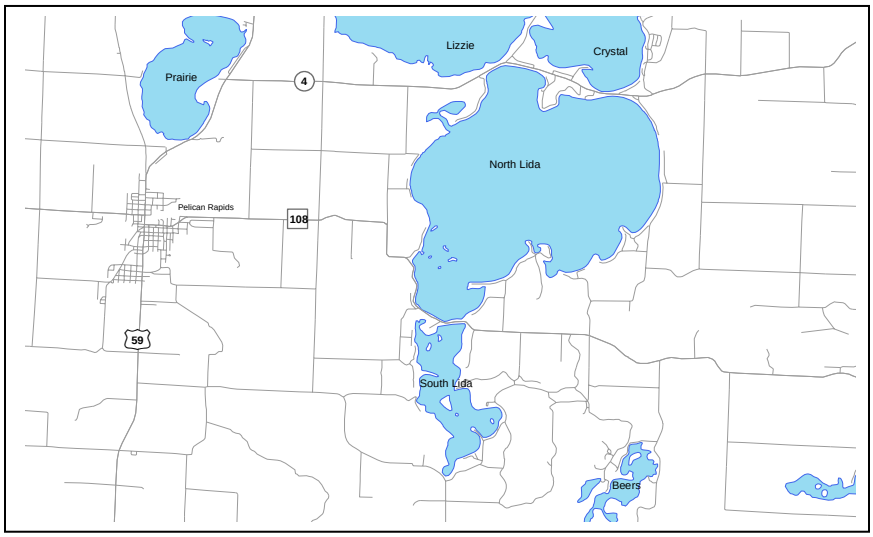
LAKE ASSESSMENT PROGRAM

Lida Lake: #56-0747

Otter Tail County, Minnesota



Minnesota Pollution Control Agency

Environmental Analysis and Outcomes Division

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SUMMARY AND RECOMMENDATIONS

Lida Lake is located in Otter Tail County, 4 miles east of Pelican Rapids, Minnesota. Lida Lake has two basins, the main basin with a surface area of 5,564 acres and the south basin with a surface area of 856 acres. With a total surface area of about 6,420 acres, it is among the top five percent of lakes in the state in terms of size. The main basin of Lida Lake has a maximum depth of 58 feet and a mean depth of 19 feet. The southern basin has a maximum depth of 48 feet and a mean depth of 21 feet. The total watershed is approximately 43 square miles (27,299 acres). Land use in the watershed is characterized primarily by forested (35 percent) and wetland (27 percent) uses. These values are very comparable to other lake watersheds in this region of the state - *North Central Hardwood Forests ecoregion*.

Lida Lake was sampled during the summer of 2000 by the Minnesota Pollution Control Agency (MPCA) staff. Main basin water quality data collected during the study reveal summer-mean total phosphorus (TP) concentration of 16 µg/L, chlorophyll-*a* of 6.2 µg/L and Secchi transparency of 10.3 feet. South basin water quality data collected during the study reveal summer-mean total phosphorus (TP) concentration of 24 µg/L, chlorophyll-*a* of 11.5 µg/L and Secchi transparency of 8.2 feet. All three parameters from both basins are well within or better than the range of values exhibited by reference lakes in the NCHF ecoregion. Total phosphorus, chlorophyll-*a* and Secchi transparency help to characterize the trophic status of a lake. These measures indicate *mesotrophic* conditions for both basins of Lida Lake.

A good historical data base is available for assessing trends in the transparency of Lida Lake. These data include 12 years of Secchi data in the main basin, and 9 years in the south basin. Based on an analysis of Secchi transparency data, both basins of Lida Lake exhibited no trend in transparency over time. Summer-mean Secchi transparency in the main basin ranged from 6.6 feet (2.0 m) in 1976 to 12.5 feet (3.8 m) in 2001 and in the southern basin ranged from 8.2 feet (2.5 m) in 1998 to 9.8 feet (3.0) in 2000.

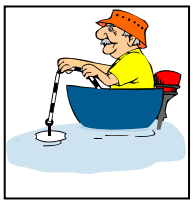
Two lake water quality models were used to estimate the water quality of Lida Lake based on morphometry and watershed characteristics. These models provide a means to compare the measured water quality of the lake relative to the predicted water quality. The first model, MINLEAP, predicted a summer-mean phosphorus (P) concentration for the main basin of 24 µg/L which is higher, but not significantly different, than the observed summer-mean of 16 µg/L for the main basin. MINLEAP predicted a summer-mean phosphorus (P) concentration of 34 µg/L which is also higher than the observed concentration in the south basin of 24 µg/L. For the main basin, this model estimated a phosphorus loading of ~ 2,094 kg P/year and a water residence time of about 12.5 years. Estimates for the south basin show the phosphorus loading at ~812 kg P/year and a residence time of approximately 4.5 years. A regression model, Vighi and Chiaudani (1985), predicted a background P concentration of 25 µg/L for the main basin of Lida Lake which is higher than the 2000 summer-mean P of 16 µg/L. The predicted value for

the south basin mirrored the observed, with the background P concentration estimate and observed both being 24 µg/L.

The following recommendations are based on the Lake Assessment Program (LAP) study of Lida Lake:

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

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



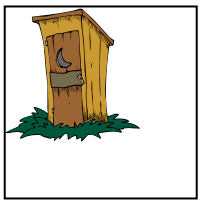
b) **The Association should continue to participate in the CLMP and related monitoring programs**. Data from this program provides an excellent basis for assessing long-term and year-to-year variations in algal productivity, i.e., trophic status of the lakes. At a minimum, measurements should be taken weekly during the summer at a consistent site(s). Sites 201 and 202 in the south basin, and site 208 of the main basin are probably the most valuable for long-term characterization of the transparency of the lake.

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

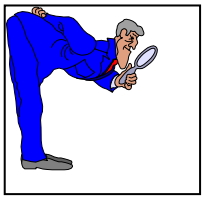
- In the shoreland areas, setback provisions should be strictly followed. MDNR and county shoreland regulations will be important in this regard.
- Stormwater regulations should be adhered to during and following any major construction/development activities in the

watershed. Limiting the amount of impervious surfaces can have beneficial affects as well, in terms of reduced runoff and P-loading.

- Activities in the total watershed that change drainage patterns, such as wetland removal or major alterations in lake use, should be discouraged unless they are carefully planned and adequately controlled. Restoring or improving wetlands in the watershed may also be beneficial for reducing the amount of nutrients or sediments which reach Lida Lake. The U.S. Fish and Wildlife Service at Fort Snelling may be able to provide technical and financial assistance for these activities.
- The Association should continue to seek representation on boards or commissions that address land management activities so that their impact can be minimized. The booklet, Protecting Minnesota's Waters: The Land-Use Connection, may be a useful educational tool in this area.

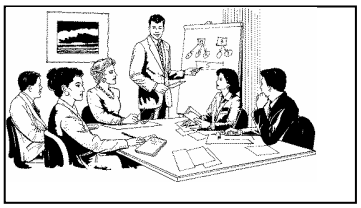


d) **On-site septic systems are a potential source of nutrients to Lida Lake**. Given its watershed size, poorly functioning on-site systems could *potentially* be an important source of nutrient loading to Lida Lake. A house-to-house septic system survey of the homeowners would reveal who was or was not familiar with the age and maintenance (pumping) of their systems. The Association and Otter Tail County should continue to educate homeowners on proper maintenance of their systems and encourage all homeowners with non-code systems to bring their systems up to code. The Association may want to facilitate a lake-wide schedule for pumping systems.



e) **An examination of land use practices in the watershed and identification of possible nutrient sources such as lawn fertilizer, the effects of ditching and draining of wetlands, and agricultural practices etc., may aid the Association in determining areas where best management practices may be needed**. The Association, together with Otter Tail County, should promote and educate about the use of P-free fertilizers on lawns in the watershed. Beginning in 2005, a statewide law prevents the use of fertilizers containing phosphorus on lawns. Exemptions include agricultural crops, flower and vegetable gardens, golf courses, and establishing new lawns. For regular lawn use, a soil test must indicate that the phosphorus is needed for the lawn to be exempt. Likewise, there may be opportunities to implement/promote Best Management Practices (BMP's) that may reduce nutrient loading from other sources in the watershed.

f) **The MPCA's Clean Water Partnership Program (CWP) is also an option for further assessing and dealing with nonpoint sources of nutrients in the watershed**. However, since there is extensive competition for CWP funding, it may be in the best interest of the Association and Lida Lake to continue to work with Otter Tail County, local water planner 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. If these steps prove to be inadequate or lake conditions worsen (as evidenced by significant declines in Secchi transparency measurements), application to CWP may then be appropriate. One indication of a declining trend in water quality would be if summer-mean transparency remained consistently below the current long-term mean of 10.7 feet (3.3 m) or if summer-mean TP increased above 20 µg/L for the main basin. In the south basin, a declining water quality trend would be observed if summer-mean transparency remained consistently below the currently long-term mean of 9.2 feet (2.8 m) or if summer-mean TP increased above 20-25 µg/L.

LAKE ASSESSMENT PROGRAM: 2000

INTRODUCTION

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

This study was conducted at the request of the Association. Lida Lake was sampled by Mike Vavricka from the MPCA on three occasions during the spring and summer of 2000. Land-use and watershed information for Lida Lake was assembled by the Otter Tail County SWCD. This report, which includes lake association-collected data from 1998 to present, was prepared by Pam Skon, Environmental Analysis and Outcomes Division, MPCA.

BACKGROUND: Watershed, Soils, and Land Use

Lida Lake is located in Otter Tail County, 4 miles east of Pelican Rapids, Minnesota. Lida Lake is in the upper five percent of lakes in the state in terms of size (6,420 acres). The main basin, with a surface area of 5,564 acres has a maximum depth of 58 feet and a mean depth of 19 feet. The southern basin, with a surface area of 856 acres has a maximum depth of 48 feet and mean depth of 21 feet (Table 1). Lida Lake has a watershed of approximately 43 square miles and watershed:lake surface ratio of 4:1.

The general flow of water is from south to north (Figure 2). Water flows into South Lida and then into the north basin, which outlets towards Lizzie Lake. Besides water that enters via the south basin of Lida, the north (main) basin has two rather distinct subwatersheds that drain from the southwest and east sides of the lake.

Lida Lake was formed by an ice block basin in glacial till in the Keewatin Sheet of the late Wisconsin Glaciation (Zumberge, 1952). Soils near the lake consist of the Waukon-Barnes and Nebish-Rockwood series. This area is generally rolling to hilly terrain and the soils are well drained. The Waukon-Barnes soils are formed from calcareous glacial

till and are dark in color. The Nebish-Rockwood soils are light in color and also developed from calcareous glacial till (Arneman, 1963).

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

Figure 1. Lida Lake Location and Ecoregion Map

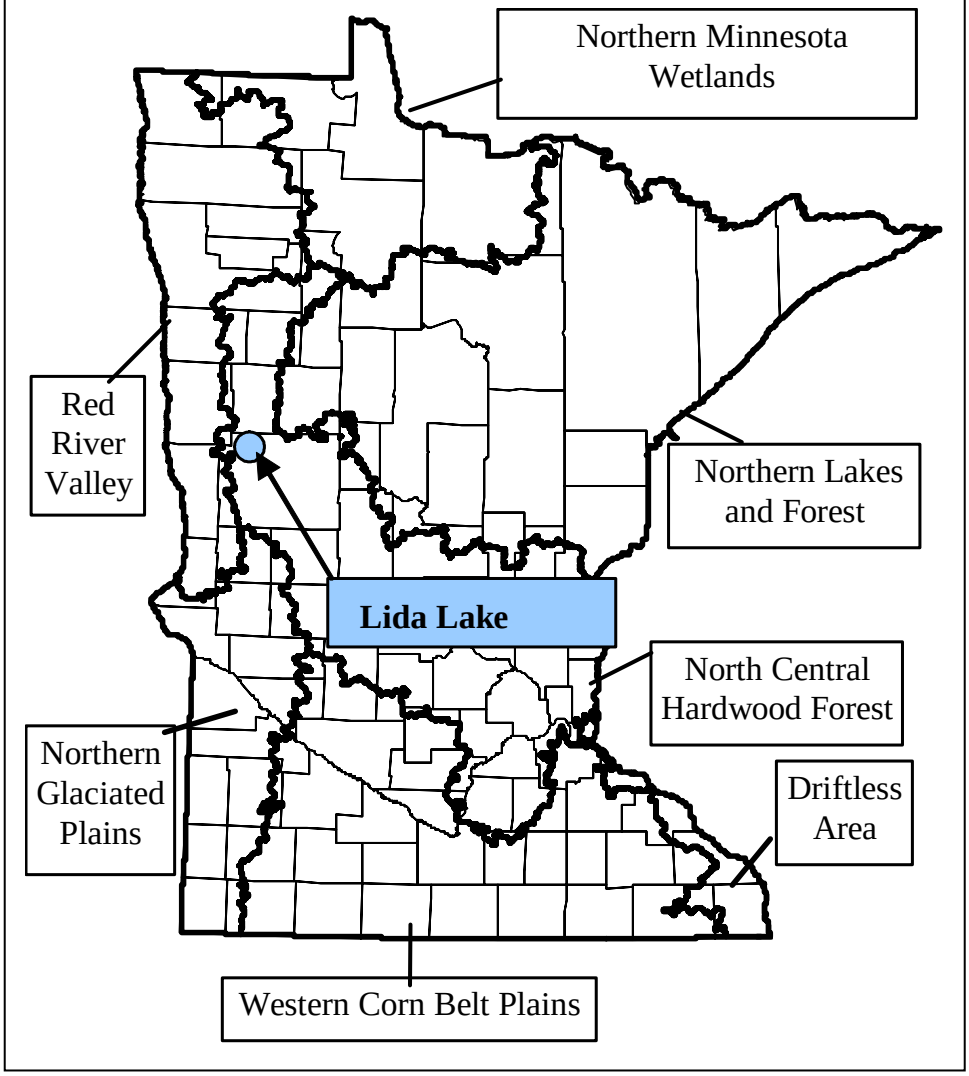


TABLE 1a. MORPHOMETRIC, WATERSHED, FISHERY CHARACTERISTICS
Lida Lake (56-0747-01)

Area[1]: 5,564 acres (2,253 ha)

Mean Depth[2]: 19 feet (5.8 m)

Maximum Depth[1]: 58 feet (17.7 m)

Littoral[1]: 2,380 acres (43 %)

Volume[2]: 105,716 acre-feet (130.5 hm^3)

Watershed Area[3]: 18,208 acres (29 mi^2) (7,369 ha) (excludes lake)
23,772 acres (37 mi^2) (9,620 ha) (includes lake)

Watershed Area Lake Surface Ratio: ~ 3:1
Estimated Average Water Residence Time: 12.5 years

Fisheries[1]: Schupp's Lake class: 27

Public Access[1]: 1

LAND USE	Forest	Water & Marsh	Pasture & Open	Cultivated	Urban/ Residential
Lida Watershed[2] (Acres)	6,273	7,716	3,264	6,344	175
Lida Watershed[3] (%)	**26**	**32**	**14**	**27**	**1**
NCHF Ecoregion[4] (%)	**6 - 25**	**14 - 30**	**11 - 25**	**22 - 50**	**2 - 9**

[1]Supplied by MN Department of Natural Resources.
[2]Planimetered by MPCA.
[3]Supplied by Otter Tail County.
[4]Derived from Heiskary and Wilson (1990) Table 6.

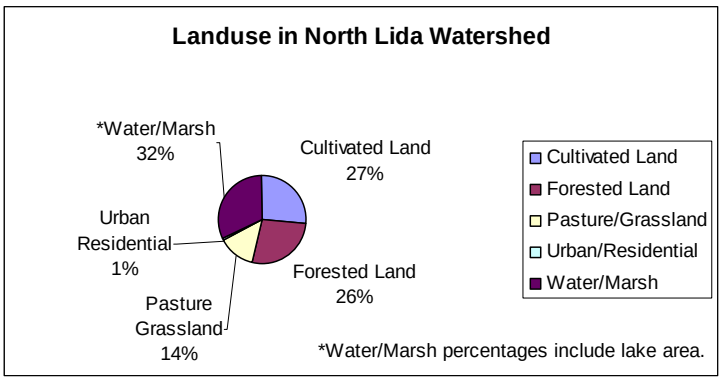


TABLE 1b. MORPHOMETRIC, WATERSHED, FISHERY CHARACTERISTICS
Lida Lake (56-0747-02)

Area[1]: 856 acres (347 ha)

Mean Depth[2]: 21 feet (6.4 m)

Maximum Depth[1]: 48 feet (14.6 m)

Littoral[1]: 356 acres (42 %)

Volume[2]: 17,976 acre-feet (22.2 hm^3)

Watershed Area[3]: 9,091 acres (14 mi^2) (3,679 ha) (excludes lake)
9,947 acres (16 mi^2) (4,025 ha) (includes lake)

Watershed Area Lake Surface Ratio: ~ 11:1
Estimated Average Water Residence Time: 4.5 years

Fisheries[1]: Schupp's Lake class: 25

Public Access[1]: 1

LAND USE	Forest	Water & Marsh	Pasture & Open	Cultivated	Urban/ Residential
Lida Watershed[3] (Acres)	*4,360*	*2,169*	*1,804*	*1,523*	*90*
Lida Watershed[3] (%)	**44**	**22**	**18**	**15**	**1**
NCHF Ecoregion[4] (%)	**6 - 25**	**14 - 30**	**11 - 25**	**22 - 50**	**2 - 9**

[1]Supplied by MN Department of Natural Resources.
[2]Planimetered by MPCA.
[3]Supplied by Otter Tail County.
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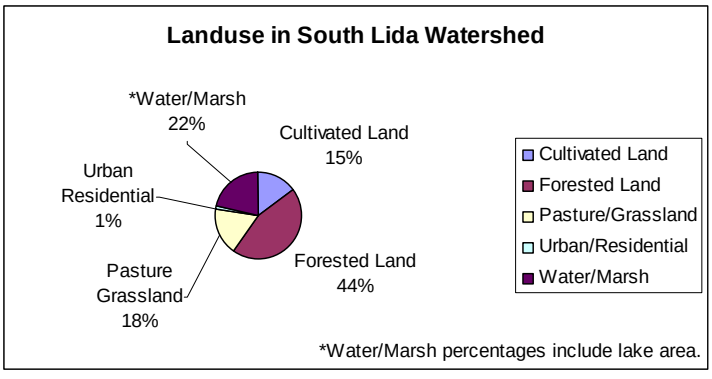


Lida Lake's watershed is about 27,300 acres (43 mi^2), excluding the main and south basins of the lake (Figure 2). The majority (35 %) of the watershed is forested. Other land uses in the watershed include water/marsh (27 percent), cultivated (21 percent), pasture/open (16 percent), and urban/residential (1 percent) uses. These percentages are very comparable to other lake watersheds in this region of the state - *North Central Hardwood Forests ecoregion*.

Climate

Based on State Climatology records, precipitation averages 24 inches (0.61 m) annually in this part of the state. Water-year precipitation near Lida Lake was normal for 2000 based on State Climatology Office records (Appendix 1). Site-specific precipitation data for this area noted several events in summer 2000 where one inch of rain or more fell in the area in one day – June 4 (1.26 in) and September 23 (1.09 in). There was also a 2 day event (July 25-26) that had a combined total of 1.5 inches (www.dnr.state.mn.us). Evaporation typically exceeds precipitation in this part of the state and averages about 36 inches (0.91) per year. Runoff averages for this area are about 4 inches, with a 1-in-10 year low and high values (low and high runoff values which might occur once in ten years) of 0.8 and 6 inches, respectively (Gunard, 1985).

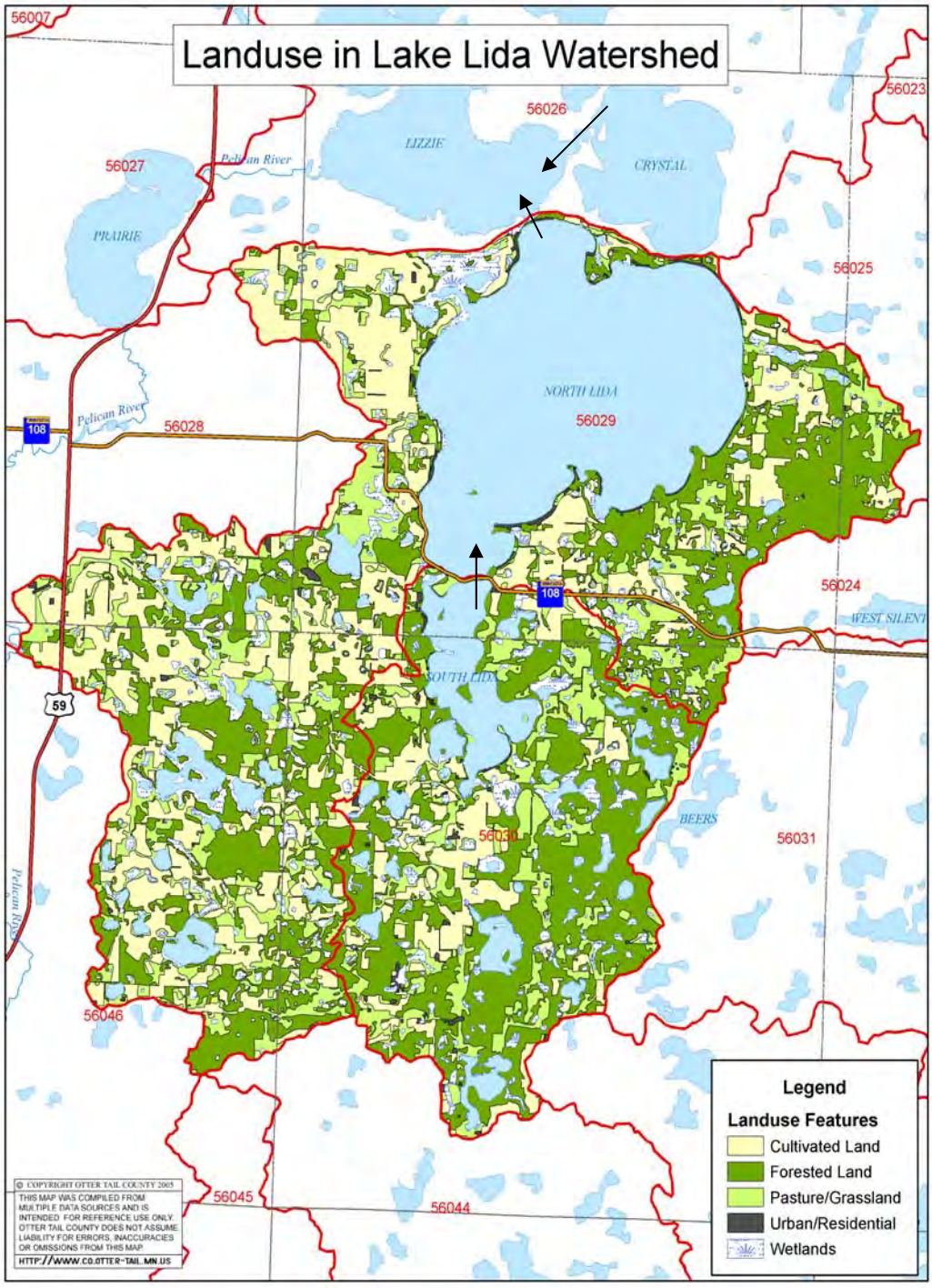
Lake Level

The MDNR Division of Waters, with the cooperation of volunteer readers, monitored water level in 2000 (Appendix 2). During the period of record (1953 – 2004) the lake level has varied by 2.82 feet, based on 217 readings. The highest and lowest recorded elevations are 1,315.8 on 05/17/1994 and 1,312.98 on 10/28/2003, respectively. The OHW (ordinary high water mark) for this lake is 1,314.3 feet.

Fisheries

DNR fisheries managers utilize netting survey information to assess the well-being of fish communities and measure the efficacy of management programs. Presence, absence, abundance, physical condition of captured fishes, and community relationships among fish species within survey catch information also provide good indicators of current habitat conditions and trophic state of a lake (Schupp and Wilson 1993). This long term fisheries survey database has also proven valuable in qualifying and quantifying changes in environmental and fisheries characteristics over time. The fishery of Lida Lake is managed by the Minnesota Department of Natural Resources Fisheries Office located in Fergus Falls, Minnesota. A copy of the Status of the Fishery can be found in Appendix 3 or a current report can be found at www.dnr.state.mn.us.

Figure 2. Lida Lake Watershed Map



RESULTS AND DISCUSSION

Water quality data was collected in June, July, and August 2000. Two sites were used on each basin of Lida Lake. In the main basin sites 101, located in the mid-lake on the west side and site 102, located in the mid-lake on the east end of the lake were monitored. In the southern basin, site 101, located in the southeast end of the lake and site 102, located in the north central end of the lake were monitored (Figure 3). 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 1.24 inches (3.2 centimeters). Seasonal averages were calculated using June - August data.

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, alkalinity, chloride and chlorophyll-*a* (Table 2). Temperature and dissolved oxygen profiles (June only) and Secchi disk transparency measurements were also taken.

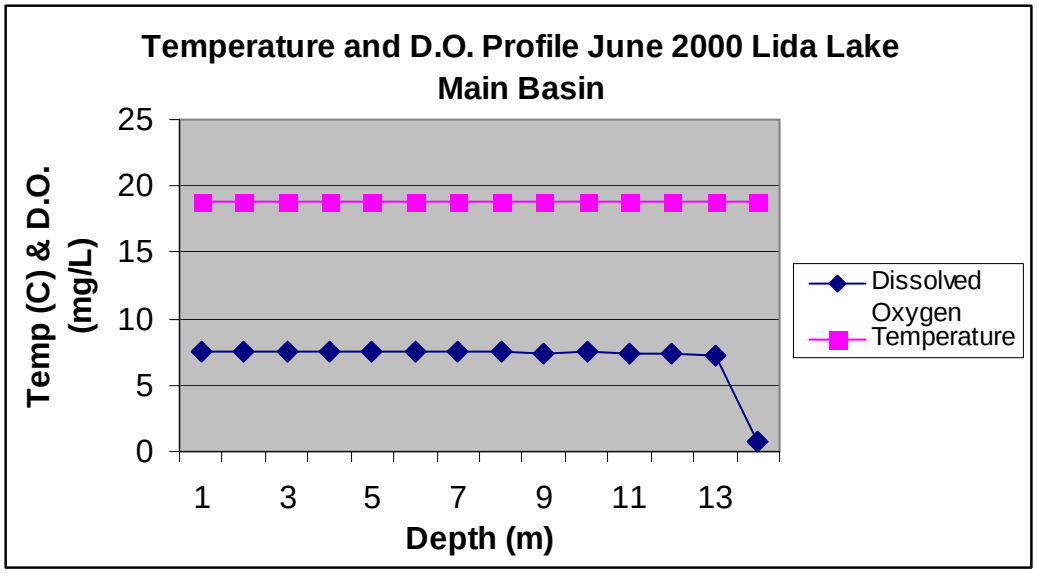
A good historical data base of Secchi data was available for comparison. All data was stored in STORET, the EPA's national water quality data bank. The following discussion assumes that the reader is familiar with basic water quality terminology as used in the Citizens' Guide to Lake Protection.

In-lake Conditions: 2000

Dissolved oxygen and temperature profiles were taken at one meter intervals at site 101 in each basin in June. The main basin was well mixed with a temperature of 18.9 degrees C and a dissolved oxygen concentration of 7.5 mg/L throughout the water column (Figure 3).

In the south basin, thermal stratification was evident in June with the thermocline (zone of rapid change in temperature over a short range in depth) forming between 6 - 7 m (20 - 23 feet). Temperature varied from 19.4 degrees C at the surface to 9 degrees C at the lake bottom. Dissolved oxygen concentrations ranged from 7.5 mg/L in the epilimnion (upper well mixed layer) to well below 2 mg/L in the hypolimnion (generally below 9 – 12 m) during stratification in the south basin (Figure 3). This would be too low for game fish, which typically require a dissolved oxygen concentration of 5 mg/L or greater for long-term survival. Also, as oxygen concentrations fall below 2 mg/L at the sediment-water interface, internal recycling of phosphorus from the sediments to the water may occur.

Figure 3. Lida Lake Main and South Basin
Dissolved Oxygen and Temperature Profiles



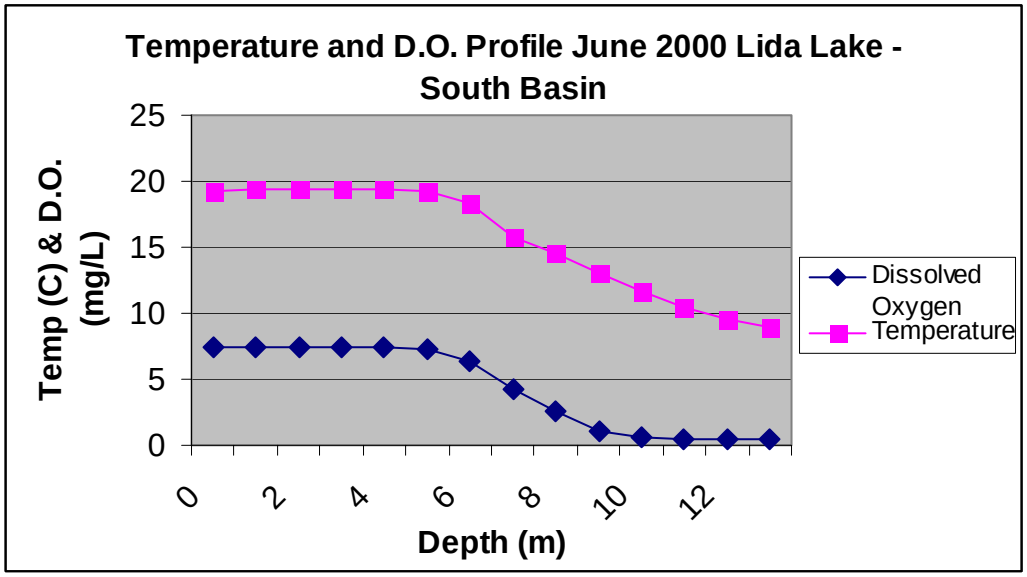


Figure 4. Lida Lake Bathymetric Map and Monitoring Locations

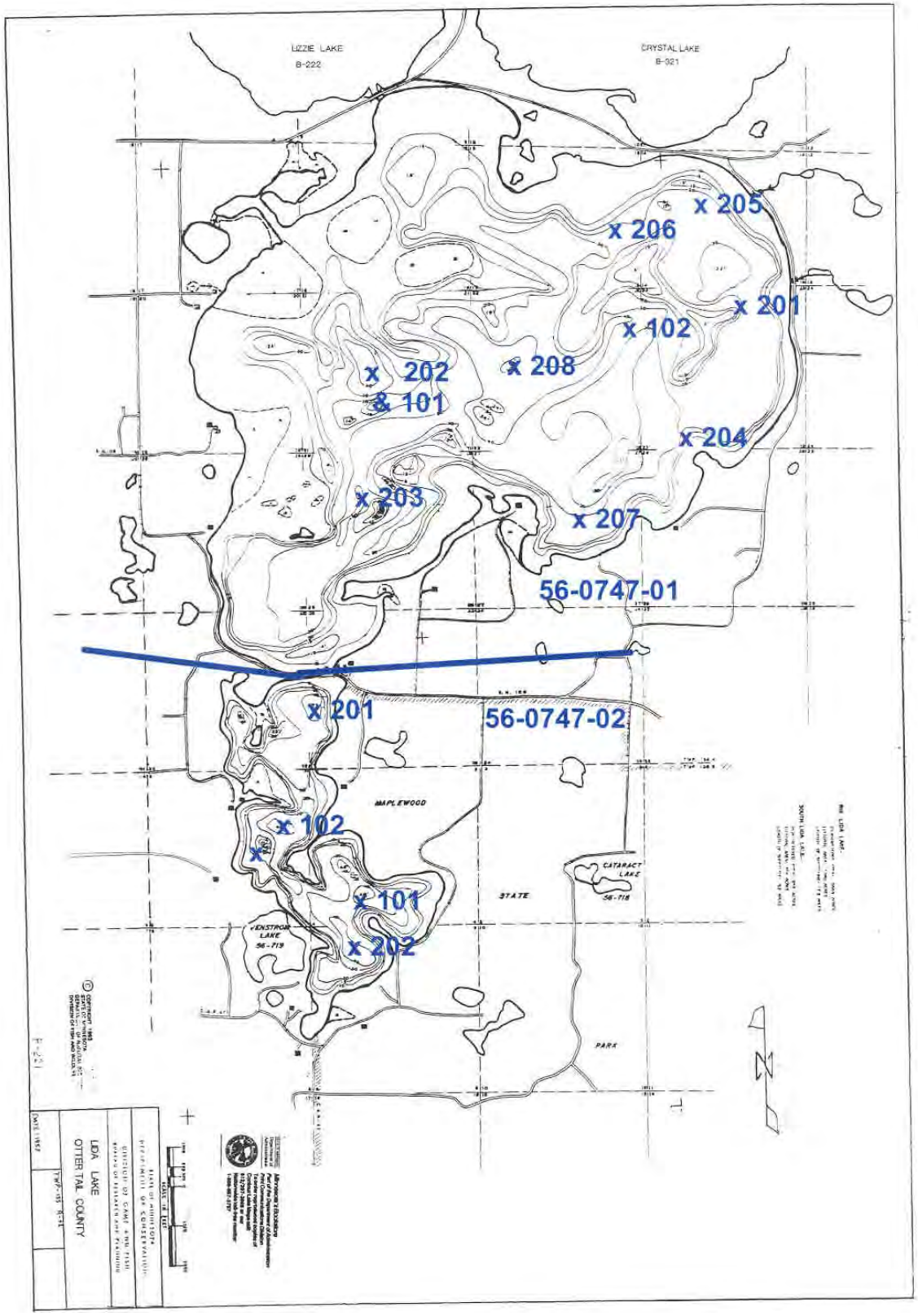


TABLE 2: AVERAGE SUMMER WATER QUALITY AND TROPHIC STATUS INDICATORS: Lida Lake, Based on 2000 MPCA Epilimnetic data.

Parameters	Main Basin Mean[1]	South Basin Mean[1]	**Typical Range for NCHF Ecoregion[2]**
Total Phosphorus (µg/L)	16	24	**23 - 50**
Chlorophyll-*a* (µg/L)[3]			
Mean	6.2	11.5	**5 - 22**
Maximum	9.48	22.1	**7 - 37**
Secchi disk (m)	3.1	2.5	**1.5 – 3.2**
Secchi disk (feet)	10.3	8.2	**4.9 – 10.5**
Total Kjeldahl Nitrogen (mg/l)	0.73	0.89	**<0.60 – 1.2**
Alkalinity (mg/L)	210	197	**75 – 150**
Color (Pt-Co Units)	10	10	**10 – 20**
Chloride (mg/L)	5.6	5.4	**4 – 10**
Total Suspended Solids (mg/l)	3.1	5.0	**2- 6**
Total Suspended Inorganics (mg/l)	2.5	3.7	**1 - 2**
TN:TP Ratio	46:1	49:1	**25:1-35:1**

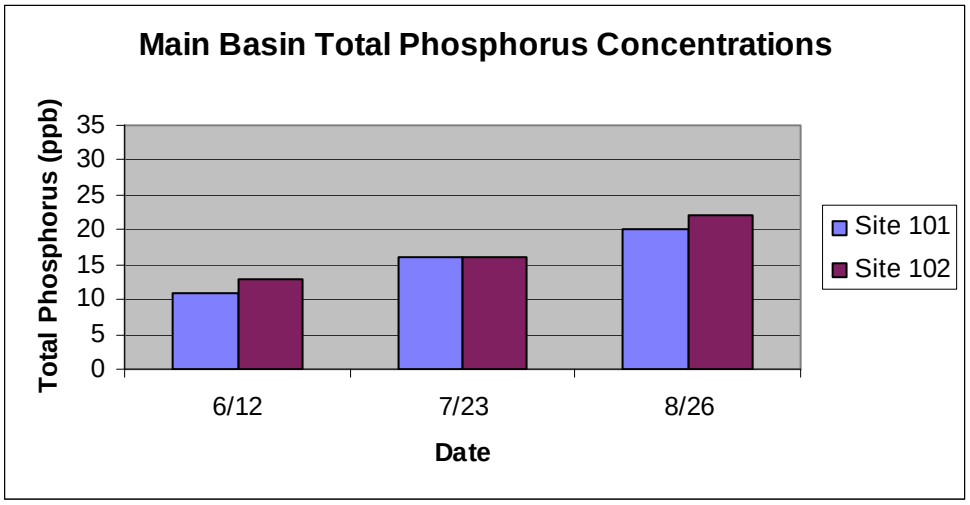
Trophic Status Indicators: 2000

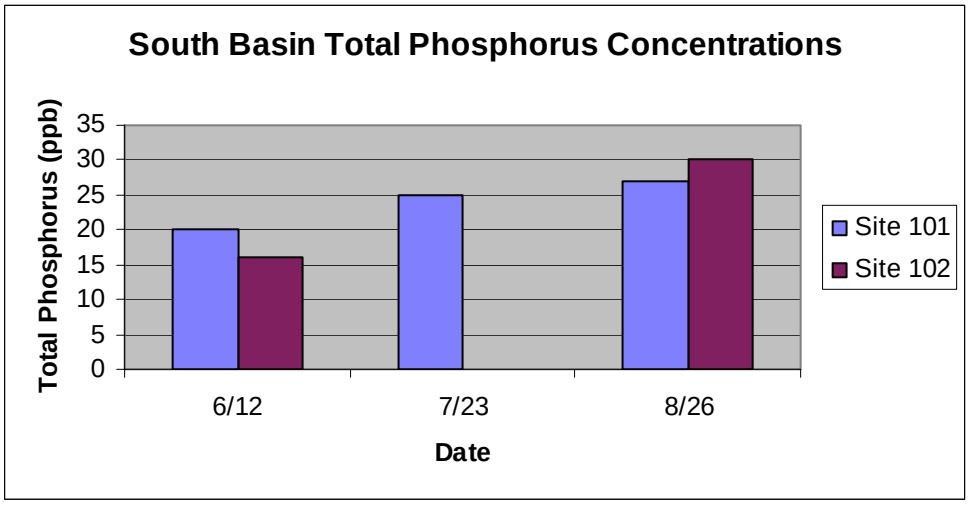
	Carlson's TSI For Lida Lake	
Site	**Main**	**South**
TP TSIP =	44	50
Chl-*a* TSIC =	49	55
Secchi TSIS =	44	47
Mean (All) TSI =	46	51

[1] Mean calculated using June-August data.
[2] Derived from Heiskary and Wilson (1990).
[3] Chlorophyll-*a* measurements have been corrected for pheophytin.

Total phosphorus (TP) concentrations (an important nutrient for plant growth) for 2000 averaged approximately 16.3 µg/L (micrograms per liter or parts per billion) for the main basin of the lake (15.7 µg/L and 17 µg/L, respectively for sites 101 and 102). In the south basin, total phosphorus concentration averaged 23.6 µg/L (sites 101 and 102 each averaged 23 µg/L). It should be noted that at site 102 in the south basin, the value for July was below the detection limit. This is inconsistent with the value found at site 101, and was not included in the calculation of summer-mean total phosphorus. These values are well below (better than) the range of concentrations typically found in reference lakes in the NCHF ecoregion (Table 2). TP concentration was generally elevated in August as compared to the other months in both basins, and ranged from 11 – 30 µg/L across all dates and sites (Figure 5).

Figure 5. Lida Lake Main and South Basin 2000 Total Phosphorus Concentrations



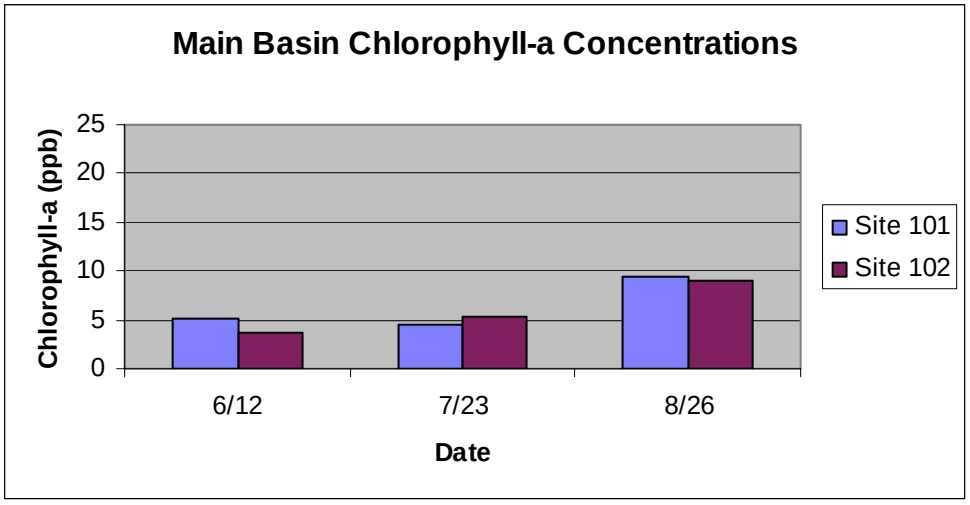


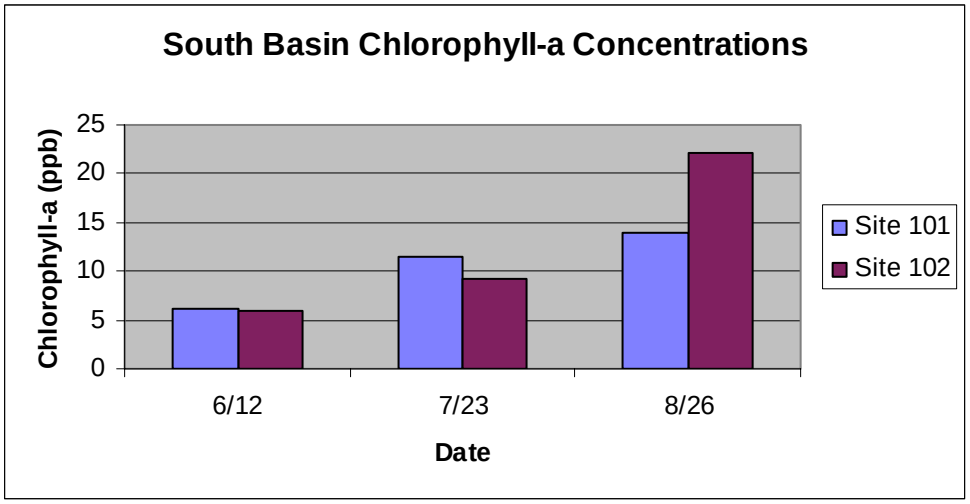
Total Kjeldahl nitrogen (TKN) concentrations averaged 0.7 mg/L in the main basin of Lida Lake over the summer in 2000. In the southern basin, the average TKN concentration was higher at 0.9 mg/L. Both concentrations are well within the range of values for TKN concentrations found in reference lakes in the NCHF ecoregion.

The ratio of TKN:TP can provide an indication as to which nutrient is limiting the production of algae in the lake. For the main basin, the TKN:TP ratio is about 46:1. The southern basin is slightly higher at 49:1. This suggests that phosphorus is the limiting nutrient in Lida Lake. Generally, phosphorus is the least abundant nutrient and, therefore, is the limiting nutrient for biological productivity in a lake. The TKN:TP ratio for Lida is slightly higher than expected TKN:TP ratios in the NCHF reference lakes.

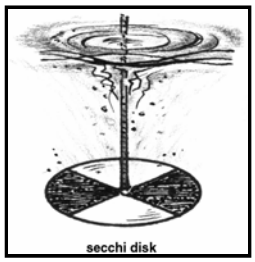
Chlorophyll-*a* concentrations provide an estimate of the amount of algal production in a lake. During the summer of 2000, chlorophyll-*a* concentrations on Lida Lake ranged from about 3.67 µg/l to 9.48 µg/L with an average of 6.2 µg/L in the main basin. In the southern basin, chlorophyll-*a* concentrations ranged from 5.96 µg/L to 22.1 µg/L with an average of 11.5 µg/L (Figure 6). Concentrations from 10 – 20 µg/L are frequently perceived as a *mild algal bloom*, while concentrations greater than 30 µg/L may be perceived as a severe nuisance (Heiskary and Walker, 1988). The average and maximum chlorophyll-*a* concentrations for Lida Lake were well within the range of values compared to the NCHF reference lakes (Table 2). Concentrations generally increased from June through August at three of four sites, with the exception of site 101 in the main basin. At that site, chlorophyll-*a* concentrations decreased slightly between June and July, and then doubled in August.

Figure 6. Lida Lake Main and South Basin 2000 Chlorophyll-*a* Concentrations





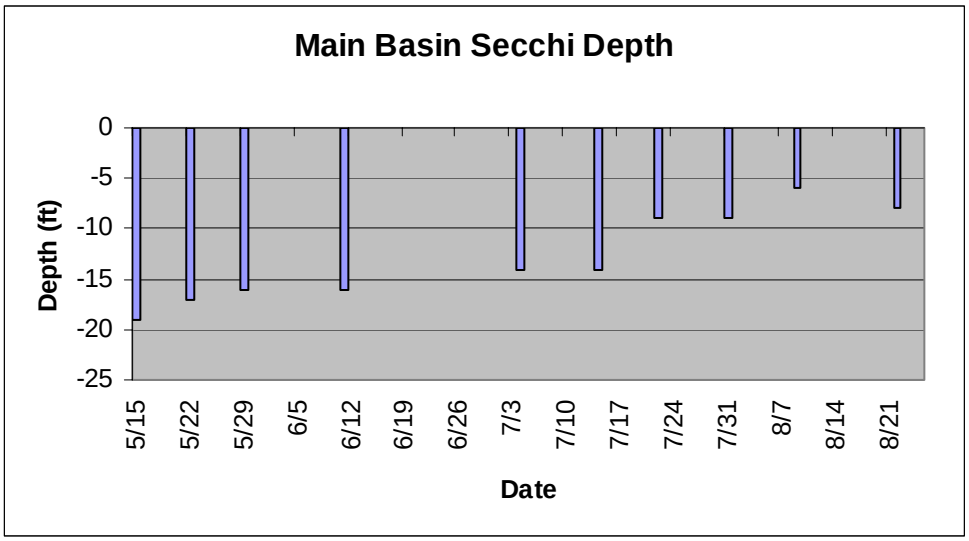
Secchi disk transparency is generally a function of the amount of algae in the water.

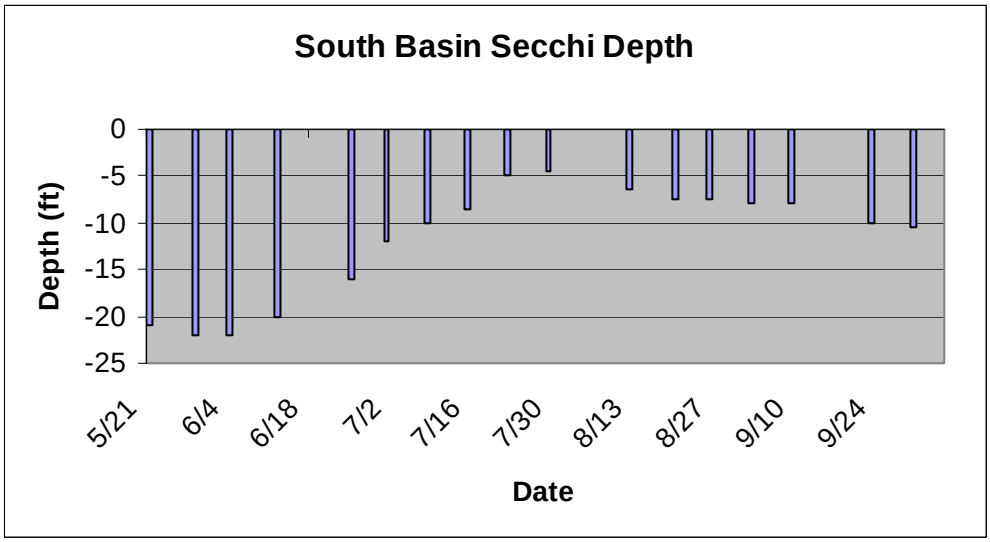


Suspended sediments or color due to dissolved organic material may also reduce water transparency. Color for both basins of Lida Lake averaged 10 Pt-Co Units, indicating low coloration due to incompletely dissolved organic matter (Table 2). Total suspended solids (TSS) averaged 3.1 mg/L in the main basin and 5 mg/L in the southern basin over the summer (Table 2). Organic matter (primarily algae) is the primary contributor to the TSS. The total suspended and inorganic solids values are comparable to values found in reference lakes in this region. These levels of color and total suspended solids should not limit water transparency in Lida Lake.

Secchi disk transparency in the main basin, ranged from a minimum of 7.5 feet (2.3 m) in August to a maximum of 12.8 feet (3.9 m) in June; and averaged 10.2 (3.1 m) feet (Figure 7). Transparency in the south basin ranged from a minimum of 4.6 feet (1.4 m) in July to a maximum of 13.8 feet (4.2 m) in June with an average transparency of 8.2 feet (2.5 m). These transparency measures are similar to the typical range for reference lakes in the NCHF ecoregion (Table 2).

Figure 7. Lida Lake Main and South Basin 2000 Secchi Transparency





Along with transparency measurements, subjective measures of Lida Lake's "physical appearance" and "recreational suitability" were made. 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). Based on the 2000 data, lake conditions were typically characterized as "not quite crystal clear" (Class 2) and "minor aesthetic problems" (Class 2) throughout the summer for the main basin. For the southern basin, lake conditions ranged from "not quite crystal clear" to "definite algae" to "high algae

levels" (Classes 2, 3, and 4) and "beautiful" and "minor aesthetic problems" (Classes 1 and 2) throughout the summer (Appendix 4).

The change in the transparency of Lida Lake over the course of the summer is fairly typical for lakes in Minnesota. Typically, transparency is high in the spring when the water is cool and algae populations are low. Frequently, zooplankton (small crustaceans which feed on algae) populations are high at this time of year also, but will decline later in the summer because of predation by young fish. As the summer goes on, the waters warm and the algae make use of available nutrients. As the algae become more abundant, the transparency declines. The decrease in the abundance of zooplankton may allow for further increases in the amount of algae. Later in the summer, surface blooms of algae may appear.

One means to evaluate the **trophic status** of a lake and 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:

Total phosphorus TSI (TSIP) = 14.42 1n (TP) + 4.15
Chlorophyll-*a* TSI (TSIC) = 9.81 1n (Chl-a) + 30.6
Secchi disk TSI (TSIS) = 60 - 14.41 1n (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 ten units represents a doubling of algal biomass.

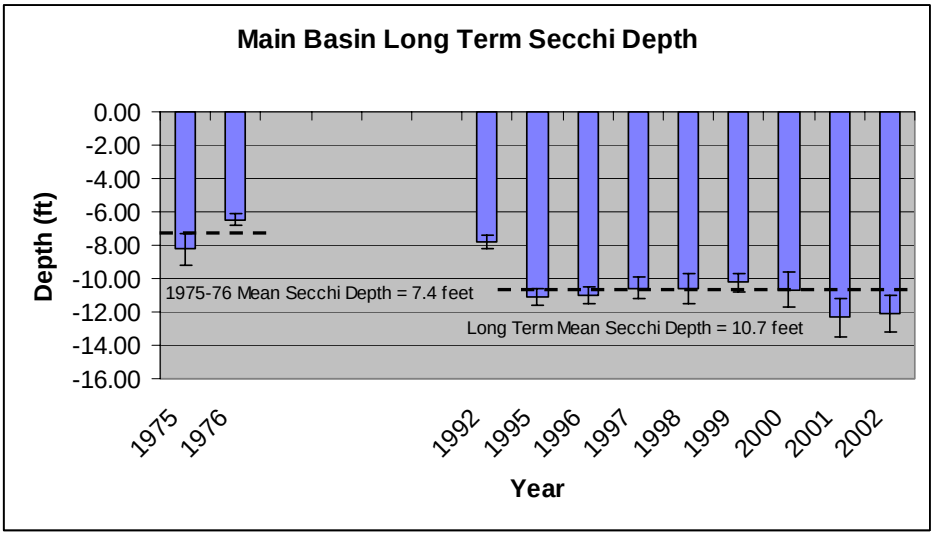
Average values for the trophic variables in Lida Lake and respective TSIs are presented in Figure 9. Based on these values and a TSI value of 46 in the main basin, and 51 in the south basin; Lida Lake's condition would be characterized as *mesotrophic*. The individual TSI values for TP, chlorophyll-*a* agree very well with one another. The TSI value for chlorophyll-*a* is slightly higher in both basins, indicating somewhat poorer water quality conditions than the other two TSI values. As such, it is still very comparable to the other two TSI values and therefore, Secchi transparency should provide a good estimation of trophic status for Lida Lake.

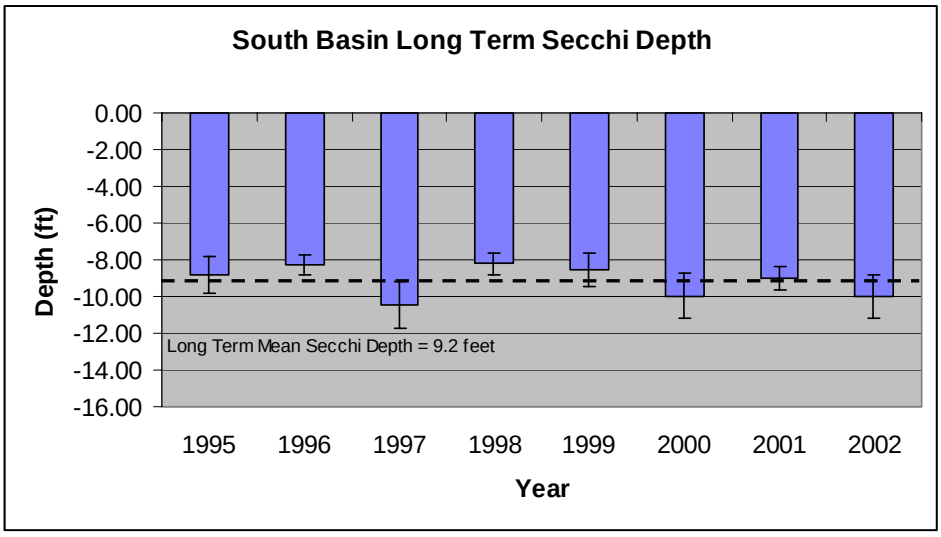
Alkalinity is above the typical range (75-150 mg/L) for the reference lakes with 210 mg/L in the main basin and 197 in the south basin. Chloride concentrations are within the typical range (4 – 10 mg/L) at 5.6 mg/L in the main basin and 5.4 mg/L in the south basin.

Water Quality Trends

A good data base is available for assessing trends in transparency for Lida Lake. The majority of the data was collected by citizen volunteers through the CLMP and monitoring conducted by the MPCA. Secchi transparency data date back to 1975 for the main basin and 1995 for the southern basin. Based on 11 years of record, the long-term mean Secchi is 10.1 feet (3.1 m) in the main basin. For the southern basin, based on 8 years of data, the long-term mean Secchi is 9.2 feet (2.8 m). No significant improvement or decline in Secchi transparency over time was noted for either basin based on the available data. However, a comparison of the mean from the 1975-76 time period (7.4 ft) to that from the 1992-2002 time period (10.7 ft) suggests that transparency may have improved in the main basin between these two time periods.

Figure 8. Lida Lake Main and South Basin Summer-Mean Secchi Transparency



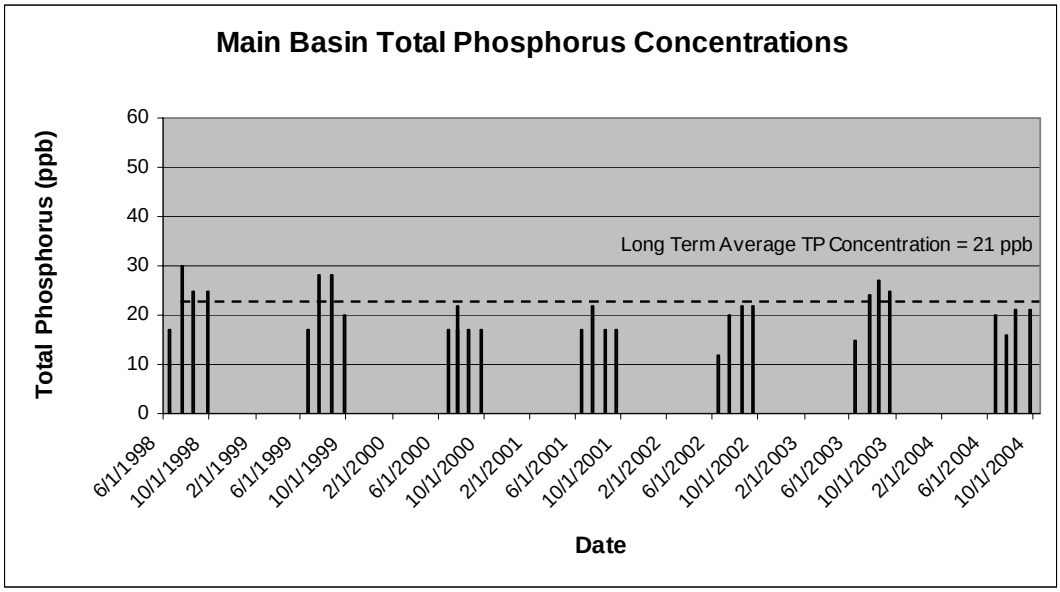


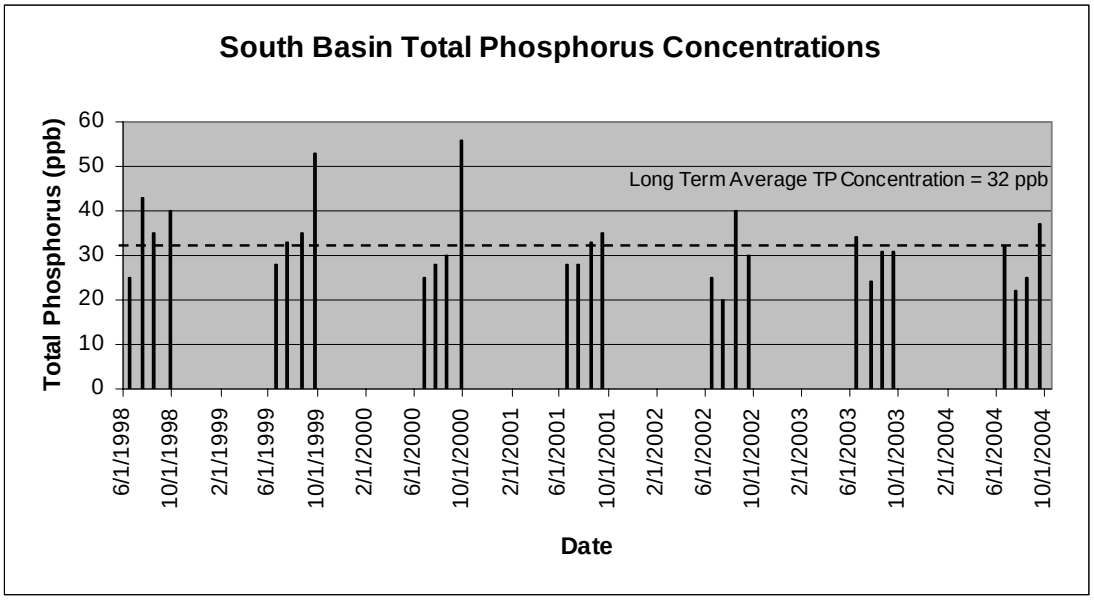
Long term data has been collected by Lida Lake Property Owners Association as part of the Otter Tail County Coalition of Lake Associations (COLA) monitoring program. Secchi, chlorophyll-*a*, and total phosphorus data have been collected monthly from 1998 to 2004 for both basins of the lake. This long record provides the ability to track changes in the lake, since the initial sampling for this report in 2000 (Appendix 6).

Total Phosphorus surface samples have been collected at site 208 in the main basin for seven years. This pattern of elevated late summer/early fall concentrations indicates that the lake is well mixed during that period. Total phosphorus readings range from a low of 15 µg/L in June of 2003 to a high of 30 µg/L in July of 1998. The long term average total phosphorus concentration, calculated over the period of record from samples collected between June and September, is 21 µg/L (Figure 9).

In the south basin, samples were collected at site 202 from 1998 to 2004. Concentrations ranged from 20 µg/L in July of 2002 to a high of 56 µg/L in September of 2000. The long term average is 32 µg/L. As in the main basin, it appears that the lake is well mixed during the later part of the summer and into early fall, as indicated by the relative increase in total phosphorus concentration over the season. Total phosphorus concentrations are significantly higher in the southern basin compared to the main basin (Figure 9).

Figure 9. Main and South Basin Long Term Total Phosphorus Concentrations

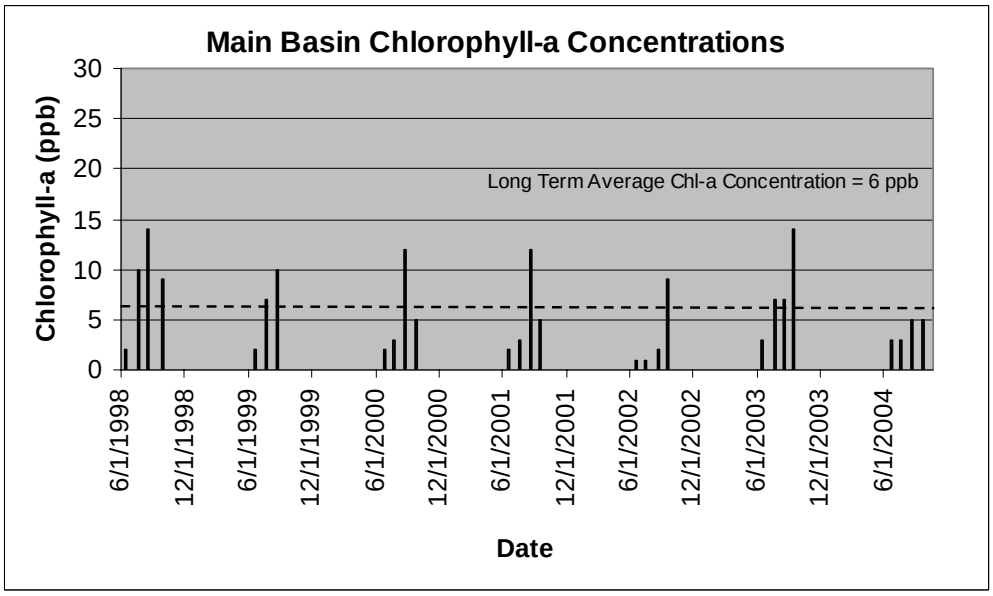


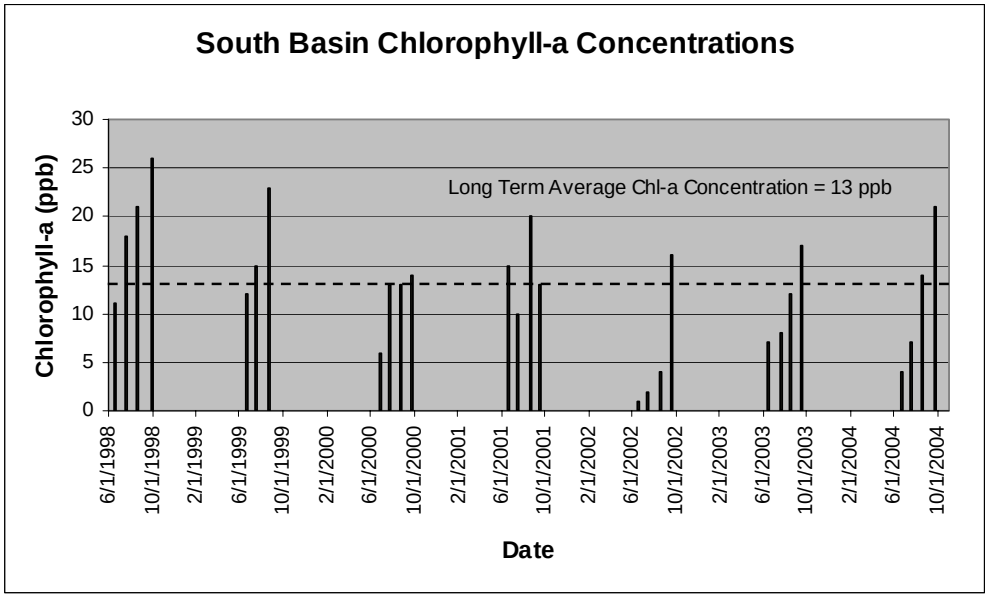


Chlorophyll-*a* was also sampled in the main basin from 1998 to 2004 at site 208. Concentrations ranged from readings of 1 and <1 µg/L in June and July of 2002 to a high of 14 µg/L in August of 1998 and September of 2003. The long term average concentration for the main basin is 6 µg/L.

In the south basin, chlorophyll-*a* samples were collected at site 202. The lowest concentration was 1 µg/L, taken in September 2002 and the highest was recorded in September 1998 at 26 µg/L. The long term average concentration in the south basin is 13 µg/L.

Figure 10. Lida Lake Main and South Basin Long Term Chlorophyll-*a* Concentrations





Modeling and Phosphorus Loading

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 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 flow of amount of water that enters the lake. To analyze the in-lake water quality of Lida Lake, the model, **MINLEAP** (Wilson and Walker, 1989), was used. The "Minnesota Lake Eutrophication Analysis Procedures" (MINLEAP), was developed by MPCA staff based on an analysis of data collected from the ecoregion reference lakes. It is intended to be used as a screening tool for estimating lake conditions with minimal input data and is described in greater detail in Wilson and Walker (1989). The model, Vighi and Chiaudani (1985), was also used estimated a background phosphorus (P) concentration for Lida Lake. This model is built into the MINLEAP model and is run concurrently with MINLEAP.

Lida Lake was modeled using data from 2000 for comparative purposes. **MINLEAP** predicted an in-lake TP of 24 (± 10) µg/L for the main basin and 34 (± 13) µg/L TP for the southern basin (Table 3).

A second mathematical model developed by Vighi and Chiaudani (1985) estimated a background phosphorus (P) concentration for Lida Lake at 25 µg/L for the main basin and 24 µg/L for the southern basin. These predictions are based on the morphoedaphic index routinely used in fishery science and predict background (~ natural) P based on the lake's alkalinity and mean depth. The P-loading rate based on the MINLEAP model is estimated at 2,094 kg/yr for the main basin and at 812 kg/yr in the southern basin. The lake retains a very high percentage of the P which enters the lake (88% main basin and 79% southern basin). The model estimates

Figure 11. Carlson's Trophic State Index for Lida Lake, Otter Tail County
R.E. Carlson

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

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

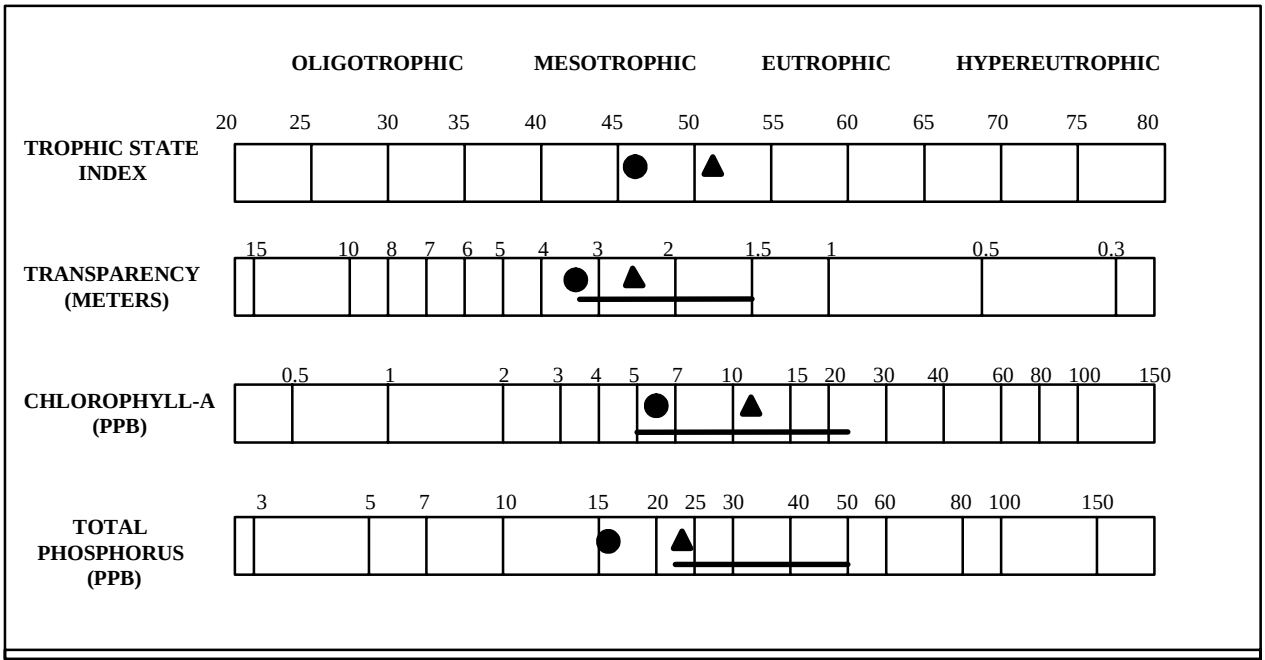
TSI 40 - 50 Water moderately clear, but increasing probability of anoxia in hypolimnion during summer.

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

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

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

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



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

NCHF Ecoregion Range:_____ Lida Lake, Main Basin: ● Lida Lake, South Basin: ▲

water residence time (time it would take to fill the lake if it was completely empty) at about 12.5 years for the main basin and about 4.5 years for the southern basin.

The initial MINLEAP model run predicted values that were unrealistic for both basins. Upon closer examination of the watershed map and model inputs for Lida Lake, it was thought that the southern basin of Lida Lake retains much of the TP that would enter the main basin. As such, the southern basin is expected to have higher concentrations of phosphorus and poorer Secchi disk readings. The model was calibrated and run a second time, using an area weighted approach and treating the two basins as one lake. This predicted much closer to observed readings for all 3 parameters (TP, chlorophyll-a, Secchi), with a predicted in-lake TP of 26 (± 11) µg/L (Table 4).

TABLE 3. MINLEAP Model Results for 2000 Lida Lake

Parameter	Main Observed	Main Predicted	South Observed	South Predicted
TP (µg/L)	16 ± 1.7	24 ± 10	24 ± 2.5	34 ± 13
Chl-*a* (µg/L)	6.2 ± 1.0	7 ± 4.9	11.5 ± 2.5	11.6 ± 7.6
% Chl-*a* >20 µg/L	0	1	8	8
% Chl-*a* >30 µg/L	0	0	1	1
Secchi (meters)	3.1 ± 0.3	2.5 ± 1.1	2.5 ± 0.5	1.8 ± 0.8
P loading rate	--	2,094 kg/yr	--	812 kg/yr
P retention (%)	--	88 %	--	79 %
P inflow conc.	--	200 µg/L	--	165 µg/L
water load	--	0.47 m/yr	--	1.42 m/yr
outflow volume	--	10.48 hm^3/yr	--	4.92 hm^3/yr
Vighi Background P	--	25 µg/L	--	24 µg/L
residence time	--	12.5 yrs	--	4.5 yrs

TABLE 4. MINLEAP Model Results for Lida Lake
Whole Lake - Calibrated

Parameter	Observed 2000	Predicted
TP (μg/L)	20 ± 1.8	26 ± 11
Chl-*a* (μg/L)	8.8 ± 1.5	7.8 ± 5.4
% Chl-*a* >20 μg/L	0	1
% Chl-*a* >30 μg/L	0	0
Secchi (meters)	2.8 ± 0.3	2.3 ± 1.0
P loading rate	--	2,906 kg/yr
P retention (%)	--	86 %
P inflow conc.	--	189 μg/L
water load	--	0.59 m/yr
outflow volume	--	15.4 hm^3/yr
Vighi Background P	--	24 μg/L
residence time	--	10.0 yrs

Goal Setting

The phosphorus criteria value for lakes in the North Central Hardwoods Forest ecoregion, for support of swimmable use, is less than 40 μg/L (Heiskary and Wilson, 1990). At or below 40 μg P/L, "nuisance algal blooms" (chlorophyll a > 20 μg/L) should occur less than 20 percent of the summer and transparency should remain above 1 m over 90 percent of the summer. Lida Lake, with an area weighted summer-mean P of 20 μg/L and a summer-mean chlorophyll-*a* of 8.8 μg/L, never experienced nuisance blooms during the summer (MINLEAP model, Table 4) in 2000.

For Lida Lake, it would be desirable to maintain the currently low in-lake P concentration. An in-lake goal on the order of 20-25 μg/L may be appropriate for the southern basin using data from 2000 and model results (Table 4). In the main basin, an in-lake P goal of less than 20 μg/L may be appropriate based on data from 2000, and model results (Table 3). The 2000 summer-mean P concentration in the main basin was below the background concentrations as estimated by Vighi and Chiaudani regression – 25 μg/L. In the southern basin, the 2000 summer-mean P concentration was at the Vighi and Chiaudani regression estimate of 24 μg/L, with an observed mean of 24 μg/L. Should in-lake P concentrations increase, it is likely that the frequency of nuisance algal blooms would increase and transparency would decrease.

The south basin of Lida Lake acts as a sink for phosphorus. This means it traps much of the phosphorus before it drains into the main basin of the lake. This explains the higher concentrations and the higher phosphorus goal in the south basin.

Based on user perception information for 2000, perceptions of “impaired swimming” and “high algal color” never occurred. Maintaining a summer-mean P concentration at or below 20 μg/L in the main basin, and of about 20-25 μg/L or lower for the south basin, over the long term may ultimately require that P-loading to the lake be reduced. Important considerations include implementation of BMP’s in the shoreland area and ultimately through the watershed with a particular emphasis on the direct drainage area. A more comprehensive review of land use practices in the watershed may reveal opportunities for implementing BMPs in the watershed and reducing P-loading to the lake. Proper maintenance of buffers areas between lawns and the lakeshore, minimizing use of fertilizers, and minimizing the introduction of new significant sources of P loading, e.g., stormwater from nearshore development activities in the watershed, will serve to minimize loading to the lake. These and other considerations will be important if the 2000 good water quality of Lida Lake is to be maintained over the long term.

REFERENCES

Arneman, H.F. 1963. Soils of Minnesota. University of Minnesota, Agricultural Extension Service and U.S. Department of Agriculture.

Bublitz, C. and J. Goplin. 1985. Lake Sounding Field Summary, June 12, 1985. Minnesota Department of Natural Resources. Section of Fisheries Lake Files. Brainerd Regional Fisheries Office. 1601 Minnesota Dr., Brainerd, MN 56401. 1 pg.

Carlson, R.E. 1977. A trophic state index for lakes. Limnology and Oceanography 22: 361-369.

Goebel, J.E. and M. Watson. 1979. Geologic Map of Minnesota. Minnesota Geological Survey. University of Minnesota.

Gunard, L. 1985. U.S. Geological Survey. Water Supply Paper 2300. U.S.G.S. 702 Post Office Building, St. Paul, Minnesota.

Heiskary, S.A. and W.W. Walker. 1988. Developing phosphorus criteria for Minnesota lakes. Lake Reservoir Management. 4(1):1-10.

Heiskary, S.A. and C.B. Wilson. 1990. Minnesota Lake Water Quality Assessment Report. MPCA, Water Quality Division St. Paul, MN.

Heiskary, S.A. and C.B. Wilson. 1999. Phosphorus export coefficients and the Reckhow-Simpson spreadsheet: Use and application in routine assessments of Minnesota's lakes. A working paper. MPCA, St. Paul, Minnesota.

Henderson, C., C. Dindorf, and F. Rozumalski. 1999. Lakescaping for Wildlife and Water Quality. Minnesota Dept of Natural Resources Nongame Wildlife Program. St. Paul. 176 pgs.

Hotchkiss, N. 1932. Marsh and aquatic vegetation of Minnesota and its value to waterfowl. U.S. Dept. of Agriculture. Bureau of Biological Survey. Division of Food Habits Research. Wash., D.C. 136 pgs.

Jessen, R. and R. Lound. 1962. An evaluation of survey techniques for submerged aquatic plants. Minnesota Dept. of Conservation. Game Investigational Report 6, St. Paul. 10 pgs.

Minnesota Department of Natural Resources. 1968. An Inventory of Minnesota Lakes: Bulletin 25. MDNR, St. Paul, Minnesota.

Minnesota Pollution Control Agency, St. Paul, Minnesota and Freshwater Society, Navarre, Minnesota. 1985. A Citizens' Guide to Lake Protection.

Minnesota Pollution Control Agency. 1986. Protecting Minnesota's Waters: The Land Use Connection. MPCA, St. Paul, Minnesota.

Prairie, Y.T. and J. Kalff. 1986. Effect of catchment size on phosphorus export. Water Resource Bulletin 22(3):465-470.

Reckhow, K.H., and J.T. Simpson. 1980. A procedure using modeling and error analysis for the prediction of the lake phosphorus concentration from land use information. Can. J. Fish Aquat. Sci. 37:1439-1448.

Reckhow, K.H., and S.C. Chapra. 1983. Engineering approaches for lake management. Volume 1: Data analysis and empirical modeling. Butterworth Publishers. U.S. EPA.

Schupp D. and C.B. Wilson. 1993. Developing lake goals for water quality and fisheries. LakeLines. December 1993:18-21.

U.S. Geological Survey. 1973. Water Resources Data For Minnesota, Part 1. U.S. Geological Survey. 363 pages.

Vighi and Chiaudani. 1985. A simple method to estimate lake phosphorus concentrations resulting from natural background loading. Wat. Res. 19: 987-991.

Walker, W.W., Jr. 1985. Urban nonpoint source impacts on surface water supply. Pages 129-137. Perspectives on Nonpoint Source Pollution. Proceedings of a national conference. Kansas City, Missouri, May 19-22, 1985. U.S. EPA 440/5-85-01.

Wilson, C.B. 1989. Lake water quality modeling used in Minnesota. Pages 33-44 in National Conference on Enhancing State Lake Management Program. May 12-13. 1988. Chicago, Illinois.

Wilson, C.B. and W.W. Walker 1989. Development of lake assessment methods based upon the aquatic ecoregion concept. Lake and Reserv. Manage. 5(2):11-22.

Zumberge, J.H. 1952. The Lakes of Minnesota. Their origin and classification. Minnesota Geological Survey. University of Minnesota Press. Minneapolis, Minnesota.

Appendix

Appendix 1. Precipitation Data

Appendix 2. Lake Levels

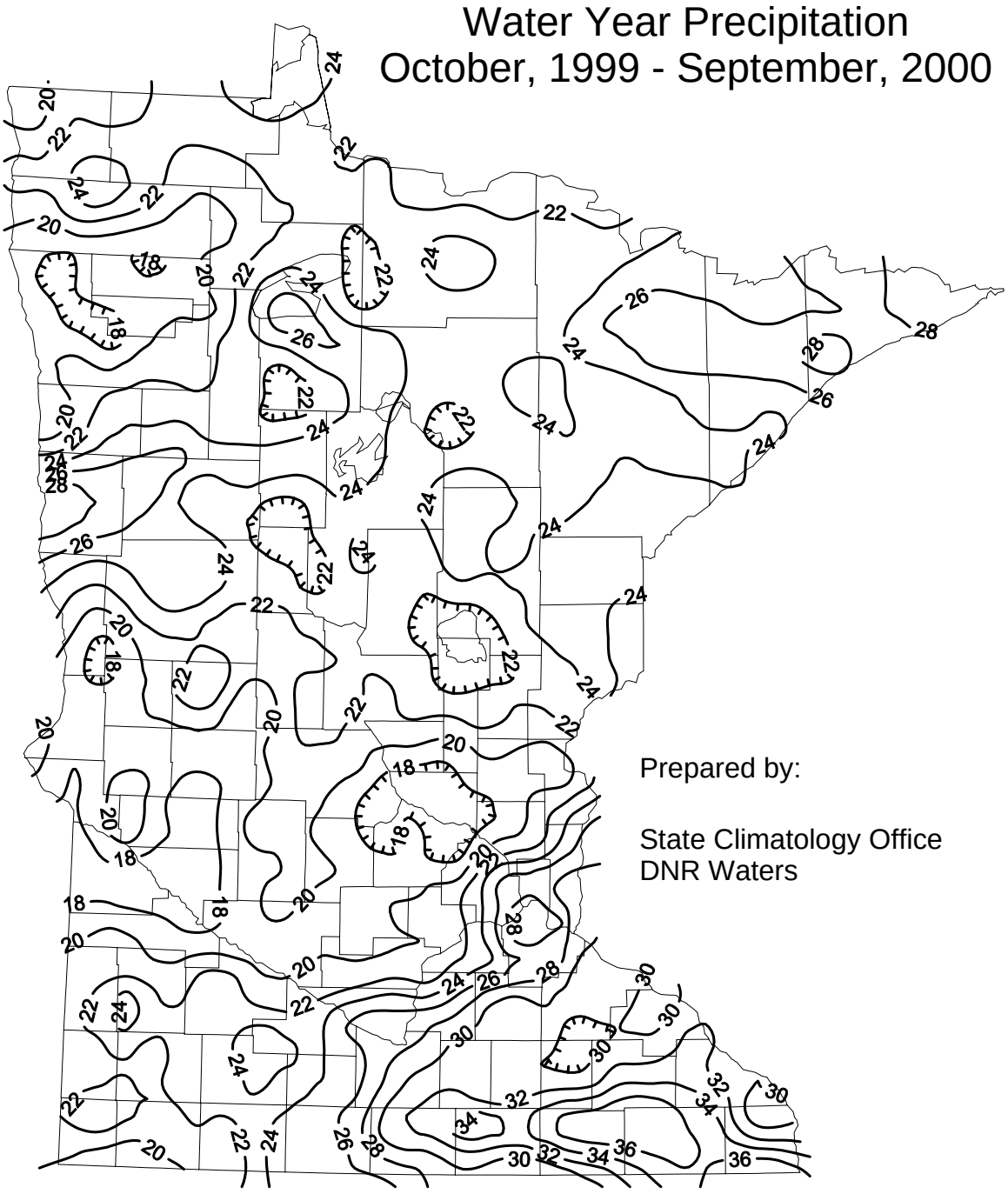
Appendix 3. Status of the Fishery

Appendix 4. 2000 Secchi Disk and User Perception Data

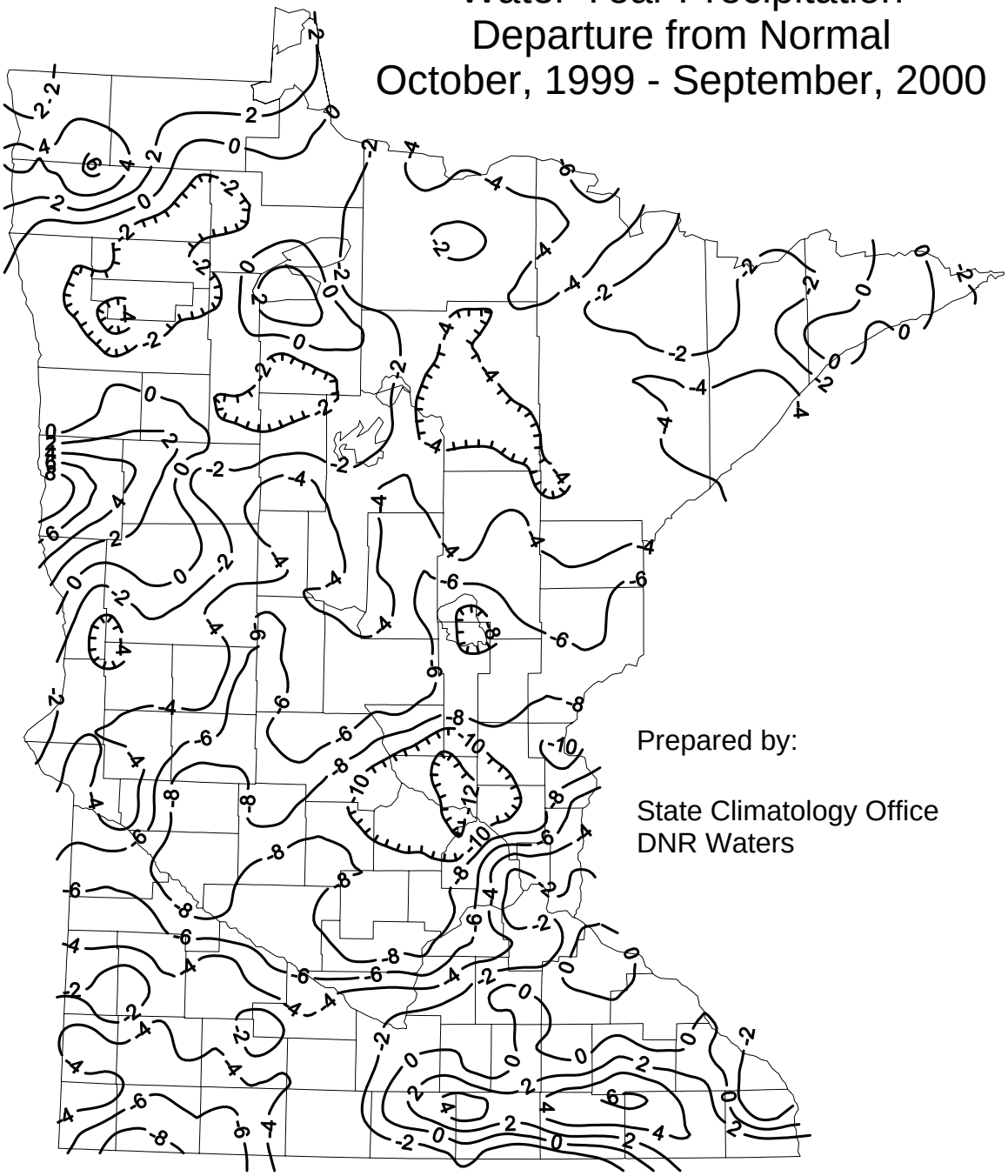
Appendix 5. Lake Water Quality Data - MPCA

Appendix 6. Lake Water Quality Data - COLA

Appendix 1. Precipitation Data
(From DNR Office of Climatology www.dnr.state.mn.us)



Water Year Precipitation
Departure from Normal
October, 1999 - September, 2000



Prepared by:

State Climatology Office
DNR Waters

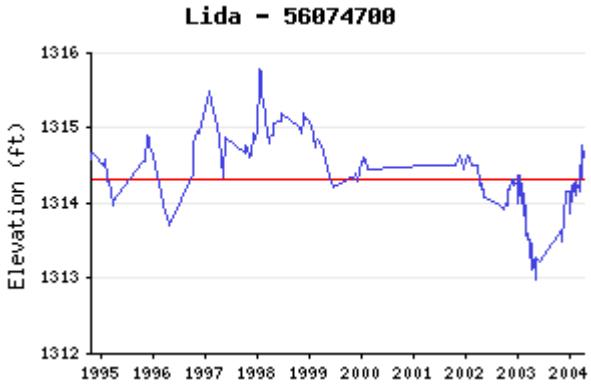
values are in inches

Appendix 2. Lake Water Level Data
(From DNR website www.dnr.state.mn.us)

Lake water level report

Lake Name: Lida ***County: Otter Tail***

Water Level Data



Period of record: 05/26/1953 to 09/23/2004
# of readings: 232
Highest recorded: 1315.8 ft (05/17/1994)
Highest known: 1316.03 ft (05/09/02)
Lowest recorded: 1312.98 ft (10/28/2003)
Recorded range: 2.82 ft
Average water level: 1314.52 ft
Last reading: 1314.6 ft (09/23/2004)
OHW elevation: 1314.3 ft
Datum: 1912 (ft)

Benchmarks

Elevation:	Date Set:	Benchmark Location
1317.36 ft Datum: 1912 (ft)	05/20/1987	Township: 136 Range: 42 Section: 9

Description: The top of bolt located on W side of the northerly timber headwall of the existing culvert under Co. Highway No. 4 bet Lida & Lizzie Lakes

Elevation:	Date Set:	Benchmark Location
1317.47 ft Datum: 1912 (ft)	06/24/2003	Township: 136 Range: 42 Section: 9

Description: Set a chiseled "X" on the top centerline of the high portion of the upstream (south) headwall of the concrete box culvert under County Road 4.

Appendix 3. Fisheries Information

(From DNR website www.dnr.state.mn.us)

Name: LIDA, NORTH

Nearest Town: PELICAN RAPIDS, MN
Primary County: Otter Tail

Survey Date: 08/04/2003
Inventory Number: 56-0747-01

Public Access Information

Ownership	Type	Description
Minnesota DNR	Concrete	A STATE OWNED PUBLIC ACCESS IS LOCATED ALONG THE SOUTHEAST SHORELINE OF THE LAKE IN MAPLEWOOD STATE PARK.

Lake Characteristics

Lake Area (acres): 5,564.00
Littoral Area (acres): 2,380.00
Maximum Depth (ft): 58.00
Water Clarity (ft): 7.00

Dominant Bottom Substrate: N/A
Abundance of Aquatic Plants: N/A
Maximum Depth of Plant Growth (ft): N/A

Fish Sampled up to the 2003 Survey Year

Species	Gear Used	Number of fish per net Caught	Normal Range	Average Fish Weight (lbs)	Normal Range (lbs)
Black Bullhead	Gill net	0.2	0.5 - 4.1	1.34	0.6 - 1.0
	Trap net	0.2	0.3 - 2.1	0.94	0.4 - 0.8
Black Crappie	Gill net	0.5	0.2 - 1.1	0.55	0.2 - 0.5
	Trap net	0.3	0.3 - 1.7	0.36	0.3 - 0.6
Bluegill	Gill net	3.3	N/A - N/A	0.14	N/A - N/A
	Trap net	41.1	3.7 - 42.9	0.20	0.1 - 0.2
Bowfin (Dogfish)	Gill net	trace	0.1 - 0.2	5.51	3.0 - 5.2
	Trap net	1.0	0.3 - 1.1	4.33	3.9 - 5.1
Brown Bullhead	Gill net	0.2	0.3 - 1.6	2.09	0.7 - 1.2
	Trap net	0.2	0.3 - 1.7	1.16	0.7 - 1.1
Freshwater Drum	Gill net	0.2	0.3 - 0.6	9.22	0.2 - 0.9
	Trap net	0.3	0.1 - 0.6	8.65	7.3 - 10.2
Green Sunfish	Gill net	trace	0.1 - 0.5	0.04	N/A - N/A
Hybrid Sunfish	Gill net	1.4	N/A - N/A	0.16	N/A - N/A
	Trap net	3.7	N/A - N/A	0.25	N/A - N/A
Largemouth Bass	Gill net	0.6	0.3 - 1.2	1.18	0.6 - 1.0
	Trap net	1.1	0.4 - 1.4	0.62	0.3 - 0.7
Northern Pike	Gill net	4.7	3.0 - 7.9	1.85	1.7 - 2.8

	Trap net	0.5	N/A - N/A	2.38	N/A - N/A
Pumpkinseed Sunfish	Gill net	1.8	N/A - N/A	0.13	N/A - N/A
	Trap net	3.5	1.6 - 6.9	0.22	0.1 - 0.3
Painted Turtle	Trap net	1.9	N/A - N/A	ND	N/A - N/A
Rock Bass	Gill net	2.7	1.0 - 6.6	0.31	0.3 - 0.5
	Trap net	1.2	0.7 - 3.3	0.31	0.2 - 0.5
Smallmouth Bass	Gill net	0.8	0.2 - 0.9	1.04	0.9 - 1.8
	Trap net	0.2	0.1 - 0.6	0.08	0.1 - 0.6
Tullibee (Cisco)	Gill net	4.1	0.5 - 5.2	1.20	0.4 - 1.0
Walleye	Gill net	9.1	4.0 - 9.6	1.12	1.1 - 1.9
	Trap net	0.3	0.3 - 0.9	1.30	1.0 - 2.2
White Sucker	Gill net	0.7	1.0 - 3.5	2.40	1.5 - 2.3
	Trap net	trace	0.2 - 0.8	2.87	1.4 - 2.7
Yellow Bullhead	Gill net	9.3	0.6 - 6.4	1.17	0.6 - 0.9
	Trap net	0.8	0.9 - 4.8	1.25	0.7 - 1.0
Yellow Perch	Gill net	3.7	7.1 - 33.9	0.10	0.1 - 0.2
	Trap net	0.4	0.7 - 3.7	0.11	0.1 - 0.2

Normal Ranges represent typical catches for lakes with similar physical and chemical characteristics.

Length of Selected Species Sampled for All Gear for the 2003 Survey Year

	Number of fish caught in each category (inches)								
Species	***0-5***	***6-8***	***9-11***	***12-14***	***15-19***	***20-24***	***25-29***	***>29***	***Total***
Black Bullhead	0	0	1	4	0	0	0	0	5
Black Crappie	1	6	3	1	0	0	0	0	11
Bluegill	135	133	2	0	0	0	0	0	270
Brown Bullhead	0	0	0	3	2	0	0	0	5
Green Sunfish	1	0	0	0	0	0	0	0	1
Hybrid Sunfish	31	37	1	0	0	0	0	0	69
Largemouth Bass	1	4	12	5	1	0	0	0	23
Northern Pike	0	0	1	1	34	34	6	1	77
Pumpkinseed Sunfish	43	30	0	0	0	0	0	0	73
Rock Bass	16	34	5	0	0	0	0	0	55
Smallmouth Bass	2	2	5	3	2	0	0	0	14
Tullibee (Cisco)	0	19	4	12	25	0	0	0	60
Walleye	0	20	34	23	52	12	0	0	141
Yellow Bullhead	0	2	32	115	0	0	0	0	149
Yellow Perch	26	27	1	0	0	0	0	0	54

Fish Consumption Advisory

Meal Advice for Pregnant Women, Women who may become pregnant and Children under age 15

Species	less than 15"	15" to 20"	20" to 25"	25" to 30"	greater than 30"
Bluegill Sunfish	◔				
Carp			◔	◔	
Cisco	◔	◔			
Northern Pike		◔	◑	◑	◑
Rock Bass	◔				
Smallmouth Bass	◔				
Walleye	◔	◑	◑		
White Sucker	○	◔	◔		

Meal Advice for the General Population

Species	less than 15"	15" to 20"	20" to 25"	25" to 30"	greater than 30"
Bluegill Sunfish	○				
Carp			○	○	
Cisco	○	○			
Northern Pike		◔	◔	◔	◔

Rock Bass			
Smallmouth Bass			
Walleye			
White Sucker			

Symbol Key	unlimited	1 meal per week	1 meal per month	1 meal every 2 months	do not eat
Mercury					
PCBs					

Status of the Fishery (as of 08/04/2003)

North Lida Lake is located in northwestern Otter Tail County five miles east of Pelican Rapids, MN. North Lida Lake is a 5,564-acre mesotrophic (moderately fertile) lake that is located within the Otter Tail River Watershed. North Lida Lake is connected to South Lida Lake by a navigable culvert under State Highway 108. North Lida Lake is also connected to Lizzie Lake by an unnavigable culvert under County Road 4. The immediate watershed is composed primarily of agricultural land interspersed with hardwood woodlots. The maximum depth is 58 feet; however, 43% of the lake is less than 15 feet in depth. The secchi disk reading during the 2003 lake survey was 7.0 feet. Previous secchi disk readings have ranged from 6.0 to 9.5 feet. North Lida Lake is included in lake class 27 of the Minnesota DNR lake classification scheme. A majority of the shoreline on North Lida Lake has been developed. Homes, cottages, and resorts compose the development. The 1995 lake resurvey referenced 471 homes/cottages and nine resorts. A DNR owned concrete public water access is located off of County Road 4 along the north shoreline. Large stands of hardstem bulrush are scattered along various shorelines of the lake and on several midlake sunken islands. Emergent aquatic plants such as bulrush and cattail provide valuable fish and wildlife habitat, and are critical for maintaining good water quality. They protect shorelines and lake bottoms, and can actually absorb and break down polluting chemicals. Emergent plants provide spawning areas for fish such as northern pike, largemouth bass, and panfish. They also serve as important nursery areas for all species of fish. Because of their ecological value, emergent plants may not be removed without a DNR permit. North Lida Lake is a popular angling lake and is one of the best all around angling lakes in Otter Tail County. Walleye, northern pike, smallmouth bass, bluegill, and black crappie are the dominant fish species in North Lida Lake. Data from recent lake surveys indicate that these species are abundant and have good size distributions as well. The test-net catch rate of walleye

exceeded the upper limit of the normal range for class 27 lakes. Walleye ranged in length from 7.2 to 22.0 inches with an average length and weight of 14.0 inches and 1.1 pounds. Age and catch data indicate that the 2001 year class is strong and should provide consistently good walleye angling for several years. Walleye attain an average length of 14.5 inches at four years of age. Northern pike population characteristics have demonstrated stability over the recent series of surveys. Pike abundance has remained at a moderate density and natural reproduction has continued to be consistently good. Northern pike ranged in length from 11.7 to 30.0 inches with an average length and weight of 20.4 inches and 1.9 pounds. Pike attain an average length of 23.0 inches at four years of age. Data from recent lake surveys indicate that the smallmouth bass population may be improving. Smallmouth bass ranged in length from 4.9 to 16.4 inches. Smallmouth bass up to 17.0 inches in length were sampled during a 1997 electrofishing assessment. Target catch rates for smallmouth bass anglers in the 1995 and 1996 creel surveys were good. The bluegill test-net catch rate in the recent series of lake surveys has remained within the normal range for lake class 27. Bluegill size structure has remained stable in recent surveys. Twenty-three percent of the bluegills sampled were at least 7.0 inches in length. Bluegills attain an average length of 7.8 inches at six years of age. As part of a statewide experimental regulations project, an 11-inch minimum size limit for black crappie was implemented in 1997 on North and South Lida Lakes and will be in effect through 2005. The intent of the regulation is to increase the average size of black crappie in the Lida Lakes. A spring trapnetting assessment was conducted in 2002 to analyze the black crappie population. Crappies ranged in length from 5.2 to 13.4 inches with an average length and weight of 9.9 inches and 0.7 pounds. Thirty-eight percent of the crappies were at least 11.0 inches in length. Crappies attain an average length of 11.1 inches at five years of age. The DNR does not stock any fish in North Lida Lake. The fish species present are able to sustain their levels at or above DNR management goals. This is an indication of the quality of fish habitat that is present. To maintain the excellent angling and water quality that this lake has to offer, it is imperative to preserve the quality of the aquatic habitat. The DNR and the Lida Lakes Association have been involved in several cooperative projects designed to improve and protect water quality and fish habitat. In 1998, a shoreline stabilization project was completed. Rock rip-rap was used to stabilize several areas of shoreline that were experiencing varying degrees of erosion. In 1997, 160 smallmouth bass nesting structures were constructed and placed in North Lida Lake. These structures will help smallmouth bass reproduce more successfully. Anglers can also maintain the quality of angling by practicing selective harvest. Selective harvest encourages the release of medium to large-size fish while allowing the harvest of more abundant smaller fish for table fare. Releasing the medium to large fish will ensure that the lake will have enough spawning age fish on an annual basis and will provide anglers with more opportunities to catch large fish in the future.

Name: LIDA, SOUTH

Nearest Town: PELICAN RAPIDS, MN
Primary County: Otter Tail

Survey Date: 07/07/2003
Inventory Number: 56-0747-02

Public Access Information

Ownership	Type	Description
Minnesota DNR	Concrete	A STATE OWNED PUBLIC ACCESS IS LOCATED ALONG THE SOUTHEAST SHORELINE OF THE LAKE IN MAPLEWOOD STATE PARK.

Lake Characteristics

Lake Area (acres): 856.00
Littoral Area (acres): 356.00
Maximum Depth (ft): 48.00
Water Clarity (ft): 8.00

Dominant Bottom Substrate: N/A
Abundance of Aquatic Plants: N/A
Maximum Depth of Plant Growth (ft): N/A

Fish Sampled up to the 2003 Survey Year

Species	Gear Used	Number of fish per net Caught	Normal Range	Average Fish Weight (lbs)	Normal Range (lbs)
Black Bullhead	Gill net	trace	0.5 - 4.1	1.36	0.6 - 1.0
	Trap net	0.1	0.3 - 2.1	1.06	0.4 - 0.8
Black Crappie	Gill net	0.4	0.2 - 1.1	0.45	0.2 - 0.5
	Trap net	0.5	0.3 - 1.7	0.22	0.3 - 0.6
Bluegill	Gill net	6.3	N/A - N/A	0.20	N/A - N/A
	Trap net	18.3	3.7 - 42.9	0.13	0.1 - 0.2
Bowfin (Dogfish)	Trap net	1.6	0.3 - 1.1	3.96	3.9 - 5.1
Brown Bullhead	Gill net	2.3	0.3 - 1.6	1.69	0.7 - 1.2
	Trap net	0.5	0.3 - 1.7	1.40	0.7 - 1.1
Freshwater Drum	Trap net	0.5	0.1 - 0.6	7.50	7.3 - 10.2
Green Sunfish	Trap net	1.2	0.2 - 1.0	0.05	0.1 - 0.2
Hybrid Sunfish	Gill net	2.9	N/A - N/A	0.31	N/A - N/A
	Trap net	3.9	N/A - N/A	0.17	N/A - N/A
Largemouth Bass	Gill net	0.4	0.3 - 1.2	1.07	0.6 - 1.0
	Trap net	0.5	0.4 - 1.4	0.73	0.3 - 0.7
Northern Pike	Gill net	5.8	3.0 - 7.9	2.54	1.7 - 2.8
	Trap net	0.4	N/A - N/A	2.05	N/A - N/A
Pumpkinseed Sunfish	Gill net	8.8	N/A - N/A	0.23	N/A - N/A
	Trap net	1.5	1.6 - 6.9	0.12	0.1 - 0.3
Painted Turtle	Trap net	1.7	N/A - N/A	ND	N/A - N/A

Rock Bass	Gill net	1.3	1.0 - 6.6	0.35	0.3 - 0.5
	Trap net	0.5	0.7 - 3.3	0.48	0.2 - 0.5
Tullibee (Cisco)	Gill net	0.4	0.5 - 5.2	2.06	0.4 - 1.0
Walleye	Gill net	11.1	4.0 - 9.6	1.33	1.1 - 1.9
	Trap net	0.8	0.3 - 0.9	3.28	1.0 - 2.2
White Sucker	Gill net	2.3	1.0 - 3.5	2.34	1.5 - 2.3
	Trap net	0.1	0.2 - 0.8	2.59	1.4 - 2.7
Yellow Bullhead	Gill net	12.3	0.6 - 6.4	1.11	0.6 - 0.9
	Trap net	12.1	0.9 - 4.8	1.08	0.7 - 1.0
Yellow Perch	Gill net	14.5	7.1 - 33.9	0.10	0.1 - 0.2
	Trap net	0.5	0.7 - 3.7	0.13	0.1 - 0.2

Normal Ranges represent typical catches for lakes with similar physical and chemical characteristics.

Length of Selected Species Sampled for All Gear for the 2003 Survey Year

	Number of fish caught in each category (inches)								
Species	***0-5***	***6-8***	***9-11***	***12-14***	***15-19***	***20-24***	***25-29***	***>29***	***Total***
Black Bullhead	0	0	0	2	0	0	0	0	2
Black Crappie	4	3	4	0	0	0	0	0	11
Bluegill	151	69	0	0	0	0	0	0	220
Brown Bullhead	0	0	0	27	7	0	0	0	34
Green Sunfish	13	0	0	0	0	0	0	0	13
Hybrid Sunfish	39	39	0	0	0	0	0	0	78
Largemouth Bass	0	2	4	4	0	0	0	0	10
Northern Pike	0	0	0	0	14	48	7	4	73
Pumpkinseed Sunfish	43	76	0	0	0	0	0	0	119
Rock Bass	3	16	2	0	0	0	0	0	21
Tullibee (Cisco)	0	1	0	0	4	0	0	0	5
Walleye	0	10	15	45	50	14	4	0	138
Yellow Bullhead	0	1	93	187	0	0	0	0	281
Yellow Perch	93	66	0	0	0	0	0	0	159

Fish Consumption Advisory

No fish consumption information is available for this lake. For more information, see the "Fish Consumption Advice" pages at the Minnesota Department of Health.

Status of the Fishery (as of 07/07/2003)

South Lida Lake is a 856-acre moderately fertile lake located in northwestern Otter Tail County five miles east of Pelican Rapids, MN. South Lida Lake is connected to North Lida Lake by a navigable culvert under State Highway 108. The immediate watershed is composed primarily of hardwood forest. The maximum depth is 48 feet. The secchi disk reading during the 2003 lake

survey was 8.0 feet. Previous secchi disk readings have ranged from 4.5 to 9.3 feet. Water clarity in this lake diminishes periodically due to plankton/algae blooms. South Lida Lake is included in lake class 25 of the MNDNR lake classification scheme. The south and west shorelines of South Lida Lake have been extensively developed. Eighty-six homes/cabins and two resorts/campgrounds were recorded in the 1997 lake resurvey. A majority of the east shoreline is located within the boundaries of Maplewood State Park. A DNR owned public water access is located within the state park along the southeast shoreline and a private access is located along the north shoreline. A public swimming beach and campground are also located along the eastern shoreline in the state park. Large stands of hardstem bulrush and common cattail are scattered along the undeveloped sections of shoreline. Emergent aquatic plants such as bulrush and cattail provide valuable fish and wildlife habitat, and are critical for maintaining good water quality. They protect shorelines and lake bottoms, and can actually absorb and break down polluting chemicals. Emergent plants provide spawning areas for fish such as northern pike, largemouth bass, and panfish. They also serve as important nursery areas for all species of fish. Because of their ecological value, emergent plants may not be removed without a DNR permit. South Lida Lake is a popular angling lake. The species most sought after are walleye, northern pike, bluegill, and black crappie. Data from recent lake surveys indicate that these species are abundant. The test-net catch rate of walleye exceeded the upper limit of the normal range for class 25 lakes. The walleye test-net catch rate has been within or exceeded the normal range in every survey conducted on this lake. Walleye ranged in length from 6.8 to 24.6 inches with an average length and weight of 15.0 inches and 1.3 pounds. Walleye attain an average length of 15.7 inches at four years of age. The northern pike test-net catch rate was within the normal range for class 25 lakes. Northern pike reproduction rates increased during the late 1990's due to high water levels which increased accessability to suitable spawning habitat. Northern pike ranged in length from 17.6 to 34.3 inches with an average length and weight of 22.5 inches and 2.5 pounds. Twenty-six percent of the pike were at least 24.0 inches in length. Pike attain an average length of 21.1 inches at four years of age. The bluegill test-net catch rate in the recent series of surveys has remained within the normal range for lake class 25. Age data from recent surveys indicate that bluegill year class strength is variable which results in fluctuations of size structure. In this survey, only five percent of the bluegill were 7.0 inches or greater in length. Bluegills attain an average length of 7.2 inches at six years of age. As part of a statewide experimental regulations project, an 11-inch minimum size limit for black crappie was implemented in 1997 on South and North Lida Lakes and will be in effect through 2005. The intent of the regulation is to increase the average size of black crappie in the Lida Lakes. A spring trapnetting assessment was conducted in 2002 to analyze the black crappie population. Crappies ranged in length from 5.6 to 12.1 inches with an average length and weight of 9.6 inches and 0.6 pounds. Fifteen percent of the crappies were at least 11.0 inches in length. Crappies attain an average length of 10.4 inches at four years of age. The DNR does not stock any fish in South Lida Lake. The fish species present are able to sustain their levels at or above DNR management goals. This is an indication of the quality of fish habitat that is present. To maintain the excellent angling and water quality that this lake has to offer, it is imperative to preserve the quality of the aquatic habitat. Anglers can also maintain the quality of angling by practicing selective harvest. Selective harvest encourages the release of medium to large-size fish while allowing the harvest of more abundant smaller fish for table fare. Releasing the medium to large fish will ensure that the lake will have enough spawning age fish on an annual basis and will provide anglers with more opportunities to catch large fish in the future.

Appendix 4.

Secchi Depth and Physical Condition / Recreational Suitability Rankings

56-0747-01 Main Basin				
DATE	SITE	Secchi (ft)	Physical Condition	Recreational Suitability
6/12	101	12.8	2	2
7/23	101	10.2	2	2
8/26	101	7.9	2	2
6/12	102	12.8	2	2
7/23	102	10.5	2	2
8/26	102	7.5	2	2
57-0747-02 South Basin				
DATE	SITE	Secchi (ft)	Physical Condition	Recreational Suitability
6/12	101	14	2	1
7/23	101	4.5	4	2
8/26	101	5.9	3	2
6/12	102	13.5	2	1
7/23	102	5.5	3	2
8/26	102	5.5	3	2

Number	Physical Condition	Recreational Suitability
1	Crystal clear water	Beautiful, could NOT be better
2	Not quite crystal clear – a little algae present/visible	Very minor aesthetic problems; excellent for swimming, boating
3	Definite algae green, yellow, or brown color apparent	Swimming and aesthetic enjoyment slightly impaired because of algae levels
4	High algal levels with limited clarity and/or mild odor apparent	Desire to swim and level of enjoyment of the lake substantially reduced because of algae levels (i.e., would not swim, but boating is okay)
5	Severely high algae levels with one or more of the following: massive floating scums on the lake or washed up on shore, strong, foul odor, and/or fish kill	Swimming and aesthetic enjoyment of the lake nearly impossible because of algae levels

Appendix 5.
Lida Lake Water Quality Data From MPCA Sampling

Lake ID = 56-0747-01

DATE	D	SITE	TP	TKN	ALK	CL	COLOR	CHLA	PHEO	SDF
6/12/2000	0	101	0.011	0.7	210	5.7	10	5.05	1.08	12.8
6/12/2000	0	102	0.013	.	.	.	.	3.67	1.01	12.8
7/23/2000	0	101	0.016	0.7	210	5.5	10	4.53	1.9	10.2
7/23/2000	0	102	0.016	.	.	.	.	5.4	1.71	10.5
8/26/2000	0	101	0.02	0.8	210	5.5	10	9.48	<0.32	7.9
8/26/2000	0	102	0.022	.	.	.	.	9.04	0.41	7.5
Mean			**16.33**	**0.73**	**210**	**5.57**	**10**	**6.20**	**1.22**	**10.28**
Minimum			**11**	**0.68**	**210**	**5.50**	**10**	**3.67**	**0.41**	**7.50**
Maximum			**22**	**0.84**	**210**	**5.70**	**10**	**9.48**	**1.90**	**12.80**
Count			**6**	**3.00**	**3**	**3.00**	**3**	**6.00**	**5.00**	**6.00**
Standard Deviation			**4.13**	**0.09**	**0**	**0.12**	**0**	**2.45**	**0.60**	**2.28**
Standard Error			1.7	0.1	0	0.1	0.0	1.0	0.3	0.9

Lake ID = 56-0747-02

DATE	D	SITE	TP	TKN	ALK	CL	COLOR	CHLA	PHEO	SDF
6/12/2000	0	101	0.02	0.82	200	5.6	10	6.14	1.9	14
6/12/2000	0	102	0.016	.	.	.	.	5.96	1.06	13.5
7/23/2000	0	101	0.025	0.94	190	5.3	10	11.4	2.32	4.5
7/23/2000	0	102	<0.002	.	.	.	.	9.2	1.55	5.5
8/26/2000	0	101	0.027	0.91	200	5.3	10	14	1.35	5.9
8/26/2000	0	102	0.03	.	.	.	.	22.1	1.76	5.5
Mean			**23.6**	**0.89**	**197**	**5.40**	**10.00**	**11.47**	**1.66**	**8.15**
Minimum			**16**	**0.82**	**190**	**5.30**	**10.00**	**5.96**	**1.06**	**4.50**
Maximum			**30**	**0.94**	**200**	**5.60**	**10.00**	**22.10**	**2.32**	**13.5**
Count			**5**	**3**	**3**	**3**	**3**	**6**	**6**	**6**
Standard Deviation			**5.59**	**0.06**	**6**	**0.17**	**0.00**	**6.06**	**0.44**	**4.37**
Standard Error			2.5	0.0	3	0.1	0.0	2.5	0.2	1.8

Dissolved Oxygen Data **Temperature Data**

Depth	June (Main) 56-0747-01	June (South) 56-0747-02	Depth	June (Main) 56-0747-01	June (South) 56-0747-02
0	7.5	7.4	0	18.9	19.3
-1	7.6	7.5	-1	18.9	19.4
-2	7.6	7.5	-2	18.9	19.4
-3	7.6	7.5	-3	18.9	19.4
-4	7.6	7.5	-4	18.9	19.4
-5	7.6	7.3	-5	18.9	19.3
-6	7.5	6.3	-6	18.9	18.4
-7	7.5	4.2	-7	18.9	15.8
-8	7.4	2.6	-8	18.9	14.6
-9	7.5	1.1	-9	18.9	13
-10	7.4	0.6	-10	18.9	11.7
-11	7.4	0.5	-11	18.9	10.4
-12	7.3	0.5	-12	18.8	9.5
-13	0.7	0.5	-13	18.8	9

Appendix 6. Water Quality Data from Otter Tail COLA
RMB Environmental Laboratories, Inc
(http://www.rmbel.info)

Lida Lake, Main Basin 56-0747-01
Site 208

Date	TP ug/l	Chl –a ug/l	Secchi (ft)
6/14/1998	17	2	15.0
7/19/1998	30	10	9.5
8/16/1998	25	14	5.0
9/27/1998	25	9	11.0
6/20/1999	17	2	13.5
7/18/1999	28	7	11.0
8/22/1999	28	10	6.5
9/25/1999	20		11.5
6/25/2000	17	2	15.0
7/21/2000	17		21.0
7/22/2000	22	3	11.5
8/20/2000	17	12	10.0
9/24/2000	17	5	17.5
6/17/2001	17	2	15.0
7/15/2001	22	3	11.5
8/19/2001	17	12	10.0
9/16/2001	17	5	17.5
6/16/2002	12	1	18.0
7/14/2002	20	1	21.0
8/18/2002	22	2	11.0
9/15/2002	22	9	9.0
6/15/2003	15	3	19.0
7/20/2003	24	7	11.5
8/17/2003	27	7	7.0
9/14/2003	25	14	9.5
6/20/2004	20	3	22.0
7/18/2004	16	3	19.0
8/15/2004	21	5	15.0
9/19/2004	21	5	13.0

Lida Lake, South Basin 56-0747-02
Site 202

Date	TP ug/l	Chl –a ug/l	Secchi (ft)
6/14/1998	25	11	11.5
7/19/1998	43	18	6.5
8/16/1998	35	21	4.5
9/27/1998	40	26	7.5
6/20/1999	28	12	9.5
7/15/1999	33	15	5.5
8/22/1999	35	23	6.5
9/25/1999	53		8.5
6/25/2000	25	6	15.0
7/23/2000	28	13	5.0
8/20/2000	30	13	7.5
9/24/2000	56	14	10.5
6/17/2001	28	15	8.0
7/15/2001	28	10	6.0
8/19/2001	33	20	6.5
9/16/2001	35	13	9.5
6/16/2002	25	1	13.5
7/14/2002	20	2	12.5
8/18/2002	40	4	7.0
9/15/2002	30	16	6.6
6/15/2003	34	7	12.5
7/20/2003	24	8	6.0
8/17/2003	31	12	5.5
9/14/2003	31	17	8.0
6/20/2004	32	4	20.0
7/18/2004	22	7	13.0
8/15/2004	25	14	10.0
9/19/2004	37	21	10.0