2008 SUMMARY REPORT
of
Sun Lake

Lake County, Illinois

Prepared by the

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TABLE OF CONTENTS

EXECUTIVE SUMMARY 1

LAKE FACTS 2

SUMMARY OF WATER QUALITY.....3

SUMMARY OF AQUATIC MACROPHYTES.....14

SUMMARY OF SHORELINE CONDITION 24

OBSERVATIONS OF WILDLIFE AND HABITAT.....30

LAKE MANAGEMENT RECOMMENDATIONS 31

TABLES

Table 1. Summary of water quality data for Sun Lake, 2001 and 2008 5
Table 2. Comparison of epilimnetic averages for Secchi disk transparency, total suspended solids, total phosphorus and conductivity readings in the Sequiot Creek watershed 8
Table 3. Approximate land uses and retention time for Sun Lake, 2008.....12
Table 4. Lake County average TSI phosphorous (TSIp) ranking 2000-2008.....
Table 5. Aquatic plant species found in Sun Lake in 2008. 15
Table 6a. Aquatic plant species found at the 101 sampling sites on Sun Lake, August 2008 Maximum depth that plants were found was 18.2 feet. 20
Table 6b. Distribution of rake density across all sampled sites... 21
Table 7. Floristic quality index (FQI) of lakes in Lake County, calculated with exotic species (w/Adventives) and with native species only (native). 25

FIGURES

Figure 1. Water quality sampling site on Sun Lake, 2008.....4
Figure 2. Secchi depth vs. total suspended solid (TSS) concentrations in Sun Lake, 2008.....7
Figure 3. Approximate watershed delineation of Sun Lake, 2008 10
Figure 4. Approximate land use within the Sun Lake watershed, 2008 11
Figure 5. Chloride (Cl-) concentration vs. conductivity for Sun Lake, 2008. 13
Figure 6. Aquatic plant sampling grid that illustrates plant density on Sun Lake, August 2008.....19
Figure 7. Aquatic plant sampling grid that illustrates Eurasian Watermilfoil density on Sun Lake, August 2008.....22
Figure 8. Bathymetric map of Sun Lake, 2008.....23
Figure 9. Shoreline erosion on Sun Lake, 2008.....29

APPENDICES

Appendix A. Methods for field data collection and laboratory analyses.
Appendix B. Multi-parameter data for Sun Lake in 2008
Appendix C. Interpreting your lake's water quality data.
Appendix D. Lake management options.
D1. Options to reduce conductivity and chloride concentrations
D2. Participation in Volunteer Lake Management Program
D3. Assess Fishery
Appendix E. Water quality statistics for all Lake County lakes.
Appendix F. Grant program opportunities.

EXECUTIVE SUMMARY

Sun Lake is a glacial lake located in Lake Villa Township. The lake has a surface area of 24.6 acres and a mean depth of 7.5 feet. Sun Lake lies completely within Forest Preserve property and is solely owned by the Lake County Forest Preserve District. The lake is surrounded by a flat, wetland area dominated by emergent vegetation. It is used by the public for shoreline fishing and recreational hiking

Sun Lake is listed as an ADID (advanced identification) wetland by the U.S. Environmental Protection Agency and an Illinois Natural Areas Inventory (INAI) by the state of Illinois. This indicates that the lake and surrounding natural environments have potential to have high quality aquatic resources based on water quality and hydrology values.

Sun Lake receives water from Deep Lake and empties into East Loon Lake. Due to the downstream location of the lake within its watershed lake levels were influenced by rain events. Sun Lake was stratified May through August with a strong thermocline. Dissolved oxygen levels in the epilimnion were adequate to support aquatic life (> 5 mg/L) for the entire sampling season.

The 2008 water quality in Sun Lake was above average with many parameters below the county medians. Total phosphorus (TP) in the epilimnion of Sun Lake averaged 0.022 mg/L and the median for the county was 0.065 mg/L. Total suspended solid (TSS) concentrations averaged 2.2 mg/L, which is almost four times lower than the county median of 8.2 mg/L. As a result of low TSS concentrations, the average Secchi depth for the season was 6.33 feet. A Total Nitrogen to Total Phosphorus (TN:TP) ratio of 49:1 in Sun Lake means phosphorus was limiting. Also using phosphorus as an indicator, the trophic state index (TSIp) ranked Sun Lake as mesotrophic with a TSIp value of 48.7. The average conductivity reading for Sun Lake was 1.0548 mS/cm. This was the only parameter above the county median of 0.8195 mS/cm.

Common Bladderwort, Eurasian Watermilfoil (EWM) and Coontail were the most abundant species in the plant community in 2008. Small Pondweed which was found in August, 2008 was not found at anytime during 2001. A healthy plant community provided Sun Lake with good fish habitat and kept water clarity high by reducing sediment resuspension in shallow areas and competing with planktonic algae for nutrients.

In 2008 the shoreline was reassessed for changes in erosion since the 2001 study. The Lake County Forest Preserve has successfully demonstrated their commitment to maintaining natural areas and open space within the county by sustaining 100% of the shoreline exhibiting no erosion. Wetland, woodland, and especially buffered shorelines should be maintained for exotic shoreline vegetation that included Reed Canary Grass and Purple Loosestrife.

LAKE FACTS

Lake Name:	Sun
Historical Name:	None
Nearest Municipality:	Lake Villa
Location:	T 46N, R 10E, Sections 28, 33
Elevation:	780.0 feet msl
Major Tributaries:	Deep Lake Drain
Watershed:	Fox River
Sub-watershed:	Sequoit Creek
Receiving Water body:	East Loon Lake
Surface Area:	24.6 acres
Shoreline Length:	0.8 miles
Maximum Depth:	18.2 feet
Average Depth:	7.5 feet
Lake Volume:	183.3 acre-feet
Lake Type:	Glacial
Watershed Area:	1671.0 acres
Major Watershed Land uses:	Water, Public, Private Open Space, and Single Family
Bottom Ownership:	Lake County Forest Preserve District
Management Entities:	Lake County Forest Preserve District
Current and Historical uses:	Fishing, hiking, bicycling, cross country skiing, and aesthetics
Description of Access:	Access available through Sun Lake Forest Preserve

SUMMARY OF WATER QUALITY

Water samples were collected from May through August in Sun Lake at the deepest point located near the middle of the lake (Figure 1). Samples were taken at 3 feet below the surface and approximately 3 feet above the lake bottom and analyzed for various water quality parameters (Appendix A). Water level was taken from a piling on the south west side of the lake each month during sampling. Sun Lake is within the Sequiot Creek watershed which the Lakes Management Unit (LMU) sampled in its entirety in 2008. This watershed also includes Cedar Lake, Deep Lake, East Loon Lake, West Loon Lake and Little Silver Lake. Sun Lake receives water from Deep Lake.

Sun Lake was stratified June through August. When stratified, the epilimnetic and hypolimnetic waters do not mix, and the hypolimnion typically becomes anoxic (dissolved oxygen <1 mg/L). Sun Lake was stratified in May at 12 ft. The thermocline (the transitional region between the epilimnion and the hypolimnion) remained through August. Sun Lake experienced anoxic conditions in the hypolimnion June through August (Appendix B). The anoxic boundary ranged from 18ft in June to 13ft in August. The volume of the oxygenated water in Sun Lake ranged from 99.98% in June to 93.71% in August based on a bathymetric map created by the LMU in 2008.

Historically Sun Lake has had above average water quality for Lake County lakes, many water quality parameters remain above county medians. The total suspended solid (TSS) concentrations averaged 2.2 mg/L (Table 1), which is almost four times lower than the county median of 8.2 mg/L (Appendix E). High TSS values are typically correlated with poor water clarity (Secchi disk depth) and can be detrimental to many aspects of the lake ecosystem such as the plant and fish communities. As a result of low TSS concentrations, the average Secchi depth for the season was deep (6.33 feet). In August there was a notable decrease in the Secchi depth corresponding to an increase in TSS (Figure 2). In 2001 the water quality was slightly better; although the TSS average was slightly higher 2.4 mg/L the Secchi disk average was 8.22 feet. Sun Lake had the lowest average Secchi depth within the Sequiot Creek watershed (Table 2). This however was the not the same trend for the TSS within the watershed. Sun Lake had a slightly lower TSS value than Cedar, Deep, and East Loon but greater than Little Silver and West Loon Lake. West Loon, which is at the top of the watershed, had the highest average Secchi depth (16.64 feet) and lowest average TSS (1.6 mg/L), however, these values are also influenced by the presence of zebra mussels within the lake that filter the water lowering the TSS values. All these glacial lakes have abundance diverse aquatic plant populations that contribute to the high water quality.

Phosphorus is a nutrient that limits plant and algal growth, therefore any addition of phosphorus to the lake could produce algal blooms. Total phosphorus (TP) in the epilimnion of Sun Lake averaged 0.022 mg/L and the median for the county was 0.065 mg/L. The historical average from 1993 to 2001 was 0.036 mg/L. The same watershed trend of TSS and Secchi disk occurred with TP. Sun Lake had a TP concentration comparable to Cedar, Deep, and Little Silver. West Loon Lake had the lowest TP concentration (0.014 mg/L) while East Loon had the highest (0.049 mg/L). Phosphorus can enter a lake either internally (typically linked to sediment) or externally (point or non-point sources). Point source pollution can be from storm pipes or

Figure 1. Water quality sampling site on Sun Lake, 2008.

Table 1. Water quality data for Sun Lake, 2001 and 2008.

2008	Epilimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
20-May	3	156	0.86	<0.1	<0.05	0.013	<0.005	NA	226	1.9	592	92	5.83	1.0940	8.03	9.75
17-Jun	3	147	0.86	<0.1	<0.05	0.024	<0.005	NA	223	1.5	604	115	6.23	1.0520	8.14	10.14
15-Jul	3	138	0.83	<0.1	<0.05	0.019	<0.005	NA	214	2.0	574	116	8.86	1.0050	8.24	8.14
19-Aug	3	149	1.03	<0.1	<0.05	0.032	<0.005	NA	226	3.4	619	137	4.40	1.0680	8.50	8.16
	Average	148	0.89	<0.1	<0.05	0.022	<0.005	NA	222	2.2	597	115	6.33	1.0548	8.23	9.05

2001	Epilimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
16-May	3	148	0.92	<0.1	<0.05	0.034	<0.005	452	NA	1.9	471	116	9.19	0.7742	7.91	8.46
20-Jun	3	152	0.83	<0.1	<0.05	0.032	<0.005	472	NA	1.6	496	143	9.55	0.8008	7.66	7.45
25-Jul	3	159	1.22	<0.1	<0.05	0.039	<0.005	492	NA	2.7	499	116	5.97	0.8438	8.08	6.34
22-Aug	3	157	1.22	<0.1	<0.05	0.052	<0.005	502	NA	4.3	509	160	6.36	0.7948	8.35	8.40
19-Sep	3	158	1.37	<0.1	<0.05	0.048	<0.005	482	NA	1.3	493	141	10.04	0.8203	7.40	5.33
	Average	155	1.11	<0.1	<0.05	0.041	<0.005	480	NA	2.4	494	135	8.22	0.8068	7.88	7.20

Glossary

ALK = Alkalinity, mg/L $CaCO_3$
TKN = Total Kjeldahl nitrogen, mg/L
NH_3-N = Ammonia nitrogen, mg/L
NO_2+NO_3-N = Nitrate + Nitrite nitrogen, mg/L
NO_3-N = Nitrate + Nitrite nitrogen, mg/L
TP = Total phosphorus, mg/L
SRP = Soluble reactive phosphorus, mg/L
Cl^- = Chloride, mg/L

TDS = Total dissolved solids, mg/L
TSS = Total suspended solids, mg/L
TS = Total solids, mg/L
TVS = Total volatile solids, mg/L
SECCHI = Secchi disk depth, ft.
COND = Conductivity, milliSiemens/cm
DO = Dissolved oxygen, mg/L

Note: "k" denotes that the actual value is known to be less than the value presented.
NA = Not Applicable
* = Prior to 2006 only Nitrate was analyzed

Table 1. Continued.

2008	Hypolimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
20-May	16	154	1.06	0.241	<0.005	0.024	0.01	NA	226	2.3	577	88	NA	1.0860	7.75	4.04
17-Jun	15	156	0.84	<0.1	<0.005	0.018	<0.005	NA	228	3.3	624	126	NA	1.0900	7.69	0.19
15-Jul	15	156	1.15	<0.1	<0.005	0.065	<0.005	NA	225	8.0	619	131	NA	1.0905	7.43	0.41
19-Aug	15	226	2.22	1.23	<0.005	0.123	0.043	NA	224	7.0	681	130	NA	1.1660	7.69	0.11
	Average	173	1.32	0.736[k]	<0.005	0.058	0.027[k]	NA	226	5.2	625	119	NA	1.1081	7.64	1.19

2001	Hypolimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
5/16/01	16	150	1.23	0.30	<0.05	0.039	<0.005	440	NA	1.5	458	118	NA	0.7730	6.93	0.03
6/20/01	16	149	1.00	<0.1	<0.05	0.040	<0.005	470	NA	3.2	470	118	NA	0.7913	6.77	0.04
7/25/01	15	166	1.59	0.16	<0.05	0.073	<0.005	482	NA	8.8	498	134	NA	0.8276	6.65	0.06
8/22/01	14	188	2.52	<0.1	<0.05	0.146	0.024	519	NA	20.0	532	178	NA	0.8031	6.65	0.07
9/19/01	14	162	1.42	0.19	<0.05	0.051	<0.005	478	NA	2.0	482	128	NA	0.8221	7.39	5.15
	Average	163	1.55	0.22[k]	<0.05	0.070	0.024[k]	478	NA	7.1	488	135	NA	0.8034	6.88	1.07

Glossary

ALK = Alkalinity, mg/L $CaCO_3$
TKN = Total Kjeldahl nitrogen, mg/L
NH_3-N = Ammonia nitrogen, mg/L
NO_2+NO_3-N = Nitrate + Nitrite nitrogen, mg/L
NO_3-N = Nitrate + Nitrite nitrogen, mg/L
TP = Total phosphorus, mg/L
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SECCHI = Secchi disk depth, ft.
COND = Conductivity, milliSiemens/cm
DO = Dissolved oxygen, mg/L

Note: "k" denotes that the actual value is known to be less than the value presented.
NA = Not Applicable
* = Prior to 2006 only Nitrate was analyzed

Figure 2. Total suspended solid (TSS) concentrations vs. Secchi disk depth for Sun Lake, 2008.

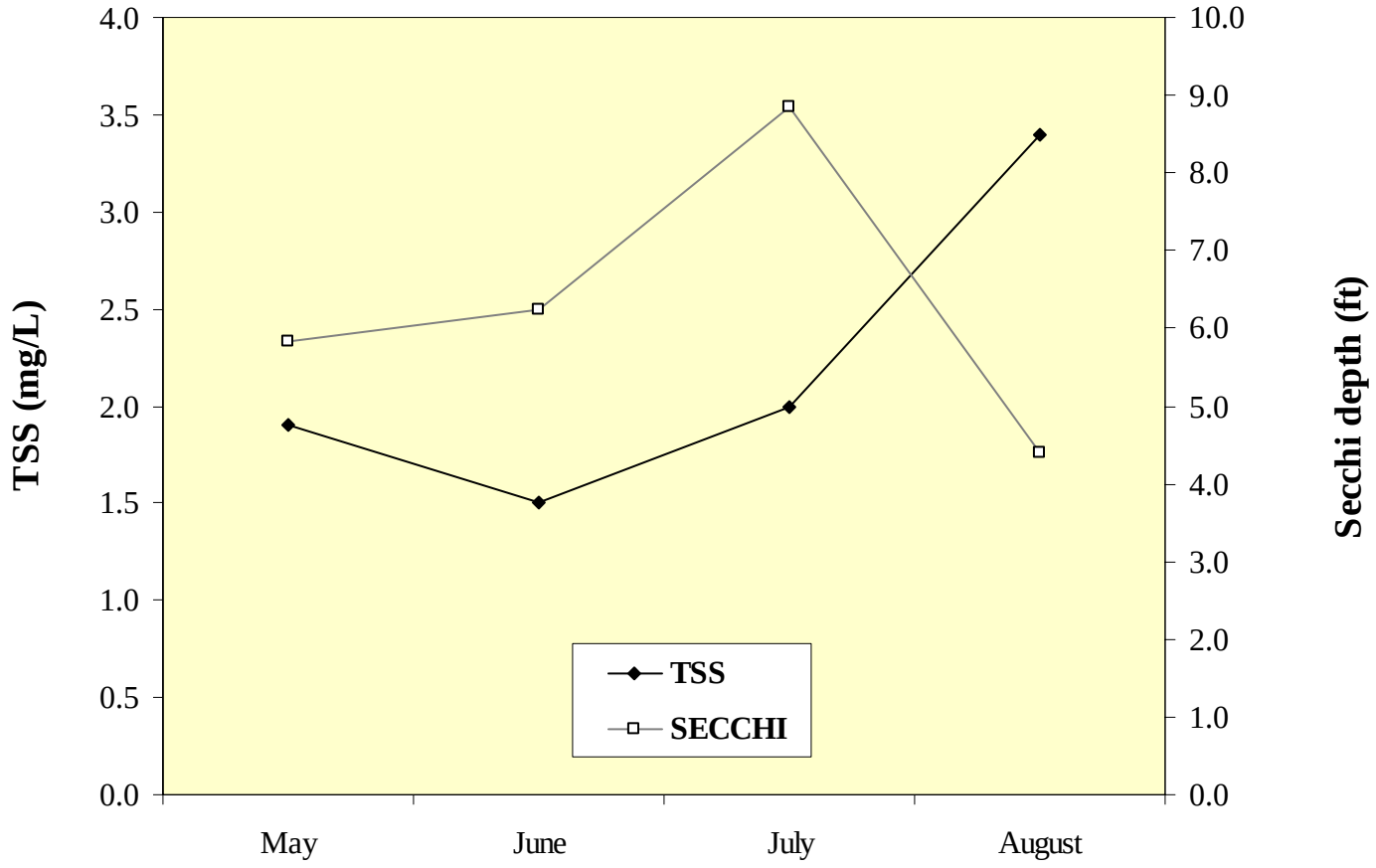


Table 2. Comparison of epilimnetic averages for Secchi disk transparency, total suspended solids, total phosphorus and conductivity readings in the Sequiot Creek watershed (Cedar Lake, Deep Lake, Sun Lake, East Loon Lake, West Loon Lake, and Little Silver Lake)

	Cedar Lake	Cedar Lake	Cedar Lake	Cedar Lake	Cedar Lake	Cedar Lake	Deep Lake	Deep Lake	Deep Lake	Deep Lake	Deep Lake	Deep Lake	Sun Lake	Sun Lake	Sun Lake
Year	**1998**	**2003**	**2005**	**2006**	**2007**	**2008**	**1989**	**1992**	**1993**	**1998**	**2003**	**2008**	**1993**	**2001**	**2008**
Secchi (feet)	8.5	12.16	8.58	13.07	11.35	7.04	11.55	10.34	9.65	9.76	12.48	8.14	8.46	8.22	6.33
TSS (mg/L)	3.1	2.2	2.4	1.9	2.1	2.6	6.3	1.7	2.0	2.6	2.4	3.0	0.5	2.4	2.2
TP (mg/L)	0.015	0.021	0.018	0.015	0.016	0.022	0.040	0.021	0.025	0.023	0.024	0.023	0.031	0.041	0.022
Conductivity (milliSiemens/cm)	0.5816	0.5932	0.6447	0.6745	0.6690	0.6723	NA	NA	NA	0.8112	0.9520	1.0726	NA	0.8068	1.0548

∞	West Loon Lake	West Loon Lake	West Loon Lake	West Loon Lake	West Loon Lake	West Loon Lake	East Loon Lake	East Loon Lake	East Loon Lake	East Loon Lake	East Loon Lake	East Loon Lake	Little Silver Lake	Little Silver Lake	Little Silver Lake
Year	**1991**	**1992**	**1993**	**1998**	**2003**	**2008**	**1991**	**1992**	**1993**	**1998**	**2003**	**2008**	**1999**	**2003**	**2008**
Secchi (feet)	8.00	11.13	9.08	9.88	11.96	16.64	4.30	6.26	4.01	5.94	5.32	6.39	10.72	10.12	9.42
TSS (mg/L)	10.7	2.7	5.8	2.2	1.8	1.6	5.3	3.4	3.1	4.0	4.1	4.6	1.5	1.8	1.8
TP (mg/L)	0.016	0.013	0.017	0.011	0.018	0.014	0.026	0.018	0.052	0.028	0.028	0.049	0.020	0.025	0.025
Conductivity (milliSiemens/cm)	NA	NA	NA	0.6476	0.6483	0.6907	NA	NA	NA	0.6710	0.8160	0.8148	0.6024	0.7619	0.7270

Direction of Watershed Flow

wastewater discharge and non-point source pollution is from groundwater runoff, which picks up phosphorus from agricultural fields, septic systems, lawns, or impervious surfaces. There were external sources of TP affecting Sun Lake such as stormwater from the 1670.45 acres within its watershed (Figure 3). Public and private open space (17%) and single family (16%) were the major land uses within the watershed (Figure 4). For Sun Lake transportation (25%), single family (24%) and government and institutional (17%) were the land uses contributing the highest percentages of estimated runoff (Table 3). It is important to keep in mind that although the amount of estimated runoff from certain areas may be low, they can still deliver high concentrations of TSS and TP. The retention time (the amount of time it takes for water entering a lake to flow out of it again) was calculated to be approximately 71 days. (probably less so during heavy rain events)

Nitrogen is also critical for the growth of plants and algae. Nitrogen sources vary from fertilizer to human waste and sewage treatment plants, to groundwater, air, and rainfall. Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen, and is typically bound up in algal and plant cells. The average TKN for Sun Lake was 0.89 mg/L, which was below the county median (1.20 mg/L) and a decrease from the 2001 average (1.11 mg/L). The TN:TP (total nitrogen to total phosphorus) ratio looks at which nutrient is limiting plant and algal growth in a lake. Ratios < 10:1 indicate nitrogen is limiting. Ratios of >15:1 indicate phosphorus is limiting. Ratios >10:1, <15:1 indicate there is enough of both nutrients for excessive algal growth. Sun Lake had a TN:TP ratio of 41:1 which means that phosphorus is the limiting nutrient. The plant abundance on Sun Lake also influences nutrient levels in the lake by using available phosphorus.

Conductivity readings, which are correlated with chloride concentrations, have been increasing throughout the past few years in the county (Figure 5). Road salts used in winter road maintenance consist of sodium chloride, calcium chloride, potassium chloride, magnesium chloride or ferrocyanides which are detected when chlorides are analyzed. The 2008 average conductivity reading for Sun Lake was 1.0548 mS/cm. This is above the county median of 0.8195 mS/cm and was a 31% increase since 2001 (0.8068 mS/cm). Chloride concentrations averaged 222 mg/L for the season and were also greater than the county median of 166 mg/L. A study done in Canada reported 10% of aquatic species were harmed by prolonged exposure to chloride concentrations greater than 220 mg/L. Additionally, shifts in algal populations were associated with chloride concentrations as low as 12 mg/l. (potentially shifts from green algae to blue-green algae). It appears that the road salt is compounding in many lakes in the county. Some lakes in the county have seen a doubling of conductivity readings in the past 5-10 years. Deep Lake which is located upstream had higher conductivity levels than Sun Lake. Alternatives to road salt should be considered. While alternatives may contain chloride, they tend to work faster at lower temperatures and therefore require less application to achieve the same result that common road salt.

The Illinois EPA has indices used for assessing lakes for aquatic life and recreational use impairment. The indices are calculated using the mean trophic state index (TSI), percent macrophyte coverage, and the median nonvolatile suspended solids concentration. The TSI index classifies the lake into one of four categories: oligotrophic (nutrient-poor, biologically unproductive), mesotrophic (intermediate nutrient availability and biological productivity), eutrophic (nutrient-rich, highly productive), or hypereutrophic (extremely nutrient-rich,

Figure 3. Approximate watershed delineation for Sun Lake, 2008.

Figure 4. Approximate land use within the Sun Lake watershed, 2008.

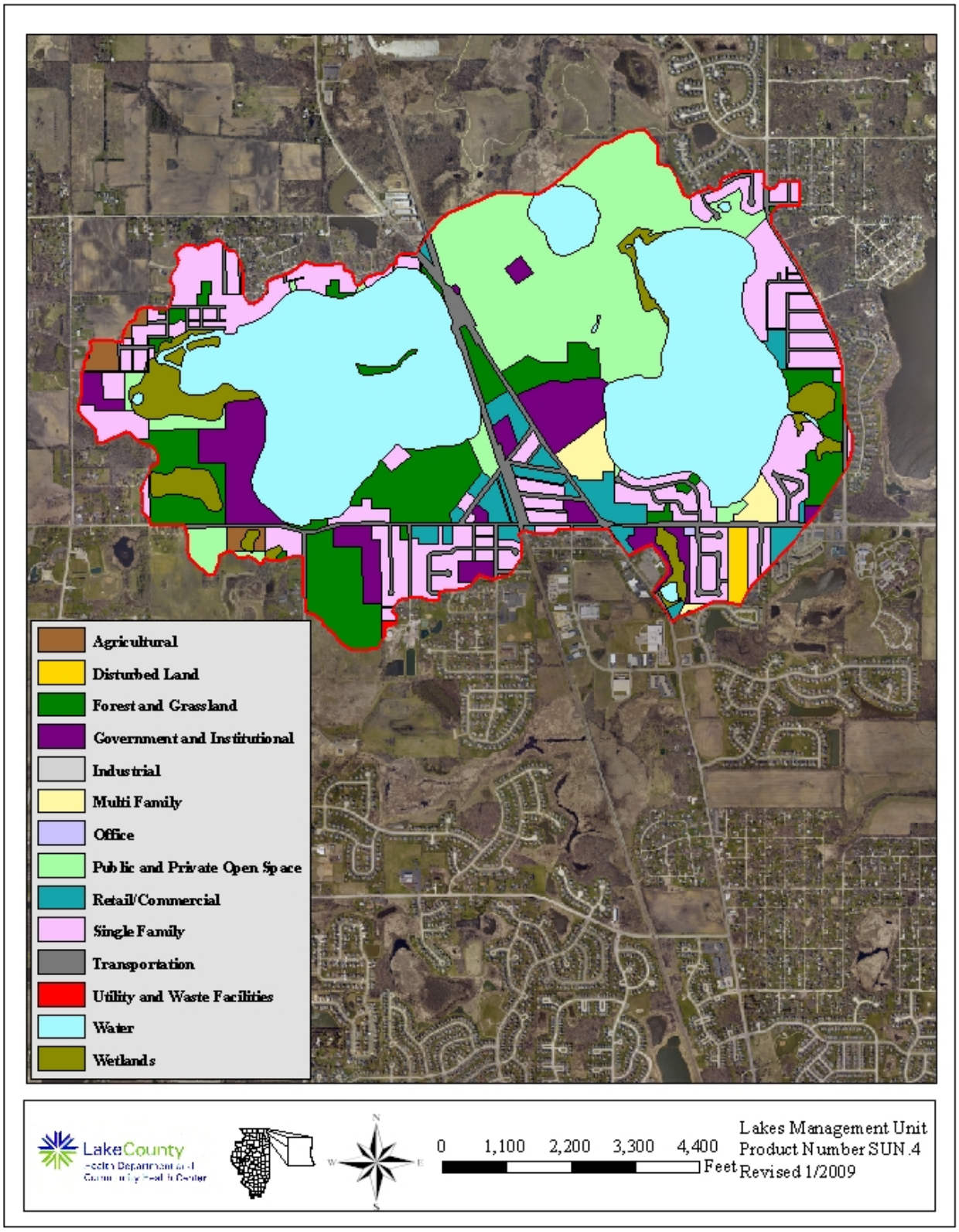


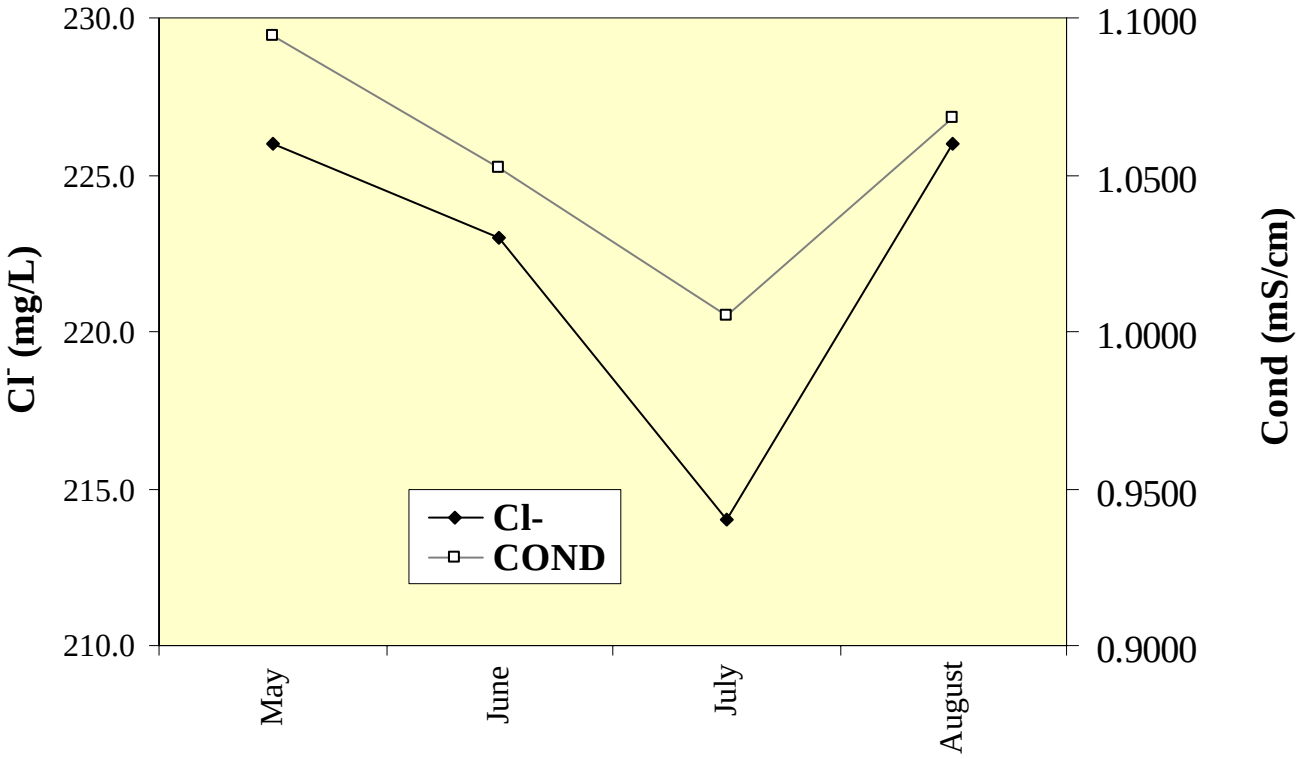
Table 3. Approximate land uses and retention time for Sun Lake, 2008.

Land Use	Acreage	% of Total
Agricultural	12.69	0.8%
Disturbed Land	9.82	0.6%
Forest and Grassland	179.73	10.8%
Government and Institutional	112.88	6.8%
Multi Family	24.22	1.4%
Office	0.67	0.0%
Public and Private Open Space	275.46	16.5%
Retail/Commercial	58.20	3.5%
Single Family	271.69	16.3%
Transportation	101.97	6.1%
Utility and Waste Facilities	0.86	0.1%
Water	549.94	32.9%
Wetlands	72.33	4.3%
Total Acres	**1670.45**	**100.0%**

Land Use	Acreage	Runoff Coeff.	Estimated Runoff, acft.	% Total of Estimated Runoff
Agricultural	12.69	0.05	1.7	0.2%
Disturbed Land	9.82	0.05	1.4	0.1%
Forest and Grassland	179.73	0.05	24.7	2.6%
Government and Institutional	112.88	0.50	155.2	16.5%
Multi Family	24.22	0.50	33.3	3.5%
Office	0.67	0.85	1.6	0.2%
Public and Private Open Space	275.46	0.15	113.6	12.1%
Retail/Commercial	58.20	0.85	136.0	14.5%
Single Family	271.69	0.30	224.1	23.8%
Transportation	101.97	0.85	238.3	25.3%
Utility and Waste Facilities	0.86	0.30	0.7	0.1%
Water	549.94	0.00	0.0	0.0%
Wetlands	72.33	0.05	9.9	1.1%
TOTAL	**1670.45**		**940.7**	100.0%

Lake volume	**183.29**	**acre-feet**
Retention Time (years)= lake volume/runoff	**0.19**	**years**
	71.12	**days**

Figure 5. Chloride (Cl^-) concentration vs. conductivity for Sun Lake, 2008.



productive). This index can be calculated using TP values obtained at or near the surface. In 2001 Sun Lake was eutrophic with a TSIp value of 57.7 with aquatic life having full support and recreational use scoring partial support. In 2008 Sun Lake ranked 18th in the county of 163 lakes for TSIp scoring a mesotrophic 48.7 (Table 4). The impairment indices determined that Sun Lake had full support for aquatic life and partial for recreational use do to substantial macrophyte impairment. (The IEPA discontinued calculating the Swimming Use Index in 2007).

SUMMARY OF AQUATIC MACROPHYTES

Plant sampling was conducted on Sun Lake in August 2008. There were 109 points generated based on a computer grid system with points 30 meters apart (Figure 6). Aquatic plants existed at 61 of 102 sites. Of the sites sampled 60% had plants present with 15 aquatic plant species and one macro-algae found (Table 5). This is a small decrease in plant diversity from 2001 where 16 species where found. However, the overall composition shifted slightly. Threadleaf Pondweed and Spiny Naiad were not found in 2008; although the native plant Small Pondweed was added to the plant community. This could be contributed to the timing of the survey event during the sampling season or annual variation. Fernleaf Pondweed endangered in Illinois has not been observed since 1990. Two exotic aquatic plants, Eurasian Water Milfoil (EWM) and Curlyleaf Pondweed, were found in Sun Lake. Both of these exotics compete with native plants, eventually crowding them out, providing little or poor natural diversity in addition to limited uses by wildlife. Removal or control of exotic species is recommended. EWM (48.0% of sample sites), Common Bladderwort (47.1%), and Coontail (37.3%) were the most abundant species found in 2008 (Table 6a, b). In 2001 EWM was present at 74% of the sampled sites and was the dominant plant species within the community. The aquatic plant community was located within the littoral zone shallower than nine feet. EWM was scattered within the plant community with its highest densities on the west side of the lake (Figure7). EWM overall abundance and location has decreased in Sun Lake since 2001. The high abundance of native plants within the littoral zone has kept EWM populations low in these areas. EWM should be monitored for increasing densities especially within the littoral zone.

The diversity and health of plant populations can be influenced by a variety of factors. Water clarity and depth are the major limiting factors in determining the maximum depth at which aquatic plants will grow. When the light level in the water column falls below 1% of the surface light level, plants can no longer photosynthesize. The 1% light level in Sun Lake ranged from 12-16ft. during the sampling season. Plants were found at a maximum depth of 8.9 feet. The morphology of Sun Lake drops quickly from nine to 18 feet (Figure 8). This is likely why plants were only found to depths of nine feet. A healthy aquatic plant population is critical to good lake health. Aquatic vegetation provides important wildlife habitat and food sources. Additionally, aquatic plants provide many water quality benefits such as sediment stabilization and competition with algae for available resources.

Floristic quality index (FQI) is an assessment tool designed to evaluate the closeness the flora of an area is to that of undisturbed conditions. It can be used to: 1) identify natural areas, 2) compare the quality of different sites or different locations within a single site, 3) monitor long-

Table 4. Lake County average TSI phosphorous (TSIp) ranking 2000-2008.

RANK	LAKE NAME	TP AVE	TSIp
1	Lake Carina	0.0100	37.35
2	Sterling Lake	0.0100	37.35
3	Independence Grove	0.0135	39.24
4	Lake Zurich	0.0130	41.14
5	Sand Pond (IDNR)	0.0165	41.36
6	West Loon Lake	0.0140	42.21
7	Windward Lake	0.0158	43.95
8	Bangs Lake	0.0170	45.00
9	Pulaski Pond	0.0180	45.83
10	Timber Lake	0.0180	45.83
11	Fourth Lake	0.0182	45.99
12	Lake Kathryn	0.0200	47.35
13	Lake of the Hollow	0.0200	47.35
14	Banana Pond	0.0202	47.49
15	Lake Minear	0.0204	47.63
16	Cedar Lake	0.0220	48.72
17	Cross Lake	0.0220	48.72
18	**Sun Lake**	**0.0220**	**48.72**
19	Dog Pond	0.0222	48.85
20	Stone Quarry Lake	0.0230	49.36
21	Deep Lake	0.0234	49.61
22	Druce Lake	0.0244	50.22
23	Little Silver	0.0250	50.57
24	Round Lake	0.0254	50.80
25	Lake Leo	0.0256	50.91
26	Cranberry Lake	0.0270	51.68
27	Dugdale Lake	0.0274	51.89
28	Peterson Pond	0.0274	51.89
29	Lake Miltmore	0.0276	51.99
30	Third Lake	0.0280	52.20
31	Lake Fairfield	0.0296	53.00
32	Gray's Lake	0.0302	53.29
33	Highland Lake	0.0302	53.29
34	Hook Lake	0.0302	53.29
35	Lake Catherine (Site 1)	0.0308	53.57
36	Lambs Farm Lake	0.0312	53.76
37	Old School Lake	0.0312	53.76
38	Sand Lake	0.0316	53.94
39	Sullivan Lake	0.0320	54.13
40	Lake Linden	0.0326	54.39
41	Gages Lake	0.0338	54.92
42	Honey Lake	0.0340	55.00
43	Hendrick Lake	0.0344	55.17
44	Diamond Lake	0.0372	56.30
45	Channel Lake (Site 1)	0.0380	56.60
46	Ames Pit	0.0390	56.98

Table 4. Continued.

RANK	LAKE NAME	TP AVE	TSIp
47	White Lake	0.0408	57.63
48	Potomac Lake	0.0424	58.18
49	Duck Lake	0.0426	58.25
50	Old Oak Lake	0.0428	58.32
51	Deer Lake	0.0434	58.52
52	Schreiber Lake	0.0434	58.52
53	Nielsen Pond	0.0448	58.98
54	Turner Lake	0.0458	59.30
55	Seven Acre Lake	0.0460	59.36
56	Willow Lake	0.0464	59.48
57	Lucky Lake	0.0476	59.85
58	Davis Lake	0.0476	59.85
59	East Meadow Lake	0.0478	59.91
60	East Loon Lake	0.0490	60.27
61	College Trail Lake	0.0496	60.45
62	Lake Lakeland Estates	0.0524	61.24
63	Butler Lake	0.0528	61.35
64	West Meadow Lake	0.0530	61.40
65	Heron Pond	0.0545	61.80
66	Little Bear Lake	0.0550	61.94
67	Lucy Lake	0.0552	61.99
68	Lake Christa	0.0576	62.60
69	Lake Charles	0.0580	62.70
70	Crooked Lake	0.0608	63.38
71	Waterford Lake	0.0610	63.43
72	Lake Naomi	0.0616	63.57
73	Lake Tranquility S1	0.0618	63.62
74	Wooster Lake	0.0620	63.66
75	Countryside Lake	0.0620	63.66
76	Werhane Lake	0.0630	63.89
77	Liberty Lake	0.0632	63.94
78	Countryside Glen Lake	0.0642	64.17
79	Lake Fairview	0.0648	64.30
80	Leisure Lake	0.0648	64.30
81	Tower Lake	0.0662	64.61
82	St. Mary's Lake	0.0666	64.70
83	Mary Lee Lake	0.0682	65.04
84	Hastings Lake	0.0684	65.08
85	Spring Lake	0.0726	65.94
86	ADID 203	0.0730	66.02
87	Bluff Lake	0.0734	66.10
88	Harvey Lake	0.0766	66.71
89	Broberg Marsh	0.0782	67.01
90	Sylvan Lake	0.0794	67.23
91	Big Bear Lake	0.0806	67.45
92	Petite Lake	0.0834	67.94

Table 4. Continued.

RANK	LAKE NAME	TP AVE	TSIp
93	Timber Lake (South)	0.0848	68.18
94	Lake Marie (Site 1)	0.0850	68.21
95	North Churchill Lake	0.0872	68.58
96	Grand Avenue Marsh	0.0874	68.61
97	Grandwood Park, Site II, Outflow	0.0876	68.65
98	North Tower Lake	0.0878	68.68
99	South Churchill Lake	0.0896	68.97
100	Rivershire Pond 2	0.0900	69.04
101	McGreal Lake	0.0914	69.26
102	International Mine and Chemical Lake	0.0948	69.79
103	Eagle Lake (Site I)	0.0950	69.82
104	Valley Lake	0.0950	69.82
105	Dunns Lake	0.0952	69.85
106	Fish Lake	0.0956	69.91
107	Lochanora Lake	0.0960	69.97
108	Owens Lake	0.0978	70.23
109	Woodland Lake	0.0986	70.35
110	Island Lake	0.0990	70.41
111	McDonald Lake 1	0.0996	70.50
112	Longview Meadow Lake	0.1024	70.90
113	Lake Barrington	0.1053	71.31
114	Redwing Slough, Site II, Outflow	0.1072	71.56
115	Lake Forest Pond	0.1074	71.59
116	Bittersweet Golf Course #13	0.1096	71.88
117	Fox Lake (Site 1)	0.1098	71.90
118	Osprey Lake	0.1108	72.04
119	Bresen Lake	0.1126	72.27
120	Round Lake Marsh North	0.1126	72.27
121	Deer Lake Meadow Lake	0.1158	72.67
122	Long Lake	0.1170	72.82
123	Taylor Lake	0.1184	72.99
124	Columbus Park Lake	0.1226	73.49
125	Nippersink Lake (Site 1)	0.1240	73.66
126	Echo Lake	0.1250	73.77
127	Grass Lake (Site 1)	0.1288	74.21
128	Lake Holloway	0.1322	74.58
129	Lakewood Marsh	0.1330	74.67
130	Summerhill Estates Lake	0.1384	75.24
131	Redhead Lake	0.1412	75.53
132	Forest Lake	0.1422	75.63
133	Antioch Lake	0.1448	75.89
134	Slocum Lake	0.1496	76.36
135	Drummond Lake	0.1510	76.50
136	Pond-a-Rudy	0.1514	76.54
137	Lake Matthews	0.1516	76.56
138	Buffalo Creek Reservoir	0.1550	76.88

Table 4. Continued.

RANK	LAKE NAME	TP AVE	TSIp
139	Pistakee Lake (Site 1)	0.1592	77.26
140	Grassy Lake	0.1610	77.42
141	Salem Lake	0.1650	77.78
142	Half Day Pit	0.1690	78.12
143	Lake Eleanor Site II, Outflow	0.1812	79.13
144	Lake Farmington	0.1848	79.41
145	Lake Louise	0.1850	79.43
146	ADID 127	0.1886	79.71
147	Dog Bone Lake	0.1990	80.48
148	Redwing Marsh	0.2072	81.06
149	Stockholm Lake	0.2082	81.13
150	Bishop Lake	0.2156	81.63
151	Hidden Lake	0.2236	82.16
152	Fischer Lake	0.2278	82.43
153	Lake Napa Suwe (Outlet)	0.2304	82.59
154	Patski Pond (outlet)	0.2512	83.84
155	Oak Hills Lake	0.2792	85.36
156	Loch Lomond	0.2954	86.18
157	McDonald Lake 2	0.3254	87.57
158	Fairfield Marsh	0.3264	87.61
159	ADID 182	0.3280	87.69
160	Slough Lake	0.4134	91.02
161	Flint Lake Outlet	0.4996	93.75
162	Rasmussen Lake	0.5025	93.84
163	Albert Lake, Site II, outflow	1.1894	106.26

Figure 6. Aquatic plant sampling grid that illustrates plant density on Sun Lake, August 2008.

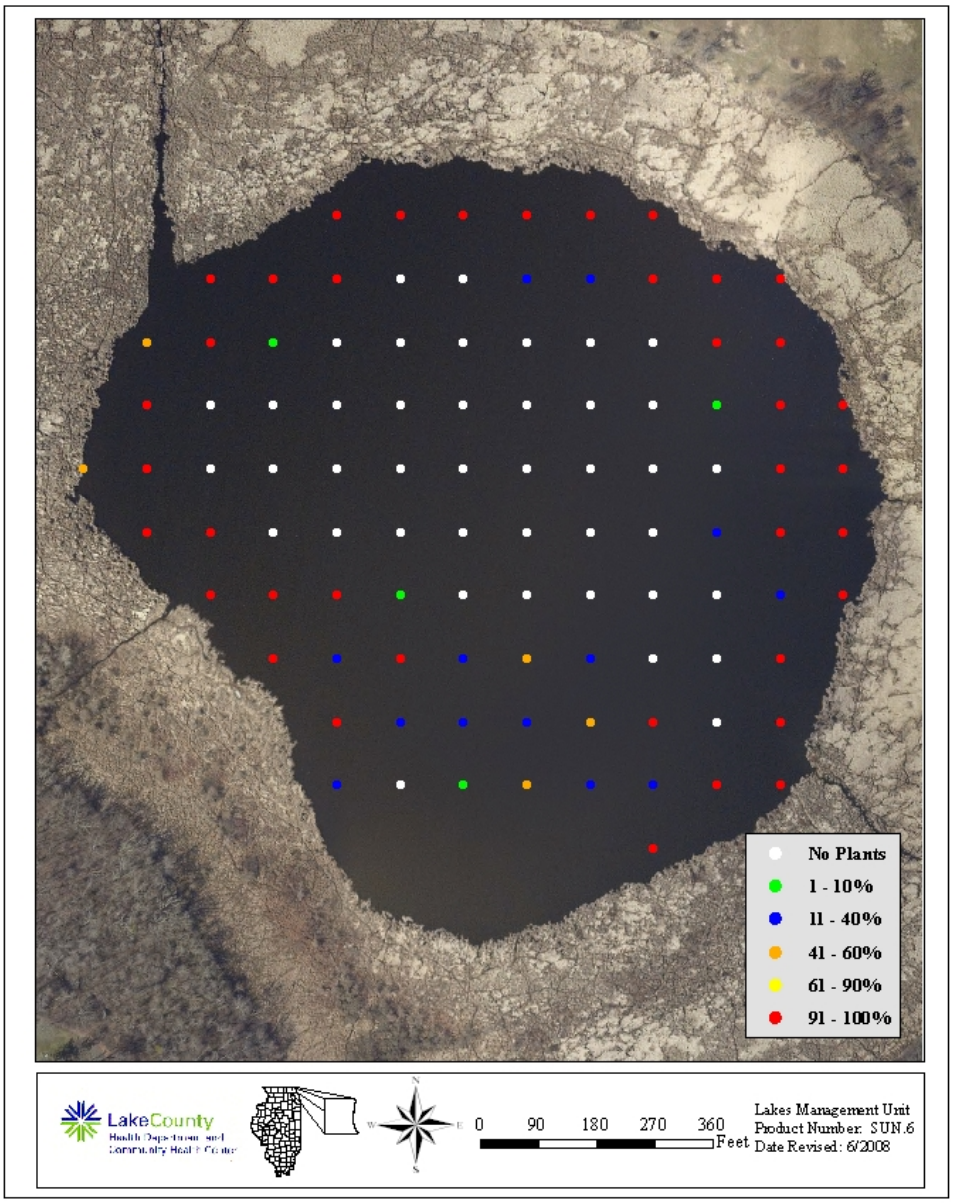


Table 5. Aquatic plant species found in Sun Lake in 2008.

Coontail	*Ceratophyllum demersum*
Chara (Macro algae)	*Chara* spp.
American Elodea	*Elodea canadensis*
Water Stargrass	*Heteranthera dubia*
Small Duckweed	*Lemna minor*
Eurasian Watermilfoil^	*Myriophyllum spicatum*
Northern Watermilfoil	*Myriophyllum sibiricum*
Spatterdock	*Nuphar variegata*
Largeleaf Pondweed	*Potamogeton amplifolius*
Curlyleaf Pondweed^	*Potamogeton crispus*
Floatingleaf Pondweed	*Potamogeton natans*
Sago Pondweed	*Potamogeton pectinatus*
Small Pondweed	*Potamogeton pusillus*
Flatstem Pondweed	*Potamogeton zosteriformis*
White Water Crowfoot	*Ranunculus longirostris*
Common Bladderwort	*Utricularia vulgaris*

^ Exotic plant
*** Threatened/Endangered plant**

Table 6a. Aquatic plant species found at the 101 sampling sites on Sun Lake, August 2008
Maximum depth that plants were found was 18.2 feet.

Plant Density	Bladderwort	Chara	Coontail	Curlyleaf Pondweed	Duckweed	Elodea	Eurasian Watermilfoil	Flatstem Pondweed
Absent	54	95	64	99	101	91	53	90
Present	14	6	20	2	1	7	18	7
Common	18	0	5	0	0	3	13	3
Abundant	7	0	5	1	0	1	6	1
Dominant	9	1	8	0	0	0	12	1
% Plant Occurrence	47.1%	6.9%	37.3%	2.9%	1.0%	10.8%	48.0%	11.8%

Plant Density	Floatingleaf Pondweed	Largeleaf Pondweed	Northern Watermilfoil	Sago Pondweed	Small Pondweed	Spatterdock	White Water Crowfoot	Water Stargrass
Absent	82	93	88	71	100	101	101	88
Present	11	4	12	15	2	1	1	7
Common	5	4	2	12	0	0	0	4
Abundant	3	1	0	4	0	0	0	1
Dominant	1	0	0	0	0	0	0	2
% Plant Occurrence	19.6%	8.8%	13.7%	30.4%	2.0%	1.0%	1.0%	13.7%

Table 6b. Distribution of rake density across all sampled sites.

Rake Density (Coverage)	# of Sites	%
No plants	41	40.2
>0 to 10%	5	4.9
>10 to 40%	13	12.7
>40 to 60%	5	4.9
>60 to 90%	0	0.0
>90%	38	37.3
Total Sites with Plants	61	59.8
Total # of Sites	102	100.0

Figure 7. Aquatic plant sampling grid that illustrates Eurasian Watermilfoil density on Sun Lake, August 2008.

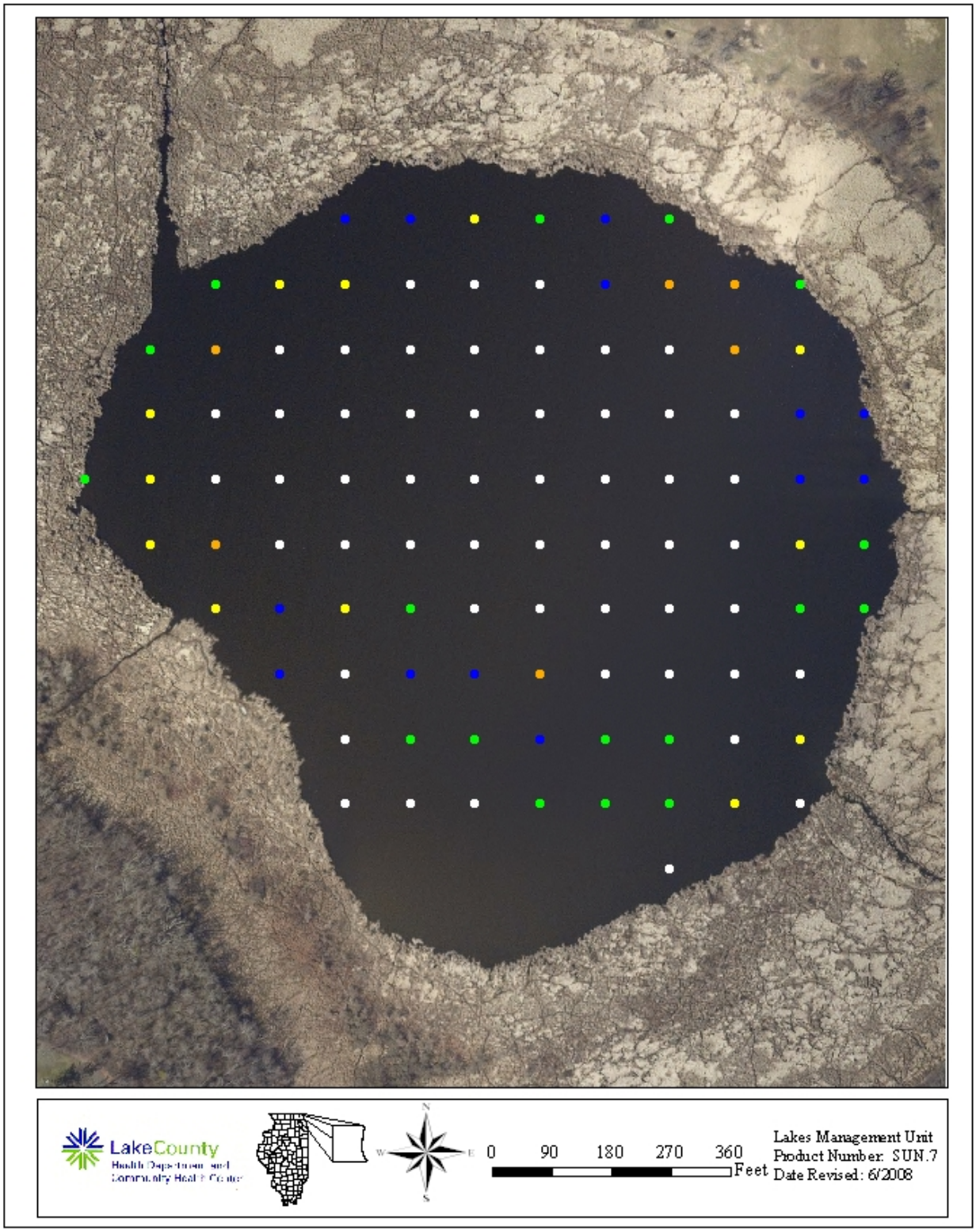
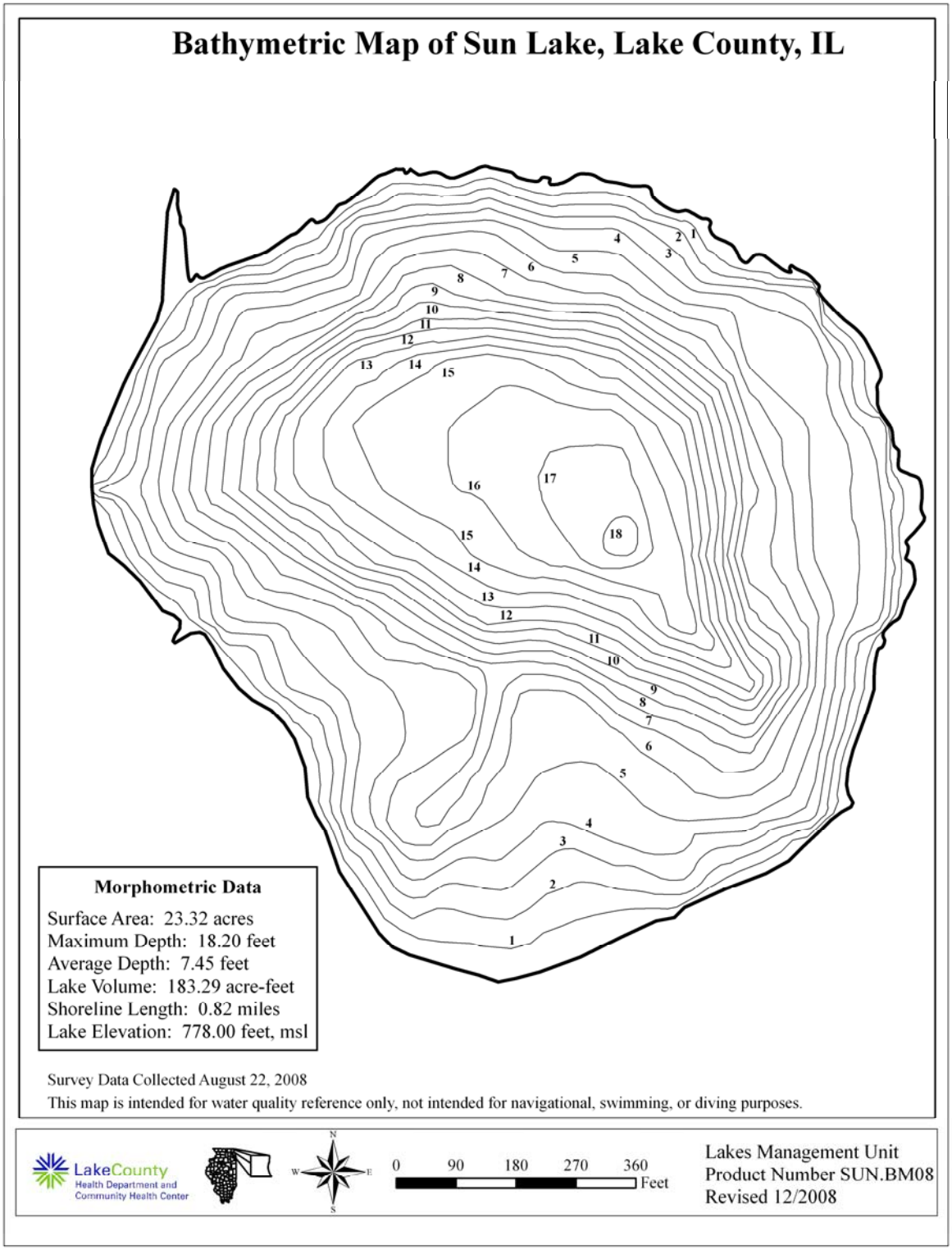


Figure 8. Bathymetric map of Sun Lake, 2008.



term floristic trends, and 4) monitor habitat restoration efforts. Each floating or submersed aquatic plant is assigned a number between 1 and 10 (10 indicating the plant species most sensitive to disturbance). An FQI is calculated by multiplying the average of these numbers by the square root of the number of these plant species found in the lake. A high FQI number indicate that there were large numbers of sensitive, high quality plant species present in the lake. Non-native species were also included in the FQI calculations for Lake County lakes. The average FQI for Lake County lakes from 2000-2008 was 14.9. Sun Lake has an FQI of 26.1. Sun Lake was well above the average lake, by Lake County standards ranking16th of 152 lakes (Table 7).

SUMMARY OF SHORELINE CONDITION

Lakes with stable water levels potentially have less shoreline erosion problems. The water level fluctuations on the Sun Lake were substantial. There was only a slight seasonal change from May to August of two inches. However, Sun Lake appears to be influenced by rain events due to the watershed size of 1670.45 acres. The most significant water level fluctuation occurred in May to June when the lake level increased 13.5 inches, the water level increased another 3.0 inches June through July. Then there was a dramatic decrease from July to of August of 11.5 inches. These fluctuations seem to be associated with rain events, according to the Stormwater Management Commission Lindenhurst rain gage by Stormwater Management Commission 5.92 inches of rain was recorded May to June. This correlated with the increased water level as compared with July to August when only 2.38 inches fell and the lake level decreased. These types of water level fluctuations can have detrimental effects on shorelines however due to the 100% vegetated and buffered shoreline these rain events had a reduced impact on shoreline erosion. In order to accurately monitor water levels it is recommended that a staff gauge be installed and levels measured and recorded frequently (daily or weekly).

A shoreline assessment was conducted at Sun Lake in September 2001. The shoreline was assessed for a variety of criteria, and based on this assessment, several important generalizations were made. One hundred percent of Sun Lake's shoreline consists of wetland. There is no development around the lake and no erosion was occurring along any part of the shoreline. The only negative aspect to the shoreline around the lake was that invasive plant species, Purple Loosestrife and Reed Canary Grass were present in areas around 100% of the shoreline. This does not mean that the shoreline is made up solely of these plants, but that they are present among native plants and cattails around the entire shoreline of the lake. These plants are extremely invasive and exclude native plants from the areas they inhabit. Reed Canary Grass and Purple Loosestrife are common to wetland areas and compete with native plants. Additionally, they do not provide the quality habitat that native plants provide. The relative densities of Purple Loosestrife and Reed Canary Grass were high along the wetland areas of Sun Lake and steps to eliminate these plants should be carried out before they take over these areas.

The shoreline was reassessed in 2008 for significant changes in erosion since 2001. Based on the 2008 assessment, 100% of Sun Lake's shoreline had no erosion (Figure 9). Wetland, woodland, and especially buffered shorelines should be maintained.

Table 7. Floristic quality index (FQI) of lakes in Lake County, calculated with exotic species (w/Adventives) and with native species only (native).

RANK	LAKE NAME	FQI (w/A)	FQI (native)
1	Cedar Lake	36.3	38.4
2	East Loon Lake	30.6	32.7
3	Cranberry Lake	30.1	31.6
4	Deep Lake	29.7	31.2
5	Little Silver	29.6	31.6
6	Round Lake Marsh North	29.1	29.9
7	Deer Lake	28.2	29.7
8	Sullivan Lake	28.2	29.7
9	Schreiber Lake	26.8	27.6
10	Bangs Lake	25.7	27.4
11	West Loon Lake	25.7	27.3
12	Cross Lake	25.2	27.8
13	Independence Grove	24.6	27.5
14	Sterling Lake	24.5	26.9
15	Lake Zurich	24.3	27.1
16	**Sun Lake**	**24.3**	**26.1**
17	Lake of the Hollow	23.8	26.2
18	Lakewood Marsh	23.8	24.7
19	Round Lake	23.5	25.9
20	Honey Lake	23.3	25.1
21	Fourth Lake	23.0	24.8
22	Druce Lake	22.8	25.2
23	Countryside Glen Lake	21.9	22.8
24	Butler Lake	21.4	23.1
25	Duck Lake	21.1	22.9
26	Timber Lake (North)	20.8	22.8
27	Broberg Marsh	20.5	21.4
28	Davis Lake	20.5	21.4
29	ADID 203	20.5	20.5
30	McGreal Lake	20.2	22.1
31	Lake Kathryn	19.6	20.7
32	Fish Lake	19.3	21.2
33	Owens Lake	19.3	20.2
34	Redhead Lake	19.3	21.2
35	Turner Lake	18.6	21.2
36	Wooster Lake	18.5	20.2
37	Salem Lake	18.5	20.2
38	Lake Miltmore	18.4	20.3
39	Hendrick Lake	17.7	17.7
40	Summerhill Estates Lake	17.1	18.0
41	Seven Acre Lake	17.0	15.5
42	Gray's Lake	16.9	19.8
43	Lake Barrington	16.7	17.7
44	Bresen Lake	16.6	17.8

Table 7. Continued

Rank	LAKE NAME	FQI (w/A)	FQI (native)
45	Diamond Lake	16.3	17.4
46	Lake Napa Suwe	16.3	17.4
47	Windward Lake	16.3	17.6
48	Dog Bone Lake	15.7	15.7
49	Redwing Slough	15.6	16.6
50	Osprey Lake	15.5	17.3
51	Lake Fairview	15.2	16.3
52	Heron Pond	15.1	15.1
53	Lake Tranquility (S1)	15.0	17.0
54	North Churchill Lake	15.0	15.0
55	Dog Training Pond	14.7	15.9
56	Island Lake	14.7	16.6
57	Highland Lake	14.5	16.7
58	Grand Avenue Marsh	14.3	16.3
59	Taylor Lake	14.3	16.3
60	Dugdale Lake	14.0	15.1
61	Eagle Lake (S1)	14.0	15.1
62	Longview Meadow Lake	13.9	13.9
63	Ames Pit	13.4	15.5
64	Bishop Lake	13.4	15.0
65	Hook Lake	13.4	15.5
66	Long Lake	13.1	15.1
67	Buffalo Creek Reservoir	13.1	14.3
68	Mary Lee Lake	13.1	15.1
69	McDonald Lake 2	13.1	14.3
70	Old School Lake	13.1	15.1
71	Dunn's Lake	12.7	13.9
72	Old Oak Lake	12.7	14.7
73	Timber Lake (South)	12.7	14.7
74	White Lake	12.7	14.7
75	Hastings Lake	12.5	14.8
76	Sand Lake	12.5	14.8
77	Stone Quarry Lake	12.5	12.5
78	Lake Carina	12.1	14.3
79	Lake Leo	12.1	14.3
80	Lambs Farm Lake	12.1	14.3
81	Pond-A-Rudy	12.1	12.1
82	Stockholm Lake	12.1	13.5
83	Grassy Lake	12	12
84	Lake Matthews	12.0	12.0
85	Flint Lake	11.8	13.0
86	Harvey Lake	11.8	13.0
87	Rivershire Pond 2	11.5	13.3
88	Antioch Lake	11.3	13.4
89	Lake Charles	11.3	13.4
90	Lake Linden	11.3	11.3

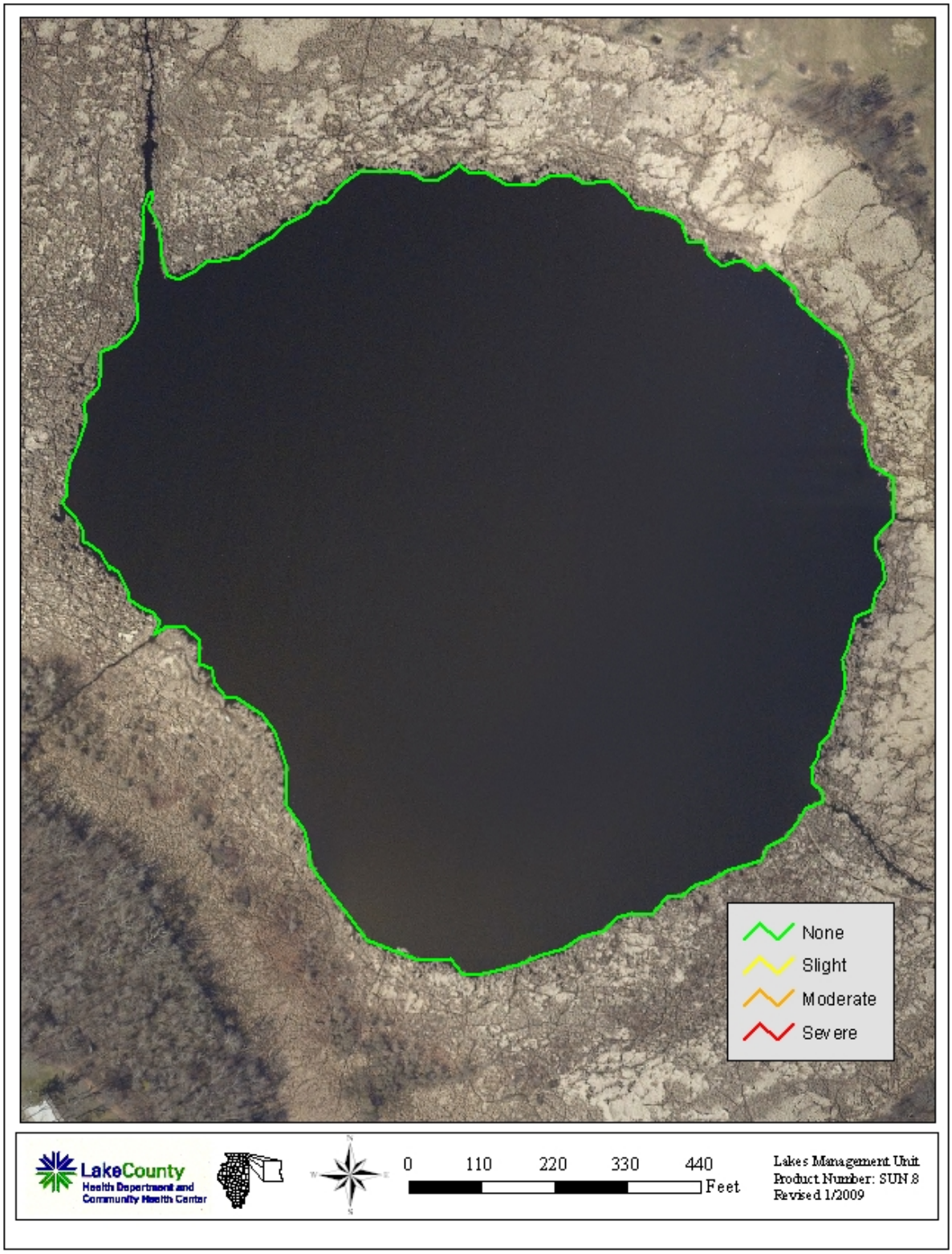
Table 7. Continued

Rank	LAKE NAME	FQI (w/A)	FQI (native)
91	Lake Naomi	11.2	12.5
92	Pulaski Pond	11.2	12.5
93	Lake Minear	11.0	13.9
94	Redwing Marsh	11.0	11.0
95	Tower Lake	11.0	11.0
96	West Meadow Lake	11.0	11.0
97	Nielsen Pond	10.7	12.0
98	Lake Holloway	10.6	10.6
99	Third Lake	10.2	12.5
100	Crooked Lake	10.2	12.5
101	College Trail Lake	10.0	10.0
102	Lake Lakeland Estates	10.0	11.5
103	Valley Lake	9.9	9.9
104	Werhane Lake	9.8	12.0
105	Big Bear Lake	9.5	11.0
106	Little Bear Lake	9.5	11.0
107	Loch Lomond	9.4	12.1
108	Columbus Park Lake	9.2	9.2
109	Sylvan Lake	9.2	9.2
110	Lake Louise	9	10.4
111	Fischer Lake	9.0	11.0
112	Grandwood Park Lake	9.0	11.0
113	Lake Fairfield	9.0	10.4
114	McDonald Lake 1	8.9	10.0
115	Countryside Lake	8.7	10.6
116	East Meadow Lake	8.5	8.5
117	Lake Christa	8.5	9.8
118	Lake Farmington	8.5	9.8
119	Lucy Lake	8.5	9.8
120	South Churchill Lake	8.5	8.5
121	Bittersweet Golf Course #13	8.1	8.1
122	Woodland Lake	8.1	9.9
123	Albert Lake	7.5	8.7
124	Banana Pond	7.5	9.2
125	Fairfield Marsh	7.5	8.7
126	Lake Eleanor	7.5	8.7
127	Patski Pond	7.1	7.1
128	Rasmussen Lake	7.1	7.1
129	Slough Lake	7.1	7.1
130	Lucky Lake	7.0	7.0
131	Lake Forest Pond	6.9	8.5
132	Leisure Lake	6.4	9.0
133	Peterson Pond	6.0	8.5
134	Gages Lake	5.8	10.0
135	Slocum Lake	5.8	7.1
136	Deer Lake Meadow Lake	5.2	6.4

Table 7. Continued

Rank	LAKE NAME	FQI (w/A)	FQI (native)
137	ADID 127	5.0	5.0
138	Drummond Lake	5.0	7.1
139	IMC Lake	5.0	7.1
140	Liberty Lake	5.0	5.0
141	Oak Hills Lake	5.0	5.0
142	Forest Lake	3.5	5.0
143	Sand Pond (IDNR)	3.5	5.0
144	Half Day Pit	2.9	5.0
145	Lochanora Lake	2.5	5.0
146	Echo Lake	0.0	0.0
147	Hidden Lake	0.0	0.0
148	North Tower Lake	0.0	0.0
149	Potomac Lake	0.0	0.0
150	St. Mary's Lake	0.0	0.0
151	Waterford Lake	0.0	0.0
152	Willow Lake	0.0	0.0
	Mean	**13.6**	**14.9**
	Median	**12.5**	**14.3**

Figure 9. Shoreline erosion on Sun Lake, 2008.



OBSERVATIONS OF WILDLIFE AND HABITAT

Wildlife observations were made on a monthly basis during water quality and plant sampling activities. All observations were either visual or audible and many types of waterfowl and songbirds were observed over the course of the study. Wildlife habitat in the form of wetland and woodland was abundant around Sun Lake. Sun Lake offers uncommon opportunities for Lake County due to the fact that it is completely owned by the Forest Preserve and contains a variety of habitats that can support a diversity of wildlife including fish, reptiles, mammals and birds. Therefore it's very important that the natural areas be maintained to provide the appropriate habitat for all wildlife species in the future.

In 2002 Sun Lake was included in a fish survey for the Northeastern Illinois Endangered and Threatened Species Recovery Project. The goal was to determine the conservation status of Blacknose Shiner, Blackchin Shiner, Pugnose Shiner, and Banded Killifish from streams, marshes, and glacial lakes to develop a management/recovery plan for Blacknose Shiner, and Blackchin Shiner. In Sun Lake the entire littoral zone was sampled around the entire perimeter of the lake using a backpack electroshocking unit. Five species were found the most abundant was Bluegill with 18 collected. Central Mudminnow (14) and Largemouth bass (9) were observed and Warmouth (3) and Green Sunfish (1) were present.

LAKE MANAGEMENT RECOMMENDATIONS

- **Reduce conductivity and chlorides**

  Conductivity concentrations in Sun Lake have increased by 31% since the 2001 average. The average chloride concentration was 222 mg/L, and the county median was 166 mg/L. The use of road salts for winter road management is a major contributor to chloride concentrations and conductivity. Proper application procedures and alternative methods can be used to keep these concentrations under control (Appendix D1).

- **Participate in the volunteer lake monitoring program (VLMP)**

  To track future water quality trends, it is recommended the lake become enrolled in the Volunteer Lake Monitoring Program (VMLP), which trains a volunteer to measure the Secchi disk readings on a bimonthly basis from April to October (Appendix D2). In addition to the VMLP, a staff gauge should be installed to monitor the lake level each month.

- **Assess your lake's fishery**

  Sun Lake's fish community was assessed in 2002 for the Northeastern Illinois Endangered and Threatened Species Recovery Project. Regular fisheries assessments should be conducted to determine the diversity and health of the fish community (Appendix D3).

- **Grant program opportunities**

  There are opportunities to receive grants to help accomplish some of the management recommendations listed above (Appendix F).

APPENDIX A. METHODS FOR FIELD DATA COLLECTION AND LABORATORY ANALYSES

Water Sampling and Laboratory Analyses

Two water samples were collected once a month from May through September. Sample locations were at the deepest point in the lake (see sample site map), three feet below the surface, and 3 feet above the bottom. Samples were collected with a horizontal Van Dorn water sampler. Approximately three liters of water were collected for each sample for all lab analyses. After collection, all samples were placed in a cooler with ice until delivered to the Lake County Health Department lab, where they were refrigerated. Analytical methods for the parameters are listed in Table A1. Except nitrate nitrogen, all methods are from the Eighteenth Edition of Standard Methods, (eds. American Public Health Association, American Water Works Association, and Water Pollution Control Federation, 1992). Methodology for nitrate nitrogen was taken from the 14th edition of Standard Methods. Dissolved oxygen, temperature, conductivity and pH were measured at the deep hole with a Hydrolab DataSonde® 4a. Photosynthetic Active Radiation (PAR) was recorded using a LI-COR® 192 Spherical Sensor attached to the Hydrolab DataSonde® 4a. Readings were taken at the surface and then every two feet until reaching the bottom.

Plant Sampling

In order to randomly sample each lake, mapping software (ArcMap 9.3) overlaid a grid pattern onto an aerial photo of Lake County and placed points 60 or 30 meters apart, depending on lake size. Plants were sampled using a garden rake fitted with hardware cloth. The hardware cloth surrounded the rake tines and is tapered two feet up the handle. A rope was tied to the end of the handle for retrieval. At designated sampling sites, the rake was tossed into the water, and using the attached rope, was dragged across the bottom, toward the boat. After pulling the rake into the boat, plant coverage was assessed for overall abundance. Then plants were individually identified and placed in categories based on coverage. Plants that were not found on the rake but were seen in the immediate vicinity of the boat at the time of sampling were also recorded. Plants difficult to identify in the field were placed in plastic bags and identified with plant keys after returning to the office. The depth of each sampling location was measured either by a hand-held depth meter, or by pushing the rake straight down and measuring the depth along the rope or rake handle. One-foot increments were marked along the rope and rake handle to aid in depth estimation.

Shoreline Assessment

In previous years a complete assessment of the shoreline was done. However, this year we did a visual estimate to determine changes in the shoreline. The degree of shoreline erosion was categorically defined as none, slight, moderate, or severe. Below are brief descriptions of each category.

> None – Includes man-made erosion control such as beach, rip-rap and sea wall.
>
> Slight – Minimal or no observable erosion; generally considered stable; no erosion control practices will be recommended with the possible exception of small problem areas noted within an area otherwise designated as “slight”.

Moderate – Recession is characterized by past or recently eroded banks; area may exhibit some exposed roots, fallen vegetation or minor slumping of soil material; erosion control practices may be recommended although the section is not deemed to warrant immediate remedial action.

Severe – Recession is characterized by eroding of exposed soil on nearly vertical banks, exposed roots, fallen vegetation or extensive slumping of bank material, undercutting, washouts or fence posts exhibiting realignment; erosion control practices are recommended and immediate remedial action may be warranted.

Wildlife Assessment

Species of wildlife were noted during visits to each lake. When possible, wildlife was identified to species by sight or sound. However, due to time constraints, collection of quantitative information was not possible. Thus, all data should be considered anecdotal.
Some of the species on the list may have only been seen once, or were spotted during their migration through the area.

Table A1. Analytical methods used for water quality parameters.

Parameter	***Method***
Temperature	Hydrolab DataSonde® 4a or YSI 6600 Sonde®
Dissolved oxygen	Hydrolab DataSonde ®4a or YSI 6600 Sonde®
Nitrate and Nitrite nitrogen	USEPA 353.2 rev. 2.0 EPA-600/R-93/100 Detection Limit = 0.05 mg/L
Ammonia nitrogen	SM 18th ed. Electrode method, #4500 NH_3-F Detection Limit = 0.1 mg/L
Total Kjeldahl nitrogen	SM 18th ed, 4500-N_{org} C Semi-Micro Kjeldahl, plus 4500 NH_3-F Detection Limit = 0.5 mg/L
pH	Hydrolab DataSonde® 4a, or YSI 6600 Sonde® Electrometric method
Total solids	SM 18th ed, Method #2540B
Total suspended solids	SM 18th ed, Method #2540D Detection Limit = 0.5 mg/L
Chloride	SM 18th ed, Method #4500C1-D
Total volatile solids	SM 18th ed, Method #2540E, from total solids
Alkalinity	SM 18th ed, Method #2320B, patentiometric titration curve method
Conductivity	Hydrolab DataSonde® 4a or YSI 6600 Sonde®
Total phosphorus	SM 18th ed, Methods #4500-P B 5 and #4500-P E Detection Limit = 0.01 mg/L
Soluble reactive phosphorus	SM 18th ed, Methods #4500-P B 1 and #4500-P E Detection Limit = 0.005 mg/L
Clarity	Secchi disk
Color	Illinois EPA Volunteer Lake Monitoring Color Chart
Photosynthetic Active Radiation (PAR)	Hydrolab DataSonde® 4a or YSI 6600 Sonde®, LI-COR® 192 Spherical Sensor

APPENDIX B. MULTI-PARAMETER DATA FOR SUN LAKE IN 2008.

Sun Lake 2008 Multiparameter data

Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission Average	Extinction Coefficient
											0.202
05/20/2008	0	0.476	15.45	9.78	98.2	1.094	8.02	2210.4	Surface		
05/20/2008	1	1.007	15.45	9.78	98.2	1.094	8.03	1366.6	Surface	100%	
05/20/2008	2	2.028	15.46	9.75	98.0	1.093	8.04	881.0	0.36	40%	1.226
05/20/2008	3	2.992	15.44	9.75	97.9	1.094	8.03	567.7	1.32	26%	0.332
05/20/2008	4	4.056	15.42	9.76	98.0	1.081	8.03	512.1	2.39	23%	0.043
05/20/2008	6	6.047	15.40	9.76	98.0	1.094	8.04	372.7	4.38	17%	0.073
05/20/2008	8	8.004	15.36	9.78	98.1	1.082	8.04	192.7	6.33	9%	0.104
05/20/2008	10	9.924	15.35	9.75	97.7	1.094	8.05	123.1	8.25	6%	0.054
05/20/2008	12	12.016	15.00	9.47	94.2	1.095	8.00	66.3	10.35	3%	0.060
05/20/2008	14	14.084	14.54	8.37	82.4	1.095	7.92	38.9	12.41	2%	0.043
05/20/2008	16	16.222	13.42	4.04	38.9	1.086	7.75	19.4	14.55	0.9%	0.048
05/20/2008	18	17.964	12.80	2.10	19.9	1.085	7.63	10.3	16.29	0.5%	0.039

Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission Average	Extinction Coefficient
											0.402
06/17/2008	0	0	21.94	10.11	105.6	1.050	8.41	3887	Surface		
06/18/2008	1	1	21.94	9.83	113.0	1.051	8.29	3233	Surface	100%	
06/19/2008	2	2	21.93	10.04	115.3	1.052	8.22	1184	0.33	37%	3.044
06/20/2008	3	3	21.92	10.14	116.1	1.052	8.14	802	1.33	25%	0.293
06/21/2008	4	4	21.91	10.24	117.4	1.052	8.12	610	2.33	19%	0.117
06/22/2008	6	6	21.88	10.37	118.7	1.052	8.09	209	4.33	6%	0.247
06/23/2008	8	8	21.82	10.48	119.8	1.053	8.05	122	6.33	4%	0.085
06/24/2008	10	10	21.49	10.13	115.0	1.052	7.98	60	8.33	2%	0.085
06/25/2008	12	12	17.81	2.62	27.3	1.087	7.80	37	10.33	1.1%	0.047
06/26/2008	14	14	15.96	0.31	3.2	1.081	7.72	22	12.33	0.7%	0.042
06/27/2008	16	16	14.86	0.26	2.0	1.098	7.64	15	14.33	0.7%	0.036
06/28/2008	18	18	14.31	0.11	1.1	1.092	7.51	10	16.33	0.5%	0.023

Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission Average	Extinction Coefficient
											0.184
07/15/2008	0	0.523	24.82	8.12	98.3	1.004	9.19	3303.6	Surface		
07/15/2008	1	1.061	24.82	8.15	98.5	1.003	8.40	3186.8	Surface	100%	
07/15/2008	2	1.960	24.81	8.10	97.9	1.004	8.24	1140.3	0.29	96%	0.124
07/15/2008	3	3.126	24.66	8.14	98.2	1.004	8.19	669.7	1.46	35%	0.706
07/15/2008	4	4.118	24.60	8.04	96.9	1.005	8.16	415.7	2.45	20%	0.217
07/15/2008	6	5.869	23.62	7.14	84.5	1.003	8.11	262.6	4.20	13%	0.114
07/15/2008	8	8.167	23.28	5.73	67.3	1.021	7.98	115.4	6.50	8%	0.071
07/15/2008	10	10.022	22.32	4.37	50.4	1.025	7.82	53.3	8.35	3.5%	0.098
07/15/2008	12	11.880	20.35	1.92	21.3	1.061	7.71	24.4	10.21	1.6%	0.076
07/15/2008	14	13.938	18.87	1.48	16.0	1.067	7.67	12.0	12.27	0.7%	0.064
07/15/2008	16	15.917	16.23	0.50	5.2	1.112	7.57	4.2	14.25	0.4%	0.050
07/15/2008	18	17.976	15.55	0.32	3.2	1.116	7.43	1.1	16.31	0.1%	0.064

	Text							PAR	Depth of	% Light	

Date MMDDYY	Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	æE/s/mý	Light Meter feet	Transmission Average	Extinction Coefficient
											0.114
08/19/2008	0	0.524	25.26	8.14	99.2	1.067	8.60	1556.5	Surface		
08/19/2008	1	1.003	25.26	8.23	100.4	1.068	8.54	1511.1	Surface	100%	
08/19/2008	2	2.015	25.27	8.22	100.3	1.068	8.52	637.1	0.35	97%	0.086
08/19/2008	3	2.935	25.26	8.16	99.6	1.068	8.50	251.5	1.27	41%	0.683
08/19/2008	4	3.998	25.22	8.11	98.8	1.068	8.50	135.8	2.33	16%	0.399
08/19/2008	5	4.993	25.19	7.94	96.7	1.069	8.49	127.9	3.32	9%	0.185
08/19/2008	6	5.997	24.78	7.13	86.1	1.071	8.45	86.9	4.33	8.2%	0.014
08/19/2008	7	7.019	24.29	7.03	84.2	1.065	8.37	61.0	5.35	5.6%	0.072
08/19/2008	8	7.921	24.02	6.68	79.6	1.064	8.31	46.8	6.25	3.9%	0.057
08/19/2008	8	9.026	23.44	5.93	69.9	1.059	8.22	31.2	7.36	3.0%	0.036
08/19/2008	10	10.108	22.78	5.06	58.9	1.059	8.15	22.0	8.44	2.0%	0.048
08/19/2008	11	11.012	21.74	2.51	28.6	1.048	8.07	15.4	9.34	1.4%	0.037
08/19/2008	12	11.971	20.72	2.34	26.1	1.041	8.00	9.6	10.30	1.0%	0.035
08/19/2008	13	13.031	19.01	0.57	6.2	1.072	7.90	4.9	11.36	0.6%	0.042
08/19/2008	14	14.048	17.82	0.22	2.3	1.132	7.78	2.2	12.38	0.3%	0.054
08/19/2008	15	15.017	17.15	0.15	1.5	1.166	7.69	1.0	13.35	0.1%	0.060
08/19/2008	16	16.034	16.32	0.13	1.4	1.192	7.64	0.4	14.36	0.1%	0.055
08/19/2008	17	17.001	15.77	0.12	1.2	1.209	7.58	0.3	15.33	0.03%	0.060
08/19/2008	18	17.932	15.75	0.10	1.0	1.087	7.54	0.2	16.26	0.02%	0.018

APPENDIX C. INTERPRETING YOUR LAKE'S WATER QUALITY DATA

Lakes possess a unique set of physical and chemical characteristics that will change over time. These in-lake water quality characteristics, or parameters, are used to describe and measure the quality of lakes, and they relate to one another in very distinct ways. As a result, it is virtually impossible to change any one component in or around a lake without affecting several other components, and it is important to understand how these components are linked.

The following pages will discuss the different water quality parameters measured by Lake County Health Department staff, how these parameters relate to each other, and why the measurement of each parameter is important. The median values (the middle number of the data set, where half of the numbers have greater values, and half have lesser values) of data collected from Lake County lakes from 2000-2008 will be used in the following discussion.

Temperature and Dissolved Oxygen:

Water temperature fluctuations will occur in response to changes in air temperatures, and can have dramatic impacts on several parameters in the lake. In the spring and fall, lakes tend to have uniform, well-mixed conditions throughout the water column (surface to the lake bottom). However, during the summer, deeper lakes will separate into distinct water layers. As surface water temperatures increase with increasing air temperatures, a large density difference will form between the heated surface water and colder bottom water. Once this difference is large enough, these two water layers will separate and generally will not mix again until the fall. At this time the lake is thermally stratified. The warm upper water layer is called the ***epilimnion***, while the cold bottom water layer is called the ***hypolimnion***. In some shallow lakes, stratification and destratification can occur several times during the summer. If this occurs the lake is described as polymictic. Thermal stratification also occurs to a lesser extent during the winter, when warmer bottom water becomes separated from ice-forming water at the surface until mixing occurs during spring ice-out.

Monthly temperature profiles were established on each lake by measuring water temperature every foot (lakes $\leq$ 15 feet deep) or every two feet (lakes > 15 feet deep) from the lake surface to the lake bottom. These profiles are important in understanding the distribution of chemical/biological characteristics and because increasing water temperature and the establishment of thermal stratification have a direct impact on dissolved oxygen (DO) concentrations in the water column. If a lake is shallow and easily mixed by wind, the DO concentration is usually consistent throughout the water column. However, shallow lakes are typically dominated by either plants or algae, and increasing water temperatures during the summer speeds up the rates of photosynthesis and decomposition in surface waters. When many of the plants or algae die at the end of the growing season, their decomposition results in heavy oxygen consumption and can lead to an oxygen crash. In deeper, thermally stratified lakes, oxygen production is greatest in the top portion of the lake, where sunlight drives photosynthesis, and oxygen consumption is greatest near the bottom of a lake, where sunken organic matter accumulates and decomposes. The oxygen difference between the top and bottom water layers can be dramatic, with plenty of oxygen near the surface, but practically none near the bottom. The oxygen profiles measured during the water quality study can illustrate if

this is occurring. This is important because the absence of oxygen (anoxia) near the lake bottom can have adverse effects in eutrophic lakes resulting in the chemical release of phosphorus from lake sediment and the production of hydrogen sulfide (rotten egg smell) and other gases in the bottom waters. Low oxygen conditions in the upper water of a lake can also be problematic since all aquatic organisms need oxygen to live. Some oxygen may be present in the water, but at too low a concentration to sustain aquatic life. Oxygen is needed by all plants, virtually all algae and for many chemical reactions that are important in lake functioning. Most adult sport-fish such as largemouth bass and bluegill require at least 3 mg/L of DO in the water to survive. However, their offspring require at least 5 mg/L DO as they are more sensitive to DO stress. When DO concentrations drop below 3 mg/L, rough fish such as carp and green sunfish are favored and over time will become the dominant fish species.

External pollution in the form of oxygen-demanding organic matter (i.e., sewage, lawn clippings, soil from shoreline erosion, and agricultural runoff) or nutrients that stimulate the growth of excessive organic matter (i.e., algae and plants) can reduce average DO concentrations in the lake by increasing oxygen consumption. This can have a detrimental impact on the fish community, which may be squeezed into a very small volume of water as a result of high temperatures in the epilimnion and low DO levels in the hypolimnion.

Nutrients:

Phosphorus:
For most Lake County lakes, phosphorus is the nutrient that limits plant and algae growth. This means that any addition of phosphorus to a lake will typically result in algae blooms or high plant densities during the summer. The source of phosphorus to a lake can be external or internal (or both). External sources of phosphorus enter a lake through point (i.e., storm pipes and wastewater discharge) and non-point runoff (i.e., overland water flow). This runoff can pick up large amounts of phosphorus from agricultural fields, septic systems or impervious surfaces before it empties into the lake.

Internal sources of phosphorus originate within the lake and are typically linked to the lake sediment. In lakes with high oxygen levels (oxic), phosphorus can be released from the sediment through plants or sediment resuspension. Plants take up sediment-bound phosphorus through their roots, releasing it in small amounts to the water column throughout their life cycles, and in large amounts once they die and begin to decompose. Sediment resuspension can occur through biological or mechanical means. Bottom-feeding fish, such as common carp and black bullhead can release phosphorus by stirring up bottom sediment during feeding activities and can add phosphorus to a lake through their fecal matter. Sediment resuspension, and subsequent phosphorus release, can also occur via wind/wave action or through the use of artificial aerators, especially in shallow lakes. In lakes that thermally stratify, internal phosphorus release can occur from the sediment through chemical means. Once oxygen is depleted (anoxia) in the hypolimnion, chemical reactions occur in which phosphorus bound to iron complexes in the sediment becomes soluble and is released into the water column. This phosphorus is trapped in the hypolimnion and is unavailable to algae until fall turnover, and can cause algae blooms once

it moves into the sunlit surface water at that time. Accordingly, many of the lakes in Lake County are plagued by dense algae blooms and excessive, exotic plant coverage, which negatively affect DO levels, fish communities and water clarity.

Lakes with an average phosphorus concentration greater than 0.05 mg/L are considered nutrient rich. The median near surface total phosphorus (TP) concentration in Lake County lakes from 2000-2008 is 0.065 mg/L and ranged from a non-detectable minimum of <0.010 mg/L on five lakes to a maximum of 3.880 mg/L on Albert Lake. The median anoxic TP concentration in Lake County lakes from 2000-2008 was 0.181 mg/L and ranged from a minimum of 0.012 mg/L in Independence Grove Lake to a maximum of 3.880 mg/L in Taylor Lake.

The analysis of phosphorus also included soluble reactive phosphorus (SRP), a dissolved form of phosphorus that is readily available for plant and algae growth. SRP is not discussed in great detail in most of the water quality reports because SRP concentrations vary throughout the season depending on how plants and algae absorb and release it. It gives an indication of how much phosphorus is available for uptake, but, because it does not take all forms of phosphorus into account, it does not indicate how much phosphorus is truly present in the water column. TP is considered a better indicator of a lake's nutrient status because its concentrations remain more stable than soluble reactive phosphorus. However, elevated SRP levels are a strong indicator of nutrient problems in a lake.

Nitrogen:
Nitrogen is also an important nutrient for plant and algae growth. Sources of nitrogen to a lake vary widely, ranging from fertilizer and animal wastes, to human waste from sewage treatment plants or failing septic systems, to groundwater, air and rainfall. As a result, it is very difficult to control or reduce nitrogen inputs to a lake. Different forms of nitrogen are present in a lake under different oxic conditions. NH_4^+ (ammonium) is released from decomposing organic material under anoxic conditions and accumulates in the hypolimnion of thermally stratified lakes. If NH_4^+ comes into contact with oxygen, it is immediately converted to NO_2 (nitrite) which is then oxidized to NO_3^- (nitrate). Therefore, in a thermally stratified lake, levels of NH_4^+ would only be elevated in the hypolimnion and levels of NO_3^- would only be elevated in the epilimnion. Both NH_4^+ and NO_3^- can be used as a nitrogen source by aquatic plants and algae. Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen plus ammonium. Adding the concentrations of TKN and nitrate together gives an indication of the amount of total nitrogen present in the water column. If inorganic nitrogen (NO_3^-, NO_2^-, NH_4^+) concentrations exceed 0.3 mg/L in spring, sufficient nitrogen is available to support summer algae blooms. However, low nitrogen levels do not guarantee limited algae growth the way low phosphorus levels do. Nitrogen gas in the air can dissolve in lake water and blue-green algae can "fix" atmospheric nitrogen, converting it into a usable form. Since other types of algae do not have the ability to do this, nuisance blue-green algae blooms are typically associated with lakes that are nitrogen limited (i.e., have low nitrogen levels).

The ratio of TKN plus nitrate nitrogen to total phosphorus (TN:TP) can indicate whether plant/algae growth in a lake is limited by nitrogen or phosphorus. Ratios of less than 10:1

suggest a system limited by nitrogen, while lakes with ratios greater than 20:1 are limited by phosphorus. It is important to know if a lake is limited by nitrogen or phosphorus because any addition of the limiting nutrient to the lake will, likely, result in algae blooms or an increase in plant density.

Solids:

Although several forms of solids (total solids, total suspended solids, total volatile solids, total dissolved solids) were measured each month by the Lakes Management Staff, total suspended solids (TSS) and total volatile solids (TVS) have the most impact on other variables and on the lake as a whole. TSS are particles of algae or sediment suspended in the water column. High TSS concentrations can result from algae blooms, sediment resuspension, and/or the inflow of turbid water, and are typically associated with low water clarity and high phosphorus concentrations in many lakes in Lake County. Low water clarity and high phosphorus concentrations, in turn, exacerbate the high TSS problem by leading to reduced plant density (which stabilize lake sediment) and increased occurrence of algae blooms. The median TSS value in epilimnetic waters in Lake County is 8.2 mg/L, ranging from below the 0.1 mg/L detection limit to 165 mg/L in Fairfield Marsh.

TVS represents the fraction of total solids that are organic in nature, such as algae cells, tiny pieces of plant material, and/or tiny animals (zooplankton) in the water column. High TVS values indicate that a large portion of the suspended solids may be made up of algae cells. This is important in determining possible sources of phosphorus to a lake. If much of the suspended material in the water column is determined to be resuspended sediment that is releasing phosphorus, this problem would be addressed differently than if the suspended material was made up of algae cells that were releasing phosphorus. The median TVS value was 132.8 mg/L, ranging from 34.0 mg/L in Pulaski Pond to 298.0 mg/L in Fairfield Marsh.

Total dissolved solids (TDS) are the amount of dissolved substances, such as salts or minerals, remaining in water after evaporation. These dissolved solids are discussed in further detail in the *Alkalinity* and *Conductivity* sections of this document. TDS concentrations were measured in Lake County lakes prior to 2004, but was discontinued due to the strong correlation of TDS to conductivity and chloride concentrations.

Water Clarity:

Water clarity (transparency) is not a chemical property of lake water, but is often an indicator of a lake's overall water quality. It is affected by a lake's water color, which is a reflection of the amount of total suspended solids and dissolved organic chemicals. Thus, transparency is a measure of particle concentration and is measured with a Secchi disk. Generally, the lower the clarity or Secchi depth, the poorer the water quality. A decrease in Secchi depth during the summer occurs as the result of an increase in suspended solids (algae or sediment) in the water column. Aquatic plants play an important role in the level of water clarity and can, in turn, be negatively affected by low clarity levels. Plants increase clarity by competing with algae for

resources and by stabilizing sediments to prevent sediment resuspension. A lake with a healthy plant community will almost always have higher water clarity than a lake without plants. Additionally, if the plants in a lake are removed (through herbicide treatment or the stocking of grass carp), the lake will probably become dominated by algae and Secchi depth will decrease. This makes it very difficult for plants to become re-established due to the lack of available sunlight and the lake will, most likely, remain turbid. Turbidity will be accelerated if the lake is very shallow and/or common carp are present. Shallow lakes are more susceptible to sediment resuspension through wind/wave action and are more likely to experience clarity problems if plants are not present to stabilize bottom sediment.

Common Carp are prolific fish that feed on invertebrates in the sediment. Their feeding activities stir up bottom sediment and can dramatically decrease water clarity in shallow lakes. As mentioned above, lakes with low water clarity are, generally, considered to have poor water quality. This is because the causes and effects of low clarity negatively impact the plant and fish communities, as well as the levels of phosphorus in a lake. The detrimental impacts of low Secchi depth to plants has already been discussed. Fish populations will suffer as water clarity decreases due to a lack of food and decreased ability to successfully hunt for prey. Bluegills are planktivorous fish and feed on invertebrates that inhabit aquatic plants. If low clarity results in the disappearance of plants, this food source will disappear too. Largemouth Bass and Northern Pike are piscivorous fish that feed on other fish and hunt by sight. As the water clarity decreases, these fish species find it more difficult to see and ambush prey and may decline in size as a result. This could eventually lead to an imbalance in the fish community. Phosphorus release from resuspended sediment could increase as water clarity and plant density decrease. This would then result in increased algae blooms, further reducing Secchi depth and aggravating all problems just discussed. The average Secchi depth for Lake County lakes is 3.12 feet. From 2000-2008, Fairfield Marsh and Patski Pond had the lowest Secchi depths (0.33 feet) and Bangs Lake had the highest (29.23 feet). As an example of the difference in Secchi depth based on plant coverage, South Churchill Lake, which had no plant coverage and large numbers of Common Carp in 2003 had an average Secchi depth of 0.73 feet (over four times lower than the county average), while Deep Lake, which had a diverse plant community and few carp had an average 2003 Secchi depth of 12.48 feet (almost four times higher than the county average).

Another measure of clarity is the use of a light meter. The light meter measures the amount of light at the surface of the lake and the amount of light at each depth in the water column. The amount of attenuation and absorption (decreases) of light by the water column are major factors controlling temperature and potential photosynthesis. Light intensity at the lake surface varies seasonally and with cloud cover, and decreases with depth. The deeper into the water column light penetrates, the deeper potential plant growth. The maximum depth at which algae and plants can grow underwater is usually at the depth where the amount of light available is reduced to 0.5%-1% of the amount of light available at the lake surface. This is called the euphotic (sunlit) zone. A general rule of thumb in Lake County is that the 1% light level is about 1 to 3 times the Secchi disk depth.

Alkalinity, Conductivity, Chloride, pH:

Alkalinity:

Alkalinity is the measurement of the amount of acid necessary to neutralize carbonate ($CO_3^{=}$) and bicarbonate (HCO_3^{-}) ions in the water, and represents the buffering capacity of a body of water. The alkalinity of lake water depends on the types of minerals in the surrounding soils and in the bedrock. It also depends on how often the lake water comes in contact with these minerals. If a lake gets groundwater from aquifers containing limestone minerals such as calcium carbonate ($CaCO_3$) or dolomite ($CaMgCO_3$), alkalinity will be high. The median alkalinity in Lake County lakes (162 mg/L) is considered moderately hard according to the hardness classification scale of Brown, Skougstad and Fishman (1970). Because hard water (alkaline) lakes often have watersheds with fertile soils that add nutrients to the water, they usually produce more fish and aquatic plants than soft water lakes. Since the majority of Lake County lakes have a high alkalinity they are able to buffer the adverse effects of acid rain.

Conductivity and Chloride:

Conductivity is the inverse measure of the resistance of lake water to an electric flow. This means that the higher the conductivity, the more easily an electric current is able to flow through water. Since electric currents travel along ions in water, the more chemical ions or dissolved salts a body of water contains, the higher the conductivity will be. Accordingly, conductivity has been correlated to total dissolved solids and chloride ions. The amount of dissolved solids or conductivity of a lake is dependent on the lake and watershed geology, the size of the watershed flowing into the lake, the land uses within that watershed, and evaporation and bacterial activity. Many Lake County lakes have elevated conductivity levels in May, but not during any other month. This was because chloride, in the form of road salt, was washing into the lakes with spring rains, increasing conductivity. Most road salt is sodium chloride, calcium chloride, potassium chloride, magnesium chloride or ferrocyanide salts. Beginning in 2004, chloride concentrations are one of the parameters measured during the lake studies. Increased chloride concentrations may have a negative impact on aquatic organisms. Conductivity changes occur seasonally and with depth. For example, in stratified lakes the conductivity normally increases in the hypolimnion as bacterial decomposition converts organic materials to bicarbonate and carbonate ions depending on the pH of the water. These newly created ions increase the conductivity and total dissolved solids. Over the long term, conductivity is a good indicator of potential watershed or lake problems if an increasing trend is noted over a period of years. It is also important to know the conductivity of the water when fishery assessments are conducted, as electroshocking requires a high enough conductivity to properly stun the fish, but not too high as to cause injury or death.

pH:
pH is the measurement of hydrogen ion (H^+) activity in water. The pH of pure water is neutral at 7 and is considered acidic at levels below 7 and basic at levels above 7. Low pH levels of 4-5 are toxic to most aquatic life, while high pH levels (9-10) are not only toxic to aquatic life but may also result in the release of phosphorus from lake sediment. The presence of high plant densities can increase pH levels through photosynthesis, and lakes dominated by a large amount of plants or algae can experience large fluctuations in pH levels from day to night, depending on the rates of photosynthesis and respiration. Few, if any pH problems exist in Lake County lakes. Typically, the flooded gravel mines in the county are more acidic than the glacial lakes as they have less biological activity, but do not usually drop below pH levels of 7. The median near surface pH value of Lake County lakes is 8.32, with a minimum of 7.06 in Deer Lake and a maximum of 10.28 in Round Lake Marsh North.

Eutrophication and Trophic State Index:

The word *eutrophication* comes from a Greek word meaning "well nourished." This also describes the process in which a lake becomes enriched with nutrients. Over time, this is a lake's natural aging process, as it slowly fills in with eroded materials from the surrounding watershed and with decaying plants. If no human impacts disturb the watershed or the lake, natural eutrophication can take thousands of years. However, human activities on a lake or in the watershed accelerate this process by resulting in rapid soil erosion and heavy phosphorus inputs. This accelerated aging process on a lake is referred to as cultural eutrophication. The term trophic state refers to the amount of nutrient enrichment within a lake system. *Oligotrophic* lakes are usually deep and clear with low nutrient levels, little plant growth and a limited fishery. *Mesotrophic* lakes are more biologically productive than oligotrophic lakes and have moderate nutrient levels and more plant growth. A lake labeled as *eutrophic* is high in nutrients and can support high plant densities and large fish populations. Water clarity is typically poorer than oligotrophic or mesotrophic lakes and dissolved oxygen problems may be present. A *hypereutrophic* lake has excessive nutrients, resulting in nuisance plant or algae growth. These lakes are often pea-soup green, with poor water clarity. Low dissolved oxygen may also be a problem, with fish kills occurring in shallow, hypereutrophic lakes more often than less enriched lakes. As a result, rough fish (tolerant of low dissolved oxygen levels) dominate the fish community of many hypereutrophic lakes. The categorization of a lake into a certain trophic state should not be viewed as a "good to bad" categorization, as most lake residents rate their lake based on desired usage. For example, a fisherman would consider a plant-dominated, clear lake to be desirable, while a water-skier might prefer a turbid lake devoid of plants. Most lakes in Lake County are eutrophic or hypereutrophic. This is primarily as a result of cultural eutrophication. However, due to the fertile soil in this area, many lakes (especially man-made) may have started out under eutrophic conditions and will never attain even mesotrophic conditions, regardless of any amount of money put into the management options. This is not an excuse to allow a lake to continue to deteriorate, but may serve as a reality check for lake owners attempting to create unrealistic conditions in their lakes.

The Trophic State Index (TSI) is an index which attaches a score to a lake based on its average

total phosphorus concentration, its average Secchi depth (water transparency) and/or its average chlorophyll *a* concentration (which represent algae biomass). It is based on the principle that as phosphorus levels increase, chlorophyll *a* concentrations increase and Secchi depth decreases. The higher the TSI score, the more nutrient-rich a lake is, and once a score is obtained, the lake can then be designated as oligotrophic, mesotrophic or eutrophic. Table 1 (below) illustrates the Trophic State Index using phosphorus concentration and Secchi depth.

Table 1. Trophic State Index (TSI).

Trophic State	TSI score	Total Phosphorus (mg/L)	Secchi Depth (feet)
Oligotrophic	<40	≤ 0.012	>13.12
Mesotrophic	≥40<50	>0.012 ≤ 0.024	≥6.56<13.12
Eutrophic	≥50<70	>0.024 ≤ 0.096	≥1.64<6.56
Hypereutrophic	≥70	>0.096	< 1.64

APPENDIX D. LAKE MANAGEMENT OPTIONS.

D1. Options to Reduce Conductivity and Chloride Concentrations

Road salt (sodium chloride) is the most commonly used winter road de-icer. While recent advances in the technology of salt spreaders have increased the efficiency to allow more even distribution, the effect to the surrounding environment has come into question. Whether it is used on highways for public safety or on your sidewalk and driveway to ensure your own safety, the main reason for road salt's popularity is that it is a low cost option. However, it could end up costing you more in the long run from the damages that result from its application.

Excess salt can effect soil and in turn plant growth. This can lead to the die-off of beneficial native plant species that cannot tolerate high salt levels, and lead to the increase of non-native, and/or invasive species that can.

Road salts end up in waterways either directly or through groundwater percolation. The problem is that animals do not use chloride and therefore it builds up in a system. This can lead to decreases in dissolved oxygen, which can lead to a loss of biodiversity.

The Lakes Management Unit monitors the levels of salts in surface waters in the county by measuring conductivity and chloride concentrations (which are correlated to each other). There has been an overall increase in salt levels that has been occurring over the past couple of decades. These increases could have detrimental effects on plants, fish and animals living and using the water.

What can you do to help maintain or reduce chloride levels?

Option 1. Proper Use on Your Property

Ultimately, the less you use of any product, the better. Physically removing as much snow and ice as possible before applying a de-icing agent is the most important step. Adding more products before removing what has already melted can result in over application, meaning unnecessary chemicals ending up in run-off to near by streams and lakes.

Option 2. Examples of Alternatives

While alternatives may contain chloride, they tend to work faster at lower temperatures and therefore require less application to achieve the same result that common road salt would.
Calcium, Magnesium or Potassium Chloride

- Aided by the intense heat evolved during its dissolution, these are used as ice-melting compounds.

Calcium Magnesium Acetate (CMA)

- Mixture of dolomic lime and acetic acid; can also be made from cheese whey and may have even better ice penetration.
- Benefits: low corrosion rates, safe for concrete, low toxicity and biodegradable, stays on surfaces longer (fewer applications necessary).

- Multi-Purpose: use straight, mix with sodium chloride, sand or as a liquid
- Negatives: slow action at low temperatures, higher cost.

Agricultural Byproducts

- Usually mixed with calcium chloride to provide anti-corrosion properties.
- Lower the freezing point of the salt they are added to.
- as a pre-wetting (anti-ice) agent, it's like a Teflon treatment to which ice and snow will not stick.

Local hardware and home improvement stores should carry at least one salt alternative. Some names to look for: Zero Ice Melt Jug, Vaporizer, Ice Away, and many others. Check labels or ask a sales associate before you buy in order to ensure you are purchasing a salt alternative.

Option 3. Talk to Your Municipality About Using an Alternative

Many municipalities are testing or already using alternative products to keep the roads safe. Check with your municipality and encourage the use of these products.

D2. Participate in the Volunteer Lake Monitoring Program

In 1981, the Illinois Volunteer Lake Monitoring Program (VLMP) was established by the Illinois Environmental Protection Agency (Illinois EPA) to gather fundamental information on Illinois' inland lakes, and to provide an educational program for citizens. Approximately 165 lakes (of 3,041 lakes in Illinois) are sampled annually by approximately 300 volunteers. The volunteers are lakeshore residents, lake owners/managers, members of environmental groups, public water supply personnel, and/or citizens with interest in a particular lake.

The VLMP relies on volunteers to gather a variety of information on their chosen lake. The primary measurement is Secchi disk depth. Analysis of the Secchi disk measurement provides an indication of the general water quality condition of the lake, as well as the amount of usable habitat available for fish and other aquatic life.

Microscopic plants and animals, water color, and suspended sediments are factors that interfere with light penetration through the water column and lessen the Secchi disk depth. As a rule, one to three times the Secchi depth is considered the lighted zone of the lake. In this region of the lake there is enough light to allow plants to grow and produce oxygen. Water below the lighted zone can be expected to have little or no dissolved oxygen. Other observations such as water color, suspended algae and sediment, aquatic plants, and odor are also recorded. The sampling season is May through October with volunteer measurements taken twice a month. After volunteers have completed one year of the basic monitoring program, they are qualified to participate in the Expanded Monitoring Program. In the expanded program, volunteers are trained to collect water samples that are shipped to the Illinois EPA laboratory for analysis of total and volatile suspended solids, total phosphorus, nitrate-nitrite nitrogen and ammonia nitrogen. Other parameters that are part of the expanded program include dissolved oxygen, temperature, and zebra mussel monitoring. Additionally, chlorophyll *a* monitoring has been added to the regiment for selected lakes.

For information, please contact:

VLMP Regional Coordinator:
Holly Hudson
Chicago Metropolitan Agency for Planning
233 S. Wacker Drive, Suite 880
Chicago, IL 60606
(312) 386-8700

D3. Options to Assess Your Lake's Fishery

Many lakes have a fish-stocking program in which fish are stocked every year or two to supplement fish species already occurring in the lake or to introduce additional fish species into the system. However, few lakes that participate in stocking check the progress or success of these programs with regular fish surveys. Lake managers should have information about whether or not funds delegated to fish stocking are being well spent, and it is difficult to determine how stocked fish species are surviving and reproducing or how they are affecting the rest of the fish community without a comprehensive fish assessment.

A simple, inexpensive way to collect information on the status of a fishery is to sample anglers actively involved in recreational fishing on the lake and evaluate the types, numbers and sizes of fish caught. Such information provides insight on the status of fish populations in the lake, as well as a direct measure of the quality of fishing and the fishing experience. However, the numbers and types of fish sampled by anglers are limited, focusing on game and catchable-sized fish. Thus, in order to obtain a comprehensive assessment of the fish community, including non-game fish species, more quantitative methods such as gill netting, trap netting, seining, trawling, angling (hook and line fishing) and electroshocking must be employed. Each method has its advantages and limitations, and frequently multiple gears are employed. The best gear and sampling methods depend on the target species and life stage, the types of information desired, and the environment to be sampled.

It is best to monitor fish populations annually. The best time of year depends on the sampling method, the target fish species, and the types of data to be collected. In many lakes and regions, the best time to sample fish is during the fall turnover period after thermal stratification breaks down and the lake is completely mixed because: (1) young-of-year (YOY) and age 1+ (one year or older) fish of most target species should be present and vulnerable to most standard collection gear, including seines, trap nets and electroshockers; (2) species that dwell in the hypolimnion during the summer may be more vulnerable to capture during fall overturn; and (3) lower water temperatures in the fall can help reduce sampling-related mortality. Sampling locations are also species, life stage, and gear dependent. As with sampling methods and time, locations should be selected to maximize capture efficiency for the target species of interest and provide the greatest gain in information for the least amount of sampling effort.

The Illinois Department of Natural Resources (IDNR) will perform a fish survey at no charge on most public and some private water bodies. In order to determine if your lake is eligible for a survey by the IDNR, contact Frank Jakubecik, Fisheries Biologist, at (815) 675-2319. If a lake

is not eligible for an IDNR fish survey or if a more comprehensive survey is desired, contact the Lakes Management Unit for a list of consultants.

APPENDIX E. WATER QUALITY STATISTICS FOR ALL LAKE COUNTY LAKES.

2000 - 2008 Water Quality Parameters, Statistics Summary

	ALKoxic <=3ft00-2008	
Average	**167**	
Median	**162**	
Minimum	**65**	**IMC**
Maximum	**330**	**Flint Lake**
STD	**42**	
n =	**802**	

	ALKanoxic 2000-2008	
Average	**202**	
Median	**194**	
Minimum	**103**	**Heron Pond**
Maximum	**470**	**Lake Marie**
STD	**50**	
n =	**243**	

	Condoxic <=3ft00-2008	
Average	**0.8934**	
Median	**0.8195**	
Minimum	**0.2542**	**Broberg Marsh**
Maximum	**6.8920**	**IMC**
STD	**0.5250**	
n =	**806**	

	Condanoxic 2000-2008	
Average	**1.0312**	
Median	**0.8695**	
Minimum	**0.3210**	**Lake Kathyrn**
Maximum	**7.4080**	**IMC**
STD	**0.7985**	
n =	**243**	

	NO3-N, Nitrate+Nitrite,oxic <=3ft00-2008	
Average	**0.508**	
Median	**0.156**	
Minimum	**<0.05**	***ND**
Maximum	**9.670**	**South Churchill Lake**
STD	**1.073**	
n =	**807**	

*ND = Many lakes had non-detects (74.1%)
Only compare lakes with detectable concentrations to the statistics above
Beginning in 2006, Nitrate+Nitrite was measured.

	NH3-Nanoxic 2000-2008	
Average	**2.192**	
Median	**1.630**	
Minimum	**<0.1**	***ND**
Maximum	**18.400**	**Taylor Lake**
STD	**2.343**	
n =	**243**	

*ND = 19.8% Non-detects from 28 different lakes

	pHoxic <=3ft00-2008	
Average	**8.32**	
Median	**8.32**	
Minimum	**7.07**	**Bittersweet #13**
Maximum	**10.28**	**Round Lake Marsh North**
STD	**0.44**	
n =	**801**	

	pHanoxic 2000-2008	
Average	**7.28**	
Median	**7.28**	
Minimum	**6.24**	**Banana Pond**
Maximum	**8.48**	**Heron Pond**
STD	**0.42**	
n =	**243**	

	All Secchi 2000-2008	
Average	**4.51**	
Median	**3.12**	
Minimum	**0.33**	**Fairfield Marsh, Patski Pon**
Maximum	**24.77**	**West Loon Lake**
STD	**3.78**	
n =	**749**	

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2000 - 2008 Water Quality Parameters, Statistics Summary (continued)

	TKNoxic <=3ft00-2008	
Average	**1.450**	
Median	**1.200**	
Minimum	**<0.1**	***ND**
Maximum	**10.300**	**Fairfield Marsh**
STD	**0.845**	
n =	**802**	

*ND = 3.9% Non-detects from 15 different lakes

	TKNanoxic 2000-2008	
Average	**2.973**	
Median	**2.330**	
Minimum	**<0.5**	***ND**
Maximum	**21.000**	**Taylor Lake**
STD	**2.324**	
n =	**243**	

*ND = 2.9% Non-detects from 4 different lakes

	TPoxic <=3ft00-2008	
Average	**0.105**	
Median	**0.065**	
Minimum	**<0.01**	***ND**
Maximum	**3.880**	**Albert Lake**
STD	**0.218**	
n =	**808**	

*ND = 2.6% Non-detects from 9 different lakes

	TPanoxic 2000-2008	
Average	**0.316**	
Median	**0.181**	
Minimum	**0.012**	**Independ. Grove**
Maximum	**3.800**	**Taylor Lake**
STD	**0.419**	
n =	**243**	

	TSSall <=3ft00-2008	
Average	**15.5**	
Median	**8.2**	
Minimum	**<0.1**	***ND**
Maximum	**165.0**	**Fairfield Marsh**
STD	**20.3**	
n =	**813**	

*ND = 1.5% Non-detects from 9 different lakes

	TVSoxic <=3ft00-2008	
Average	**132.8**	
Median	**129.0**	
Minimum	**34.0**	**Pulaski Pond**
Maximum	**298.0**	**Fairfield Marsh**
STD	**39.8**	
n =	**757**	

No 2002 IEPA Chain Lakes

	TDSoxic <=3ft00-2004	
Average	**470**	
Median	**454**	
Minimum	**150**	**Lake Kathryn, White**
Maximum	**1340**	**IMC**
STD	**169**	
n =	**745**	

No 2002 IEPA Chain Lakes.

	CLanoxic <=3ft00-2008	
Average	**234**	
Median	**139**	
Minimum	**41**	**Timber Lake (N)**
Maximum	**2390**	**IMC**
STD	**364**	
n =	**125**	

	CLoxic <=3ft00-2008	
Average	**210**	
Median	**166**	
Minimum	**30**	**White Lake**
Maximum	**2760**	**IMC**
STD	**233**	
n =	**470**	

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Anoxic conditions are defined <=1 mg/l D.O.
pH Units are equal to the -Log of [H] ion activity
Conductivity units are in MilliSiemens/cm
Secchi Disk depth units are in feet
All others are in mg/L

Minimums and maximums are based on data from all lakes from 2000-2008 (n=1351).

Average, median and STD are based on data from the most recent water quality sampling year for each lake.

LCHD Lakes Management Unit ~ 12/1/2008

APPENDIX F. GRANT PROGRAM OPPORTUNITES

Table F1. Potential Grant Opportunities

Grant Program Name	Funding Source	Contact Information	Funding Focus				Cost Share
			Water Quality/ Wetland	Habitat	Erosion	Flooding	
Challenge Grant Program	USFWS	847-381-2253 or 309-793-5800		X	X		
Chicago Wilderness Small Grants	CW	312-346-8166 ext. 30					None
Partners in Conservation (formerly C2000)	IDNR	http://dnr.state.il.us/orep/c2000/		X			None
Conservation Reserve Program	NRCS	http://www.nrcs.usda.gov/programs/crp/		X			Land
Ecosystems Program	IDNR	http://dnr.state.il.us/orep/c2000/ecosystem/		X			None
Emergency Watershed Protection	NRCS	http://www.nrcs.usda.gov/programs/ewp/			X	X	None
Five Star Challenge	NFWF	http://www.nfwf.org/AM/Template.cfm		X			None
Illinois Flood Mitigation Assistance Program	IEMA	http://www.state.il.us/iema/construction.htm				X	None
Great Lakes Basin Program	GLBP	http://www.glc.org/basin/stateproj.html?st=il	X		X		None
Illinois Clean Energy Community Foundation	ICECF	http://www.illinoiscleanenergy.org/		X			
Illinois Clean Lakes Program	IEPA	http://www.epa.state.il.us/water/financial-assistance/index.html					None
Lake Education Assistance Program (LEAP)	IEPA	http://www.epa.state.il.us/water/conservation-2000/leap/index.html	X				$500

CW = Chicago Wilderness
ICECF = Illinois Clean Energy Community Foundation
IEMA = Illinois Emergency Management Agency
IEPA = Illinois Environmental Protection Agency
IDNR = Illinois Department of Natural Resources
IDOA = Illinois Department of Agriculture
LCSMC = Lake County Stormwater Management Commission
LCSWCD = Lake County Soil and Water Conservation District
NFWF = National Fish and Wildlife Foundation
NRCS = Natural Resources Conservation Service
USACE = United States Army Corps of Engineers
USFWS = United States Fish and Wildlife Service

Table F1. Continued

Grant Program Name	Funding Source	Contact Information	Funding Focus				Cost Share
			Water Quality/ Wetland	Habitat	Erosion	Flooding	
Northeast Illinois Wetland Conservation Account	USFWF	847-381-2253	X				
Partners for Fish and Wildlife	USFWS	http://ecos.fws.gov/partners/		X			> 50%
River Network's Watershed Assistance Grants Program	River Network	http://www.rivernetwork.org	X	X	X		na
Section 206: Aquatic Ecosystems Restoration	USACE	312-353-6400, 309-794-5590 or 314-331-8404		X			35%
Section 319: Non-Point Source Management Program	IEPA	http://www.epa.state.il.us/water/financial-assistance/non point.html	X	X			>40%
Section 1135: Project Modifications for the Improvement of the Environment	USACE	312-353-6400, 309-794-5590 or 314-331-8404		X			25%
Stream Cleanup And Lakeshore Enhancement (SCALE)	IEPA	http://www.epa.state.il.us/water/watershed/scale.html	X	X			None
Streambank Stabilization & Restoration (SSRP)	IDOA/ LCSWCD	http://www.agr.state.il.us/Environment/conserv/ or call LCSWCD at (847) 223-1056		X	X		25%
Watershed Management Boards	LCSMC	http://www.co.lake.il.us/smc/projects/wmb/default.asp	X		X	X	50%
Wetlands Reserve Program	NRCS	http://www.nrcs.usda.gov/programs/wrp/	X	X			Land
Wildlife Habitat Incentive Program	NRCS	http://www.nrcs.usda.gov/programs/whip/		X			Land

CW = Chicago Wilderness
ICECF = Illinois Clean Energy Community Foundation
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IDNR = Illinois Department of Natural Resources
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