2008 SUMMARY REPORT
of
Deep Lake

Lake County, Illinois

Prepared by the

LAKE COUNTY HEALTH DEPARTMENT
ENVIRONMENTAL HEALTH SERVICES
LAKES MANAGEMENT UNIT

3010 Grand Avenue
Waukegan, Illinois 60085

Kathleen Paap
Michael Adam
Leonard Dane
Kelly Deem

TABLE OF CONTENTS

APPENDICES

EXECUTIVE SUMMARY

Deep Lake is a 226-acre glacial lake in the Village of Lake Villa in northern Lake County. Deep Lake receives water from Cedar Lake and drains to Sun Lake and later East Loon Lake, finally draining into Sequiot Creek. The lake is a recreational lake used primarily for fishing, hunting, boating, and swimming.

Deep 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.

The overall water quality of Deep Lake is very good. It remains one of the highest quality lakes in Lake County. Dissolved oxygen concentrations in the epilimnion did not indicate any significant problems during 2008. Anoxic conditions (< 1 mg/L) existed from May through September in the hypolimnion. The anoxic boundary ranged from 30 feet (May) to 18 feet (August). This represents approximately 25% to 40% of the lake volume based on a bathymetric map created by the Lakes Management Unit in 1989.

Water clarity averaged 6.39 feet during 2008 which was a 20% increase from the 2003 average of 5.32 feet. Generally an increase in water clarity is correlated with a decrease in total suspended solids (TSS), however, the TSS increased from 2003 (4.1 mg/L) to 2008 (4.6 mg/L).

The Lake County epilimnetic median conductivity reading was 0.8195 milliSiemens per centimeter (mS/cm). During 2008 the Deep Lake average epilimnetic conductivity reading was higher at 1.0726 mS/cm. This was a 13% increase from the average conductivity recorded in 2003 (0.9520 mS/cm). Total phosphorus concentrations have remained relatively stable since 1992 (0.021). In 2008 Deep Lake had a TP concentration of 0.025 mg/L.

Deep Lake had a diverse aquatic plant community with 21 plant species and one macro-algae found. Eurasian Watermilfoil (EWM) was the top dominant species and it was found at 70% of the sites sampled in August 2008. Illinois Pondweed and Chara were other co-dominant plant species found in the lake. White-Stemmed Pondweed, a state endangered species, was among the plant species found within the lake. It was found at 5% of the sites sampled in August in both 2003 and 2008. Another exotic, invasive plant, Curlyleaf Pondweed, was also present in the lake.

The shoreline was reassessed in 2008 for significant changes in erosion since 2003. Based on the 2008 assessment, there was an increase in shoreline erosion with approximately 39% of the shoreline having some degree of erosion. Overall, 60% of the shoreline had no erosion, 20% had slight erosion, 11% had moderate erosion, and 8% had severe erosion.

LAKE FACTS

Lake Name:	Deep Lake
Historical Name:	None
Nearest Municipality:	Lake Villa
Location:	T46N, R20E, Sections 33 and 34
Elevation:	777.5 feet msl
Major Tributaries:	Cedar Lake
Watershed:	Fox River
Sub-watershed:	Sequoit Creek
Receiving Waterbody:	Sun Lake
Surface Area:	225.6 acres
Shoreline Length:	3.4 miles
Maximum Depth:	47.5 feet
Average Depth:	17.5 feet
Lake Volume:	3955.0 acre-feet
Lake Type:	Glacial
Watershed Area:	1402.9 acres
Major Watershed Land Uses:	Water, Single Family, Forest and Grassland
Bottom Ownership:	Lake Villa, Private
Management Entities:	Deep Lake Improvement Association, Village of Lake Villa, Ishnala Estates Homeowner's Association, Deep Lake Shores
Current and Historical Uses:	Fishing, hunting, swimming, and boating
Description of Access:	Pubic and private access for fee

SUMMARY OF WATER QUALITY

Water samples were collected monthly from May through September at the deepest point in the lake (Figure 1, Appendix A). Deep Lake was sampled at depths of three feet and at three feet from the bottom. The samples were analyzed for various water quality parameters (Appendix C). Deep Lake participated in the Volunteer Lake Monitoring Program (VLMP) from 1988 to 2008 collecting data on years when the Lakes Management Unit (LMU) was not sampling the lake. The LMU also has data on Deep Lake in 1989, 1992, 1993, 1998 and 2003. Deep Lake is near the top of the Sequiot Creek watershed which the LMU sampled in its entirety in 2008. This watershed also includes Cedar Lake, Sun Lake, East Loon Lake, West Loon Lake, and Little Silver Lake.

Deep Lake was thermally stratified from June through September. Thermal stratification is when a lake divides into an upper, warm water layer (epilimnion) and a lower, cold-water layer (hypolimnion). When stratified, the epilimnetic and hypolimnetic waters do not mix, and the hypolimnion typically experiences anoxic conditions (where dissolved oxygen (DO) concentrations drop below 1 mg/L) by mid-summer. In 2008, Deep Lake was weakly stratified in June and strongly stratified at approximately 18 feet by August. The thermocline (the transitional region between the epilimnion and the hypolimnion) remained strong through the season. Turnover (mixing) was beginning during the September sampling, although the thermocline was still present at approximately 22 feet.

A DO concentration of 5.0 mg/L is considered adequate to support a sunfish/bass fishery, since these fish can suffer oxygen stress below this amount. DO concentrations in the epilimnion did not indicate any significant problems (Appendix B). Anoxic conditions existed from June through September in the hypolimnion. This is a normal phenomenon in large, deep lakes that stratify. The anoxic boundary ranged from 30 feet in June to 18 feet in July. This represents approximately 25% to 40% of the lake volume based on a bathymetric map created by the Lakes Management Unit in 1989. Because lakes change over time, it is recommended that any map 15 years or older be updated.

Secchi disk depth (water clarity) as measured by the LMU averaged 8.14 feet during 2008 and 12.48 feet during 2003 (Table 1). Both of these readings were above the 2008 Lake County median of 3.12 feet (Appendix E). The VLMP average Secchi depths were similar between the years 1999 through 2006, however between 2006 and 2008, the water clarity has decreased from an average of 12.15 feet in 2006 to 8.14 feet in 2008 (Figure 2).

Generally a decrease in water clarity is correlated with an increase in total suspended solids (TSS) (Figure 3), this holds true for Deep Lake as there was an increase in TSS from that recorded in 2003. TSS, which is composed of nonvolatile suspended solids, non-organic clay or sediment materials, and volatile suspended solids, algae and other organic matter, in the epilimnion averaged 3.0 mg/L in 2008, while in 2003 it averaged less than 2.4 mg/L. Both years the values were below the 2008 county median of 8.2 mg/L. The increase was likely due to the rains occurring within 48 hours of sampling during the summer of 2008. The rains were noted as varying from light to heavy and were likely responsible for the fluctuation in Secchi depth and water level measurements. There was a total 21 inches of rainfall from May though September

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

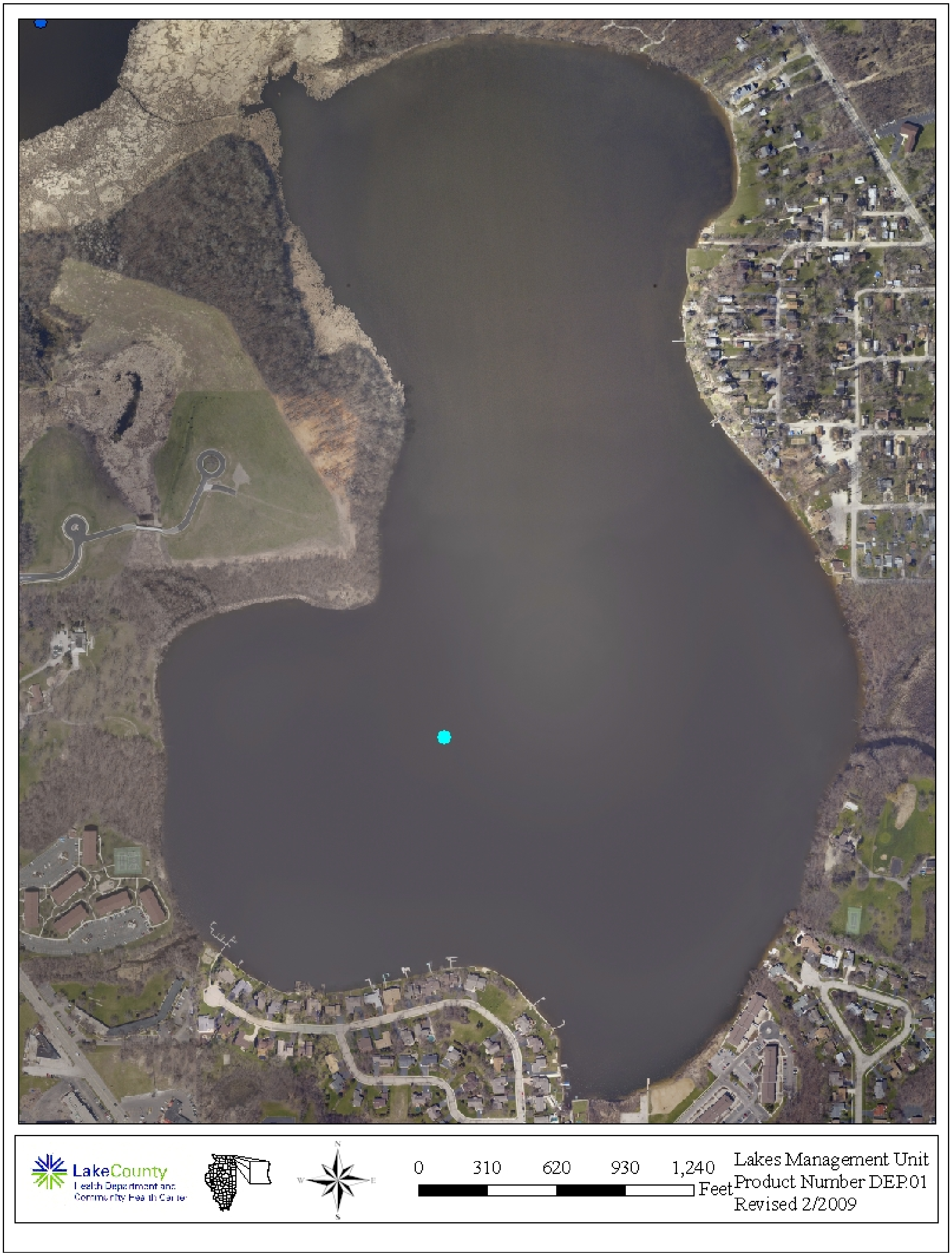


Table 1. Water quality data for Deep Lake 2003 and 2008

2008	Epilimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
14-May	3	160	0.96	<0.100	<0.050	0.029	<0.005	245	NA	3.1	937	123	6.56	1.1430	8.35	9.49
11-Jun	3	148	0.77	<0.100	<0.050	0.024	<0.005	233	NA	2.3	637	142	10.34	1.0810	8.59	10.60
09-Jul	3	141	0.92	<0.100	<0.050	0.025	<0.005	228	NA	3.7	598	127	5.91	1.0470	8.64	8.11
13-Aug	3	133	0.74	<0.100	<0.050	0.023	<0.005	225	NA	3.1	614	151	10.43	1.0290	8.8	8.24
10-Sep	3	131	0.80	<0.100	<0.050	0.016	<0.005	227	NA	2.9	393	116	7.48	1.0630	8.68	8.36
	Average	143	0.84	<0.100	<0.050	0.023	<0.005	232	NA	3.0	636	132	8.14	1.0726	8.61	8.96

2003	Epilimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N*	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
20-May	3	154	1.10	<0.100	<0.050	0.037	<0.005	NA	516	3.3	543	105	7.05	0.9724	8.68	9.45
18-Jun	3	148	1.00	<0.100	<0.050	0.030	<0.005	NA	554	1.3	553	135	17.77	0.9593	8.78	9.43
23-Jul	3	136	0.97	<0.100	<0.050	0.021	<0.005	NA	510	3.2	546	121	9.02	0.9257	8.84	8.83
20-Aug	3	136	0.73	<0.100	<0.050	0.012	<0.005	NA	534	<1.0	547	136	17.55	0.9465	8.70	7.77
24-Sep	3	146	0.85	<0.100	<0.050	0.020	<0.005	NA	484	1.9	516	99	10.99	0.9562	8.71	7.84
	Average	144	0.93	<0.100	<0.050	0.024	<0.005	NA	520	2.4[k]	541	119	12.48	0.9520	8.74	8.66

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 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

k = Denotes that the actual value is known to be less than the value presented.

NA= Not applicable

* = Prior to 2006 only Nitrate - nitrogen was analyzed

2008	Hypolimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
14-May	42	162	1.03	0.252	<0.050	0.038	0.000	246	NA	2.1	633	104	NA	1.1680	7.50	3.17
11-Jun	44	170	1.48	0.820	<0.050	0.107	0.071	249	NA	2.7	676	139	NA	1.1780	7.52	0.16
09-Jul	44	174	1.76	1.080	<0.050	0.158	0.118	248	NA	1.7	678	127	NA	1.1640	7.31	0.12
13-Aug	43	180	2.12	1.360	<0.050	0.196	0.142	247	NA	3.3	688	151	NA	1.1680	7.71	0.11
10-Sep	43	187	2.54	1.920	<0.050	0.209	0.201	249	NA	7.7	439	116	NA	1.2260	7.65	0.10
	Average	175	1.79	1.086	<0.050	0.142	0.106	248	NA	3.5	623	127	NA	1.1808	7.54	6.44

2003	Hypolimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N*	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
20-May	42	155	1.09	0.198	<0.050	0.037	0.009	NA	518	1.8	536	123	NA	0.9717	7.54	1.46
18-Jun	43	167	1.56	0.575	<0.050	0.127	0.076	NA	526	1.9	553	100	NA	0.9687	7.35	0.01
23-Jul	43	172	1.86	0.934	<0.050	0.184	0.149	NA	536	2.0	589	137	NA	0.9711	7.3	0.00
20-Aug	43	181	2.17	1.300	<0.050	0.218	0.165	NA	498	3.3	542	126	NA	0.9856	7.27	0.03
24-Sep	42	195	2.35	1.670	<0.050	0.224	0.211	NA	492	1.6	526	98	NA	0.9882	7.17	0.02
	Average	174	1.81	0.935	<0.050	0.158	0.122	NA	514	2.1	549	117	NA	0.9771	7.33	0.30

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 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

k = Denotes that the actual value is known to be less than the value presented.
NA= Not applicable
* = Prior to 2006 only Nitrate - nitrogen was analyzed

Figure 2. Secchi disk averages from VLMP and LCHD records for Deep Lake, 1986 – 2008

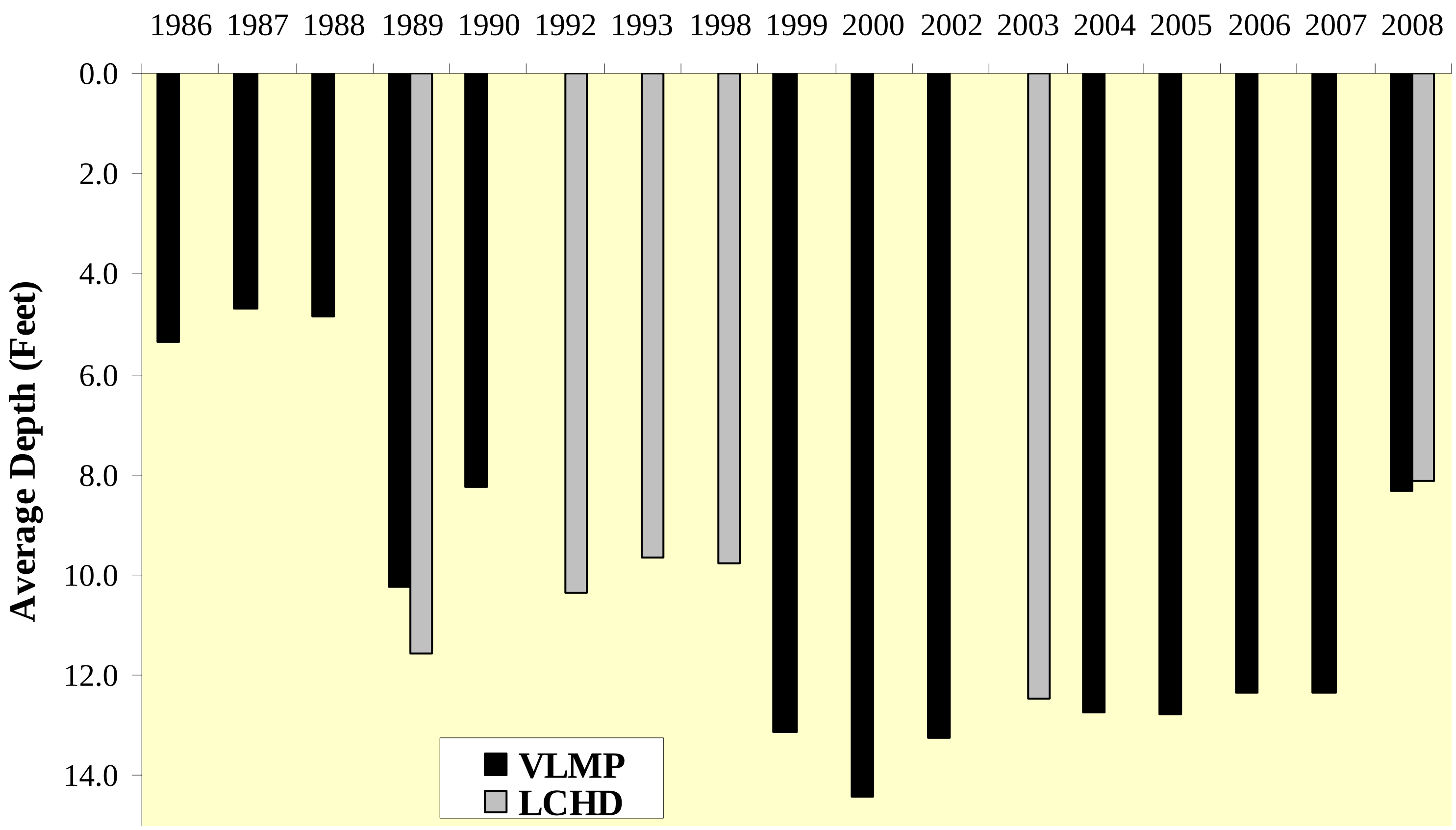
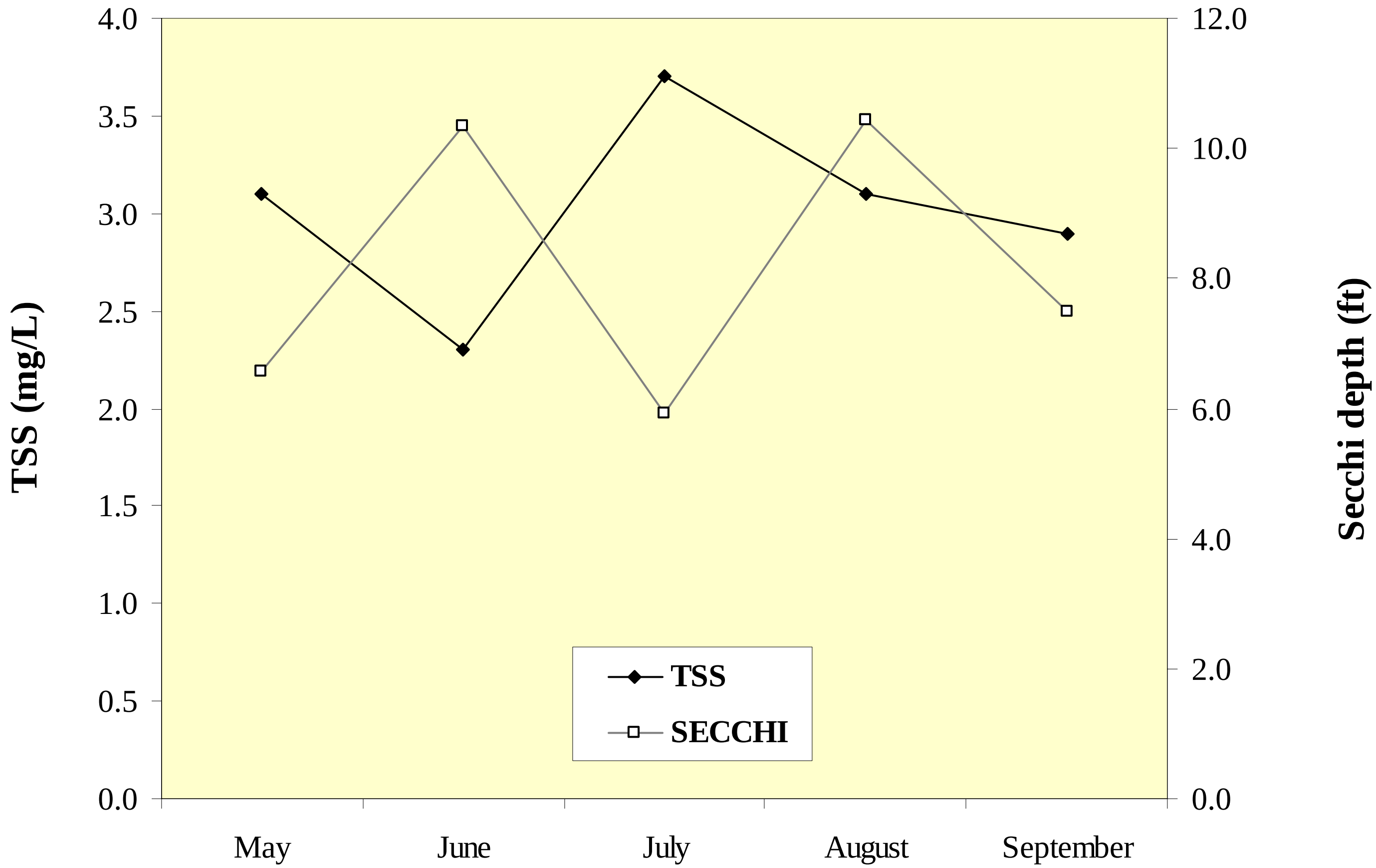


Figure 3. Total suspended solid (TSS) concentrations vs. Secchi depth for Deep Lake, 2008.



as recorded at the Stormwater Management Commission's rain gauge in Antioch. Water levels rose 3.5 inches between May and June, in July the levels fell approximately 8 inches and then increased 2.3 inches in August and continued to rise an additional 0.75 inches through September. Large water fluctuations, like those that occurred in Deep Lake during 2008, can be responsible for shoreline erosion in a lake. It is recommended that a permanent staff gauge be installed in the lake so that lake water levels can be monitored on a regular basis.

Deep Lake had the third highest Secchi depth recorded in the Sequoit Creek Watershed (Table 2). West Loon and Little Silver Lake were the only two lakes to have deeper Secchi depths recorded in 2008, and are also at the top of their watersheds. West Loon Lake had the highest recorded Secchi disk reading at 16.64 ft., however, this lake has Zebra Mussels. Zebra Mussels not only can affect the amount of solids present in the water but also the quality of the solids present (removing algae and plankton from the water leaving inorganic solids behind). The TSS concentration in Deep Lake was the second highest recorded in the watershed just behind East Loon Lake at 4.6 mg/L.

Another factor affecting water clarity was the amount of nutrients in the water. Typically, lakes are either phosphorus (P) or nitrogen (N) limited. This means that one of the nutrients is in short supply and any addition of that nutrient to the lake will result in an increase of plant and/or algal growth. Most lakes in Lake County are phosphorus limited. To compare the availability of nitrogen and phosphorus, a ratio of total nitrogen to total phosphorus (TN:TP) is used. Ratios less than or equal to 10:1 indicate nitrogen is limiting, ratios greater than or equal to 15:1 indicate phosphorus is limiting, and ratios greater than 10:1, but less than 15:1 indicate there is enough of both nutrients to facilitate excess algae or plant growth. Deep Lake had a TN:TP ratio and 36:1 in 2008, indicating the lake was phosphorous limited. Nitrogen naturally occurs in high concentrations and come from a variety of sources (soil, air, etc.), which are more difficult to control than sources of phosphorus. Lakes that are phosphorus limited may be easier to manage since controlling phosphorus is more feasible than controlling nitrogen.

Total phosphorus (TP) concentrations in 2008 in Deep Lake averaged lower than the Lake County epilimnetic median of 0.065 mg/L the hypolimnetic median of 0.181 mg/L. TP has decreased from both the epilimnetic and hypolimnetic 2003 TP average concentrations of 0.024 mg/L and 0.158 mg/L, respectively. The 2008 average TP concentration was 0.023 mg/L in the epilimnion and 0.142 mg/L in the hypolimnion. The TP concentrations found in the epilimnion have remained steady since the Lakes Management Unit (LMU) began monitoring in 1989. The only lake within the Sequoit Creek watershed that had lower average epilimnetic TP concentrations in 2008 was West Loon Lake, this lake is at the very top of that branch of the watershed.

Total phosphorus can be used to calculate the trophic state index (TSIp), which classifies lakes according to the overall level of nutrient enrichment. The TSIp score falls within the range of one of four categories: hypereutrophic, eutrophic, mesotrophic and oligotrophic. Hypereutrophic lakes are those with excessive nutrients that can support nuisance algae growth reminiscent of "pea soup" and have a TSI score greater than 70. Lakes with a TSI score of 50 or greater are classified as eutrophic and are nutrient rich and productive lakes in terms of aquatic plants and/or algae. Mesotrophic and oligotrophic lakes have lower nutrient levels. These are very clear

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

lakes, with little algal growth. Most lakes in Lake County are eutrophic. The trophic state of Deep Lake in terms of its phosphorus concentration during 2003 was slightly eutrophic, with a TSIp score of 50.0. In 2008 the TSIp score had improved slightly to 49.6 which classified it as mesotrophic. Deep Lake ranked 21 out of 163 lakes in Lake County based on average TP concentrations (Table 3).

The Illinois Environmental Protection Agency (IEPA) has assessment indices to classify Illinois lakes for their ability to support aquatic life and recreational uses. The guidelines consider several aspects, such as water clarity, phosphorus concentrations (TSIp), and aquatic plant coverage. According to this index Deep Lake provided *Full* support of aquatic life and *Partial* support of recreational activities due to the abundance of EWM. The lake provided *Partial* overall use.

Licensed beaches on Deep Lake (Deep Lake Apartments and Jack and Lidia's Resort) were sampled every two weeks by the LMU to test for the presence of *E. coli* bacteria. *E. coli* bacteria are found virtually everywhere, but are in very high numbers in the feces of warm-blooded animals, including humans. While most strains of *E. coli* are not harmful, the bacteria may indicate the presence of other pathogens such as *Giardia*, which can cause serious illness in humans. In 2008, the Deep Lake Apartments Beach was closed on 3 occasions (June 3rd, June 17th and July 1st) due to *E. coli* concentrations that exceeded 235 colonies/100 mL. These high counts can be caused by a number of things, including a large number of waterfowl, rain and high wind and wave events. The presence of a high density of waterfowl in the vicinity of the beach area could cause problems because their feces contain *E. coli*. When these feces make their way into the water, they can cause high *E. coli* counts. Rain events can increase *E. coli* counts because runoff picks up *E. coli* that is washed into the lake. The beach closing at the Apartment's does not appear to be rain-related and the high *E. coli* may have been linked to waterfowl, such as geese, in the area. Despite the high concentrations occurring on the three occasions listed above, *E. coli* contamination does not appear to be a serious problem for all Deep Lake beaches, as the other licensed beach on the lake had no violations during 2008. The beach at Glacier Park as well as any other beach that services 5 or more households should be licensed with the Illinois Department of Public Health.

A watershed is the land and water around a lake that drains to that lake. This means that any management of the land within the watershed can directly affect the lake. To reduce impacts to the lake residents can apply phosphorus free fertilizer to their lawns, have their septic tanks pumped and serviced regularly (if applicable), and use alternative material to road salt for winter de-icing of sidewalks and roads. Also, increased impervious surface creates increased run-off which can raise the lake level by not allowing as much water to infiltrate into the ground. Increased water in a lake creates a larger volume of water which can hold more nutrients and can also lead to flooding.

The Deep Lake watershed consisted of 1,403 acres (Figure 4). Water (37.5%), single family (17%) and forest and grassland (12.5%) were the major land uses within the watershed (Figure 5). Although transportation made up a small (7%) proportion of the land uses in the Deep Lake watershed, it contributed the highest percentages of estimated runoff (28%, Table 4). It is

Table 3. 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 3. 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 3. 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 3. 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 4. Approximate watershed delineation for Deep Lake, 2008

Figure 5. Approximate land use within the Deep Lake watershed, 2008

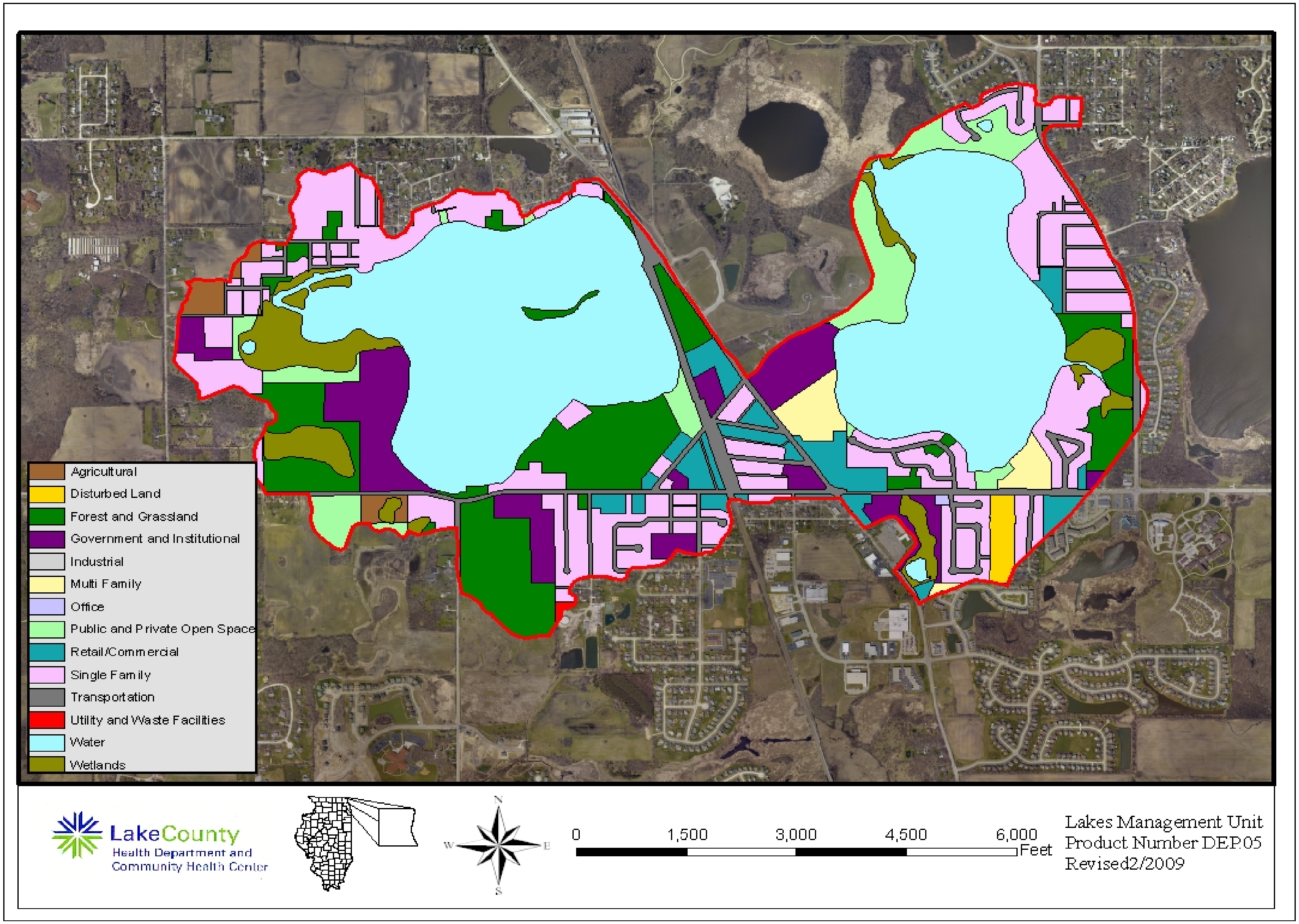


Table 4. Approximate land uses and retention time for Deep Lake, 2008

Land Use	Acreage	% of Total
Agricultural	30.12	2.1%
Disturbed Land	15.21	1.1%
Forest and Grassland	175.85	12.5%
Government and Institutional	101.46	7.2%
Multi Family	22.83	1.6%
Office	0.67	0.0%
Public and Private Open Space	65.85	4.7%
Retail/Commercial	54.08	3.9%
Single Family	238.86	17.0%
Transportation	95.36	6.8%
Utility and Waste Facilities	0.88	0.1%
Water	525.72	37.5%
Wetlands	74.59	5.3%
Total Acres	**1401.46**	**100.0%**

Land Use	Acreage	Runoff Coefficient	Estimated Runoff, acre ft.	% Total of Estimated Runoff
Agricultural	30.12	0.05	4.1	0.5%
Disturbed Land	15.21	0.05	2.1	0.3%
Forest and Grassland	175.85	0.05	24.2	3.1%
Government and Institutional	101.46	0.50	139.5	17.7%
Multi Family	22.83	0.50	31.4	4.0%
Office	0.67	0.85	1.6	0.2%
Public and Private Open Space	65.85	0.15	27.2	3.4%
Retail/Commercial	54.08	0.85	126.4	16.1%
Single Family	238.86	0.30	197.1	25.0%
Transportation	95.36	0.85	222.9	28.3%
Utility and Waste Facilities	0.88	0.30	0.7	0.1%
Water	525.72	0.00	0.0	0.0%
Wetlands	74.59	0.05	10.3	1.3%
TOTAL	**1401.46**		**787.4**	100.0%

Lake volume	**3955.00**	**acre-feet**
Retention Time (years)= lake volume/runoff	**5.02**	**years**
	1833.39	**days**

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 5.02 years.

Conductivity is a measurement of water's ability to conduct electricity and is correlated with chloride (Cl^-) concentrations (Figure 6). Lakes with residential and/or urban land uses in their watershed often have higher conductivity readings and higher Cl^- concentrations because of the use of road salts, compared to lakes in undeveloped areas. Stormwater runoff from impervious surfaces such as roads and parking lots can deliver high concentrations of Cl^- to nearby waterbodies. The Lake County epilimnetic median conductivity concentration was 0.8195 milliSiemens/cm (mS/cm). During 2008, the Deep Lake average epilimnetic conductivity reading was higher, 1.0726 mS/cm. The conductivity has increased 32% since 1998 when the average was 0.8112 mg/L. The 2008 hypolimnetic average of 1.1808 mS/cm was higher than the county median of 0.8695mS/cm. It has also increased 41% since 1998. These increases follow the current trend of lakes monitored by the LMU. Most of the lakes in the county have seen an increase in their conductivity concentrations.

The Cl^- concentration in Deep Lake was also higher than the Lake County epilimnetic median of 166 mg/L during 2008, with an epilimnetic average of 232 mg/L and the hypolimnetic average of 248 mg/L was higher than the County median of 139 mg/L. Although there is no chloride data for the previous monitoring, the increased conductivity indicates an increase in chloride concentration. Increased chloride concentrations are one of the main threats to the future quality of Deep Lake and this issue should be addressed throughout the watershed. A study done in Canada reported 10% of aquatic species are harmed by prolonged exposure to chloride concentrations greater than 220 mg/L. Additionally, shifts in algal populations in lakes were associated with chloride concentrations as low as 12 mg/l. Therefore, lakes can be negatively impacted by the high Cl^- concentrations.

SUMMARY OF AQUATIC MACROPHYTES

Aquatic plant (macrophyte) surveys were conducted in August of 2008. Sampling sites were based on a grid system created by mapping software (ArcMap), with each site located 60 meters apart for a total of 253 sites. There were 126 sites sampled (Figure 7). Overall, a total of 21 plant species and one macro-algae were found (Table 5). Plants were found at 118 sites and at a maximum depth of 12.0 feet (Table 5a). The most dominant species was Eurasian Water Milfoil (EWM) an exotic, invasive species found with a frequency of 70% in 2008 (Figure 8), however, this was down from 2003 when it was found at 88% of the sampled sites. Besides EWM only one other exotic plant species was detected in the lake. Curlyleaf Pondweed (CLP), although not a dominant, was present and does have invasive tendencies. In other words, it is known to displace native plants, providing little or poor natural diversity and it has limited uses by wildlife. It may not have been found in large densities due to it being an early season plant, sometimes even growing under the ice, and dying back once the water temperatures warm up. Continued management of both EWM and CLP is recommended. Illinois Pondweed and the macro algae (*Chara* spp.) were also among the dominant plant species found during the August 2008 sampling. Species diversity decreased by three species in 2008 when compared to the 2003

Figure 6. Chloride (Cl^-) concentration vs. conductivity for Deep Lake, 2008

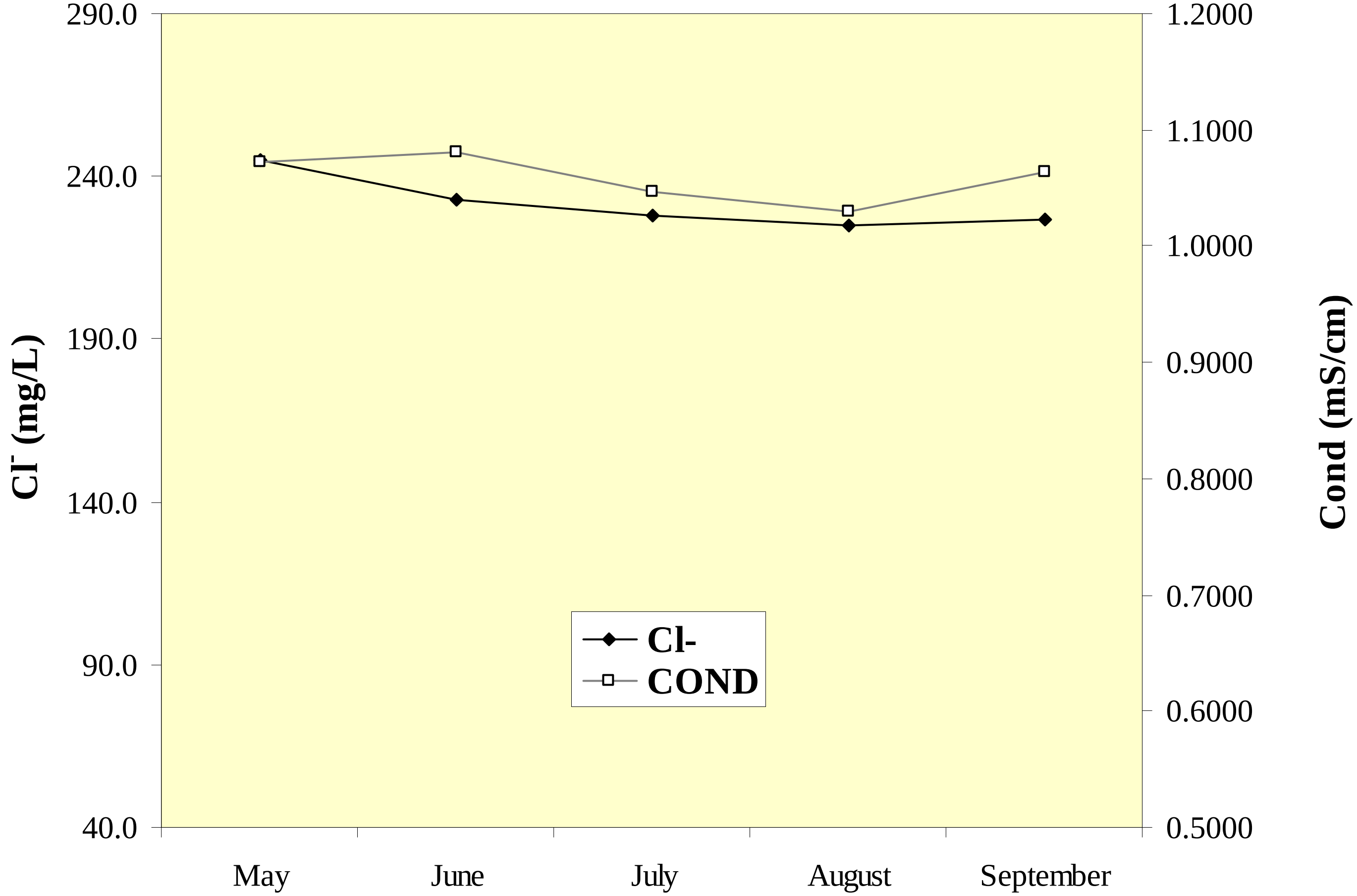


Figure 7. Aquatic plant sampling grid that illustrates plant density on Deep Lake, August 2008

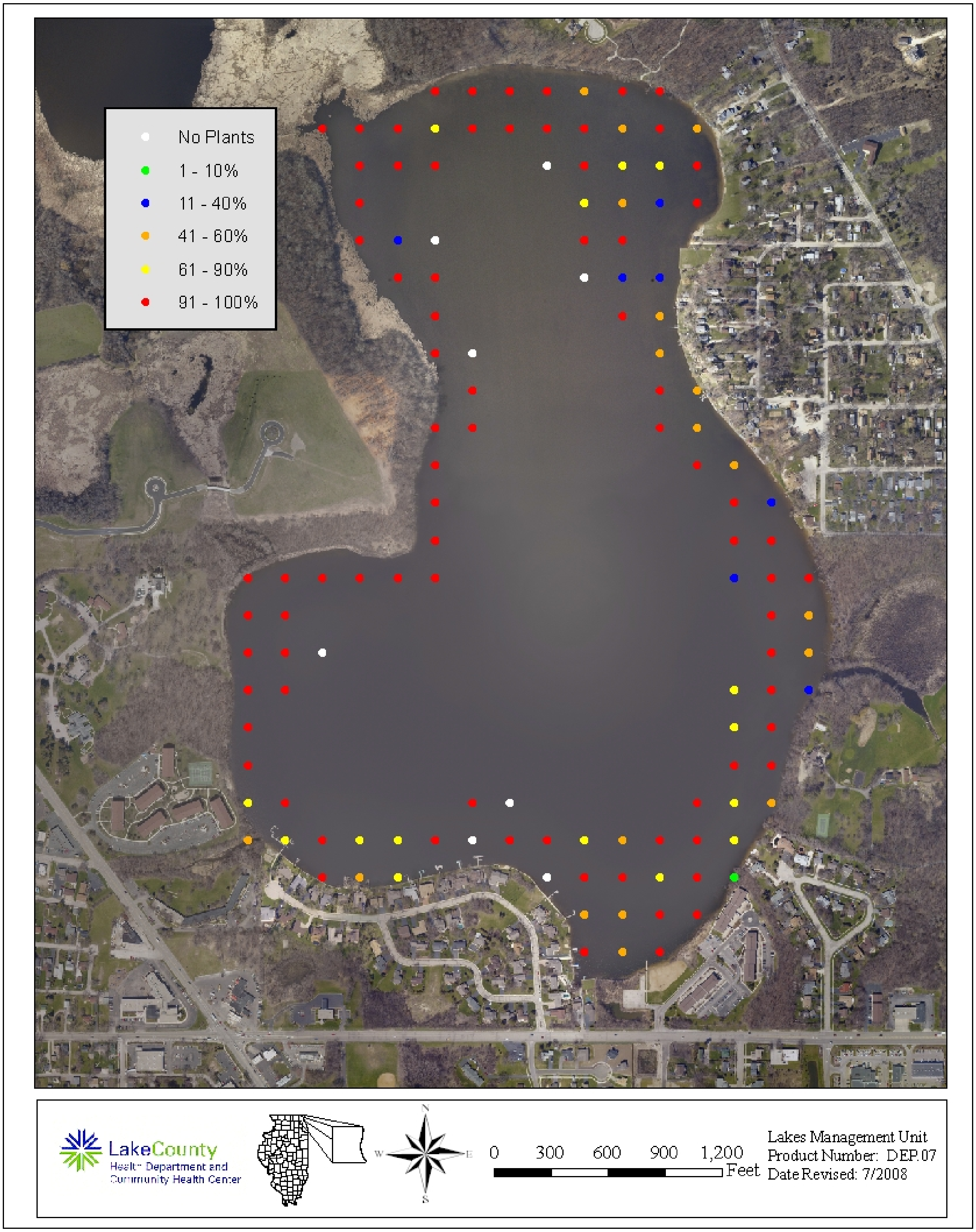


Table 5. Aquatic Plant Species found in Deep Lake, August, 2008

Coontail	*Ceratophyllum demersum*
Chara	*Chara spp. (Macro algae)*
American Elodea	*Elodea canadensis*
Water Star Grass	*Heteranthera dubia*
Small Duckweed	*Lemna minor*
Star Duckweed	*Lemna trisulca*
Eurasian Watermilfoil	*Myriophyllum spicatum*
Slender Naiad	*Najas flexilis*
Southern Naiad	*Najas guadalupensis*
White Water Lily	*Nymphaea tuberosa*
Large-leaved Pondweed	*Potamogeton amplifolius*
Curlyleaf Pondweed	*Potamogeton crispus*
Leafy Pondweed	*Potamogeton foliosus*
Illinois Pondweed	*Potamogeton illinoensis*
American Pondweed	*Potamogeton nodosus*
Sago Pondweed	*Potamogeton pectinatus*
Whitestem Pondweed^	*Potamogeton praelongus*^
Flat-stemmed Pondweed	*Potamogeton zosteriformis*
White Water Crowfoot	*Ranunculus longirostris*
Great Bladderwort	*Utricularia vulgaris*
Eel Grass	*Vallisneria americana*

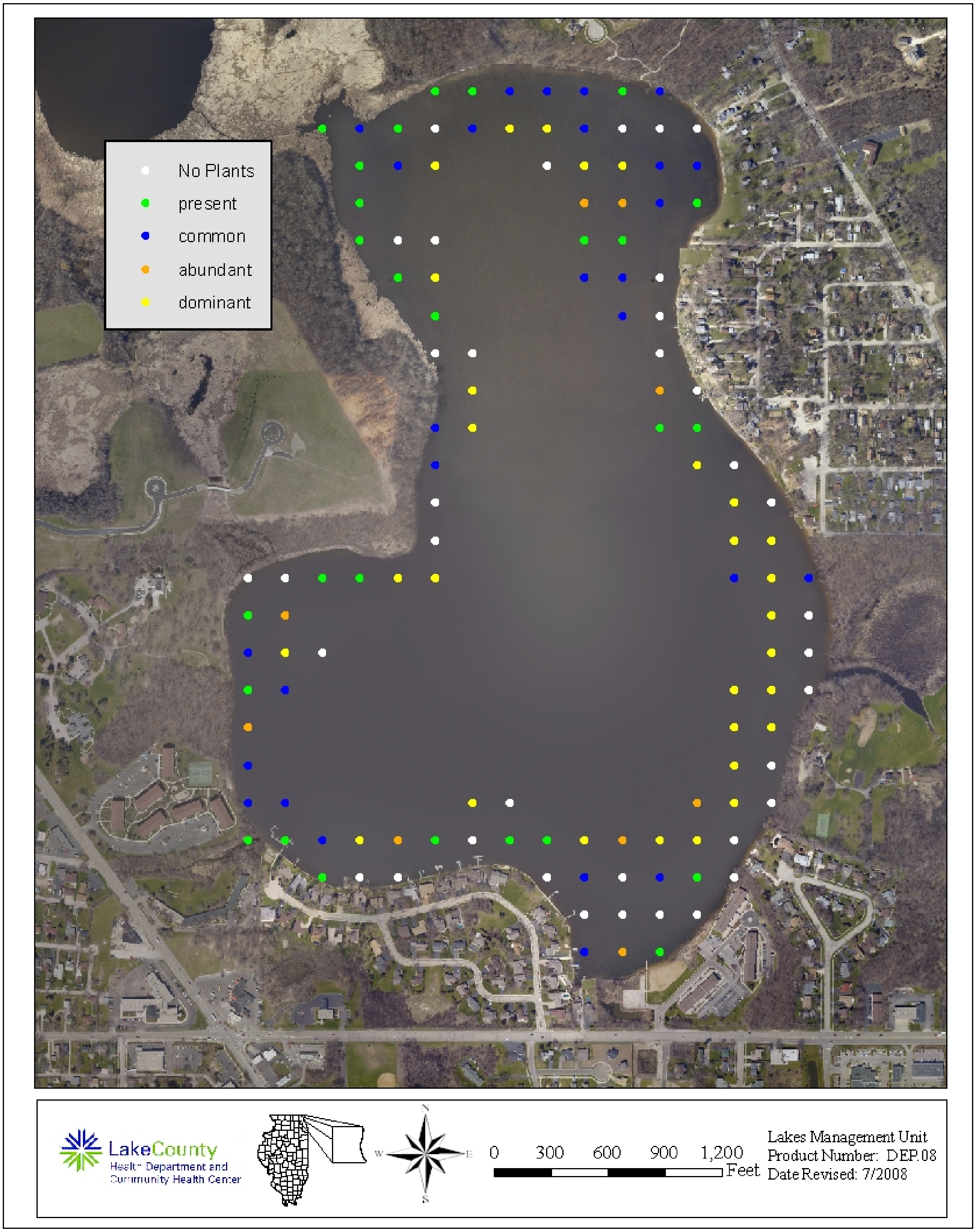
^ **Endangered Species**

Table 5a. Aquatic plant species found at the 126 sampling sites on Deep Lake, August 2008, Maximum depth that plants were found was 12.0 feet

Plant Density	American Pondweed	Great Bladderwort	Chara	Coontail	Curlyleaf Pondweed	Small Duckweed	Common Waterweed	Eurasian Watermilfoil	Flatstemmed Pondweed	Illinois Pondweed	Large Leaf Pondweed
Absent	123	124	93	97	124	123	125	38	114	69	114
Present	0	2	3	19	0	3	1	26	9	32	10
Common	1	0	9	5	2	0	0	24	1	14	1
Abundant	0	0	15	1	0	0	0	9	1	8	0
Dominant	1	0	6	4	0	0	0	29	1	3	1
% Plant Occurrence	1.6%	1.6%	26.2%	23.0%	1.6%	2.4%	0.8%	69.8%	9.5%	45.2%	9.5%

Plant Density	Leafy Pondweed	Northern Watermilfoil	Sago Pondweed	Slender Naiad	Southern Naiad	Star Duckweed	Vallisneria	White Crowfoot	Whitestem Pondweed	Water Stargrass	White Water Lily
Absent	125	114	92	112	114	125	107	125	120	95	104
Present	1	12	13	9	5	1	11	1	5	10	10
Common	0	0	5	2	1	0	7	0	1	8	6
Abundant	0	0	5	1	4	0	1	0	0	3	4
Dominant	0	0	11	2	2	0	0	0	0	10	2
% Plant Occurrence	0.8%	9.5%	27.0%	11.1%	9.5%	0.8%	15.1%	0.8%	4.8%	24.6%	17.5%

Figure 8. Aquatic plant sampling grid that illustrates Eurasian Watermilfoil density on Deep Lake, August 2008



vegetation sampling; then 24 species and *Chara* spp. were found. The species found in 2008 that were not found in 2003 were Leafy Pondweed and Star Duckweed. The species found in 2003 and not found in 2008 were Clasping Leaf Pondweed (rare in Illinois), Fernleaf Pondweed (state endangered), Floatingleaf Pondweed, Small Pondweed, and Water Marigold (state endangered). White Stem Pondweed, a state endangered species, was found at 5% of the sites sampled in 2008 (Figure 9). Care needs to be taken when managing the lake's plant community not to impact this species' populations. In August 2003, Clasping Leaf Pondweed was found in the lake, however it was not found in 2008. It is not clear if it was not detected due to changes in sampling methodology or timing of sampling in 2008. It could have been a result of vegetation management, as native pondweeds were targeted for removal in designated areas of the lake.

Active aquatic plant management occurs on Deep Lake, generally in the form of chemical treatments targeting nuisance vegetation. While EWM is often the target species, some native plants are being treated particularly along the eastern half of the lake. LMU is concerned about the active management of these native plants. Deep Lake has one of the most diverse aquatic plant communities in the state of Illinois. Care should be exercised when implementing the aquatic plant treatments. Minimal treatments should occur on these native plants.

To maintain a healthy sunfish/bass fishery, the optimal plant coverage is 30% to 40% across the lake bottom. The August survey found approximately 94% of the sites sampled had aquatic plants (Table 5b). It was calculated that 48% of the lake bottom was covered by plants. Our records indicate that detailed fish surveys took place in 2002 and 2003. In 2002, three state threatened fish species; Banded Killifish (*Fundulus diaphanus*), Blackchin Shiner (*Notropis heterdon*) and Pugnose Shiner (*Notropis anogenus*) as well as two state endangered fish species Blacknose Shiner (*Notropis heterolepis*), and Iowa Darter (*Etheostoma exile*) were discovered along seven, 100-m study reaches (SIU and Max McGraw Foundation). The presence of these five species is exceptional and very rare. It is important that their habitat is protected by maintaining a high diversity of native plants in the lake. These fish also prefer higher plant densities. In 2003 the Illinois Department of Natural Resources (IDNR) conducted an electrofishing survey. Thirteen fish species were collected, including the state-threatened Blackchin Shiner. Six schools of this shiner were observed during the 60 minute survey and they seemed fairly abundant. Other fish species found included Largemouth Bass, Redear Sunfish, Grass Pickerel, Central Mudminnow and Lake Chubsucker. The Largemouth Bass collected represented at least seven age groups, suggesting consistent reproduction. At that time, the lake appeared to have a diverse fishery that was in relative balance. It is important that lake managers consult with a fisheries biologist before stocking predatory fish species. The threatened and endangered fish species present in Deep Lake are known to be forage fish for Walleye, Northern Pike and Largemouth Bass. Care should be taken in the stocking of these sport fish species as they could have a negative impact on the threatened and endangered species.

Water clarity and depth are the major limiting factors in determining the maximum depth at which aquatic plants will grow in a specific lake. Aquatic plants will not photosynthesize in water depths with less than 1% of the available sunlight. During 2008, the 1% light level was available down to 21 feet in August and for most of the season was recorded between 15-16 feet. In August the 1% light level was 21 feet and plants were found to a depth of 12 feet.

Figure 9. Aquatic plant sampling grid that illustrates White Stem Pondweed location and density on Deep Lake, August 2008

Table 5b. Distribution of rake density across all sampled sites.

Rake Density (Coverage)	# of Sites	%
No plants	8	6.3
>0 to 10%	1	0.8
>10 to 40%	7	5.6
>40 to 60%	17	13.5
>60 to 90%	15	11.9
>90%	78	61.9
Total Sites with Plants	118	93.7
Total # of Sites	126	100.0

The Floristic Quality Index (FQI) is a rapid assessment tool designed to evaluate the closeness of the flora of an area 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-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. The average FQI for 2000-2008 Lake County lakes was 13.6 (Table 6). Non-native species were also included in the FQI calculations for Lake County lakes. Deep Lake had a FQI of 31.2 in 2008 ranking 4th of 152 lakes in Lake County. This was a decrease from 2003 when the FQI was 33.9. However, the change in the aquatic plant sampling procedure and timing are likely the reason for this although plant community diversity and composition can vary from year to year.

SUMARY OF SHORELINE CONDITION

Lakes with stable water levels potentially have less shoreline erosion problems. The water level fluctuated each month in Deep Lake. From May to June the level increased by 3.5 inches. It decreased by 8.0 inches in July. Water levels increased from July to August by 2.3 inches and an additional 0.8 inches from August to September. There was a seasonal decrease of 1.5 inches from May to September. Given the fluctuation of water levels recorded in 2008, it is expected that there would be some erosion taking place in the lake.

In 2003, the shoreline was assessed for a variety of criteria. At that time it was determined that 48% of Deep Lake's shoreline was developed and the majority of the developed shoreline was comprised of seawall (33%), woodland (19%) and rip rap (17%). The remainder of the developed shoreline consists of beach (11.4%), buffer (6.5%), manicured lawn (6.5%) and wetland (6.3%). The undeveloped portions of the lakes shoreline and the majority of the shoreline (52%) are made up of wetland (28%) and woodland (24%). Woodland, wetland and buffer are the most desirable shoreline types, providing wildlife habitat and, typically, protecting the shore from excessive erosion. The high percentage of wetland and woodland shoreline along Deep Lake is very encouraging and these shorelines should be protected from new development

Table 6. 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 6. 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 6. 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 6. 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**

or degradation. In 2003, 89.3% of Deep Lake's shoreline exhibited no erosion. Slight erosion was occurring primarily along woodland dominated shoreline that had not been properly maintained, while manicured lawns exhibited much of the remainder of the erosion. Although manicured lawn made up very little of the overall shoreline, 48% of all manicured lawn was exhibiting slight erosion. Manicured lawn is considered undesirable because it provides a poor shoreline-water interface due to the short root structure of turf grasses. These grasses are incapable of stabilizing the shoreline and will typically lead to erosion. Wetland, buffer and, especially, woodland shorelines should be maintained or added as much as possible, and the addition of manicured lawns, seawalls and rip rap should be discouraged.

In 2008, the shoreline was assessed for erosion only (Figure 10). Sixty percent of the shoreline showed no sign of erosion. Forty-percent of the shoreline showed some degree of erosion. Of that 20% of the shoreline had slight erosion, 11% had moderate erosion and 8% had severe erosion. Most of the shoreline without any signs of erosion or that were slightly eroded were those in the woodland and wetland areas, although within the unmanaged woodlands, which comprised most of the undeveloped woodland areas, there were areas of moderate to severe erosion which were occurring as the vegetation had buckthorn and honeysuckle among its components and the shoreline was being undercut (Figure 11). Trying to take care of the areas where slight erosion was taking place is more economically feasible. However, those areas with moderate to severe erosion occurring should be taken care of as soon as possible to alleviate sediment from being introduced into the lake.

OBSERVATIONS OF WILDLIFE AND HABITAT

Visual wildlife observations were made on a monthly basis during water quality and plant sampling activities. Deep Lake is located in an urban, residential setting with some buffered and natural shoreline. This provides excellent habitat for a variety of birds, mammals, and other wildlife (Table 7).

Wildlife habitat on Deep Lake was above average for a residential lake. According to the 2003 assessment, approximately 52% of the lake's shoreline is undeveloped. The undeveloped areas are woodlands and wetlands which provide good habitat for a variety of bird species. Some of the older developed areas of the shoreline still contain mature trees as well. There were some deadfalls located along the shorelines providing habitat for many species. The developed areas provided some habitat in the form of the buffer strips located between the lake and manicured lawns. Increasing the widths of the buffer strips would provide more habitats for wildlife and help reduce future inputs of nutrients and pollutants.

Figure 10. Shoreline erosion on Deep Lake, 2008

Figure 11. Photo documentation of shoreline erosion on Deep Lake, 2008

Area of severe erosion occurring on west shoreline in wooded area.

Figure 11. Continued.

Moderate erosion within woodland area of east shoreline.

Table 7. Wildlife species observed around Deep Lake, May – September, 2008

Birds	
Canada Goose	*Branta canadensis*
Mallard	*Anas platyrhnchos*
Wood Duck	*Aix sponsa*
Gull	*Larus spp.*
Great Egret	*Casmerodius albus*
Great Blue Heron	*Ardea herodias*
Green Heron	*Butorides striatus*
Barn Swallow	*Hirundo rustica*
Tree Swallow	*Iridoprocne bicolor*
American Crow	*Corvus brachyrhynchos*
Blue Jay	*Cyanocitta cristata*
Black-capped Chickadee	*Poecile atricapillus*
American Robin	*Turdus migratorius*
Red-winged Blackbird	*Agelaius phoeniceus*
Northern Oriole	*Icterus galbula*
Northern Cardinal	*Cardinalis cardinalis*
Rose-breasted Grosbeak	*Pheucticus ludovicianus*
Mammals	
Gray Squirrel	*Sciurus carolinensis*
Muskrat	*Ondatra zibethicus*
Amphibians	
Bull Frog	*Rana catesbeiana*
Fish	
Brook Silverside	*Labidesthes sicculus*
Bluegill	*Lepomis macrochirus*

* Endangered in Illinois
+Threatened in Illinois

LAKE MANAGEMENT RECOMMENDATIONS

Deep Lake is a high quality aquatic resource. However, the number of aquatic plant species has decreased in Deep Lake since 2003. Two state endangered and one rare plant species were not found in 2008. On the positive side, there was an increase in locations of White-stemmed Pondweed, also a state endangered plant. There was a decrease in water clarity and an increase in TSS in the lake since 2003. The decreased clarity could be due to rain, however, sediment entering the lake from eroding shoreline areas as well as development in the watershed could be contributors to the problem. To improve the quality of Deep Lake, the LMU has the following recommendations:

- **<u>Creating a Bathymetric Map</u>**

  1989 was the last year that a bathymetric map was created for Deep Lake. It is recommended that any map older than 15 years be updated. A bathymetric map is an essential tool for effective lake management since it provides critical information about the physical features of the lake, such as depth, surface area, volume, etc. This information is particularly important when intensive management techniques (i.e., chemical treatments for plant or algae control, dredging, fish stocking, etc.) are part of the lake's overall management (Appendix D1).

- **<u>License Bathing Beaches</u>**

  Deep Lake has association or subdivision beaches that are not licensed with the Illinois Department of Public Health. It is required by law that any beach servicing 5 or more households be licensed. Contact the LMU for details about getting the beaches licensed.

- **<u>Aquatic Plant Management and Eliminate or Control Exotic Species</u>**

  Deep Lake has one of the most diverse aquatic plant populations in the state, which is key to it being a high quality resource. Aquatic plants compete with algae for nutrients and stabilize bottom substrate, which in turn improves water clarity. The plan should be based on the management goals of the lake and involve usage issues, habitat maintenance/restoration, and limitations of the lake. It is recommended that management of the plant community focus on exotic and invasive species rather than native pondweeds. This is especially true for the state endangered species, White-stemmed pondweed along the north and northeastern portions of the lake. Follow up is critical for an aquatic plant management plan to achieve long-term success. A good aquatic plant management plan considers both the short and long-term needs of the lake (Appendix D2-3).

- **<u>Lakes with Shoreline Erosion</u>**

  Moderate to severe erosion is especially evident in the woodland areas surrounding the lake. These areas should be addressed soon. All of the eroded areas should be remediated to prevent additional loss of shoreline and prevent continued degradation of the water quality through sediment inputs. When possible, the shorelines should be repaired using natural vegetation instead of riprap or seawall (Appendix D4).

- **<u>Watershed Nutrient Reduction and Watershed Sediment Reduction</u>**

Deep Lake has seen an increase in total suspended solids concentration since 2003. Management within the watershed can help reduce nutrients and sediment entering the lake (Appendix D5-6). Deep Lake is a phosphorus limited lake and thus any addition of phosphorus may degrade water quality. One source of phosphorus is lawn fertilizer. Most established lawns do not require additional phosphorous fertilizer and run-off from lawns may contribute to phosphorus concentrations into the lake. Some local communities in Lake County have adopted ordinances banning the use of phosphorous fertilizer. For this reason, the LMU encourages the Homeowners Associations on Deep Lake and the Village of Lake Villa to adopt a similar bans.

- **<u>Reduce Conductivity and Chloride Concentrations</u>**

A continuing and future threat to the quality of Deep Lake is the increase of chlorides. The average conductivity in Deep Lake increased between 2008 and 2003. The chloride concentration for Deep Lake (232 mg/L) was much higher (40%) than the county median 166 mg/L. This concentration is high enough to potentially have impacts on aquatic life, especially the algal and plankton community. The use of road salts for winter road management is a major contributor to chloride concentrations and conductivity. Although roads only make up 7% of the landuse within the watershed, they contribute 28% of the estimated runoff. Proper application procedures and alternative methods can be used to keep these concentrations under control (Appendix D7).

- **<u>Grant program opportunities</u>**

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 DEEP LAKE IN 2008.

Deep Lake 2008 Multiparameter data

Date MMDDYY	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	Extinction Coefficient
										Average	0.39
05/14/2008	0	0.489	14.06	9.55	93.1	1.160	8.15	723.5	Surface	100%	
05/14/2008	1	1.002	14.06	9.52	92.8	1.143	8.26	534.3	Surface	100%	
05/14/2008	2	1.976	14.07	9.51	92.7	1.143	8.28	161.3	0.306	30%	3.91
05/14/2008	3	2.995	14.06	9.49	92.5	1.143	8.32	95.1	1.325	18%	0.40
05/14/2008	4	4.018	14.06	9.48	92.5	1.143	8.33	88.7	2.348	17%	0.03
05/14/2008	6	6.024	14.07	9.47	92.3	1.143	8.34	57.7	4.354	11%	0.10
05/14/2008	8	8.007	14.06	9.45	92.1	1.143	8.35	39.9	6.337	7%	0.06
05/14/2008	10	10.016	14.05	9.44	92.1	1.143	8.36	27.5	8.346	5%	0.04
05/14/2008	12	12.044	13.98	9.42	91.7	1.157	8.35	17.5	10.374	3%	0.04
05/14/2008	14	14.025	13.86	9.33	90.5	1.157	8.34	12.3	12.355	2%	0.03
05/14/2008	16	16.007	13.66	9.24	89.3	1.144	8.34	7.0	14.337	1%	0.04
05/14/2008	18	17.984	13.27	9.02	86.4	1.144	8.31	4.7	16.314	0.9%	0.02
05/14/2008	20	19.976	13.02	8.84	84.2	1.146	8.27	3.2	18.306	0.6%	0.02
05/14/2008	22	22.038	12.36	8.29	77.8	1.146	8.19	1.8	20.368	0.3%	0.03
05/14/2008	24	23.989	11.14	7.03	64.1	1.150	8.02	1.2	22.319	0.2%	0.02
05/14/2008	26	26.041	9.70	5.86	51.8	1.157	7.89	0.8	24.371	0.1%	0.02
05/14/2008	28	28.004	9.04	5.00	43.5	1.161	7.74	0.5	26.334	0.1%	0.02
05/14/2008	30	30.035	8.18	4.47	38.1	1.164	7.68	0.4	28.365	0.1%	0.01
05/14/2008	32	32.004	8.03	4.21	35.7	1.164	7.63	0.3	30.334	0.1%	0.01
05/14/2008	34	34.020	7.87	4.18	35.3	1.165	7.59	0.3	32.350	0.1%	0.00
05/14/2008	36	35.980	7.64	3.78	31.7	1.165	7.56	0.3	34.310	0.1%	0.00
05/14/2008	38	38.017	7.48	3.71	31.1	1.166	7.54	0.2	36.347	0.0%	0.01
05/14/2008	40	39.999	7.44	3.44	28.8	1.167	7.50	0.2	38.329	0.0%	0.00
05/14/2008	42	41.990	7.39	3.17	26.4	1.168	7.49	0.2	40.320	0.0%	0.00
05/14/2008	44	44.052	7.29	2.84	23.6	1.168	7.48	0.2	42.382	0.0%	0.00

Date MMDDYY	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	Extinction Coefficient
										Average	0.34
06/11/2008	0	0.491	22.26	10.61	122.3	1.082	8.57	2767.2	Surface	100%	
06/11/2008	1	1.022	22.27	10.58	122.0	1.081	8.57	2556.3	Surface	100%	
06/11/2008	2	1.982	22.27	10.59	122.1	1.081	8.58	869.8	0.312	34%	3.46
06/11/2008	3	3.042	22.26	10.60	122.2	1.081	8.59	587.5	1.372	23%	0.29
06/11/2008	4	4.005	22.26	10.60	122.2	1.081	8.59	690.4	2.335	27%	-0.07
06/11/2008	6	6.050	22.24	10.67	123.0	1.081	8.60	383.2	4.380	15%	0.13
06/11/2008	8	7.900	22.15	10.63	122.3	1.079	8.60	284.1	6.230	11%	0.05
06/11/2008	10	10.037	22.06	10.36	118.9	1.077	8.58	182.2	8.367	7%	0.05
06/11/2008	12	11.961	21.87	9.74	111.5	1.086	8.54	130.6	10.291	5%	0.03
06/11/2008	14	14.067	21.08	9.00	101.5	1.099	8.46	56.9	12.397	2%	0.07
06/11/2008	16	15.957	19.38	8.67	94.5	1.135	8.39	36.8	14.287	1.4%	0.03
06/11/2008	18	17.938	17.76	8.31	87.6	1.148	8.33	24.2	16.268	0.9%	0.03

06/11/2008	20	19.958	15.56	7.26	73.1	1.151	8.26	18.3	18.288	0.7%	0.02
06/11/2008	22	22.007	14.49	5.98	58.9	1.155	8.12	13.2	20.337	0.52%	0.02
06/11/2008	24	24.045	13.54	5.05	48.7	1.159	8.05	10.6	22.375	0.41%	0.01
06/11/2008	26	26.039	12.17	3.71	34.7	1.165	7.98	7.3	24.369	0.29%	0.02
06/11/2008	28	28.191	10.33	1.31	11.8	1.169	7.86	5.2	26.521	0.20%	0.01
06/11/2008	30	30.081	9.45	0.29	2.5	1.168	7.76	4.1	28.411	0.16%	0.01
06/11/2008	32	32.005	8.83	0.22	1.9	1.170	7.70	3.2	30.335	0.13%	0.01
06/11/2008	34	34.026	8.24	0.19	1.7	1.173	7.66	2.5	32.356	0.10%	0.01
06/11/2008	36	35.945	8.01	0.19	1.6	1.173	7.63	2.0	34.275	0.08%	0.01
06/11/2008	38	37.992	7.80	0.16	1.3	1.174	7.58	1.1	36.322	0.04%	0.02
06/11/2008	40	40.019	7.63	0.16	1.4	1.176	7.56	0.8	38.349	0.03%	0.01
06/11/2008	42	42.008	7.58	0.16	1.3	1.176	7.54	0.6	40.338	0.02%	0.01
06/11/2008	44	44.036	7.45	0.15	1.2	1.178	7.52	0.5	42.366	0.02%	0.00
06/11/2008	46	45.989	7.33	0.15	1.3	1.164	7.49	0.3	44.319	0.01%	0.01

Date MMDDYY	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	Extinction Coefficient
										Average	0.16
07/09/2008	0	0.509	24.51	8.04	96.7	1.046	8.51	3361.7	Surface	100%	
07/09/2008	1	0.999	24.52	8.13	97.8	1.047	8.55	3566.8	Surface	100%	
07/09/2008	2	2.005	24.52	8.13	97.8	1.048	8.63	1436.4	0.335	40%	2.72
07/09/2008	3	3.003	24.54	8.11	97.6	1.048	8.64	1178.3	1.333	33%	0.15
07/09/2008	4	4.012	24.54	8.11	97.6	1.048	8.65	570.7	2.342	16%	0.31
07/09/2008	6	6.045	24.53	8.09	97.3	1.048	8.64	367.2	4.375	10%	0.10
07/09/2008	8	7.985	24.51	8.07	97.1	1.047	8.64	182.5	6.315	5%	0.11
07/09/2008	10	10.024	24.47	8.04	96.6	1.048	8.63	102.4	8.354	3%	0.07
07/09/2008	12	12.022	24.40	7.87	94.5	1.047	8.60	60.0	10.352	2%	0.05
07/09/2008	14	14.078	23.47	5.87	69.2	1.054	8.46	39.8	12.408	1.1%	0.03
07/09/2008	16	16.000	22.49	4.69	54.3	1.065	8.31	23.3	14.330	0.7%	0.04
07/09/2008	18	17.977	20.22	0.66	7.3	1.090	7.89	12.4	16.307	0.3%	0.04
07/09/2008	20	20.018	18.35	0.34	3.6	1.113	7.84	7.5	18.348	0.21%	0.03
07/09/2008	22	22.012	15.48	0.25	2.5	1.141	7.77	5.1	20.342	0.14%	0.02
07/09/2008	24	24.002	13.49	0.24	2.4	1.145	7.72	3.6	22.332	0.10%	0.02
07/09/2008	26	26.044	12.06	0.21	1.9	1.147	7.62	2.7	24.374	0.08%	0.01
07/09/2008	28	28.012	10.76	0.19	1.7	1.151	7.58	1.9	26.342	0.05%	0.01
07/09/2008	30	30.022	9.86	0.17	1.5	1.154	7.51	1.0	28.352	0.03%	0.02
07/09/2008	32	32.004	9.07	0.16	1.4	1.156	7.48	0.6	30.334	0.02%	0.02
07/09/2008	34	33.983	8.63	0.16	1.4	1.158	7.45	0.4	32.313	0.01%	0.01
07/09/2008	36	35.991	8.34	0.15	1.3	1.159	7.41	0.4	34.321	0.01%	0.00
07/09/2008	38	37.983	8.11	0.14	1.2	1.159	7.38	0.3	36.313	0.01%	0.01
07/09/2008	40	39.961	7.96	0.12	1.0	1.161	7.35	0.3	38.291	0.01%	0.00
07/09/2008	42	42.065	7.83	0.12	1.0	1.162	7.33	0.3	40.395	0.01%	0.00
07/09/2008	44	44.032	7.72	0.11	0.9	1.164	7.30	0.3	42.362	0.01%	0.00
07/09/2008	46	45.704	7.61	0.10	0.8	1.165	7.27	0.2	44.034	0.01%	0.01

Date	Depth	Dep25	Temp	DO	DO%	SpCond	pH	PAR	Depth of Light Meter	% Light	Extinction

MMDDYY	feet	feet	øC	mg/l	Sat	mS/cm	Units	æE/s/mý	feet	Transmission	Coefficient
										Average	0.25
08/13/2008	0	0.584	24.27	8.17	97.8	1.031	8.83	677.7	Surface	100%	
08/13/2008	1	1.022	24.36	8.28	99.3	1.028	8.78	412.6	Surface	100%	
08/13/2008	2	2.026	24.38	8.26	99.1	1.029	8.80	176.2	0.356	43%	2.39
08/13/2008	3	3.021	24.38	8.24	98.8	1.029	8.80	204.2	1.351	49%	-0.11
08/13/2008	4	4.042	24.38	8.20	98.4	1.029	8.79	156.6	2.372	38%	0.11
08/13/2008	6	6.020	24.38	8.20	98.4	1.029	8.77	103.0	4.350	25%	0.10
08/13/2008	8	8.010	24.38	8.18	98.1	1.029	8.77	72.6	6.340	18%	0.06
08/13/2008	10	10.027	24.38	8.17	98.1	1.029	8.76	45.2	8.357	11%	0.06
08/13/2008	12	12.003	24.38	8.16	97.9	1.029	8.75	33.0	10.333	8%	0.03
08/13/2008	14	14.027	24.38	8.16	98.0	1.029	8.74	20.7	12.357	5%	0.04
08/13/2008	16	16.005	24.25	7.03	84.2	1.030	8.70	13.7	14.335	3.3%	0.03
08/13/2008	18	18.023	22.99	4.21	49.2	1.051	8.57	9.2	16.353	2.2%	0.02
08/13/2008	20	20.012	19.62	0.93	10.2	1.109	8.41	5.6	18.342	1.357%	0.03
08/13/2008	22	22.008	16.86	0.24	2.5	1.132	8.26	3.0	20.338	0.727%	0.03
08/13/2008	24	24.025	14.51	0.21	2.0	1.146	8.22	1.8	22.355	0.436%	0.02
08/13/2008	26	26.012	12.06	0.18	1.7	1.165	8.17	1.1	24.342	0.267%	0.02
08/13/2008	28	28.003	10.85	0.17	1.6	1.155	8.10	0.4	26.333	0.097%	0.04
08/13/2008	30	30.009	9.95	0.17	1.5	1.159	8.04	0.2	28.339	0.048%	0.02
08/13/2008	32	32.003	9.37	0.17	1.5	1.160	7.97	0.2	30.333	0.048%	0.00
08/13/2008	34	34.004	8.94	0.16	1.4	1.162	7.92	0.2	32.334	0.048%	0.00
08/13/2008	36	36.009	8.58	0.15	1.3	1.165	7.88	0.2	34.339	0.048%	0.00
08/13/2008	38	38.009	8.43	0.14	1.2	1.166	7.82	0.2	36.339	0.048%	0.00
08/13/2008	40	40.031	8.40	0.13	1.1	1.165	7.76	0.2	38.361	0.048%	0.00
08/13/2008	42	42.013	8.38	0.11	1.0	1.166	7.73	0.2	40.343	0.048%	0.00
08/13/2008	44	44.017	8.17	0.11	0.9	1.169	7.69	0.2	42.347	0.048%	0.00
08/13/2008	46	45.997	7.93	0.06	0.5	1.200	7.41	0.2	44.327	0.048%	0.00

Date MMDDYY	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	Extinction Coefficient
										Average	0.31
09/10/2008	0	0.496	20.75	8.42	94.2	1.063	9.00	3407.4	Surface	100%	
09/10/2008	1	1.009	20.75	8.41	94.1	1.063	8.86	3463.6	Surface	100%	
09/10/2008	2	2.005	20.75	8.46	94.7	1.063	8.68	1002.8	0.335	29%	3.70
09/10/2008	3	3.008	20.75	8.36	93.6	1.063	8.68	890.8	1.338	26%	0.09
09/10/2008	4	4.003	20.75	8.35	93.5	1.063	8.67	492.0	2.333	14%	0.25
09/10/2008	6	6.007	20.74	8.33	93.2	1.063	8.66	256.6	4.337	7%	0.15
09/10/2008	8	8.009	20.74	8.31	93.0	1.063	8.64	189.7	6.339	5%	0.05
09/10/2008	10	10.002	20.74	8.29	92.8	1.063	8.63	114.3	8.332	3.3%	0.06
09/10/2008	12	12.004	20.73	8.27	92.6	1.063	8.62	62.4	10.334	1.8%	0.06
09/10/2008	14	14.001	20.73	8.24	92.2	1.063	8.61	41.7	12.331	1.2%	0.03
09/10/2008	16	16.003	20.72	8.20	91.8	1.063	8.61	27.1	14.333	0.8%	0.03
09/10/2008	18	18.004	20.60	7.60	84.8	1.066	8.60	17.4	16.334	0.5%	0.03
09/10/2008	20	20.004	20.27	6.51	72.2	1.074	8.54	12.0	18.334	0.3%	0.02
09/10/2008	22	22.003	19.02	3.21	34.7	1.124	8.39	7.8	20.333	0.2%	0.02
09/10/2008	24	23.998	15.58	1.30	13.1	1.202	8.33	4.7	22.328	0.1%	0.02
09/10/2008	26	26.002	13.54	0.35	3.4	1.191	8.22	1.8	24.332	0.1%	0.04
09/10/2008	28	27.995	11.83	0.26	2.4	1.200	8.14	0.9	26.325	0.03%	0.03

09/10/2008	30	30.006	10.47	0.19	1.7	1.203	8.03	0.0	28.336	0.00%
09/10/2008	32	32.002	9.59	0.17	1.5	1.207	7.97	0.0	30.332	0.00%
09/10/2008	34	34.000	8.99	0.15	1.3	1.208	7.90	0.0	32.330	0.00%
09/10/2008	36	36.001	8.69	0.14	1.2	1.212	7.83	0.0	34.331	0.00%
09/10/2008	38	37.994	8.50	0.12	1.0	1.214	7.80	0.0	36.324	0.00%
09/10/2008	40	40.006	8.25	0.13	1.1	1.219	7.73	0.0	38.336	0.00%
09/10/2008	42	41.999	8.11	0.10	0.9	1.222	7.69	0.0	40.329	0.00%
09/10/2008	44	44.005	7.89	0.10	0.9	1.230	7.61	0.0	42.335	0.00%
09/10/2008	46	46.001	7.78	0.06	0.5	1.245	7.46	0.0	44.331	0.00%

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

D1. Option for Creating a Bathymetric Map

A bathymetric (depth contour) map is an essential tool for effective lake management since it provides critical information about the physical features of the lake, such as depth, surface area, volume, etc. This information is particularly important when intensive management techniques (i.e., chemical treatments for plant or algae control, dredging, fish stocking, etc.) are part of the lake's overall management plan. Some bathymetric maps for lakes in Lake County do exist, but they are frequently old, outdated and do not accurately represent the current features of the lake. Maps can be created by the Lake County Health Department - Lakes Management Unit (LMU). LMU recently purchased a BioSonics DT-X™ Echosounder. With this equipment the creation of an accurate bathymetric map of almost any size lake in the county is possible. Costs vary, but can range from $2,000-5,000 depending on lake size.

D2. Options for Aquatic Plant Management

Option 1: Aquatic Herbicides

Aquatic herbicides are the most common method to control nuisance vegetation/algae. When used properly, they can provide selective and reliable control. Products cannot be licensed for use in aquatic situations unless there is less than a 1 in 1,000,000 chance of any negative effects on human health, wildlife, and the environment. Prior to herbicide application, licensed applicators should evaluate the lake's vegetation and, along with the lake's management plan, choose the appropriate herbicide and treatment areas, and apply the herbicides during appropriate conditions (i.e., low wind speed, DO concentration, temperature).

When used properly, aquatic herbicides can be a powerful tool in management of excessive vegetation. Often, aquatic herbicide treatments can be more cost effective in the long run compared to other management techniques. The fisheries and waterfowl populations of the lake would benefit greatly due to an increase in quality habitat and food supply. Dense stands of plants would be thinned out and improve spawning habitat and food source availability for fish. By implementing a good management plan with aquatic herbicides, usage opportunities of the lake would increase.

The most obvious drawback of using aquatic herbicides is the input of chemicals into the lake. Even though the United States Environmental Protection Agency (USEPA) approved these chemicals for use, human error can make them unsafe and bring about undesired outcomes. If not properly used, aquatic herbicides can remove too much vegetation from the lake. Another problem associated with removing too much vegetation is the loss of sediment stabilization by plants, which can lead to increased turbidity and resuspension of nutrients. After the initial removal, there is a possibility for regrowth of vegetation. Upon regrowth, weedy plants such as Eurasian Watermilfoil and Coontail quickly reestablish, form dense stands, and prevent the growth of desirable species. This causes a decrease in plant biodiversity. Over-removal, and possible regrowth of nuisance vegetation that may follow will drastically impair recreational use of the lake.

Option 2: Mechanical Harvesting

Mechanical harvesting involves the cutting and removal of nuisance aquatic vegetation by large specialized boats with underwater cutting bars. The total removal or over removal (neither of which should never be the plan of any management entity) of plants by mechanical harvesting should never be attempted. To avoid complete or over removal, the management entity should have a harvesting plan that determines where and how much vegetation is to be removed.

Mechanical harvesting can be a selective means to reduce stands of nuisance vegetation in a lake. Typically, plants cut low enough to restore recreational use and limit or prevent regrowth. This practice normally improves habitat for fish and other aquatic organisms.
High initial investment, extensive maintenance, and high operational costs have led to decreased use. Mechanical harvesters cannot be used in less than 2-4 feet of water (depending on draft of the harvester) and cannot maneuver well in tight places. The harvested plant material must be disposed of properly to a place that can accommodate large quantities of plants and prevent any from washing back into the lake. Fish, mussels, turtles and other aquatic organisms are commonly caught in the harvester and injured or even removed from the lake in the harvesting process. After the initial removal, there is a possibility for vegetation regrowth. If complete/over removal does occur several problems can result. One problem is the loss of sediment stabilization by plants, which can lead to increased turbidity and resuspension of nutrients. Another problem with mechanical harvesting, even if properly done, is that it can be a nonselective process.

Option 3: Hand Removal

Hand removal of excessive aquatic vegetation is a commonly used management technique. Hand removal is normally used in small ponds/lakes and limited areas for selective vegetation removal. Areas surrounding piers and beaches are commonly targeted areas. Typically tools such as rakes and cutting bars are used to remove vegetation. Hand removal is a quick, inexpensive, and selective way to remove nuisance vegetation. There are few negative attributes to hand removal. One negative implication is labor. Depending on the extent of infestation, removal of a large amount of vegetation can be quite tiresome. Another drawback can be disposal. Finding a site for numerous residents to dispose of large quantities of harvested vegetation can sometimes be problematic.

Option 4: Water Milfoil Weevil

Euhrychiopsis lecontei (*E. lecontei*) is a biological control organism used to control Eurasian Watermilfoil (EWM). *E. lecontei* is a native weevil, which feeds exclusively on milfoil species. It is stocked as a biocontrol and is commonly referred to as the Eurasian Watermilfoil weevil. Currently, the LCHD-Lakes Management Unit has documented weevils in 35 Lake County lakes. Many of these lakes have seen declines in EWM densities in recent years. Weevils are stocked in known quantities to achieve a density of 1-4 weevils per stem. As weevil populations expand, EWM populations may decline. After EWM declines, weevil populations decline and do not feed on any other aquatic plants. Currently only one company, EnviroScience Inc., has a stocking program (called the MiddFoil® process). The program includes evaluation of EWM densities, of current weevil populations (if any), stocking, monitoring, and restocking as needed.

If control with milfoil weevils were successful, the quality of the lake would be improved. Native plants could start to recolonize, and the fishery of the lake would improve due to more balanced predation and higher quality habitat. Waterfowl would benefit due to increased food sources and availability of prey. Use of milfoil weevils does have some drawbacks. Control using the weevil has been inconsistent in many cases. Also, milfoil control using weevils may not work well on plants in deep water. Furthermore, weevils do not work well in areas where plants are continuously disturbed by activities such as powerboats, swimming, harvesting or herbicide use. One of the most prohibitive aspects to weevil use is price. Typically weevils are stocked to achieve a density of 1-4 weevils per stem. This translates to 500-3000 weevils per acre.

Option 5: Reestablishing Native Aquatic Vegetation

Revegetation should only be done when existing nuisance vegetation, such as Eurasian Watermilfoil, are under control using one of the above management options. If the lake has poor clarity due to excessive algal growth or turbidity, these problems must be addressed before a revegetation plan is undertaken. At maximum, planting depth light levels must be greater than 1-5% of the surface light levels for plant growth and photosynthesis.

There are two methods by which reestablishment can be accomplished. The first is use of existing plant populations to revegetate other areas within the lake. The second method of reestablishment is to import native plants from an outside source. A variety of plants can be ordered from nurseries that specialize in native aquatic plants. By revegetating newly opened areas that were once infested with nuisance species, the lake will benefit in several ways. There are few negative impacts to revegetating a lake. One possible drawback is the possibility of new vegetation expanding to nuisance levels and needing control. However, this is an unlikely outcome. Another drawback could be the high costs of extensive revegetation with imported plants.

D3. Options to Eliminate or Control Exotic Species

Option 1: Biological Control

Biological control (bio-control) is a means of using natural relationships already in place to limit, stop, or reverse an exotic species' expansion. In most cases, insects that prey upon the exotic plants in its native ecosystem are imported. Since there is a danger of bringing another exotic species into the ecosystem, state and federal agencies require testing before any bio-control species are released or made available for purchase.

Control of exotics by a natural mechanism is preferable to chemical treatments, however there are few exotics that can be controlled by biological means. Insects, being part of the same ecological system as the exotic plant (i.e., the beetles with Purple Loosestrife and weevils with Eurasian Watermilfoil) are more likely to provide long-term control. Chemical treatments are usually non-selective while bio-control measures target specific plant species. Bio-control can also be expensive and labor intensive.

Option 2: Control by Hand

Controlling exotic plants by hand removal is most effective on small areas (< 1 acre) and if done prior to heavy infestation. Some exotics, such as Purple Loosestrife and Reed Canary Grass, can be controlled to some degree by digging, cutting, or mowing if done early and often during the year. Digging may be required to ensure the entire root mass is removed. Spring or summer is the best time to cut or mow, since late summer and fall is when many of the plant seeds disperse. Proper disposal of excavated plants is important since seeds may persist and germinate even after several years. Once exotic plants are removed, the disturbed ground should be planted with native vegetation and closely monitored since regrowth of the removed species is common. Many exotic species, such as Purple Loosestrife, Buckthorn, and Garlic Mustard are proficient at colonizing disturbed sites. This method can be labor intensive but costs are low.

Option 3: Herbicide Treatment

Chemical treatments can be effective at controlling exotic plant species, and works best on individual plants or small areas already infested with the plant. In some areas where individual spot treatments are prohibitive or impractical (i.e., large expanses of a wetland or woodland), chemical treatments may not be an option because in order to chemically treat the area, a broadcast application would be needed. Because many of the herbicides are not selective, meaning they kill all plants they contact, this may be unacceptable if native plants are found in the proposed treatment area.

Herbicides are commonly used to control nuisance shoreline vegetation by applying it to green foliage or cut stems. They provide a fast and effective way to control or eliminate nuisance vegetation by killing the root of the plant, preventing regrowth. Products are applied by either spraying or wicking (wiping) solution on plant surfaces. Spraying is used when large patches of undesirable vegetation are targeted. Herbicides are sprayed on growing foliage using a hand-held or backpack sprayer. Wicking is used when selected plants are to be removed from a group of plants. It is best to apply herbicides when plants are actively growing, such as in the late spring/early summer, but before formation of seed heads. Herbicides are often used in conjunction with other methods, such as cutting or mowing, to achieve the best results. Proper use of these products is critical to their success. Always read and follow label directions.

D4. Options for Lakes with Shoreline Erosion

Option 1: Install a Seawall

Seawalls are designed to prevent shoreline erosion on lakes in a similar manner they are used along coastlines to prevent beach erosion or harbor siltation. Today, seawalls are generally constructed of steel, although in the past seawalls were made of concrete or wood (frequently old railroad ties). A new type of construction material being used is vinyl or PVC. Vinyl seawalls will not rust over time.

If installed properly and in the appropriate areas (i.e., shorelines with severe erosion) seawalls provide effective erosion control. Seawalls are made to last many years and have relatively low maintenance. However, seawalls are disadvantageous for several reasons. One of the main disadvantages is that they are expensive, since a professional contractor and heavy equipment are needed for installation. Also, if any fill material is placed in the floodplain along the shoreline, compensatory storage may also be needed. Compensatory storage is the process of excavating in a portion of a property or floodplain to compensate for the filling of another portion. Permits and surveys are needed whether replacing old seawall or installing a new one. Seawalls also provide little habitat for fish or wildlife. Because there is no structure for fish, wildlife, or their prey, few animals use shorelines with seawalls. In addition, poor water clarity that may be caused by resuspension of sediment from deflected wave action contributes to poor fish and wildlife habitat, since sight feeding fish and birds (i.e., bass, herons, and kingfishers) are less successful at catching prey. This may contribute to a lake's poor fishery (i.e., stunted fish populations).

Option 2: Install Rock Rip-Rap or Gabions

Rip-rap is the procedure of using rocks to stabilize shorelines. Size of the rock depends on the severity of the erosion, distance to rock source, and aesthetic preferences. Generally, four to eight inch diameter rocks are used. Gabions are wire cages or baskets filled with rock. They provide similar protection as rip-rap, but are less prone to displacement. They can be stacked, like blocks, to provide erosion control for extremely steep slopes.

Rip-rap and gabions can provide good shoreline erosion control. Rocks can absorb some of the wave energy while providing a more aesthetically pleasing appearance than seawalls. If installed properly, rip-rap and gabions will last for many years. Maintenance is relatively low, however, undercutting of the bank can cause sloughing of the rip-rap and subsequent shoreline. Fish and wildlife habitat can also be provided if large (not small) boulders are used. A major disadvantage of rip-rap is the initial expense of installation and associated permits. Installation is expensive since a licensed contractor and heavy equipment are generally needed to conduct the work. Permits are required if replacing existing or installing new rip-rap or gabions and must be acquired prior to work beginning.

Option 3: Create a Buffer Strip

Another effective, more natural method of controlling shoreline erosion is to create a buffer strip with existing or native vegetation. Native plants have deeper root systems than turfgrass and thus hold soil more effectively. Native plants also provide positive aesthetics and good wildlife habitat. Allowing vegetation to naturally propagate the shoreline would be the most cost effective, depending on the severity of erosion and the composition of the current vegetation. Stabilizing the shoreline with vegetation is most effective on slopes less than 2:1 to 3:1, horizontal to vertical, or flatter. Usually a buffer strip of at least 25 feet is recommended, however, wider strips (50 or even 100 feet) are recommended on steeper slopes or areas with severe erosion problems.

Buffer strips can be one of the least expensive means to stabilize shorelines. If no permits or heavy equipment are needed (i.e., no significant earthmoving or filling is planned), the property owner can complete the work without the need of professional contractors. Once established (typically within 3 years), a buffer strip of native vegetation will require little maintenance and may actually reduce the overall maintenance of the property, since the buffer strip will not have to be continuously mowed, watered, or fertilized. Buffer strips may slow the velocity of floodwaters, thus preventing shoreline erosion. Native plants also can withstand fluctuating water levels more effectively than commercial turfgrass. In addition, many wildlife species prefer the native shoreline vegetation habitat and various species are even dependent on native shoreline vegetation for their existence. In addition to the benefits of increased wildlife use, a buffer strip planted with a variety of native plants may provide a season long show of colors from flowers, leaves, seeds, and stems. This is not only aesthetically pleasing to people, but also benefits wildlife and the overall health of the lake’s ecosystem.

There are few disadvantages to native shoreline vegetation. Certain species (i.e., cattails) can be aggressive and may need to be controlled occasionally. If stands of shoreline vegetation become dense enough, access and visibility to the lake may be compromised to some degree. However, small paths could be cleared to provide lake access or smaller plants could be planted in these areas.

Option 4: Install Biolog, Fiber Roll, or Straw Blanket with Plantings

These products are long cylinders of compacted synthetic or natural fibers wrapped in mesh. The rolls are staked into shallow water. Biologs, fiber rolls, and straw blankets provide erosion control that secure the shoreline in the short-term and allow native plants to establish which will eventually provide long-term shoreline stabilization. They are most often made of bio-degradable materials, which break down by the time the natural vegetation becomes established (generally within 3 years). They provide additional strength to the shoreline, absorb wave energy, and effectively filter run-off from watershed sources. They are most effective in areas where plantings alone are not effective due to existing erosion.

Option 5: Install A-Jacks®

A-Jacks® are made of two pieces of pre-cast concrete when fitted together resemble a playing jacks. These structures are installed along the shoreline and covered with soil and/or an erosion control product. Native vegetation is then planted on the backfilled area. They can be used in areas where severe erosion does not justify a buffer strip alone.
The advantage to A-Jacks® is that they are quite strong and require low maintenance once installed. In addition, once native vegetation becomes established the A-Jacks® cannot be seen. A disadvantage is that installation cost can be high since labor is intensive and requires some heavy equipment. A-Jacks® need to be pre-made and hauled in from the manufacturing site.

Option 6: Establish a "No Wake" Zone or No Motor Area

Establishing a "no wake" zone or no motor area will not solve erosion problems by itself. However, since shoreline erosion is generally not caused by one specific factor, these techniques can be effective if used in combination with one or more of the techniques described above. Limiting boat activity, particularly near shorelines or in shallow areas, may also have an additional benefit by improving water quality since less sediment may be disturbed and resuspended in the water column. Less motorboat disturbance will also benefit wildlife and may encourage many species to use the lake both during spring and fall migration and for summer residence. This may add to the lake's aesthetics and increasing recreational opportunities for some lake users.

Enforcement and public education are the primary obstacles with the "no wake" techniques. Public resistance to any regulation change may be strong, particularly if the lake is open to the public and has had no similar regulations in the past. Depending on the regulations implemented, there may be some loss of recreational use for some users, particularly powerboating. However, if the lake is large enough, certain parts of the lake (i.e., the middle or deepest) may be used for this activity without negatively influencing other uses.

D5. Options for Watershed Nutrient Reduction

The two key nutrients for plant and algae growth are nitrogen and phosphorus. Fertilizers used for lawn and garden care have significant amounts of both. The three numbers on the fertilizer bag identify the percent of nitrogen, phosphorus and potash in the fertilizer mixture. For example, a fertilizer with the numbers 5-10-5 has 5% nitrogen, 10% phosphorus and 5% potash. Fertilizers considered low in phosphorus (the second number) have a number of 5 or lower. A lower concentration of phosphorus applied to a lawn will result in a smaller concentration of phosphorus in stormwater runoff. An established lawn will not be negatively affected by a lower phosphorus rate. However, for areas with new seeding or new sod, the homeowner would still want to use a fertilizer formulated for encouraging growth until the lawn is established. A simple soil test can determine the correct type and amount of fertilizer needed for the soil. Knowing this, homeowners can avoid applying the wrong type or amount of fertilizer.

Option 1. Buffer Strips

Buffer strips of unmowed native vegetation at least 25 feet wide along the shoreline can slow nutrient laden runoff from entering a lake. It can help prevent shoreline erosion and provide habitat beneficial for wildlife. Different plant mixes can be chosen to allow for more aesthetically pleasing buffer strips and tall species can be used to deter waterfowl from congregating along the shore. Initially the cost of plants can be expensive, however, over time less maintenance is required for the upkeep of a buffer strip.

Option 2. Lake Friendly Lawn and Garden Care Practices – Phosphorus Reduction

a. Compost yard waste instead of burning. Ashes from yard waste contain nutrients and are easily washed into a lake.

b. Avoid dumping yard waste along or into a ditch, pond, lake, or stream. As yard waste decomposes, the nutrients are released directly into the water, or flushed to the lake via the ditch.

c. Avoid applying fertilizer up to the water's edge. Leave a buffer strip of at least 25 feet of unfertilized yard before the shoreline.

d. Avoid applying fertilizers when heavy rains are expected, or over-watering the ground after applying fertilizer.

e. When landscaping, keep site disturbance to a minimum, especially the removal of vegetation and exposure of bare soil. Exposed soil can easily erode.

f. When landscaping, seed or plant exposed soil and cover it with mulch as soon as possible to minimize erosion and runoff.

g. Use lawn and garden chemicals sparingly, or do not use them at all.

e. Most lawns in Lake County do not need additional phosphorus for sufficient plant growth. Consider using a phosphorus-free fertilizer.

Option 3. Street Sweeping

Street sweeping has been used in communities to help prevent debris from clogging stormsewer drains, but it also benefits lakes by removing excess phosphorus, sand, silt and other pollutants. Leftover sand and salt applied to streets has been found to contain higher concentrations of silt, phosphorus and trace metals than new sand and salt mixes. If a municipality does not manage the lake, the lake management entity may be able to offer the village or city extra payment for sweeping streets closest to the lake.

Option 4: Reduce Stormwater Volume from Impervious Surfaces

The quality and quantity of runoff directly affects the lake's water quality. With continued growth and development in Lake County, more impervious surfaces such as parking lots and buildings contribute to the volume of stormwater runoff. Runoff picks up pollutants such as nutrients and sediment as it moves over land or down gutters. A faster flow rate and higher volume can result in erosion and scouring, adding sediment and nutrients to the runoff.

Roof downspouts should be pointed away from driveways and foundations and toward lawns or planting beds where water can soak into the soil. A splash block directly below downspouts helps prevent soil erosion. If erosion still occurs, a flexible perforated plastic tubing attached to the downspout can dissipate the water flow.

Option 5: Required Practices for Construction

Follow the requirements in the Watershed Development Ordinance (WDO) concerning buffer strips. Buffer strips can slow the velocity of runoff and trap sediment and attached nutrients. Setbacks, buffer strips and erosion control features, when done properly, will help protect the lake from excessive runoff and associated pollutants. Information about the contents of the ordinance can be obtained through Lake County Planning and Development, (847) 360-6330.

Option 6. Organize a Local Watershed Organization

A watershed organization can be instrumental in circulating educational information about watersheds and how to care for them. Often a galvanized organization can be a stronger working unit and a stronger voice than a few individuals. Watershed residents are the first to notice problems in the area, such as a lack of erosion control at construction sites. This organization would be an advocate for the watershed, and members could voice their concerns about future development impacts to local officials. This organization could educate the community about how phosphorus (and other pollutants) affect lakes and can help people implement watershed controls. Several types of educational outreaches can be used together for best results. These include: community newsletters, newspaper articles, local cable and radio station announcements. In some cases fundraising may be utilized to secure more funding for a project.

Option 7. Motor Boat Restrictions for Shallow Lakes

To reduce resuspension of phosphorus from the sediment, communities that have a shallow lake or large shallow areas in their lake may want to restrict motorized boating. The action of a spinning prop in shallow areas can disturb the sediment. Flocculent sediment particles can release loosely attached phosphorus into the water. Restrictions could include a ban of motorized traffic in certain areas or ban the use of motors entirely, however this could be hard to enforce without hiring law enforcement personnel. This would work best for lakes with shallow areas that have a large phosphorus source in the sediment.

Option 8. Discourage Waterfowl from Congregating

Waterfowl droppings (feces) can be a source of phosphorus (and bacteria) to the water, especially if they are congregating in large numbers along beaches and/or other nearshore areas. The annual nutrient load from two Canada Geese can be greater than the annual nutrient load from residential areas (Gremlin and Malone, 1986). These birds prefer habitat with short plants or no plants, such as lawns mowed to the water's edge and beaches. Waterfowl avoid areas with tall, dense vegetation through which they are unable to see predators. Tactics to discourage waterfowl from congregating in large groups include scare devices, a buffer strip of tall plants along the shoreline, and discouraging people from feeding geese and ducks. Signage could be erected at public parks/beaches discouraging people from feeding waterfowl. A template is available from Lakes Management Unit.

D6. Options for Watershed Sediment Reduction

Continued sediment inflow can fill areas of the lake and cause the water to become turbid. Incoming sediment can smother fish eggs or cover young aquatic plants. Increased turbidity reduces sunlight penetration limiting aquatic plant growth. Damage to native aquatic plants from multiple sediment inputs can lead to the loss of these plant species and the animals that depend on them. Sight-feeding fish have a difficult time finding food in turbid water. Often nutrients, such as phosphorus, are attached to sediment particles that reach the lake through stormwater runoff, which can contribute to plant and algae growth.

Option 1. Municipal Street Sweeping

Street sweeping has been used by communities to help prevent debris from clogging stormsewer drains, but it also benefits a lake by removing excess sand, silt, phosphorus, and other pollutants. Leftover sand and salt applied to streets has been found to contain higher concentrations of silt, phosphorus and trace metals than new sand and salt mixes.

Option 2. Lake Friendly Lawn, Garden and Home Building Practices – Sediment

Please refer to the Watershed Development Ordinance for requirements.

a. Seed and mulch bare soil as soon as possible to minimize erosion and runoff.

b. During home building projects, disturb as little vegetation as possible to minimize erosion and runoff.

c. Incorporate a buffer strip of native vegetation next to the shoreline to improve the area for wildlife, enhance the aesthetics, and possibly increase the property value.

d. Minimize impervious surfaces when considering installing pathways or even driveways. Gravel can be a suitable and less expensive option than asphalt or concrete. This will allow water to infiltrate into the ground rather than flow across impervious surfaces.

Option 3. Agricultural Practices

Soil conservation practices such as leaving crop residue on agricultural fields helps protect the soil from erosion and potential delivery to lakes and streams by runoff. The soils and their nutrients stay where the crops can use them. In turn, less money is spent on fertilizers. Crop rotation can help rejuvenate soil that has been stripped of nutrients due to years of one crop being grown. Soil conservation practices can help protect soil from eroding and aid in maintaining the integrity of the soil.

D7. 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.

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

2000 - 2008 Water Quality Parameters, Statistics Summary

	ALKoxic <=3ft00-2008			ALKanoxic 2000-2008	
Average	**167**		Average	**202**	
Median	**162**		Median	**194**	
Minimum	**65**	**IMC**	Minimum	**103**	**Heron Pond**
Maximum	**330**	**Flint Lake**	Maximum	**470**	**Lake Marie**
STD	**42**		STD	**50**	
n =	**802**		n =	**243**	

	Condoxic <=3ft00-2008			Condanoxic 2000-2008	
Average	**0.8934**		Average	**1.0312**	
Median	**0.8195**		Median	**0.8695**	
Minimum	**0.2542**	**Broberg Marsh**	Minimum	**0.3210**	**Lake Kathyrn**
Maximum	**6.8920**	**IMC**	Maximum	**7.4080**	**IMC**
STD	**0.5250**		STD	**0.7985**	
n =	**806**		n =	**243**	

	NO3-N, Nitrate+Nitrite,oxic <=3ft00-2008			NH3-Nanoxic 2000-2008	
Average	**0.508**		Average	**2.192**	
Median	**0.156**		Median	**1.630**	
Minimum	**<0.05**	***ND**	Minimum	**<0.1**	***ND**
Maximum	**9.670**	**South Churchill Lake**	Maximum	**18.400**	**Taylor Lake**
STD	**1.073**		STD	**2.343**	
n =	**807**		n =	**243**	

*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.

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

	pHoxic <=3ft00-2008			pHanoxic 2000-2008	
Average	**8.32**		Average	**7.28**	
Median	**8.32**		Median	**7.28**	
Minimum	**7.07**	**Bittersweet #13**	Minimum	**6.24**	**Banana Pond**
Maximum	**10.28**	**Round Lake Marsh North**	Maximum	**8.48**	**Heron Pond**
STD	**0.44**		STD	**0.42**	
n =	**801**		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**	

LakeCounty
Health Department and
Community Health Center

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**	

LakeCounty
Health Department and
Community Health Center

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: Water Quality/ Wetland	Funding Focus: Habitat	Funding Focus: Erosion	Funding Focus: Flooding	Cost Share
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: Water Quality/ Wetland	Funding Focus: Habitat	Funding Focus: Erosion	Funding Focus: Flooding	Cost Share
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
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