2009 SUMMARY REPORT
of
Highland Lake

Lake County, Illinois

Prepared by the

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APPENDICES

EXECUTIVE SUMMARY

Highland Lake is a 102.8 acre glacial lake in west central Lake County. Highland Lake receives water from Cranberry Lake and empties into Round Lake and eventually into the Fox River. Members of the Highland Lake Property Owners Association use the lake for swimming, fishing, and boating (electric motors are allowed).

Secchi disk (water clarity) readings averaged 6.97 feet during 2009, which was above the Lake County median of 3.15 feet. This was an increase from the 2001 average (6.58 feet). The 2009 average TSS concentration in the epilimnion was 3.2 mg/L compared to 3.3 mg/L in 2001. Both values were below the county median of 7.9 mg/L.

The Lake County median conductivity reading was 0.7910 mS/cm. During 2009, the average conductivity reading in Highland Lake was lower at 0.5834 mS/cm. This was a 5% increase from the 2001 average of 0.5556 mS/cm and a 43% increase from the 1996 average of 0.4076 mS/cm. Conductivity is positively correlated with chloride (Cl^-) concentrations. The average Cl^- concentration in Highland Lake was also less than the Lake County median of 145 mg/L during 2009, with an average of 101 mg/L. The 2009 average total phosphorus (TP) concentration of 0.020 mg/L was below the county median of 0.063 mg/L. This was a decrease from the 2001 survey when the average TP concentration was 0.030 mg/L.

Highland Lake had a diverse aquatic plant community, with a total of nine plant species and one macro-algae found. The most common species were *Chara* spp. and Spiny Naiad at 52% of the sampled sites, while Sago Pondweed, Horned Pondweed, and White Water Lily were the next most abundant species. In 2001, *Chara* spp. and Sago Pondweed were the most common aquatic plant species found at the sites sampled. Curlyleaf Pondweed, an exotic aquatic plant, was found in Highland Lake in both 2001 and 2009.

The shoreline was reassessed in 2009 for significant changes in erosion since 2001. Based on the 2009 assessment, several areas had experienced further erosion while other areas had been repaired. Overall, 85% of the shoreline had no erosion, 12% had slight erosion, 2% had moderate erosion, and 1% had severe erosion.

Since Highland Lake is located in the middle of a residential setting with the majority of the shoreline riprap, habitat for wildlife was limited. Mainly birds were observed along with a couple of mammals. Most of the birds were those common to residential settings. The Illinois Department of Natural Resources (IDNR) conducted a fish survey on Highland Lake in 1998 and 2009. The results for the 2009 survey were not available at the time this report was written. In 1998 a total of 242 fish representing nine species were collected. Bluegill and Yellow Bass were the most frequently captured species. Black Crappie, Largemouth Bass, Common Carp, Walleye, Yellow Perch, Northern Pike, and Yellow Bullhead were the other species collected.

LAKE FACTS

Lake Name:	Highland Lake
Historical Name:	Taylor's Lake
Nearest Municipality:	Hainesville/Grayslake
Location:	T45N, R10E, Section 21 and 22
Elevation:	781.4 feet mean sea level
Major Tributaries:	None
Watershed:	Fox River
Sub-watershed:	Squaw Creek
Receiving Waterbody:	Round Lake
Surface Area:	102.8 acres
Shoreline Length:	1.6 miles
Maximum Depth:	29.1 feet
Average Depth:	7.3 feet
Lake Volume:	745.9 acre-feet
Lake Type:	Glacial
Watershed Area:	423.3 acres
Major Watershed Land Uses:	Single Family, Public and Private Open Space, Transportation, and Multi Family
Bottom Ownership:	Private
Management Entities:	Homeowners
Current and Historical Uses:	Fishing, swimming, and boating (electric motors only)
Description of Access:	Private

SUMMARY OF WATER QUALITY

Water samples were collected monthly from May through September at the deepest point in the lake (Figure 1, Appendix A). Samples were collected three feet below the surface and three feet off the bottom and analyzed for various water quality parameters (Appendix C). The Lake County Health Department – Environmental Services (ES, formerly the Lakes Management Unit) also sampled Highland Lake in 1991, 1996, and 2001 and those results were compared with the 2009 data. Highland Lake has participated in the Volunteer Lake Monitoring Program (VLMP) in 1981, 1990-1991, and 2007-2009. Highland Lake is within the Squaw Creek watershed which the ES sampled in 2009 (Figure 2). Lakes within this watershed that are directly connected to Highland Lake include Cranberry Lake, Round Lake, Long Lake, Patski Pond, and Hook Lake. Other lakes within this watershed that were sampled by the ES in 2009 include Old Oak Lake, Schreiber Lake, Owens Lake, Davis Lake, Lake Helen, Summerhill Estates Lake, and Nippersink Lake (LCFPD).

A dissolved oxygen (DO) concentration of 5.0 mg/L is considered adequate to support a healthy fishery, since fish can suffer oxygen stress below this amount. DO concentrations in the epilimnion did not indicate any significant problems during this study (Appendix B). Anoxic conditions (< 1 mg/L) existed from May through September in the hypolimnion. This is a normal phenomenon in lakes that stratify. The anoxic boundary was at 22– 28 feet for the entire sampling season. However, this is of little concern since it only accounts for a small percentage of the lake volume (0.1%-7.1%). An updated bathymetric map was created by the ES in September of 2009 (Figure 3, Table 1).

During the winter of 2008-09 Highland Lake had experienced a winter fish kill. There were Common Carp, Yellow Bass, Largemouth Bass, and various panfish species noted frozen in the ice. Since there were multiple species, it was likely that the fish died from the lack of oxygen. When the lake was completely frozen, there was a significant amount of snow on the ice prohibiting light penetration. Without the light penetration, algae and plants can not photosynthesize and release oxygen and since decomposition of organic matter consumes oxygen and continues throughout the year the DO concentrations likely continued to drop to a critical level. It is likely that this was what lead to a depletion in dissolved oxygen and the die off of the fish found frozen in the ice.

In 2009, Highland Lake was thermally stratified from May through September at approximately 14 – 16 feet. Thermal stratification occurs when a lake divides into an upper, warm water layer (epilimnion) and a lower, cold-water layer (hypolimnion). When stratified, the epilimnetic and hypolimnetic waters do not mix, and the hypolimnion typically experiences anoxic conditions (where DO concentrations drop below 1 mg/L) by mid-summer. The thermocline (the transitional region between the epilimnion and the hypolimnion) remained strong. Turnover was beginning during the September sampling, although the thermocline was still present.

Secchi disk depth (water clarity) averaged 6.97 feet during 2009 and 6.58 feet during 2001 (Table 2). Both of these readings were above the Lake County median of 3.15 feet (Appendix E). The VLMP average Secchi depth has fluctuated from 5.31 feet (2009) to 12.54 feet (2007) with an average of 7.57 feet (Figure 4). This could be due to factors such as plant or algae

Figure 1. Water quality sampling site on Highland Lake, 2009.

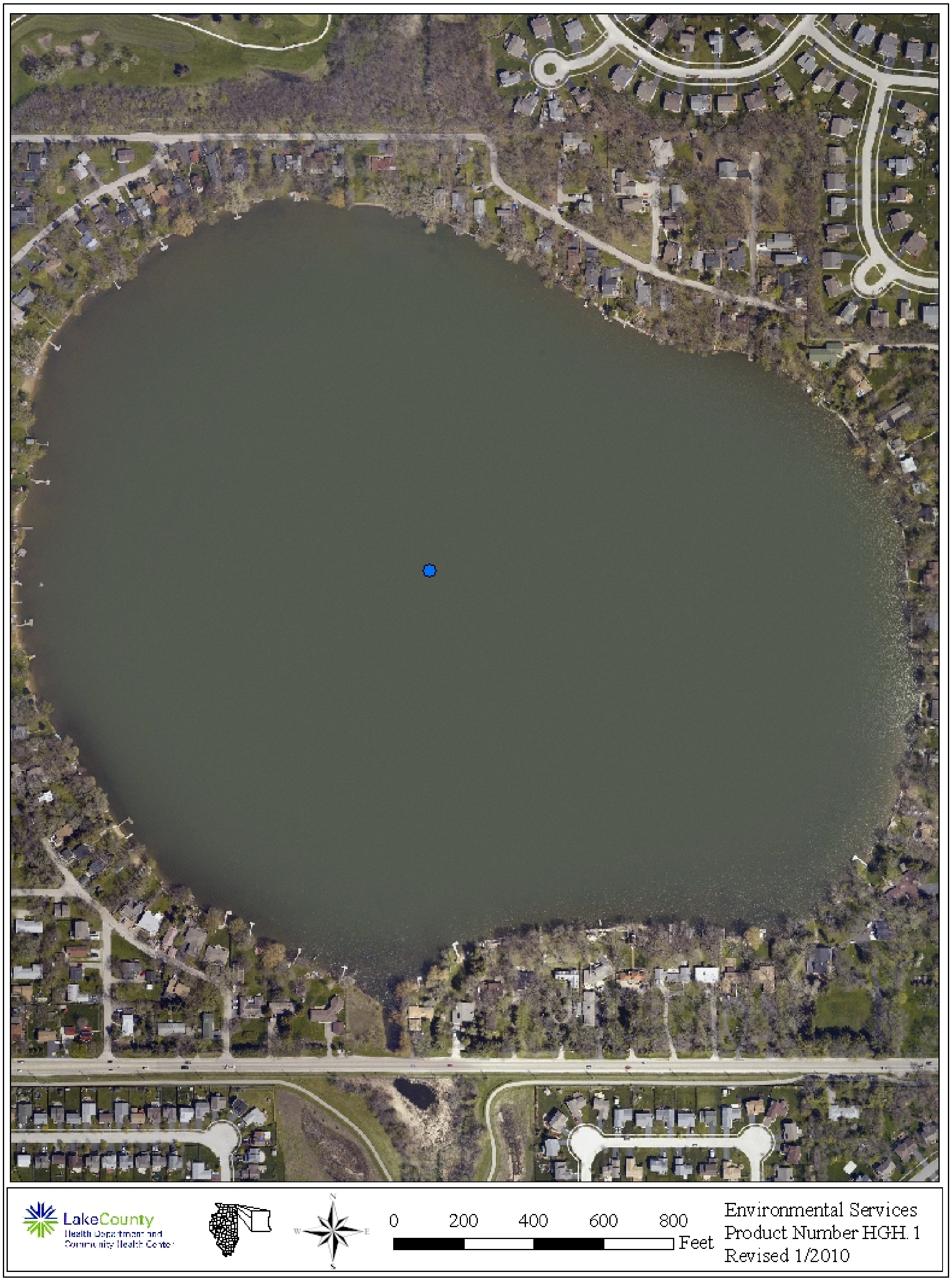


Figure 2. Lakes sampled in the Squaw Creek Watershed, 2009.

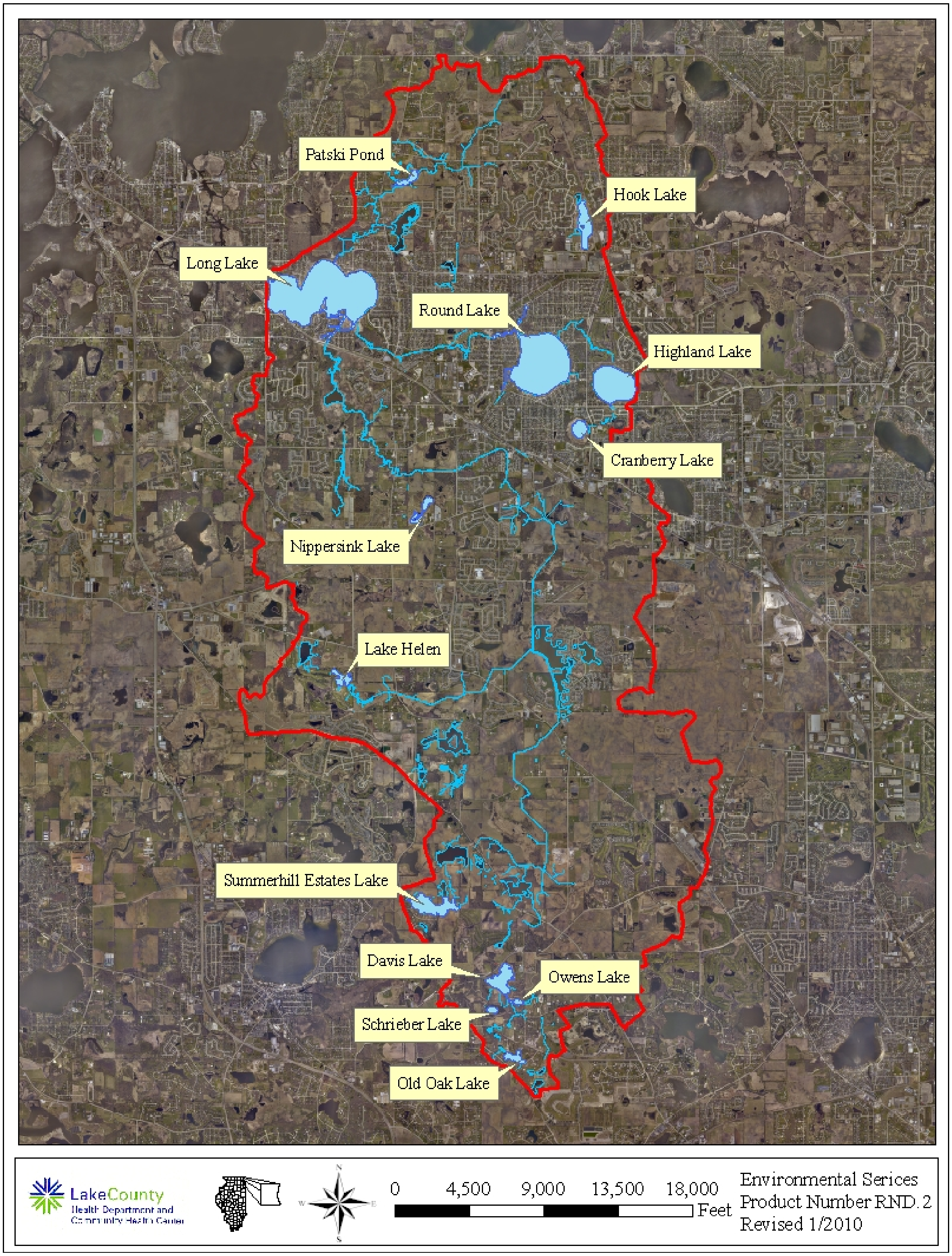


Figure 3. Bathymetric map of Highland Lake, 2009.

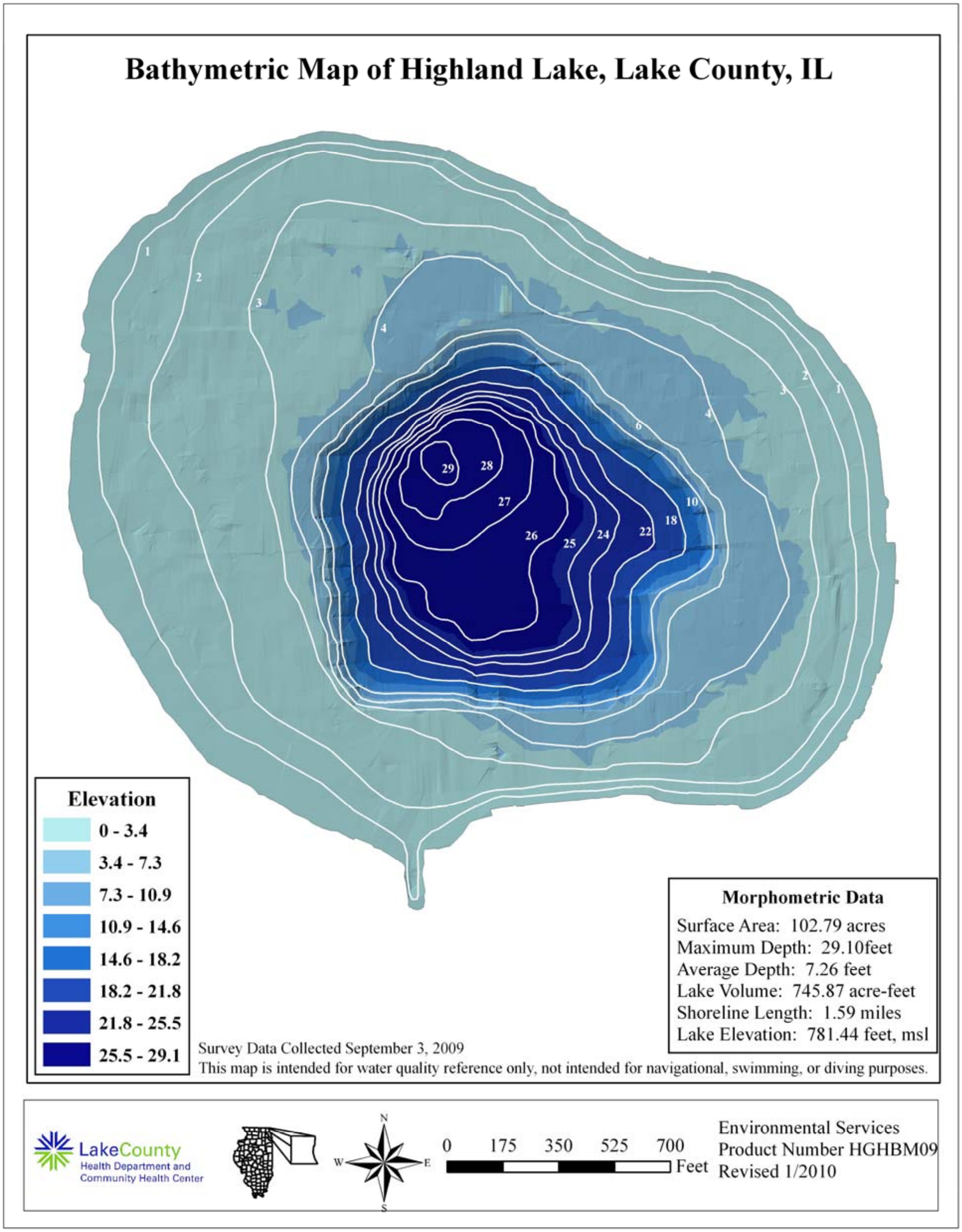


Table 1. Morphometric features of Highland Lake, 2009.

Data From the September 2009 Bathymetric Survey, LCHD Environmental Services

Contour (Feet)	Area Enclosed (Acres)	Percent of total acres	Volume (Acre-feet)	Depth Zone (Feet)	Area (Acres)	Percent (Depth zone to total acres)	Percent (Acre-feet to Total Volume)
0	102.79	100%	97.32	0 - 1	10.83	10.5%	13.0%
1	91.95	89%	84.67	1 - 2	14.36	14.0%	11.4%
2	77.59	75%	65.80	2 - 3	22.93	22.3%	8.8%
3	54.67	53%	46.09	3 - 4	16.65	16.2%	6.2%
4	38.02	37%	33.98	4 - 5	7.94	7.7%	4.6%
5	30.09	29%	28.64	5 - 6	2.87	2.8%	3.8%
6	27.21	26%	26.46	6 - 7	1.49	1.5%	3.5%
7	25.72	25%	25.30	7 - 8	0.83	0.8%	3.4%
8	24.89	24%	24.56	8 - 9	0.65	0.6%	3.3%
9	24.24	24%	23.94	9 - 10	0.59	0.6%	3.2%
10	23.64	23%	23.37	10 - 11	0.55	0.5%	3.1%
11	23.09	22%	22.81	11 - 12	0.56	0.5%	3.1%
12	22.53	22%	22.25	12 - 13	0.56	0.5%	3.0%
13	21.97	21%	21.68	13 - 14	0.58	0.6%	2.9%
14	21.39	21%	21.08	14 - 15	0.62	0.6%	2.8%
15	20.77	20%	20.42	15 - 16	0.70	0.7%	2.7%
16	20.07	20%	19.68	16 - 17	0.78	0.8%	2.6%
17	19.29	19%	18.86	17 - 18	0.84	0.8%	2.5%
18	18.44	18%	17.99	18 - 19	0.90	0.9%	2.4%
19	17.54	17%	17.04	19 - 20	0.99	1.0%	2.3%
20	16.55	16%	16.01	20 - 21	1.07	1.0%	2.1%
21	15.47	15%	14.90	21 - 22	1.13	1.1%	2.0%
22	14.34	14%	13.71	22 - 23	1.25	1.2%	1.8%
23	13.10	13%	12.32	23 - 24	1.53	1.5%	1.7%
24	11.56	11%	10.68	24 - 25	1.74	1.7%	1.4%
25	9.82	10%	8.39	25 - 26	2.78	2.7%	1.1%
26	7.05	7%	5.02	26 - 27	3.81	3.7%	0.7%
27	3.24	3%	2.26	27 - 28	1.83	1.8%	0.3%
28	1.41	1%	0.55	28 - 29	1.38	1.3%	0.1%
29	0.03	0.03%	0.07	29 +	0.03	0.03%	0.01%
			745.87		102.79	100%	100%

Maximum Depth of Lake: 29.10 Feet
Average Depth of Lake: 7.26 Feet
Volume of Lake: 745.87 Acre-Feet

Area of Lake: 102.79 Acres
Shoreline Length: 1.59 Miles
Water elevation at 779.40 feet above mean sea level

LakeCounty Health Department and Community Health Center

Table 2. Water quality data for Highland Lake, 2001 and 2009.

2009	Epilimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
13-May	3	146	1.07	<0.1	<0.05	0.034	<0.005	106	NA	11.0	393	92	3.11	0.6530	8.67	8.14
10-Jun	3	145	0.79	<0.1	<0.05	0.025	<0.005	101	NA	4.9	383	82	5.68	0.6480	8.58	12.16
15-Jul	3	118	0.79	<0.1	<0.05	0.012	<0.005	96	NA	4.1	373	102	5.20	0.5880	8.79	9.87
12-Aug	3	79	0.70	<0.1	<0.05	0.017	0.005	99	NA	2.7	329	101	8.40	0.5100	9.56	11.22
16-Sep	3	76	0.66	<0.1	<0.05	0.013	<0.005	100	NA	1.2	316	93	12.45	0.5180	9.75	9.98
	Average	113	0.80	<0.1	<0.05	0.020	0.005[k]	101	NA	4.8	359	94	6.97	0.5834	9.07	10.27

2001	Epilimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N*	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
8-May	3	153	0.92	<0.1	0.102	0.027	<0.005	NA	362	4.0	370	102	6.37	0.5698	8.31	9.52
12-Jun	3	139	1.01	<0.1	<0.05	0.015	0.005	NA	322	2.4	353	122	7.02	0.5404	8.44	8.99
17-Jul	3	135	0.91	<0.1	<0.05	0.037	0.006	NA	347	2.8	362	131	6.92	0.5706	8.24	8.18
14-Aug	3	139	0.93	<0.1	<0.05	0.040	<0.005	NA	350	4.9	364	124	4.33	0.5523	8.12	7.09
11-Sep	3	130	1.08	<0.1	<0.05	0.032	<0.005	NA	288	2.4	321	81	8.24	0.5450	8.05	6.81
	Average	139	0.97	<0.1[k]	0.102[k]	0.030	0.006[k]	NA	334	3.3	354	112	6.58	0.5556	8.23	8.12

Glossary

ALK = Alkalinity, mg/L $CaCO_3$	TDS = Total dissolved solids, mg/L
TKN = Total Kjeldahl nitrogen, mg/L	TSS = Total suspended solids, mg/L
NH_3-N = Ammonia nitrogen, mg/L	TS = Total solids, mg/L
NO_2+NO_3-N = Nitrate + Nitrite nitrogen, mg/L	TVS = Total volatile solids, mg/L
NO_3-N = Nitrate + Nitrite nitrogen, mg/L	SECCHI = Secchi disk depth, ft.
TP = Total phosphorus, mg/L	COND = Conductivity, milliSiemens/cm
SRP = Soluble reactive phosphorus, mg/L	DO = Dissolved oxygen, mg/L
Cl^- = Chloride, mg/L	

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

NA= Not applicable

* = Prior to 2006 only Nitrate - nitrogen was analyzed

Table 2. Continued.

2009	Hypolimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
13-May	27	156	1.53	0.636	<0.05	0.048	<0.005	108	NA	8.7	404	100	NA	0.6830	7.72	0.30
10-Jun	27	167	1.91	1.16	<0.05	0.038	0.038	105	NA	8.4	392	85	NA	0.6880	7.38	0.51
15-Jul	27	177	2.84	1.530	<0.05	0.108	<0.005	103	NA	13.0	407	83	NA	0.7090	7.12	0.32
12-Aug	27	155	2.63	1.650	<0.05	0.073	<0.005	102	NA	7.6	392	99	NA	0.7170	7.31	0.96
16-Sep	27	175	2.52	1.61	<0.05	0.052	<0.005	102	NA	8.5	413	104	NA	0.7830	7.71	0.45
	Average	166	2.29	1.317	<0.05	0.064	0.038[k]	104	NA	9.2	402	94	NA	0.7160	7.45	0.51

2001	Hypolimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N*	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
8-May	28	162	1.80	0.86	<0.05	0.045	0.01	NA	364	4.5	366	111	NA	0.5848	7.1	0.26
12-Jun	28	149	1.12	0.291	<0.05	0.034	0.005	NA	336	2.9	367	134	NA	0.5597	7.39	1.95
17-Jul	28	187	4.29	3.090	<0.05	0.123	<0.005	NA	354	11.0	367	140	NA	0.6272	6.77	0.08
14-Aug	26	187	3.08	1.780	<0.05	0.096	<0.005	NA	354	7.5	374	124	NA	0.6143	6.53	0.05
11-Sep	26	211	5.01	4.08	<0.05	0.098	0.009	NA	350	5.5	358	78	NA	0.6618	6.49	0.01
	Average	179	3.06	2.020	<0.05	0.079	0.008[k]	NA	352	6.3	366	117	NA	0.6096	6.86	0.47

Glossary

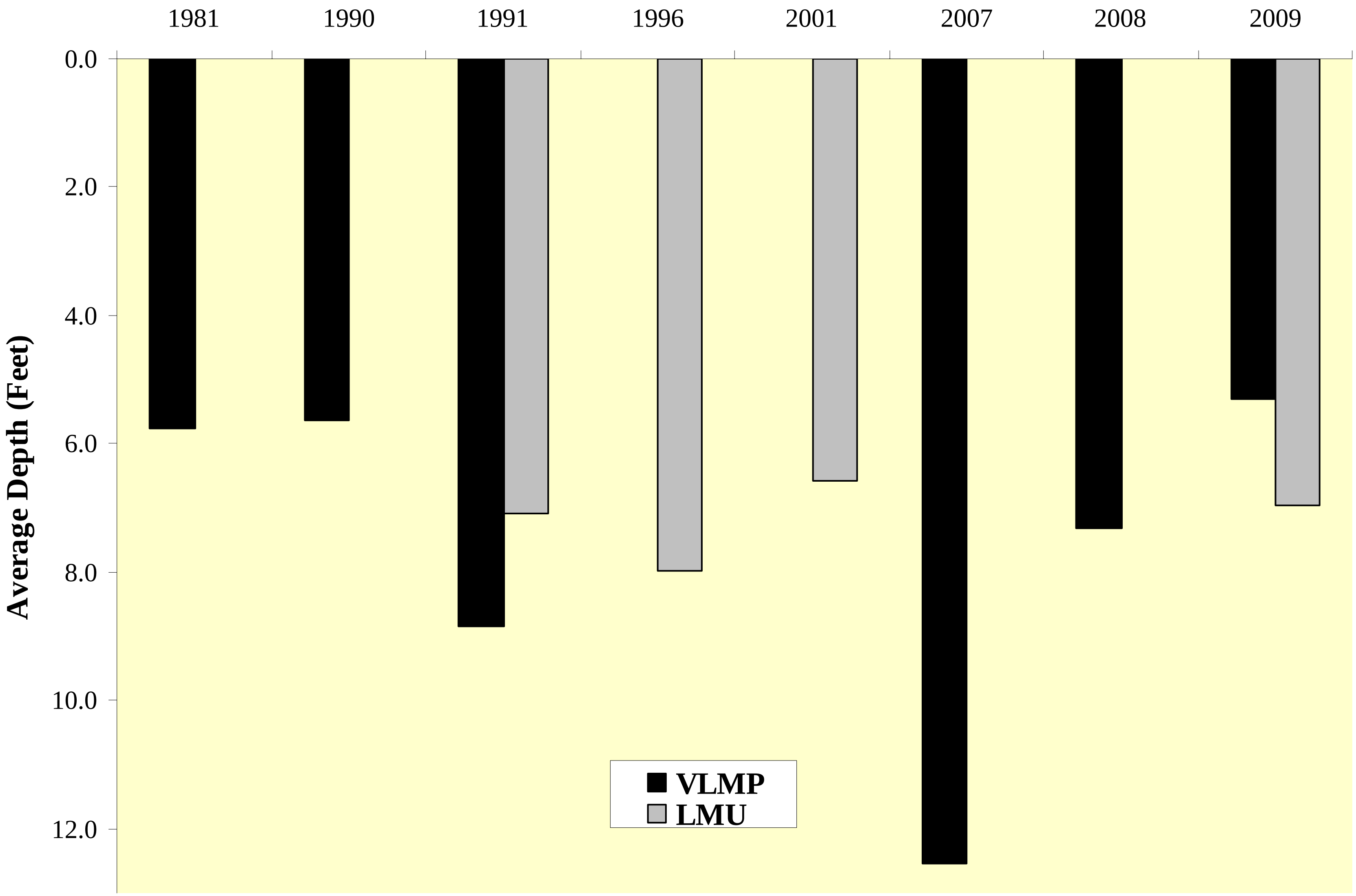
ALK = Alkalinity, mg/L $CaCO_3$	TDS = Total dissolved solids, mg/L
TKN = Total Kjeldahl nitrogen, mg/L	TSS = Total suspended solids, mg/L
NH_3-N = Ammonia nitrogen, mg/L	TS = Total solids, mg/L
NO_2+NO_3-N = Nitrate + Nitrite nitrogen, mg/L	TVS = Total volatile solids, mg/L
NO_3-N = Nitrate + Nitrite nitrogen, mg/L	SECCHI = Secchi disk depth, ft.
TP = Total phosphorus, mg/L	COND = Conductivity, milliSiemens/cm
SRP = Soluble reactive phosphorus, mg/L	DO = Dissolved oxygen, mg/L
Cl^- = Chloride, mg/L	

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

NA= Not applicable

* = Prior to 2006 only Nitrate - nitrogen was analyzed

Figure 4. Secchi disk averages from VLMP and LCHD records for Highland Lake.



growth and the amount of stormwater run-off. The water clarity increased from May through September. This increase in clarity was correlated with a decrease in total suspended solids (TSS) in the water column (Figure 5). TSS is composed of nonvolatile suspended solids, non-organic clay or sediment materials, and volatile suspended solids, algae and other organic matter. The decrease in TSS can be attributed to the aquatic plants that established through the summer which kept the bottom sediment more stable and used available nutrients which resulted in less algal growth. In 2009 the average TSS in the epilimnion was 4.8 mg/L while in 2001 it averaged 3.3 mg/L (a 45% increase). However approximately one inch of rain had fallen May 13, 2009, the day the lake was sampled. This rain caused a decrease in Secchi depth and an elevated TSS concentration. If the May value was omitted, the 2009 averages were 7.93 feet for Secchi and 3.2 mg/L for TSS. The TSS and Secchi values have been relatively constant since 1991 (Figure 6). All TSS values were below the county median of 7.9 mg/L. It is important to note that even though there was an increase in Secchi depth and an increase in TSS from 2001 to 2009, this may be due to seasonal variables. Also the VLMP average Secchi depths vary from year to year likely due to yearly variations in plant abundance and environmental parameters (i.e., temperature, rainfall).

One possible factor that could affect the clarity and TSS of Highland Lake in the future is run-off from the proposed expansion of Washington Road. Proper erosion control should be monitored during the construction to ensure no negative impacts to the lake.

Within the Squaw Creek Watershed, Lake Nippersink had the poorest average Secchi depth (1.73 feet) and Patski Pond had the highest average TSS (33.7 mg/L, Table 3). Since Patski Pond was sampled at the outlet, no Secchi depth was collected. It is expected that Patski Pond would have had a Secchi depth less than Lake Nippersink if it would have been collected. Lake Nippersink and Patski Pond had these elevated levels due to their shallow nature, lack of aquatic plants, and abundant Common Carp. In contrast, Davis Lake had the greatest average Secchi depth (9.65 feet) and the lowest average TSS concentration (2.6 mg/L). Davis Lake is located near the top of the watershed and has an abundant aquatic plant community stabilizing the bottom sediments and consuming available nutrients.

Another factor affecting water clarity was the amount of nutrients in the water. Typically, lakes are either phosphorus (P) or nitrogen (N) limited. This means that one of the nutrients is in short supply and any addition of that nutrient to the lake will result in an increase of plant and/or algal growth. Most lakes in Lake County are phosphorus limited. To compare the availability of nitrogen and phosphorus, a ratio of total nitrogen to total phosphorus (TN:TP) is used. Ratios less than or equal to 10:1 indicate nitrogen is limiting, ratios greater than or equal to 15:1 indicate phosphorus is limiting, and ratios greater than 10:1, but less than 15:1 indicate there is enough of both nutrients to facilitate excess algae or plant growth. Highland Lake had a TN:TP ratio of 32:1 in 2001 and 40:1 in 2009, indicating the lake was phosphorous limited. Nitrogen, naturally occurs in high concentrations and come from a variety of sources (soil, air, etc.), which are more difficult to control than sources of phosphorus. Lakes that are phosphorus-limited may be easier to manage, since controlling phosphorus is more feasible than controlling nitrogen.

Total phosphorus (TP) concentrations in Highland Lake have remained stable over the years and have averaged lower than the Lake County epilimnetic median of 0.063 mg/L and hypolimnetic

Figure 5. Total suspended solid (TSS) concentrations vs. Secchi depth for Highland Lake, 2009.

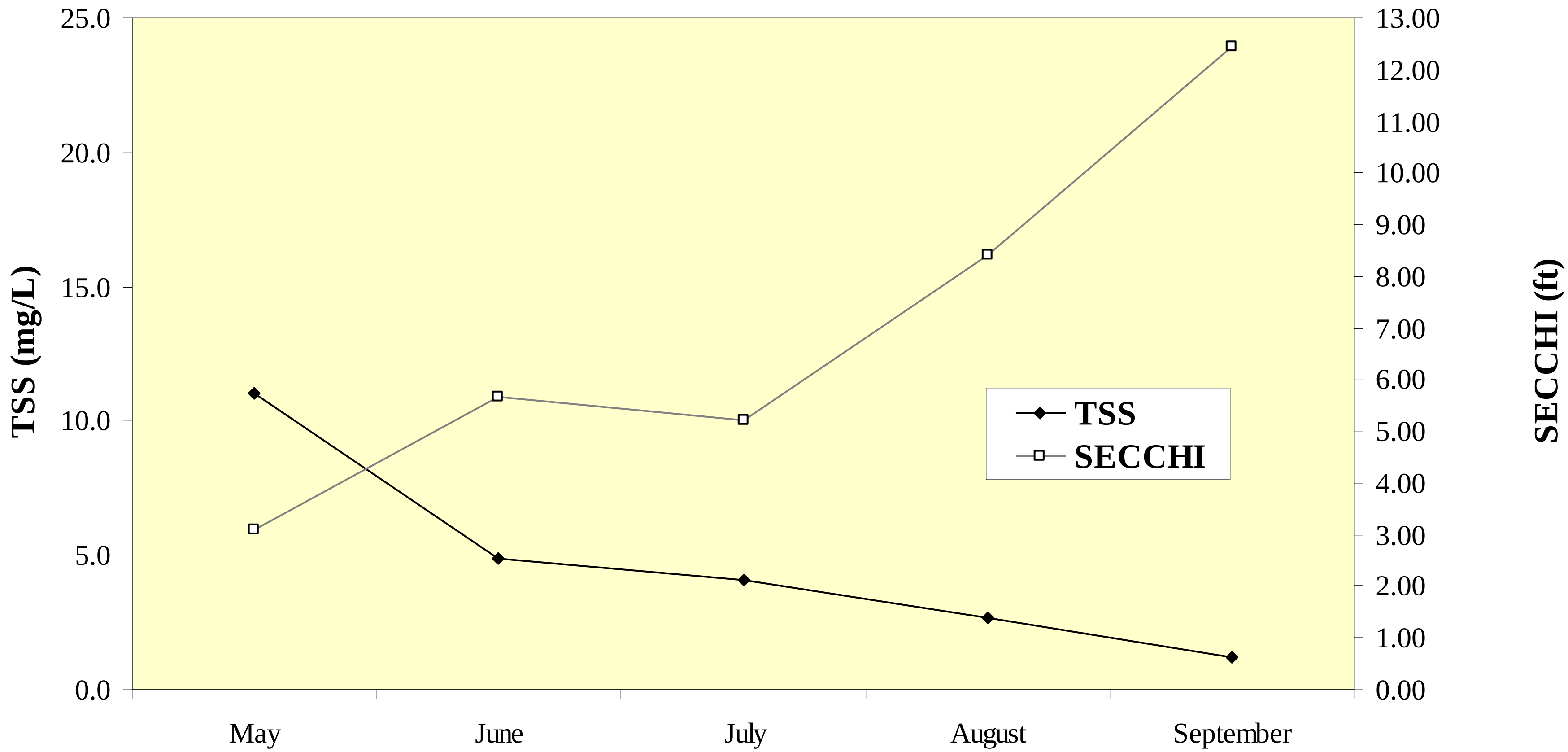


Figure 6. Total suspended solid (TSS) concentrations vs. Secchi depth for Highland Lake, 1991 – 2009.

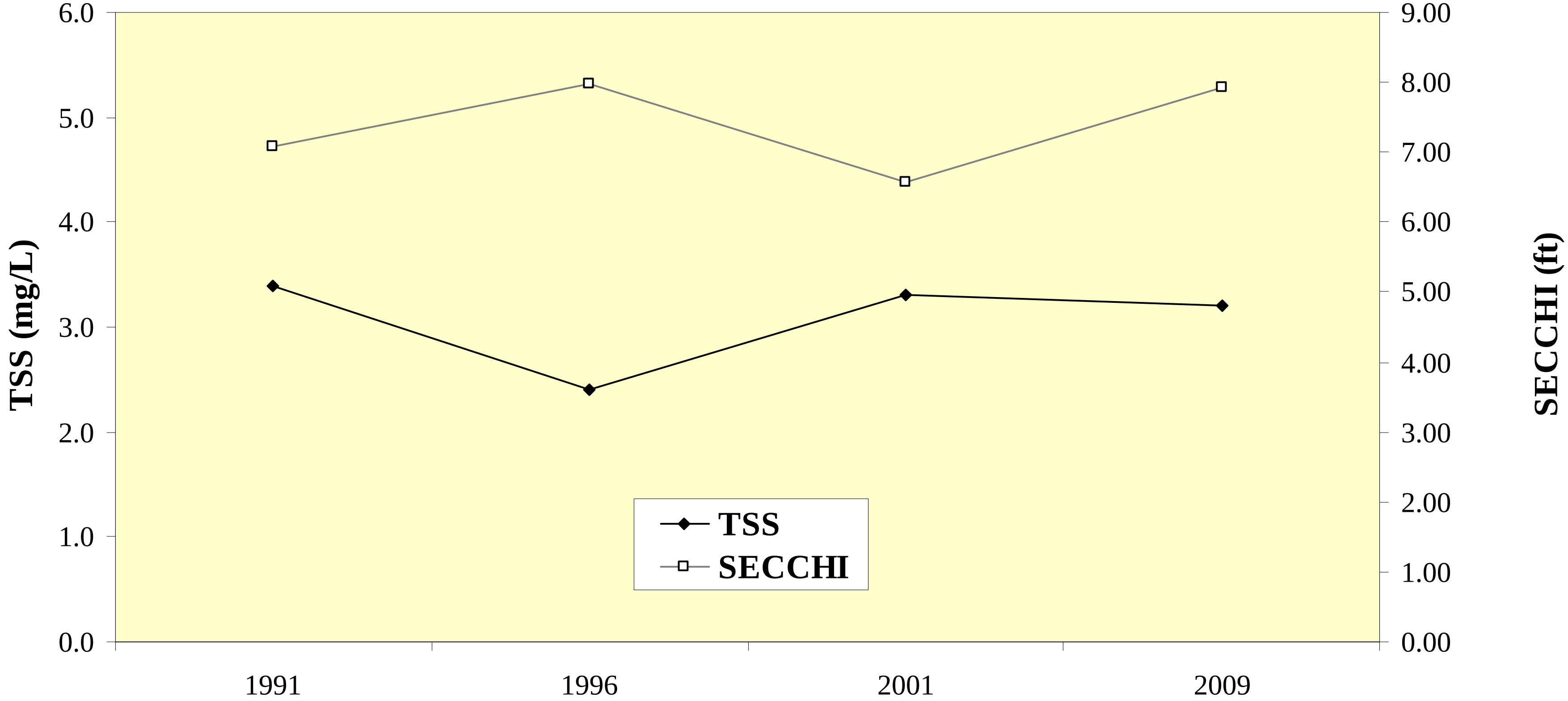


Table 3. Comparison of epilimnetic averages for Secchi disk transparency, total suspended solids, total phosphorus, and conductivity within the Squaw Creek watershed.

	Cranberry Lake	Cranberry Lake	Cranberry Lake	Cranberry Lake	Cranberry Lake	Cranberry Lake	Highland Lake	Highland Lake	Highland Lake	Highland Lake
Year	**2000**	**2005**	**2006**	**2007**	**2008**	**2009**	**1991**	**1996**	**2001**	**2009**
Secchi (feet)	10.96	10.52	9.33	9.06	9.63	8.56	7.08	7.98	6.58	6.97
TSS (mg/L)	1.2	1.5	1.6	1.8	2.2	3.7	3.4	2.4	3.3	4.8
TP (mg/L)	0.024	0.024	0.024	0.023	0.027	0.036	0.039	0.023	0.030	0.020
Conductivity (milliSiemens/cm)	0.3809	0.5625	0.6019	0.5138	0.5070	0.4262	NA	0.4076	0.5560	0.5834

	Round Lake	Round Lake	Round Lake	Round Lake	Round Lake	Round Lake	Long Lake	Long Lake	Long Lake	Long Lake	Long Lake	Long Lake	Long Lake
Year	**1989**	**1991**	**1995**	**1999**	**2003**	**2009**	**1996**	**2001**	**2005**	**2006**	**2007**	**2008**	**2009**
Secchi (feet)	7.07	5.20	7.44	10.32	6.25	7.01	2.44	4.11	4.18	4.52	3.24	2.69	4.16
TSS (mg/L)	4.4	5.4	3.4	2.7	3.5	3.0	13.9	9.7	10.9	7.2	11.1	11.6	10.2
TP (mg/L)	0.100	0.031	0.024	0.015	0.025	0.023	0.086	0.092	0.076	0.068	0.103	0.117	0.092
Conductivity (milliSiemens/cm)	NA	NA	0.6290	0.8364	1.0730	1.2292	0.5222	0.9430	1.0821	1.112	0.9066	0.8722	0.7587

	Old Oak Lake	Old Oak Lake	Schreiber Lake	Schreiber Lake	Owens Lake	Owens Lake	Davis Lake	Davis Lake	Summerhill Estates Lake	Summerhill Estates Lake	Lake Helen	Lake Nippersink
Year	**2003**	**2009**	**2003**	**2009**	**2000**	**2009**	**2000**	**2009**	**2004**	**2009**	**2009**	**2009**
Secchi (feet)	5.08	4.85	9.59	7.25	4.38	5.30	8.14	9.65	3.65	3.27	6.43	1.73
TSS (mg/L)	3.6	4.9	3.1	2.8	11.0	3.5	2.1	2.6	6.1	9.4	4.1	18.9
TP (mg/L)	0.043	0.049	0.043	0.040	0.124	0.058	0.048	0.065	0.138	0.199	0.072	0.100
Conductivity (milliSiemens/cm)	0.7240	0.7700	0.2882	0.2582	0.5395	0.5274	0.5143	0.6306	0.5858	0.5552	0.4742	0.4588

	Patski Pond	Patski Pond	Hook Lake	Hook Lake
Year	**2004**	**2009**	**2004**	**2009**
Secchi (feet)	NA	NA	5.03	3.95
TSS (mg/L)	52.7	33.7	5.1	6.5
TP (mg/L)	0.251	0.197	0.030	0.041
Conductivity (milliSiemens/cm)	0.8194	0.8994	1.1067	1.4690

Direction of Watershed Flow →

median of 0.167 mg/L. The epilimnetic TP averaged 0.023 mg/L in 1996, 0.030 mg/L in 2001, and 0.020 mg/L in 2009. The hypolimnetic average TP has decreased over the years from the 1996 average of 0.081 mg/L to the 2009 average of 0.064 mg/L. This decrease could be due the stratification breaking down between the July and August 2009 sampling events and allowing the hypolimnion to mix with the epilimnion. The breakdown could have been a result of changes in the weather. The mixing caused a decrease in hypolimnetic and an increase in the epilimnetic TP. This increase in the epilimnetic nutrients caused an algae bloom as can be seen by an increase in the DO concentration and pH that corresponds with a decrease in alkalinity. Another explanation for the TP decrease could be development within the watershed. Between 1991 and 2009 there was a housing development replaced farm fields south of Washington Road. The run-off from this development flows through a wetland complex which helps to remove nutrients before reaching the lake. Prior to the housing development the run-off from the agricultural field flowed directly into the lake carrying any nutrients from the field. Within the watershed, Summerhill Estates Lake had the highest average TP (0.199 mg/L) while Highland Lake had the lowest average TP (0.020 mg/L). Highland Lake and Summerhill Estates Lake are located near the top of their watersheds and have small areas draining into them. However Summerhill Estates Lake is shallow and was historically surrounded by agricultural fields.

There were external sources of TP affecting Highland Lake such as stormwater from the 423.3 acres within its watershed (Figure 7). Single family (26%), public and private open space (13%), and transportation (11%) were the major land uses within the watershed (Figure 8). For Highland Lake transportation (36%) and single family (31%) were the land uses contributing the highest percentages of estimated run-off (Table 4). It is important to keep in mind that although the amount of estimated run-off from certain areas may be low, those areas can still deliver high concentrations of TSS and TP. In the Highland Lake watershed where single family homes are a major land use contributing to run-off, applying lawn fertilizers containing zero phosphorus would be an effective way to reduce phosphorus. When applying lawn fertilizers near lakes it is important to remember that one pound of phosphorus can produce 300-500 pounds of algae (Figure 9). Phosphorus free fertilizer should be relatively easy to find since Round Lake Beach and Round Lake Park have passed ordinances banning the use of lawn fertilizers containing phosphorus. It is recommended that the Highland Lake Property Owners Association also enact a ban. The retention time (the amount of time it takes for water entering a lake to flow out again) was calculated to be approximately 2.6 years.

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 that can support nuisance algae growth reminiscent of “pea soup” and have a TSI score greater than 70. Lakes with a TSI score of 50 or greater are classified as eutrophic 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 Highland Lake in terms of its phosphorus concentration during 2001 was eutrophic, with a TSIp score of 53.3. In 2009 the TSIp score was lower at 47.5, and classified Highland Lake as mesotrophic and ranked 13th out of 165 lakes in Lake County based on average TP concentrations (Table 5).

Figure 7. Approximate watershed delineation for Highland Lake, 2009.

Figure 8. Approximate land use within the Highland Lake watershed, 2009.

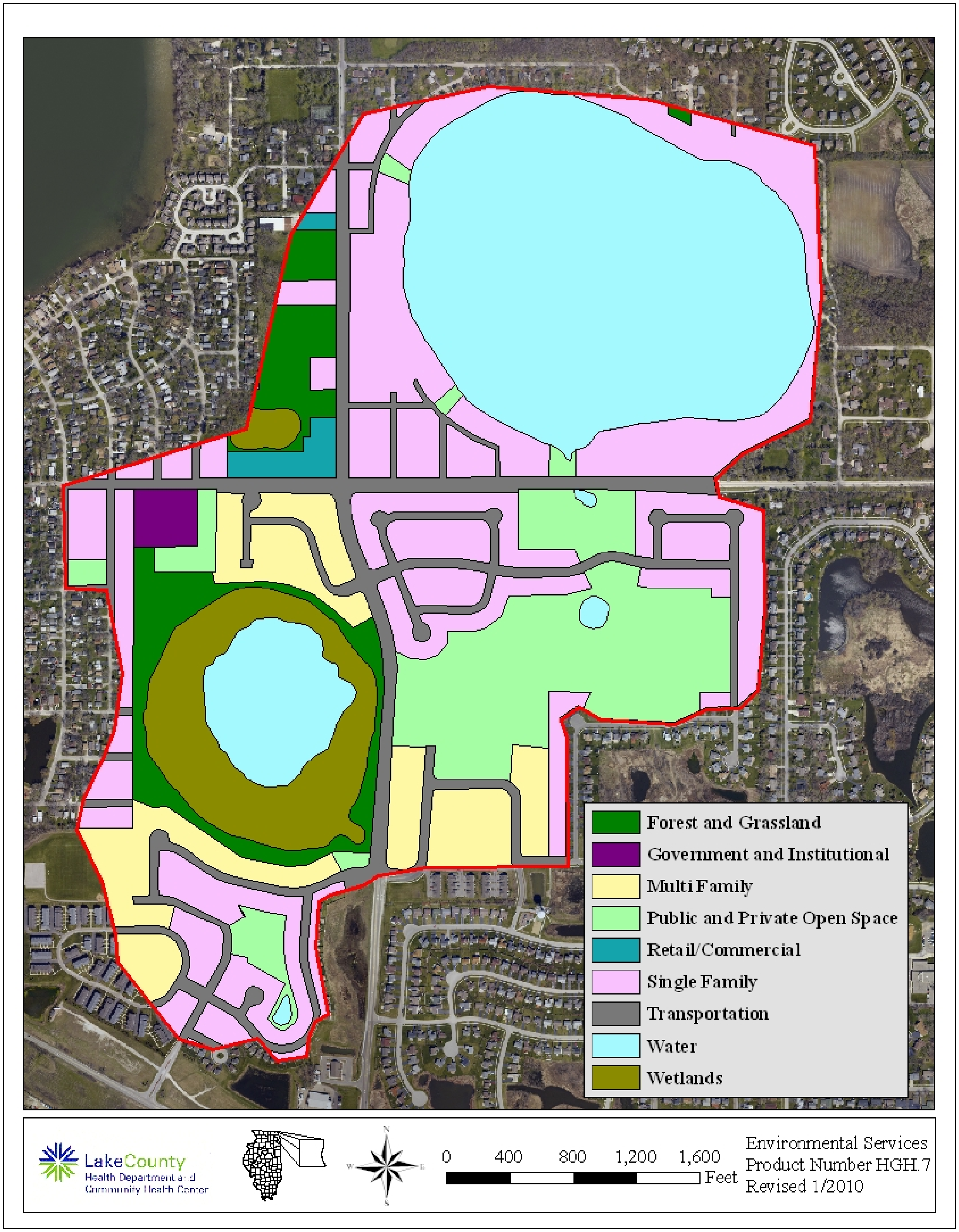


Table 4. Approximate land uses and retention time for Highland Lake, 2009.

Land Use	Acreage	% of Total
Forest and Grassland	24.31	5.7%
Government and Institutional	3.49	0.8%
Multi Family	35.86	8.5%
Public and Private Open Space	54.23	12.8%
Retail/Commercial	4.23	1.0%
Single Family	108.54	25.6%
Transportation	44.33	10.5%
Water (102.79 acres Highland Lake)	119.49	28.2%
Wetlands	28.85	6.8%
Total Acres	**423.33**	**100.0%**

Land Use	Acreage	Run-off Coeff.	Estimated Run-off, acft.	% Total of Estimated Run-off
Forest and Grassland	24.31	0.05	3.3	1.2%
Government and Institutional	3.49	0.50	4.8	1.7%
Multi Family	35.86	0.50	49.3	17.2%
Public and Private Open Space	54.23	0.15	22.4	7.8%
Retail/Commercial	4.23	0.85	9.9	3.4%
Single Family	108.54	0.30	89.5	31.2%
Transportation	44.33	0.85	103.6	36.1%
Water	119.49	0.00	0.0	0.0%
Wetlands	28.85	0.05	4.0	1.4%
TOTAL	**423.33**		**286.8**	**100.0%**

Lake volume	**745.87**	**acre-feet**
Retention Time (years)= lake volume/run-off	**2.60**	**years**
	949.10	**days**

Figure 9. An illustration of the production of algae from lawn fertilizer use in a watershed.

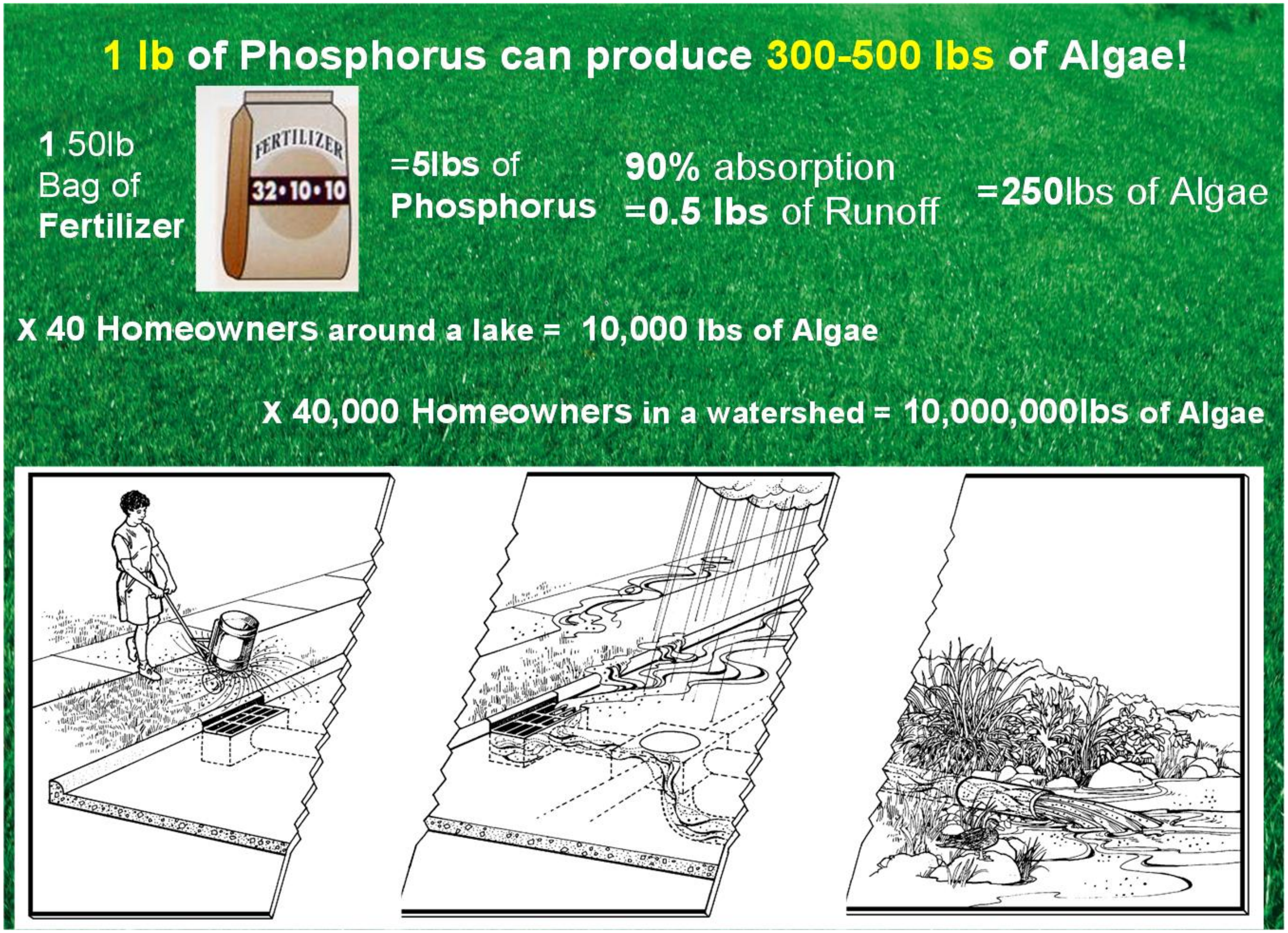


Table 5. Lake County average TSI phosphorous (TSIp) ranking 2000-2009.

RANK	LAKE Name	TP AVE	TSIp
1	Lake Carina	0.0100	37.35
2	Sterling Lake	0.0100	37.35
3	Independence Grove	0.0135	39.24
4	Lake Zurich	0.0130	41.14
5	Sand Pond (IDNR)	0.0165	41.36
6	West Loon Lake	0.0140	42.21
7	Windward Lake	0.0158	43.95
8	Cedar Lake	0.0170	45.00
9	Pulaski Pond	0.0180	45.83
10	Timber Lake	0.0180	45.83
11	Fourth Lake	0.0182	45.99
12	Lake Kathryn	0.0200	47.35
13	**Highland Lake**	**0.0200**	**47.35**
14	Banana Pond	0.0202	47.49
15	Lake Minear	0.0204	47.63
16	Cross Lake	0.0220	48.72
17	Sun Lake	0.0220	48.72
18	Dog Pond	0.0222	48.85
19	Lake of the Hollow	0.0230	49.36
20	Stone Quarry Lake	0.0230	49.36
21	Round Lake	0.0230	49.36
22	Deep Lake	0.0234	49.61
23	Bangs Lake	0.0240	49.98
24	Druce Lake	0.0244	50.22
25	Little Silver	0.0250	50.57
26	Lake Leo	0.0256	50.91
27	Dugdale Lake	0.0274	51.89
28	Peterson Pond	0.0274	51.89
29	Lake Miltmore	0.0276	51.99
30	Lake Fairfield	0.0296	53.00
31	Third Lake	0.0300	53.20
32	Gray's Lake	0.0302	53.29
33	Lake Catherine (Site 1)	0.0308	53.57
34	Lambs Farm Lake	0.0312	53.76
35	Old School Lake	0.0312	53.76
36	Sand Lake	0.0316	53.94
37	Lake Linden	0.0326	54.39
38	Gages Lake	0.0338	54.92
39	Honey Lake	0.0340	55.00
40	Hendrick Lake	0.0344	55.17
41	Cranberry Lake	0.0360	55.82
42	Sullivan Lake	0.0370	56.22
43	Diamond Lake	0.0372	56.30
44	Channel Lake (Site 1)	0.0380	56.60
45	Ames Pit	0.0390	56.98
46	Schreiber Lake	0.0400	57.34

Table 5. Continued.

RANK	LAKE NAME	TP AVE	TSIp
47	White Lake	0.0408	57.63
48	Hook Lake	0.0410	57.70
49	Potomac Lake	0.0424	58.18
50	Duck Lake	0.0426	58.25
51	Deer Lake	0.0434	58.52
52	Nielsen Pond	0.0448	58.98
53	Turner Lake	0.0458	59.30
54	Seven Acre Lake	0.0460	59.36
55	Willow Lake	0.0464	59.48
56	Lucky Lake	0.0476	59.85
57	East Meadow Lake	0.0478	59.91
58	Old Oak Lake	0.0490	60.27
59	East Loon Lake	0.0490	60.27
60	Countryside Lake	0.0490	60.27
61	College Trail Lake	0.0496	60.45
62	Lake Lakeland Estates	0.0524	61.24
63	Butler Lake	0.0528	61.35
64	West Meadow Lake	0.0530	61.40
65	Heron Pond	0.0545	61.80
66	Little Bear Lake	0.0550	61.94
67	Lucy Lake	0.0552	61.99
68	Lake Napa Suwe (Outlet)	0.0570	62.45
69	Lake Christa	0.0576	62.60
70	Lake Charles	0.0580	62.70
71	Owens Lake	0.0580	62.70
72	Crooked Lake	0.0608	63.38
73	Waterford Lake	0.0610	63.43
74	Wooster Lake	0.0610	63.43
75	Lake Naomi	0.0616	63.57
76	Lake Tranquility S1	0.0618	63.62
77	Werhane Lake	0.0630	63.89
78	Liberty Lake	0.0632	63.94
79	Countryside Glen Lake	0.0642	64.17
80	Lake Fairview	0.0648	64.30
81	Leisure Lake	0.0648	64.30
82	Davis Lake	0.0650	64.34
83	Tower Lake	0.0662	64.61
84	St. Mary's Lake	0.0666	64.70
85	Mary Lee Lake	0.0682	65.04
86	Hastings Lake	0.0684	65.08
87	Lake Helen	0.0720	65.82
88	Spring Lake	0.0726	65.94
89	ADID 203	0.0730	66.02
90	Bluff Lake	0.0734	66.10
91	Harvey Lake	0.0766	66.71
92	Broberg Marsh	0.0782	67.01

Table 5. Continued.

RANK	LAKE NAME	TP AVE	TSIp
93	Sylvan Lake	0.0794	67.23
94	Big Bear Lake	0.0806	67.45
95	Petite Lake	0.0834	67.94
96	Timber Lake (South)	0.0848	68.18
97	Lake Marie (Site 1)	0.0850	68.21
98	North Churchill Lake	0.0872	68.58
99	Grand Avenue Marsh	0.0874	68.61
100	Grandwood Park, Site II, Outflow	0.0876	68.65
101	North Tower Lake	0.0878	68.68
102	South Churchill Lake	0.0896	68.97
103	Rivershire Pond 2	0.0900	69.04
104	McGreal Lake	0.0914	69.26
105	Long Lake	0.0920	69.35
106	International Mine and Chemical Lake	0.0948	69.79
107	Eagle Lake (Site I)	0.0950	69.82
108	Valley Lake	0.0950	69.82
109	Dunns Lake	0.0952	69.85
110	Fish Lake	0.0956	69.91
111	Lochanora Lake	0.0960	69.97
112	Woodland Lake	0.0986	70.35
113	Island Lake	0.0990	70.41
114	McDonald Lake 1	0.0996	70.50
115	Nippersink Lake	0.1000	70.56
116	Longview Meadow Lake	0.1024	70.90
117	Lake Barrington	0.1053	71.30
118	Redwing Slough, Site II, Outflow	0.1072	71.56
119	Lake Forest Pond	0.1074	71.59
120	Bittersweet Golf Course #13	0.1096	71.88
121	Fox Lake (Site 1)	0.1098	71.90
122	Osprey Lake	0.1108	72.04
123	Bresen Lake	0.1126	72.27
124	Round Lake Marsh North	0.1126	72.27
125	Deer Lake Meadow Lake	0.1158	72.67
126	Taylor Lake	0.1184	72.99
127	Columbus Park Lake	0.1226	73.49
128	Nippersink Lake (Site 1)	0.1240	73.66
129	Echo Lake	0.1250	73.77
130	Grass Lake (Site 1)	0.1288	74.21
131	Lake Holloway	0.1322	74.58
132	Lakewood Marsh	0.1330	74.67
133	Redhead Lake	0.1412	75.53
134	Forest Lake	0.1422	75.63
135	Antioch Lake	0.1448	75.89
136	Slocum Lake	0.1496	76.36
137	Pond-a-Rudy	0.1514	76.54
138	Lake Matthews	0.1516	76.56

Table 5. Continued.

RANK	LAKE NAME	TP AVE	TSIp
139	Buffalo Creek Reservoir	0.1550	76.88
140	Pistakee Lake (Site 1)	0.1592	77.26
141	Grassy Lake	0.1610	77.42
142	Salem Lake	0.1650	77.78
143	Half Day Pit	0.1690	78.12
144	Lake Eleanor Site II, Outflow	0.1812	79.13
145	Lake Farmington	0.1848	79.41
146	Lake Louise	0.1850	79.43
147	ADID 127	0.1886	79.71
148	Patski Pond (outlet)	0.1970	80.33
149	Summerhill Estates Lake	0.1990	80.48
150	Dog Bone Lake	0.1990	80.48
151	Redwing Marsh	0.2072	81.06
152	Stockholm Lake	0.2082	81.13
153	Bishop Lake	0.2156	81.63
154	Ozaukee Lake	0.2200	81.93
155	Hidden Lake	0.2236	82.16
156	Fischer Lake	0.2278	82.43
157	Oak Hills Lake	0.2792	85.36
158	Loch Lomond	0.2954	86.18
159	McDonald Lake 2	0.3254	87.57
160	Fairfield Marsh	0.3264	87.61
161	ADID 182	0.3280	87.69
162	Slough Lake	0.4134	91.02
163	Flint Lake Outlet	0.4996	93.75
164	Rasmussen Lake	0.5025	93.84
165	Albert Lake, Site II, outflow	1.1894	106.26

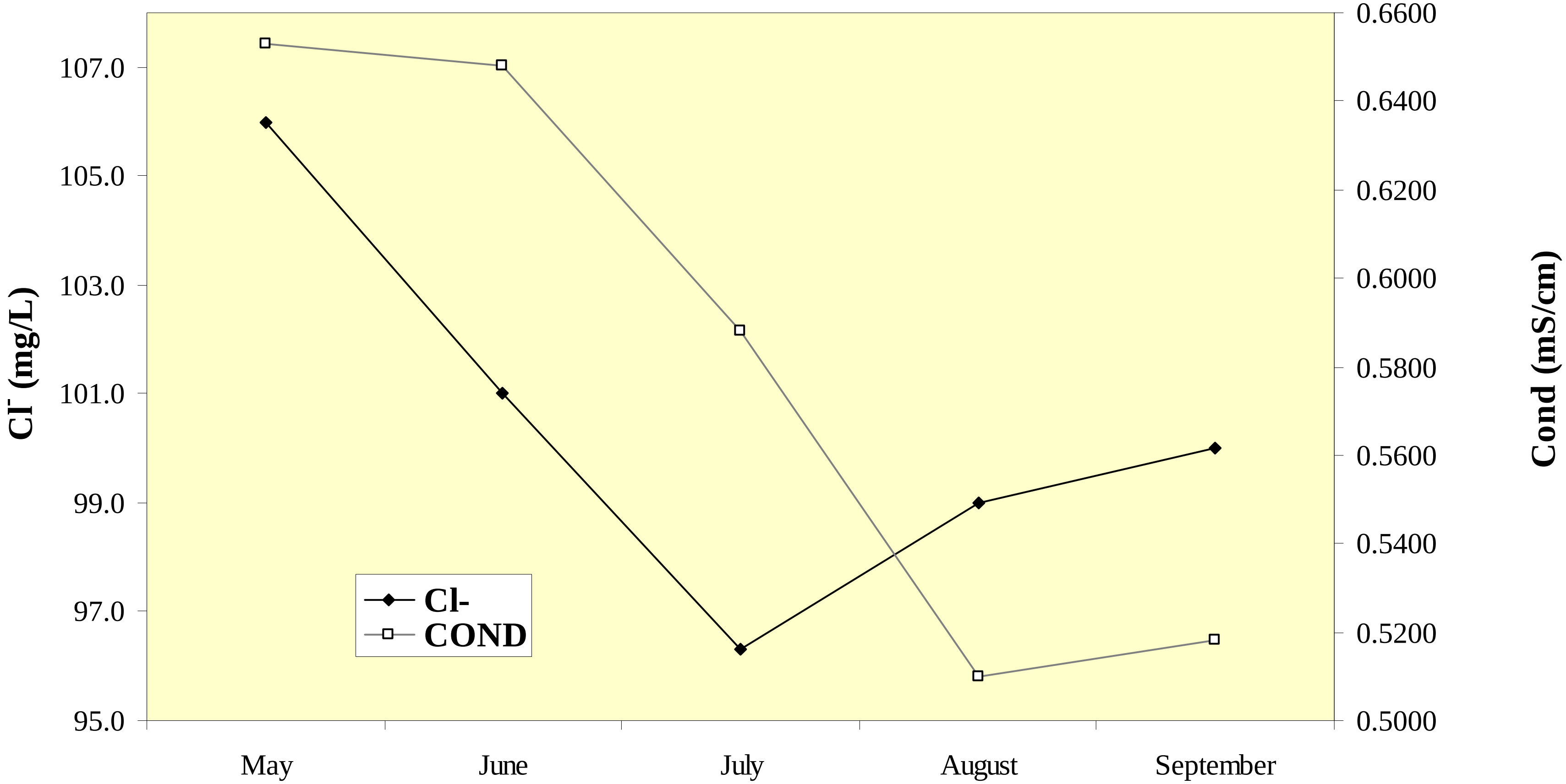
The pH averaged 9.07 in 2009. This value is considered high and out of the applicable standard set by the Illinois Environmental Protection Agency (IEPA). This high pH correlated with a decreased alkalinity and was likely due to rapid photosynthesis by plants and algae. The plants species found in Highland Lake generally develop later in the growing season and caused an increase in photosynthesis. The rapid photosynthesis stripped hydrogen ions (H^+) from the water which drove the alkalinity down and pH up. Plants use carbon dioxide (CO_2) during photosynthesis to produce carbohydrates (CH_2O)n. When the rate of photosynthesis exceeds the rate in which atmospheric CO_2 dissolving in the water, aquatic plants us dissolved carbonates as their source of carbon. As a result of using the carbonates oxygen and hydroxyl ions (OH^-) are produced which result in increased lake pH. In addition, H^+ are consumed during photosynthesis which also raised pH. In lakes undergoing photosynthesis by phytoplankton the pH can exceed 10 by late afternoon. High pH and Low alkalinity makes copper sulfate more toxic to fish so any algae treatments need to take the pH and alkalinity into consideration.

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

Conductivity concentrations in Highland Lake have increased over the years, and are an area of concern. Conductivity is a measurement of water's ability to conduct electricity and is correlated with chloride (Cl^-) concentrations (Figure 10). Compared to lakes in undeveloped areas, lakes with residential and/or urban land uses in their watershed often have higher conductivity readings and higher Cl^- concentrations because of the use of road salts. Stormwater run-off from impervious surfaces such as roads and parking lots can deliver high concentrations of Cl^- to nearby waterbodies. The Lake County epilimnetic median conductivity reading was 0.7910 milliSiemens/cm (mS/cm). During 2009, the Highland Lake average epilimnetic conductivity was lower, at 0.5834 mS/cm. This was a 5% increase from the 2001 average of 0.5556 mS/cm and a 43% increase from the 1996 average of 0.4076 mS/cm. The hypolimnetic averages were also lower than the county median of 0.8431 mS/cm in 1996 (0.4724 mS/cm), 2001 (0.6096 mS/cm) and 2009 (0.7160 mS/cm). Cl^- concentration in Highland Lake was lower than the Lake County epilimnetic median of 145 mg/L during 2009, with an epilimnetic average of 101 mg/L. Chloride was not measured in 1998 or 2001. As mentioned previously, transportation contributed 36% of the estimated run-off within the watershed. Within the watershed, Hainesville Road and Washington Road are two major roads that can contribute to the Cl^- run-off and increased conductivity.

A study done in Canada reported 10% of aquatic species were harmed by prolonged exposure to Cl^- concentrations greater than 220 mg/L. Additionally, shifts in algal populations in lakes were associated with Cl^- concentrations as low as 12 mg/l. Therefore, lakes can be negatively impacted by the high Cl^- concentrations.

Figure 10. Chloride (Cl^-) concentration vs. conductivity for Highland Lake, 2009.



SUMMARY OF AQUATIC MACROPHYTES

An aquatic plant (macrophyte) survey was conducted in July of 2009. Sampling sites were based on a grid system created by mapping software (ArcMap), with each site located 60 meters apart for a total of 116 sites. Ninety-four sites were sampled and plants were found at 79 sites (Figure 11), at a maximum depth of 10.4 feet (Table 6a, b). Overall, a total of nine plant species and one macro-algae (*Chara* spp.) were found (Table 7). The most common species was Spiny Naiad and *Chara* spp. both at 52% of the sites sampled, while Sago Pondweed (27%), Horned Pondweed (15%), and White Water Lily (12%) were the next most abundant species. In July 2001, *Chara* spp. (70%) and Sago Pondweed (43%) were the most common aquatic plant species found at the sites sampled. Curlyleaf Pondweed, an exotic aquatic plant, was found in Highland Lake during 2001 (20%) and 2009 (7%). Exotics compete with native plants, eventually crowding them out, providing little or poor natural diversity in addition to limited uses by wildlife. Removal or control of exotic species is recommended. Species composition was lower in July 2001 with only eight plant species and *Chara* spp. were found. In 2001 the aquatic plants were sampled at approximately 30 sites each month. The entire 2001 sampling yielded 11 aquatic plant species and *Chara* spp. Coontail, Eurasian Watermilfoil, and Northern Watermilfoil were found in 2001 and not in 2009 while American Pondweed was found in 2009 and not in 2001. The aquatic plant community is in good condition with only one exotic species found. There was a decrease in diversity from 2001, however the plants that were not found in 2009 can be invasive. The Highland Lake Property Owners Association (HLPOA) has managed the aquatic plants with fluridone chemical treatments. HLPOA had the lake treated every 2 – 3 years from 1990 – 2008. Whole lake treatments are not recommended on a regular basis for Highland Lake. The plant community in Highland Lake should be allowed to recover to provide habitat for aquatic organisms and stabilize bottom sediments. However, it is suggested that the CLP be monitored and if any whole lake treatments are planned they be early in the year to avoid treating the native plants.

Water clarity and depth are the major limiting factors in determining the maximum depth at which aquatic plants will grow in a specific lake. Aquatic plants will not photosynthesize in water depths with less than 1% of the available sunlight. During 2009, the 1% light level was available down to 10 feet deep in May, 15 feet in June, 22 feet in July, and 21 feet in August. The meter malfunctioned so data for September is unavailable. Even though the 1% light level was 22 feet, plants were only found down to 10.4 feet in July. This could be due to the previous months only having a 1% light level of 10 feet.

To maintain a healthy sunfish/bass fishery, the optimal plant coverage is 30% to 40% across the lake bottom. It was calculated that approximately 68% of the lake bottom was covered by plants in 2009. Although this is above the recommended bottom coverage, the density of the aquatic plant community is not a problem at this time. As previously stated *Chara* spp. was one of the dominant species and although it is a desirable species it does not provide the quality habitat that higher vascular plants can provide. Care should be taken when putting together a good aquatic plant management plan. The plan should be based on the management goals of the lake and involve usage issues, habitat maintenance/restoration, and limitations of the lake. Follow up is critical for an aquatic plant management plan to achieve long-term success. A good aquatic plant management plan considers both the short and long-term needs of the lake.

Figure 11. Aquatic plant sampling grid that illustrates plant density on Highland Lake, July 2009.

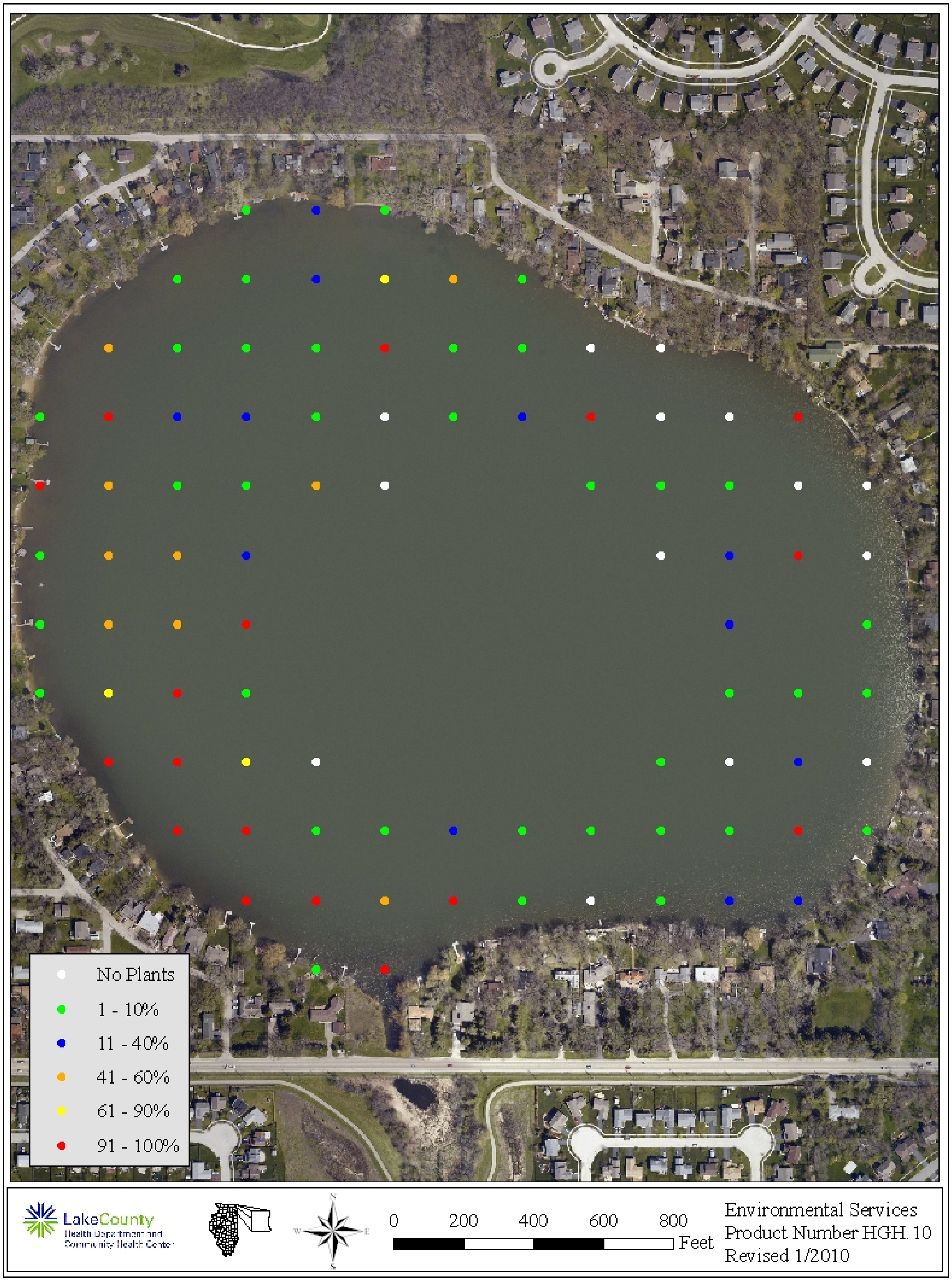


Table 6a. Aquatic plant species found at the 116 sampling sites on Highland Lake, July 2009. Maximum depth that plants were found was 10.4 feet.

July										
Plant Density	American Pondweed	Chara	Curlyleaf Pondweed	Horned Pondweed	Sago Pondweed	Slender Naiad	Small Pondweed	Spadderdock	Spiny Naiad	White Water Lily
Absent	92	45	87	80	69	91	87	93	45	83
Present	2	26	4	9	8	3	3	0	29	11
Common	0	11	3	3	1	0	3	0	12	0
Abundant	0	5	0	1	7	0	1	1	5	0
Dominant	0	7	0	1	9	0	0	0	3	0
% Plant Occurrence	2.1	52.1	7.4	14.9	26.6	3.2	7.4	1.1	52.1	11.7

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

July		
Rake Density (Coverage)	# of Sites	%
No plants	15	16.0%
>0 to 10%	37	39.4%
>10 to 40%	12	12.8%
>40 to 60%	10	10.6%
>60 to 90%	3	3.2%
>90%	17	18.1%
Total Sites with Plants	79	84.0%
Total # of Sites	94	100.0%

Table 7. Aquatic plant species found in Highland Lake in 2009.

Chara (macro algae)	*Chara* spp.
Slender Naiad	*Najas flexis*
Spiny Naiad	*Najas marina*
Spadderdock	*Nuphar variegata*
White Water Lily	*Nymphaea tuberosa*
Curlyleaf Pondweed^	*Potamogeton crispus*^
American Pondweed	*Potamogeton nodosus*
Sago Pondweed	*Potamogeton pectinatus*
Small Pondweed	*Potamogeton pusillus*
Horned Pondweed	*Zannichellia palustris*

^ Exotic plant

The Floristic Quality Index (FQI) is a rapid assessment tool designed to evaluate the closeness of the flora of an area to that of undisturbed conditions. It can be used to: 1) identify natural areas, 2) compare the quality of different sites or different locations within a single site, 3) monitor long-term floristic trends, and 4) monitor habitat restoration efforts. Each floating or submersed aquatic plant is assigned a number between 1 and 10 (10 indicating the plant species most sensitive to disturbance). An FQI is calculated by multiplying the average of these numbers by the square root of the number of these plant species found in the lake. A high FQI number indicate that there were large numbers of sensitive, high quality plant species present in the lake. Non-native species were also included in the FQI calculations for Lake County lakes. The average FQI for 2000-2009 Lake County lakes was 13.7 (Table 8). Highland Lake had a FQI of 16.7 in 2009. This was an increase from 2001 when the FQI was 14.5.

SUMARY OF SHORELINE CONDITION

Lakes with stable water levels potentially have less shoreline erosion problems. The water level was measured each month off the north side of the seawall just north of Downy Park. The highest level was found in May with the lowest level in September. For the season, May to September, the water level increased by 9.13 inches.

In 2001 an assessment was conducted to determine the condition of the shoreline at the water/land interface. The entire shoreline was developed, with 44% typified as riprap. The two other major shoreline types were seawall (33%) and buffer (10%). Beach and lawn each made up less than 8% of the total shoreline. One positive aspect of the shoreline was only about 8% was eroding. Approximately 4% of the eroding shoreline was classified as slightly eroding, with the remainder classified as moderately eroding (2%) and severely eroding (2%).

The shoreline was reassessed in 2009 for significant changes in erosion. This survey, however, was not as extensive as in 2001. Based on the 2009 assessment, some of the eroded areas have been repaired while other areas still remain eroded or developed erosion (Figure 12). Overall, 85% of the shoreline had no erosion, 12% had slight erosion, 2% had moderate erosion, and 1%

Table 8. 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	38.2	40.2
2	Cranberry Lake	32.5	33.3
3	East Loon Lake	30.6	32.7
4	Deep Lake	29.7	31.2
5	Little Silver	29.6	31.6
6	Bangs Lake	29.5	31.0
7	Round Lake Marsh North	29.1	29.9
8	Deer Lake	28.2	29.7
9	Sullivan Lake	26.9	28.5
10	West Loon Lake	25.7	27.3
11	Cross Lake	25.2	27.8
12	Wooster Lake	25.0	26.6
13	Independence Grove	24.6	27.5
14	Sterling Lake	24.5	26.9
15	Lake Zurich	24.3	27.1
16	Sun Lake	24.3	26.1
17	Schreiber Lake	23.9	24.8
18	Lakewood Marsh	23.8	24.7
19	Round Lake	23.5	25.9
20	Honey Lake	23.3	25.1
21	Fourth Lake	23.0	24.8
22	Lake of the Hollow	23.0	24.8
23	Druce Lake	22.8	25.2
24	Countryside Glen Lake	21.9	22.8
25	Butler Lake	21.4	23.1
26	Davis Lake	21.4	21.4
27	Duck Lake	21.1	22.9
28	Timber Lake (North)	20.8	22.8
29	ADID 203	20.5	20.5
30	Broberg Marsh	20.5	21.4
31	McGreal Lake	20.2	22.1
32	Lake Kathryn	19.6	20.7
33	Fish Lake	19.3	21.2
34	Redhead Lake	19.3	21.2
35	Turner Lake	18.6	21.2
36	Salem Lake	18.5	20.2
37	Lake Miltmore	18.4	20.3
38	Lake Helen	18.0	18.0
39	Old Oak Lake	18.0	19.1
40	Hendrick Lake	17.7	17.7
41	Long Lake	17.2	19.0
42	Seven Acre Lake	17.0	15.5
43	Gray's Lake	16.9	19.8
44	Owens Lake	16.3	17.3

Table 8. Continued

Rank	LAKE NAME	FQI (w/A)	FQI (native)
45	Countryside Lake	16.7	17.7
46	**Highland Lake**	**16.7**	**18.9**
47	Lake Barrington	16.7	17.7
48	Bresen Lake	16.6	17.8
49	Diamond Lake	16.3	17.4
50	Windward Lake	16.3	17.6
51	Dog Bone Lake	15.7	15.7
52	Redwing Slough	15.6	16.6
53	Osprey Lake	15.5	17.3
54	Lake Fairview	15.2	16.3
55	Heron Pond	15.1	15.1
56	Lake Tranquility (S1)	15.0	17.0
57	North Churchill Lake	15.0	15.0
58	Dog Training Pond	14.7	15.9
59	Island Lake	14.7	16.6
60	Grand Avenue Marsh	14.3	16.3
61	Lake Nippersink	14.3	16.3
62	Taylor Lake	14.3	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	Third Lake	13.9	16.6
67	Ames Pit	13.4	15.5
68	Bishop Lake	13.4	15.0
69	Buffalo Creek Reservoir	13.1	14.3
70	Mary Lee Lake	13.1	15.1
71	McDonald Lake 2	13.1	14.3
72	Old School Lake	13.1	15.1
73	Dunn's Lake	12.7	13.9
74	Summerhill Estates Lake	12.7	13.9
75	Timber Lake (South)	12.7	14.7
76	White Lake	12.7	14.7
77	Hastings Lake	12.5	14.8
78	Sand Lake	12.5	14.8
79	Stone Quarry Lake	12.5	12.5
80	Lake Carina	12.1	14.3
81	Lake Leo	12.1	14.3
82	Lambs Farm Lake	12.1	14.3
83	Pond-A-Rudy	12.1	12.1
84	Stockholm Lake	12.1	13.5
85	Grassy Lake	12.0	12.0
86	Lake Matthews	12.0	12.0
87	Flint Lake	11.8	13.0
88	Harvey Lake	11.8	13.0
89	Lake Napa Suwe	11.7	13.9
90	Rivershire Pond 2	11.5	13.3

Table 8. Continued

Rank	LAKE NAME	FQI (w/A)	FQI (native)
91	Antioch Lake	11.3	13.4
92	Hook Lake	11.3	13.4
93	Lake Charles	11.3	13.4
94	Lake Linden	11.3	11.3
95	Lake Naomi	11.2	12.5
96	Pulaski Pond	11.2	12.5
97	Lake Minear	11.0	13.9
98	Redwing Marsh	11.0	11.0
99	Tower Lake	11.0	11.0
100	West Meadow Lake	11.0	11.0
101	Nielsen Pond	10.7	12.0
102	Lake Holloway	10.6	10.6
103	Crooked Lake	10.2	12.5
104	College Trail Lake	10.0	10.0
105	Lake Lakeland Estates	10.0	11.5
106	Valley Lake	9.9	9.9
107	Werhane Lake	9.8	12.0
108	Big Bear Lake	9.5	11.0
109	Little Bear Lake	9.5	11.0
110	Loch Lomond	9.4	12.1
111	Columbus Park Lake	9.2	9.2
112	Sylvan Lake	9.2	9.2
113	Fischer Lake	9.0	11.0
114	Grandwood Park Lake	9.0	11.0
115	Lake Fairfield	9.0	10.4
116	Lake Louise	9	10.4
117	McDonald Lake 1	8.9	10.0
118	East Meadow Lake	8.5	8.5
119	Lake Christa	8.5	9.8
120	Lake Farmington	8.5	9.8
121	Lucy Lake	8.5	9.8
122	South Churchill Lake	8.5	8.5
123	Bittersweet Golf Course #13	8.1	8.1
124	Woodland Lake	8.1	9.9
125	Albert Lake	7.5	8.7
126	Banana Pond	7.5	9.2
127	Fairfield Marsh	7.5	8.7
128	Lake Eleanor	7.5	8.7
129	Patski Pond	7.1	7.1
130	Rasmussen Lake	7.1	7.1
131	Slough Lake	7.1	7.1
132	Lucky Lake	7.0	7.0
133	Lake Forest Pond	6.9	8.5
134	Ozaukee Lake	6.7	8.7
135	Leisure Lake	6.4	9.0
136	Peterson Pond	6.0	8.5

Table 8. Continued

Rank	LAKE NAME	FQI (w/A)	FQI (native)
137	Gages Lake	5.8	10.0
138	Slocum Lake	5.8	7.1
139	Deer Lake Meadow Lake	5.2	6.4
140	ADID 127	5.0	5.0
141	IMC Lake	5.0	7.1
142	Liberty Lake	5.0	5.0
143	Oak Hills Lake	5.0	5.0
144	Forest Lake	3.5	5.0
145	Sand Pond (IDNR)	3.5	5.0
146	Half Day Pit	2.9	5.0
147	Lochanora Lake	2.5	5.0
148	Echo Lake	0.0	0.0
149	Hidden Lake	0.0	0.0
150	North Tower Lake	0.0	0.0
151	Potomac Lake	0.0	0.0
152	St. Mary's Lake	0.0	0.0
153	Waterford Lake	0.0	0.0
154	Willow Lake	0.0	0.0
	Mean	**13.7**	**15.0**
	Median	**12.5**	**14.3**

Figure 12. Shoreline erosion on Highland Lake, 2009.

had severe erosion. Even though only a small percentage was eroding, continued neglect of these shorelines could lead to further erosion, resulting not only in a loss of property, but additional soil inputs into the water that negatively affect water clarity.

It is much easier and less costly to mitigate slightly eroding shorelines than those with more severe erosion. If these shorelines are repaired by the installation of a buffer strip with native plants, the benefits can be three-fold. First, the erosion is repaired and the new native plants can stabilize the shoreline to prevent future erosion. Second, the addition of native plants adds habitat for wildlife to a shoreline that is otherwise limited in habitat. Although some people are hesitant about installing buffer strips along their shoreline, buffer strips can be attractive and still allow lake access by adding a mowed path to the water. Thirdly, buffer habitat can help filter pollutants and nutrients from the near shore areas and keep geese and gulls from congregating, as it is not desirable habitat for them. A few areas around Highland Lake had some exotic shoreline plants such as Reed Canary Grass, Honeysuckle, and Purple Loosestrife. These plants are aggressively invasive and can crowd out beneficial native species. They do not offer ideal wildlife habitat and should be removed.

OBSERVATIONS OF WILDLIFE AND HABITAT

Wildlife observations were made on a monthly basis during water quality activities. Since Highland Lake is located in the middle of a residential setting with the majority of the shoreline riprap, habitat for wildlife was limited. Mainly birds were observed along with a couple of mammals (Table 9). Most of the birds were those common to residential settings. There are healthy populations of mature trees that provide good habitat for a variety of bird species. However, there are several areas in need of habitat improvement on Highland Lake. Enhancing habitat for terrestrial wildlife such as birds and small mammals can be accomplished through the addition of shoreline buffer zones and are recommended as one aspect of shoreline protection. Erecting birdhouses and allowing brush or trees that have fallen into the water to remain creates additional habitat for birds, fish, reptiles, and amphibians.

The Illinois Department of Natural Resources (IDNR) conducted fish surveys on Highland Lake in 1998, 2002, and 2009. The 1998 and 2002 surveys consisted of 60 minutes of electrofishing and overnight sets of two trapnets and one gillnet. The 2009 survey consisted of 60 minutes of electrofishing only. In 1998, a total of 242 fish representing nine species were collected. The catch and diversity increased in 2002 to 287 fish representing 10 species. In 2009 the number of fish collected dropped to 101 and the species dropped to eight. In addition to the use of less collection gear (nets not used in 2009), the IDNR contributes the decrease in fish to the lack of aquatic plants. During all survey Bluegill was the dominant species collected. The IDNR recommended establishing the following regulations for gamefish: a 15 inch length limit and daily bag limit of one for Largemouth Bass, a 24 inch minimum length limit and daily bag limit of one for Northern Pike. In addition they recommended stocking of Largemouth Bass and Northern Pike, liberally harvesting Common Carp and Yellow Bass, and allowing the aquatic plants to grow so the lake remains healthy.

Highland Lake experienced a fish kill during the winter of 2008-09. There were Common Carp, Yellow Bass, Largemouth Bass, and various panfish species noted frozen in the ice. The IDNR

Table 9. Wildlife species observed on and around Highland Lake, May – September 2009.

Birds	
Canada Goose	*Branta canadensis*
Mallard	*Anas platyrhnchos*
Ring-billed Gull	*Larus delawarensis*
Great Blue Heron	*Ardea herodias*
Barn Swallow	*Hirundo rustica*
Tree Swallow	*Iridoprocne bicolor*
American Crow	*Corvus brachyrhynchos*
Blue Jay	*Cyanocitta cristata*
Black-capped Chickadee	*Poecile atricapillus*
American Robin	*Turdus migratorius*
Mammals	
Eastern Chipmunk	*Tamias striatus*
Gray Squirrel	*Sciurus carolinensis*

feels that if the young of year fish from 2009 survive the 2010 winter that the lake will begin its road to recovery.

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From 1986 through 2009 the HLPOA has stocked Walleye, Largemouth Bass, Northern Pike, Channel Catfish, Musky, Fathead Minnow, and Golden Shiner to supplement natural reproduction and increase the predator base of Highland Lake.

In an effort to remove the exotic Common Carp from Highland Lake, the HLPOA have conducted Carp derbies annually since 1999. A total of 683 Common Carp have been removed through these derbies.

LAKE MANAGEMENT RECOMMENDATIONS

Highland Lake has an active lake management group, low nutrient levels, only one exotic invasive aquatic plant, an updated bathymetric map, and participates in the VLMP. Highland Lake participated in the VLMP in 1981, 1990-1991, and 2007-2009 providing valuable data from the years the ES did not sample the lake. In addition to continuing to collect the VLMP data, the ES recommends installing staff gauge to monitor the lake water level. Phosphorous and nitrogen levels were similar for the studies done by the ES. To improve the quality of Highland Lake, the ES has the following recommendations:

- **Control Exotic Species**

  A key to a healthy lake is a well-balanced aquatic plant population. Aquatic plants compete with algae for nutrients and stabilize bottom substrate, which in turn improves water clarity. Putting together a good aquatic plant management plan should not be rushed. The plan should be based on the management goals of the lake and involve usage issues, habitat maintenance/restoration, and limitations of the lake. Follow up is critical for an aquatic plant management plan to achieve long-term success. A good aquatic plant management plan considers both the short and long-term needs of the lake. It is recommended that the aquatic plants be allowed to re-establish themselves in Highland Lake. Curlyleaf Pondweed was found in low density and was the only exotic aquatic plant found in 2009; however Eurasian Watermilfoil was found in previous years. The shoreline exotic plants Purple Loosestrife, Reed Canary Grass, and Honeysuckle were found in 2001 and 2009. Exotics compete with native plants, eventually crowding them out, providing little or poor natural diversity in addition to limited uses by wildlife. The lake should be monitored for these exotic species and managed to keep them under control (Appendix D1)

- **Reduce Conductivity and Chloride Concentrations**

  The average conductivity in Highland Lake was up 43% in the epilimnion since 1996. The use of road salts for winter road management is a major contributor to chloride concentrations and conductivity. Although roads only make up 11% of the landuse within the watershed, they contribute 36% of the estimated run-off. The expansion of Washington Road could increase the Cl^- concentrations. Proper application procedures and alternative methods should be considered to keep these concentrations under control (Appendix D2). Due to the multiple jurisdiction of the roads in the watershed (local, county, state and federal), reduction of road salt can be a challenge.

- **Watershed Nutrient Reduction**

  Highland Lake has relatively stable nutrient levels. With the levels at a manageable level now is the time to consider proper management to keep the levels low. Although the nutrient levels have been fairly steady in Highland Lake, steps should be taken throughout the watershed to help maintain these levels to prevent problematic algae blooms (Appendix D3). Most established lawns do not require additional phosphorous fertilizer so any applied generally runs off and into the lake. Some local communities within Lake County have adopted an ordinance banning the use of phosphorous fertilizer. For this reason, the ES encourages the adoption of a phosphorous fertilizer ban.

- **Lakes with Shoreline Erosion**

Highland lake has seen an increase in shoreline erosion since 2001. The area that was severely eroding in 2001 has been repaired, however, there is another area of severe erosion along the south shore that should be addressed soon. Also there are many areas of slight erosion that have developed. These areas should be addressed soon. All of the eroded areas should be remediated to prevent additional loss of shoreline and prevent continued degradation of the water quality through sediment inputs. When possible, the shorelines should be repaired using natural vegetation instead of riprap or seawalls (Appendix D4).

- **Enhance Wildlife Habitat Conditions on a Lake**

With the lake being in a residential setting with the majority of the shoreline as riprap, seawall, or lawn, wildlife habitat is limited. Enhancing habitat for terrestrial wildlife such as birds and small mammals can be accomplished through the addition of shoreline buffer zones which is recommended as one aspect of shoreline protection. There is also limited in-lake habitat for aquatic species such as fish and turtles due to the limited areas of aquatic plants (Appendix D5).

- **Reducing Bacteria Inputs to a Lake**

Although there are no association or public beaches on Highland Lake, there is an association raft anchored near the deep hole. In 2009 this raft was a place where Gulls and Great Blue Herons would congregate. The raft would get covered with bird feces. Bird feces is a known source of bacteria. The feces from this raft should be cleaned up and thrown in a garbage bag and not just swept into the lake. Actions should be taken to discourage the birds from congregating on the raft (Appendix D6).

- **Proper Disposal of Unused and Expired Medication**

Many households and businesses have gotten into the habit of flushing waste pharmaceuticals down the toilet or pouring them down the drain because it was low cost and the simplest way to prevent unintended use. However, wastewater treatment plants and septic systems are generally not designed to treat pharmaceutical waste and this practice has led to medications being found in surface and ground water, both of which are sources of drinking water. Research has shown that trace amounts of pharmaceuticals and personal care products (PPCPs) can cause ecological harm. If you have unused PPCPs you should save them for an IEPA-sponsored household hazardous waste collection (Appendix D7).

- **Become a Member of Illinois Lakes Management Association**

It is recommended that the Highland Lake Property Owners Association become a member of Illinois Lake Management Association (ILMA). ILMA is a group of professional and citizens with interests in lakes management. There is an annual conference where ideas are exchanged and questions can be answered. In addition, you will receive a membership directory with contact information if you have questions between conferences.

Grant Program Opportunities

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

APPENDIX A. METHODS FOR FIELD DATA COLLECTION AND LABORATORY ANALYSES

Water Sampling and Laboratory Analyses

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

Plant Sampling

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

Shoreline Assessment

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

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

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

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

Wildlife Assessment

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

Table A1. Analytical methods used for water quality parameters.

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

APPENDIX B. MULTI-PARAMETER DATA FOR HIGHLAND LAKE IN 2009.

Highland Lake 2009 Multiparameter data

Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission Average	Extinction Coefficient 0.80
05/13/2009	0	0.49	16.51	8.54	87.6	0.6530	8.96	177	Surface		
05/13/2009	1	1.00	16.51	8.21	84.2	0.6530	8.80	191	Surface	100%	
05/13/2009	2	2.00	16.52	8.17	83.8	0.6530	8.73	36	0.254	20%	6.588
05/13/2009	3	3.00	16.51	8.14	83.5	0.6530	8.67	37	1.252	21%	-0.024
05/13/2009	4	4.06	16.51	8.12	83.3	0.6530	8.62	27	2.309	15%	0.132
05/13/2009	6	6.03	16.50	8.11	83.2	0.6530	8.59	12	4.281	6.8%	0.191
05/13/2009	8	8.04	16.48	8.11	83.1	0.6530	8.54	6	6.289	3.3%	0.113
05/13/2009	10	10.02	16.45	8.10	83	0.6530	8.51	2	8.269	1.3%	0.114
05/13/2009	12	12.03	16.42	8.11	83.1	0.6520	8.48	1	10.278	0.7%	0.063
05/13/2009	14	14.00	16.33	8.13	83.1	0.6530	8.47	1	12.252	0.4%	0.044
05/13/2009	16	15.98	14.77	5.67	56.0	0.6520	8.25	1	14.229	0.3%	0.024
05/13/2009	18	18.05	13.46	5.87	56.4	0.6530	8.23	0	16.297		
05/13/2009	20	20.08	12.64	4.95	46.7	0.6540	8.13	0	18.328		
05/13/2009	22	22.09	11.44	1.30	11.9	0.6630	7.98	0	20.335		
05/13/2009	24	24.08	10.62	0.41	3.7	0.6690	7.88	0	22.325		
05/13/2009	26	26.11	9.97	0.31	2.7	0.6760	7.82	0	24.356		
05/13/2009	28	28.08	9.57	0.28	2.4	0.6810	7.75	0	26.328		
05/13/2009	30	30.01	9.22	0.27	2.4	0.6850	7.68	0	28.262		

Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission Average	Extinction Coefficient 0.48
06/10/2009	0	0.50	19.39	12.13	132.0	0.6460	8.57	3544	Surface		
06/10/2009	1	1.01	19.38	12.14	132.1	0.6480	8.57	3509	Surface	100%	
06/10/2009	2	1.99	19.38	12.16	132.3	0.6480	8.58	804	0.236	23%	6.245
06/10/2009	3	3.03	19.36	12.16	132.3	0.6480	8.58	1109	1.276	32%	-0.252
06/10/2009	4	4.01	19.31	12.17	132.3	0.6480	8.58	928	2.256	26%	0.079
06/10/2009	6	6.00	19.25	12.15	131.8	0.6480	8.58	495	4.247	14%	0.148
06/10/2009	8	8.01	19.18	12.15	131.7	0.6490	8.57	264	6.255	8%	0.100
06/10/2009	10	10.03	19.15	12.14	131.5	0.6480	8.57	152	8.277	4.3%	0.067
06/10/2009	12	12.02	19.02	12.12	131.0	0.6490	8.57	83	10.271	2.4%	0.059
06/10/2009	14	14.04	18.82	11.89	128.0	0.6490	8.53	49	12.288	1.4%	0.044
06/10/2009	16	16.00	17.86	10.12	106.8	0.6600	8.14	27	14.249	0.8%	0.042

06/10/2009	18	18.01	16.54	8.03	82.4	0.6670	7.77	17	16.261	0.5%	0.030
06/10/2009	20	20.01	15.53	2.30	23.1	0.6660	7.57	11	18.259	0.3%	0.024
06/10/2009	22	22.01	13.68	0.86	8.3	0.6730	7.52	6	20.259	0.2%	0.025
06/10/2009	24	24.01	12.41	0.64	6.0	0.6790	7.46	3	22.262	0.1%	0.034
06/10/2009	26	26.04	11.53	0.52	4.8	0.6850	7.40	1	24.285	0.0%	0.045
06/10/2009	28	28.02	10.97	0.49	4.4	0.6910	7.35	0	26.271		
06/10/2009	30	30.02	10.71	0.41	3.7	0.6950	7.32	0	28.265		

Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission Average	Extinction Coefficient 0.35
07/15/2009	0	0.49	23.61	8.22	97.1	0.6130	8.81	575	Surface		
07/15/2009	1	1.00	23.63	9.88	116.7	0.5890	8.79	575	Surface	100%	
07/15/2009	2	2.01	23.63	9.87	116.7	0.5880	8.79	204	0.264	35%	3.929
07/15/2009	3	3.01	23.62	9.87	116.6	0.5880	8.79	127	1.257	22%	0.375
07/15/2009	4	3.91	23.62	9.82	116.0	0.5880	8.79	126	2.162	22%	0.003
07/15/2009	6	5.99	23.62	9.81	115.8	0.5880	8.79	113	4.244	20%	0.026
07/15/2009	8	8.01	23.60	9.80	115.7	0.5880	8.79	108	6.264	18.8%	0.007
07/15/2009	10	9.98	23.52	9.75	115.0	0.5870	8.79	72	8.231	12.6%	0.049
07/15/2009	12	12.00	23.00	9.47	110.6	0.5900	8.72	43	10.251	7.4%	0.052
07/15/2009	14	14.00	21.81	5.72	65.3	0.6150	8.31	37	12.253	6.5%	0.010
07/15/2009	16	16.02	20.03	3.93	43.3	0.6350	7.98	27	14.272	4.6%	0.024
07/15/2009	18	17.99	18.29	1.94	20.7	0.6550	7.72	17	16.241	3.0%	0.027
07/15/2009	20	20.05	15.96	1.18	11.9	0.6680	7.59	11	18.299	2.0%	0.023
07/15/2009	22	22.01	14.74	0.53	5.2	0.6700	7.49	6	20.262	1.1%	0.028
07/15/2009	24	24.01	13.49	0.35	3.4	0.6810	7.33	2	22.259	0.3%	0.057
07/15/2009	26	25.96	12.26	0.33	3.1	0.6980	7.19	0	24.212		
07/15/2009	28	27.94	11.50	0.31	2.9	0.7190	7.04	0	26.192		
07/15/2009	30	30.03	11.29	0.10	0.9	0.7340	6.77	0	28.277		

Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission Average	Extinction Coefficient 0.59
08/12/2009	0	0.50	25.55	10.66	130.5	0.5100	9.51	3346	Surface		
08/12/2009	1	1.06	25.58	11.16	136.7	0.5100	9.55	3300	Surface	100%	
08/12/2009	2	2.03	25.57	11.20	137.1	0.5190	9.56	1186	0.278	36%	3.681
08/12/2009	3	3.03	25.55	11.22	137.3	0.5100	9.56	1057	1.278	32%	0.090
08/12/2009	4	4.05	25.55	11.00	134.7	0.5240	9.56	776	2.302	24%	0.134

08/12/2009	6	6.08	25.48	11.22	137.2	0.5090	9.58	592	4.325	17.9%	0.063
08/12/2009	8	8.05	25.26	10.75	130.9	0.5200	9.52	381	6.303	11.6%	0.070
08/12/2009	10	10.01	25.14	10.20	123.9	0.5120	9.44	263	8.259	8.0%	0.045
08/12/2009	12	11.99	24.82	10.02	121.0	0.5140	9.37	189	10.239	5.7%	0.032
08/12/2009	14	14.06	23.65	8.98	106.2	0.5180	9.30	138	12.309	4.2%	0.026
08/12/2009	16	16.03	22.35	8.32	96.0	0.5280	9.16	104	14.284	3.2%	0.020
08/12/2009	18	18.14	20.74	6.83	76.4	0.5770	8.74	73	16.39	2.2%	0.022
08/12/2009	20	19.89	18.16	6.69	71.1	0.6360	8.55	53	18.142	1.6%	0.018
08/12/2009	22	22.01	15.93	6.41	65.0	0.6480	8.33	24	20.26	0.7%	0.039
08/12/2009	24	24.01	13.96	3.30	32.0	0.6690	7.90	6	22.255	0.2%	0.060
08/12/2009	26	25.60	12.86	1.25	11.9	0.7020	7.39	1	23.852	0.02%	0.093
08/12/2009	28	27.87	12.10	0.67	6.3	0.7310	7.22	0	26.121		
08/12/2009	30	29.82	11.88	0.09	0.8	0.7470	7.08	0	28.073		

Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission Average	Extinction Coefficient NA
09/16/2009	0	0.51	23.33	8.92	104.7	0.5170	9.63	NA	Surface		
09/16/2009	1	1.00	23.38	9.83	115.6	0.5180	9.70	NA	Surface	NA	NA
09/16/2009	2	2.00	23.39	9.95	117.0	0.5190	9.72	NA	0.252	NA	NA
09/16/2009	3	2.98	23.38	9.98	117.4	0.5180	9.75	NA	1.228	NA	NA
09/16/2009	4	4.02	23.39	9.98	117.3	0.5190	9.77	NA	2.272	NA	NA
09/16/2009	6	6.03	23.39	9.94	116.9	0.5180	9.77	NA	4.281	NA	NA
09/16/2009	8	8.01	23.39	9.90	116.4	0.5190	9.78	NA	6.264	NA	NA
09/16/2009	10	10.03	23.38	9.70	114.1	0.5190	9.76	NA	8.275	NA	NA
09/16/2009	12	12.02	22.75	9.05	105.2	0.5220	9.60	NA	10.268	NA	NA
09/16/2009	14	13.99	21.33	8.11	91.6	0.5200	9.46	NA	12.243	NA	NA
09/16/2009	16	16.03	20.68	7.72	86.2	0.5180	9.45	NA	14.276	NA	NA
09/16/2009	18	18.02	20.03	6.81	75.0	0.5220	9.34	NA	16.271	NA	NA
09/16/2009	20	20.06	19.28	5.05	54.9	0.5370	9.13	NA	18.313	NA	NA
09/16/2009	22	21.99	18.55	1.39	14.9	0.5530	8.79	NA	20.236	NA	NA
09/16/2009	24	24.05	16.24	0.54	5.5	0.6700	8.27	NA	22.298	NA	NA
09/16/2009	26	26.06	14.71	0.44	4.3	0.7470	7.85	NA	24.314	NA	NA
09/16/2009	28	28.04	13.00	0.46	4.3	0.8190	7.56	NA	26.293	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 2000-2009 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 2000-2009 was 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 2000-2009 was 0.167 mg/L and ranged from a minimum of 0.012 mg/L in Independence Grove Lake to a maximum of 3.880 mg/L in Taylor Lake.

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

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

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

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

Solids:

Although several forms of solids (total solids, total suspended solids, total volatile solids, total dissolved solids) were measured each month by the Lakes Management Staff, total suspended solids (TSS) and total volatile solids (TVS) have the most impact on other variables and on the lake as a whole. TSS are particles of algae or sediment suspended in the water column. High TSS concentrations can result from algae blooms, sediment resuspension, and/or the inflow of turbid water, and are typically associated with low water clarity and high phosphorus concentrations in many lakes in Lake County. Low water clarity and high phosphorus concentrations, in turn, exacerbate the high TSS problem by leading to reduced plant density (which stabilize lake sediment) and increased occurrence of algae blooms. The median TSS value in epilimnetic waters in Lake County was 7.9 mg/L, ranging from below the 0.1 mg/L detection limit to 165 mg/L in Fairfield Marsh.

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

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

Water Clarity:

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

Common Carp are prolific fish that feed on invertebrates in the sediment. Their feeding activities stir up bottom sediment and can dramatically decrease water clarity in shallow lakes. As mentioned above, lakes with low water clarity are, generally, considered to have poor water quality. This is because the causes and effects of low clarity negatively impact the plant and fish communities, as well as the levels of phosphorus in a lake. The detrimental impacts of low Secchi depth to plants has already been discussed. Fish populations will suffer as water clarity decreases due to a lack of food and decreased ability to successfully hunt for prey. Bluegills are planktivorous fish and feed on invertebrates that inhabit aquatic plants. If low clarity results in the disappearance of plants, this food source will disappear too. Largemouth Bass and Northern Pike are piscivorous fish that feed on other fish and hunt by sight. As the water clarity decreases, these fish species find it more difficult to see and ambush prey and may decline in size as a result. This could eventually lead to an imbalance in the fish community. Phosphorus release from resuspended sediment could increase as water clarity and plant density decrease. This would then result in increased algae blooms, further reducing Secchi depth and aggravating all problems just discussed. The average Secchi depth for Lake County lakes is 3.12 feet. From 2000-2009, Ozaukee Lake had the lowest Secchi depths (0.25 feet) and West Loon Lake had the highest (24.77 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 was 8.34, with a minimum of 7.07 in Bittersweet #13 Lake and a maximum of 10.40 in Summerhill Estates Lake.

Eutrophication and Trophic State Index:

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

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

Table 1. Trophic State Index (TSI).

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

APPENDIX D. LAKE MANAGEMENT OPTIONS.

D1. Options to Eliminate or Control Exotic Species

Option 1: Biological Control

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

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

Option 2: Control by Hand

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

Option 3: Herbicide Treatment

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

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

D2. 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 Environmental Services 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.

D3. 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 Environmental Services.

D4. Options for Lakes with Shoreline Erosion

Option 1: Install a Seawall

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

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

Option 2: Install Rock Rip-Rap or Gabions

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

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

Option 3: Create a Buffer Strip

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

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

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

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

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

Option 5: Install A-Jacks®

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

D5. Options to Enhance Wildlife Habitat Conditions on a Lake

Option 1: Increase Habitat Cover

One of the best ways to increase habitat cover is to leave a minimum 25-foot buffer between the edge of the water and any mowed grass. Allow native plants to grow or plant native vegetation along shorelines, including emergent vegetation such as cattails, rushes, and bulrushes. This will provide cover from predators and provide nesting structure for many wildlife species and their prey.

Brush piles also make excellent wildlife habitat. They provide cover as well as food resources for many species. Brush piles are easy to create and will last for several years. They should be place at least 10 feet away from the shoreline to prevent any debris from washing into the lake. Trees that have fallen on the ground or into the water are beneficial by harboring food and providing cover for many wildlife species. In a lake, fallen trees provide excellent cover for fish, basking sites for turtles, and perches for herons and egrets. Increasing habitat cover should not be limited to the terrestrial environment. Native aquatic vegetation, particularly along the shoreline, can provide cover for fish and other wildlife. Finally, by increasing habitat, wildlife is attracted to and uses the area as a place to raise their young. However, if vegetation is allowed to grow, lake access and visibility may be limited. If this occurs, a small path can be made to the shoreline.

Option 2: Increase Natural Food Supply

This can be accomplished in conjunction with Option 1. Habitats with a diversity of native plants will provide an ample food supply for wildlife. Food comes in a variety of forms, from seeds to leaves or roots to invertebrates that live on or are attracted to the plants. Beneficial aquatic plants are particularly important to waterfowl in the spring and fall, as they replenish energy reserves lost during migration. Supplying natural foods artificially (i.e., birdfeeders, nectar feeders, corn cobs, etc.) will attract wildlife and in most cases does not harm the animals. However, "people food" such as bread should be avoided. Care should be given to maintain clean feeders and birdbaths to minimize disease outbreaks. Providing food for wildlife will increase the likelihood they will use the area. Migrating wildlife can be attracted with a natural food supply, primarily from seeds, but also from insects, aquatic plants or small fish.

D6. Options for Reducing Bacteria Inputs to a Lake

Option 1. Septic Care and Maintenance

A lack of septic tank maintenance can result in septic failure. A failing septic system can deliver a high number of bacteria or other pathogens to a lake. In addition, nutrients are added to the water, which increases the risk of a nuisance algal bloom.

a. The tank should be inspected yearly to check the level of solids, especially if the homeowner is unfamiliar with the age of the septic system or its size. Depending on usage, one septic tank can fill with solids faster than another. If a homeowner is not sure how quickly solids will fill their septic tank, checking the level yearly can give the homeowner a better idea when their tank needs pumping. For the average use of a 1,200 – 1,500 gallon septic tank, the Health Department recommends pumping the tank every three to five years.
b. Avoid washing several loads of laundry in one day, and only wash with full loads. Similarly, only run a dishwasher when full. If heavy rains have caused the ground to become over-saturated, avoid using these appliances. Take the laundry to a laundromat and/or wash dishes by hand. When washing dishes by either method, scrape as much leftover food off as possible to lessen the amount of food particles that reach the septic tank.
c. Conserve water by installing flow saving devices in sinks, toilets and washing machines.
d. Avoid installing or using a garbage disposal. If one is used, pump your septic tank annually. In this case, the tank should be 1.5 times larger than normal, and have two compartments.

Option 2: Pet Waste

Pick up pet waste and dispose of it properly to help prevent bacteria and nutrients from entering the lake via runoff. To encourage people to pick up pet waste in public areas, the managing entity could provide waste disposal bags (such as "Mutt Mitts") onsite, and post signs about cleaning up after pets.

Option 3. Discourage Waterfowl from Congregating

Waterfowl droppings (feces) can be a source of bacteria (and phosphorus) to the water, especially if they are congregating in large numbers along beaches and/or other nearshore areas. 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 discouraging people from feeding waterfowl. A template is available from Environmental Services.

D7. Options for the proper disposal of unused and expired medication

What do you do with your unused prescription drugs? Most people would say "flush them down the toilet." Well, the age-old advice of flushing pharmaceuticals down the toilet is now considered to be the least desirable of all alternatives. Many households and businesses have gotten into the habit of flushing waste pharmaceuticals down the toilet or pouring them down the drain because it was low cost and the simplest way to prevent unintended use. However, wastewater treatment plants and septic systems are generally not designed to treat pharmaceutical waste and this practice has led to medications being found in surface and ground water, both of which are sources of drinking water. Research has shown that trace amounts of pharmaceuticals and personal care products (PPCPs) can cause ecological harm. The PPCPs have probably been present in water and the environment for as long as humans have been using them since they are added to the environment through the elimination of waste from the body, bathing, and disposal of unwanted medications into sewers and trash.

To discourage people and businesses from flushing PPCPs down the drain Governor Pat Quinn recently signed a law that prohibits hospitals or other health care facilities from dumping unused medicines into public wastewater systems. The law will take effect January 1, 2010 and imposes a $500 fine on offenders. In addition, Illinois Environmental Protection Agency (IEPA) Director Doug Scott has voiced public service announcements on the radio to alert people about the proper disposal of medications and Pontiac Township High School teacher Paul Ritter works with students and anyone else who wants to spread the message about keeping pharmaceuticals out of the water supply.

If you have unused PPCPs you should save them for an IEPA-sponsored household hazardous waste collection. In addition, the IEPA is partnering with many counties to sponsor dedicated collections for old/unwanted pharmaceuticals. The IEPA has spent about $75,000 on collection programs this year and, although the funding was swept for other programs, hopes to fund more collection programs in 2010. Other counties haven't waited for the state funding; instead they have fully funded their own program or partnered with other groups to fund collections. One such program was recently launched by Mayor Richard M. Daley along with the Chicago Department of Environment and the Chicago Police Department offering permanent prescription drop box locations at five Chicago Police Department Area Centers. Chicago is the first big city to offer permanent drop-off locations. This program has already collected over 2400 pounds of PPCPs. Other communities and counties have hosted collection events that have taken in hundreds to thousands of pounds of PPCPs.

So if you have expired or unused medications don’t flush/pour them down the drain because they'll contaminate the water supply. Burning them is a bad idea because the release of dioxins will pollute the air. Instead, the IEPA offers the following recommendations for disposing of outdated pharmaceuticals:

- Reduce pharmaceutical waste when possible by taking all doses of prescribed antibiotics and by buying only as much aspirin or other medicine as can be used before the expiration date.
- Take unused pharmaceuticals to a designated pharmaceutical-collection program or to an IEPA-sponsored household hazardous waste collection event, if possible.
- Throw old medicines in the trash. First, remove all labels. Next, make the medicines less appealing to children or thieves by dissolving pills in a small amount of water or alcohol, or by grinding them into pieces and mixing them into cat litter or coffee grounds. Finally, place them in a plastic bag or similar container and hide them with other trash.

For more information, go to www.epa.state.il.us and click on the box labeled "Medication Disposal."

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

2000 - 2009 Water Quality Parameters, Statistics Summary

	ALKoxic <=3ft00-2009	
Average	**166**	
Median	**161**	
Minimum	**65**	**IMC**
Maximum	**330**	**Flint Lake**
STD	**42**	
n =	**819**	

	ALKanoxic 2000-2009	
Average	**198**	
Median	**189**	
Minimum	**103**	**Heron Pond**
Maximum	**470**	**Lake Marie**
STD	**49**	
n =	**251**	

	Condoxic <=3ft00-2009	
Average	**0.8846**	
Median	**0.7910**	
Minimum	**0.2260**	**Schreiber Lake**
Maximum	**6.8920**	**IMC**
STD	**0.5217**	
n =	**823**	

	Condanoxic 2000-2009	
Average	**1.0121**	
Median	**0.8431**	
Minimum	**0.3210**	**Lake Kathyrn, Schreiber Lake**
Maximum	**7.4080**	**IMC**
STD	**0.7784**	
n =	**251**	

	NO3-N, Nitrate+Nitrite,oxic <=3ft00-2009	
Average	**0.514**	
Median	**0.160**	
Minimum	**<0.05**	***ND**
Maximum	**9.670**	**South Churchill Lake**
STD	**1.087**	
n =	**824**	

*ND = Many lakes had non-detects (76.5%)
Only compare lakes with detectable
concentrations to the statistics above
Beginning in 2006, Nitrate+Nitrite was measured.

	NH3-Nanoxic 2000-2009	
Average	**2.134**	
Median	**1.430**	
Minimum	**<0.1**	***ND**
Maximum	**18.400**	**Taylor Lake**
STD	**2.325**	
n =	**251**	

*ND = 20.3% Non-detects from 32 different lakes

	pHoxic <=3ft00-2009	
Average	**8.35**	
Median	**8.34**	
Minimum	**7.07**	**Bittersweet #13**
Maximum	**10.40**	**Summerhill Estates**
STD	**0.46**	
n =	**818**	

	pHanoxic 2000-2009	
Average	**7.31**	
Median	**7.33**	
Minimum	**6.24**	**Banana Pond**
Maximum	**8.48**	**Heron Pond**
STD	**0.41**	
n =	**251**	

	All Secchi 2000-2009	
Average	**4.56**	
Median	**3.15**	
Minimum	**0.25**	**Ozaukee Lake**
Maximum	**24.77**	**West Loon Lake**
STD	**3.80**	
n =	**763**	

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2000 - 2009 Water Quality Parameters, Statistics Summary (continued)

	TKNoxic <=3ft00-2009	
Average	**1.418**	
Median	**1.180**	
Minimum	**<0.1**	***ND**
Maximum	**10.300**	**Fairfield Marsh**
STD	**0.826**	
n =	**824**	

*ND = 3.8% Non-detects from 15 different lakes

	TKNanoxic 2000-2009	
Average	**2.883**	
Median	**2.235**	
Minimum	**<0.5**	***ND**
Maximum	**21.000**	**Taylor Lake**
STD	**2.300**	
n =	**251**	

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

	TPoxic <=3ft00-2009	
Average	**0.099**	
Median	**0.063**	
Minimum	**<0.01**	***ND**
Maximum	**3.880**	**Albert Lake**
STD	**0.171**	
n =	**824**	

*ND = 2.4% Non-detects from 8 different lakes

	TPanoxic 2000-2009	
Average	**0.311**	
Median	**0.167**	
Minimum	**0.012**	**Independ. Grove**
Maximum	**3.800**	**Taylor Lake**
STD	**0.417**	
n =	**251**	

	TSSall <=3ft00-2009	
Average	**15.3**	
Median	**7.9**	
Minimum	**<0.1**	***ND**
Maximum	**165.0**	**Fairfield Marsh**
STD	**20.3**	
n =	**830**	

*ND = 1.3% Non-detects from 8 different lakes

	TVSoxic <=3ft00-2009	
Average	**129.7**	
Median	**125.5**	
Minimum	**34.0**	**Pulaski Pond**
Maximum	**298.0**	**Fairfield Marsh**
STD	**39.8**	
n =	**774**	

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 <=3ft00-2009	
Average	**198**	
Median	**117**	
Minimum	**3.5**	**Schreiber Lake**
Maximum	**2390**	**IMC**
STD	**327**	
n =	**159**	

	CLoxic <=3ft00-2009	
Average	**191**	
Median	**145**	
Minimum	**2.7**	**Schreiber Lake**
Maximum	**2760**	**IMC**
STD	**220**	
n =	**561**	

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

Minimums and maximums are based on data from all lakes from 2000-2009 (n=1378).

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

LCHD Lakes Management Unit ~ 12/9/2009

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APPENDIX F. GRANT PROGRAM OPPORTUNITES

Table F1. Potential Grant Opportunities

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

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

Table F1. Continued

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

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