2006 SUMMARY REPORT
of
Hastings Lake

Lake County, Illinois

Prepared by the

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EXECUTIVE SUMMARY

Hastings Lake is a 76-acre glacial lake with a maximum depth of 26.8 feet. Water samples were taken from May through September and the lake was stratified for most of the sampling season. Dissolved oxygen levels were adequate to support aquatic life (>5.0 mg/L) in the epilimnion for most of the summer, however the hypolimnion had anoxic conditions (<1 mg/L) May through August.

The average total phosphorus concentration for Hastings Lake was 0.068 mg/L which was close to the county median (0.060 mg/L). Hasting Lake's phosphorus concentration did not significantly change from 2001 (0.066 mg/L), which was when the lake was last sampled by LMU. Nitrogen is the other nutrient critical for algal growth. The average Total Kjeldahl nitrogen concentration for Hastings Lake was 1.78 mg/L, which was higher than the county median of 1.22 mg/L and higher than the 2001 concentration (1.05 mg/L).

The 2006 epilimnetic average total suspended solids (TSS) concentration for Hastings Lake was 6.2 mg/L, which was greater than the county median and down from the 2001 average of 7.6 mg/L. Water clarity was measured by Secchi depth, with the lowest reading in September (2.46 feet) corresponding to the high TSS value. The average Secchi depth for the season was 4.85 feet, which was greater than the county median (3.27 feet).

Conductivity concentrations, which are correlated with chloride concentrations, have been increasing throughout the past few years in the county. The average conductivity reading for Hastings Lake was 1.0886 mS/cm, which was well above the county median (0.7948 mS/cm). This was a 38% increase from the 2001 average (0.7863 mg/L). The chloride concentration in Hastings Lake in 2006 was 209 mg/L which is well above the county median of 171 mg/L.

Aquatic plant sampling was conducted on Hastings Lake in July. Seven species of plants were present covering 79% of all sites sampled. Eurasian Watermilfoil and Coontail were the two dominant species. Curlyleaf Pondweed was also found in the lake. Eurasian Watermilfoil and Curlyleaf Pondweed are invasive, exotic species that tend to crowd out native species. Aquatic plants were found a

The shoreline was reevaluated in 2006 in order to assess any changes in erosion since 2001. Overall, there was little erosion occurring on the lake due to the good amount of wetland and woodland areas. The large amount of wooded and buffered areas offer good habitat for wildlife.

LAKE FACT SHEET

Lake Name:	Hastings Lake
Historical Name:	None
Nearest Municipality:	Lake Villa
Location:	T46N, R10E, Section 35
Major Tributaries:	None
Watershed:	Des Plaines
Sub-watershed:	North Mill Creek
Receiving Water body:	Mill Creek which enters Rasmussen Lake
Surface Area:	76.5 acres
Shoreline Length:	2.4 miles
Maximum Depth:	26.8 feet
Average Depth:	13.4 feet
Lake Volume (est.):	1008.0 acre-feet
Lake Type (est.):	Glacial
Watershed Area:	1438.0 acres
Major Watershed Land uses:	Single Family Housing and Public and Private open space
Bottom Ownership:	Lake County Forest Preserve District, Private (YMCA)
Management Entities:	Lake County Forest Preserve District, Private (YMCA)
Current and Historical uses:	Historically the lake was used for fishing. Access currently is limited to YMCA employees and camp attendees access.
Description of Access:	No public access.

SUMMARY OF WATER QUALITY

Water samples were collected from May through September in Hastings Lake at the deepest point near the center of the lake (Figure 1). Samples were taken at 3 feet below the surface and approximately 3 feet above the lake bottom (Appendix A). Water levels in Hastings Lake (taken from a stake installed by the LMU) decreased throughout the season as a result of low rainfall with an approximate loss of 4 inches occurred from May to September. In order to accurately monitor water levels it is recommended that a permanent staff gauge be installed. The Hastings Lake watershed (Figure 2) is approximately 1438.0 acres and includes Slough Lake, which flows into Crooked Lake and then into Hastings Lake. The lake is surrounded by wetland, forest, and grassland which help to absorb runoff and nutrients before it enters the lake. However, 23% of the watershed consists of single family homes (Figure 3).

Hastings Lake was stratified from May through August. Stratification occurs when the lake divides into an upper, warm water layer (epilimnion) and a lower, cold-water layer (hypolimnion). The layer between the epilimnion and hypolimnion, where the temperature changes quickly is the thermocline. A slight thermocline formed around 14 feet in May and 18 feet in June. In July and August the thermocline was around 16 feet. A dissolved oxygen (DO) concentration >5.0 mg/L is considered adequate to support a sunfish/bass fishery, since many fish suffer from oxygen stress below this amount. DO levels were adequate to support aquatic life in the epilimnion for most the summer (no data for September), however the hypolimnion had anoxic conditions (<1 mg/L) May through August (Appendix B). Anoxic conditions occurred below 24 feet in May, 18 feet in June, and 14 feet in July and August. Since a bathymetric map with volumetric calculations of Hastings Lake does not exist, an accurate assessment of the volume of water affected by these low DO conditions cannot be made.

Two important nutrients for algal growth, are nitrogen and phosphorus (Appendix E). Phosphorus is a nutrient that limits plant and algal growth, therefore any addition of phosphorus to the lake would produce algal blooms (Appendix C). The average total phosphorus (TP) for Hastings Lake was 0.068 mg/L (Table 1) and the county median was 0.060 mg/L. Directly upstream from Hastings Lake is Crooked Lake, which had a 2006 TP concentration of 0.061 mg/L (Table 2). Slough Lake sits above Crooked Lake at the top of the watershed and had a 2006 TP concentration of 0.413 mg/L. Slough Lake historically had a duck farm contributing to the phosphorus levels in the lake. However, water leaving Slough Lake travels through a wetland which may filter some of the phosphorus out. It then enters Crooked Lake which has a good aquatic plant abundance to utilize the phosphorus before it enters Hasting Lake. Nitrogen is the other nutrient critical for algal growth. Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen, and is typically bound up in algal and plant cells. The average TKN for Hastings Lake was 1.78 mg/L, which was higher than the county median of 1.22 mg/L. The TN:TP (total nitrogen to total phosphorus) ratio looks at which nutrient is limiting plant and algal growth in a lake. Ratios < 10:1 indicate nitrogen is limiting. Ratios of >15:1 indicate phosphorus is limiting. Ratios >10:1, <15:1 indicate there is enough of both nutrients for excessive algal growth. Hastings Lake had a TN:TP ratio of 26:1 which indicated phosphorus was limiting.

Figure 1. Water quality sampling site on Hastings Lake, 2006.

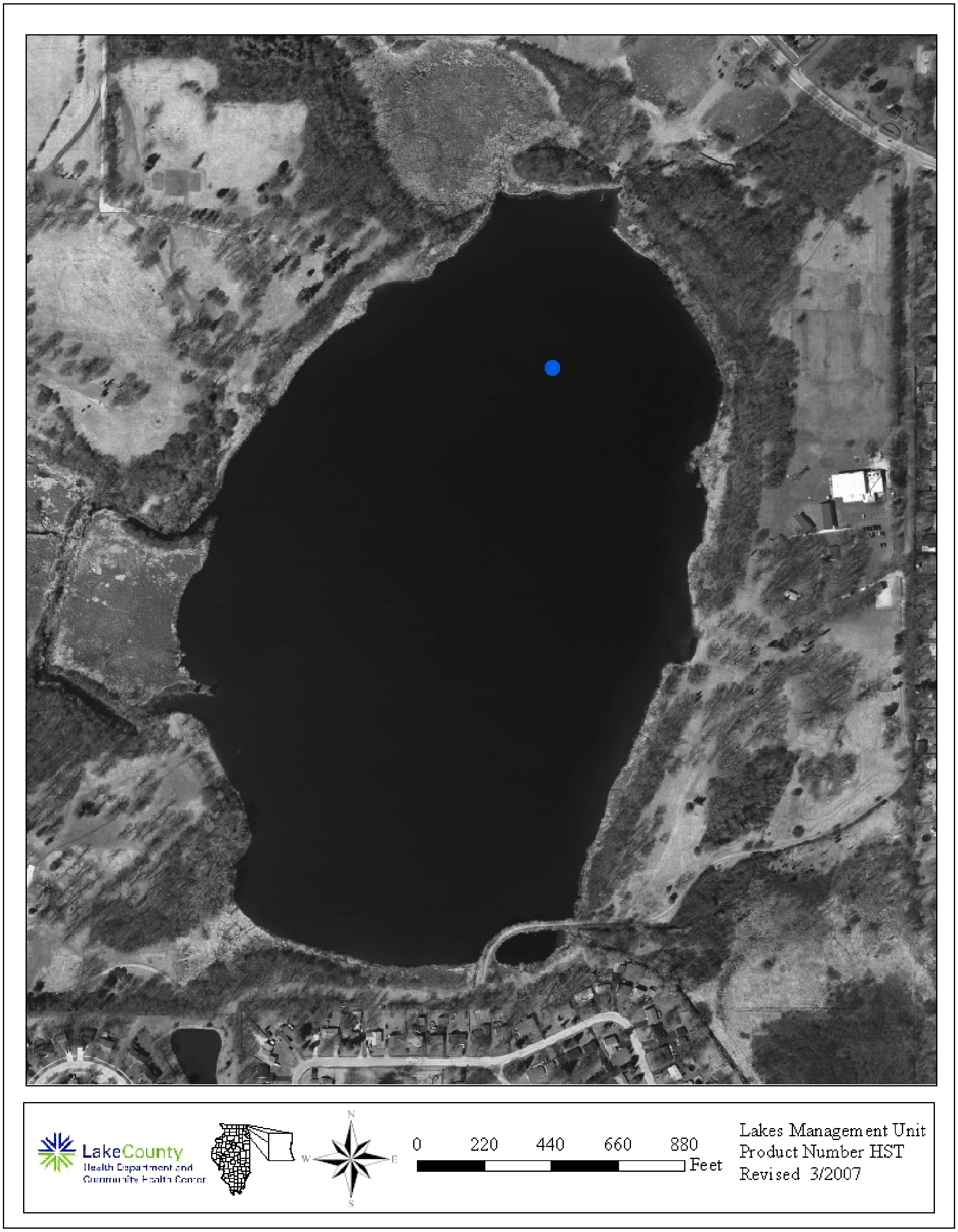

Figure 2. Approximate watershed delineation of Hastings Lake, 2006.

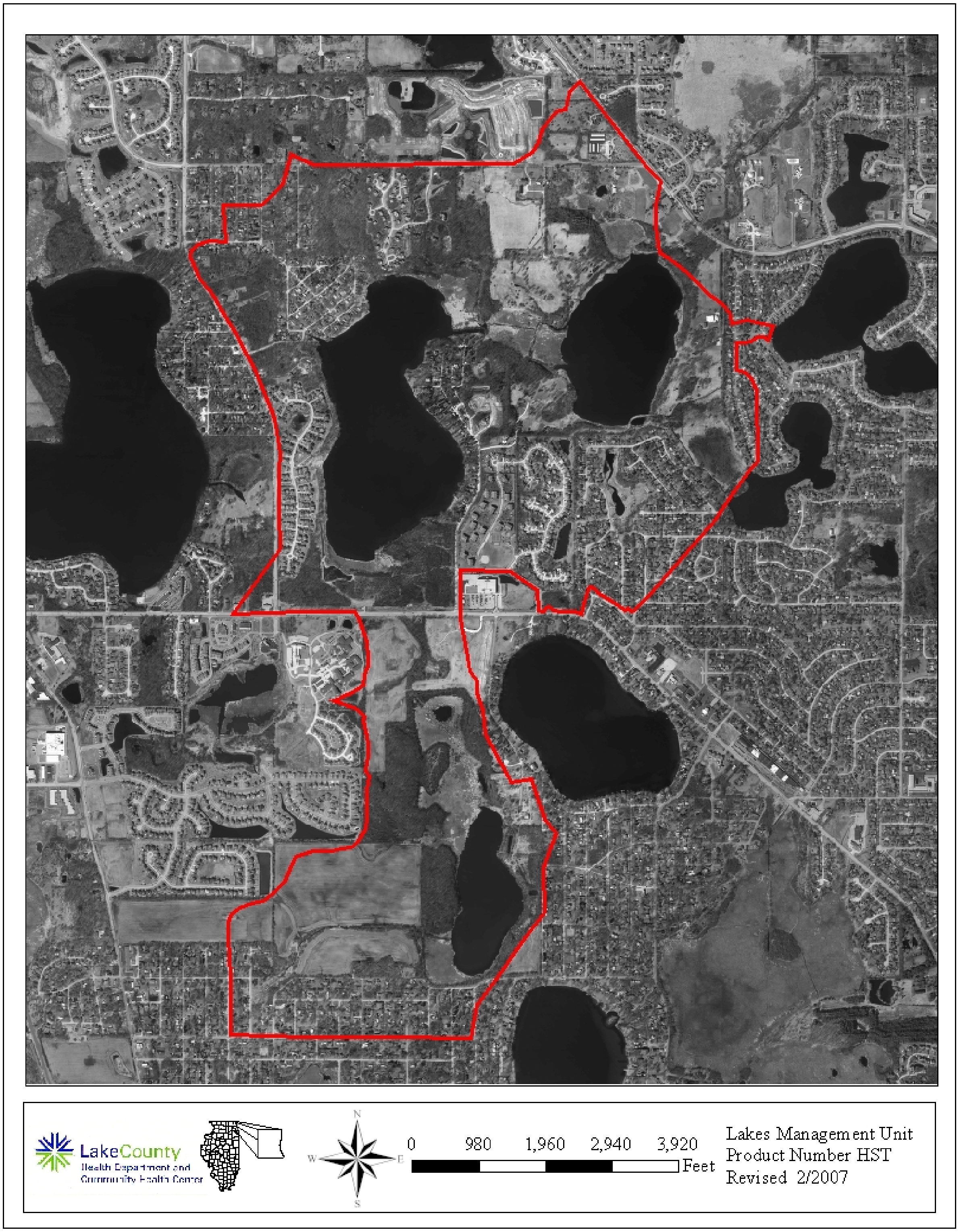

Figure 3. Approximate land use within the Hastings Lake watershed, 2006.

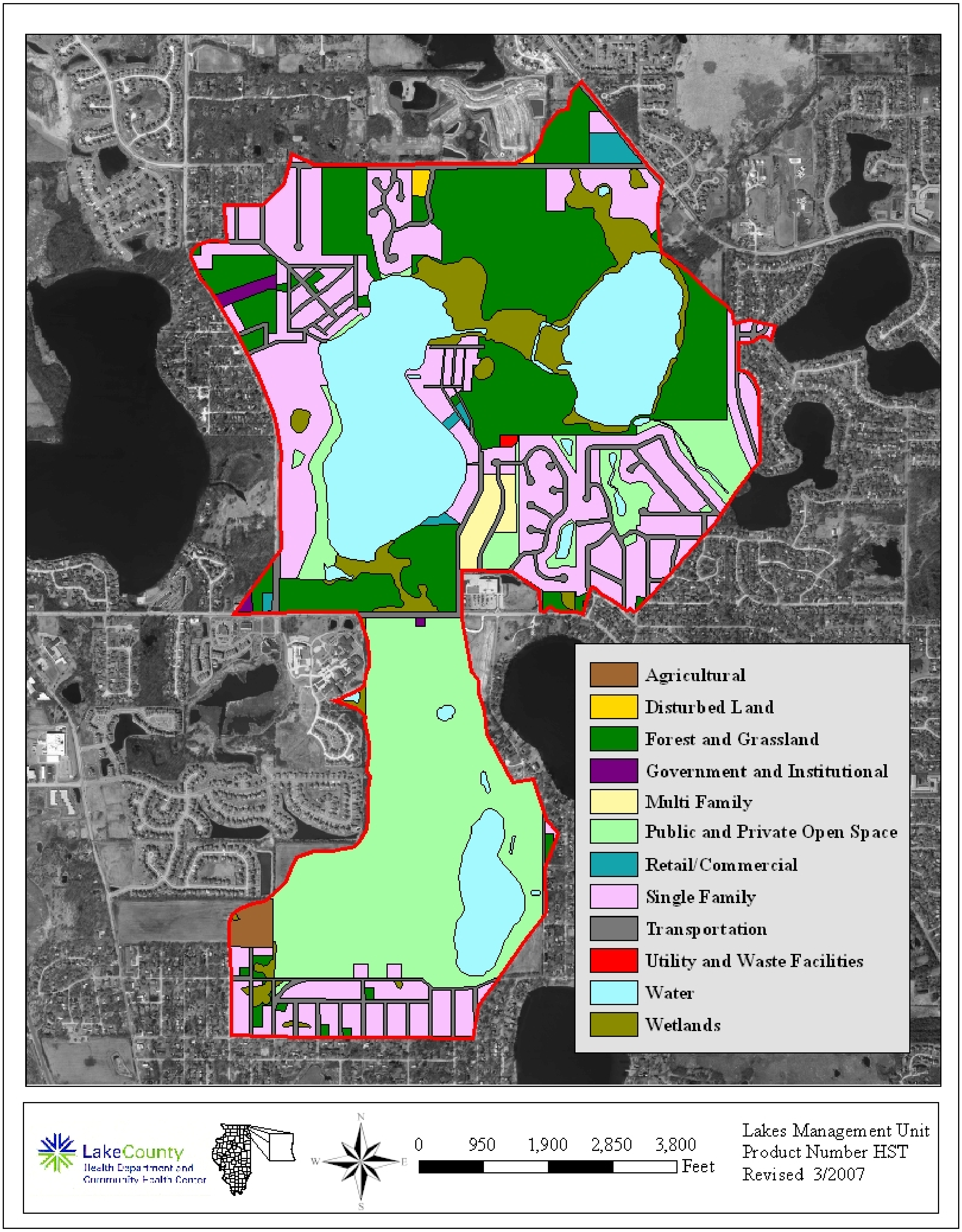

Table 1. Summary of water quality data for Hastings Lake, 2001 and 2006.

2006	**Epilimnion**															
DATE	DEPTH	ALK	TKN	NO_2+NO_3-N	NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
17-May	3	173	1.91	0.103	<0.05	0.084	<0.005	585	205	4.4	638	161	6.23	1.0700	8.32	10.73
21-Jun	3	180	1.68	<0.1	<0.05	0.074	<0.005	590	202	7.3	653	166	4.75	1.0790	8.41	11.55
19-Jul	3	178	1.71	<0.1	<0.05	0.057	<0.005	585	207	5.8	669	178	5.25	1.0700	8.54	6.35
16-Aug	3	165	1.53	<0.1	<0.05	0.037	<0.005	615	216	4.6	646	164	5.57	1.1280	8.53	7.49
20-Sep	3	164	2.09	0.203	<0.05	0.090	<0.005	599	217	8.8	664	173	2.46	1.0960	7.86	4.34
	Average	172	1.78	0.061[k]	<0.05[k]	0.068	<0.005[k]	595	209	6.2	654	168	4.85	1.0886	8.33	8.09

2001	**Epilimnion**															
DATE	DEPTH	ALK	TKN	NH3	NO_3-N*	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
16-May	3	169	0.58	<0.1	<0.05	0.063	<0.005	492	NA	6.3	528	149	4.62	0.8185	8.44	9.21
20-Jun	3	160	1.24	<0.1	<0.05	0.118	<0.005	500	NA	12.0	525	150	2.72	0.7973	8.40	10.20
25-Jul	3	138	1.12	<0.1	<0.05	0.045	<0.005	498	NA	6.5	517	140	2.99	0.7929	8.55	7.65
22-Aug	3	134	0.97	<0.1	<0.05	0.041	<0.005	496	NA	6.0	500	156	3.35	0.7503	8.45	7.32
19-Sep	3	138	1.32	<0.1	<0.05	0.065	<0.005	457	NA	7.3	488	148	2.76	0.7725	8.24	6.72
	Average	148	1.05	<0.1[k]	<0.05[k]	0.066	<0.005[k]	489	NA	7.6	512	149	3.29	0.7863	8.42	8.22

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

Table 1. Continued.

2006	Hypolimnion															
DATE	DEPTH	ALK	TKN	NO_2+NO_3-N	NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
17-May	23	176	2.33	0.605	<0.05	0.143	0.064	585	203	3.0	616	143	NA	1.0700	7.86	1.16
21-Jun	22	191	2.47	1.100	<0.05	0.212	0.145	597	201	2.3	660	174	NA	1.0930	7.54	0.09
19-Jul	21	212	3.58	2.210	<0.05	0.367	0.294	597	203	3.4	679	182	NA	1.0930	7.83	0.19
16-Aug	22	271	7.88	6.890	<0.05	0.974	0.895	650	210	4.1	693	171	NA	1.1990	6.91	0.34
20-Sep	21	165	2.16	0.259	<0.05	0.093	<0.005	591	216	11.0	642	161	NA	1.0810	7.75	3.01
	Average	203	3.68	2.213	<0.05[k]	0.358	0.280[k]	604	207	4.8	658	166	NA	1.1072	7.23	0.96

2001	Hypolimnion															
DATE	DEPTH	ALK	TKN	NH3	NO_3-N*	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
16-May	25	180	0.60	0.433	<0.05	0.117	0.049	483	NA	6.6	530	141	NA	0.8580	6.82	0.02
20-Jun	23	173	2.29	0.910	<0.05	0.223	0.147	507	NA	6.2	527	144	NA	0.8336	6.86	0.05
25-Jul	23	220	4.62	2.920	<0.05	0.467	0.380	544	NA	6.0	546	158	NA	0.8907	6.55	0.04
22-Aug	22	251	6.73	5.390	<0.05	1.240	1.110	564	NA	3.8	559	166	NA	0.9039	6.43	0.00
19-Sep	23	205	5.26	4.320	<0.05	1.270	0.398	510	NA	5.8	532	148	NA	0.9643	6.36	0.00
	Average	206	3.90	2.795	<0.05[k]	0.663	0.417	522	NA	5.7	539	151	NA	0.8901	6.60	0.02

Glossary

ALK = Alkalinity, mg/L $CaCO_3$
TKN = Total Kjeldahl nitrogen, mg/L
NH_3-N = Ammonia nitrogen, mg/L
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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

Table 2. Comparison of epilimnetic averages for selected water quality parameters in the Hastings Lake watershed.

	Slough Lake	Slough Lake	Crooked Lake	Crooked Lake	Hastings Lake	Hastings Lake
Year	**2000**	**2006**	**2001**	**2006**	**2001**	**2006**
Secchi (feet)	1.53	2.00	2.51	4.39	3.29	4.85
TSS (mg/L)	33.8	18.8	13.7	7.7	7.6	6.2
TP (mg/L)	0.263	0.413	0.101	0.061	0.066	0.068
Conductivity (milliSiemens/cm)	0.8659	1.5228	0.7927	1.1034	0.7863	1.0886

Direction of Watershed Flow

Another way to look at phosphorus levels and how they affect productivity of the lake is to use a Trophic State Index (TSI) based on phosphorus (TSIp). TSIp values are commonly used to classify and compare lake productivity levels (trophic state). The TSIp index classifies the lake into one of four categories: oligotrophic (nutrient-poor, biologically unproductive), mesotrophic (intermediate nutrient availability and biological productivity), eutrophic (nutrient-rich, highly productive), or hypereutrophic (extremely nutrient-rich, productive). In 2006, Hastings Lake was eutrophic with a TSIp value of 65.1, placing it 81st out of 162 lakes in the county (Table 3).

The Illinois EPA has a use index for assessing lakes for aquatic life, swimming, and recreational use impairment. TSI values along with other water quality parameters were used to make the analyses. According to this index, Hastings Lake provided full support of aquatic life, and partial support for swimming and recreational activities. The overall support was partial.

Total suspended solids (TSS) are composed of nonvolatile suspended solids such as non-organic clay or sediment materials, and volatile suspended solids such as algae and other organic matter. The average TSS concentration in Hastings Lake was 6.2 mg/L, which was just below the county median of 7.7 mg/L. TSS concentrations fluctuated throughout the season with a maximum concentration of 8.8 mg/L in September. This could be due to carp activity and fall turnover. However, it has improved since 2001 when the average was 7.6 mg/L. Water clarity is a direct result of the amount of TSS in the water column, and is usually the first thing people notice about a lake, as it typifies the overall lake quality. High TSS values are typically correlated with poor water clarity and can be detrimental to many aspects of the lake ecosystem, including the plant and fish communities. Water clarity was measured by Secchi disk depth, with the lowest reading in September (2.46 feet) corresponding to the high TSS value (Figure 4). The average Secchi depth for the season was 4.85 feet, which is slightly deeper than the county median (3.27 feet). This was an increase from the 2001 average of 3.29 feet. Traveling from the top to the bottom in the watershed, TSS concentrations and Secchi depth quality improve. The 2006 average TSS concentrations for Slough and Crooked Lake were 18.8 mg/L and 7.7 mg/L, respectively. The Secchi depth averages in Slough and Crooked Lakes were 2.0 feet and 4.39 feet, respectively. The decrease in TSS concentrations and increase in Secchi depth travelling through the watershed can be explained by the increase in aquatic plant abundance and the decrease in carp populations. Crooked Lake and Hastings Lake have been removing carp via electrofishing for at least 2 years, while Slough Lake has a high carp population. Carp are most likely contributing to the high TSS levels in Slough Lake by rooting around in the bottom sediment. In turn, aquatic plants are rare.

Conductivity readings, which are correlated with chloride concentrations, have been increasing throughout the past few years in the county. It is believed that road salt is probably the reason for the increase because chloride concentrations detect sodium chloride and calcium chloride, which are what most road salt consists of. The average conductivity reading for Hastings Lake was 1.0886 mS/cm, which was 37% above the county median (0.7948 mS/cm), and a 38% increase from 2001 (0.7863 mS/cm). Once again watershed concentrations decrease traveling top to bottom, possibly due to nutrients being filtered by the wetland north of Slough Lake or due to lower water levels which prohibited water flow from Slough to Crooked Lake. The average conductivity concentration for Slough Lake was 1.5228 mS/cm while Crooked Lake had a concentration of 1.1034 mS/cm. Chloride concentrations in Hastings Lake averaged 209.0 mg/L for the season while the county median was 171.0 mg/L. A study done in Canada reported 10%

Table 3. Lake County average TSI phosphorous (TSIp) ranking 2000-2006.

RANK	LAKE NAME	TP AVE	TSIp
1	Cedar Lake	0.0154	43.61
2	Windward Lake	0.0158	43.95
3	Sterling Lake	0.0162	44.31
4	Lake Minear	0.0165	44.57
5	Pulaski Pond	0.0180	45.83
6	Timber Lake	0.0180	45.83
7	Fourth Lake	0.0182	45.99
8	West Loon Lake	0.0182	45.99
9	Lake Carina	0.0193	46.86
10	Independence Grove	0.0194	46.91
11	Lake Kathyrn	0.0200	47.35
12	Lake of the Hollow	0.0200	47.35
13	Banana Pond	0.0202	47.49
14	Bangs Lake	0.0220	48.72
15	Cross Lake	0.0220	48.72
16	Third Lake	0.0221	48.82
17	Dog Pond	0.0222	48.85
18	Sand Pond	0.0230	49.36
19	Stone Quarry Lake	0.0230	49.36
20	Cranberry Lake	0.0240	49.98
21	Deep Lake	0.0240	49.98
22	Druce Lake	0.0244	50.22
23	Little Silver Lake	0.0246	50.33
24	Round Lake	0.0254	50.80
25	Lake Leo	0.0256	50.91
26	Dugdale Lake	0.0274	51.89
27	Peterson Pond	0.0274	51.89
28	Lake Miltmore	0.0276	51.99
29	Ames Pit	0.0278	52.10
30	East Loon Lake	0.0280	52.20
31	Lake Zurich	0.0282	52.30
32	Lake Fairfield	0.0296	53.00
33	Gray's Lake	0.0302	53.29
34	Highland Lake	0.0302	53.29
35	Hook Lake	0.0302	53.29
36	Lake Catherine (Site 1)	0.0308	53.57
37	Lambs Farm Lake	0.0312	53.76
38	Old School Lake	0.0312	53.76
39	Sand Lake	0.0316	53.94
40	Sullivan Lake	0.0320	54.13
41	Lake Linden	0.0326	54.39
42	Gages Lake	0.0338	54.92
43	Hendrick Lake	0.0344	55.17

Table 3. Continued.

RANK	LAKE NAME	TP AVE	TSIp
44	Diamond Lake	0.0372	56.30
45	Channel Lake (Site 1)	0.0380	56.60
46	White Lake	0.0408	57.63
47	Sun Lake	0.0410	57.70
48	Potomac Lake	0.0424	58.18
49	Duck Lake	0.0426	58.25
50	Old Oak Lake	0.0428	58.32
51	Wooster Lake	0.0433	58.48
52	Deer Lake	0.0434	58.52
53	Schreiber Lake	0.0434	58.52
54	Nielsen Pond	0.0448	58.98
55	Turner Lake	0.0458	59.30
56	Seven Acre Lake	0.0460	59.36
57	Willow Lake	0.0464	59.48
58	Lucky Lake	0.0476	59.85
59	Davis Lake	0.0476	59.85
60	East Meadow Lake	0.0478	59.91
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	Werhane Lake	0.0630	63.89
75	Liberty Lake	0.0632	63.94
76	Countryside Glen Lake	0.0642	64.17
77	Leisure Lake	0.0648	64.30
78	St. Mary's Lake	0.0666	64.70
79	Long Lake	0.0680	65.00
80	Mary Lee Lake	0.0682	65.04
81	**Hastings Lake**	**0.0684**	**65.08**
82	Honey Lake	0.0690	65.21
83	North Tower Lake	0.0718	65.78
84	Lake Fairview	0.0724	65.90
85	Spring Lake	0.0726	65.94
86	ADID 203	0.0730	66.02

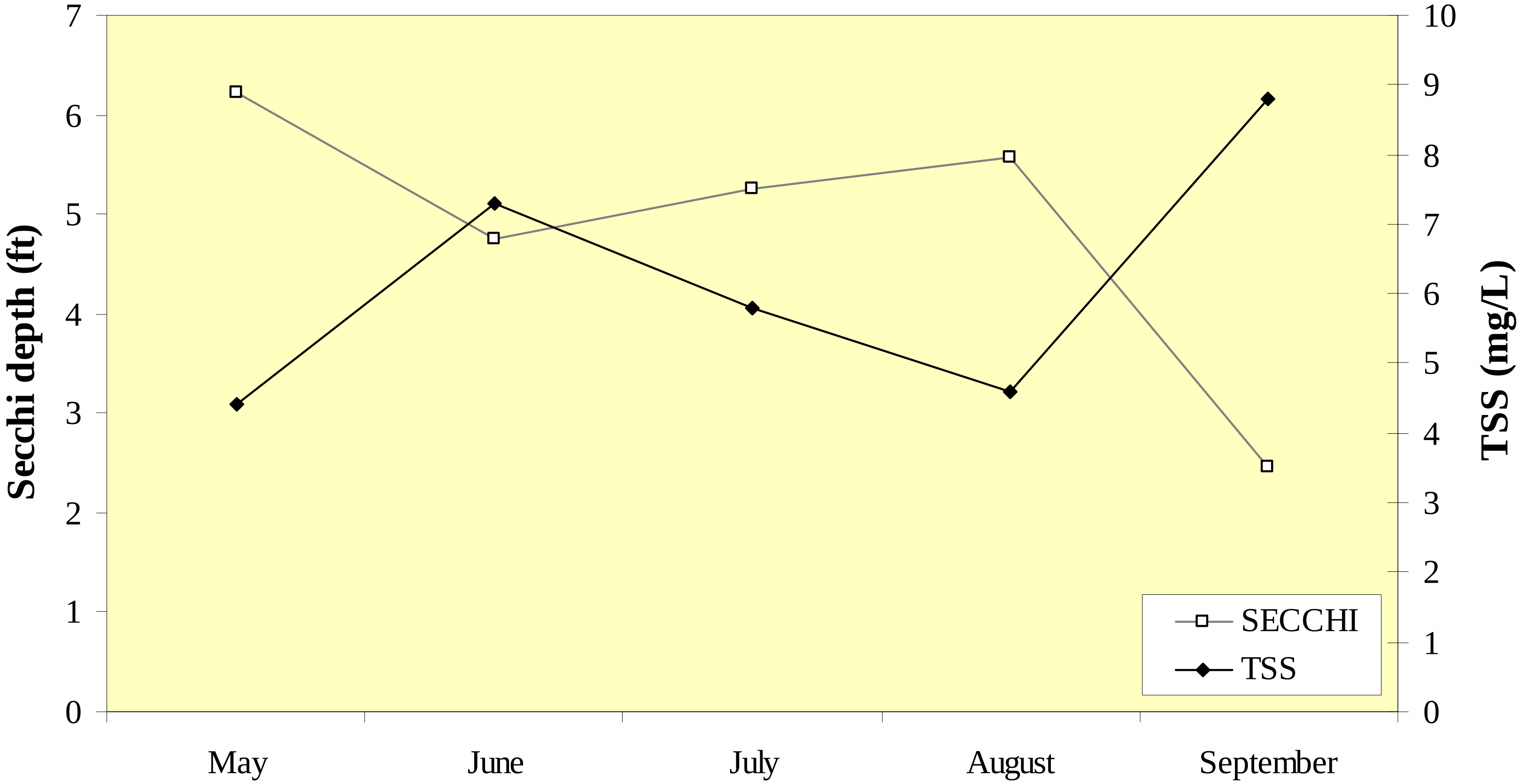
Table 3. Continued.

RANK	LAKE NAME	TP AVE	TSIp
87	Bluff Lake	0.0734	66.10
88	Harvey Lake	0.0766	66.71
89	Broberg Marsh	0.0782	67.01
90	Countryside Lake	0.0788	67.12
91	Echo Lake	0.0792	67.19
92	Sylvan Lake	0.0794	67.23
93	Big Bear Lake	0.0806	67.45
94	Petite Lake	0.0834	67.94
95	Lake Marie (Site 1)	0.0850	68.21
96	North Churchill Lake	0.0872	68.58
97	Grandwood Park, Site II, Outflow	0.0876	68.65
98	South Churchill Lake	0.0896	68.97
99	Rivershire Pond 2	0.0900	69.04
100	McGreal Lake	0.0914	69.26
101	International Mine and Chemical Lake	0.0948	69.79
102	Eagle Lake (Site I)	0.0950	69.82
103	Dunns Lake	0.0952	69.85
104	Fish Lake	0.0956	69.91
105	Lake Barrington	0.0956	69.91
106	Lochanora Lake	0.0960	69.97
107	Owens Lake	0.0978	70.23
108	Woodland Lake	0.0986	70.35
109	Island Lake	0.0990	70.41
110	McDonald Lake 1	0.0996	70.50
111	Tower Lake	0.1000	70.56
112	Longview Meadow Lake	0.1024	70.90
113	Redwing Slough, Site II, Outflow	0.1072	71.56
114	Lake Forest Pond	0.1074	71.59
115	Bittersweet Golf Course #13	0.1096	71.88
116	Fox Lake (Site 1)	0.1098	71.90
117	Bresen Lake	0.1126	72.27
118	Round Lake Marsh North	0.1126	72.27
119	Timber Lake S	0.1128	72.29
120	Deer Lake Meadow Lake	0.1158	72.67
121	Taylor Lake	0.1184	72.99
122	Grand Avenue Marsh	0.1194	73.11
123	Columbus Park Lake	0.1226	73.49
124	Nippersink Lake (Site 1)	0.1240	73.66
125	Grass Lake (Site 1)	0.1288	74.21
126	Lake Holloway	0.1322	74.58
127	Lakewood Marsh	0.1330	74.67
128	Summerhill Estates Lake	0.1384	75.24
129	Redhead Lake	0.1412	75.53

Table 3. Continued.

RANK	LAKE NAME	TP AVE	TSIp
130	Forest Lake	0.1422	75.63
131	Antioch Lake	0.1448	75.89
132	Valley Lake	0.1470	76.11
133	Slocum Lake	0.1496	76.36
134	Drummond Lake	0.1510	76.50
135	Pond-a-Rudy	0.1514	76.54
136	Lake Matthews	0.1516	76.56
137	Buffalo Creek Reservoir	0.1550	76.88
138	Pistakee Lake (Site 1)	0.1592	77.26
139	Salem Lake	0.1650	77.78
140	Half Day Pit	0.1690	78.12
141	Lake Eleanor Site II, Outflow	0.1812	79.13
142	Lake Farmington	0.1848	79.41
143	ADID 127	0.1886	79.71
144	Lake Louise Inlet	0.1938	80.10
145	Grassy Lake	0.1952	80.20
146	Dog Bone Lake	0.1990	80.48
147	Redwing Marsh	0.2072	81.06
148	Stockholm Lake	0.2082	81.13
149	Bishop Lake	0.2156	81.63
150	Hidden Lake	0.2236	82.16
151	Fischer Lake	0.2278	82.43
152	Lake Napa Suwe (Outlet)	0.2304	82.59
153	Patski Pond (outlet)	0.2512	83.84
154	Oak Hills Lake	0.2792	85.36
155	Loch Lomond	0.2954	86.18
156	McDonald Lake 2	0.3254	87.57
157	Fairfield Marsh	0.3264	87.61
158	ADID 182	0.3280	87.69
159	Slough Lake	0.4134	91.02
160	Flint Lake Outlet	0.4996	93.75
161	Rasmussen Lake	0.5025	93.84
162	Albert Lake, Site II, outflow	1.1894	106.26

Figure 4. Secchi depth vs. total suspended solid (TSS) concentrations in Hastings Lake, 2006.



of aquatic species were 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. The Chloride concentrations for Slough and Crooked Lakes were 317 mg/L and 225 mg/L, respectively.

A plankton sample was collected each month from May through September at the same location water samples were taken. Plankton are microscopic plants and animals that are free-floating within the water column and serve as the base of the food chain. Samples were collected to get a general idea of the types of algae and zooplankton found in the lake. Zooplankton populations were relatively stable throughout the season with a small increase in rotifers in June. There was a blue-green algal bloom in July and an increase in populations in September. All other phytoplankton remained stable throughout the summer.

SUMMARY OF AQUATIC MACROPHYTES

Aquatic plant sampling was conducted on Hastings Lake in July. There were 47 points sampled based on a computer generated grid system with points 60 meters apart. Aquatic plants were found at 79% of all sites with seven different species found (Table 4). In 2001 six species were found. Flatstem Pondweed and Spatterdock were not found in 2001. Spatterdock may have been misidentified in 2001 as Yellow Pond Lily. This is a rare plant found in only 2 lakes in the county. Eurasian Watermilfoil and Coontail were the two most abundant species found at 63.8% and 46.8 % of the sites, respectively (Table 5; Figure 5). Eurasian Watermilfoil and Curlyleaf Pondweed (also found in Hastings Lake) are invasive, exotic species that tend to crowd out native species and they should be kept under control to ensure the survival of native species.

Water clarity and depth are the major limiting factors in determining the maximum depth at which aquatic plants will grow in a lake. When the light level in the water column falls below 1% of the surface light level, plants can no longer grow. The 1% light level in Hastings Lake was at 12 feet in May and June and 10 feet in July when the plant survey was conducted. This corresponds to the maximum depth where plants were found.

Floristic quality index (FQI; Swink and Wilhelm 1994) is an assessment tool designed to evaluate the closeness the flora of an area is to that of undisturbed conditions. It can be used to: 1) identify natural areas, 2) compare the quality of different sites or different locations within a single site, 3) monitor long-term floristic trends, and 4) monitor habitat restoration efforts. Each aquatic plant in a lake is assigned a number between 1 and 10 (10 indicating the plant species most sensitive to disturbance). This is done for every floating and submersed plant species found in the lake. These numbers are averaged and multiplied by the square root of the number of species present to calculate an FQI. A high FQI number indicates there are a large number of sensitive, high quality plant species present in the lake. Non-native species were counted in the FQI calculations for Lake County lakes. In 2006, Hastings Lake had an FQI of 12.5 and ranked 77th of 151 lakes in the county (Table 6). This is an improvement from 2001 when it had an FQI of 9.8. The median FQI of lakes that we have studied from 2000-2006 was 12.5.

Table 4: Aquatic plant species found in Hastings Lake, 2006.

Coontail	*Ceratophyllum demersum*
Eurasian Watermilfoil^	*Myriophyllum spicatum*
Spatterdock	*Nuphar variegata*
White Water Lily	*Nymphaea tuberosa*
Curlyleaf Pondweed^	*Potamogeton crispus*
Sago Pondweed	*Potamogeton pectinatus*
Flatstem Pondweed	*Potamogeton zosteriformis*

^ Exotic plant

Table 5. Aquatic plant species found at the 47 sampling sites on Hastings Lake, 2006. The maximum depth that plants were found was 10 feet.

Plant Density	Coontail	Curlyleaf Pondweed	Eurasian Watermilfoil	Flatstem Pondweed	Sago Pondweed	Spatterdock	White Water Lily
Absent	25	45	17	46	44	46	28
Present	16	2	20	1	2	1	9
Common	4	0	6	0	1	0	2
Abundant	0	0	1	0	0	0	6
Dominant	2	0	3	0	0	0	2
% Plant Occurrence	46.8	4.3	63.8	2.1	6.4	2.1	40.4

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

Rake Density (coverage)	# of Sites	% of Sites
No Plants	10	21
>0-10%	15	32
10-40%	8	17
40-60%	5	11
60-90%	5	11
>90%	4	9
Total Sites with Plants	37	79
Total # of Sites	47	100

Figure 5. Aquatic plant sampling grid illustrating plant density on Hastings Lake, 2006.

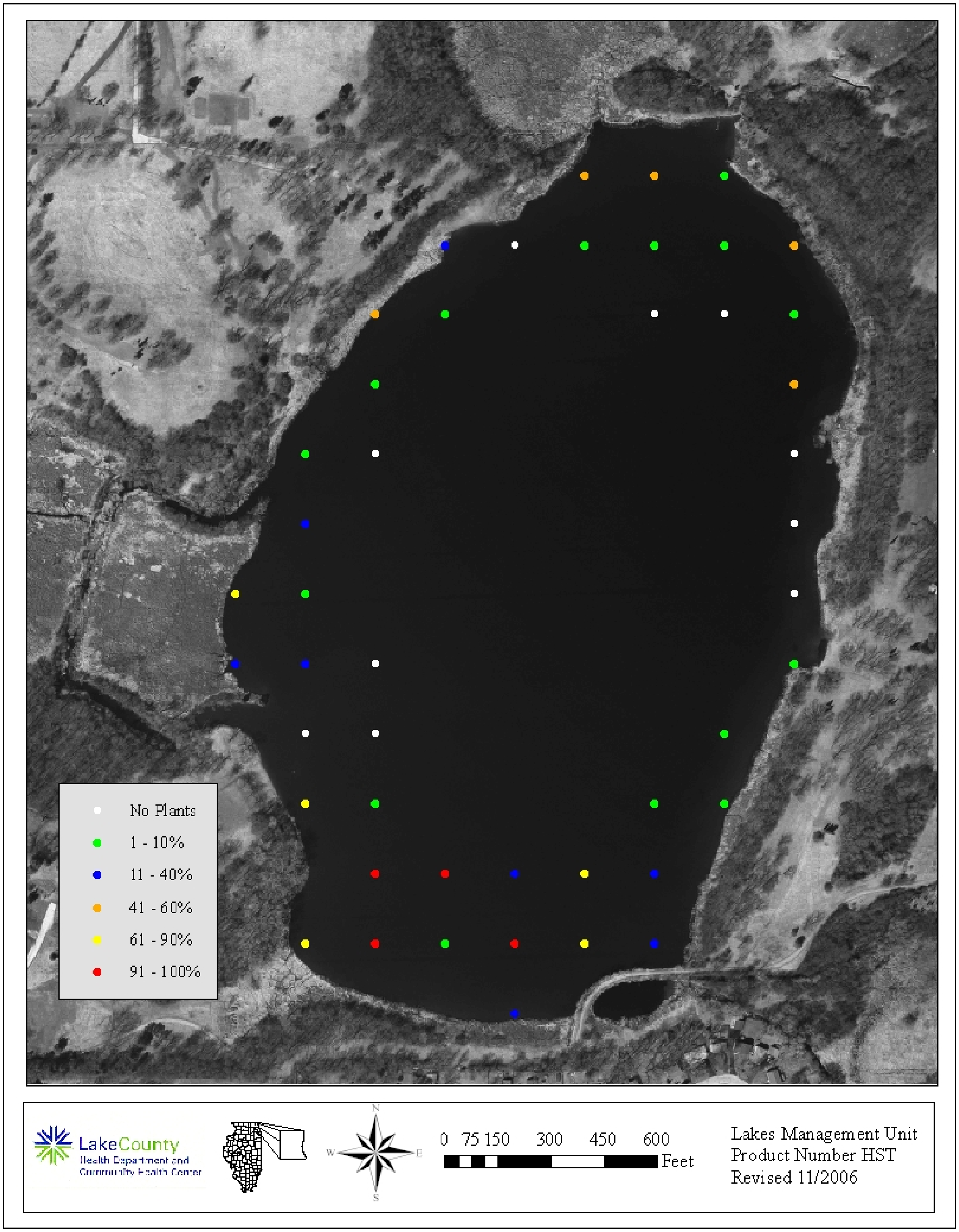


Table 6. Floristic quality index (FQI) of lakes in Lake County, calculated with exotic species (w/Adventives) and with native species only (native).

RANK	LAKE NAME	FQI (w/A)	FQI (native)
1	Cedar Lake	35.7	37.9
2	Deep Lake	33.9	35.4
3	Round Lake Marsh North	29.1	29.9
4	East Loon Lake	28.4	29.9
5	Deer Lake	28.2	29.7
6	Sullivan Lake	28.2	29.7
7	Little Silver Lake	27.9	30.0
8	Schreiber Lake	26.8	27.6
9	Cranberry Lake	26.6	28.6
10	Bangs Lake	26.4	28.0
11	West Loon Lake	26.0	27.6
12	Cross Lake	25.2	27.8
13	Lake Zurich	24.0	26.0
14	Lake of the Hollow	23.8	26.2
15	Lakewood Marsh	23.8	24.7
16	Round Lake	23.5	25.9
17	Fourth Lake	23.0	24.8
18	Druce Lake	22.8	25.2
19	Sun Lake	22.7	24.5
20	Countryside Glen Lake	21.9	22.8
21	Sterling Lake	21.8	24.1
22	Butler Lake	21.4	23.1
23	Duck Lake	21.1	22.9
24	Timber Lake (North)	20.8	22.8
25	Broberg Marsh	20.5	21.4
26	Davis Lake	20.5	21.4
27	ADID 203	20.5	20.5
28	McGreal Lake	20.2	22.1
29	Wooster Lake	19.8	22.3
30	Lake Kathryn	19.6	20.7
31	Fish Lake	19.3	21.2
32	Redhead Lake	19.3	21.2
33	Owens Lake	19.3	20.2
34	Lake Minear	18.8	20.6
35	Turner Lake	18.6	21.2
36	Salem Lake	18.5	20.2
37	Lake Miltmore	18.4	20.3
38	Hendrick Lake	17.7	17.7
39	Summerhill Estates Lake	17.1	18.0
40	Ames Pit	17.0	18.0
41	Seven Acre Lake	17.0	15.5
42	Gray's Lake	16.9	19.8
43	Grand Avenue Marsh	16.9	18.7

Table 6. Continued.

Rank	Lake Name	FQI (w/A)	FQI (native)
44	Long Lake	16.9	18.7
45	Bresen Lake	16.6	17.8
46	Windward Lake	16.3	17.6
47	Lake Barrington	16.3	17.4
48	Diamond Lake	16.3	17.4
49	Lake Napa Suwe	16.3	17.4
50	Dog Bone Lake	15.7	15.7
51	Redwing Slough	15.6	16.6
52	Independence Grove	15.5	16.7
53	Tower Lake	15.2	17.6
54	Heron Pond	15.1	15.1
55	Lake Tranquility (S1)	15.0	17.0
56	North Churchill Lake	15.0	15.0
57	Island Lake	14.7	16.6
58	Dog Training Pond	14.7	15.9
59	Highland Lake	14.5	16.7
60	Lake Fairview	14.3	16.3
61	Taylor Lake	14.3	16.3
62	Third Lake	14.1	16.3
63	Dugdale Lake	14.0	15.1
64	Eagle Lake (S1)	14.0	15.1
65	Longview Meadow Lake	13.9	13.9
66	Hook Lake	13.4	15.5
67	Timber Lake (South)	13.4	15.5
68	Bishop Lake	13.4	15.0
69	Mary Lee Lake	13.1	15.1
70	Old School Lake	13.1	15.1
71	Buffalo Creek Reservoir	13.1	14.3
72	McDonald Lake 2	13.1	14.3
73	Old Oak Lake	12.7	14.7
74	White Lake	12.7	14.7
75	Dunn's Lake	12.7	13.9
76	Echo Lake	12.5	14.8
77	**Hastings Lake**	**12.5**	**14.8**
78	Sand Lake	12.5	14.8
79	Countryside Lake	12.5	14.0
80	Stone Quarry Lake	12.5	12.5
81	Honey Lake	12.1	14.3
82	Lake Leo	12.1	14.3
83	Lambs Farm Lake	12.1	14.3
84	Stockholm Lake	12.1	13.5
85	Pond-A-Rudy	12.1	12.1
86	Lake Matthews	12.0	12.0

Table 6. Continued.

Rank	Lake Name	FQI (w/A)	FQI (native)
87	Flint Lake	11.8	13.0
88	Harvey Lake	11.8	13.0
89	Rivershire Pond 2	11.5	13.3
90	Antioch Lake	11.3	13.4
91	Lake Charles	11.3	13.4
92	Lake Linden	11.3	11.3
93	Lake Naomi	11.2	12.5
94	Pulaski Pond	11.2	12.5
95	Redwing Marsh	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	Lake Carina	10.2	12.5
100	Crooked Lake	10.2	12.5
101	Lake Lakeland Estates	10.0	11.5
102	College Trail Lake	10.0	10.0
103	Werhane Lake	9.8	12.0
104	Big Bear Lake	9.5	11.0
105	Little Bear Lake	9.5	11.0
106	Loch Lomond	9.4	12.1
107	Sand Pond (IDNR)	9.4	12.1
108	Columbus Park Lake	9.2	9.2
109	Sylvan Lake	9.2	9.2
110	Fischer Lake	9.0	11.0
111	Grandwood Park Lake	9.0	11.0
112	Lake Fairfield	9.0	10.4
113	McDonald Lake 1	8.9	10.0
114	East Meadow Lake	8.5	8.5
115	South Churchill Lake	8.5	8.5
116	Lake Christa	8.5	9.8
117	Lake Farmington	8.5	9.8
118	Lucy Lake	8.5	9.8
119	Bittersweet Golf Course #13	8.1	8.1
120	Woodland Lake	8.1	9.9
121	Albert Lake	7.5	8.7
122	Lake Eleanor	7.5	8.7
123	Fairfield Marsh	7.5	8.7
124	Lake Louise	7.5	8.7
125	Banana Pond	7.5	9.2
126	Patski Pond	7.1	7.1
127	Rasmussen Lake	7.1	7.1
128	Slough Lake	7.1	7.1
129	Lucky Lake	7.0	7.0

Table 6. Continued.

Rank	Lake Name	FQI (w/A)	FQI (native)
130	Lake Forest Pond	6.9	8.5
131	Leisure Lake	6.4	9.0
132	Peterson Pond	6.0	8.5
133	Grassy Lake	5.8	7.1
134	Slocum Lake	5.8	7.1
135	Gages Lake	5.8	10.0
136	Deer Lake Meadow Lake	5.2	6.4
137	ADID 127	5.0	5.0
138	Liberty Lake	5.0	5.0
139	Oak Hills Lake	5.0	5.0
140	Drummond Lake	5.0	7.1
141	IMC Lake	5.0	7.1
142	North Tower Lake	4.9	7.0
143	Forest Lake	3.5	5.0
144	Half Day Pit	2.9	5.0
145	Lochanora Lake	2.5	5.0
146	Hidden Lake	0.0	0.0
147	St. Mary's Lake	0.0	0.0
148	Valley Lake	0.0	0.0
149	Waterford Lake	0.0	0.0
150	Potomac Lake	0.0	0.0
151	Willow Lake	0.0	0.0
	Mean	**13.6**	**14.9**
	Median	**12.5**	**14.3**

SUMMARY OF SHORELINE CONDITION

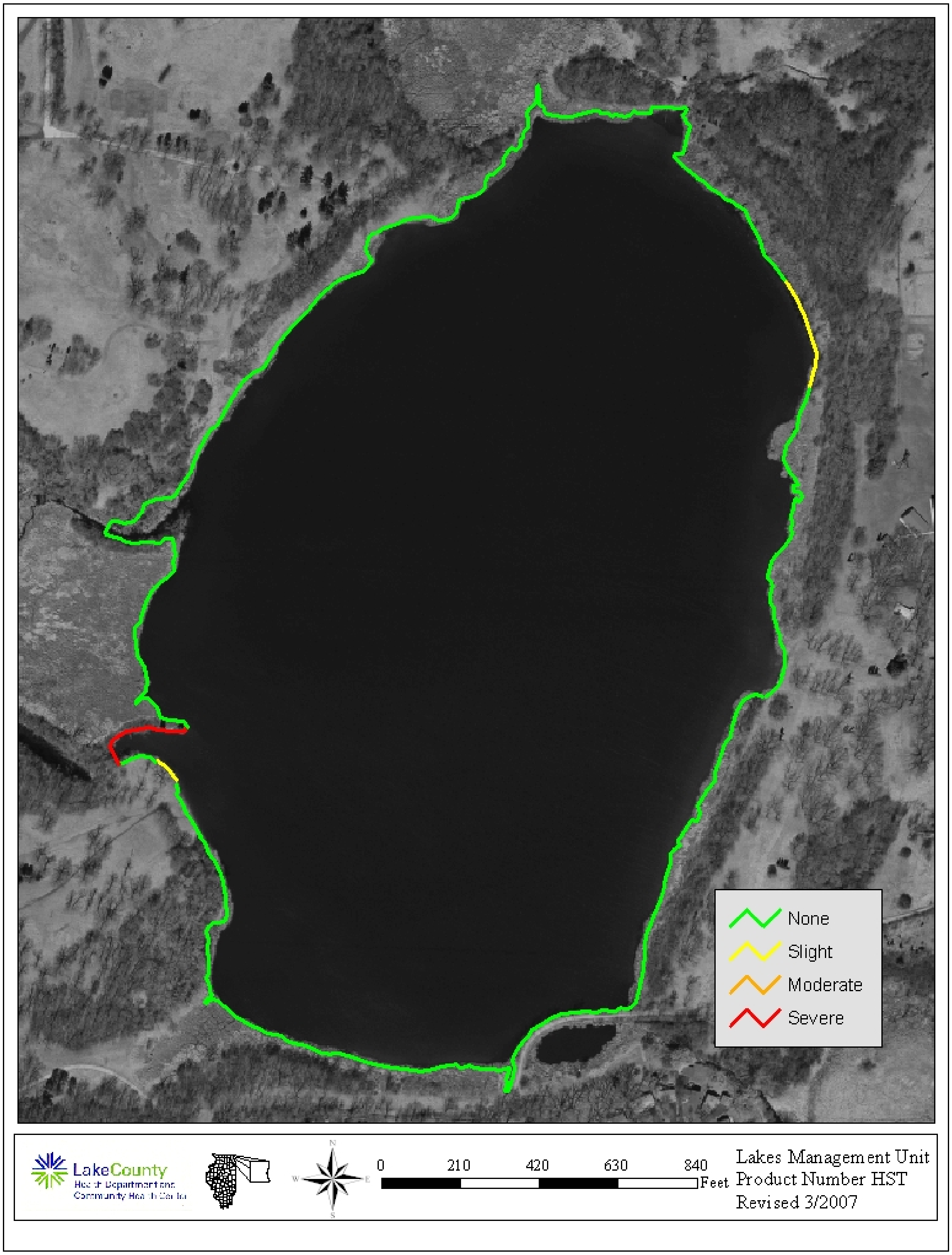
In 2001 the shoreline was assessed at the water/land interface. Approximately 87% of the shoreline consisted of wetland. The major portions of the lake were comprised of wetland, woodland and buffer. Woodland and wetland are very desirable shoreline types because they provide wildlife habitat and can protect the shore from excessive erosion. As a result of the dominance of wetland shoreline, 92.7% of Hastings Lake's shoreline exhibited no erosion. Slight erosion was occurring on 3.5% of a woodland shoreline, moderate erosion was occurring on 0.9% of a manicured lawn shoreline and severe erosion was occurring on 2.9% of a woodland shoreline (Figure 6). Although woodland-dominated lots may seem to provide the ideal shoreline, if the slope is steep, lots are not maintained, or they have manicured lawn, erosion can occur. Deciduous trees present along these shorelines shade out all understory plants (whose roots provide the best stabilization) beneath them potentially causing erosion. The erosion occurring along the woodland shore should be addressed, while efforts should be made to ensure that wetland dominated shorelines remain intact. In 2006 the shoreline was reevaluated for erosion. The area on the southwest portion of the lake with moderate erosion in 2001 has improved to slight erosion.

Although almost no erosion was occurring around Hastings Lake, invasive plant species, including Reed Canary Grass, Buckthorn, and Purple Loosestrife were present along 93.4% of the shoreline in 2001. These plants are extremely invasive and exclude native plants from the area they inhabit. Buckthorn provides very poor shoreline stabilization and may lead to increasing erosion problems in the future. Reed Canary Grass and Purple Loosestrife inhabit mostly wetland areas and can easily outcompete native plants. Additionally, all three do not provide the quality wildlife habitat or shoreline stabilization that native plants provide and steps to eliminate these plants should be carried out before they take over these areas.

SUMMARY OF WILDLIFE AND HABITAT

The last complete fish survey on Hastings Lake was conducted by the Illinois Department of Natural Resources (IDNR) in 2005. Nine species of fish were found with a high abundance of Yellow Bass and Common Carp. The IDNR recommends removing carp when possible. This may help reduce turbidity and allow predators and panfish to repopulate and possibly return to a more balanced fishery. The IDNR removed carp that were caught during the survey and recommend this as a way of controlling the population. They also removed another 212 in May of 2006.

Figure 6. Shoreline erosion on Hastings Lake, 2006.



LAKE MANAGEMENT RECOMMENDATIONS

Hastings Lake has good water quality which can be attributed to the 87% of the shoreline surrounded by wetland. Due to this, shoreline erosion was minimal on the lake. Although aquatic plant coverage on the lake was good, plant diversity was low and included exotic species. There are many grant opportunities available to do improvements around or in the lake (Appendix F).

Creating a Bathymetric Map

An up to date bathymetric (depth contour) map is an essential tool in effective lake management since it provides information on the morphometric features of the lake, such as depth, surface area, volume, etc. The knowledge of this morphometric information would be necessary if lake management practices, such as aquatic herbicide use or fish stocking, were part of the overall lake management plan. Hastings Lake does not have a current bathymetric map with volume calculations (Appendix D1).

Eliminate or Control Exotic Species

In 2001 aggressive, exotic shoreline plant species were found. These species are especially detrimental, as they can crowd out native, beneficial plants used by wildlife. Their removal is recommended (Appendix D2).

Options For Lakes With High Carp Populations

Common Carp are contributing to the high phosphorus levels in the lake by resuspension of sediment. The only way to truly eradicate them from a lake is with rotenone (Appendix D3).

Options to Reduce Conductivity and Chloride Concentrations

The current concentration of chloride in Hastings Lake has the potential to negatively impact aquatic life, from plants to algae to fish. Road salt (sodium chloride) is the most commonly used winter road de-icer and is the major contributor to chloride and conductivity levels (Appendix D4).

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 9.1) overlaid a grid pattern onto a 2006 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.

Plankton Sampling

Plankton were sampled at the same location as water quality samples. Using the Hydrolab DataSonde® 4a or YSI 6600 Sonde® 1% light level depth (depth where the water light is 1% of the surface irradiance) was determined. A plankton net/tow, with 63μm mesh, was then lowered to the pre-determined 1% light level depth and retrieved vertically. On the way up the water column, plankton were collected within a small cup on the bottom of the tow. The collected sample was then emptied into a pre-labeled brown plastic bottle. The net was rinsed with deionized water into the bottle in order to ensure all the plankton were collected. The sample was then transferred to a graduated cylinder to measure the amount of milliliters (mL) that the sample was. The sample was then returned to the bottle and preserved with Lugol's iodine solution (5 drops/mL). The sample bottle was then closed and stored in a cooler until returning to the lab, where it was transferred to the refrigerator until enumeration. Enumeration was performed within three months, but ideally within one month, under a microscope. Prior to sub-sample being removed for enumeration, the sample bottle was inverted several times to ensure proper homogenization. An automated pipette was used to retrieve 1 mL of sample, which was then placed in a Sedgewick Rafter slide. This is a microscope slide on which a rectangular chamber has been constructed, measuring 50 mm x 20 mm in area and 1 mm deep. The slide was then placed under the microscope and counted at a 20X magnification (phytoplankton) or 10X magnification (zooplankton). For phytoplankton, twenty fields of view were randomly counted with all species within each field counted. Due to their larger size, zooplankton were counted throughout the entire slide. Through calculations, it was determined how many of each species were in 1 mL of lake water.

Phytoplankton (algae) are free-floating and microscopic and are distinguished from plants because they lack roots, stems and leaves. There are four distinct groups of phytoplankton found in Lake County lakes: blue-greens, greens, diatoms, and dinoflagellates/chrysophytes. Blue-greens are also known as cyanobacteria because they are the only group of bacteria that obtain their energy from photosynthesis like plants. Some of these species can be toxic. Green algae are the closest ancestors of land plants and are the most common group. Diatoms are unique because they are encased in a cell wall made of silica that can be very ornate. Dinoflagellates and chrysophytes are almost always flagellated (able to move by flagella, a whip-like tail) and some can both photosynthesize and consume bacteria for food.

Zooplankton are made up of rotifers and two crustacean groups; the cladocerans and the copepods (broken down further into calanoids and cyclopoids). Rotifers are smaller and most have a crown of cilia (hair-like structure) used for movement and drawing in suspended particles to eat. Crustaceans have jointed appendages and are enclosed in an exoskeleton. Cladocerans, such as the “water flea” Daphnia species, are filter-feeding like rotifers, while the copepod group contains both filter-feeders (calanoids and cyclopoids) and raptorial species (cyclopoids).

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.

> <u>None</u> – Includes man-made erosion control such as beach, rip-rap and sea wall.
>
> <u>Slight</u> – 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”.
>
> <u>Moderate</u> – 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 HASTINGS LAKE IN 2006

Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission	Extinction Coefficient
										Average	0.20
05/09/2006	0.5	0.480	17.19	10.78	112.3	1.0690	8.52	1326.2	Surface		
05/09/2006	1	1.006	17.20	10.77	112.2	1.0690	8.38	756.9	Surface	100%	
05/09/2006	2	2.488	17.20	10.74	111.9	1.0690	8.35	178.2	0.818	24%	1.77
05/09/2006	3	3.100	17.20	10.73	111.8	1.0700	8.32	85.9	1.430	11%	0.51
05/09/2006	4	3.975	17.18	10.74	111.9	1.0710	8.31	100.5	2.305	13%	-0.07
05/09/2006	6	6.000	17.14	10.42	108.5	1.0710	8.30	48.0	4.330	6%	0.17
05/09/2006	8	8.030	17.10	10.20	106.1	1.0690	8.30	24.9	6.360	3%	0.10
05/09/2006	10	10.087	16.99	9.91	102.8	1.0690	8.28	13.4	8.417	2%	0.07
05/09/2006	12	12.036	16.14	8.52	86.9	1.0790	8.23	7.6	10.366	1%	0.05
05/09/2006	14	14.039	14.66	4.38	43.3	1.0710	8.09	4.8	12.369	1%	0.04
05/09/2006	16	16.074	14.40	3.41	33.5	1.0700	8.02	2.9	14.404	0%	0.03
05/09/2006	18	18.004	14.26	2.90	28.4	1.0700	7.93	2.0	16.334	0%	0.02
05/09/2006	20	20.029	13.96	2.12	20.6	1.0700	7.87	1.2	18.359	0%	0.03
05/09/2006	22	22.323	13.64	1.37	13.2	1.0690	7.84	0.7	20.653	0%	0.03
05/09/2006	24	24.052	13.56	0.95	9.2	1.0700	7.79	0.5	22.382	0%	0.02
05/09/2006	26	25.981	13.34	0.33	3.2	1.0700	7.76	0.4	24.311	0%	0.01

Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission	Extinction Coefficient
										Average	0.36
06/13/2006	0.5	0.512	21.69	10.99	125.3	1.080	8.24	3370.2	Surface		
06/13/2006	1	1.072	21.62	11.42	130.1	1.081	8.31	2975.4	Surface	100%	
06/13/2006	2	2.007	21.27	11.52	130.3	1.082	8.39	956.2	0.337	32%	3.37
06/13/2006	3	3.027	20.87	11.55	129.6	1.079	8.41	692.6	1.357	23%	0.24
06/13/2006	4	4.000	20.54	11.60	129.3	1.080	8.43	194.1	2.330	7%	0.55
06/13/2006	6	6.012	20.33	10.99	122.0	1.080	8.40	196.7	4.342	7%	0.00
06/13/2006	8	8.020	20.26	10.37	115.0	1.081	8.38	108.1	6.350	4%	0.09
06/13/2006	10	10.019	20.03	9.61	106.1	1.082	8.34	46.4	8.349	2%	0.10
06/13/2006	12	12.017	19.58	6.11	66.9	1.085	8.17	17.8	10.347	1%	0.09
06/13/2006	14	14.063	18.91	3.18	34.3	1.088	7.97	10.5	12.393	0%	0.04
06/13/2006	16	16.016	18.24	1.16	12.3	1.089	7.85	4.7	14.346	0%	0.06
06/13/2006	18	17.993	17.24	0.26	2.7	1.089	7.76	2.3	16.323	0%	0.04
06/13/2006	20	20.011	14.95	0.13	1.3	1.092	7.64	1.3	18.341	0%	0.03
06/13/2006	22	22.025	14.16	0.09	0.9	1.093	7.54	0.8	20.355	0%	0.02
06/13/2006	24	24.006	13.87	0.05	0.5	1.102	7.47	0.5	22.336	0%	0.02

Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission	Extinction Coefficient
										Average	0.35
07/11/2006	0.5	0.499	24.61	6.43	77.5	1.069	8.53	946.7	Surface		
07/11/2006	1	1.044	24.62	6.43	77.5	1.069	8.53	735.5	Surface	100%	
07/11/2006	2	2.038	24.61	6.41	77.2	1.069	8.54	207.6	0.368	28%	3.44
07/11/2006	3	3.002	24.60	6.35	76.5	1.070	8.54	140.1	1.332	19%	0.30
07/11/2006	4	4.030	24.59	6.33	76.2	1.071	8.54	97.8	2.360	13%	0.15
07/11/2006	6	5.993	24.54	6.41	77.2	1.070	8.56	41.6	4.323	6%	0.20
07/11/2006	8	8.019	24.43	6.55	78.7	1.069	8.57	21.5	6.349	3%	0.10
07/11/2006	10	10.002	24.32	4.19	50.3	1.072	8.51	10.7	8.332	1%	0.08
07/11/2006	12	12.045	24.07	1.79	21.3	1.074	8.39	6.1	10.375	1%	0.05
07/11/2006	14	14.059	23.92	0.73	8.6	1.074	8.30	2.8	12.389	0%	0.06
07/11/2006	16	16.006	22.47	0.26	3.0	1.079	8.18	1.3	14.336	0%	0.05
07/11/2006	18	18.014	20.53	0.25	2.8	1.079	8.03	0.8	16.344	0%	0.03
07/11/2006	20	20.057	17.67	0.21	2.2	1.093	7.83	0.4	18.387	0%	0.04
07/11/2006	22	22.034	15.40	0.16	1.6	1.104	7.73	0.3	20.364	0%	0.01
07/11/2006	24	24.022	14.38	0.03	0.3	1.123	7.67	0.2	22.352	0%	0.02

Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission Average	Extinction Coefficient NA
08/08/2006	0.5	0.481	27.32	7.44	94.2	1.127	8.52	NA	Surface		
08/08/2006	1	1.013	27.33	7.57	95.9	1.128	8.53	NA	Surface	NA	
08/08/2006	2	2.076	27.33	7.47	94.5	1.127	8.53	NA	0.406	NA	NA
08/08/2006	3	3.006	27.28	7.49	94.8	1.128	8.53	NA	1.336	NA	NA
08/08/2006	4	4.033	27.14	7.52	94.8	1.129	8.52	NA	2.363	NA	NA
08/08/2006	6	6.036	27.03	7.37	92.8	1.128	8.52	NA	4.366	NA	NA
08/08/2006	8	7.996	26.97	7.86	98.9	1.127	8.54	NA	6.326	NA	NA
08/08/2006	10	10.010	26.78	3.72	46.7	1.132	8.13	NA	8.340	NA	NA
08/08/2006	12	11.982	26.72	2.70	33.9	1.133	7.99	NA	10.312	NA	NA
08/08/2006	14	14.049	26.41	0.73	9.1	1.136	7.76	NA	12.379	NA	NA
08/08/2006	16	16.003	24.31	0.06	0.7	1.150	7.43	NA	14.333	NA	NA
08/08/2006	18	18.015	21.28	0.33	3.7	1.165	7.15	NA	16.345	NA	NA
08/08/2006	20	20.003	19.08	0.26	2.8	1.177	7.03	NA	18.333	NA	NA
08/08/2006	22	22.030	16.90	0.34	3.5	1.199	6.91	NA	20.360	NA	NA
08/08/2006	24	24.121	15.80	0.36	3.7	1.232	6.79	NA	22.451	NA	NA

Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission Average	Extinction Coefficient NA
09/12/2006	0.5	0.510	20.68	7.14	79.8	1.093	8.03	NA	Surface		
09/12/2006	1	1.086	20.60	6.22	69.4	1.093	8.01	NA	Surface	NA	
09/12/2006	2	2.016	20.34	4.89	54.3	1.096	7.91	NA	0.346	NA	NA
09/12/2006	3	2.982	20.29	4.34	48.2	1.096	7.86	NA	1.312	NA	NA
09/12/2006	4	4.034	20.28	3.90	43.3	1.096	7.85	NA	2.364	NA	NA
09/12/2006	6	5.963	20.27	3.65	40.5	1.096	7.84	NA	4.293	NA	NA
09/12/2006	8	8.014	20.27	3.61	40.1	1.097	7.82	NA	6.344	NA	NA
09/12/2006	10	9.960	20.24	3.46	38.3	1.098	7.80	NA	8.290	NA	NA
09/12/2006	12	11.975	20.22	3.58	39.6	1.098	7.79	NA	10.305	NA	NA
09/12/2006	14	14.022	20.21	3.90	43.2	1.099	7.76	NA	12.352	NA	NA
09/12/2006	16	15.999	20.21	3.77	41.7	1.085	7.75	NA	14.329	NA	NA
09/12/2006	18	18.002	20.17	3.76	41.6	1.097	7.75	NA	16.332	NA	NA
09/12/2006	20	19.950	20.13	3.13	34.6	1.096	7.76	NA	18.280	NA	NA
09/12/2006	22	21.984	20.12	2.88	31.8	1.081	7.75	NA	20.314	NA	NA
09/12/2006	24	24.026	20.12	2.66	29.4	1.095	7.75	NA	22.356	NA	NA

APPENDIX C. INTERPRETING YOUR LAKES 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 2000-2005 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 2000-2005 is 0.063 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 2000-2005 was 0.174 mg/L and ranged from a minimum of 0.012 mg/L in West Loon 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) were measured each month by the Lakes Management Staff, total suspended solids (TSS) 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 7.9 mg/L, ranging from below the 1 mg/L detection limit (10 lakes) 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 mg/L, ranging from 34 mg/L in Pulaski Pond to 298 mg/L in Fairfield Marsh.

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 3.17 feet. From 2000-2005, 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 8.30, with a minimum of 7.06 in Deer Lake and a maximum of 10.28 in Round Lake Marsh North.

Eutrophication and Trophic State Index:

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

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

Table 1. Trophic State Index (TSI).

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

APPENDIX D. LAKE MANAGEMENT OPTIONS

D1. 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 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 and weevils with Purple Loosestrife) 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.

<u>Option 3: Herbicide Treatment</u>

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.

D3. Option for Lakes with a High Carp Population

Rotenone is a piscicide that is naturally derived from the stems and roots of several tropical plants, making it biodegradable. It kills fish by chemically inhibiting the use of oxygen in biochemical pathways, therefore adult fish are much more susceptible than fish eggs. In the aquatic environment, fish come into contact with the rotenone by a different method than other organisms. With fish, the rotenone comes into direct contact with the exposed respiratory surfaces (gills), which is the route of entry. In other organisms this type of contact is minimal.

Rotenone has varying levels of toxicity on different fish species. Some species of fish can detoxify rotenone quicker than it can build up in their systems. Unfortunately, concentrations to remove undesirable fish, such as carp, bullhead and Green Sunfish, are high enough to kill more desirable species such as bass, Bluegill, crappie, Walleye, and Northern Pike. Rotenone is most effectively used when waters are cooling down (fall) not warming up (spring) and is most effective when water temperatures are $<50^{o}$F. To use rotenone in a body of water over 6 acres a *Permit to Remove Undesirable Fish* must be obtained from the Illinois Department of Natural Resources (IDNR), Natural Heritage Division, Endangered and Threatened Species Program. Furthermore, only an IDNR fisheries biologist licensed to apply aquatic pesticides can apply rotenone in the state of Illinois, as it is a restricted use pesticide.

Rotenone is one of the only ways to effectively remove undesirable fish species, however it can be expensive. It allows for rehabilitation of the lake’s fishery, which will allow for improvement of the aquatic plant community, and overall water quality. There are some negative impacts that may also occur with the use of rotenone. In the process of removing carp with rotenone, other desirable fish species will also be removed. The fishery can be replenished with restocking and quality sport fishing normally returns within 2-3 years. The IDNR will not approve application of rotenone to waters known to contain threatened and endangered fish species.

As with most intensive lake management techniques, a good bathymetric map is needed so that an accurate lake volume can be determined. To achieve a concentration of 6 ppm, which is the rate needed for most total rehabilitation projects (remove carp, bullhead and Green Sunfish), 2.022 gal/AF is required. In waters with high turbidity and/or planktonic algal blooms, the ppm may have to be higher. An IDNR fisheries biologist will be able to determine if higher concentrations will be needed.

D4. 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 - 2006 Water Quality Parameters, Statistics Summary

	ALKoxic <=3ft00-2006			ALKanoxic 2000-2006	
Average	**167.2**		Average	**201**	
Median	**162.0**		Median	**191**	
Minimum	**64.9**	**IMC**	Minimum	**103**	**Heron Pond**
Maximum	**330.0**	**Flint Lake**	Maximum	**470**	**Lake Marie**
STD	**41.8**		STD	**49**	
n =	**798**		n =	**247**	

	Condoxic <=3ft00-2006			Condanoxic 2000-2006	
Average	**0.8838**		Average	**0.9949**	
Median	**0.7954**		Median	**0.8276**	
Minimum	**0.2542**	**Broberg Marsh**	Minimum	**0.3210**	**Lake Kathyrn**
Maximum	**6.8920**	**IMC**	Maximum	**7.4080**	**IMC**
STD	**0.5391**		STD	**0.7811**	
n =	**796**		n =	**247**	

	NO3-N, Nitrate+Nitrite,oxic <=3ft00-2006			NH3-Nanoxic 2000-2006	
Average	**0.521**		Average	**2.103**	
Median	**0.153**		Median	**1.350**	
Minimum	**<0.05**	***ND**	Minimum	**<0.1**	***ND**
Maximum	**9.670**	**South Churchill Lake**	Maximum	**18.400**	**Taylor Lake**
STD	**1.060**		STD	**2.354**	
n =	**803**		n =	**247**	

*ND = Many lakes had non-detects (71.5%)
Only compare lakes with detectable
concentrations to the statistics above
Beginning in 2006, Nitrate+Nitrite was measured.

*ND = 18.6% Non-detects from 27 different lakes

	pHoxic <=3ft00-2006			pHanoxic 2000-2006	
Average	**8.30**		Average	**7.20**	
Median	**8.30**		Median	**7.18**	
Minimum	**5.21**	**Redwing Slough**	Minimum	**6.24**	**Banana Pond**
Maximum	**10.28**	**Round Lake Marsh North**	Maximum	**8.48**	**Heron Pond**
STD	**0.48**		STD	**0.39**	
n =	**796**		n =	**247**	

	All Secchi 2000-2006	
Average	**4.48**	
Median	**3.27**	
Minimum	**0.33**	**Fairfield Marsh, Patski Pond**
Maximum	**21.82**	**Bangs Lake**
STD	**3.69**	
n =	**740**	

81 of 161 lakes had anoxic conditions
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

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2000 - 2006 Water Quality Parameters, Statistics Summary (continued)

	TKNoxic <=3ft00-2006	
Average	**1.481**	
Median	**1.260**	
Minimum	**<0.5**	***ND**
Maximum	**10.300**	**Fairfield Marsh**
STD	**0.828**	
n =	**798**	

*ND = 3.6% Non-detects from 14 different lakes

	TKNanoxic 2000-2006	
Average	**2.971**	
Median	**2.270**	
Minimum	**<0.5**	***ND**
Maximum	**21.000**	**Taylor Lake**
STD	**2.341**	
n =	**247**	

*ND = 3.2% Non-detects from 5 different lakes

	TPoxic <=3ft00-2006	
Average	**0.101**	
Median	**0.061**	
Minimum	**<0.01**	***ND**
Maximum	**3.880**	**Albert Lake**
STD	**0.179**	
n =	**798**	

*ND = 0.1% Non-detects from 5 different lakes
(Carina, Minear,& Stone Quarry)

	TPanoxic 2000-2006	
Average	**0.279**	
Median	**0.162**	
Minimum	**0.012**	**West Loon Lake**
Maximum	**3.800**	**Taylor Lake**
STD	**0.369**	
n =	**247**	

	TSSall <=3ft00-2006	
Average	**15.4**	
Median	**7.9**	
Minimum	**<0.1**	***ND**
Maximum	**165.0**	**Fairfield Marsh**
STD	**20.5**	
n =	**810**	

*ND = 1.3% Non-detects from 10 different lakes

	TVSoxic <=3ft00-2006	
Average	**137.7**	
Median	**134.0**	
Minimum	**34.0**	**Pulaski Pond**
Maximum	**298.0**	**Fairfield Marsh**
STD	**41.2**	
n =	**752**	

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 <=3ft00-2006	
Average	**261**	
Median	**116**	
Minimum	**41**	**Timber Lake (N)**
Maximum	**2390**	**IMC**
STD	**450**	
n =	**79**	

	CLoxic <=3ft00-2006	
Average	**220**	
Median	**171**	
Minimum	**30**	**White Lake**
Maximum	**2760**	**IMC**
STD	**275**	
n =	**317**	

LakeCounty
Health Department and
Community Health Center

APPENDIX F. GRANT PROGRAM OPPORTUNITES

Table F1. A list of potential grant opportunities

Grant Program Name	Funding Source	Funding Focus			Cost Share	Typical Award
		Water Quality	Flooding	Habitat		
Challenge Grant Program	USFWS			X	>50%	<$10,000
Chicago Wilderness Small Grants Program	CW			X	None	$15,000
Conservation 2000 (C2000)	IDNR			X	None	$10,000 to $500,000
Conservation Reserve Program	NRCS			X	Land	Variable
Five Star Challenge Grant	NFWF			X	None	$5,000 to $20,000
Flood Mitigation Assistance Program	IEMA		X		25%	$200,000
Habitat Restoration Program for the Fox Watershed	LCSWCD			X	25%	<$1,000K
Illinois Clean Lakes Program (ICLP)	IEPA	X			>50%	$5,000 to $30,000
Illinois Clean Energy Community Foundation	ICECF			X	None	Variable
Lakes Education Assistance Grant Program (LEAP)	IEPA	X			None	$500
Northeast Illinois Wetland Conservation Account	USFWS	X		X	>50%	$600 to $200,000
Partners for Fish and Wildlife Program	USFWS			X	>50%	$3,000
Section 206: Aquatic Ecosystem Restoration	USACE			X	35%	<$1,000,000
Section 319: Non-Point Source Management Program	IEPA	X		X	>40%	Variable
STAG Grants	LCSMC	X			None	Variable
Stream Cleanup And Lakeshore Enhancement (SCALE)	IEPA	X			None	$2,000
Streambank Stabilization and Restoration Program (SSRP)	LCSWCD	X		X	25%	Variable
Unincorporated Lake County Drainage Fund	LCPBD		X		>50%	$5,000 to $10,000
Wildlife Habitat Incentives Program	NRCS			X	Land	Variable
Watershed Management Board	LCSMC	X	X	X	>50%	$5K to $10K
Wetland Reserve Program	NRCS			X	Land	Variable

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
LCPBD = Lake County Planning, Building, and Development Department
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 F2. Grant Contacts

Chicago Wilderness (CW)
Elizabeth McCance, Director of Conservation Programs
Phone: (312) 580-2138
E-mail: emccance@chicagowilderness.org
http://www.chicagowilderness.org/

Illinois Clean Energy Community Foundation (ICECF)
2 N. LaSalle Street
Suite 950
Chicago, IL 60602
Phone: (312) 372-5191
Fax: (312) 372-5190
http://www.illinoiscleanenergy.org/

Illinois Department of Natural Resources (IDNR)
One Natural Resources Way
Springfield, IL 62702-1271
Phone: (217) 782-9740
http://dnr.state.il.us/orep/C2000

Illinois Emergency Management Agency (IEMA)
110 East Adams Street
Springfield, Illinois 62701
Phone: (217) 785-0229
http://www.state.il.us/iema/index.htm

Illinois Environmental Protection Agency (IEPA)
Bureau of Water - Surface Water Section
1021 North Grand Avenue East
P.O. Box 19276
Springfield, Illinois 62794-9276
Telephone: (217) 782-3362
Fax: (217) 785-1225
http://www.epa.state.il.us/water/financial-assistance/non-point.html

Lake County Planning, Building, and Development Department (LCPBD)
18 N. County Street
Waukegan, IL 60085
Phone: (847) 377-2875
Fax: (847) 782-3016

Lake County Soil and Water Conservation District (LCSWCD)
100 N. Atkinson Road
Suite 102A
Grayslake, IL 60030
Phone: (847)-223-1056
Fax: (847)-223-1127
http://www.lakeswcd.org/

Lake County Stormwater Management Commission (LCSMC)
333-B Peterson Road
Libertyville, IL 60048
Phone: (847) 918-5260
Fax: (847) 918-9826
http://www.co.lake.il.us/smc

National Fish and Wildlife Foundation (NFWF)
Attn: Five Star Restoration Program
1120 Connecticut Avenue N.W., Suite 900
Washington, DC 20036
Phone: (202) 857-0166
Fax: (202) 857-0162
http://nfwf.org/programs/5star-rfp.htm

Natural Resources Conservation Service (NRCS)
Wildlife Habitat Incentives Program Coordinator
USDA Natural Resources Conservation Service
1902 Fox Drive
Champaign, IL 61820
Phone: (217) 398-5267
http://www.nrcs.usda.gov/programs/whip/

United States Army Corps of Engineers (USACE)
111 N. Canal Street
Chicago, Illinois 60606-7206
Telephone: (312)-846-5333
Fax: (312)-353-2169
http://www.lrc.usace.army.mil/

United States Fish and Wildlife Service (USFWS)
Chicago Field Office
1250 South Grove Avenue, Suite 103
Barrington, IL 60010
Phone: (847)-381-2253
Fax: (847)-381-2285

Other Related Contacts

Catalog of Federal Funding Sources for Watershed Protection Web Site
http://cfpub.epa.gov/fedfund/

Fox River Ecosystem Partnership (FREP)
http://foxriverecosystem.org/

North American Wetlands Conservation Act Grants Program
http://birdhabitat.fws.gov/NAWCA/grants.htm

North American Wetland Conservation Act Programs
http://birdhabitat.fws.gov/NAWCA/grants.htm

U.S. Fish and Wildlife Foundation
http://www.nfwf.org/