2006 SUMMARY REPORT
of
Deer Lake

Lake County, Illinois

Prepared by the

LAKE COUNTY HEALTH DEPARTMENT
ENVIRONMENTAL HEALTH SERVICES
LAKES MANAGEMENT UNIT

3010 Grand Avenue
Waukegan, Illinois 60085

Leonard Dane
Michael Adam
Shaina Keseley
Adrienne Orr

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EXECUTIVE SUMMARY

Deer Lake is a 59-acre glacial lake east of Antioch in northern Lake County. Deer Lake receives water from Redwing Slough and drains to North Mill Creek. Waterfowl hunters who are able to successfully draw a permit from the Illinois Department of Natural Resources (IDNR) use Deer Lake during the fall hunting season.

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

Water clarity was best in September (6.43 feet) and poorest in July (3.96 feet), averaging 5.59 feet in 2006, which is down slightly from the 2001 average of 5.99 feet. Dissolved oxygen concentrations of at least 5.0 mg/L were recorded in Deer Lake from the water's surface down to near the lake bottom for the entire sample season. The low DO levels near the bottom were likely a result of the highly organic lake bottom.

The Lake County median conductivity reading was 0.7948 milliSiemens/cm (mS/cm). During 2006, the average conductivity reading in Deer Lake was lower at 0.5468 mS/cm. However, this was up 50% from the 2000 average of 0.3653 mS/cm. Conductivity is positively correlated with chloride (Cl^-) concentrations. The average Cl^- concentration in Deer Lake was lower than the Lake County median of 171 mg/L during 2006, with an average of 64 mg/L. The 2006 average total phosphorus (TP) concentration of 0.043 mg/L was also below the county median of 0.061 mg/L. This was a decrease from the 2000 survey when the average TP concentration was 0.054 mg/L.

Deer Lake had a diverse aquatic plant community, with a total of 20 plant species and one macro-algae found. The most common species was Coontail at 92 % of the sampling sites and Eurasian Watermilfoil was the second most common species at 77 % of the sampling sites. In 2000, Coontail and Eurasian Watermilfoil were also the two most abundant aquatic plants found.

Deer Lake provides excellent habitat for a variety of birds, mammals, and other wildlife because it is located in a rural setting with the shoreline mainly undeveloped. The only development is the earthen dam and culvert at the northeast end of the lake and the small boat house development on the southeast end.

LAKE FACTS

Lake Name:	Deer Lake
Historical Name:	None
Nearest Municipality:	Antioch
Location:	T46N, R10E, Section 11, NW 1/4
Elevation:	768.0 feet
Major Tributaries:	Redwing Slough
Watershed:	Des Plaines River
Sub-watershed:	North Mill Creek
Receiving Waterbody:	North Mill Creek
Surface Area:	58.9 acres
Shoreline Length:	3.6 miles
Maximum Depth:	8.0 feet
Average Depth:	4.0 feet (estimated)
Lake Volume:	241.2 acre-feet (estimated)
Lake Type:	Glacial
Watershed Area:	2293.5 acres
Major Watershed Land Uses:	Agriculture, Public and Private Open Space, Wetlands, and Single Family
Bottom Ownership:	State of Illinois, Private
Management Entities:	Illinois Department of Natural Resources
Current and Historical Uses:	Hunting
Description of Access:	Access can be attained with a hunting permit during limited times of the year.

SUMMARY OF WATER QUALITY

Water samples were collected from May through September at the deepest point in the lake (Figure 1, Appendix A). Deer Lake was sampled at a depth of three feet and the samples were analyzed for various water quality parameters (Appendix C).

Due to the shallow nature of the lake, wind and wave action keep the waters well mixed. A dissolved oxygen (DO) concentration of 5.0 mg/L is considered adequate to support a sunfish/bass fishery, since these fish can suffer oxygen stress below this amount. A concentration of at least 5.0 mg/L was recorded in Deer Lake from the water's surface down to near bottom for the entire sample season (Appendix B). The low DO levels near the bottom were likely a result of the highly organic bottom in the lake.

Secchi disk depths averaged 5.59 feet during 2006 and 5.99 feet during 2000 (Table 1). Both of these values were above the Lake County median of 3.27 feet (Appendix E). The decrease correlated with an increase in total suspended solids (TSS). TSS is composed of nonvolatile suspended solids, non-organic clay or sediment materials, and volatile suspended solids, algae and other organic matter. In 2006 the average TSS was 3.0 mg/L while in 2000 it averaged 2.5 mg/L. Both values are below the county median of 7.9 mg/L. The higher TSS concentration in July (4.3 mg/L) could have been due to a filamentous algae bloom. Correlated with the high July TSS reading was the lowest Secchi disk transparency reading of the season (3.96 feet).

Another factor affecting water clarity is the amount of nutrients in the water. Typically, lakes are either phosphorus (P) or nitrogen (N) limited. This means that one of the nutrients is in short supply and any addition of that nutrient to the lake will result in an increase of plant and/or algal growth. Most lakes in Lake County are phosphorus limited. To compare the availability of nitrogen and phosphorus, a ratio of total nitrogen to total phosphorus (TN:TP) is used. Ratios less than or equal to 10:1 indicate nitrogen is limiting, ratios greater than or equal to 15:1 indicate phosphorus is limiting, and ratios greater than 10:1, but less than 15:1 indicate there are enough of both nutrients to facilitate excess algae or plant growth. Deer Lake had a TN:TP ratio of 19:1 in 2000 and 32:1 in 2006. This indicates the lake was phosphorous limited in 2000 and 2006. Nitrogen, as well as carbon, naturally occur in high concentrations and come from a variety of sources (soil, air, etc.), which are more difficult to control than sources of phosphorus. Lakes that are phosphorus-limited may be easier to manage, since controlling phosphorus is more feasible than controlling nitrogen or carbon. Redwing Slough, which drains into Deer Lake, had high levels of TP entering the outflow culvert (2006 average = 0.107 mg/L). Thus, Deer Lake may have a high internal load of phosphorus, as a result of years of accumulation from Redwing Slough.

Deer Lake had a 2006 seasonal average total phosphorus (TP) concentration of 0.043 mg/L, which was below the county median of 0.061 mg/L. This was a decrease from the 2000 survey when the average TP concentration was 0.054 mg/L. Phosphorus can be released from sediment through biological or mechanical processes, or from plant or algae as they die. This typically occurs in lakes like Deer Lake that do not stratify, therefore phosphorus attached to bottom sediment or released from dying algae/plants can be easily distributed throughout the water column.

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

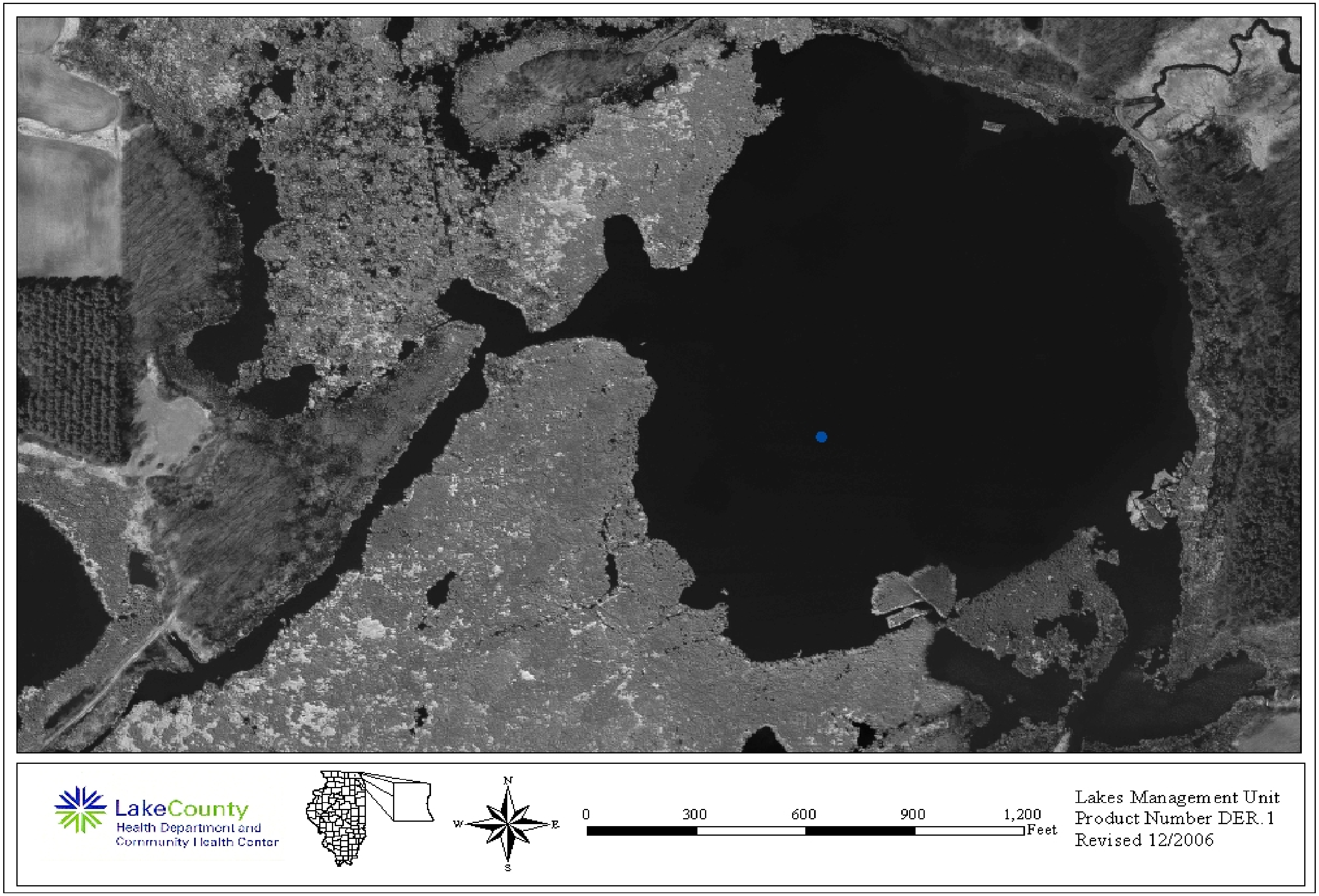


Table 1. Water quality data for Deer Lake, 2000 and 2006.

2006	Epilimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
10-May	3	177	1.44	<0.1	<0.05	0.041	<0.005	59	NA	3.6	358	109	4.86	0.5810	NA	9.12
14-Jun	3	169	1.18	<0.1	<0.05	0.035	<0.005	62	NA	1.0	367	127	6.10	0.5550	8.31	10.96
12-Jul	3	154	1.49	<0.1	<0.05	0.063	<0.005	63	NA	4.3	365	136	3.96[a]	0.5300	7.74	5.40
09-Aug	3	141	1.39	<0.1	<0.05	0.040	<0.005	66	NA	3.0	361	143	4.98	0.5280	8.31	6.48
13-Sep	3	150	1.58	0.233	<0.05	0.038	0.009	68	NA	2.9	326	100	6.43	0.5400	7.90	6.02
	Average	158	1.42	0.233[k]	<0.05	0.043	0.009[k]	64	NA	3.0	355	123	5.59[b]	0.5468	8.07[e]	7.60

2000	Epilimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N*	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
24-May	3	181	1.27	<0.1	0.064	0.04	<0.005	NA	296	1.6	321	131	6.23	0.4734	8.07	9.20
28-Jun	3	125	<0.5	<0.1	0.07	0.045	0.015	NA	226	1.3	234	105	7.48	0.3177	7.17	5.10
26-Jul	3	138	0.62	<0.1	0.075	0.062	<0.005	NA	228	1.9	234	105	5.64	0.3323	7.06	3.40
30-Aug	2	143	1.3	<0.1	0.077	0.081	0.006	NA	200	6.6	242	114	4.59	0.3493	7.37	3.70
27-Sep	3	152	1.53	0.193	<0.05	0.043	0.012	NA	240	0.9	242	85	0[c]	0.3538	7.62	6.70
	Average	148	0.94[k]	0.193[k]	0.072[k]	0.054	0.011[k]	NA	238	2.5	255	108	5.99[d]	0.3653	7.46	5.62

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

a = Secchi depth was obstructed by plants
b = Secchi disk depth average does not include data from July because Secchi disk was obstructed by plants
c = Secchi depth was obstructed by the bottom
d = Secchi disk depth average does not include data from September because Secchi disk was on the bottom and therefore the reading could have been deeper
e = Does not include May due to bad pH probe
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

In addition to Redwing Slough, there may also be external sources contributing to the TP of Deer Lake. One source may have been stormwater from the 2293.5 acres within its watershed (Figure 2). Agriculture (29%), public and private open space (28%), wetland (9%), and single family homes (8%) were the major land uses within the watershed (Figure 3). For Deer Lake, public and private open space (33%) and transportation (23%) were the land uses contributing the highest percentages of estimated runoff (Table 2). Even though it was the largest land use, the agricultural areas within the watershed contributed approximately 12% of the estimated runoff. It is important to keep in mind, however, that although the amount of estimated runoff from certain areas may be low, it can deliver high concentrations of TSS and TP. The retention time (the amount of time it takes for water entering a lake to flow out of it again) was calculated to be approximately 111 days. Increased changes in land use within the watershed are the primary threat to Deer Lake.

Total Phosphorous can be used to calculate the trophic state index (TSIp), which classifies lakes according to the overall level of nutrient enrichment. The TSIp score falls within the range of one of four categories: hypereutrophic, eutrophic, mesotrophic and oligotrophic. Hypereutrophic lakes are those with excessive nutrients, nuisance algae growth reminiscent of "pea soup," and have a TSI score greater than 70. Lakes with a TSI score of 50 or greater are classified as eutrophic or nutrient rich, and are productive lakes in terms of aquatic plants and/or algae. Mesotrophic and oligotrophic lakes have lower nutrient levels. These are very clear lakes, with little algal growth. Most lakes in Lake County are eutrophic. The trophic state of Deer Lake in terms of its phosphorus concentration during 2000 was eutrophic, with a TSIp score of 61.8. In 2006 the TSIp score was slightly lower at 58.5, but still eutrophic and ranked Deer Lake 52nd out of 162 lakes in Lake County based on average TP concentrations (Table 3).

The Illinois Environmental Protection Agency (IEPA) has assessment indices to classify Illinois lakes for their ability to support aquatic life, swimming, and recreational uses. The guidelines consider several aspects, such as water clarity, phosphorus concentrations (TSIp), and aquatic plant coverage. According to this index, Deer Lake provides *Full* support of aquatic life, *Partial* support of swimming and recreational activities (such as boating), and provides *Partial* overall use. The lake is used primarily for waterfowl hunting during the fall migration season.

Conductivity is the measurement of water's ability to conduct electricity and is positively correlated with chloride (Cl^-) concentrations (Figure 4). Compared to lakes in undeveloped areas, lakes with residential and/or urban land uses in their watershed often have higher concentrations because of the use of road salts. Stormwater runoff from impervious surfaces such as roads and parking lots can deliver high concentrations of this Cl^- (from road salts) to nearby waterbodies. The Lake County median conductivity reading for near surface samples was 0.7954 milliSiemens/cm (mS/cm). During 2006, the average conductivity reading in Deer Lake was lower, at 0.5468 mS/cm. This was up 50% from the 2000 average of 0.3653 mS/cm. The 2006 readings were highest in May and decreased throughout the season. Typically lakes that receive runoff containing road salts have higher readings early in the year as spring rains flush salts from the watershed. Readings may decline through the summer. Chloride concentration in Deer Lake was lower than the Lake County median of 171 mg/L during 2006, with a seasonal average of 64 mg/L. In comparison, Redwing Slough had an average Cl^- concentration of 86 mg/L. A study done in Canada reported 10% of aquatic species are harmed

Figure 2. Approximate watershed delineation for Deer Lake, 2006.

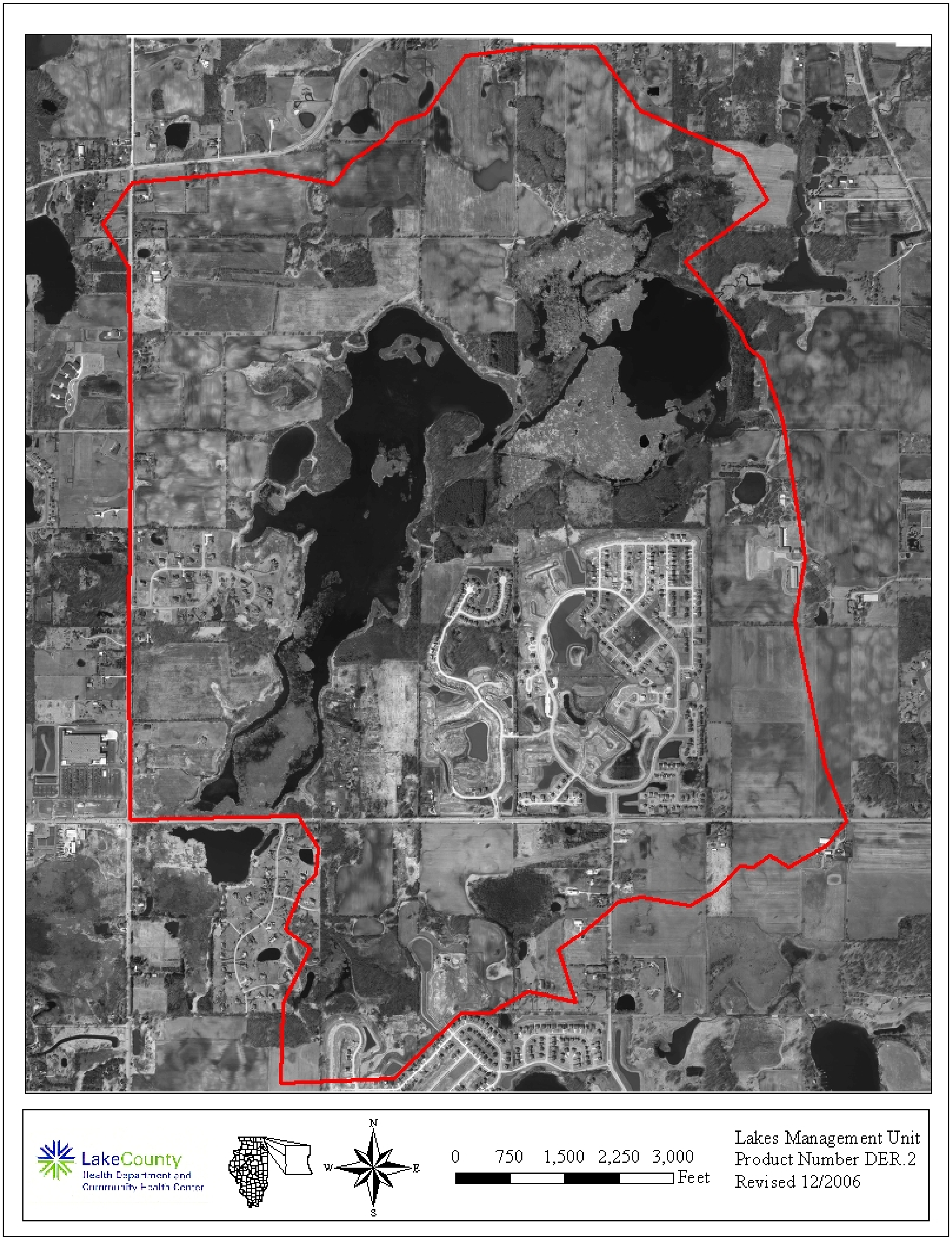


Figure 3. Approximate land use within the Deer Lake watershed, 2006.

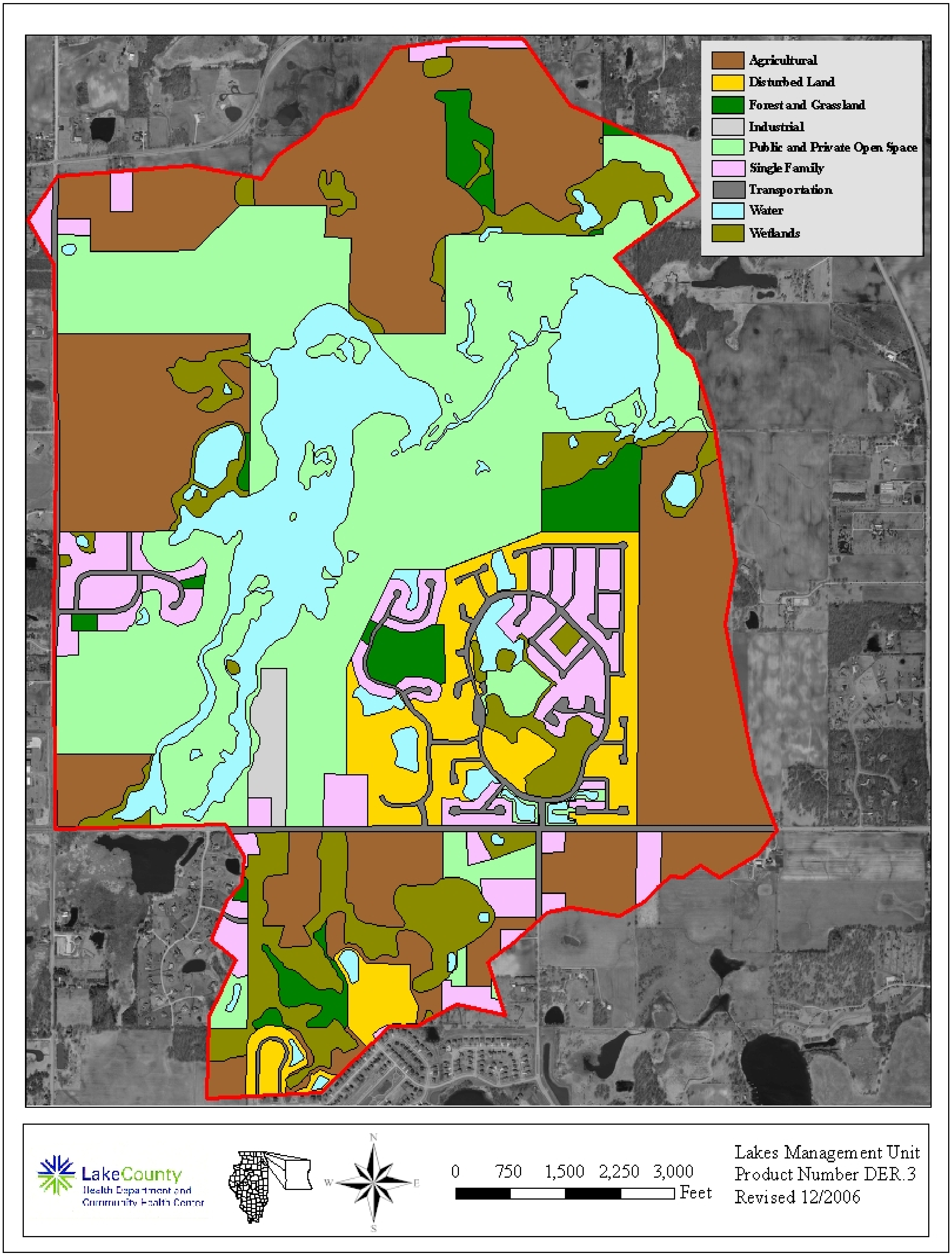


Table 2. Approximate land uses and retention time for Deer Lake, 2006.

Land Use	Acreage	% of Total
Agricultural	668.73	29.2%
Disturbed Land	149.78	6.5%
Forest and Grassland	79.59	3.5%
Industrial	19.35	0.8%
Public and Private Open Space	639.19	27.9%
Single Family	179.23	7.8%
Transportation	77.93	3.4%
Water	275.22	12.0%
Wetlands	204.57	8.9%
Total Acres	**2293.60**	**100.0%**

Land Use	Acreage	Runoff Coeff.	Estimated Runoff, acft.	% Total of Estimated Runoff
Agricultural	668.73	0.05	92.0	5.5%
Disturbed Land	149.78	0.05	20.6	1.2%
Forest and Grassland	79.59	0.50	109.4	6.6%
Industrial	19.35	0.85	45.2	2.7%
Public and Private Open Space	639.19	0.15	263.7	15.9%
Single Family	179.23	0.85	419.0	25.3%
Transportation	77.93	0.30	64.3	3.9%
Water	275.22	0.85	643.3	38.8%
Wetlands	204.57	0.00	0.0	0.0%
TOTAL	**2293.60**		**1657.5**	**100.0%**

Lake volume	**241.2**	**acre-feet**
Retention Time (years)= lake volume/runoff	**0.15**	**years**
	53.12	**days**

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

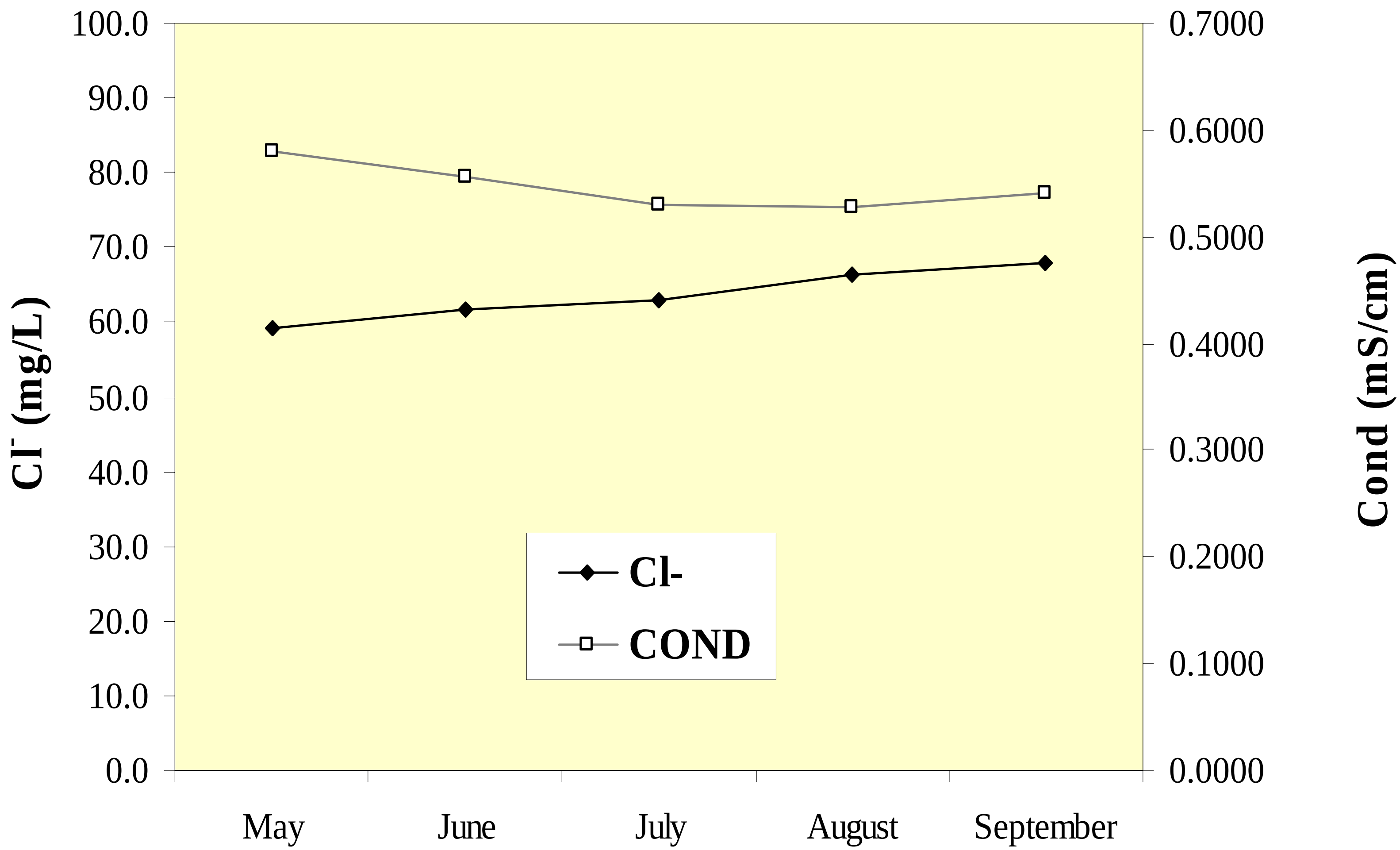
Table 3. Continued.

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. Chloride (Cl^-) concentration vs. conductivity for Deer Lake, 2006



by prolonged exposure to chloride concentrations greater than 220 mg/L. Additionally, shifts in algal populations in lakes were associated with chloride concentrations as low as 12 mg/l. Therefore, lakes can be negatively impacted by high Cl^- concentrations.

Water levels on Deer Lake decreased slightly throughout the season. The highest levels were found in May and the lowest levels in July. The total water level decreased by 7.88 inches from May to July. Fluctuating water levels do not appear to be an issue on Deer Lake. Lakes with stable water levels potentially have less shoreline erosion problems.

SUMMARY OF AQUATIC MACROPHYTES

To maintain a healthy sunfish/bass fishery, the optimal plant coverage is 30% to 40% across the lake bottom. An aquatic plant (macrophyte) survey was conducted in July of 2006 and found 100% of the lake bottom had aquatic plant coverage. Sampling sites were based on a grid system created by mapping software (ArcMap), with each site located 60 meters apart. On Deer Lake, there were 62 sites sampled (Figure 5). Plants were found at all 62 sites sampled and at a maximum depth of 7.4 feet (Table 4a,b). Overall, there was a total of 20 plant species and one macro-algae found (Table 5), with the most common species being Coontail at 92 % of the sampling sites. Eurasian Watermilfoil (EWM) was the second most common species at 77 % of the sampling sites. In 2000, Coontail and Eurasian Watermilfoil were also the two most abundant aquatic plants found. Species composition was also similar between the two years, however, in 2000 Slender Naiad (*Najas flexilis*), Spiny Naiad (*Najas marina*), and Horned Pondweed (*Zannichellia palustris*) were found while Spatterdock (*Nuphar variegata*) and Giant Duckweed (*Spirodella polyrhiza*) were not found.

Two exotic aquatic plants, EWM and Curlyleaf Pondweed, were found in Deer Lake. Both of these exotics compete with native plants, eventually crowding them out, providing poor natural diversity, and limited use by wildlife. Removal or control of exotic species is recommended.

The Floristic Quality Index (FQI) is a rapid assessment tool designed to evaluate the closeness of the flora of an area to that of undisturbed conditions. It can be used to: 1) identify natural areas, 2) compare the quality of different sites or different locations within a single site, 3) monitor long-term floristic trends, and 4) monitor habitat restoration efforts (Nichols, 1999). Each floating or submersed aquatic plant is assigned a number between 1 and 10 (10 indicating the plant species most sensitive to disturbance). An FQI is calculated by multiplying the average of these numbers by the square root of the number of these plant species found in the lake.

A high FQI number indicates there was a large number of sensitive, high quality plant species present in the lake. Non-native species were also included in the FQI calculations for Lake County lakes. The average FQI for 2000-2006 Lake County lakes is 13.6 (Table 6). Deer Lake had a FQI of 28.2 in 2006 ranking 5th out of 151 lakes in Lake County. This is an increase from 2000 when the FQI was 27.9. However, the change in the aquatic plant sampling procedure could be a potential reason for this decrease. Also, plant composition may vary from year to year.

Figure 5. Aquatic plant sampling grid that illustrates plant density on Deer Lake, July 2006.

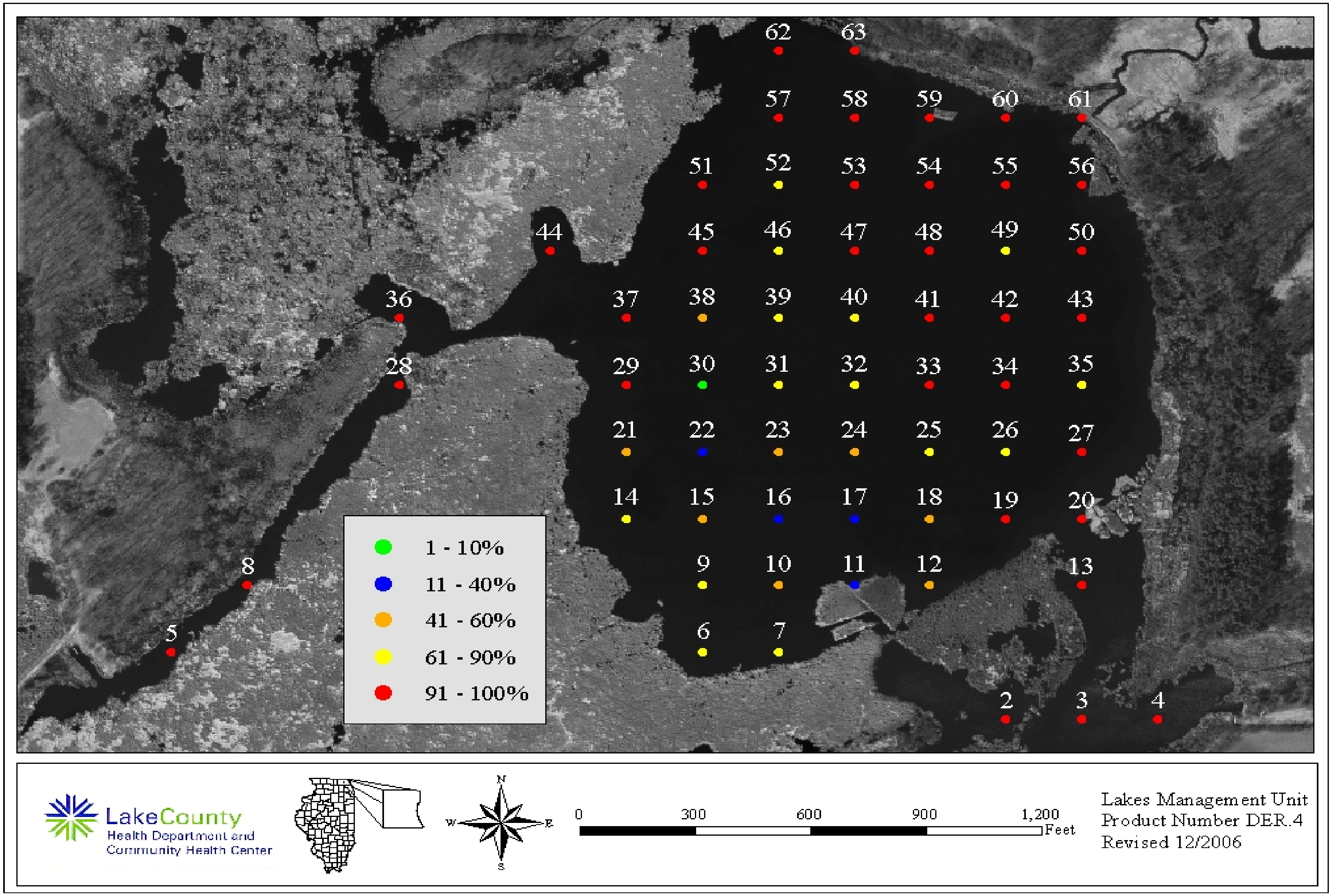


Table 4a. Aquatic plant species found at the 62 sampling sites on Deer Lake, July 2006. Maximum depth that plants were found was 7.4 feet.

Plant Density	Bladderwort	Chara	Coontail	Curlyleaf Pondweed	Duckweed	Elodea	Eurasian Watermilfoil	Flatstem Pondweed	Giant Duckweed	Illinois Pondweed	Largeleaf Pondweed
Absent	55	27	5	61	54	52	14	52	54	57	56
Present	6	16	6	1	1	4	12	9	1	5	4
Common	1	16	14	0	7	5	14	1	7	0	2
Abundant	0	2	18	0	0	1	7	0	0	0	0
Dominant	0	1	19	0	0	0	15	0	0	0	0
% Plant Occurrence	11.3	56.5	91.9	1.6	12.9	16.1	77.4	16.1	12.9	8.1	9.7

Plant Density	Leafy Pondweed	Northern Watermilfoil	Sago Pondweed	Small Pondweed	Spatterdock	Star Duckweed	Watermeal	Water Stargrass	White Water Lily	Yellow Pond Lily
Absent	60	59	38	58	61	59	54	59	38	57
Present	2	3	17	4	0	3	4	3	7	1
Common	0	0	6	0	1	0	4	0	4	4
Abundant	0	0	0	0	0	0	0	0	5	0
Dominant	0	0	1	0	0	0	0	0	8	0
% Plant Occurrence	3.2	4.8	38.7	6.5	1.6	4.8	12.9	4.8	38.7	8.1

Table 4b. Distribution of rake density across all sampled sites.

Rake Density (Coverage)	# of Sites	%
No plants	0	0.0
>0 to 10%	1	1.6
>10 to 40%	4	6.5
>40 to 60%	8	12.9
>60 to 90%	14	22.6
>90%	35	56.5
Total Sites with Plants	62	100.0
Total # of Sites	62	100.0

Table 5. Aquatic plant species found in Deer Lake in 2006.

Coontail	*Ceratophyllum demersum*
Chara (Macro algae)	*Chara* spp.
American Elodea	*Elodea canadensis*
Water Stargrass	*Heteranthera dubia*
Duckweed	*Lemna* spp.
Star Duckweed	*Lemna trisulca*
Northern Watermilfoil	*Myriophyllum sibiricum*
Eurasian Watermilfoil^	*Myriophyllum spicatum*
Spatterdock	*Nuphar variegata*
White Water Lily	*Nymphaea tuberosa*
Largeleaf Pondweed	*Potamogeton amplifolius*
Curlyleaf Pondweed^	*Potamogeton crispus*
Leafy Pondweed	*Potamogeton foliosus*
Illinois Pondweed	*Potamogeton illinoensis*
Sago Pondweed	*Potamogeton pectinatus*
Small Pondweed	*Potamogeton pusillus*
Flatstem Pondweed	*Potamogeton zosteriformis*
Giant Duckweed	*Spirodella polyrhiza*
Common Bladderwort	*Utricularia vulgaris*
Watermeal	*Wolffia columbiana*
Yellow Pond Lily	*Nuphar advena*

^ Exotic plant

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**

Plankton are microscopic plants and animals that are free-floating within the water column. Samples were collected during water quality testing and analyzed for species content. Diatoms and Dioflagellates/Chrysophytes were the dominant phytoplankton from May through July while little phytoplankton occurred in August and September (Figure 6). Little zooplankton occurred in 2006 in Deer Lake. In May (*Keratella*) and August (unidentified Rotifer) Rotifers dominated the zooplankton community (Figure 7).

SUMMARY OF SHORELINE CONDITION

The entire shoreline of Deer Lake, with the exception of the earthen dam and culvert on the northeast section of the lake, was comprised of cattails. No erosion problems were noted.

No exotic species were noted growing along the shoreline. Of particular concern was Purple Loosestrife which was not seen around Deer Lake; however, it was seen on Redwing Slough. Continual monitoring for this exotic is recommended. Cattails currently dominate the shorelines and may become problematic in the future if current stands expand, as it can be an invasive species.

SUMMARY OF WILDLIFE AND HABITAT

Historically, the Redwing Hunt Club used Deer Lake for waterfowl hunting. Fish winterkills occurred in the 1950's enabling strong carp populations to become established. The lake was treated with rotenone in 1963. Another severe winterkill occurred in 1970. Current fish populations were not surveyed during this study.

Many of the noted wildlife species were seen and/or heard at Redwing Slough and Deer Lake, since some of the species were noted at the culvert that separates Redwing Slough from Deer Lake (Table 7). The lakes are located in a rural setting with the shorelines mainly undeveloped. This provides excellent habitat for a variety of birds, mammals, and other wildlife.

Figure 6. Phytoplankton counts for Deer Lake, 2006.

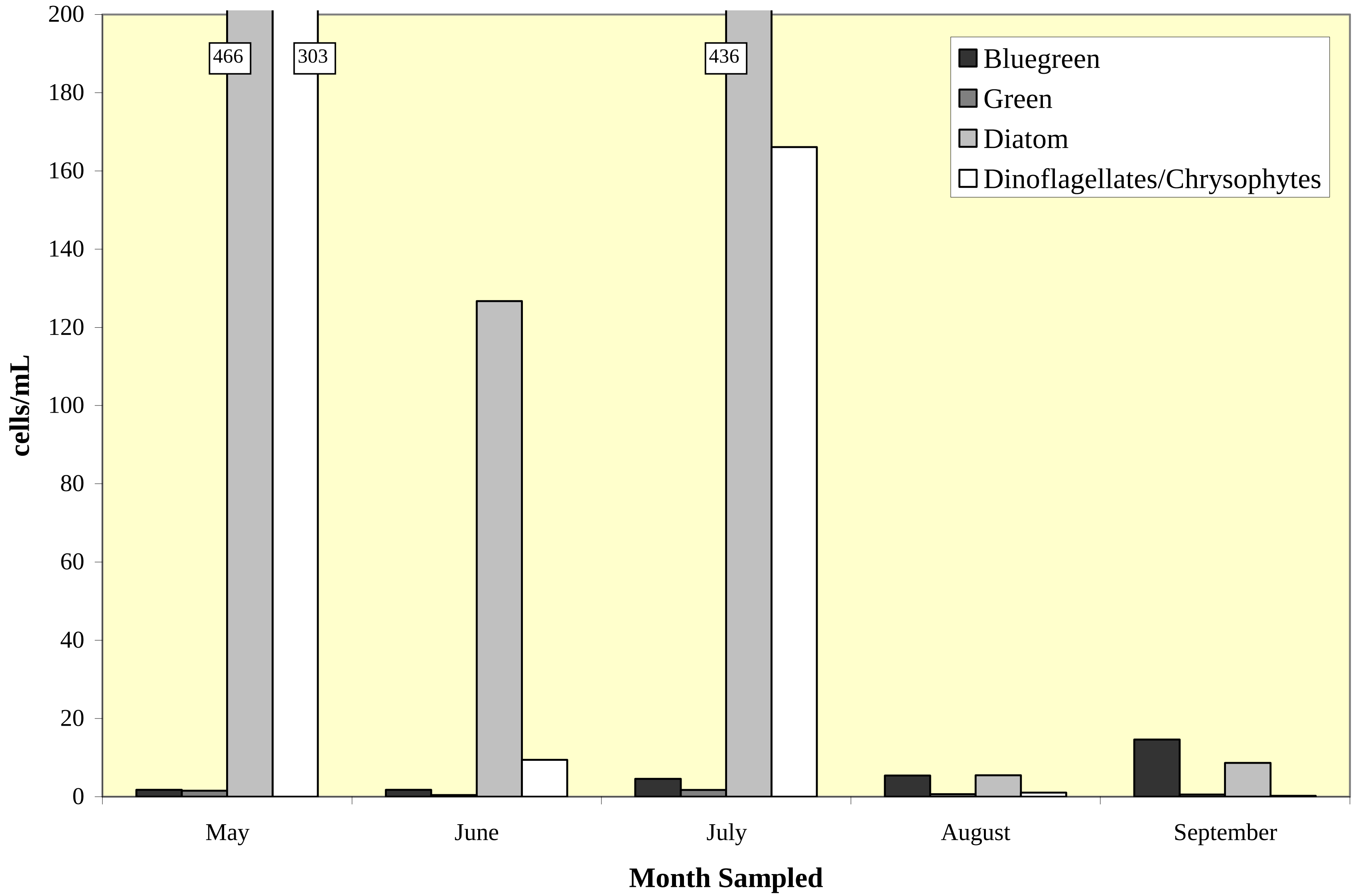


Figure 7. Zooplankton counts for Deer Lake, 2006.

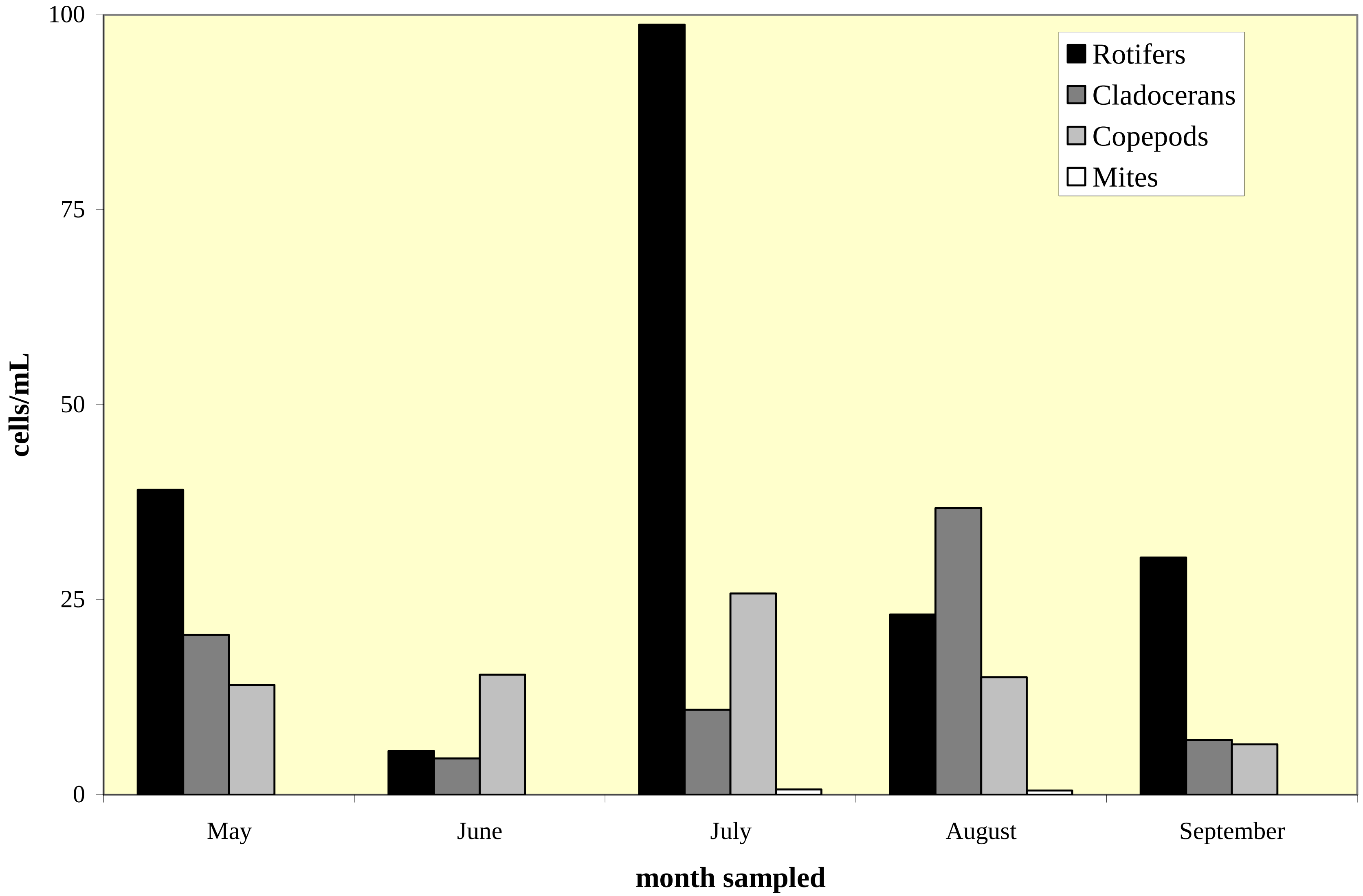


Table 7. Wildlife species observed on and around Deer Lake, May – September 2006.

Birds	
Mute Swan	*Cygnus olor*
Canada Goose	*Branta canadensis*
Mallard	*Anas platyrhnchos*
Wood Duck	*Aix sponsa*
American Coot	*Fulica americana*
Ring-billed Gull	*Larus delawarensis*
Common Tern*	*Sterna hirundo*
Great Blue Heron	*Ardea herodias*
Great Egret	*Casmerodius albus*
Great Blue Heron	*Ardea herodias*
Green Heron	*Butorides striatus*
Sandhill Crane+	*Grus canadensis*
American Woodcock	*Philohela minor*
Wild Turkey	*Meleagris gallopavo*
Great Horned Owl	*Bubo virginianus*
Tree Swallow	*Iridoprocne bicolor*
Marsh Wren	*Cistothorus palustris*
Yellow-throated Vireo	*Vireo flavifrons*
Yellow-rumped Warbler	*Dendroica coronata*
Yellow Warbler	*Dendroica petechia*
Common Yellowthroat	*Geothlypis trichas*
Red-winged Blackbird	*Agelaius phoeniceus*
Brown-headed Cowbird	*Molothrus ater*
Northern Oriole	*Icterus galbula*
Scarlet Tanager	*Piranga olivacea*
American Goldfinch	*Carduelis tristis*
Swamp Sparrow	*Melospiza georgiana*
Mammals	
Eastern Fox Squirrel	*Sciurus niger*
Eastern Cottontail	*Sylvilagus floridanus*
White-tailed Deer	*Odocoileus virginianus*
Raccoon	*Procyon lotor*
Amphibians	
Bull Frog	*Rana catesbeiana*
Reptiles	
Snapping Turtle	*Chelydra serpentina*

Table 7. Continued

<u>*Fish*</u>	
Bluegill	*Lepomis macrochirus*
Largemouth Bass	*Micropterus salmoides*

*Endangered species in Illinois
+Threatened species in Illinois

LAKE MANAGEMENT RECOMMENDATIONS

Deer Lake's water quality was better than most lakes in Lake County. Most of the water quality parameters were below the averages of other lakes in the county that the Lakes Management Unit has monitored. The land surrounding Deer Lake is undeveloped and a good refuge for many wildlife species. To improve the quality of Deer Lake, the LCHD-LMU has the following recommendations.

- **Creating a Bathymetric Map**

  A bathymetric (depth contour) map is an essential tool in effective lake management since it provides information on the morphometric features such as depth, surface area, volume, etc. Deer Lake does not have a current bathymetric map with volumetric calculations. Maps can be created by the LCHD-LMU (Appendix D1).

- **Assess Your Lake's Fishery**

  At this time no information about the fishery in Deer Lake is known. A formal fisheries assessment should be conducted to determine the diversity and health of the fish community (Appendix D2).

- **Watershed nutrient reduction, watershed sediment reduction, and large scale sediment and nutrient controls**

  Deer Lake has seen and increase in TSS, TP, and conductivity since 2000. Activities within the watershed can contribute to the nutrients and sediment of the receiving waterbody. Proper management of water within the watershed can help reduce the impacts to the receiving waterbody (Appendix D3-5).

- **Reduce Conductivity and Chloride Concentrations**

  The average conductivity reading in Deer Lake has nearly doubled since 2000. Although the chloride concentration was below the county median, it was still high enough to potentially have impacts on aquatic life. The use of road salts for winter road management is a major contributor to chloride concentrations and conductivity. Proper application procedures and alternative methods can be used to keep these concentrations under control (Appendix D6).

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.

Shoreline Assessment

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

None – Includes man-made erosion control such as beach, rip-rap and sea wall.

Slight – Minimal or no observable erosion; generally considered stable; no erosion control practices will be recommended with the possible exception of small problem areas noted within an area otherwise designated as “slight”.

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

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

Wildlife Assessment

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

Table A1. Analytical methods used for water quality parameters.

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

APPENDIX B. MULTI-PARAMETER DATA FOR DEER LAKE IN 2006.

Deer Lake 2006 Multiparameter data

Date	Time	Text Depth	Dep25	Temp	DO	DO%	SpCond	pH	PAR	Depth of Light Meter	% Light	Extinction
MMDDYY	HHMMSS	feet	feet	øC	mg/l	Sat	mS/cm	Units	æE/s/mý	feet	Transmission	Coefficient
											Average	0.75
05/10/2006		0.5	0.492	16.81	9.21	95.1	0.5800	NA	2238.2	Surface		
05/10/2006		1	0.947	16.85	8.99	92.9	0.5790	NA	718.4	Surface	100%	
05/10/2006		2	2.005	16.66	9.07	93.4	0.5810	NA	335.3	0.335	47%	2.27
05/10/2006		3	3.001	16.54	9.12	93.6	0.5810	NA	59.5	1.331	8%	1.30
05/10/2006		4	3.962	16.44	8.95	91.7	0.5810	NA	57.5	2.292	8%	0.01
05/10/2006		5	4.980	15.45	3.91	39.2	0.5860	NA	48.1	3.310	7%	0.05
05/10/2006		6	6.000	14.84	2.38	23.6	0.5930	NA	30.9	4.330	4%	0.10

Date	Time	Text Depth	Dep25	Temp	DO	DO%	SpCond	pH	PAR	Depth of Light Meter	% Light	Extinction
MMDDYY	HHMMSS	feet	feet	øC	mg/l	Sat	mS/cm	Units	æE/s/mý	feet	Transmission	Coefficient
											Average	0.85
06/14/2006		0.5	0.517	21.67	10.71	121.9	0.5540	8.37	3131.3	Surface		
06/14/2006		1	1.006	21.69	10.81	123.1	0.5540	8.32	3077.6	Surface	428%	
06/14/2006		2	2.004	21.58	10.86	123.4	0.5550	8.31	773.2	0.334	108%	4.14
06/14/2006		3	3.004	21.47	10.96	124.2	0.5550	8.31	528.8	1.334	74%	0.28
06/14/2006		4	4.003	21.02	11.28	126.8	0.5510	8.34	367.0	2.333	51%	0.16
06/14/2006		5	5.001	20.60	10.16	113.3	0.5490	8.31	266.0	3.331	37%	0.10
06/14/2006		6	5.987	20.34	7.31	81.0	0.5600	8.12	17.0	4.317	2%	0.64
06/14/2006		7	7.001	20.17	4.14	45.7	0.5650	7.84	44.9	5.331	6%	-0.18

Deer Lake 2006 Multiparameter data

Date	Time	Text Depth	Dep25	Temp	DO	DO%	SpCond	pH	PAR	Depth of Light Meter	% Light	Extinction
MMDDYY	HHMMSS	feet	feet	øC	mg/l	Sat	mS/cm	Units	æE/s/mý	feet	Transmission	Coefficient
											Average	1.04
07/12/2006		0.5	0.503	23.71	5.62	66.5	0.5300	7.73	799.4	Surface		
07/12/2006		1	1.007	23.72	5.29	62.6	0.5290	7.72	834.9	Surface	116%	
07/12/2006		2	2.007	23.71	5.42	64.2	0.5290	7.74	154.5	0.337	22%	5.01
07/12/2006		3	3.002	23.71	5.40	63.9	0.5300	7.74	90.9	1.332	13%	0.40
07/12/2006		4	4.001	23.71	5.39	63.7	0.5290	7.75	45.9	2.331	6%	0.29
07/12/2006		5	5.001	23.71	5.34	63.2	0.5300	7.75	34.6	3.331	5%	0.08
07/12/2006		6	6.006	23.71	5.13	60.7	0.5300	7.75	18.4	4.336	2.6%	0.15
07/12/2006		7	7.024	23.46	2.33	27.4	0.5860	7.37	3.8	5.354	0.5%	0.29

Date	Time	Text Depth	Dep25	Temp	DO	DO%	SpCond	pH	PAR	Depth of Light Meter	% Light	Extinction
MMDDYY	HHMMSS	feet	feet	øC	mg/l	Sat	mS/cm	Units	æE/s/mý	feet	Transmission	Coefficient
											Average	NA
08/09/2006		0.5	0.498	26.09	6.55	80.9	0.5290	8.20	NA	Surface		
08/09/2006		1	1.008	26.10	6.07	75.0	0.5390	8.21	NA	Surface	NA	
08/09/2006		2	1.999	26.03	6.26	77.2	0.5280	8.27	NA	0.329	NA	NA
08/09/2006		3	3.000	25.96	6.48	79.9	0.5280	8.31	NA	1.330	NA	NA
08/09/2006		4	4.010	25.91	6.62	81.5	0.5270	8.34	NA	2.340	NA	NA
08/09/2006		5	5.005	25.88	6.49	79.9	0.5270	8.33	NA	3.335	NA	NA
08/09/2006		6	6.000	25.90	2.23	27.4	0.5470	7.60	NA	4.330	NA	NA

Deer Lake 2006 Multiparameter data

Date	Time	Text Depth	Dep25	Temp	DO	DO%	SpCond	pH	PAR	Depth of Light Meter	% Light	Extinction
MMDDYY	HHMMSS	feet	feet	øC	mg/l	Sat	mS/cm	Units	æE/s/mý	feet	Transmission	Coefficient
											Average	NA
09/13/2006		0.5	0.499	18.52	6.52	69.7	0.5400	7.96	NA	Surface		
09/13/2006		1	1.002	18.55	6.03	64.5	0.5400	7.92	NA	Surface	NA	
09/13/2006		2	2.008	18.55	6.08	65.0	0.5400	7.91	NA	0.338	NA	NA
09/13/2006		3	3.005	18.55	6.02	64.4	0.5400	7.90	NA	1.335	NA	NA
09/13/2006		4	4.016	18.55	5.99	64.1	0.5400	7.89	NA	2.346	NA	NA
09/13/2006		5	5.015	18.55	5.93	63.4	0.5400	7.89	NA	3.345	NA	NA
09/13/2006		6	6.004	18.56	5.80	62.0	0.5400	7.88	NA	4.334	NA	NA

APPENDIX C. INTERPRETING YOUR LAKE'S WATER QUALITY DATA.

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

The following pages will discuss the different water quality parameters measured by Lake County Health Department staff, how these parameters relate to each other, and why the measurement of each parameter is important. The median values (the middle number of the data set, where half of the numbers have greater values, and half have lesser values) of data collected from Lake County lakes from 2000-2005 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, total dissolved solids) were measured each month by the Lakes Management Staff, total suspended solids (TSS) and total volatile solids (TVS) have the most impact on other variables and on the lake as a whole. TSS are particles of algae or sediment suspended in the water column. High TSS concentrations can result from algae blooms, sediment resuspension, and/or the inflow of turbid water, and are typically associated with low water clarity and high phosphorus concentrations in many lakes in Lake County. Low water clarity and high phosphorus concentrations, in turn, exacerbate the high TSS problem by leading to reduced plant density (which stabilize lake sediment) and increased occurrence of algae blooms. The median TSS value in epilimnetic waters in Lake County is 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.

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

Water Clarity:

Water clarity (transparency) is not a chemical property of lake water, but is often an indicator of a lake's overall water quality. It is affected by a lake's water color, which is a reflection of the amount of total suspended solids and dissolved organic chemicals. Thus, transparency is a measure of particle concentration and is measured with a Secchi disk. Generally, the lower the clarity or Secchi depth, the poorer the water quality. A decrease in Secchi depth during the summer occurs as the result of an increase in suspended solids (algae or sediment) in the water column. Aquatic plants play an important role in the level of water clarity and can, in turn, be negatively affected by low clarity levels. Plants increase clarity by competing with algae for resources and by stabilizing sediments to prevent sediment resuspension. A lake with a healthy plant community will almost always have higher water clarity than a lake without plants. Additionally, if the plants in a lake are removed (through herbicide treatment or the stocking of grass carp), the lake will probably become dominated by algae and Secchi depth will decrease. This makes it very difficult for plants to become re-established due to the lack of available sunlight and the lake will, most likely, remain turbid. Turbidity will be accelerated if the lake is very shallow and/or common carp are present. Shallow lakes are more susceptible to sediment resuspension through wind/wave action and are more likely to experience clarity problems if plants are not present to stabilize bottom sediment.

Common Carp are prolific fish that feed on invertebrates in the sediment. Their feeding activities stir up bottom sediment and can dramatically decrease water clarity in shallow lakes. As mentioned above, lakes with low water clarity are, generally, considered to have poor water quality. This is because the causes and effects of low clarity negatively impact the plant and fish communities, as well as the levels of phosphorus in a lake. The detrimental impacts of low Secchi depth to plants has already been discussed. Fish populations will suffer as water clarity decreases due to a lack of food and decreased ability to successfully hunt for prey. Bluegills are planktivorous fish and feed on invertebrates that inhabit aquatic plants. If low clarity results in the disappearance of plants, this food source will disappear too. Largemouth Bass and Northern Pike are piscivorous fish that feed on other fish and hunt by sight. As the water clarity decreases, these fish species find it more difficult to see and ambush prey and may decline in size as a result. This could eventually lead to an imbalance in the fish community. Phosphorus release from resuspended sediment could increase as water clarity and plant density decrease. This would then result in increased algae blooms, further reducing Secchi depth and aggravating all problems just discussed. The average Secchi depth for Lake County lakes is 3.17 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 assess your lake's fishery

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

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

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

The Illinois Department of Natural Resources (IDNR) will perform a fish survey at no charge on most public and some private water bodies. In order to determine if your lake is eligible for a survey by the IDNR, contact Frank Jakubecik, Fisheries Biologist, at (815) 675-2319. If a lake is not eligible for an IDNR fish survey or if a more comprehensive survey is desired, contact the Lakes Management Unit for a list of consultants.

D3. Options for Large Scale Sediment and Nutrient Controls

Below are controls that are helpful in sediment and/or nutrient controls within a watershed. These are expensive, and are usually municipal projects or those set in place by developers as part of their projects.

Option 1. Detention Basins

Detention basins are man made bodies of water with restricted discharge outlets that allow gradual release of stormwater runoff to a downstream drainage system. The primary method of runoff pollutant (sediment, nutrients) removal is settling. Detention basins have a removal efficiency of at least 60% for sediment, between 20% - 80% for total phosphorus, and between 20% - 60% for total nitrogen. When designed properly and maintained, these basins can enhance wildlife habitat and add to the aesthetics of the neighborhood, however water is often turbid and nutrient enriched.

Option 2. Catch Basins

Stormwater that flows down streets with curbs and gutters empty into stormwater drains. During construction, these drains are fitted with a catch basin to collect coarse sediment. Some existing stormwater drains can be retrofitted with catch basins. These catch basins have a short holding time, and need to be regularly cleaned out in order for them to function properly.

Option 3. Constructed Wetlands

Wetlands can act as traps for nutrients and sediment as stormwater flows toward a lake or pond. The removal efficiency of constructed wetlands depends on the design and is site specific. A naturally established wetland is easier to use for this purpose than constructing a new one, but a natural wetland cannot properly perform these functions under high flows or repeatedly for years. Construction of a wetland can be difficult and expensive and may take a few years for plants to establish, however once established it most likely will provide good wildlife habitat.

Option 4. Vegetated Swales

Vegetated swales are open, vegetated ditches that are frequently used as an alternative to curb and gutter, and are well suited for road drainage. The plants within the swales can slow the runoff flow, and allows runoff to infiltrate into the soil. The runoff flow velocity usually decreases in swales with flatter side slopes and wider bottom widths. Standing water may be an issue because it encourages the breeding of mosquitoes; some maintenance may be needed.

Option 5. Infiltration Devices

Infiltration devices such as basins, trenches and dry wells temporarily store runoff and then release the water over time into the surrounding soil. Infiltration basins are similar to detention basins except they have only an overflow outlet. They don't have an outlet that allows low, or continual flow. Runoff eventually drains through the bottom and sides of the basin filled with stones. Infiltration basins are suitable as an alternative or supplement to detention basins for larger lot residential developments or campus developments. They have high failure rate if the runoff carries high concentrations of sediment, which clogs the basin or trench and does not allow drainage.

Option 6. Settling Basins

Settling basins are devices that are primarily used for reducing sediment runoff velocity. This allows protection of downstream stormwater facilities and natural areas from sedimentation, debris clogging and scouring. They do not significantly control runoff velocity from large flood events, however. They are designed in a manner that provides an access for sediment removal and initial costs are expensive. Settling basins are rarely used alone; they are intended for use as part of an overall system that uses one or more different methods of runoff management. For example, a settling basin is frequently placed upstream for a detention basin or infiltration device. The settling basin can extend the life of a detention basin or infiltration device by trapping some sediment before the runoff reaches its destination. This can reduce the cost of future sediment removal or repairs to a clogged infiltration device. They should always be used as pretreatment for infiltration basins or trenches and for existing wetlands that will be receiving stormwater runoff from a development, especially if no other means to manage runoff will be used. These devices should be considered at the inlets to most detention basins. Settling basins can be appropriate where full-scale detention basins are impractical due to the small size of the site. This is because of the difficulty in designing reliable outlet structures for small release rates.

D4. Options for Watershed Nutrient Reduction

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

Option 1. Buffer Strips

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

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

a. Compost yard waste instead of burning. Ashes from yard waste contain nutrients and are easily washed into a lake.
b. Avoid dumping yard waste along or into a ditch, pond, lake, or stream. As yard waste decomposes, the nutrients are released directly into the water, or flushed to the lake via the ditch.
c. Avoid applying fertilizer up to the water's edge. Leave a buffer strip of at least 25 feet of unfertilized yard before the shoreline.
d. Avoid applying fertilizers when heavy rains are expected, or over-watering the ground after applying fertilizer.
e. When landscaping, keep site disturbance to a minimum, especially the removal of vegetation and exposure of bare soil. Exposed soil can easily erode.
f. When landscaping, seed or plant exposed soil and cover it with mulch as soon as possible to minimize erosion and runoff.
g. Use lawn and garden chemicals sparingly, or do not use them at all.

Option 3. Street Sweeping

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

Option 4: Reduce Stormwater Volume from Impervious Surfaces

The quality and quantity of runoff directly affects the lake's water quality. With continued growth and development in Lake County, more impervious surfaces such as parking lots and buildings contribute to the volume of stormwater runoff. Runoff picks up pollutants such as nutrients and sediment as it moves over land or down gutters. A faster flow rate and higher volume can result in erosion and scouring, adding sediment and nutrients to the runoff.
Roof downspouts should be pointed away from driveways and foundations and toward lawns or planting beds where water can soak into the soil. A splash block directly below downspouts helps prevent soil erosion. If erosion still occurs, a flexible perforated plastic tubing attached to the downspout can dissipate the water flow.

Option 5: Required Practices for Construction

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

Option 6. Organize a Local Watershed Organization

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

Option 7. Discourage Waterfowl from Congregating

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

D5. Options for Watershed Sediment Reduction

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

Option 1. Municipal Street Sweeping

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

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

Please refer to the Watershed Development Ordinance for requirements.

a. Seed and mulch bare soil as soon as possible to minimize erosion and runoff.
b. During home building projects, disturb as little vegetation as possible to minimize erosion and runoff.
c. Incorporate a buffer strip of native vegetation next to the shoreline to improve the area for wildlife, enhance the aesthetics, and possibly increase the property value.
d. Minimize impervious surfaces when considering installing pathways or even driveways. Gravel can be a suitable and less expensive option than asphalt or concrete. This will allow water to infiltrate into the ground rather than flow across impervious surfaces.

Option 3. Agricultural Practices

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

D6. 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	
Average	**167.0**	
Median	**162.0**	
Minimum	**64.9**	**IMC**
Maximum	**330.0**	**Flint Lake**
STD	**41.8**	
n =	**798**	

	ALKanoxic 2000-2006	
Average	**201**	
Median	**192**	
Minimum	**103**	**Heron Pond**
Maximum	**470**	**Lake Marie**
STD	**49**	
n =	**246**	

	Condoxic <=3ft00-2006	
Average	**0.8834**	
Median	**0.7948**	
Minimum	**0.2542**	**Broberg Marsh**
Maximum	**6.8920**	**IMC**
STD	**0.5389**	
n =	**797**	

	Condanoxic 2000-2006	
Average	**0.9968**	
Median	**0.8285**	
Minimum	**0.3031**	**White Lake**
Maximum	**7.4080**	**IMC**
STD	**0.7821**	
n =	**246**	

	NO3-N, Nitrate+Nitrite,oxic <=3ft00-2006	
Average	**0.518**	
Median	**0.150**	
Minimum	**<0.05**	***ND**
Maximum	**9.670**	**South Churchill Lake**
STD	**1.058**	
n =	**803**	

*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.

	NH3-Nanoxic 2000-2006	
Average	**2.112**	
Median	**1.375**	
Minimum	**<0.1**	***ND**
Maximum	**18.400**	**Taylor Lake**
STD	**2.356**	
n =	**246**	

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

	pHoxic <=3ft00-2006	
Average	**8.31**	
Median	**8.31**	
Minimum	**7.06**	**Deer Lake**
Maximum	**10.28**	**Round Lake Marsh North**
STD	**0.45**	
n =	**792**	

	pHanoxic 2000-2006	
Average	**7.19**	
Median	**7.18**	
Minimum	**6.24**	**Banana Pond**
Maximum	**8.48**	**Heron Pond**
STD	**0.38**	
n =	**246**	

	All Secchi 2000-2006	
Average	**4.48**	
Median	**3.27**	
Minimum	**0.33**	**Fairfield Marsh, Patski Pond**
Maximum	**29.23**	**Bangs Lake**
STD	**3.69**	
n =	**740**	

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

	TKNoxic <=3ft00-2006	
Average	**1.414**	
Median	**1.220**	
Minimum	**<0.5**	***ND**
Maximum	**10.300**	**Fairfield Marsh**
STD	**0.844**	
n =	**798**	

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

	TKNanoxic 2000-2006	
Average	**2.973**	
Median	**2.270**	
Minimum	**<0.5**	***ND**
Maximum	**21.000**	**Taylor Lake**
STD	**2.346**	
n =	**246**	

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

	TPoxic <=3ft00-2006	
Average	**0.098**	
Median	**0.060**	
Minimum	**<0.01**	***ND**
Maximum	**3.880**	**Albert Lake**
STD	**0.171**	
n =	**798**	

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

	TPanoxic 2000-2006	
Average	**0.280**	
Median	**0.163**	
Minimum	**0.012**	**West Loon Lake**
Maximum	**3.800**	**Taylor Lake**
STD	**0.369**	
n =	**246**	

	TSSall <=3ft00-2006	
Average	**15.3**	
Median	**7.9**	
Minimum	**<0.1**	***ND**
Maximum	**165.0**	**Fairfield Marsh**
STD	**20.3**	
n =	**809**	

*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 =	**753**	

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	**263**	
Median	**116**	
Minimum	**41**	**Timber Lake (N)**
Maximum	**2390**	**IMC**
STD	**452**	
n =	**78**	

	CLoxic <=3ft00-2006	
Average	**220**	
Median	**171**	
Minimum	**30**	**White Lake**
Maximum	**2760**	**IMC**
STD	**275**	
n =	**318**	

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

Minimums and maximums are based on data from all lakes from 1988-2006 (n=3053).

Average, median and STD are based on data from the most recent water quality sampling year for each lake.
LCHD Lakes Management Unit ~ 1/4/2007

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