LAKE ASSESSMENT PROGRAM

1994

Long Lake
(ID # 83-0040)
Watonwan County, Minnesota

Minnesota Pollution Control Agency
Division of Water Quality
in cooperation with

Minnesota Department of Natural Resources
Windom Area Fisheries Office

Watonwan County Natural Resource Conservation Service

Watonwan County Soil and Water Conservation District

Long Lake Homeowner's Association

January 1996

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SUMMARY AND CONCLUSIONS

Long Lake was sampled during the spring and summer of 1994 as part of the Minnesota Pollution Control Agency's (MPCA) Lake Assessment Program (LAP). Data collected during the study showed that in terms of total phosphorus, chlorophyll-a, Secchi disk transparency, and a number of other parameters, the water quality of Long Lake is better than most lakes in the Western Corn Belt Plains (WCBP) ecoregion. The mean summer concentrations of total phosphorus and chlorophyll-a were 59 and 35 µg/L (µg/L = micrograms per liter) respectively, and the mean Secchi disk transparency was 1.0 meters (3.2 feet). Based on these values and Carlson's Trophic Status Index (TSI) (Carlson, 1977), which ranges from 0 (very oligotrophic) to 100 (hypereutrophic), Long Lake would be considered eutrophic. The average TSI value for Long Lake is 63. Long Lake is considered by the MPCA to be "minimally impacted" and was used as a reference lake for the ecoregion. Results from sampling done in 1993 showed results similar to those listed above.

The reasonably good water quality exhibited by Long Lake can be at least partially attributed to it's relatively small watershed. Another important factor may be the relatively flat topography in the watershed. Land slope is an important factor controlling erosion and subsequent runoff of soil and other pollutants. Copper sulphate has been used in recent years for short-term control of algae growth during the summer. These treatments appear to be having a small impact on water quality.

Two empirical computer lake models were used to predict 1994 water quality and the results were compared to observed conditions. The results from both models indicate water quality conditions in 1994 that are close to expected given the characteristics of Long Lake and it's watershed.

Because of the small size of the Long Lake watershed, opportunities exist for lake protection and improvement not available for many other lakes in this ecoregion. The activities of relatively few people (the lakeshore community and a few larger land owners) can have a strong positive influence on water quality. The lakeshore community should not underestimate their potential to protect or improve water quality with upgraded wastewater treatment and better lawn and garden practices.

Water quality data was collected on Long Lake during several years prior to 1994. The data from most of these years show somewhat worse conditions than 1993 and 1994. It is difficult to know whether these two years represent water quality conditions that can be maintained or are simply unique years. Yearly variations in weather, for example, can have a significant effect on water quality in some lakes.

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INTRODUCTION

The Long Lake Homeowners Association applied for inclusion in the MPCA Lake Assessment Program in 1993. Excessive weed growth was the only water quality problem specifically described by the Association in the application . Perceived causes included "septic systems, feedlot, tile outlets from agricultural drainage (and) lawn care products."

The Lake Assessment Program was designed to assist lake associations, counties, and municipalities in the collection and analysis of baseline water quality data for the purpose of assessing the current trophic status of their lake. Trophic status is defined by the degree of nutrient enrichment of a lake and by the secondary effects (e.g. algae growth, fish kills) of this enrichment. The addition of nutrients to lakes is a natural process. Nutrients are found in even the most pristine runoff and are deposited from the atmosphere. Cultural eutrophication as a result of the activities of humans, however, is a frequent cause of water quality problems in lakes.

The work plan for local participants in the Lake Assessment Program includes collection of lake transparency data through the Citizens Lake-Monitoring Program (CLMP), completion of a septic system survey, compilation of a watershed history, and examination of land use and drainage patterns in the watershed. Unfortunately, only the examination of land use and drainage was completed for this project. With assistance from lake association members, staff of the MPCA collect water quality data. Conclusions and recommendations based on this cooperative work arrangement are included in the report.

The report is written with the assumption that the reader is familiar with basic water quality terminology as used in the Citizens Guide to Lake Protection.

BACKGROUND

Long Lake was sampled five times during the summer of 1994 by Lee Ganske and Ed Weir of the MPCA Rochester regional office, Will Munson of the MPCA St. Paul office, and representatives of the Association. Watershed information was gathered by staff of the Watonwan County Natural Resource Conservation Service office and the Wantonwan County Soil and Water Conservation District. Bob Davis of the Minnesota Department of Natural Resources (MDNR) provided fisheries information.

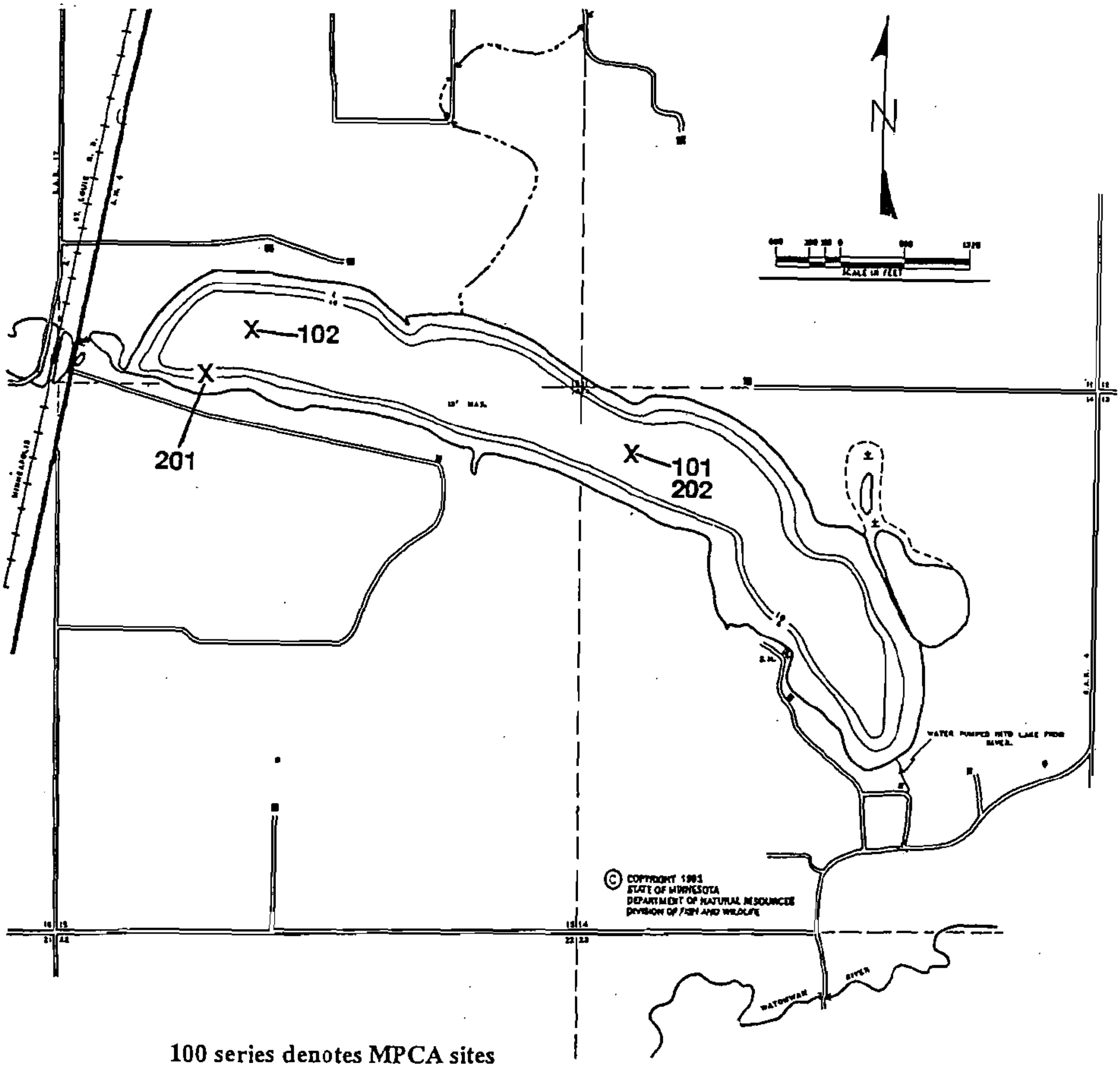
Long Lake is located approximately 5 miles south of the City of St. James in southwest Watonwan County. The surface area of the lake is 107 hectares (264 acres), making it smaller than half of 85 mostly "recreational" lakes in the Western Corn Belt Plains Ecogregion (MPCA, 1994). If one were to consider all lakes in Minnesota, Long Lake would fall in the largest 10-15 % (MDNR, 1968). Long Lake has a maximum depth of 4 meters (13 feet). This is shallower than 85 percent of lakes included in a statewide survey of approximately 1000 lakes (Heiskary, 1985). The mean depth of the lake is approximately 2.4 meters (8 feet), and the littoral zone (the lake zone which can potentially support rooted vegetation) covers the entire lake. According to Zumberge (1952), Long Lake was formed as the irregular deposition of glacial till created a closed basin. The watershed of Long Lake covers approximately 514 hectares (1270 acres). Figure 1 shows depth contours and the watershed boundary for Long Lake.

Soils in the Long Lake watershed belong to the Clarion-Webster-Nicollet and Webster-Nicollet-Canisteo associations. These associations are on nearly level to undulating ground moraines. Clarion soils are found on convex side slopes and knolls. Webster soils are in drainageways and on flats and are poorly drained. Nicollet soils are located on low rises of till plains, and are moderately well drained. Canisteo soils are located on slightly convexed areas and rims of depressions on till plains; and are poorly drained and calcareous.

The native vegetation of the Long Lake watershed following the last glaciation was dominated by prairie (Marschner, 1930). Soil conditions, climate, and fire combined to create this largely treeless landscape.

Since the landscape affects water quality, it is helpful to divide the state into areas of similar landscape and water resources. These areas are termed ecoregions. Minnesota can be divided into seven ecoregions based on soils, land surface form, natural vegetation, and current land use (Figure 2). Long Lake is located in the Western Corn Belt Plains (WCBP) Ecoregion. Typical land use composition in the watersheds of this ecoregion as well as Long Lake are shown in Table 1. In this report, Long Lake water quality is compared with the water quality of "reference" lakes in the WCBP ecoregion. These comparisons are useful for water quality goal setting.

FIGURE 1. LONG LAKE MORPHOMETRY AND SAMPLING SITE LOCATIONS



100 series denotes MPCA sites
200 series denotes CLMP sites

FIGURE 2. LONG LAKE LOCATION AND WATERSHED MAP

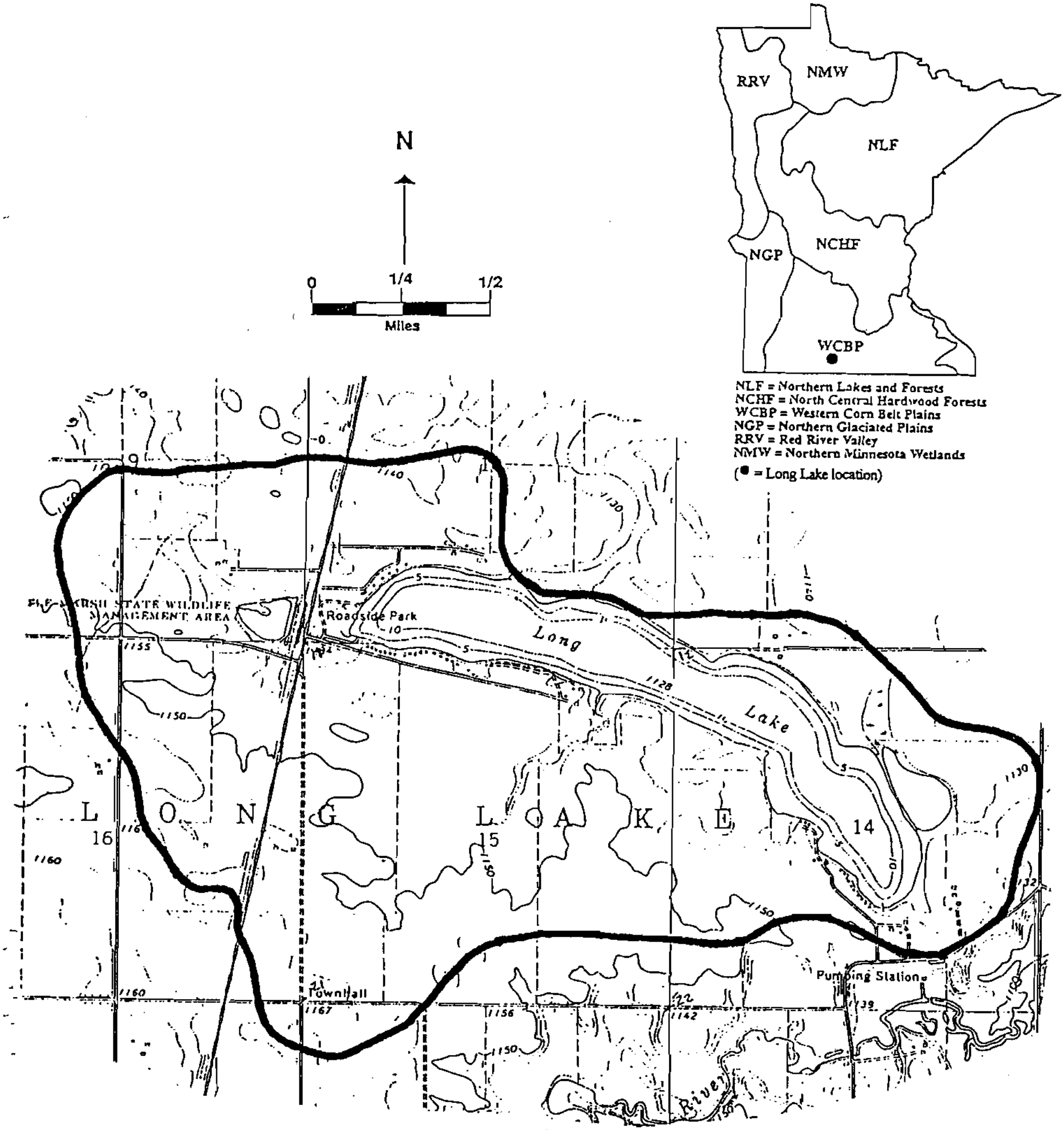


TABLE 1: LONG LAKE MORPHOMETRIC, WATERSHED, AND FISHERY CHARACTERISTICS

MDNR I.D.:	# 83-0040
Area :	264 acres (107 ha)
Mean Depth:	8 feet (2.4 meters)
Maximum Depth:	13 feet (4 meters)
Volume:	2112 acre-feet
Littoral Area[2]:	100%
Shoreline Length[2]:	5 miles
Watershed Area[1]:	1270 acres (514 ha)(excluding lake surface)
Watershed Area/Lake Surface Area Ratio:	4.8 : 1
Estimated Average Water Residence Time[3]:	3.5 years
Ecological Classification[2]:	Roughfish-Gamefish
Management Classification[2]:	Warm-Water Gamefish

Land Use (percentage):

	Forests	Water/Marsh	Pasture/CRP	Cultivated	Urban
Long Lake[1]	2.3	2.6	3.6	85	6.5
WCBP[4]	0-15	3-26	0-7	42-75	0-16

Public Access: 1 - west side of lake
Inlets: 1 intermittent stream on south side
Outlets: 1 stream on north side

Shoreland Zoning: Recreational development

Development (Homes)

Year	Seasonal	Permanent	Total
1967	12	24	36
1982	27	41	68
1994	29	44	63

1 - Watonwan County Natural Resources Conservation Service (NRCS)
2 - State Planning Agency SWIM file
3 - Estimated using MINLEAP
4 - 25-75th percentile for representative lakes in the ecoregion
(Heiskary & Wilson, 1990)

Precipitation

Precipitation is an important factor affecting water quality in lakes. The timing and amount of rainfall in a watershed can affect whether, and to what extent, pollutants are carried to a lake in runoff. Based on a fairly general map (Appendix) rainfall amount was about 30 inches in the water year October 1993 through September 1994. This amount is slightly more than "normal." For this project, annual runoff of precipitation was estimated at 5 inches (0.125 meters).

Lake Level

The MDNR have information on the water level of Long Lake that date back to 1935. Volunteer Charlie Jass assisted in the monitoring of water level in 1994. An ordinary high water elevation has been established at 1128.7 feet. The highest recorded water level was 1129.25 feet in 1960. The lowest was 1118.6 feet in 1935. The average water level in 1994 was 1128.4 feet. The outlet of Long Lake is controlled by a stop log dam. The Appendix contains additional water level information.

Fishery

The MDNR used seining and gillnetting to survey Long Lake in 1994. An increase in walleye and black crappie numbers were seen from 1990. According to the DNR, Long Lake has a history of good walleye and black crappie fishing. The population of these species, as well as bluegill and yellow perch, are considered to be normal for this lake class.

METHODS

Water quality information was collected on April 26, June 14, July 19, August 22, and September 14, 1994 at two sites on Long Lake (Figure 1). Site 101 is located near the middle of the lake. Site 102 is located at the west end of the lake, near the public access. Lake surface samples were collected with an integrated sampler, a PVC tube 2 meters (6.6 ft.) in length with an inside diameter of 3.5 centimeters (1.4 inches). Near-bottom samples were collected with a 2-liter Kemmerer sampler, a "water trap" that closes at the depth a sample is desired. Zooplankton samples were collected from a 5-meter tow using a Wisconsin plankton net.

Sampling procedures were followed as described in the MPCA Quality Control Manual and analyzed by the Minnesota Department of Health for total phosphorus (TP), total Kjeldahl nitrogen, nitrate-nitrite nitrogen, suspended solids, alkalinity, chloride, color, turbidity, and chlorophyll-a. Duplicate samples for TP in 1994 revealed a mean difference of 7 µg/l and a percent difference of 16 percent. For chlorophyll-a duplicate samples, the mean difference was 1.36 µg/l and the percent difference was 10 percent. Field measurements of pH, conductivity, Secchi disk transparency, and temperature and dissolved oxygen profiles were taken by MPCA staff. Algal composition was determined from surface samples by means of a rapid assessment method. A qualitative evaluation of the zooplankton sample was made in the field. Citizen Lake-Monitoring Program (CLMP) transparency measurements taken during the summers of 1987-1990, along with water quality data collected in 1981, 1985 and 1993 are available for comparison. All data with the exception of algal composition was stored in STORET, the U.S. Environmental Protection Agency's national water quality data bank.

Results from the April 26 sampling are not included in the "summer-mean" values used throughout this report. For purposes of comparing data from different lakes and different years, it is most appropriate to use data collected from June to mid-September. The April 26 data is still useful, however, as it reflects winter and spring conditions in lakes and their watersheds that may carry into the summer.

RESULTS AND DISCUSSION

In-lake Conditions: 1994

Temperature

In temperate climates, lakes deeper than Long Lake generally stratify into three layers during the summer as a result of temperature caused water density differences. The metalimnion, or thermocline (layer of rapid temperature change) separates the epilimnion (warmer surface water) from the hypolimnion (cooler deeper water). This stratification usually remains stable through the summer. Lakes like Long Lake and most WCBP ecoregion lakes, do not exhibit stable stratification because the shallower water column is relatively easily mixed by wind. Whether a lake stratifies or not, and how stable the stratification is, can greatly affect dissolved oxygen concentrations in a lake and how a lake responds to nutrient loading. The temperature and dissolved oxygen profiles measured at both sampling sites are indicative of very weak stratification (profiles for site 101 shown in Figure 3). The maximum temperature between surface and bottom water was measured at 2.3 °C at site 102 on July 19.

Dissolved Oxygen

The amount of dissolved oxygen at different depths and areas of a lake will determine where, and if, fish and other organisms are found. Dissolved oxygen concentrations greater than 5 mg/l (milligrams per liter) are considered necessary for long-term survival of game fish. In addition, very low dissolved oxygen at the sediment-water interface can allow for the release of phosphorus from the sediments into the water column. As oxygen concentrations approach zero, iron compounds in the sediments lose their ability to bind phosphorus.

During the summer of 1994, dissolved oxygen concentrations fell below 5 mg/l only in the deepest water at each sampling site (figure 3). And because oxygen was not completely lost in this deep water, phosphorus release from the sediments may have been limited. These conditions confirm that the water in Long Lake is frequently mixed and reoxygenated.

Total Phosphorus (TP)

Phosphorus is an important nutrient for plant growth. In most lakes it is the nutrient which limits the amount of aquatic plant and algae growth. The mean (average) TP concentration of the epilimnion between June and September of the 1994 sampling period was 59 µg/L. Concentrations ranged from 47 to 81 µg/L (Appendix). The mean TP value is at the low end of the range of concentrations measured in a set of 16 representative, minimally impacted (reference) lakes in the WCBP ecoregion of Minnesota (Heiskary 1990). The TP concentrations in the reference lakes tend to fall between 65 and 150 µg/L (Table 2). Based on total phosphorus concentrations measured in 72 lakes in the WCBP ecoregion, only about 5 percent of the lakes have mean TP concentrations less than 59 µg/L (Heiskary 1994). Summer-mean TP for three samples collected during 1993 was 60 µg/L.

Figure 3. DISSOLVED OXYGEN AND TEMPERATURE PROFILES
Long Lake Site 101

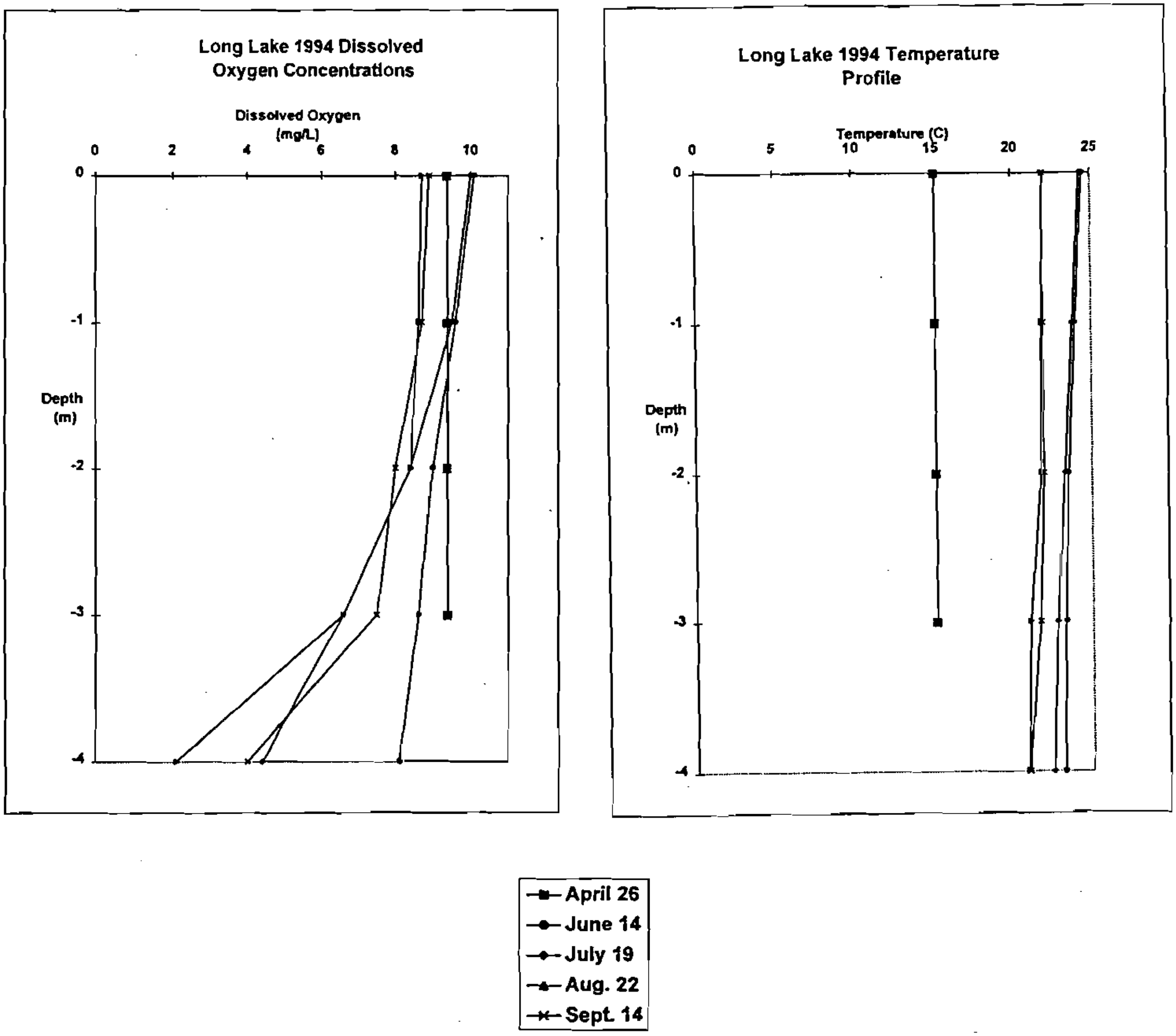
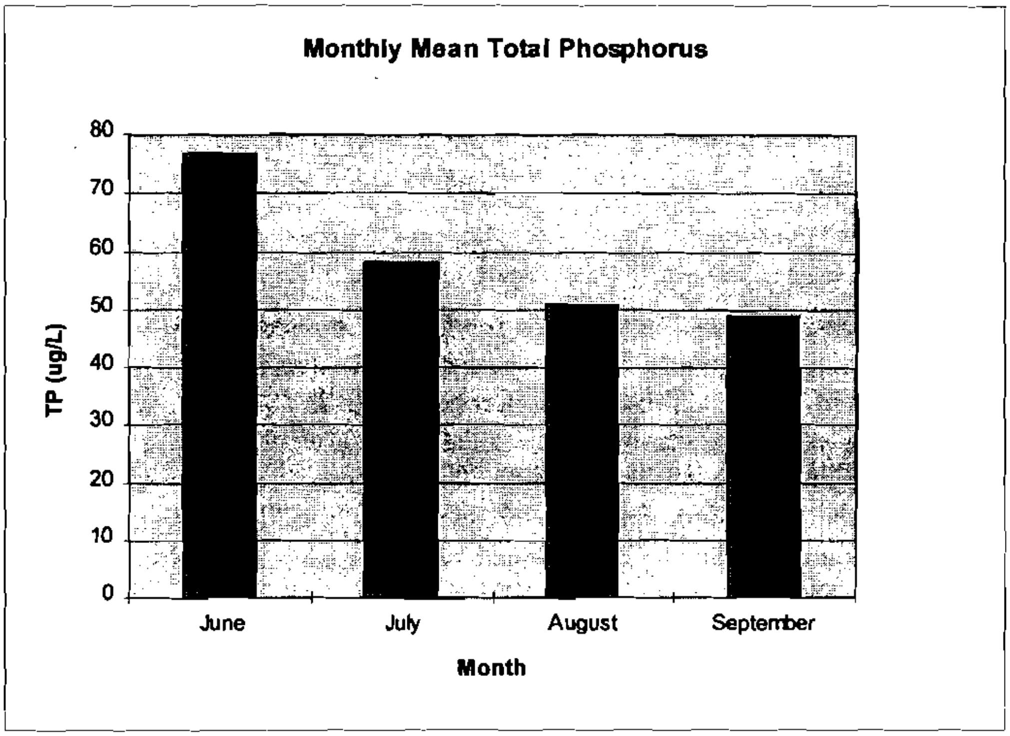


FIGURE 4. MONTHLY MEAN TOTAL PHOSPHORUS
Long Lake Summer of 1994



In lakes that maintain stable stratification over the summer, epilimnetic (surface water) phosphorus concentrations often decrease over the summer. Algae in the epilimnion assimilate phosphorus as they grow. When algae die, they settle into the hypolimnion (deep water) where phosphorus is released into the water during decomposition. In stratified lakes, the phosphorus tends to remain in the deep water. Although Long Lake did not stratify, near-bottom samples in August and September have slightly higher TP concentrations than surface samples. In Long Lake, this phosphorus could be stirred into the surface water, a process know as internal loading. Figure 4 shows the variation in total epilimnetic phosphorus concentrations over the 1994 sampling period.

Total nitrogen (TN)

Total Nitrogen, which is defined as the sum of the total Kjeldahl nitrogen and nitrate-nitrite nitrogen, averaged 1.3 mg/l during the summer of 1994. This value is on the low end of the range for minimally impacted lakes in the WCPB ecoregion. The nitrate/nitrite-N is higher than the range of concentrations found in the reference lakes (Table 2), which is indicative of some pollution reaching the lake.

TN:TP

Nitrogen as well as phosphorus are required for growth of aquatic plants and algae. Although phosphorus is usually the nutrient limiting the productivity of a lake, nitrogen may be the limiting nutrient in some situations. The ratio of TN:TP can indicate which nutrient is limiting the growth of algae and aquatic plants in the lake. For Long Lake, the mean TN:TP ratio is 22:1. Given that the lowest ratio for the summer of 1994 was 18:1, phosphorus is considered the limiting nutrient for algal growth in Long Lake. A ratio closer to 10:1 would be indicative of nitrogen limitation.

Chlorophyll-a

Chlorophyll-a (a pigment produced by algae) concentrations provide an estimate of the amount of algae in the lake. During the summer, chlorophyll-a concentrations ranged from 22 to 53 µg/L with a mean concentration of 35 µg/L (Table 2). Concentrations from 10 to 20 µg/L would be perceived as a mild algal bloom, and concentrations greater than 30 µg/L would often be perceived as severe nuisance conditions (Heiskary and Walker, 1988). The chlorophyll-a values measured for Long Lake were significantly above the nuisance threshold only in June. These summer-mean values fall at the low end of the range for the WCBP ecoregion reference lakes (30 to 80 µg/L). Figure 5 shows chlorophyll-a concentrations over the 1994 sampling period.

For the past few years, including 1994, the Long Lake Association has treated the lake with copper sulphate to kill algae. Copper sulphate is used during the summer and will generally suppress algae for no longer than a month. As such, the MDNR permit allows up to two treatments. The lower chlorophyll-a values measured in July, August, and September appear to reflect these treatments. The effects of copper sulphate seem to be even more apparent in the August 1993 data, where chlorophyll-a levels were near zero.

Phytoplankton

Phytoplankton (algae) samples show a transition from diatoms in the late April sample to predominately blue-green algae for the rest of the summer. A more typical transition would be from diatom to green algae to blue-green dominance by late summer. Asterionella and Melosira dominated the late April sample. By August Oscillatoria/Lyngbya blue-greens composed 85 percent of the sample. In September, the blue-greens Anabaena and Anacystis composed 15 and 10 percent of the sample, respectively. While copper sulfate can certainly affect the amount of algae living in a lake, it is difficult to say how it might change the relative mix of different kinds of algae.

Zooplankton

Zooplankton (microscopic animals) were collected and analyzed qualitatively during each sampling event. "Abundant small varieties" were noted on all sampling dates. Zooplankton, particularly large-bodied varieties, can be beneficial for lakes because of their ability to consume large quantities of algae. Small zooplankton may "graze" on smaller algal forms. This reduction in algae may have a noticeable effect on lake transparency. It should be noted, however, that even large-bodied zooplankton may not feed on all algae varieties. Zooplankton feed preferentially on small algal forms. Zooplankton play another important role in lakes in that they are a major source of food for small fish.

Transparency (Secchi disk)

Secchi disk transparency is an indirect measurement of the amount of algae and other suspended material in the lake. Transparency values can often be correlated to chlorophyll-a and total phosphorus concentrations. The average transparency in 1994 was 1.0 meters (3.2 feet). Minimum transparency was 0.6 meters (2 feet) in June which corresponds to the maximum chlorophyll-a concentration. Again, copper sulphate treatments seem to be partially responsible for the clearer water later in the summer.

Good transparency is desirable not only from the standpoint of aesthetics or recreation. The aquatic plants, fish, waterfowl, reptiles, and amphibians that make up a lake ecosystem can also benefit from clearer water.

Physical Condition/Recreational Suitability

Subjective measures of the lake's "physical condition" and "recreational suitability" (Heiskary and Wilson, 1988) were made during LAP sampling (Appendix). Physical condition ratings range from "crystal clear" (class 1) to "dense algal bloom, odor, etc." (class 5), and recreational suitability ratings range from "beautiful, could not be nicer" (class 1) to "no recreation possible" (class 5). For all sampling dates except Sept. 14, physical conditions was “some algae present” and recreational suitablility was “beautiful.” On Sept. 14, physical condition was “definite algae present” and recreation suitability was “swimming and aesthetic enjoyment slightly impaired.” These changes are interesting because there does not seem to be coincident change in chemical water quality measures. There may be a link to the type and distribution of algae in the lake, there was a shift in the blue-greens from 85% Ocillatoria to 50% Ocillatoria, 15% Anabaena, and 10% Anacystis)

Other water quality parameters including color, total suspended solids, total suspended inorganic solids, pH, turbidity, alkalinity, chloride, and conductivity were generally within the range of values for the reference lakes in the WCBP ecoregion (Table 2). Historical and 1994 water quality data for individual sampling dates are found in the Appendix.

TABLE 2: LONG LAKE AVERAGE SUMMER WATER QUALITY AND TROPHIC STATUS INDICATORS for 1994.

Water Quality Parameter	Long Lake	Typical Range for WCBP Ecoregion[1]
Total Phosphorus µg/L	59	65-150
Chlorophyll a µg/L:		
Mean	35	30-80
Maximum	53	60-140
Secchi disk (feet)	3.2	1.6-3.3
Total Kjeldahl Nitrogen (mg/l)	1.2	1.3-2.7
Nitrite + Nitrate-N (mg/l)	0.12	0.01-0.02
Alkalinity (mg/l)	155	125-165
Color (Pt-Co Units)	12.5	15-25
pH (SU)	8.5	8.2-9.0
Chloride (mg/l)	25	13-22
Total Suspended Solids (mg/l)	10.8	7-18
Total Suspended Inorganic Solids	5.65	3-9
Turbidity	7.1	3-8
Conductivity (umhos/cm)	365	300-650
TN:TP Ratio	22	17:1-27:1

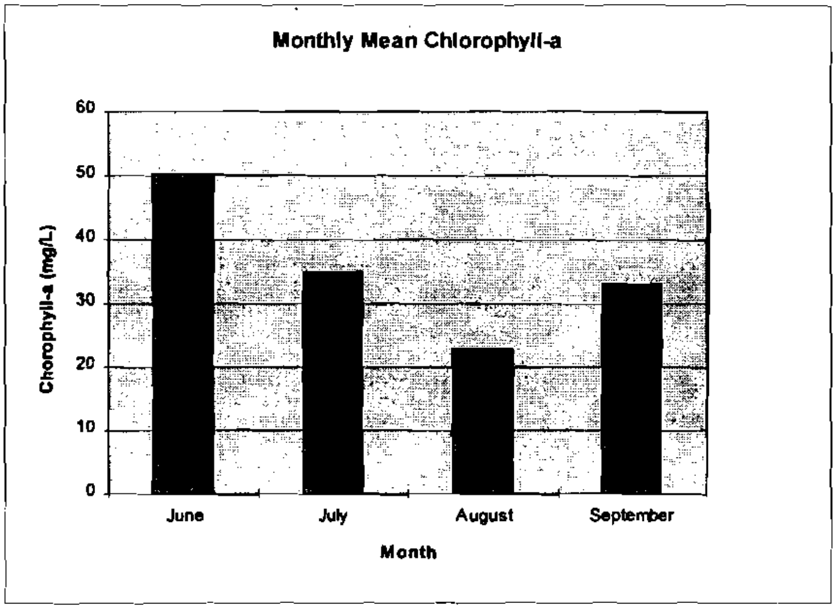
Trophic Status Indicators: 1994

Carlson Trophic State Index Values	Long Lake	Percentile[2] WCBP Ecoregion
TP TSIP =	63	95
Chl-a TSIC =	65	75
Secchi TSIS =	61	75
Mean(All)TSI =	63	90

1: 25-75th percentile for representative, minimally impacted lakes in the WCBP ecoregion (Heiskary and Wilson, 1990).

2: Relative to approximately 100 assessed lakes in the WCBP ecoregion. One hundred percent level implies lowest TP and chlorophyll-a concentration and deepest Secchi disk measurement.

FIGURE 5. MONTHLY MEAN CHLOROPHYLLa
Long Lake summer of 1994



Trophic Status

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

Total phosphorus TSI (TSIP) = $14.42 \ln(TP) + 4.15$
Chlorophyll TSI (TSIC) = $9.81 \ln(Chl\ \underline{a}) + 30.6$
Secchi disk TSI (TSIS) = $60 - 14.41 \ln(SD)$

Note units: TP in µg/L, Chlorophyll-a in µg/L, Secchi disk transparency in meters.

Possible values for TSI range from 0 (ultra-oligotrophic) to 100 (hypereutrophic). With this index, each increase of 10 units represents a doubling of algal biomass.

The TSI values of total phosphorus, chlorophyll, and Secchi disk transparency for Long Lake are 63, 65, and 61 respectively, with an average of 63 (Table 2, Figure 6). Based on these values the lake would be considered eutrophic or moderately nutrient rich. The good agreement between index values points to the importance of Secchi disk monitoring of Long Lake as it is a reliable indicator of the algal and phosphorus trends.

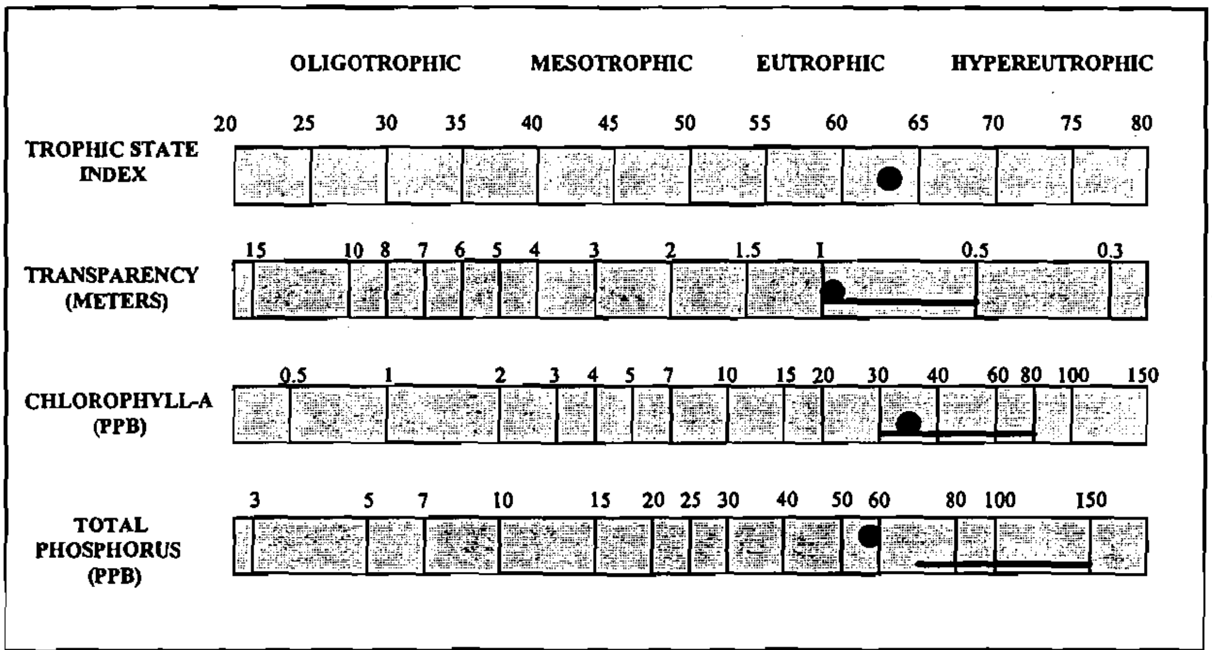
Comparison of TSI values for Long Lake to those of other lakes in the WCPB ecoregion can provide a basis for evaluating the water quality of the lake. A TSI value of 63 ranks in the 90th percentile for the WCPB ecoregion. In other words, only 10 percent of the lakes in the ecoregion have TSI values less (are less eutrophic) than Long Lake.

Trend Analysis/Historical Data

A limited amount of historical data is available for Long Lake. There is Citizen Lake Monitoring Program data for the years 1987-1990 and water chemistry data for 1981, 1985, 1993 and 1994 (Table 3 and Appendix). Data from 1985 and 1993 was collected as a part of MPCA's ecoregion reference lake monitoring. The summer-mean transparency appears to have improved in the later four years, although this change is not statistically significant. Chlorophyll-a levels are also lower in recent years, suggesting that copper sulphate treatments may explain some of the change. There was also a decrease in TP levels from 1981 and 1985 to 1993 and 1994. Copper sulphate treatments may also explain this because significant amounts of phosphorus are tied up in algae at any given time. Phosphorus is lost to the sediments when algae die and settle to the bottom of a lake. However, there also could have been changes in the amount of phosphorus entering the lake as a result of changes in agricultural practices or other land uses.

FIGURE 6. CARLSON'S TROPHIC STATE INDEX VALUES FOR LONG LAKE
TSI Relationships based on mean summer data for 1994

TSI < 30	Classical Oligotrophy: Clear water, oxygen throughout the year in the hypolimnion, salmonid fisheries in deep lakes.
TSI 30 - 40	Deeper lakes still exhibit classical oligotrophy, but some shallower lakes will become anoxic in the hypolimnion during the summer.
TSI 40 - 50	Water moderately clear, but increasing probability of anoxia in hypolimnion during summer.
TSI 50 - 60	Lower boundary of classical eutrophy: Decreased transparency, anoxic hypolimnia during the summer, macrophyte problems evident, warm-water fisheries only.
TSI 60 - 70	Dominance of blue-green algae, algal scums probable, extensive macrophyte problems.
TSI 70 - 80	Heavy algal blooms possible throughout the summer, dense macrophyte beds, but extent limited by light penetration. Often would be classified as hypereutrophic.
TSI > 80	Algal scums, summer fish kills, few macrophytes, dominance of rough fish.



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

WCBP Ecoregion Range: ———— Long Lake: ●

Table 3. Long Lake Summer Means for Phosphorus, Chlorophyll-a, and Secchi Transparency by Year

Year	Total Phosphorus (µg/L)			Chlorophyll-a (µg/L)			Secchi Transparency (meters)		
	Mean	SE	N	Mean	SE	N	Mean	SE	N
1981	85		1	40.5		1	0.7		1
1985	128	.	3	55.6	.	3	0.5		3
1987	.	.	0	.	.	0	0.6		13
1988	.	.	0	.	.	0	0.5		8
1989	.	.	0	.	.	0	1.0		16
1990	.	.	0	.	.	0	0.8		13
1993	60		3	28.6		3	0.8		4
1994	59		8	35.3		8	1.0		8

Aquatic Plants (Macrophytes)

A macrophyte survey of Long Lake was done by the MDNR in 1994. River bulrush and cattail (emergents), sago pondweed and curled pondweed (submergents), and the tiny floating-leaved lesser duckweed were all noted as "rare" in the lake. The presence of curled pondweed is cause for a bit of concern. Curled pondweed (*Potamogetan crispus*) is a very aggressive exotic (from Europe) that can dominate the macrophyte community of a lake. At low abundance, however, it shouldn't create problems.

Macrophytes, even curled leaf pondweed, can provide multiple benefits in lakes. Macrophytes may provide cover for zooplankton. The zooplankton, in turn, can reduce algae concentrations in a lake through grazing. Macrophytes provide spawning and nursery areas for fish. Macrophytes may encourage the sedimentation of soil and soil-attached nutrients that enter the lake. Finally, macrophytes can also be important for holding bottom sediment in place and stabilizing shoreline. This helps water clarity and minimizes nutrient resuspension. Attempts have and are being made to plant desirable macrophytes in southern Minnesota Lakes. These attempts have shown limited success. Because seed stock already exists in the sediment of lakes, improving water clarity and allowing natural fluctuations in water level are two ways desirable macrophyte communities may become reestablished.

A number of techniques may be used to control nuisance macrophytes in small areas. Manual or mechanical harvesting can be an effective and control technique for small swimming areas or boat paths. Sediment covers or surface shading are experimental techniques which may effectively control weed growth by controlling light. The Lake and Reservoir Restoration Guidance Manual (USEPA 1990) contains information on this topic. Although the benefit would be small, harvesting removes small amounts of nutrients from a lake. If low oxygen is a problem, the removal of plant material that depletes oxygen as it decays may be a more important benefit. All plants must be removed from the lake during any harvesting operation. In many cases permits from the DNR are required for aquatic weed control.

Nutrient Sources

Watershed

Long Lake has one clearly identifiable surface inlet; and an intermittent stream on the south side of the lake. The water that flows in this stream consists of surface runoff and subsurface tile drainage from perhaps 1/2 of the watershed. The remaining watershed area drains directly or indirectly to the lake as surface runoff, tile drainage, or seepage through the ground. Nonpoint source pollution carried in runoff is likely the major contributor of nutrients to Long Lake. Nonpoint pollution sources include: agricultural runoff; pesticide and fertilizer use on agricultural land and lawns; feedlot runoff; runoff from streets, yards, and construction sites; seepage from septic systems; dredging and drainage activities; and impacts from the loss of wetlands.

While it is unrealistic to expect that all nonpoint pollution sources can be eliminated, the implementation of Best Management Practices (BMP's) and other land use changes can minimize human impacts on water quality. To control soil erosion, reduce the use of fertilizers and pesticides, and improve manure management on agricultural land, BMP's should be selected that meet water quality goals and fit individual farm operations. Refer to the MPCA's Agriculture and Water Quality publication for more information on agricultural BMP's. Best management practices are also available for construction activities and for lakeshore property owners.

Livestock

Livestock waste contains nutrients, organic material, and bacteria that can enter streams and lakes if not managed properly. Proper management includes containing manure on any open lots, and land application at rates that can be used by crops and in a manner that reduces runoff. A small livestock facility is located on the south side of the lake. The facility was inspected in 1993 and 1994 by MPCA and Watonwan County staff. Some fairly minor problems that could lead to manure runoff to the lake were identified. Further discussion of the pollution potential of this facility is contained in the section on modeling. It should be noted that even if this is the only livestock facility located in the watershed, manure that is produced elsewhere could be applied to fields in the watershed.

On-site sewage treatment systems

Old, malfunctioning, or improperly installed on-site sewage treatment systems can contribute to the amount of nutrients and disease-causing organisms entering a lake. There is evidence that a number of the systems around the lake fall into one of these categories. As an example, there are developed areas on the north side of the lake where high water table conditions are such that a conventional soil treatment (drainfield) system will not function properly.

Even properly designed, functioning on-site systems need to be properly maintained. Minnesota Extension Service recommends pumping every one to three years for a 1,000 gallons tank serving a three bedroom house and four occupants (assumes year round use). Water conservation practices and care in regard to the types of products placed in a system can also be very important for good operation and system longevity.

Holding tanks may be an option for lots that are very small or have soil conditions unsuitable for a soil treatment system. They must be watertight, never be allowed to overflow, and be pumped regularly by a licensed professional..

Lawn Care

Lawn fertilizers can be a source of nitrogen and phosphorus, and therefore, are not recommended for use around lakes or in residential areas which are serviced by storm sewers that drain into lakes. In particular, those high in phosphorus should be used only in the quantities needed, as determined by present soil nutrient conditions. A buffer of unfertilized natural vegetation should be maintained along the shoreline to help control erosion as well as trap some of the nutrients that may run off the lawn and into the lake. Leaving grass clippings on a lawn can reduce the need for fertilizers; however, in areas where clippings and leaves could wash into the lake, removal to a compost site away from the lake is recommended. Leaves should not be burned, particularly where ash may wash into the lake.

In-lake

A portion of the nutrients which enter a lake from the watershed settle out and become bound to the lake sediments. As discussed in the results section, some of these nutrients can be released back into the lake under certain temperature and oxygen conditions. Phosphorus, for example, is released from sediments when the layer of water near the sediment becomes very low in oxygen. The contribution of phosphorus from the sediment can represent a significant part of the phosphorus load to a lake. It is important to note, however, that most lakes with excessive internal phosphorus loading have or had excessive external phosphorus loading. An ultimate solution to internal loading can be to reduce external loading.

Modeling Summary

Numerous 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 a lake. Alternately, they may be used for estimating changes in the quality of a lake as a result of altering nutrient inputs to the lake (e.g., changing land uses in the watershed) or altering the flow of water entering the lake. The "Minnesota Eutrophication Analysis Procedure" (MINLEAP) model and the Reckhow and Simpson (1980) model were used to assess the current water quality of Long Lake.

MINLEAP was developed by MPCA staff based on an analysis of data collected from a set of minimally impacted reference lakes for each ecoregion. Total phosphorus (TP), chlorophyll-a, and transparency values calculated by MINLEAP should reflect the values found in a minimally impacted lake with the watershed size, lake morphometry, and geographic location of Long Lake. It is intended to be used as a screening tool for estimating lake condition with minimal data input and is described in greater detail in Heiskary and Wilson (1990). The uncertainty associated with the predictions is substantial. Inputs to, and results from the model are shown in Table 4.

The MINLEAP model predicts an inlake TP of 83 µg/L, chlorophyll-a of 42 µg/L, and secchi transparency of 0.9 meters. None of these are significantly different from the values observed in the summer of 1994. Thus, based on MINLEAP, the trophic status of Long Lake is close to projected based on it's size, depth, and region of the state. The agreement also suggests that the predicted annual TP load of 413 kilograms may be reasonable.

The second model used was Reckhow and Simpson (1980) which predicts the impact of watershed characteristics and management on lake phosphorus concentrations. The uncertainty associated with this simplified (although more detailed than the MINLEAP) assessment requires that the model output be expressed as a range of values (low, average, and high). 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 data from the State Climatology Office (1989). Phosphorus export coefficients used are comparable to previous LAP studies. Inputs to, and results from the model are shown in Table 5.

The Reckhow and Simpson model predicts in-lake TP concentrations ranging from 49 to 96 µg/L with an average value of 70 µg/L. The observed mean in Long Lake was 59 µg/L in 1994. The model predicts chlorophyll-a ranging from 19 to 52 µg/L with an average of 33 µg/L. The observed value was 35 µg/L. Predicted Secchi transparency ranged from 1.3 to 0.8 meters with an average of 1 meter. The observed summer-mean Secchi transparency was 1 meter.

TABLE 4. MINLEAP MODELING RESULTS

```
INPUT DATA:
LAKE NAME =Long                       ECOREGION=WCP
LAKE AREA = 107  HA
WATERSHED AREA (EXCLUDING LAKE) = 514  HA
MEAN DEPTH = 2.4  METERS
OBSERVED MEAN TP = 59  UG/L
OBSERVED MEAN CHL-A = 35.3  UG/L
OBSERVED MEAN SECCHI = 1  METERS



LAKE = Long                                 ECOREGION = WCP
AVERAGE INFLOW TP = 563.864  UG/L       TOTAL P LOAD        = 412.974  KG/YR
LAKE OUTFLOW      = .7324  HM3/YR       AREAL WATER LOAD    = .684486 M/YR
RESIDENCE TIME    = 3.506281  YRS       P RETENTION COEF    = .8533542

VARIABLE  UNITS        OBSERVED PREDICTED STD ERROR  RESIDUAL    T-TEST
TOTAL P   (UG/L)          59.00     82.69     33.42     -0.15     -0.77
CHL-A     (UG/L)          35.30     41.66     28.69     -0.07     -0.22
SECCHI    (METERS)         1.00      0.86      0.39      0.07      0.32
NOTE: RESIDUAL = LOG10(OBSERVED/PREDICTED)
      T-TEST FOR SIGNIFICANT DIFFERENCE BETWEEN OBS. AND PREDICTED

CHLOROPHYLL-A INTERVAL FREQUENCIES (%)
CHL-A              PREDICTED PREDICTED PREDICTED
  PPB  OBSERVED      CASE A    CASE B    CASE C
   10     99.15       99.69     99.42     93.58
   20     82.76       90.14     88.30     76.36
   30     54.00       67.19     65.95     59.81
   60      8.92       15.84     17.77     28.86
CASE A = WITHIN-YEAR VARIATION CONSIDERED
CASE B = WITHIN-YEAR + YEAR-TO-YEAR VARIATION CONSIDERED
CASE C = CASE B + MODEL ERROR CONSIDERED
```

The Reckhow and Simpson model also predicts phosphorus loading to lakes. Observed in-lake TP and chlorophyll-a concentrations and Secchi readings that are "average" according to the model suggests TP loading of around 300 kg/year. Of this load, the model predicts that 60% comes from agriculture lands, 18% from septic systems, and 11% from lakeshore property runoff.. The remaining 11% is attributed to forest, wetland, and grassland areas, as well as precipitation.

As part of the Reckhow and Simpson modeling, estimates are made of the potential contribution of phosphorus to the lake from livestock. It is estimated that the livestock in the watershed at the time of the study could produce 470 kg of phosphorus annually. Based on the in-lake TP concentrations, it would seem that little of this phosphorus reached Long Lake in 1994 (i.e. no direct runoff). Even a small percentage of this total, however, could have a significant impact on Long Lake. Good manure management practices will be necessary to protect and improve water quality in Long Lake.

Copper sulphate treatments of Long Lake add additional uncertainty to the interpretation of the results from both models. If the treatment are having a significant impact on algae, in-lake concentrations of chlorophyll-a and possibly TP should be less than predicted, and Secchi transparency greater than predicted. On one hand, this does seem to be the case for both models. On the other hand, the observed and predicted in-lake conditions are not significantly different. This may mean that the copper sulphate treatments are not having a large impact.

Goal Setting

In 1993 and 1994, the summer mean TP for Long Lake was below the 70-90 µg/L goal for lakes in the WCBP ecoregion. This indicates that Long Lake is in good condition relative to other lakes in the region and should warrant protection if not further improvement. The 70-90 µg/L goal, however, is for partial support of swimmable use, while full support would require a TP concentration of 40 µg/L. At or below 40 µg/L, swimmable uses can be maintained through most or all of the summer. It is estimated that with a summer-mean TP of 59 µg/L Long Lake may experience nuisance algae blooms about 83% of the summer and severe nuisance blooms about 54% percent of the summer (Chlorophyll-a interval frequencies from Table 4). Given it's small watershed, improvements in in-lake water quality would seem possible and a TP concentration of 50 µg/L may be a reasonable goal for Long Lake. If this goal is met, severe nuisance blooms should occur about 20-25% of the summer in contrast to 55% of the summer under current conditions. Achieving a lower TP will require a concentrated effort to reduce loading from agricultural land, septic systems and lakeshore property. With or without copper sulphate treatments, conditions could revert back to those seen prior to 1986 if no action is taken.

TABLE 5. RECKHOW-SIMPSON MODELING SUMMARY

INPUT SECTION

Long Lake - Watonwan			
Watershed Area (ha)	514	0.059	= Observed TP (mg/l)
Lake Area (ha)	107	0.06	= Observed TP Standard Deviation
Water Runoff (m)	0.125	8	= N
Precipitation (m)	0.78	35.3	= Observed Chla (ug/l)
Mean Evaporation (m)	0.87	1	= Observed Secchi (m)
Mean Depth (m)	2.4	2.568	= Calculated Volume (Hm3)
County capitas/cabin	2.8		
No. Seasonal Cabins	29		
No. Permanent Res.	44		

*Fill in estimated animal units at cell A102

	Before	After	Delta	%Total
Forest Area (ha)	12	12	0	2%
Agric Area (ha)	437	437	0	85%
Urban Area (ha)	33	33	0	6%
Wetland Area (ha)	13	13	0	3%
Pasture/Open (ha)	19	19	0	4%
Sum of land uses	514	514		100%

Export Values	units	Low	Average	High
Forest P Export	(kg/ha)	0.1	0.12	0.15
Agric P Export	(kg/ha)	0.2	0.4	0.8
Urban P Export	(kg/ha)	0.5	1	1.25
Wetland P Export	(kg/ha)	0.1	0.1	0.1
Pasture/open Export	(kg/ha)	0.2	0.3	0.4
Atmospheric Export	(kg/ha)	0.3	0.3	0.5
Soil Retention Coef	(percent)	0.8	0.6	0.6
Point Source Before	(kg/yr)	0	0	0
Point Source After	(kg/yr)	0	0	0
Delta Point Source	(kg/yr)	0	0	0
Unnaccounted for P	(kg/yr)	0	0	0
Capita Years	(years)	140.4	140.4	140.4

TABLE 5 (cont.)

OUTPUT SECTION #1
Reckhow-Simpson Modeling Summary

Low	Average	High	kg P/year
1	1	2	Forested Flux
87	175	350	Ag flux
17	33	41	Urban flux
1	1	1	etland flux
4	6	6	a/Open flux
32	32	64	Ppt flux
28	66	66	Septic flux
0	0	0	Int Source
0	0	0	Unaccounted for P
170	304	512	Total P Flux
159	284	479	P LOAD (kg)
266	476	800	Inflow P ug/l

			CANFIELD/BACHMANN
49	70	96	*Predicted Inlake P (ug/l)*

OUTPUT SECTION #2
Estimated phosphorus contributions by different sources in the watershed.

	Low Flux	%	Average Flux	%	High Flux	%
Wshed	110	65%	216	71%	402	79%
Septic	28	16%	56	18%	56	11%
Ppt	32	19%	32	11%	54	11%
Point	0	0%	0	0%	0	0%
Unacc for	0		0		0	
Sum kg/yr	170		304		512	

Reference Phosphorus export coefficients corrected for catchment size.

Prairie and Kalff, 1986. Effect of catchmen size on phosphorus export.Wat. Res. Bull. 22:465-470

Wilson & Walker, 1989. Development of on the aquatic ecoregion concept. Lake and Res. Mngmt. 5:11-22

Use	Hectares	P export	Ecoreg.	Dominant Landuse	*Net P Export
Forest	12	0.08	NCHF	Cul+Mixed	0.19
Ag-mix	437	0.69	NLF	For (75%)	0.12
Row crop ag.#	437	0.41	NGP	Cul (83%)	0.76
Non-row ag.#	437	0.65	WCBP	Cul (84%)	0.74
Pasture	19	0.72			

#Fill in estimated area of these land uses. * P export from all land uses.

OUTPUT SECTION 3. Reckhow-Simpson and MINLEAP modeling summary, predicted changes in Secchi disk transparency, chlorophyll concentrations, and trophic status based on observed or predicted total phosphorus concentrations.

		Observed lake conditions	Low TP conc. predicted)*	Average TP conc. predicted)*	High TP conc. predicted)*	MINLEAP values (predicted)
LAKE TP	mg/l	0.059	0.049	0.070	0.096	0.063
LAKE CHLA	ug/l	35.3	19.4	32.7	51.6	42
LAKE SECCHI	m	1	1.3	1	0.8	0.9
MINLEAP load prediction (kg/yr)						413
TSI TP		63	60	65	70	64
TSI CHLA		66	60	65	69	67
TSI SD		60	56	60	63	62

* Fill in predicted TP concentrations from output section 1 (Canfield and Bachman), or use other estimates.

Hydrologic Summary Information

Estimated Flo	642477.5	(m3/year)	0.64	(hm3)
Estimated Q	0.6	(m/yr)		
Residence tim	4.00	(years)		

Useful conversions: 1hm3 = 1,000,000 m3; hm3 = Acre-feet/811; Ha = Acres/2.47; km2 = 2.59(mile2)

Recommendations for maintaining and improving water quality

The following recommendations are based on 1994 Lake Assessment Program (LAP) study of Long Lake:

It is important to note that because of the small size of the Long Lake watershed, opportunities exist for lake protection and improvement not available for many other lakes in this ecoregion. The activities of relatively few people (the lakeshore community and a few agricultural land owners) can have a strong positive influence on water quality. The lakeshore community should not underestimate their potential to protect or improve water quality through upgraded wastewater treatment and better lawn and garden practices.

It is essential that the goals of lake protection efforts be conveyed to all local government groups with land use/zoning authorities for Long Lake. The Long Lake Association should be commended for their efforts to date, which include interacting with Watonwan County, the County Soil and Water Conservation District and the Minnesota Department of Natural Resources. To compliment these efforts, the Association should develop a plan for protecting the water quality of Long Lake. This plan, referred to as a lake water quality management plan, should incorporate a series of activities in a prioritized fashion which will aid in the long-term protection and improvement of Long Lake. The following activities could be included in the plan:

a. **The Association should reactivate their participation 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 consistent sites. Sites 201 and 202 are goods sites for long-term characterization of the transparency of the lake.

b. **The Association should provide educational materials to lakeshore owners on shoreline and shoreland protection.** Protection of the existing vegetation along the shore will minimize erosion and preserve the aesthetic value of the lake. In addition to providing water quality and fishery benefits, lakeshore with a diverse community of native vegetation provides better habitat for songbirds and other small animals than large areas of lawn. The MPCA, MDNR, and county offices may be able to provide assistance in this area. The booklet, A Citizen's Guide to Lake Protection and the book, Landscaping for Wildlife are good guides and may be useful educational tools for the Association.

c. **Further development in the watershed should occur in a manner that minimizes water quality impacts on the lake.** Provisions for setbacks and vegetative buffer strips should be strictly followed. MDNR's shoreland regulations will be important in this regard. Soil loss can be reduced by utilizing best management practices during construction or road building. Watonwan County's shoreland regulations will be important in this regard. Activities within the watershed such as wetland removal or major land use alterations that change the drainage or flow patterns should be discouraged. Maintenance of effective buffers between agricultural areas and ditches, streams, and the lake will help to minimize nutrient rich runoff.

Although it can be difficult to assess how much impact individual projects within the watershed will have on the lake, the cumulative effect can be significant. In addition to the positive effects on water quality, watershed projects such as restoration of wetland, protection of natural areas, and creation of buffer strips will improve the wildlife habitat, plant diversity, and aesthetics of the watershed.

d. **The Association should conduct a survey of individual sewage treatment systems around the lake.** The information obtained through such a survey can guide the efforts of the Association and Watonwan County to upgrade inadequate systems and improve system maintenance practices. Much can be accomplished through education of all lakeshore property owners.

e. **The Association should work closely with the Minnesota Department of Natural Resources (MDNR) Division of Fisheries to maintain a healthy fish community.** A healthy fish community can benefit water quality and vice versa. Degraded water quality could shift the balance from desirable fish species to less desirable species of fish. Because changes in species composition are difficult to reverse, they should be avoided whenever possible.

f. **The Association should reevaluate the use of copper sulphate to control algae on a regular basis.** Copper sulphate could be considered a "band-aid" approach to water quality problems in a lake. The time and money spent on copper sulphate might be better spent on lakeshore and watershed projects that will have longer term benefits.

g. **The Association should develop a working relationship with the agricultural land owners in the watershed.** If changes in agricultural land should be needed to protect or improve water quality, they are most likely to be accomplished in a cooperative manner. In addition, small pieces of agricultural land may be needed for lakeshore wastewater treatment.

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APPENDIX

LAKE WATER QUALITY DATA. All MPCA data in STORET

LAKEID=83-0040

DATE	SITE	D	TP	RTP	TKN	N2N3	RN2N3	TSS	TSIN	ALK	PHF	CL	CONF	TURB	COLOR	CHLA	PHEO	SDF	PHYS	REC	DO	TEMP
810910	101	0	.085		1.78	0.01	K	.	.	130	.	.	.	.	25	40.50	.	2.3			8.0	21.0
850807	101	0	.125		1.81	0.01	K	9.0	.	140	.	33	.	4.2	20	55.00	.	2.0			12.0	25.9
850829	101	0	.108		1.97	0.03		17.0	.	140	.	34	.	18	20	23.40	.	1.6			8.0	22.0
850829	102	0	.150		2.46	.		.	.	.	.	.	.	.	.	88.40	.	1.0			.	.
930422	101	0	.074		1.58	0.69		8.0	5.0	160	8.3	31	500	6.3	10	28.00	4.81	3.3			11.7	7.5
930601	101	0	.043		0.92	0.75		7.6	5.0	200	8.0	30	460	3.8	10	6.09	0.96	4.6	2	2	8.5	15.1
930727	101	0	.066		1.45	0.50		14.0	6.2	160	8.7	23	400	9.4	10	78.20	0.64	2.0	3	3	10.6	24.4
930824	101	0	.072		1.16	0.01	K	15.0	5.8	140	8.7	25	360	8.0	20	1.60	68.1	1.6	3	3	11.1	26.0
940426	101	0	.070		1.15	0.52		23.0	18.0	160	8.3	24	430	7.7	10	27.60	6.41	2.5	2	2	9.4	15.2
940426	102	0	.068		.	.		.	.	.	8.4	.	430	.	.	21.80	4.48	2.5	2	2	.	.
940614	101	0	.074		1.47	0.24		14.0	7.8	170	.	26	.	13	20	52.90	2.14	2.3	2	1	10.1	24.5
940614	102	0	.081		1.32	0.21		.	.	.	.	.	.	.	.	47.70	0.71	2.0	2	1	10.2	24.5
940719	101	0	.060		1.04	0.05	K	12.0	7.0	150	8.3	25	380	5.5	10	37.20	1.60	3.0	2	1	10.0	24.3
940719	102	0	.057		1.08	.		.	.	.	8.5	.	360	.	.	32.70	2.07	4.1	2	1	11.2	25.3
940822	101	0	.052		1.09	0.05	K	10.0	4.4	150	8.6	25	370	4.5	10	22.40	3.52	3.0	2	1	8.7	22.0
940822	101	11	.077		.	.		.	.	.	.	.	.	.	.	.	.	.			.	.
940822	102	0	.051		.	.		.	.	.	8.6	.	370	.	.	23.40	2.56	3.6	2	1	8.7	22.0
940914	101	0	.052		1.29	0.05	K	7.2	3.4	150	8.6	25	365	5.5	10	32.00	0.64	3.9	3	3	8.9	22.0
940914	101	11	.064		.	.		.	.	.	.	.	.	.	.	.	.	.			.	.
940914	102	0	.047		.	.		.	.	.	8.6	.	345	.	.	34.00	0.64	3.6	3	3	8.4	22.0

Water Quality Data Abbreviations and Units

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

LAKE WATER QUALITY DATA. All MPCA data in STORET

LAKEID=83-0040 SITE=101 YR=94
Temperature and DO Profiles

Date	D	NDM	DO	TEMP
426	0	0	9.4	15
426	-3	-1	9.4	15
426	-6	-2	9.4	15
426	-9	-3	9.4	15
614	0	0	10	25
614	-3	-1	9.6	24
614	-6	-2	9	24
614	-9	-3	8.6	23
614	-11	-3.5	8.1	23
719	0	0	10	24
719	-3	-1	9.5	24
719	-6	-2	8.4	23
719	-9	-3	6.6	23
719	-11	-3.5	4.4	23
822	0	0	8.7	22
822	-3	-1	8.6	22
822	-6	-2	8.4	22
822	-9	-3	6.6	21
822	-13	-4	2.1	21
914	0	0	8.9	22
914	-3	-1	8.7	22
914	-6	-2	8	22
914	-9	-3	7.5	22
914	-13	-4	4	21

LAKEID=83-0040 SITE=102 YR=94

Date	D	NDM	DO	TEMP
614	0	0	10	25
614	-3	-1	9.3	24
614	-6	-2	7.6	23
614	-9	-3	6.8	23
719	0	0	11	25
719	-3	-1	11	25
719	-6	-2	9.6	24
719	-9	-3	8.5	23
719	-11	-3.5	3.9	23
822	0	0	8.7	22
822	-3	-1	8.8	22
822	-6	-2	8.6	22
822	-9	-3	7.4	21
914	0	0	8.4	22
914	-3	-1	9.4	22
914	-6	-2	9	22
914	-9	-3	7.8	22

Boat Electrofishing Catch Summary

No data reported in ELECTROF.DBF

Historical Electrofishing Catch Summary

There are no pre-93 electrofishing data.

There are no data for length-frequency distribution.

Discussion

Gillnet catch indices for walleye were within the normal range for lake class 43 indicating a normal population. Walleye lengths ranged from 11.0 to 25.8 in gillnets and 9.4 to 23.1 in trapnets. The mean weight for walleye sampled in gillnets was 2.7 lbs. The walleye population was dominated by age 3 and 4 fish (74% of the walleye aged). The two dominant year classes were produced in years walleye were not stocked indicating natural recruitment. According to a 1990 population assessment, a strong year class was produced from natural reproduction. No age two walleye were sampled in 1994 indicating a 1992 fry stocking may not have been successful. Walleye CPUE increased from 1.8 in 1990 to 4.0 fish/net in 1994. Mean weight increased from 2.2 in 1990 to 2.7 lbs in 1994.

Trapnet catch indices for black crappie were within the normal range for this lake class indicating a normal population. Black crappie CPUE increased from 4.4 in 1990 to 14.9 fish/net in 1994 while the mean weight remained the same at 0.3 lbs. Black crappie lengths ranged from 6.0 to 9.9 inches with a mean length of 7.8 inches. All black crappie sampled in trapnets were age 2 and 3.

Trapnet catch indices for bluegill were within the normal range for this lake class indicating a normal population. Bluegill CPUE increased from 1.3 in 1990 to 5.8 fish/net in 1994. This may be attributed to a strong year class produced in 1991. Bluegill lengths ranged from 5.4 to 8.0 inches with a mean length of 6.7 inches.

Channel catfish have never been stocked in Long Lake by the Minnesota DNR, however two year classes produced in 1989 and 1990 were observed duing the 1994 survey. Some local anglers claim that someone threw adult Catfish into the lake at one time. Another explanation for the sudden appearance of channel catfish may be from the pumping of water into the lake during 1989 and 1990 from the Watonwan River. A total of 21 channel catfish were sampled in gillnets and trapnets. Lengths ranged from 11.9 to 17.2 inches. Thirteen spines were collected during the survey. Of the spines collected, five were from a 1990 year class and 8 from a 1989 year class.

Gillnet catch indices for yellow perch increased from 0.3 to 21.2 fish/net from 1990 to 1994. This may be attributed to a strong year class produced in 1992. Gillnet catch indices for yellow perch were within the normal range for this lake class indicating a normal population. Trapnet catch indices for black bullhead have declined from an all time high in 1990 of 65.8 fish per net to 3.3 fish per net in 1994. Trapnet catch indices for black bullhead were below the lower end of the normal range for this lake class indicating a low population. It is unclear at this time if the introduction of channel catfish may have contributed to the decline in the black bullhead numbers.

Shoreline seining data indicated natural reproduction of black bullhead, yellow perch, freshwater drum, bluegill and largemouth bass. A fairly large year class of largemouth bass appears to have been produced. Largemouth bass have never been sampled in Long Lake prior to 1994 and were last stocked in 1984.

Status of the Fishery

Long Lake has a history of good walleye and black crappie fishing. Walleye numbers have increased over the last four years according to our most recent survey in 1994. Lengths ranged from 9.5 to almost 26 inches and the average weight from fish in gillnets was almost 2.7 lbs. Many of the walleye sampled were in the 17 to 21 inch range. Local anglers reported good success on walleye up to 9 lbs with several fish above 6 lbs.

Black crappie and bluegill numbers have also increased since 1990 according to our survey. Black crappie lengths ranged from 6 to 10 inches with most of the crappie in the 8 inch category. Bluegill lengths ranged from 5.5 to 8 inches with the majority of the fish in the 7 inch range.

The channel catfish population appears to be good in Long Lake. Lengths ranged from 12 to 17 inches. Black bullhead numbers are low in Long Lake according to our survey. Of the black bullhead that were sampled, the majority of fish were in the 10 to 11 inch range.

Yellow perch numbers have also increased in Long Lake since 1990. The majority of fish were age 2 and should provide some excellent angling in 1995 and 1996.

Robert A Davis 4-19-95
Area Fisheries Supervisor Date

22 May 95
Regional Fisheries Manager Date

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MINNESOTA DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATERS
LAKES-DB                                    REPORT DATE  03/06/95
LAKE SUMMARY


LAKE NAME: Long                          DNR ID #: 83-0040 00

ALTERNATE NAME:                             SHORELAND CLASS:
                                             Recreational Development
NEAREST CITY:  ST JAMES

PRIMARY COUNTY:   Watonwan                  NUMBER OF COUNTIES:  1

PWI CLASS: P        AREA:    256 AC.     LOCATION: RNG     TWP    SEC
MEANDERED: Y                                       32 W    105    15

WETLAND TYPE:  5            BULLETIN 25 LOCATION: RNG     TWP    SEC
SOURCE:  6                                        32    105     10,14,15

WSHD.NO.: 31014                                  USGS QUAD: W11b
MAJOR WATERSHED NAME: Watonwan River              ST JAMES WEST
MINOR WATERSHED NAME: Co Ditch #1

************************* WATER LEVEL DATA *************************

OHW ELEVATION: 1128.70  DATUM: 1929

100Yr FLOOD ELEVATION:            STUDY DATE:

10Yr FLOOD ELEVATION:

HIGHEST KNOWN WATER LEVEL:          DATE:


RECORDED WATER LEVELS:

   PERIOD OF RECORD: 08/09/35 - 09/21/94     # OF READINGS:   838

   HIGHEST RECORDED:  1129.25  05/10/60

   LOWEST RECORDED:   1118.60  08/09/35     RECORDED RANGE: 10.65

   AVERAGE OF RECORDED: 1127.61

   LAST READING:  1128.13  09/21/94

************************* RUNOUT DATA *****************************

  RUNOUT ELEVATION:          DATUM: 1929

  RUNOUT TYPE: SL      Stop Log Dam

  LOCATION:     Q-SEC     SEC TWP RNG
                NW SW SE  10  105 32 W
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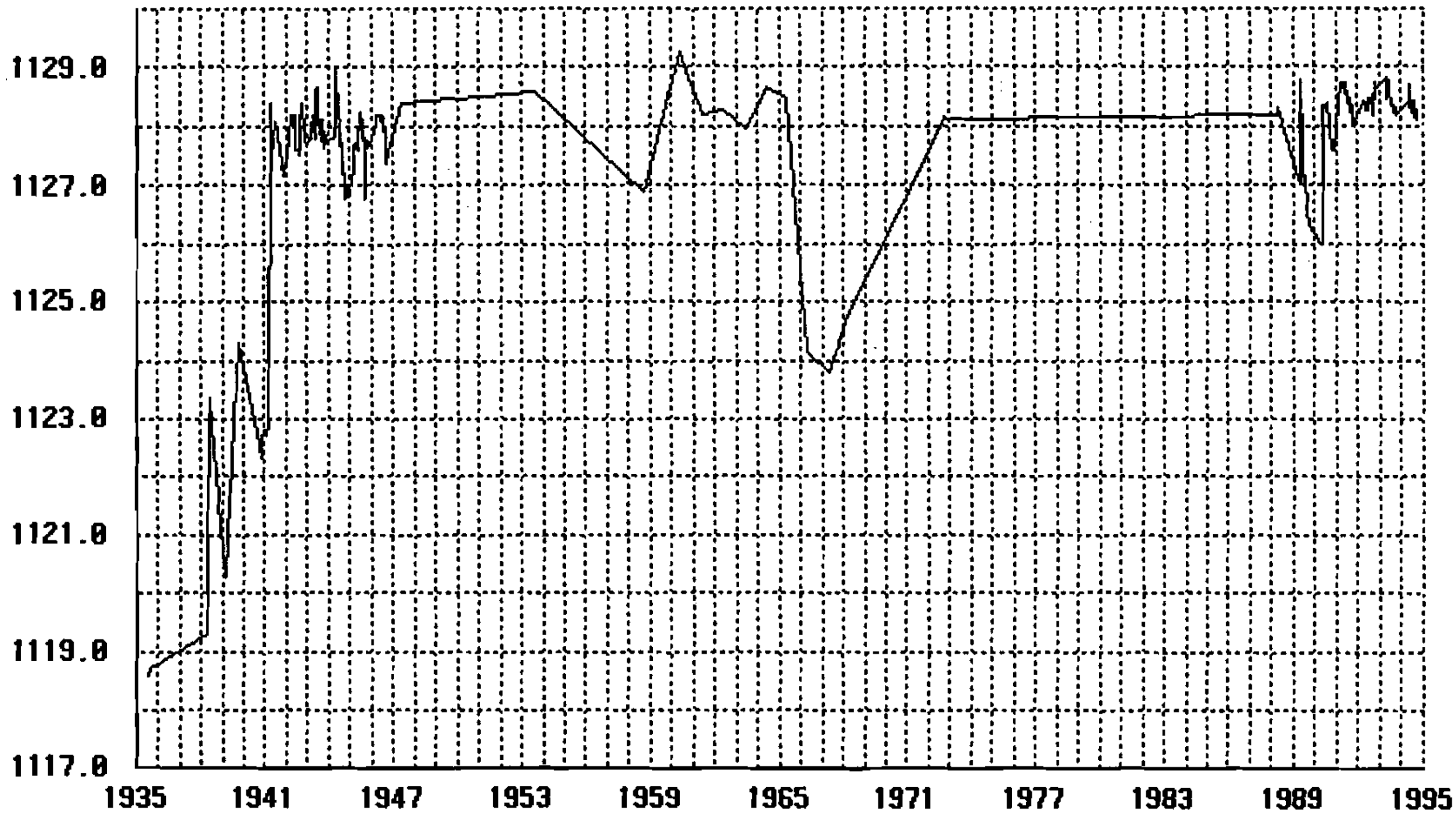
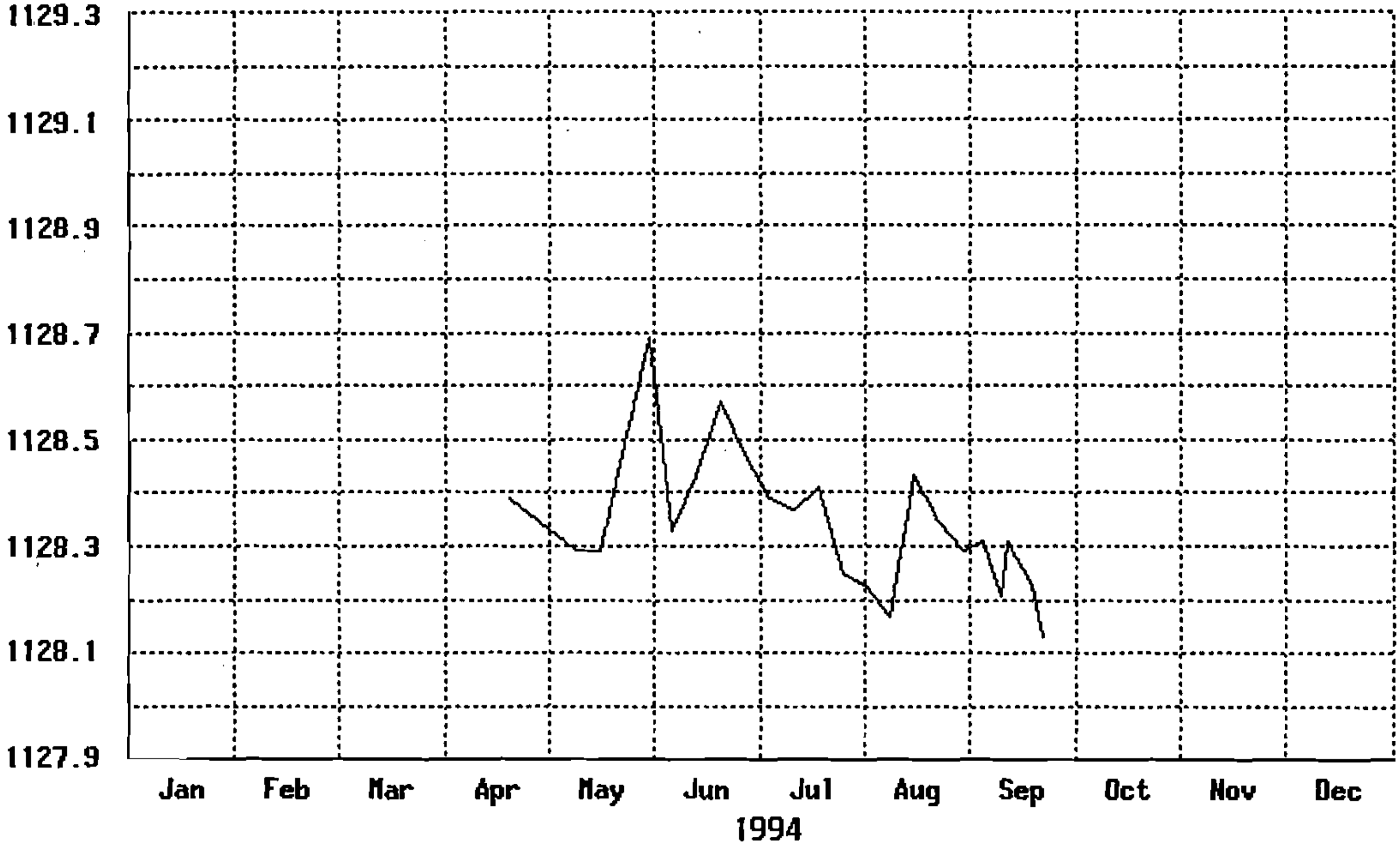
Long Lake Watonwan County

RECORDED WATER LEVELS



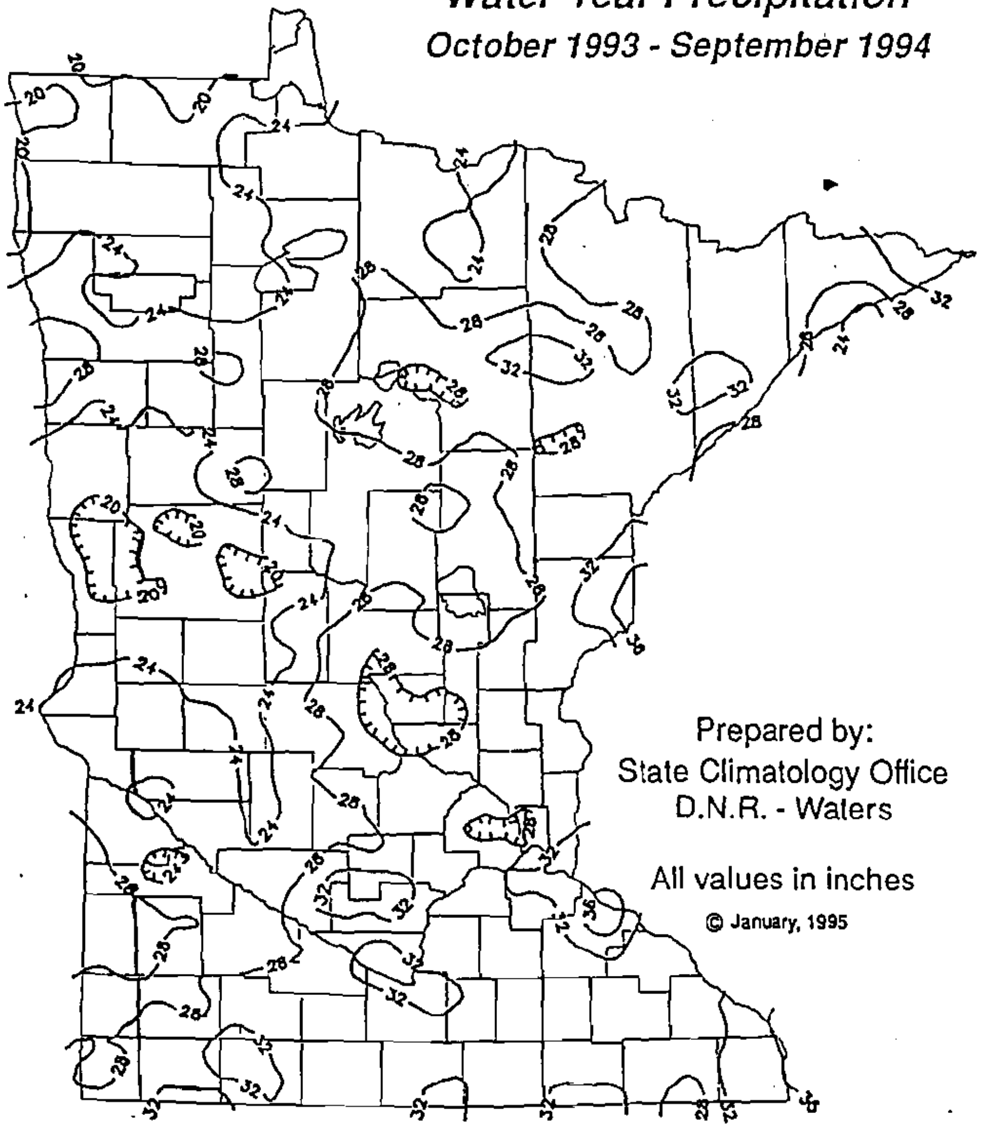
Long Lake Watonwan County

RECORDED WATER LEVELS



Water Year Precipitation

October 1993 - September 1994



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

All values in inches

Data sources: *National Weather Service, Soil & Water Conservation Districts, DNR - Forestry,* Metro Mosquito Control District, DNR/NWS Backyard Rain Gauge Network, Minnesota Association of Watersheds, Future Farmers of America, Minnesota Power and Light, Deep Portage Conservation District, Metropolitan Waste Control Commission

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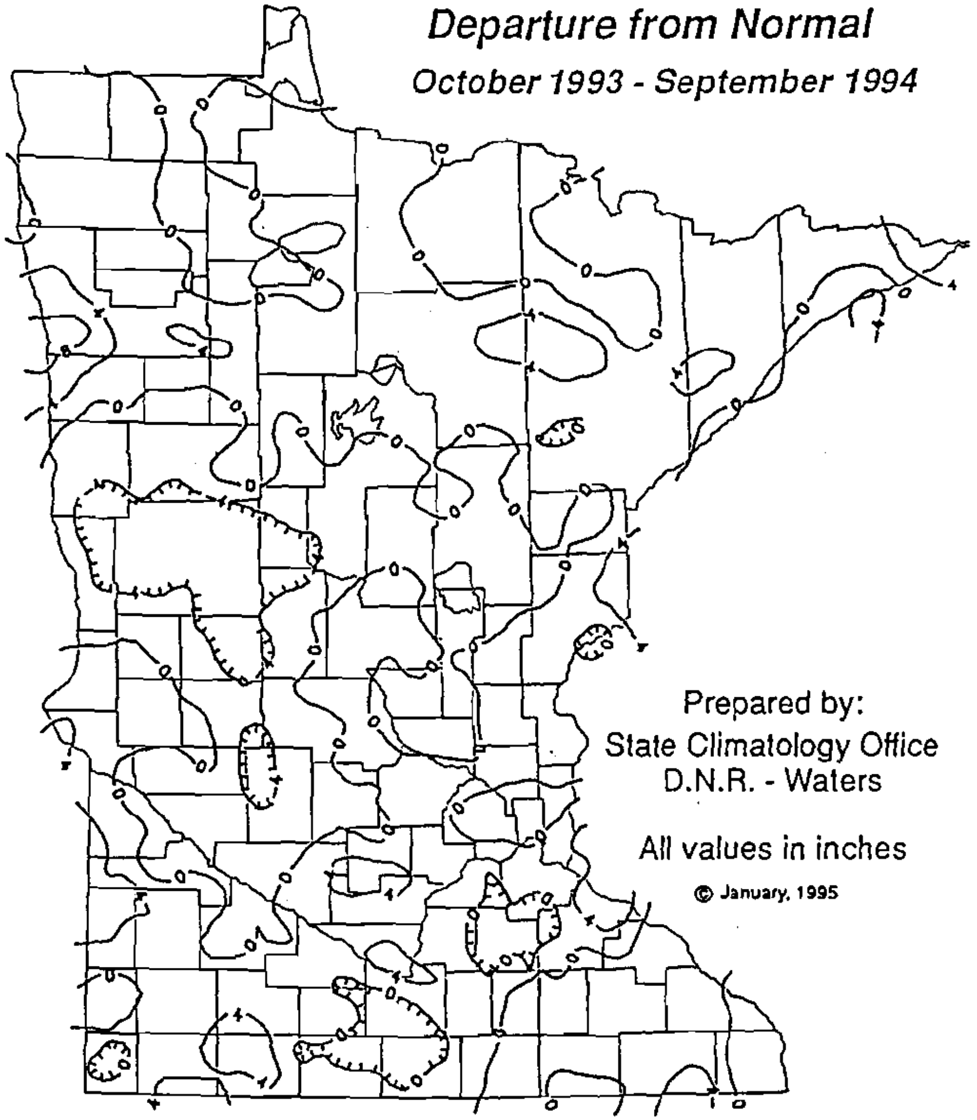
Water Year Precipitation Departure from Normal

October 1993 - September 1994



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

All values in inches

Data sources: National Weather Service, Soil & Water Conservation Districts, DNR - Forestry, Metro Mosquito Control District, DNR/NWS Backyard Rain Gauge Network, Minnesota Association of Watersheds, Future Farmers of America, Minnesota Power and Light, Deep Portage Conservation District, Metropolitan Waste Control Commission