000	1.5000000
PHYSN	1	3.0000000	.	3.0000000	3.0000000
RECN	1	3.0000000	.	3.0000000	3.0000000

SITE=101 MO=09

Variable	N	Mean	Std Dev	Minimum	Maximum
SDF	1	4.9000000	.	4.9000000	4.9000000
SD	1	1.5000000	.	1.5000000	1.5000000
PHYSN	0	.	.	.	.
RECN	0	.	.	.	.

SITE=102 MO=06

Variable	N	Mean	Std Dev	Minimum	Maximum
SDF	1	6.6000000	.	6.6000000	6.6000000
SD	1	2.0000000	.	2.0000000	2.0000000
PHYSN	1	2.0000000	.	2.0000000	2.0000000
RECN	1	2.0000000	.	2.0000000	2.0000000

SITE=102 MO=07

Variable	N	Mean	Std Dev	Minimum	Maximum
SDF	1	3.3000000	.	3.3000000	3.3000000
SD	1	1.0000000	.	1.0000000	1.0000000
PHYSN	1	3.0000000	.	3.0000000	3.0000000
RECN	1	3.0000000	.	3.0000000	3.0000000

SITE=102 MO=08

Variable	N	Mean	Std Dev	Minimum	Maximum
SDF	1	4.9000000	.	4.9000000	4.9000000
SD	1	1.5000000	.	1.5000000	1.5000000
PHYSN	1	3.0000000	.	3.0000000	3.0000000
RECN	1	3.0000000	.	3.0000000	3.0000000

SITE=102 MO=09

Variable	N	Mean	Std Dev	Minimum	Maximum
SDF	1	5.6000000	.	5.6000000	5.6000000
SD	1	1.6999998	.	1.6999998	1.6999998
PHYSN	0	.	.	.	.
RECN	0	.	.	.	.

SITE=202 MO=06

Variable	N	Mean	Std Dev	Minimum	Maximum
SDF	3	5.8333333	1.0408330	5.0000000	7.0000000
SD	3	1.7779992	0.3172459	1.5239992	2.1335993
PHYSN	2	2.0000000	0	2.0000000	2.0000000
RECN	2	1.0000000	0	1.0000000	1.0000000

The SAS System

SITE=202 MO=07

Variable	N	Mean	Std Dev	Minimum	Maximum
SOF	1	3.0000000	.	3.0000000	3.0000000
SD	1	0.9144000	.	0.9144000	0.9144000
PHYSN	1	4.0000000	.	4.0000000	4.0000000
RECN	1	3.0000000	.	3.0000000	3.0000000

SITE=202 MO=08

Variable	N	Mean	Std Dev	Minimum	Maximum
SOF	1	4.5000000	.	4.5000000	4.5000000
SD	1	1.3715992	.	1.3715992	1.3715992
PHYSN	1	4.0000000	.	4.0000000	4.0000000
RECN	1	3.0000000	.	3.0000000	3.0000000

Green Lake Historic Water Quality Data by Seasonal Means.

LAKEID=30-0136

OBS	YR	MTP	NP	SP	MSDF	NS	SS	MCHLA	NC	SC
44	73	.	0	.	4.13333	15	0.05909	.	0	.
45	74	.	0	.	5.52941	17	0.40781	.	0	.
46	88	0.044167	6	0.009579	4.08235	17	0.22479	24.5150	6	9.73527
47	89	0.037000	1	.	5.78333	12	0.55389	6.8900	2	0.48000
48	90	.	0	.	2.50000	4	0.50000	.	0	.
49	91	0.~~039~~000 .04300	8	0.010825	4.95385	13	0.33980	25.2750	8	1.74681

Key

OBS = [redacted]
YR = year
MTP = Mean Total Phosphorus
NP =
SP = Soluble Phosphorus
MSDF = Mean Secci Disc Feet
NS =
SS = Suspended Solids
MCHLA = Mean Chlorophyll A
NC =
SC =

APPENDIX 2

Phytoplankton Data

Phytoplankton - Rapid Assessement Analysis

GREEN LAKE
DNR # 30-136
SITE : 101
SAMPLE DATE : 6/3/91

DIVISION	TAXON	PERCENT BY VOLUME
CHLOROPHYTA (GREEN ALGAE)	Closterium sp.	1
	Oocystis parva	1
	Schroederia Judayi	1
	Sphaerocystis Schroeteri	1
	Staurastrum sp.	1
CYANOPHYTA (BLUE-GREEN ALGAE)	Aphanizomenon flos-aquae	87
	Gomphosphaeria Naegelianum	3
	Anabaena spiroides v. crassa	1
BACILLARIOPHYTA (DIATOMS)	Stephanodiscus Hantzschii	1
PYRROPHYTA (DINOFLAGELLATES)	Ceratium hirundinella	2
CRYPTOPHYTA (CRYPTOMONADS)	Cryptomonas erosa	1

Abundant algal population

Phytoplankton - Rapid Assessment Analysis

GREEN LAKE
DNR # 30-0136
SITE : 101 S
SAMPLE DATE : 7/1/91

DIVISION	TAXON	PERCENT BY VOLUM
CHLOROPHYTA (GREEN ALGAE)	Closterium sp.	3
	Pediastrum duplex v. clathratum	2
	Chlamydomonas globosa	1
	Pyramimonas sp.	1
CYANOPHYTA (BLUE-GREEN ALGAE)	Aphanizomenon flos-aquae	25
	Gomphosphaeria Naegelianum	25
	Anabaena spiroides v. crassa	5
	Anabaena affinis	3
	Anabaena flos-aquae	3
	Oscillatoria Agardhii	3
BACILLARIOPHYTA (DIATOMS)	Melosira granulata	1
	Navicula sp.	1
	Stephanodiscus Hantzschii	1
PYRROPHYTA (DINOFLAGGELLATES)	Ceratium hirundinella	25
CRYPTOPHYTA (CRYPTOMONADS)	Cryptomonas erosa	1

Phytoplankton - Rapid Assessment Analysis

GREEN LAKE
DNR # 30-0136
SITE: 10/S
SAMPLE DATE: 8/5/91

DIVISION	TAXON	PERCENT BY VOLUME
CHLOROPHYTA (GREEN ALGAE)	Closterium sp.	5
	Schroederia Judayi	5
	Cosmarium sp.	3
	Staurastrum sp.	3
	Lagerheimia sp.	1
	Oocystis parva	1
	Scenedesmus quadricauda	1
	Sphaerocystis Schroeteri	1
	Tetraedron sp.	1
CYANOPHYTA (BLUE-GREEN ALGAE)	Aphanizomenon flos-aquae	30
	Gomphosphaerium Naegelianum	2C
	Anabaena spiroides v. crassa	10
	Anabaena affinis	3
	Oscillatoria limnetica	3
BACILLARIOPHYTA (DIATOMS)	Stephanodiscus Hantzschii	1
	Stephanodiscus niagarae	1
PYRROPHYTA (DINO FLAGGELLATES)	Ceratium hirundinella	10
CRYPTOPHYTA (CRYPTOMONADS)	Cryptomonas erosa	1

(DIATOMS) Cocconeis placentula 2

APPENDIX 3

APPENDIX III

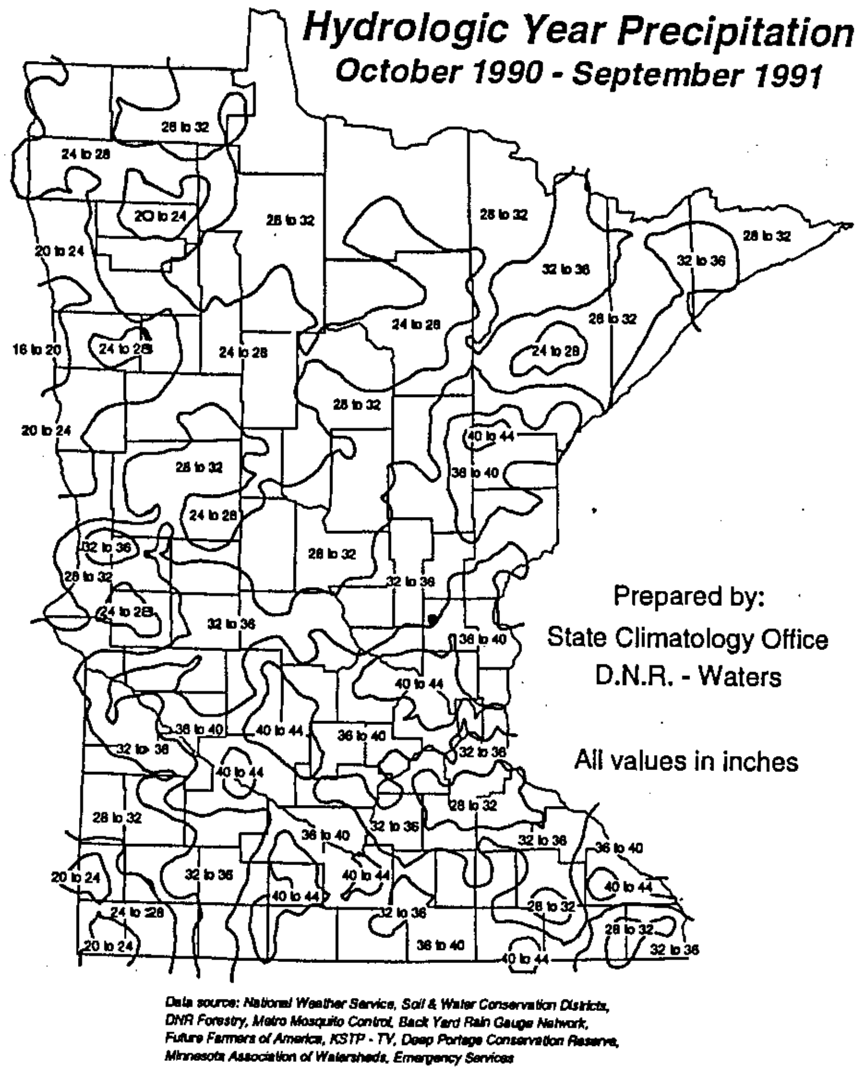
Ecoregion Lake Data Base
Water Quality Summary

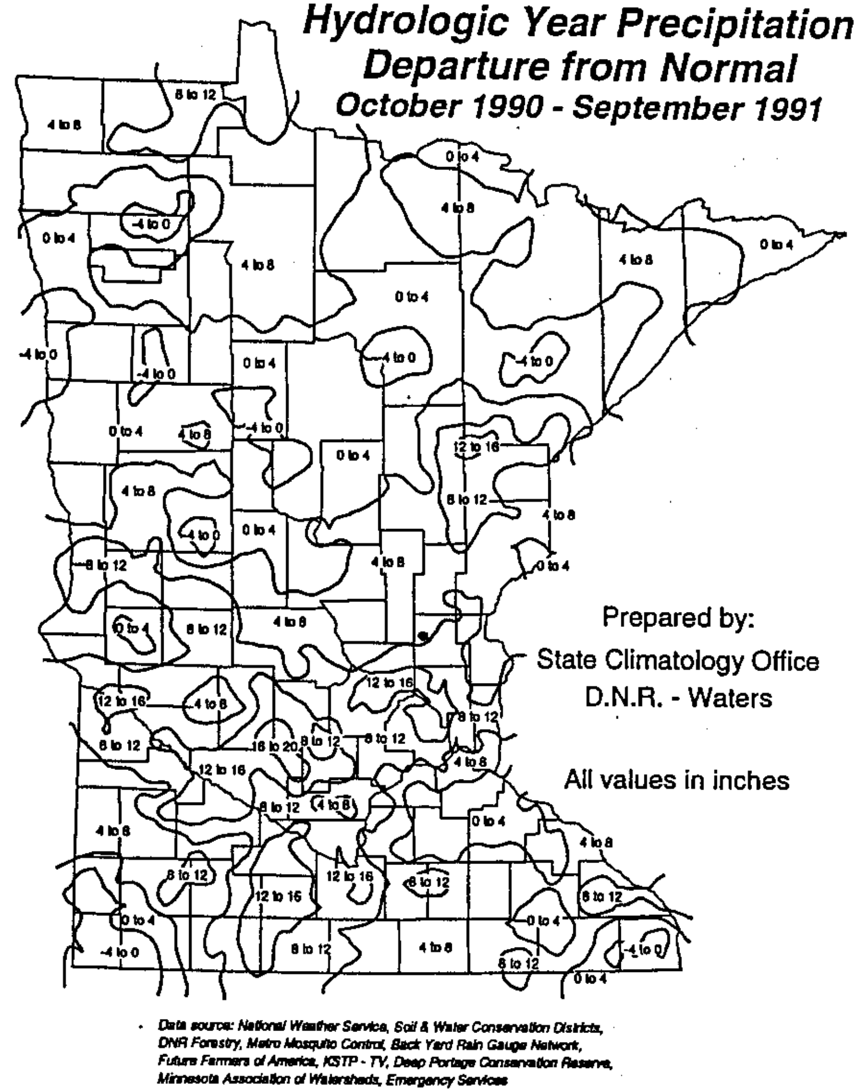
SUMMER AVERAGE WATER QUALITY CHARACTERISTICS FOR LAKES BY ECOREGION. Based on interquartile range (25th-75th percentile) for ecoregion reference lakes.[1]

	Ecoregion			
Parameter	Northern Lakes and Forests	North Central Hardwood Forests	Western Corn Belt Plains	Northern Glaciated Plains
Total Phosphorus (ug/l)	14 - 27	23 - 50	65 - 150	130 - 250
Chlorophyll mean (ug/l)	<10	5 - 22	30 - 80	30 - 55
Chlorophyll maximum (ug/l)	<15	7 - 37	60 - 140	40-90
Secchi Disk (feet) (meters)	8 - 15 (2.4 - 4.6)	4.9 - 10.5 (1.5 - 3.2)	1.6 - 3.3 (0.5 - 1.0)	1.0-3.3 (0.3 - 1.0)
Total Kjeldahl Nitrogen (mg/l)	<0.75	<0.60 - 1.2	1.3 - 2.7	1.8 - 2.3
Nitrite + Nitrate-N (mg/l)	<0.01	<0.01	0.01 - 0.02	.01 - .1
Alkalinity (mg/l)	40 - 140	75 - 150	125 - 165	160 - 260
Color (Pt-Co Units)	10 - 35	10 - 20	15 - 25	20 - 30
pH (SU)	7.2 - 8.3	8.6 - 8.8	8.2 - 9.0	8.3 - 8.6
Chloride (mg/l)	<2	4 - 10	13 - 22	11 - 18
Total Suspended Solids (mg/l)	<1 - 2	2 - 6	7 - 18	10 - 30
Total Suspended Inorganic Solids (mg/l)	<1 - 2	1 - 2	3 - 9	5 - 15
Turbidity (NTU)	<2	1 - 2	3 - 8	6 - 17
Conductivity (umhos/cm)	50 - 250	300 - 400	300 - 650	640 - 900
TN:TP ratio	25:1 - 35:1	25:1 - 35:I	17:1 - 27:1	7:1 - 18:1

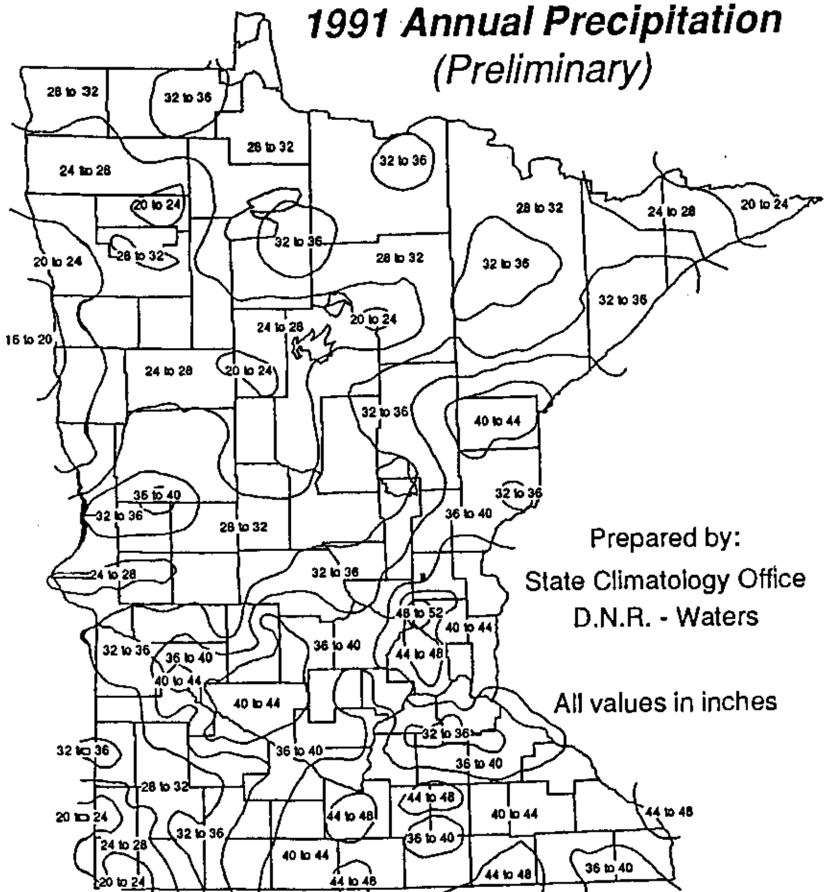
[1]Derived in part from Heiskary and Wilson (1989).

APPENDIX 4


Hydrologic Year Precipitation
October 1990 - September 1991
Prepared by:
State Climatology Office
D.N.R. - Waters
All values in inches
Data source: National Weather Service, Soil & Water Conservation Districts, DNR Forestry, Metro Mosquito Control, Back Yard Rain Gauge Network, Future Farmers of America, KSTP - TV, Deep Portage Conservation Reserve, Minnesota Association of Watersheds, Emergency Services


Hydrologic Year Precipitation
Departure from Normal
October 1990 - September 1991
Prepared by:
State Climatology Office
D.N.R. - Waters
All values in inches
Data source: National Weather Service, Soil & Water Conservation Districts, DNR Forestry, Metro Mosquito Control, Back Yard Rain Gauge Network, Future Farmers of America, KSTP - TV, Deep Portage Conservation Reserve, Minnesota Association of Watersheds, Emergency Services

1991 Annual Precipitation
(Preliminary)

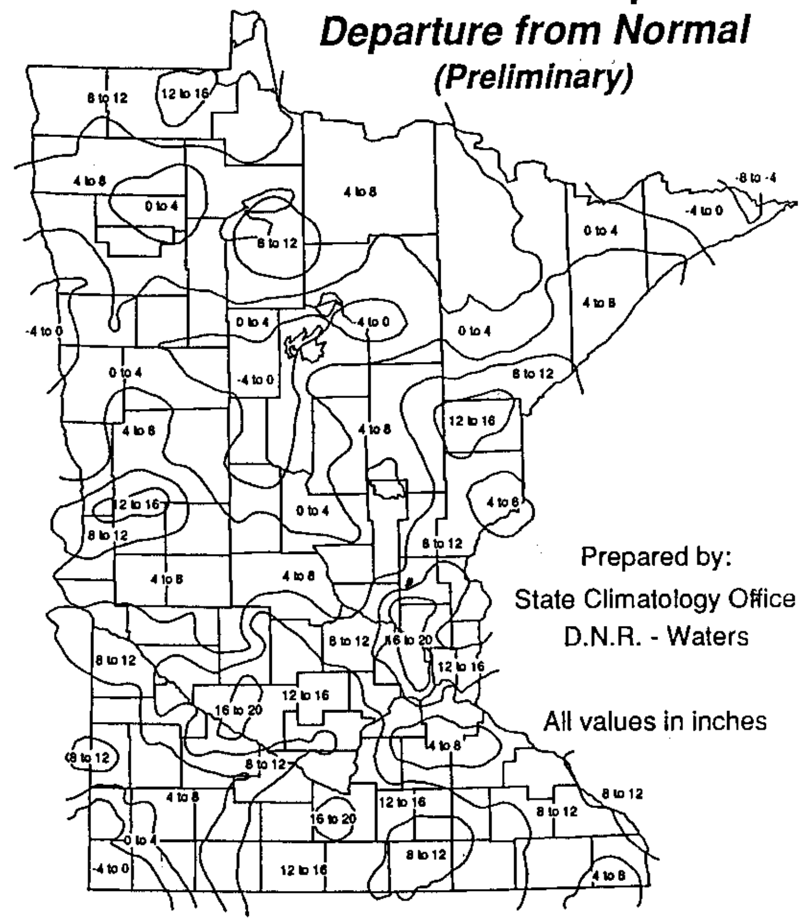


Prepared by:
State Climatology Office
D.N.R. - Waters

All values in inches

Data source: National Weather Service, Soil & Water Conservation Districts, DNR Forestry, Metro Mosquito Control, Back Yard Rain Gauge Network, Future Farmers of America, KSTP - TV, Deep Portage Conservation Reserve, Minnesota Association of Watersheds

1991 Annual Precipitation Departure from Normal
(Preliminary)



Prepared by:
State Climatology Office
D.N.R. - Waters

All values in inches

Data source: National Weather Service, Soil & Water Conservation Districts, DNR Forestry, Metro Mosquito Control, Back Yard Rain Gauge Network, Future Farmers of America, KSTP - TV, Deep Portage Conservation Reserve, Minnesota Association of Watersheds

The precipitation data displayed below are derived from an electronic scan of the State Climatology Office precipitation data base. This scan will locate available data nearest to the point of interest. The observing location is identified geographically using county name, township number, range number, and section number. You may notice changes in what is found to be the nearest observing location from month to month. This is due to the nature of volunteer-based observing networks where individuals join and leave the network, leave for vacations, choose not to observe winter-time precipitation, and other factors.

Below is a key to the data structure:

```
month
  |  year
  |   |
  |   |
  |   |
Jan 1985  Precipitation
HENNEPIN            118  21  28 CCDC   4          62 —— monthly total
   |                 |   |   |   |     |               precipitation in
county name    township  |   |   |     |               hundredths of an
                    range    |   |     |               inch (i.e. 62 equals
                       section   |     |               0.62 inches)
                            ignore ignore
```

Jan 1988 Precipitation						
ISANTI	36	25	21	CCDC	7	92
Feb 1988 Precipitation						
ISANTI	36	25	21	CCDC	7	15
Mar 1988 Precipitation						
ISANTI	36	25	21	CCDC	7	140
Apr 1988 Precipitation						
ISANTI	36	25	21	CCDC	7	80
May 1988 Precipitation						
ISANTI	36	25	21	CCDC	7	303
Jun 1988 Precipitation						
ISANTI	36	25	21	CCDC	7	71
Jul 1988 Precipitation						
ISANTI	36	25	21	CCDC	7	363
Aug 1988 Precipitation						
ISANTI	36	25	21	CCDC	7	428
Sep 1988 Precipitation						
ISANTI	36	25	21	CCDC	7	387
Oct 1988 Precipitation						
ISANTI	36	25	21	CCDC	7	67
Nov 1988 Precipitation						
ISANTI	36	25	21	CCDC	7	295
Dec 1988 Precipitation						
ISANTI	36	25	21	CCDC	7	108
Jan 1989 Precipitation						
ISANTI	36	25	21	ACCC	7	74
Feb 1989 Precipitation						
ISANTI	36	25	21	ACCC	7	57
Mar 1989 Precipitation						
ISANTI	36	25	21	ACCC	7	163
Apr 1989 Precipitation						
ISANTI	36	25	21	ACCC	7	191
May 1989 Precipitation						
ISANTI	36	25	21	ACCC	7	416
June 1989 Precipitation						
Isanti	36	25	21	ACCC	7	206

Jul 1989 Precipitation						
ISANTI	36	25	21	ACCC	7	236
Aug 1989 Precipitation						
ISANTI	36	25	21	ACCC	7	726
Sep 1989 Precipitation						
ISANTI	36	25	21	ACCC	7	257
Oct 1989 Precipitation						
ISANTI	36	25	21	ACCC	7	85
Nov 1989 Precipitation						
ISANTI	36	25	21	ACCC	7	96
Dec 1989 Precipitation						
ISANTI	36	25	21	ACCC	7	49
Jan 1990 Precipitation						
ISANTI	36	25	21	ACCC	7	3
Feb 1990 Precipitation						
ISANTI	36	25	21	ACCC	7	77
Mar 1990 Precipitation						
ISANTI	36	25	21	ACCC	7	324
Apr 1990 Precipitation						
ISANTI	36	25	21	ACCC	7	278
May 1990 Precipitation						
ISANTI	36	25	21	ACCC	7	333
Jun 1990 Precipitation						
ISANTI	36	25	21	ACCC	7	1144
Jul 1990 Precipitation						
ISANTI	36	25	21	ACCC	7	761
Aug 1990 Precipitation						
ISANTI	36	25	21	ACCC	7	638
Sep 1990 Precipitation						
ISANTI	36	25	21	ACCC	7	167
Oct 1990 Precipitation						
ISANTI	36	25	21	ACCC	7	351
Nov 1990 Precipitation						
ISANTI	36	25	21	ACCC	7	73
Dec 1990 Precipitation						
ISANTI	36	25	21	ACCC	7	46
Jan 1991 Precipitation						
ISANTI	36	25	21	ACCC	7	63
Feb 1991 Precipitation						
ISANTI	36	25	21	ACCC	7	120
Mar 1991 Precipitation						
ISANTI	36	25	21	ACCC	7	194
Apr 1991 Precipitation						
ISANTI	36	25	21	ACCC	7	371
May 1991 Precipitation						
ISANTI	36	25	21	ACCC	7	477
Jun 1991 Precipitation						
ISANTI	36	25	21	ACCC	7	421
Jul 1991 Precipitation						
ISANTI	36	25	21	ACCC	7	515
Aug 1991 Precipitation						
ISANTI	36	25	21	ACCC	7	461
Sep 1991 Precipitation						
ISANTI	36	25	21	ACCC	7	313
Oct 1991 Precipitation						
ISANTI	36	25	21	ACCC	7	255
Nov 1991 Precipitation						
ISANTI	36	25	21	ACCC	7	520
Dec 1991 Precipitation						
ISANTI	36	25	21	ACCC	7	25

1991 TOTAL = 37.4 inches

Station: (211227) Cambridge,MN From Year=1961 To Year=1990

Missing Data: 4.3%

	Total Precipitation							Snow			#Days Precip		
	Mean	High--Yr		Low--Yr		1-Day Max		Mean	High--Yr		=>.10	=>.50	=>1.
Ja	0.80	2.99	75	0.00	90	1.36	10/1975	11.1	34.0	75	3	0	0
Fe	0.63	1.67	79	0.00	70	0.78	14/1976	7.0	19.5	74	2	0	0
Ma	1.36	3.90	77	0.26	81	1.30	8/1990	9.4	35.2	65	4	1	0
Ap	2.13	5.33	75	0.50	80	3.76	27/1975	2.3	10.0	83	5	1	0
Ma	3.27	5.86	62	0.96	67	2.73	22/1962	0.0	0.0	0	7	3	0
Jn	4.52	9.25	75	0.68	88	4.05	12/1984	0.0	0.0	0	8	3	1
Jl	3.78	11.37	72	1.00	76	5.47	22/1972	0.0	0.0	0	6	2	1
Au	3.89	8.56	89	0.83	76	3.80	27/1977	0.0	0.0	0	6	3	1
Se	3.43	8.06	68	0.35	76	4.84	22/1968	0.0	0.0	0	6	2	1
Oc	2.38	7.58	68	0.23	76	2.66	27/1971	0.4	5.0	87	5	2	1
No	1.45	4.57	75	0.05	67	1.89	20/1975	5.2	21.8	83	3	1	0
De	0.97	3.06	68	0.00	80	1.08	27/1982	10.2	36.0	69	3	0	0
An	28.59	40.87	75	12.89	76	5.47	22/07/72	45.5	83.0	75	57	18	6
Wi	2.40	5.44	69	0.80	63	1.36	10/01/75	28.3	56.6	67	8	1	0
Sp	6.76	11.77	65	2.74	67	3.76	27/04/75	11.7	36.2	65	15	5	1
Su	12.18	19.74	90	4.17	76	5.47	22/07/72	0.0	0.0	0	19	8	4
Fa	7.26	16.18	68	0.93	76	4.84	22/09/68	5.5	21.8	83	15	5	2

ST. PAUL PAN EVAPORATION MONTHLY TOTALS

YEAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	TOTAL
1988	1.77	10.38	11.83	11.73	8.96	5.20	1.54	51.41
1989	1.74	6.47	7.80	8.93	7.26	5.90	1.57	39.67
1990	1.96	6.27	7.24	7.65	6.63	5.45	1.71	36.91
1991	2.09	5.24	7.90	7.44	6.31	4.04	1.08	34.10
AVERAGE (23 YRS)	1.97	7.12	8.17	8.65	7.03	4.85	1.27	39.05

* Remember to apply an empirical coefficient to estimate lake evaporation from pan evaporation.
(I suggest .... Lake evap = Pan evap * 0.6)

APPENDIX 5

The rain fall for the summer of 1991. Compiled on Green Lake North East side by Glenn Okan

Started on May 17, 1991 *thru Sept 9, 91*

Sun	Mon	Tues	Wed	Thurs	Fri	Sat
					17 rain 1/8"	18 rain 0
19 rain 0	20 rain 0	21 rain 0	22 rain 0	23 rain .1	24 rain 0	25 rain 0
26 rain 1/2"	27 rain 3/8"	28 rain 1"	29 rain 1/4"	30 rain 0	31 rain 1/8"	June 1 rain 1/4"
2 rain 1/4"	3 rain 0	4 rain 0	5 rain 0	6 rain 0	7 rain 0	8 rain 0
9 rain 1/2"	10 rain 0	11 rain 0	12 rain 0	13 rain 3/4"	14 rain 0	15 rain 1/8"
16 rain 0	17 rain 0	18 rain 3/8"	19 rain 0	20 rain 1/2"	21 rain 5/8"	22 rain 0
23 rain 0	24 rain 0	25 rain 0	26 rain 0	27 rain 0	28 rain 0	29 rain 0
30 rain1/16"	July 1 rain 7/8"	2 rain 0	3 rain 1/2"	4 rain 3/4"	5 rain 0	6 rain 0
7 rain 1/4"	8 rain 0	9 rain 1/8"	10 rain 0	11 rain 1/8"	12 rain 1/2"	13 rain 0
14 rain 0	15 rain 0	16 rain 0	17 rain 1/2"	18 rain 0	19 rain 1/4"	20 rain 0
21 rain 1/4"	22 rain 0	23 rain 0	24 rain 0	25 <-------	26 -1 1/4"--	27 --------
28 ------->	29 rain 0	30 rain 0	31 rain 0	Aug 1 rain 1/8"	2 rain 1 1/2	3 rain 0
4 rain 0	5 rain 0	6 rain 0	7 rain 0	8 rain 1/8"	9 rain 0	10 rain 0
11 rain 0	12 rain 0	13 rain 0	14 rain 0	15 rain 0	16 rain 1 3/4"	17 rain 1/4"
18 rain 0	19 rain 0	20 rain 0	21 rain 0	22 rain 0	23 rain 1/4"	24 rain 0
25 rain 5/8"	26 rain 0	27 rain 0	28 rain 0	29 rain 0	30 rain 0	31 rain 0
Sept 1 rain 0	2 rain 0	3 rain 3/8"	4 rain 1/8"	5 rain 0	6 rain 0	7 rain 3/8"
8 rain 1 3/4"	9 rain 3/4					

3.5

TOTAL May 17 — Sept 9, 91 19.3 inch

Green Lake
Isanti County
1991 Lake Levels

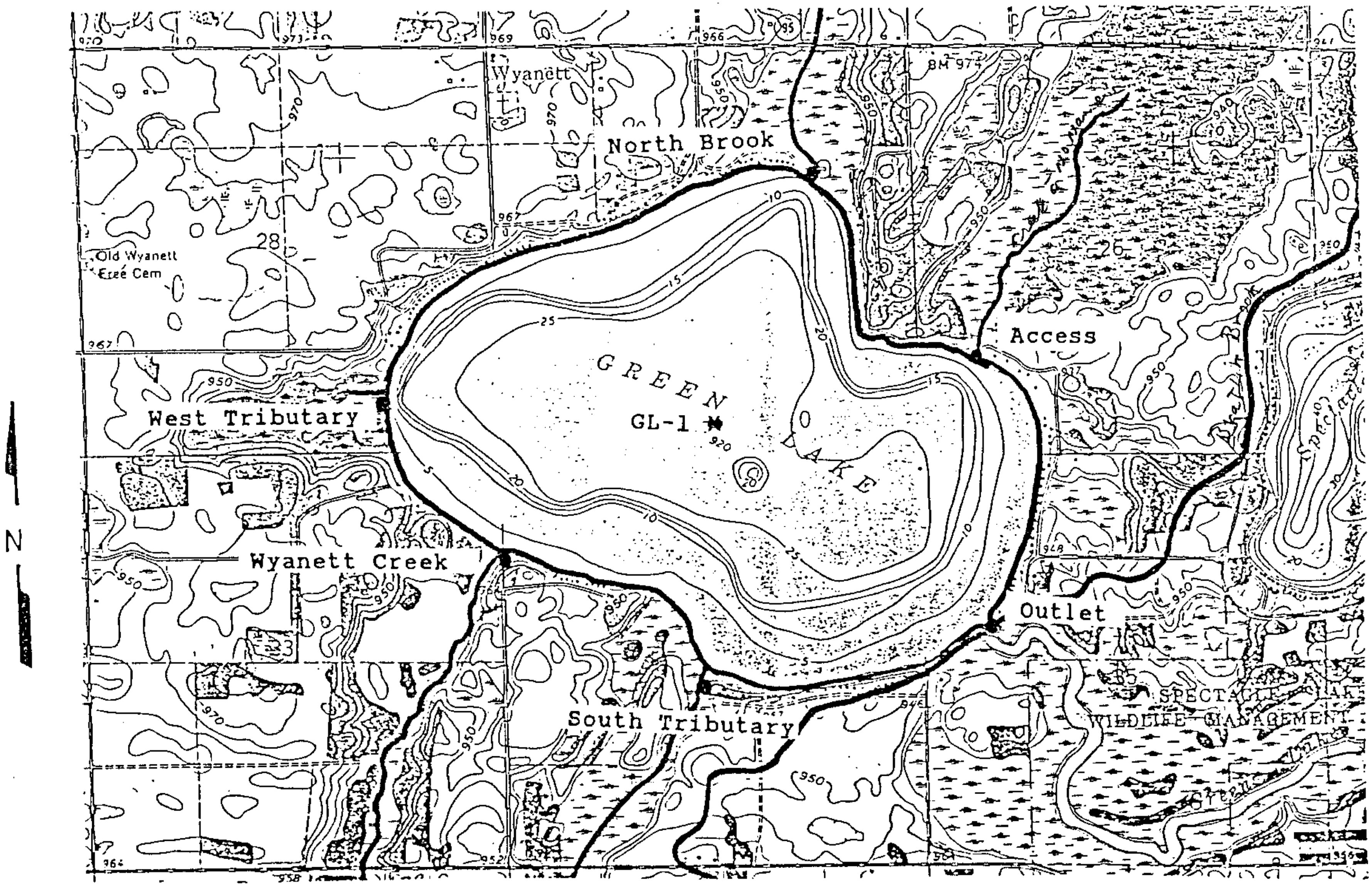
Date	My Gauge	Outlet Gauge	Rain
04-06-91	Ice off lake		
04-17-91		5.10 Rum River running in lake	
05-06-91		5.64 Rum River running in	
05-08-91		6.00 Rum River running in	
05-09-91		6.10 Rum River running in	
05-10-91		6.18 Rum River running in	
05-11-91		6.24 Rum River running in	
05-13-91		6.28 Water flowing out	
05-22-91	2.08	5.38	
05-23-91	2.04		Trace
05-24-91	2.04		Trace
05-26-91	2.02		5/10"
05-27-91	2.00	5.28	4/10"
05-28-91	2.06		1"
05-29-91	2.12		4/10"
05-30-91	2.16		0
05-31-91	2.18		0
06-01-91	2.20	River backing in lake	4/10"
06-02-91	2.28		Trace
06-03-91	2.40		5/10"
06-04-91	2.44		0
06-05-91	2.46	5.76 River backing in	0
06-06-91	2.48		0
06-10-91	2.34		6/10"
06-11-91	2.34		0
06-12-91	2.30		0
06-13-91	2.24		0
06-14-91	2.26		9/10"
06-15-91	2.26		0
06-16-91	2.18		0
06-17-91	2.12		0
06-18-91	2.08		5/10"
06-19-91	2.02		0
06-20-91	2.00		5/10"
06-21-91	2.04		8/10"
06-22-91	2.00		0
06-23-91	1.90		0
06-24-91	1.82		0
06-25-91	1.78		0
06-26-91	1.70		0
06-27-91	1.64		0
06-28-91	1.60		1/10"
06-29-91	1.52		1/10"
07-01-91	1.58		9/10"
07-02-91	1.56		0
07-03-91	1.54		Trace
07-04-91	1.54		5/10"
07-05-91	1.60		8/10"
07-06-91	1.70		0

07-07-91	1.68		2/10"
07-08-91	1.66		0
07-09-91	1.60		1/10"
07-10-91	1.58		0
07-11-91	1.54		1/10"
07-12-91	1.58		8/10"
07-13-91	1.58		0
07-14-91	1.56		0
07-15-91	1.50		0
07-16-91	1.48		0
07-17-91	1.46		0
07-18-91	1.44		4/10"
07-19-91	1.46		2/10"
07-20-91	1.44		0
07-21-91	1.42		0
07-22-91	1.40		2/10"
07-23-91	1.38		0
07-24-91	1.34		0
08-08-91	1.38		2/10"
08-09-91	1.38		0
08-10-91	1.36		0
08-11-91	1.34		0
08-12-91	1.34		0
08-13-91	1.32		0
08-14-91	1.30		0
08-15-91	1.28		0
08-16-91	1.28		0
08-17-91	1.48		2 1/10
08-18-91	1.48		0
08-19-91	1.46		0
08-20-91	1.46		0
08-21-91	1.44		0
08-22-91	1.42	4.68	0
08-23-91	1.40		3/10"
08-24-91	1.38		0
08-25-91	1.42		6/10"
08-26-91	1.42		0
08-27-91	1.40		0
08-28-91	1.38		0
08-29-91	1.38		0
08-30-91	1.36		0
08-31-91	1.34		0
09-01-91	1.32		0
09-02-91	1.28		0
09-03-91	1.28		4/10"
09-04-91	1.26		0
09-05-91	1.24		0
09-06-91	1.24		1/10"
09-07-91	1.24		0
09-08-91	1.40		2 1/10"

Total 16.7"

APPENDIX 6

WRM Data



Green Lake - Isanti County

Map of Sampling Locations

WATER RESEARCH
& MANAGEMENT, INC.
P.O Box 393
Sauk Rapids, MN 56379

Figure 1.

Table 1. Green Lake, Isanti County -Lake and Stream Survey Data

i County -Lake and Stream Survey Data

Bulletin 25 Lake #	Date yymmdd	Time 0000	00098 Sample Meters	00078 Secchi (m)	00010 Temp oC	00300 D.O. mg/l	00403 Lab pH	00530 TSS mg/l	00630 N-NO2+NO3 mg/l	00665 TP mg/l	70507 P-Ortho mg/l	00410 Tot. Alk. CaCO3	32211 Chl-a ug/l	CFS
30-136	890427	1100	0.50	1.22	9.2	12.19	7.98	12.00	0.047	0.088	0.035	136	2.9	
30-136	890427	1100	3.00		9.1	11.97		5.00	0.055	0.077	0.040			
30-136	890427	1100	6.00		9.0	11.73		8.00	0.072	0.060	0.037			
30-136	890628	1300	0.50	1.37	22.4	9.62		5.00		0.077	0.012			
30-136	890628	1300	3.00		21.7	8.90				0.049	0.010			
30-136	890628	1300	6.00		16.8	1.22				0.051	0.014			
30-136	890706	1200	0.50	1.25			8.43		0.035	0.084	0.017	280		
30-136	890706	1200	6.00				8.06		0.039	0.091	0.020	200		
30-136	890817	830	0.50	2.06	21.8	8.02	8.97	1.00	0.026	0.057	0.036	148	4.2	
30-136	890817	830	4.00		21.4	6.42			0.023	0.057	0.035			
30-136	890817	830	6.50		15.6	0.71			0.037	0.062	0.033			
ACCESS	890427	1030			6.8	7.05		2.00		0.053	0.023			0.09
ACCESS	890628	1400			24.1	6.83		2.00		0.089	0.057			0.44
ACCESS	890817	DRY												
N.BROOK	890427	1125			9.9	7.59		3.00		0.088	0.019			0.80
N.BROOK	890628	1515			17.6	7.01		1.00		0.126	0.068			0.80
N.BROOK	890817	915			12.2	4.44		2		0.126	0.120			0.20
OUTLET	890427	1015			8.6	10.90		9.00		0.058	0.012			4.19
OUTLET	890628	1420			25.6	12.49		3.00		0.047	0.017			2.62
OUTLET	890817	915			19.4	6.06		1		0.075	0.075			0.01
TRIB-S	890427	935			5.0	10.05		6.00		0.075	0.036			0.64
TRIB-S	890628	1430			16.8	7.83		3.00		0.710	0.048			0.04
TRIB-S	890817	915			12.7	8.01		1.00		0.089	0.071			0.20
TRIB-W	890427	1145			9.1	9.99		3.00		0.106	0.075			0.20
TRIB-W	890628	1530			14.5	8.19		12.00		0.138	0.097			0.27
TRIB-W	890817	915			10.4	5.45		13.00		0.129	0.115			0.01
WYANETT CR	890427	1005			9.5	9.40		15.00		0.126	0.059			3.00
WYANETT CR	890628	1445			24.4	4.44		13.00		0.245	0.121			0.13
WYANETT CR	890817	915						2.00		0.112	0.090			0

Table 2. Green Lake Dissolved Oxygen & Temperature Profiles

APRIL 27, 1989			JUNE 28, 1989			AUGUST 17, 1989		
DEPTH METERS	TEMP C	DO MG/L	DEPTH METERS	TEMP C	DO MG/L	DEPTH METERS	TEMP C	DO MG/L
0.5	9.2	12.19	0.5	22.4	9.62	0.5	21.8	8.02
1	9.2	11.75	1	22.4	9.70	1	21.8	8.25
2	9.2	11.83	2	22.2	9.68	2	21.7	7.33
3	9.1	11.97	3	21.7	8.90	3	21.6	7.95
4	9.1	11.87	4	20.4	7.17	4	21.4	6.42
5	9.1	11.97	5	18.9	5.07	5	21.4	6.18
6	9.0	11.73	6	16.8	1.22	6	19.2	0.77
7	8.2	10.94	7	14.8	0.11	7	15.6	0.71

Table 3. Green Lake Loading Summary

Date yymmdd	Days	Instant CFS	TSS mg/l	TP mg/l	lb TP	lb TSS	CFS-DAYs	Average lb TP/d	Average lb TSS/d	Average CFS	Conc. mg TP/l	Conc. mg TSS/l
25-Apr-89		WYANETT										
27-Apr-89	32.0	3.00	15.000	0.126	65.3	7768.8	96.0					
28-Jun-89	56.0	0.13	13.000	0.245	9.6	510.6	7.3					
17-Aug-89	25.5	0.01	2.000	0.112	0.2	2.8	0.3					
18-Aug-89												
Totals	113.5				75.0	8282.1	103.5	0.7	73.0	0.91	0.13	14.80
25-Apr-89		OUTLET										
27-Apr-89	32.0	4.19	9.000	0.058	42.0	6510.3	134.1					
28-Jun-89	56.0	2.62	3.000	0.047	37.2	2374.7	146.7					
17-Aug-89	25.5	0.01	1.000	0.075	0.1	1.4	0.3					
18-Aug-89												
Totals	113.5				79.3	8886.3	281.1	0.7	78.3	2.48	0.05	5.85
25-Apr-89		N BROOK										
27-Apr-89	32.0	0.80	3.000	0.088	12.2	414.3	25.6					
28-Jun-89	56.0	0.80	1.000	0.126	30.5	241.7	44.8					
17-Aug-89	25.5	0.20	2.000	0.126	3.5	55.0	5.1					
18-Aug-89												
Totals	113.5				46.1	711.1	75.5	0.4	6.3	0.67	0.11	1.74
25-Apr-89		ACCESS										
27-Apr-89	32.0	0.09	2.000	0.053	0.8	31.1	2.9					
28-Jun-89	56.0	0.04	2.000	0.089	1.1	24.2	2.2					
17-Aug-89	25.5	0.00	0.000	0.000	0.0	0.0	0.0					
18-Aug-89												
Totals	113.5				1.9	55.2	5.1	0.0	0.5	0.05	0.07	2.00
25-Apr-89		S TRIB										
27-Apr-89	32.0	0.64	6.000	0.075	8.3	662.9	20.5					
28-Jun-89	56.0	0.40	3.000	0.710	85.8	362.5	22.4					
17-Aug-89	25.5	0.20	1.000	0.089	2.4	27.5	5.1					
18-Aug-89												
Totals	113.5				96.5	1053.0	48.0	0.9	9.3	0.42	0.37	4.06
25-Apr-89		W TRIB										
27-Apr-89	32.0	0.20	3.000	0.106	3.7	103.6	6.4					
28-Jun-89	56.0	0.27	12.000	0.138	11.3	978.9	15.1					
17-Aug-89	25.5	0.01	13.000	0.129	0.2	17.9	0.3					
18-Aug-89												
Totals	113.5				15.1	1100.3	21.8	0.1	9.7	0.19	0.13	9.35

Table 4.

GREEN LAKE MACROPHYTE SURVEY JUNE 28, 1989

Loc	Z ft	D 0-3	A 1-5	CR %	RI %	ML %	PZ %	NP %	CT %	CH %	EL %	FL %
A1A	2	2	5			6		7	75		10	2
A1B	2	2	5		5	30		9	25		30	1
A2A	4	2	2			50				50		
A2B	4	3	5			5				90	5	
A3A	5	2	1							50		50
A3B	5	2	1						30	20	10	40
B1A	2	2	1									100
B1B	2	2	2									100
B2A	6	2	2	10		5	20	1	5		19	40
B2B	6	3	1	30				60				10
B3A	18	0	0									
C1A	2	3	5							100		
C1B	2	3	3		10	5		5		70	10	
C2A	6	2	3					1			99	
C2B	6	2	2	10			10	10			70	
D1A	2	3	5							100		
D1B	2	3	5		4	1				95		
D2A	5	2	4	1						29	70	
D2B	5	3	5			10				30	60	
D3A	7	1	2	30		10		10			50	
D3B	7	0	0									
E1A	2	3	5		5	20				75		
E1B	2	2	4			25				75		
E2A	5	2	1							50	50	
E2B	5	1	3						25	70	5	
F1A	4	1	3							100		
F1B	4	3	5							100		
G1A	3	2	1					100				
G1B	3	0	0									
G2A	5	1	1								100	
G2B	5	2	1					1			99	
H1A	1	2	2		30	10	10	10			40	
H1B	1	1	1				40	10			10	40
H2A	5	2	2						10		80	10
H2B	5	1	5								90	10
I1A	1	2	1		20	10	10	10	30		10	10
I1B	1	2	1							20	20	60
I2A	3	3	5			10				90		
I2B	3	2	4		5			5			90	
I3A	4	2	5			10	20			20	30	20
I3B	4	2	5		10	20				50		20
J1A	1	2	2		30					70		
J1B	1	2	2		30					60		10
J2A	3	2	1			100						
J2B	3	2	3			90				10		
J3A	6	2	3		18	19		1			60	2
J3B	6	0	0									
K1A	1	2	2		20					80		
K1B	1	2	1		50					50		
K2A	3	2	2							100		
K2B	3	2	1							100		
K3A	5	3	1			1					99	
K3B	5	1	1									100
L1A	1	2	1							100		
L1B	1	2	1							100		
L2A	2	2	2							100		
L2B	2	2	2							100		
L3A	3	2	1							80		20
L3B	3	2	1							90		10

Z = DEPTH
D = DENSITY
A = ABUNDANCE
CR = P. CRISPIS
RI = P. RICHARDSONI
ML = M. EXALBENSCENS
PZ = P. ZOSTERIFORMIS
NP = N. PONDWEED
CT = C. DEMERSUM
CH = C. VULGARIS
EL = E. CANADENSIS
FL = FILIMENTOUS ALGAE
% = PERCENT COMPOSITION

APPENDIX 7

SWIM-LAKE SUMMARY DATA FILE

Lake name: GREEN   DNR Division of Waters lake number 30- 136
Primary county: ISANTI   Secondary county: ISANTI
Lake GREEN   is in 1 county
Location: Township 36   Range 25
Watershed RUM

ENTER	REPORT
PHY	for physical characteristics
DEV	for development characteristics
FIS	for the fish report
PER	for permit characteristics
ALL	for all four reports
B	to go back one menu (lake choice)
C	to go back two menus (county choice)
Q	to leave this data base

Enter the report or MENU:
Esc-chr: ^] help: ^]? port:1 speed:19200 parity:none echo:rem VT320

PHYSICAL CHARACTERISTICS FOR LAKE: GREEN

Dominant forest/soil type: DECID/SAND
Size of lake: 866 Acres   Shorelength: 4.4 Miles.
Maximum depth: 28.0   Median depth: 21.0

Minnesota Pollution Control Agency   Data from 1983-1989
Secchi disk reading (water clarity): 4.6 feet.
Lake contour map number: C1032   (available at cost from Documents Division)
(phone: 612-297-3000)

DEVELOPMENT CHARACTERISTICS FOR LAKE: GREEN

Shoreland zoning classification: GENERAL DEVELOPMENT
Public accesses in 1988: 1

Development	Seasonal Homes	Permanent Homes	Total Homes
1967	105	43	148
1982	85	79	164

*** PUSH RETURN TO CONTINUE ***
Esc-chr: ^] help: ^]? port:1 speed:19200 parity:none echo:rem VT320

WATER CHEMISTRY   SURVEY DATE: 08/24/1987

Secchi disk: 2.6
Water color: GREEN   % Littoral: 45
Cause of water color: EXTREMELY HEAVY ALGAE BLOOM

LAKE DESCRIPTION

Surface water area: 802

Management class: WALLEYE-CENTRARCHID
Ecological type: CENTRARCHID-WALLEYE

Accessibility: STATE OWNED PUBLIC ACCESS IS LOCATED ON THE EAST SIDE OF THE LAKE IN SECTION 27.

Area fisheries supervisor: RICHARD TROMBLEY (612) 384-6147
P.O. BOX 398 HINCKLEY 55037

*** PUSH RETURN FOR CATCH DATA ***
Esc-chr: ^] help: ^]? port:1 speed:19200 parity:none echo:rem VT320

WATER CHEMISTRY SURVEY DATE: 08/24/1987

Secchi disk: 2.6
Water color: GREEN % Littoral: 45
Cause of water color: EXTREMELY HEAVY ALGAE BLOOM

LAKE DESCRIPTION

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Management class: WALLEYE-CENTRARCHID
Ecological type: CENTRARCHID-WALLEYE

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P.O. BOX 398 HINCKLEY 55037

*** PUSH RETURN FOR CATCH DATA ***
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*** PUSH RETURN FOR CATCH DATA *** QQQQQQQQQQBB)hC

NET CATCH DATA

GILL NETS No. of sets: 9 Gill net survey date: 8/24/1987

species	# fish	# per set	total pounds	pounds per set
Northern Pike	13	1.4	29.30	3.26
Carp	5	0.6	20.90	2.32
White Sucker	17	1.9	28.20	3.13
Black Bullhead	136	15.1	77.50	8.61
Yellow Bullhead	9	1.0	8.50	0.94
Brown Bullhead	1	0.1	1.00	0.11
Smallmouth Bass	1	0.1	0.90	0.10
Largemouth Bass	2	0.2	2.40	0.27
Black Crappie	96	10.7	14.20	1.58
Yellow Perch	355	39.4	34.10	3.79
Walleye	58	6.4	122.60	13.62

*** PUSH RETURN FOR TRAP DATA ***
Esc-chr: ^] help: ^]? port:1 speed:19200 parity:none echo:rem VT320

Black Crappie	96	10.7	14.20	1.58

Yellow Perch	355	39.4	34.10	3.79
Walleye	58	6.4	122.60	13.62

*** PUSH RETURN FOR TRAP DATA ***

TRAP NETS No. of sets: 7 Trap survey date: 8/24/1987

species	# fish	# per set	total pounds	pounds per set
Bowfin (Dogfish)	8	1.1	40.60	5.80
Northern Pike	1	0.1	0.10	0.01
Carp	4	0.6	27.40	3.91
Common Shiner	1	0.1	0.05	0.01
White Sucker	43	6.1	80.00	11.43
Black Bullhead	1	0.1	0.50	0.07
Yellow Bullhead	27	3.9	21.90	3.13
Pumpkinseed Sunfish	12	1.7	3.40	0.49
Bluegill Sunfish	55	7.9	2.75	0.39
Black Crappie	17	2.4	3.70	0.53
Yellow Perch	5	0.7	0.50	0.07
Walleye	2	0.3	5.40	0.77

*** PUSH RETURN FOR FISH COMMENTS ***
Esc-chr: ^] help: ^]? port:1 speed:19200 parity:none echo:rem VT320

FISH POPULATION COMMENTS cont.

BASED ON RESPECTIVE LOCAL MEDIANS THE PRESENT FISH POPULATION IS AS FOLLOWS: THE WALLEYE (6.44/ SET) SHOWS A REAL INCREASE FROM THE 1982 SURVEY. (3.00/SET) TO A LEVEL WELL ABOVE THE LOCAL MEDIAN (3.52/SET). GROWTH RATES ARE GOOD AND THE OVERALL SIZE DISTRIBUTION IS EXCELLENT (MEDIAN LENGTH GROUP 18.0 - 18.9 INCHES, MEAN WEIGHT 2.1 LBS). THE CURRENT WALLEYE POPULATION IS THE PRODUCT OF SUSTAINED FINGERLING STOCKING WITH A MINIMAL CON- TRIBUTION FROM NATURAL REPRODUCTION. A DROP IN THE NORTHERN PIKE NET CATCH (1.44/SET) FROM THE 1982 SURVEY (2.11/SET) IS NOT LARGE ENOUGH TO INDICATE A REAL DECLINE IN THE POPULATION. IT IS, HOWEVER, WELL BELOW THE LOCAL MEDIAN (3.88/SET). THE NORTHERN PIKE POPULATION IS THE PRODUCT OF SOME NATURAL REPRODUCTION SUPPLEMENTED WITH PERIODIC FINGERLING STOCKING. LENGTH FREQUENCY AND AGING DATA FROM THE CURRENT SURVEY SUGGESTS THAT STOCK- ING, AS OPPOSED TO NATURAL REPRODUCTION, IS CON- TRIBUTING TO THE BULK OF THE POPULATION. THIS HAS

More (Y/N):
Esc-chr: ^] help: ^]? port:1 speed:19200 parity:none echo:rem VT320

FISH POPULATION COMMENTS cont.

NOT BEEN THE CASE IN PREVIOUS SURVEYS. AN UNUSUALLY NARROW SIZE DISTRIBUTION IS SEEN IN THE CURRENT SURVEY, 13 OF 14 NORTHERN PIKE BETWEEN 19.0 - 22.9 INCHES. YELLOW PERCH (39.44/SET) SHOW A REAL DECLINE FROM 1982 (83.89/SET) BUT REMAIN WELL ABOVE THE LOCAL MEDIAN (24.27/SET). YELLOW PERCH TEND TO BE SMALL (MEDIAN LENGTH GROUP 5.5 - 5.9 INCHES). ONLY 2 LARGEMOUTH BASS WERE TAKEN IN TEST NETS BUT 78 YOY WERE RECORDED IN SHORELINE SEINING. SMALLMOUTH BASS (2) WERE TAKEN FOR THE FIRST TIME DURING THE CURRENT SURVEY. THE BLUEGILL NET CATCH (7.86/SET) IS ABOVE THAT OF 1982 (4.50/ SET) BUT STILL WELL BELOW THE LOCAL MEDIAN (25.67/

SET). THE MAJORITY OF BLUEGILLS ARE VERY SMALL
(MEDIAN LENGTH GROUP 4.0 - 4.4 INCHES). THE BLACK
CRAPPIE POPULATION (2.43/SET) REMAINS FAR BELOW
THE LOCAL MEDIAN (18.45/SET) AND CONSISTS OF
PREDOMINENTLY SMALL FISH (MEDIAN LENGTH GROUP
5.5 - 5.9 INCHES). BLACK BULLHEADS WERE TAKEN MORE
READILY IN GILLNETS THAN TRAPNETS BUT ARE STILL

More (Y/N):
Esc-chr: ^] help: ^]? port:1 speed:19200 parity:none echo:rem VT320

SET) BUT STILL WELL BELOW THE LOCAL MEDIAN (25.67/
SET). THE MAJORITY OF BLUEGILLS ARE VERY SMALL
(MEDIAN LENGTH GROUP 4.0 - 4.4 INCHES). THE BLACK
CRAPPIE POPULATION (2.43/SET) REMAINS FAR BELOW
THE LOCAL MEDIAN (18.45/SET) AND CONSISTS OF
PREDOMINENTLY SMALL FISH (MEDIAN LENGTH GROUP
5.5 - 5.9 INCHES). BLACK BULLHEADS WERE TAKEN MORE
READILY IN GILLNETS THAN TRAPNETS BUT ARE STILL

More (Y/N): y

FISH POPULATION COMMENTS cont.

WELL BELOW THE LOCAL MEDIAN. OTHER SPECIES TAKEN
IN TEST NETS (BOWFIN, CARP, WHITE SUCKER, YELLOW
BULLHEAD, COMMON SHINER, AND PUMPKINSEED) DO NOT
APPEAR TO BE SUBSTANTIALLY ABOVE OR BELOW LOCAL
MEDIANS NOR TO HAVE UNDERGONE ANY NOTEWORTHY
CHANGES FROM THE PREVIOUS SURVEY. ALTHOUGH NOT
SPECIFICALLY INDICATED BY TEST NETS, A LARGE
CARP POPULATION IS SUSPECTED AND HAS BEEN
UTILIZED BY COMMERCIAL FISHERMEN IN THE PAST.

*** PUSH RETURN FOR STOCKING DATA ***
Esc-chr: ^] help: ^]? port:1 speed:19200 parity:none echo:rem VT320

*** PUSH RETURN FOR STOCKING DATA ***

FISH STOCKING DATA

year	species	size	# released
80	Walleye	FINGERLING	2338
81	Walleye	FINGERLING	3672
81	Walleye	FINGERLING	666
82	Walleye	FINGERLING	12816
83	Walleye	FINGERLING	4123
83	Northern Pike	FINGERLING	18525
84	Walleye	FINGERLING	923
84	Walleye	FINGERLING	42283
86	Walleye	FINGERLING	5247
87	Walleye	FINGERLING	236
87	Walleye	YEARLING	2702
88	Walleye	FINGERLING	9180
89	Walleye	FINGERLING	35700
90	Walleye	FINGERLING	2844
90	Walleye	YEARLING	598

*** PUSH RETURN FOR PERMIT DATA ***
Esc-chr: ^] help: ^]? port:1 speed:19200 parity:none echo:rem VT320

88	Walleye	FINGERLING	9180
89	Walleye	FINGERLING	35700
90	Walleye	FINGERLING	2844

90 Walleye YEARLING 598

*** PUSH RETURN FOR PERMIT DATA ***

PERMIT DATA FOR LAKE GREEN

SUMMARY OF DNR PERMIT
APPLICATIONS ISSUED OR DENIED AS OF MAY 1990 FOR LAKE: GREEN

PERMIT TYPES:	NUMBER ISSUED	NUMBER DENIED
PUBLIC (PROTECTED) WATERS PERMITS		
Structural Encroachment	4	0
Excavation	2	0
Shore protection	6	0
GENERAL APPROPRIATION PERMITS	0	0

Enter the report or MENU:
Esc-chr: ^] help: ^]? port:1 speed:19200 parity:none echo:rem VT320

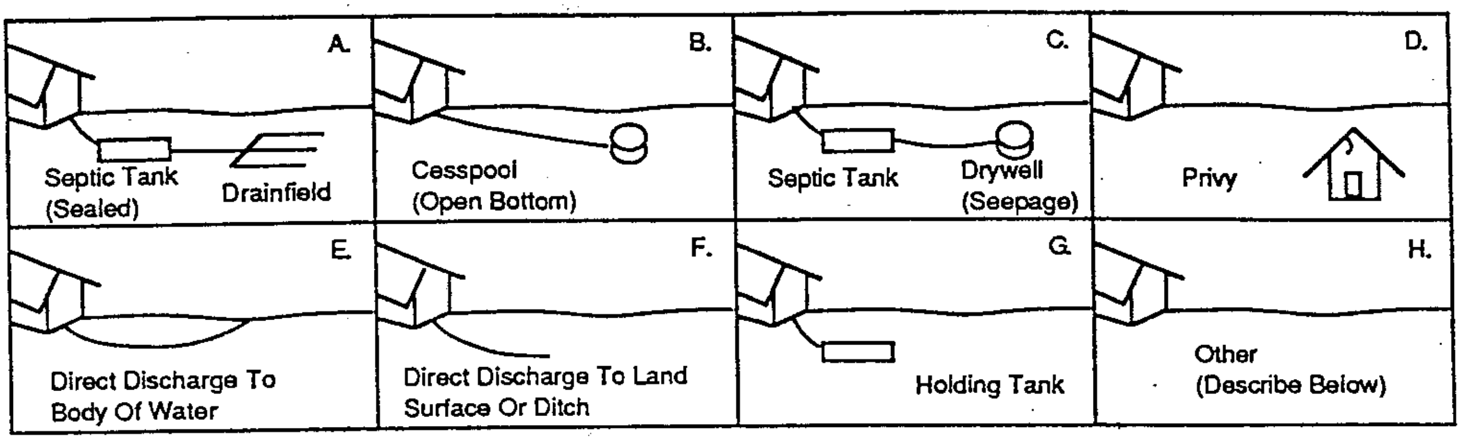
APPENDIX 8

Septic System Survey

Please complete this survey and return it in the enclosed envelope by June 15. This information will be used as part of the Lake Assessment Program. We are very fortunate to have been selected for this program. Your help will make the study more useful.

Please circle the letter that corresponds to the drawing that best describes your system.

A. B. C D. E. F. G. H.



H. (other) Please describe, for example: "mound system".

____

____

How old is your system? ______ years

Type of dwelling (please check one) ______ seasonal ______ year around

______ year around, but not used as a primary residence

Distance from drainfield, cesspool, drywell, privy or holding tank to the lake:

______ feet

Describe problems, such as backups, you may have had with your system.____________

____

How often is your system maintained? (tank pumped) ______________________

Please list any of your concerns about pollution that should be considered in the study. ____

____

Name (optional) ____

Septic System Survey Results

Participation

162 Surveys were sent to property owners around Green Lake. 102 ~~sruveys~~ surveys were returned. (63%)

System Types

Septic tank - drainfield	65	64%
Cesspool (open bottom)	11	11%
Septic Tank Drywell (seepage)	7	7%
Outhouse	1	
Direct Discharge to Body of Water	1	1%
Holding Tank	7	7%
Mound system	10	10%

System Ages

0-5 yr	30	29%
6-10 yr	26	25%
11-19 yr	15	15%
20 yr or older	25	25%
Don't know	6	6%

Type of Dwelling

Seasonal	45	44%
Year round	57	56%

Distance from lake to closes point of system (in feet)

0-50	7	7%
51-100	32	31%
101-150	23	22%
151-200	19	19%
201-250	6	6%
251+	4	4%
no response	11	11%

How often is system maintained? (Tank pumped)

		#	
once every	1-5 yr	58	57%
	5-10 yr	4	4%
	10 → over yr	3	3%
	No answer	16	16%
	Never	21	20%

APPENDIX 9

Code System/Conforming System Differences

The following list highlights the requirements for an exisitng septic system to meet the classification as a conforming system (MN Rule 7080.0600), and highlights the requirements for a new system to meet current 7080 standards (code system) :

Item	Code System	Conforming System
Surface discharge	not allowed	not allowed
System backup	not allowed (however system may be repairable)	not allowed (however system may be repairable)
Discharge to rock or soil with little treatment	not allowed	not allowed
Discharge to well	not allowed	not allowed
System receives water from footing or roof drains.	not allowed	not adressed in rule
Receives non domestic wastewater	not allowed without state and federal permit	not allowed without state and federal permit
Receives a hazardous waste	not allowed	not allowed
System requirements	Must meet all provisions of 7080	Must meet code at time of contruction plus meet all other conforming criteria listed in this column.
Cesspools, Seepage pits or Leaching pits	not allowed	not allowed
Septic tank	Must be in accordance with 7080.0130	Must be watertight (including connections) and be maintained. (This is a MPCA staff recommendation)
Distribution system	Must be in accordance with 7080.0150.	Must be to code at the time of installation, unless causing hydraulic problems.
System size	Must be in accordance with 7080.0170 Subp. 2 A	Must be to code at the time of installation, unless having hydraulic problems. These problems can be corrected by water conservation devices or other measures
System location	Must be in accordance with 7080.0170 Subp. 2 B	Must be to code at the time of installation, unless there are impacts caused by not meeting the current standards (e.g. well contamination due to improper setback).
System design and construction	Must be in accordance with 7080.0170 Subp. 2 C. Rapidly permeable soils must meet the criteria outlined in 7080.0170 Subp. 2 F.	System bottom must be 3 feet or greater to the seasonally high watertable or bedrock. Other portions of the system must be to code at the time of installation. Soils with a perc rate faster than .1 MPI should be lined

Attachment ——

APPENDIX 10

TOXIC ALGAE CAN SPELL DANGER FOR PETS, LIVESTOCK

Spending time in, on, or near one of Minnesota's thousands of lakes is a great way to beat the July heat. And going to "the lake" for the weekend is a state ritual.

But lake lovers, especially those with pets or livestock, need to be aware of a potential hazard stemming from algae growth in lakes during summer. Under certain environmental conditions, some algae species --blue green algae-- can become toxic. Pets and livestock drinking lake water containing the toxic form of blue green algae may become sick and even die.

Farmers can suffer severe livestock losses from blue-green algae poisoning of their cattle's watering source.

Algae occurs in virtually all lakes in Minnesota, but its concentration can vary considerably from lake to lake. It is most abundant during warm weather in water that is hard, alkaline, and rich in nutrients (primarily phosphorus and nitrogen, which fertilize aquatic plants as they do crops and lawns.)

Special characteristics of blue-green algae allow them to grow and multiply faster than other types of algae. Some types of blue-green algae are able to use nitrogen from the air as well as from the water, which gives them an advantage over other kinds of algae that depend on nitrogen in the water.

Blue-green algae can use sunlight more efficiently than most algae. Some of them contain pockets of gas allowing them to float on top of the water and outcompete other algae for sunlight.

In nutrient-rich lakes, blue-green algae can become so abundant that they complete dominate other free-floating plants. The whole appearance of the lake water can be changed by this rapid growth -- called an algae bloom.

(more)

The lake water will become cloudy, with a green or blue-green cast to it. It often develops a strong musty or earthy odor as the algae accumulate in large floating mats and begin to decompose. Fish in the lake may develop a temporary earthy flavor. The lake is best described as having a look of pea soup at this stage.

These are the blooms that can occasionally become toxic. Toxic algae blooms are strongly influenced by the wind. Sometimes, the wind can completely dissipate a toxic bloom in just a day or so. At other times, the wind increases the danger of a toxic bloom by blowing clumps of the floating algae mats toward the downwind shore of a lake. Most problems occur when the algae are clumped around a shoreline and livestock, pets, wild animals and birds drink the water. Toxic effects in animals can occur only when they ingest the contaminated water.

The degree to which an animal is affected depends on several factors: the amount of water ingested, the animal's body size, amount of food in the animal's stomach, the sensitivity of the species and individual animal, and the type and amount of toxin present in the bloom.

An animal that has ingested toxins from an algae bloom can show a variety of symptoms -- ranging from nausea and skin irritation to severe disorders involving the circulatory, nervous, and digestive systems, and severe skin lesions. In the worst case, the animal may suffer convulsions and die.

Humans are seldom seriously affected because the unpleasant odor and taste of water with a blue-green algae bloom tends to make them avoid it. However, while no human deaths have been caused by freshwater blue-green algae blooms, gastroenteritis, skin irritation, and allergy-like reactions have been reported.

Not all blue-green algae blooms are toxic; in fact, the vast majority of them are not. But because they can occur so quickly and can vary so much in

(more)

toxicity and frequency, all blue-green algae blooms are potentially dangerous. They cannot be accurately predicted and there are no specific laboratory tests for the toxins produced. A blue-green algae bloom can change from nontoxic to toxic or vice-versa without a significant change in appearance.

Since toxic blooms are unpredictable, and laboratory analysis is expensive and can be misleading, it is best to approach the problem as one would changing weather conditions. If the water looks threatening, avoid it until a more "normal" appearance returns. A blue-green bloom should be avoided if it changes from just "greenish water" to a thick, blue-green or green, paint-like scum. Body contact recreation (swimming, waterskiing, etc.) should be suspended, and livestock and pets should be temporarily provided with a different water source. Often the bloom can be avoided by simply moving the livestock or recreational activity to the opposite side of the lake.

If you suspect that an animal has been affected by an algae bloom, you should contact your veterinarian as quickly as possible. Some of the toxins that can form in a bloom have the ability to kill in an hour or less while some may take up to 24 hours to take effect. For more information on toxic algae, please call Bruce Wilson of the Minnesota Pollution Control at (612) 296-7255 or at the State of Minnesota toll-free number 1-800-652-9747.

###