2008 SUMMARY REPORT
of
Flint Lake

Lake County, Illinois

Prepared by the

LAKE COUNTY HEALTH DEPARTMENT
ENVIRONMENTAL HEALTH SERVICES
LAKES MANAGEMENT UNIT

3010 Grand Avenue
Waukegan, Illinois 60085

Kelly Deem
Michael Adam
Leonard Dane
Kathy Paap

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Flint Lake is an 11-acre manmade lake in southwestern Lake County. Flint Lake receives water from two main inlets, the Grassy Lake Drain (north inlet) and Flint Creek (south inlet) and empties into Flint Creek which eventually flows into Fox River. Flint Lake residents use the lake for aesthetics.

Four sewage treatment plants are operating in the Flint Lake Watershed. The largest one is the Barrington Wastewater Treatment Plant that discharges effluent into Flint Creek as well as Barrington Hills Country Club. The Mount Saint Joseph and North Barrington Elementary plants discharge into Grassy Lake Drain.

Flint Lake is known for having some of poorest water quality of all lakes sampled in Lake County. Water quality in Flint Lake has not deteriorated since the 2003 study. The 2008 average TSS was 57.7 mg/L for the north inlet and 22.9 for the south inlet which is considerably higher than the county median of 8.2 mg/L. Alkalinity also had high values the north inlet 216 mg/L $CaCO_3$ and 243 mg/L $CaCO_3$ at the south inlet both are higher than the county median of 162 mg/L $CaCO_3$. However 2008 values were reduced compared to the 2003 value of 330 mg/L $CaCO_3$ that marked the highest alkalinity concentrations recorded in Lake County.

The Lake County median conductivity reading was 0.8195 milliSiemens/cm (mS/cm). During 2008, the average conductivity reading in Flint Lake for the north inlet was 1.0970 mS/cm and 1.2780 mS/cm for the south inlet. This was decrease from the 2003 average of 1.5818 mS/cm, likely due to rain events in 2008. Conductivity is positively correlated with chloride (Cl^-) concentrations. The average Cl^- concentration in Flint Lake was also greater than the Lake County median of 166 mg/L during 2008, with an average of 200 mg/L in the north inlet and 223 in the south inlet. The 2008 average total phosphorus (TP) concentration of 0.188 mg/L for the north inlet and 0.293 mg/L for the south was significantly above the county median of 0.065 mg/L. However the average TP concentration decreased by 48% from the 2003 survey when the average TP concentration was 0.564mg/L.

Aquatic plants were scarce in Flint Lake in 2003 and 2008. Only five species of aquatic plants; Sago Pondweed, Small Duckweed, Curlyleaf Pondweed, Coontail, and Elodea were present and located near the shoreline. Algal blooms and an over abundance of Duckweed occurred in Flint Lake during the season.

The shoreline was reassessed in 2008 for significant changes in erosion since 2003. Based on the 2008 assessment, there was an increase in shoreline erosion with 100% of the shoreline having some degree of erosion. Overall, 47% of the shoreline had slight erosion, 24% had moderate erosion, and 29% had severe erosion.

Flint Lake is located in a residential setting with the shoreline mainly developed. Although residential areas usually do not offer good wildlife habitat, the mature trees in the lots surrounding the lake offer some songbird habitat.

LAKE FACTS

Lake Name:	Flint Lake
Historical Name:	None
Nearest Municipality:	Lake Barrington
Location:	T43N, R9E, S15, SE 1/4
Elevation:	748.0 feet mean sea level
Major Tributaries:	Flint Creek/Grassy Lake Drain
Watershed:	Fox River
Sub-watershed:	Flint Creek Drain
Receiving Waterbody:	Fox River
Surface Area:	11.3 acres
Shoreline Length:	1.1 miles
Maximum Depth:	3.0 feet
Average Depth:	1.5 feet (estimated)
Lake Volume:	17.0 acre-feet (estimated)
Lake Type:	Impoundment
Watershed Area:	16811.2 acres
Major Watershed Land Uses:	Single family, Private and Public Open Land, and Transportation
Bottom Ownership:	Private
Management Entities:	Flint Lake Interested Property Owners Association
Current and Historical Uses:	Aesthetics and Fishing
Description of Access:	Private – Flint Lake residents only

SUMMARY OF WATER QUALITY

Water samples were taken monthly May through September at the mouth of the north inlet and off the bridge on Woodland Drive for the south inlet (Figure 1). Both locations were sampled at the surface and analyzed for various water quality parameters (Appendix A). Flint Lake is within the Flint Creek watershed which the Lakes Management Unit (LMU) sampled in its entirety in 2008. This watershed also includes Lake Zurich, Grassy Lake, Honey Lake, Echo Lake, and Lake Louise.

Historically Flint Lake's water quality has been one of the poorest of the lakes in Lake County, with all parameters having below average water quality. In 2008, the water quality parameters remained above county medians, however water quality has not deteriorated and has remained the same since 2003. The total suspended solid (TSS) concentrations averaged 57.72 mg/L for the north inlet and 22.86 for the south inlet (Table 1), which is considerably higher than the county median of 8.2 mg/L (Appendix E). High TSS values are typically correlated with poor water clarity and can be detrimental to many aspects of the lake ecosystem such as the plant and fish communities. The north inlet TSS value was significantly higher than the south inlet. A major contributing factor influencing the difference in values is the larger watershed area being drained from the north inlet, other factors include the larger width of the tributary of the north inlet and a possible increase in common carp activity in the north inlet area due to deeper water. In 2003 the water quality was measured only at the south inlet; the TSS average was 18.1 mg/L. Flint Lake had the worst 2008 TSS value within the Flint Creek Watershed (Table 2). Lake Zurich, which is at the top of the watershed and with abundant macrophytes, had the lowest average TSS (2.7 mg/L) within the Flint Creek watershed.

Four sewage treatment plants (STP), and one historical STP, are operating or have operated within Flint Lake's watershed (Figure 2). The largest one is the Barrington Wastewater Treatment Plant in Barrington, which discharges its effluent into Flint Creek. Its average flow rate is 3.68 MGD (design maximum flow of 12.0 MGD). TSS loads average 12 pounds per month with a maximum of 24 lbs/day. Ammonia nitrogen loads average 1.2 lbs/month with a maximum of 3 lbs/day, April through October. Small treatment plants in the watershed include the Barrington Hills Country Club STP, the Mount Saint Joseph STP, and the North Barrington Elementary School STP. The Barrington Hills Country Club plant discharges into Flint Creek and has an average flow rate of 0.025 MGD. The Mount Saint Joseph plant discharges into a small tributary that flows into Grassy Lake. This plant has an average flow rate of 0.013 MGD. The North Barrington Elementary School plant discharges into the Grassy Lake Drain and has a flow rate of 0.010 MGD. The one historical plant, the Village of Lake Zurich NW STP, discharged its effluent into the Grassy Lake Drain and had a flow rate of 0.30 MGD and operated from 1954-1990.

Rain events can contribute additional sediment or nutrients to a lake, which can influence water sample results. However no rain events occurred within 48 hours prior to water sampling throughout the season May through September. A total of 25.14 inches of rain was recorded at the Lake County Stormwater Management Commission rain gage in Lake Zurich from May through September. This is a 61% increase from the 2003 rainfall of 15.2 inches. The increased rainfall from the 2003 sample year can cause a dilution effect, were some of the water quality

Figure 1. Water quality sampling sites on Flint Lake, 2008.

Table 1. Water quality data for Flint Lake, 2003 and 2008

2008	North Inlet														
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	COND	pH	DO
21-May	0	238	1.16	<0.1	<0.05	0.092	0.007	NA	231	61.2	772	130	1.2740	8.23	13.11
18-Jun	0	238	1.71	<0.1	<0.05	0.130	0.015	NA	193	41	702	142	1.1200	8.04	8.04
16-Jul	0	214	2.26	<0.1	<0.05	0.245	0.015	NA	203	83.6	707	135	1.1070	8.24	8.24
20-Aug	0	234	2.99	0.80	0.06	0.332	0.144	NA	241	88.8	800	158	1.1980	8.16	8.16
17-Sep	0	155	1.35	<0.1	0.32	0.141	0.049	NA	131	14.0	488	103	0.7860	7.68	7.68
	Average	216	1.89	0.8[k]	0.19[k]	0.188	0.046	NA	200	57.7	694	134	1.0970	8.07	9.05

2008	South Inlet														
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	COND	pH	DO
21-May	0	263	1.61	<0.1	1.71	0.353	0.194	NA	258	20.6	836	122	1.4350	8.18	8.18
18-Jun	0	278	1.25	<0.1	0.88	0.345	0.181	NA	222	34.2	821	152	1.3250	8.02	8.02
16-Jul	0	242	1.30	<0.1	0.90	0.245	0.273	NA	212	27.7	721	115	1.2200	7.97	7.97
20-Aug	0	281	1.81	<0.1	1.56	0.380	0.173	NA	336	23.2	1050	174	1.7540	7.96	7.96
17-Sep	0	152	1.02	<0.1	0.43	0.141	0.091	NA	89	8.6	400	82	0.6560	7.76	7.76
	Average	243	1.40	<0.1	1.10	0.293	0.182	NA	223	22.9	766	129	1.2780	7.98	7.98

Glossary

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

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

Table 1. Continued

2003	South Inlet														
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N*	TP	SRP	TDS	Cl^-	TSS	TS	TVS	COND	pH	DO
20-May	0	219	1.82	0.222	0.79	0.346	0.142	630	NA	42.0	689	133	1.1260	7.78	7.33
18-Jun	0	294	1.76	0.154	2.33	0.504	0.378	938	NA	10.0	990	161	1.6600	8.10	6.43
23-Jul	0	260	1.61	0.186	3.03	0.834	0.367	934	NA	15.6	991	162	1.6630	7.67	8.40
20-Aug	0	307	1.33	0.143	1.51	0.474	0.353	964	NA	12.1	1020	106	1.7020	7.82	5.46
24-Sep	0	330	1.02	<0.1	6.59	0.662	0.619	1060	NA	10.6	1130	180	1.7580	8.31	7.47
	Average	282	1.51	0.176[k]	2.85	0.564	0.372	905	NA	18.1	964	148	1.5818	7.94	7.02

Glossary

ALK = Alkalinity, mg/L $CaCO_3$
TKN = Total Kjeldahl nitrogen, mg/L
NH_3-N = Ammonia nitrogen, mg/L
NO_2+NO_3-N = Nitrate + Nitrite nitrogen, mg/L
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DO = Dissolved oxygen, mg/L

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

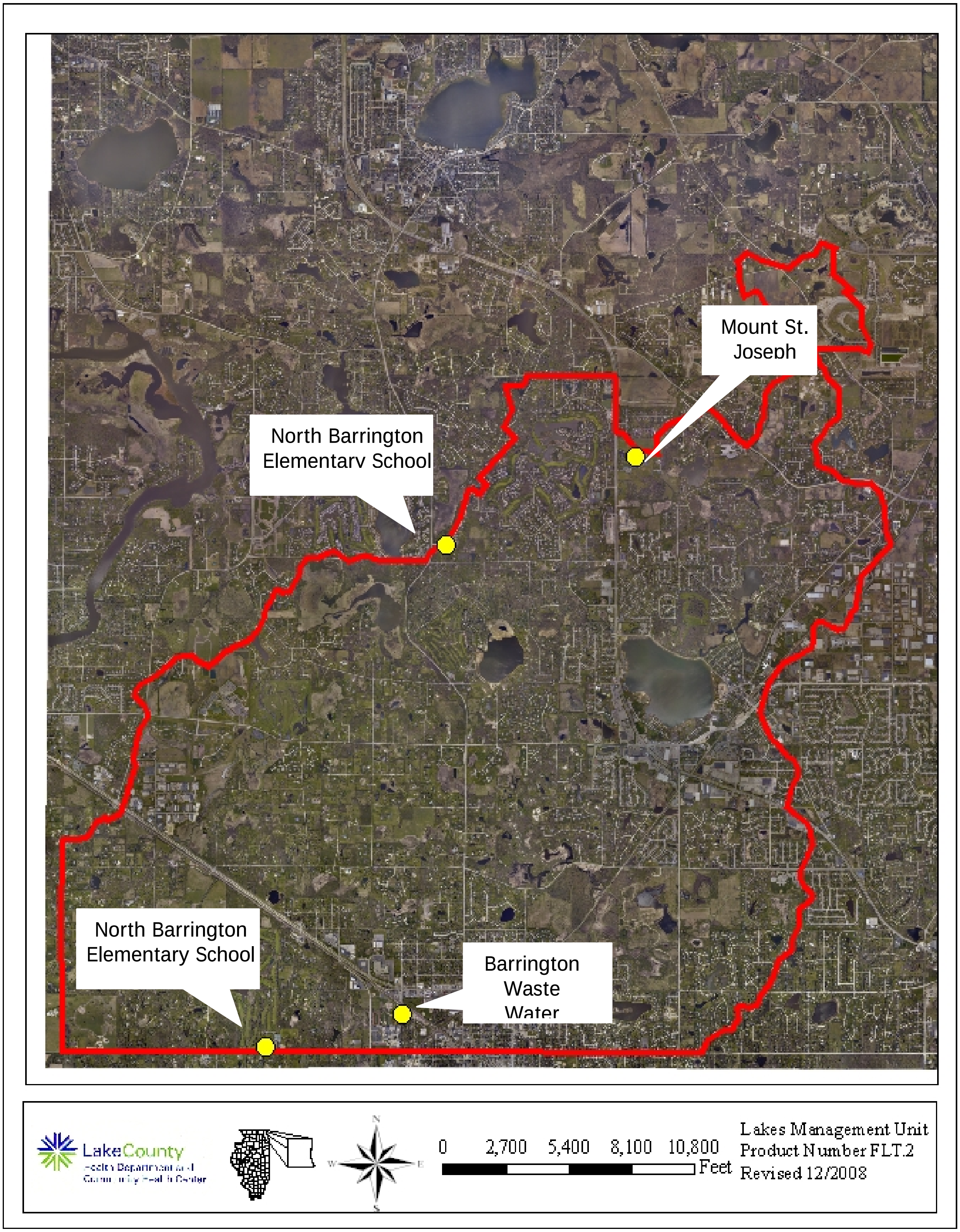
Table 2. Comparison of epilimnetic averages for Secchi disk transparency, total suspended solids, total phosphorus, and conductivity readings in the Flint Creek watershed (Lake Zurich, Echo Lake, Honey Lake, Grassy Lake, Flint Lake, and Lake Louise)

	Lake Zurich	Lake Zurich	Lake Zurich	Lake Zurich	Echo Lake	Echo Lake	Honey Lake	Honey Lake	Honey Lake	Grassy Lake	Grassy Lake	Flint Lake	Flint Lake
Year	**1991**	**1998**	**2002**	**2008**	**2000**	**2008**	**1998**	**2001**	**2008**	**2000**	**2008**	**2003**	**2008**
Secchi (feet)	8.09	5.70	5.53	10.40	3.66	2.11	5.70	8.40	7.17	1.44	1.71	NA	NA
TSS (mg/L)	4.4	4.2	4.9	2.7	9.7	13.5	3.4	1.8	3.4	27.1	20.7	18.1	22.9
TP (mg/L)	0.023	0.017	0.028	0.016	0.079	0.125	0.040	0.038	0.034	0.195	0.161	0.564	0.293
Conductivity (milliSiemens/cm)	0.5400	0.7980	0.7593	0.9573	0.8872	1.2284	0.9370	1.1126	1.3174	0.9301	1.1608	1.5818	1.5188

	Lake Louise	Lake Louise	Flint Lake	Flint Lake
Year	**2003**	**2008**	**2003**	**2008**
Secchi (feet)	1.86	1.68	NA	NA
TSS (mg/L)	20.7	23.3	18.1	22.9
TP (mg/L)	0.194	0.156	0.564	0.293
Conductivity (milliSiemens/cm)	0.9354	0.9660	1.5818	1.5188

Direction of Watershed Flow

Figure 2. Sewage treatment plants within the Flint Lake watershed.



parameters may appear to have improved but in reality are results of the addition of water from rainfall in the 2008 sampling season.

Alkalinity concentrations in Flint Lake were also extremely high, with the seasonal averages of the north inlet (216 mg/L $CaCO_3$) and south inlet (243 mg/L $CaCO_3$) well above the county median for oxic samples (162 mg/L $CaCO_3$). The September concentrations at both sample locations had the lowest concentrations 155 mg/L $CaCO_3$ and 152 mg/L $CaCO_3$, respectively. Contrary to the 2003 September value (330 mg/L $CaCO_3$) that marks the highest alkalinity concentrations recorded in Lake County since the LMU has been measuring this parameter. For comparison, Grassy Lake and Lake Louise had 2008 average epilimnetic concentrations of 204 mg/L $CaCO_3$ and 183 mg/L $CaCO_3$, respectively. The source of the high concentrations in Flint Lake may be coming from sources in Flint Creek or Grassy Lake Drain such as Sewage Treatment Plants (STP), or possibly from groundwater sources.

Phosphorus is a nutrient that limits plant and algal growth, therefore any addition of phosphorus to the lake could produce algal blooms. Total phosphorus (TP) for the north inlet averaged 0.188 mg/L and 0.293 mg/L for the south inlet, the median for the county was 0.065 mg/L (Table 3). The value for Flint Lake in 2003 was 0.564 mg/L. Coupled with the high TP concentrations, Flint Lake had high concentrations of soluble reactive phosphorus (SRP). SRP is usually utilized by aquatic organisms as it becomes available. However, due to the extreme concentrations of phosphorus, aquatic organisms were not able to assimilate all available SRP. For comparison, average epilimnetic (near surface) TP concentrations in lakes upstream were much lower. Lake Zurich, which is near the top of the watershed, had an average of 0.016 mg/L and Honey Lake had an average of 0.034 mg/L (2008). These two lakes are very different from Flint Lake since they are deep glacial lakes with large volumes, have good aquatic plant populations, and do not receive STP effluent. Grassy Lake, which is immediately upstream from Flint Lake via the Grassy Lake Drain, had an average epilimnetic TP concentration of 0.161 mg/L (2008). Grassy Lake is more similar to Flint Lake (shallow, with large numbers of carp) and is the recipient of current and historical STP effluent. Lake Louise, which is upstream from Flint Lake via Flint Creek, had an average epilimnetic TP concentration of 0.156 mg/L. The TP concentrations increased in each body of water downstream. This was not surprising since the downstream lakes receive higher water volumes coming from larger watershed areas. The nutrients in upstream lakes may be compounding in downstream lakes. Phosphorus can enter a lake either internally (typically linked to sediment) or externally (point or non-point sources). Point source pollution can be from storm pipes or wastewater discharge and non-point source pollution from groundwater or surface runoff, which pick up phosphorus from agricultural fields, septic systems, impervious surfaces, or fertilized lawns. There were external sources of TP affecting Flint Lake such as stormwater from the 23,374 acre watershed. 25% (5,952 acres) of the watershed is in Cook County, less than 1% (58 acres) is in McHenry County and 72% (16811.52 acres) of its watershed is in Lake County (Figure 3). The north inlet includes drainage from Lake Zurich, Honey Lake, Echo Lake, and Grassy Lake while the south includes only Lake Louise in Lake County. Single family (47%), public and private open space (17%), and transportation (10%) were the major land uses within the watershed (Figure 4). For Flint Lake single family (44%) transportation (28%), and Public and Private Open Space (8%) were the land uses contributing the highest percentages of estimated runoff (Table 3). It is important to

Figure 3. Approximate Lake County watershed delineation for Flint Lake, 2008.

Figure 4. Approximate land use within Lake County portion of the Flint Lake watershed, 2008.

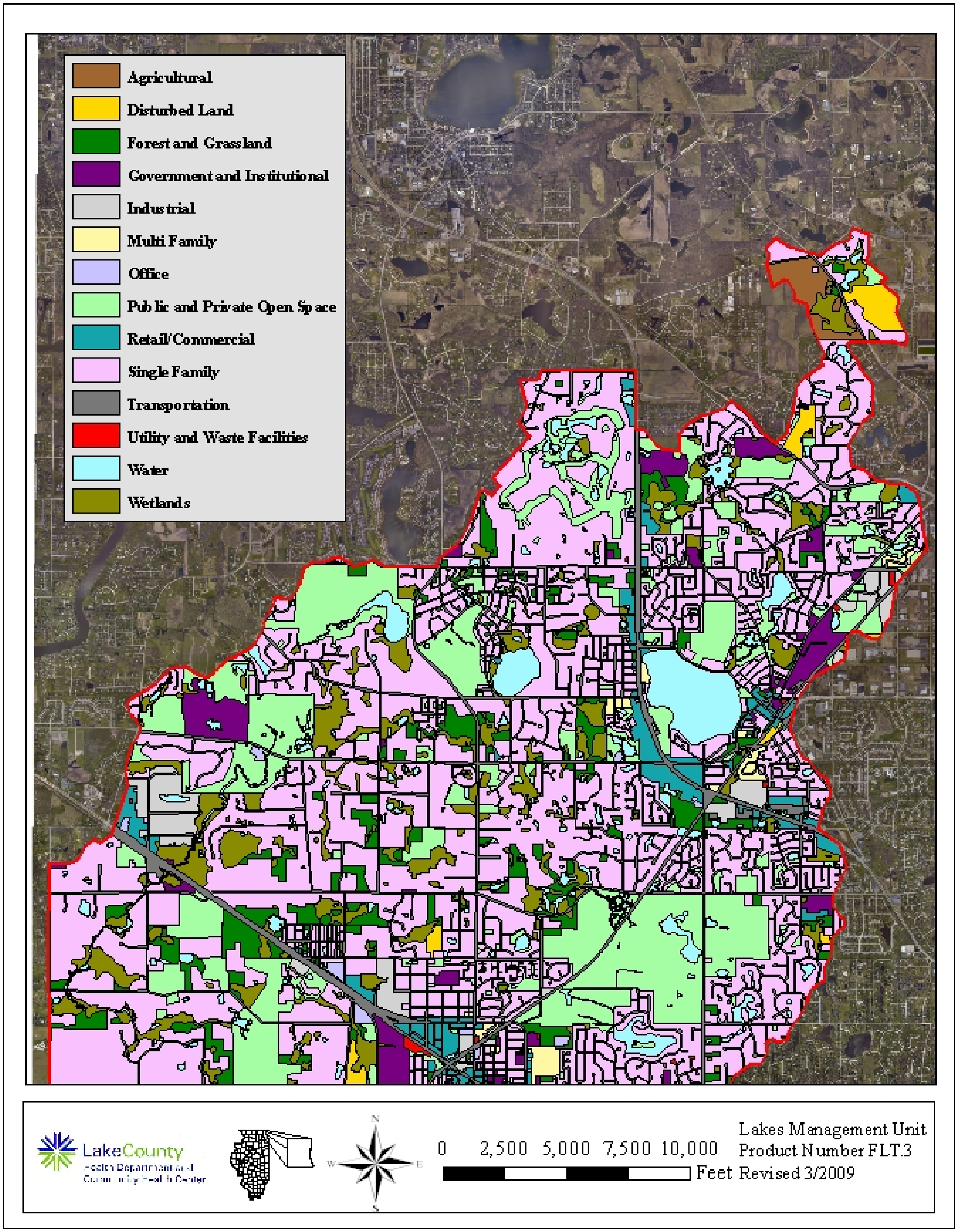


Table 3. Approximate land uses within the Lake County portion of the watershed and retention time for Flint Lake, 2008.

Land Use	Acreage	% of Total
Agricultural	99.13	0.6%
Disturbed Land	147.21	0.9%
Forest and Grassland	875.52	5.3%
Government and Institutional	429.35	2.6%
Industrial	301.44	1.8%
Multi Family	97.29	0.6%
Office	52.90	0.3%
Public and Private Open Space	2813.99	17.2%
Retail/Commercial	410.41	2.5%
Single Family	7677.19	46.8%
Transportation	1692.44	10.3%
Utility and Waste Facilities	20.70	0.1%
Water	517.91	3.2%
Wetlands	1266.07	7.7%
Total Acres	**16401.56**	**100.0%**

Land Use	Acreage	Runoff Coeff.	Estimated Runoff, acft.	% Total of Estimated Runoff
Agricultural	99.13	0.05	13.6	0.1
Disturbed Land	147.21	0.05	20.2	0.1
Forest and Grassland	875.52	0.05	120.4	0.8
Government and Institutional	429.35	0.50	590.4	4.1
Industrial	301.44	0.80	663.2	4.6
Multi Family	97.29	0.50	133.8	0.9
Office	52.90	0.85	123.7	0.9
Public and Private Open Space	2813.99	0.15	1160.8	8.1
Retail/Commercial	410.41	0.85	959.3	6.7
Single Family	7677.19	0.30	6333.7	44.4
Transportation	1692.44	0.85	3956.1	27.7
Utility and Waste Facilities	20.70	0.30	17.1	0.1
Water	517.91	0.00	0.0	0.0
Wetlands	1266.07	0.05	174.1	1.2
TOTAL	**16401.56**		**14266.2**	**100.0**

Lake volume	**16.95**	**acre-feet**
Retention Time (years)= lake volume/runoff	**0.00**	**years**
	0.43	**days**

keep in mind that although the amount of estimated runoff from certain areas may be low, they can still deliver high concentrations of TSS and TP. The retention time (the amount of time it takes for water entering a lake to flow out of it again) was calculated to be approximately 0.43 days. A watershed is an area of land that drains into a body of water, everyone lives in a watershed and the land management directly affects the water quality. In the Flint Lake watershed where single family homes is the major land use contributing runoff, applying lawn fertilizers containing zero phosphorus would be an effective way to reduce phosphorus in the Flint Lake watershed.

Nitrogen is also critical for the growth of plants and algae. Nitrogen sources vary from fertilizer to human waste and sewage treatment plants, to groundwater, air, and rainfall. Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen, and is typically bound up in algal and plant cells. The average TKN for Flint Lake was 1.89 mg/L for the north inlet and 1.40 mg/L for the south inlet; both were higher than the county median (1.20 mg/L) and a decrease from the 2003 average (2.85 mg/L). The TN:TP (total nitrogen to total phosphorus) ratio looks at which nutrient is limiting plant and algal growth in a lake. Ratios < 10:1 indicate nitrogen is limiting. Ratios of >15:1 indicate phosphorus is limiting. Ratios >10:1, <15:1 indicate there is enough of both nutrients for excessive plant and algal growth. Flint Lake had a TN:TP ratio of 11:1 for the north inlet and a 9:1 ratio for the south inlet which means that there was adequate nitrogen and phosphorus to support excessive plants and algae. The low abundance of plants in Flint Lake also influences nutrient levels in a lake since aquatic plants are not using available phosphorus. This will lead to more algae blooms. Due to the low TN:TP ratio Flint Lake was susceptible to blue-green algae blooms. Blue green algae can fix nitrogen from the atmosphere when nitrogen supplies are low. Blue green algae may release cyanotoxins under certain conditions as they die that can poison mammals, fish, and invertebrates that directly ingest the algae or the infected water.

Conductivity readings, which are correlated with chloride concentrations, have been increasing throughout the past few years in the county (Figure 5 and 6). Road salts consist of sodium chloride, calcium chloride, potassium chloride, magnesium chloride or ferrocyanides which are detected when chlorides are analyzed. The average conductivity reading for Flint Lake was 1.0970 mS/cm for the north inlet and 1.2780 mS/cm for the south. This was above the county median of 0.8195 mS/cm, but a decrease since 2003 (1.5818 mS/cm). Chloride concentrations averaged 200 mg/L for the north inlet and 223 mg/L for the south inlet and the county median was 166 mg/L. A study done in Canada reported 10% of aquatic species were harmed by prolonged exposure to chloride concentrations greater than 220 mg/L. Additionally, shifts in algal populations were associated with chloride concentrations as low as 12 mg/l. Shifts from green algae to blue-greens, which are less palatable to zooplankton. The Flint Creek watershed had a range of chloride values from 171 mg/L (Lake Louise) to 296 mg/L (Honey Lake). It appears that the road salt is compounding in many lakes in the county, including Flint Lake. Some lakes in the county have seen a doubling of conductivity readings in the past 5-10 years. Alternatives to road salt should be considered. While alternatives may contain chloride, they tend to work faster at lower temperatures and therefore require less application to achieve the same result that common road salt.

Figure 5. Chloride (Cl^-) concentration vs. conductivity for the North Inlet at Flint Lake, 2008

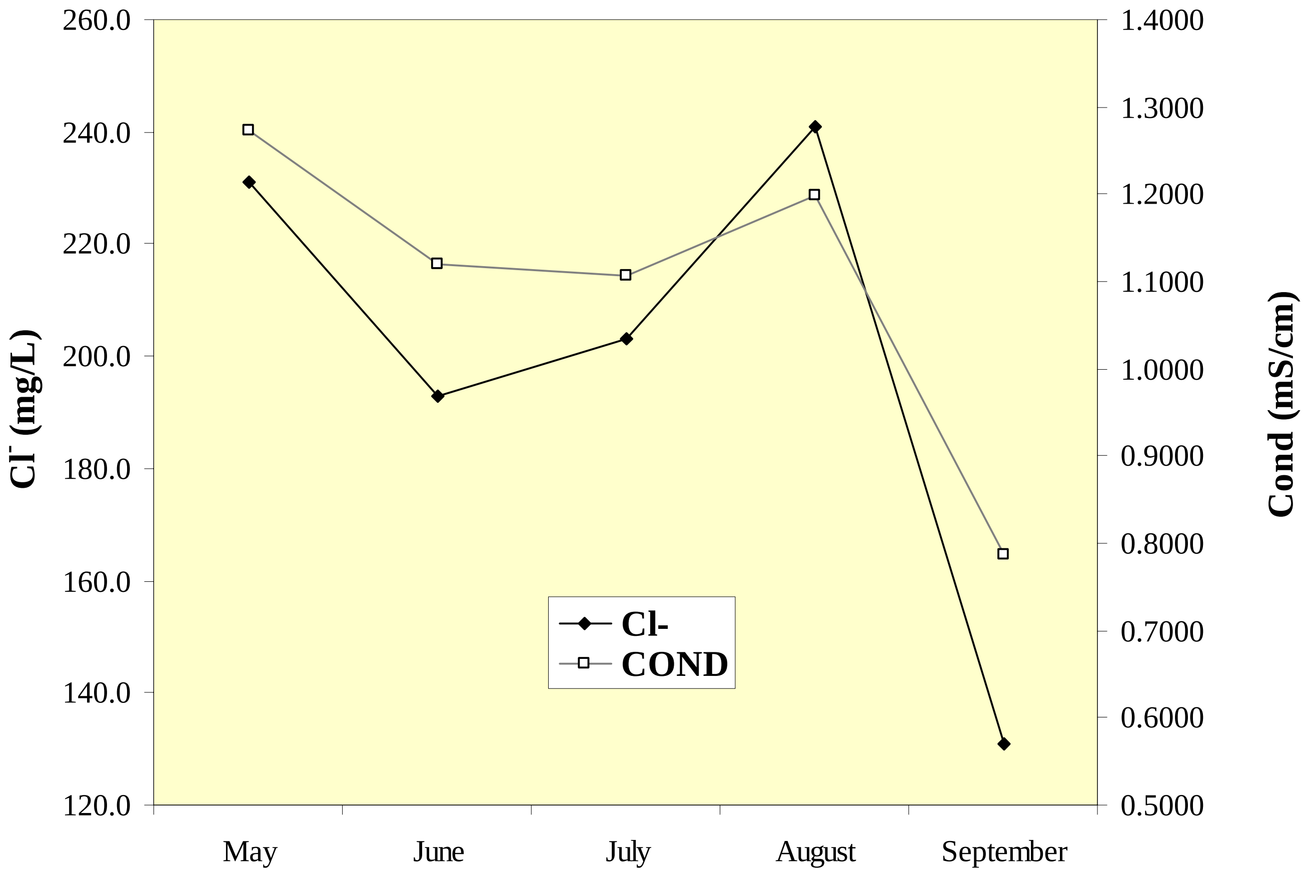
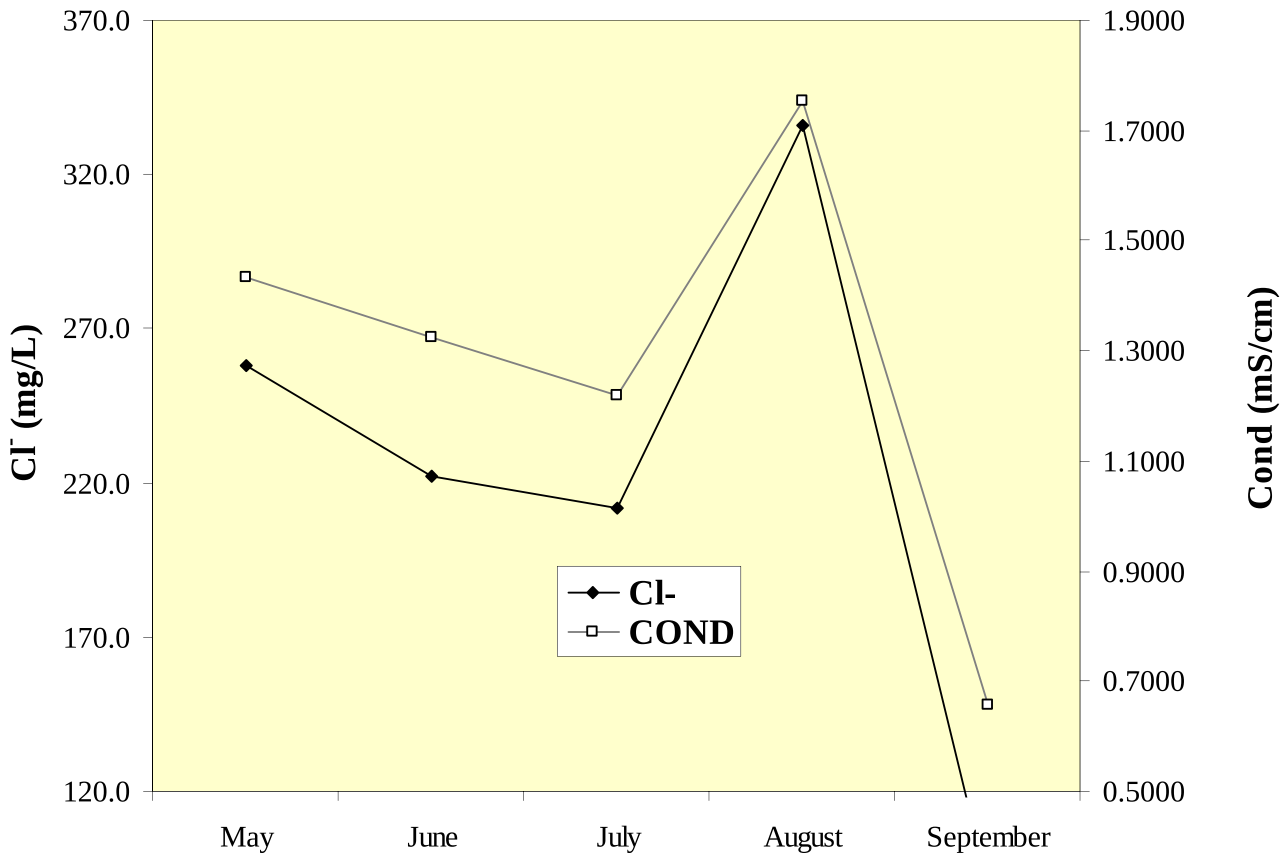


Figure 6. Chloride (Cl^-) concentration vs. conductivity for the South Inlet at Flint Lake, 2008



The Illinois EPA has indices used for assessing lakes for aquatic life and recreational use impairment. The indices are calculated using the mean trophic state index (TSI), percent macrophyte coverage, and the median nonvolatile suspended solids concentration. The TSI index classifies the lake into one of four categories: oligotrophic (nutrient-poor, biologically unproductive), mesotrophic (intermediate nutrient availability and biological productivity), eutrophic (nutrient-rich, highly productive), or hypereutrophic (extremely nutrient-rich, productive). This index can be calculated using TP values obtained at or near the surface. In 2003 Flint Lake was hypereutrophic with a TSIp value of 93.8 at the outlet and 95.6 at the south inlet. Due to the extremely poor water quality in Flint Lake, all of the IEPA indices (the aquatic life impairment index, the swimming index, the recreation use index, and thus the overall use index) indicated a level of nonsupport. Flint Lake was one of the few lakes in the county in which all indices were at the level of nonsupport. In 2008 Flint Lake ranked 161st in the county of 163 lakes for TSIp (Table 4). This ranking is based on the 2003 data from the outlet. For comparison, the LMU uses lake outlet data for this table. In 2008 Flint Lake had a TSIp of 86.1 at the south inlet and 79.7 at the north inlet, both giving a hypereutrophic rating. The impairment indices determined that Flint Lake had partial support for aquatic life and non-support for recreational use do to the high TSIp value. (IEPA Swimming Index was discontinued in 2007). Grassy Lake directly upstream from the north inlet ranked 140th and Lake Louise directly upstream from the south inlet ranked 145th.

Additional water quality sampling was conducted May through September at three sites along Flint Creek (Figure 7). All locations were sampled at the surface and analyzed for the same water quality parameters as Flint Lake. Two locations were located at the south west corner were Flint Creek crosses Lake Cook Road (Site 1) and Hart Road (Site 2). The Lake Cook Road sampling site was near a bridge that was under construction for the duration of the sampling period and the Hart Road sampling site was located downstream of the largest waste water treatment plant in the Flint Lake watershed (Barrington Waste Water Treatment Plant). The third sampling site was located north west of the Flint Creek watershed at Kelsey Road (Site 3) downstream of Flint Lake.

Stream data can be used to supplement lake data; similar to lakes the water quality parameters within a stream are used as indicators of the overall health. Stream data can help to pin point sources of containments or nutrients upstream. The TSS values for Flint Creek varied. Site 1 and Site 3 had higher concentrations, 26.1 mg/L and 25.9 mg/L respectively, while the Site 2 location had only 5.9 mg/L (Table 5). High concentrations of particulate matter can cause increased sedimentation and siltation in a stream, which in turn can ruin important habitat areas for fish and other aquatic life. Alkalinity concentrations remained high at all locations (Site1: 240 $CaCO_{3,}$ Site 2: 256 $CaCO_3$, and Site 3: 232 $CaCO_3$). The seasonal averages for total phosphorus values were high at all locations when compared to the ideal value of 0.05 mg/L to limit algae growth in water bodies. Site 2 had an average of 1.289 mg/L; this is nine times the amount of phosphorus at Site 1 (0.138 mg/L) and six times Site 3 (0.218 mg/L). Site 2 also had the highest average for nitrate-nitrite nitrogen (8.61 mg/L). The average nitrogen values for Site 2 were extreme at 41 times higher than Site 1 (<0.21 mg/L) and 18 times higher than Site 3 (0.47 mg/L). This trend was also seen in conductivity readings as Site 2 had the highest average reading at 1.6236 mS/cm. Site 1 had the lowest at 0.8792 mS/cm and Site 3 averaged 1.2178

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

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

Table 4. Continued

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

Table 4. Continued

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

Table 4. Continued

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

Figure 7. Water quality sampling sites on Flint Creek, 2008.

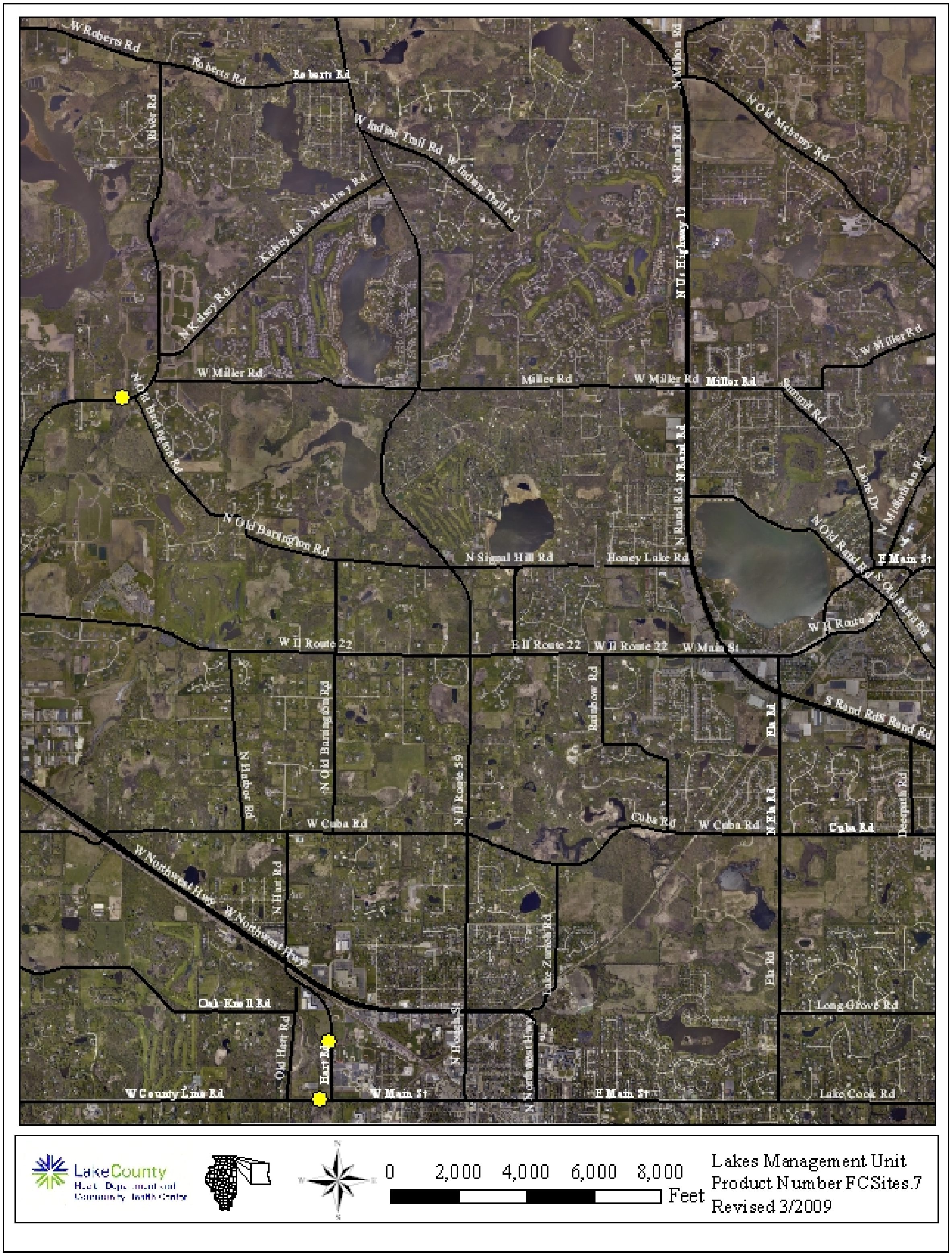


Table 5. Water quality data for Flint Creek, 2008

2008	Lake Cook													
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	COND	pH	DO
21-May	0	186	1.14	<0.1	<0.05	0.075	0.016	NA	152	38.4	549	91	0.9180	8.12	14.91
18-Jun	0	270	0.96	0.2	0.07	0.072	0.02	NA	112	18.0	593	121	0.9520	7.79	10.63
16-Jul	0	232	1.70	<0.1	0.48	0.384	0.197	NA	205	33.4	713	135	0.9660	8.20	6.46
20-Aug	0	366	0.00	<0.1	0.11	0.039	0.01	NA	44	6.7	605	159	0.9350	7.92	6.08
17-Sep	0	147	1.49	0.1	0.19	0.119	0.026	NA	110	34.2	400	94	0.6250	7.85	9.13
	Average	240	1.06	0.2[k]	0.21[k]	0.138	0.054	NA	125	26.1	572	120	0.8792	7.98	9.44

2008	Hart Road														
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	COND	pH	DO
21-May	0	275	1.08	<0.1	5.56	1.450	1.04	NA	350	4.5	1050	152	1.8210	7.97	16.54
18-Jun	0	287	1.15	0.1	2.92	1.080	0.958	NA	330	4.9	1000	156	1.7270	7.78	9.79
16-Jul	0	250	1.24	<0.1	4.03	0.781	0.68	NA	290	5.2	898	144	1.5270	8	8.90
20-Aug	0	307	0.91	<0.1	29.80	2.980	2.35	NA	449	2.9	1370	217	2.2860	7.74	9.84
17-Sep	0	160	1.20	0.1	0.73	0.155	0.085	NA	110	12.0	457	86	0.7570	7.69	9.01
	Average	256	1.12	0.1[k]	8.61	1.289	1.0226	NA	306	5.9	955	151	1.6236	7.84	10.82

Glossary

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

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

Table 5. Continued

2008	Kelsey														
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	COND	pH	DO
21-May	0	249	1.63	<0.1	1.23	0.284	0.115	NA	249	22.7	801	129	1.3940	8.26	16.95
18-Jun	0	264	1.48	<0.1	0.55	0.245	0.105	NA	214	41.2	798	167	1.2590	8.08	7.98
16-Jul	0	246	0.95	<0.1	0.10	0.075	0.008	NA	137	16.8	590	124	1.1740	8.25	7.47
20-Aug	0	249	1.54	<0.1	0.09	0.329	0.154	NA	323	13	955	171	1.5750	8.24	9.86
17-Sep	0	152	1.10	<0.1	0.39	0.157	0.075	NA	98	35.9	441	93	0.6870	7.83	7.62
	Average	232	1.34	<0.1	0.47	0.218	0.0914	NA	204	25.9	717	137	1.2178	8.13	9.98

Glossary

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

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

mS/cm. Typically water quality should be better at the headwaters and as the area that is being drained increases so does nutrients and ions. Site 2 is located directly downstream of the Barrington Waste Water Treatment Plant and upstream of Flint Lake and Site 3; however Site 2 consistently had the poorest water quality of the three sites. The most notable sampling event occurred in August when the water quality parameters were very high, and may warrant further investigation.

SUMMARY OF AQUATIC MACROPHYTES

An aquatic plant survey was attempted in July; due to the low water level of the lake a formal aquatic plant survey was not conducted. Staff noted the presence of aquatic plants from the shoreline of the lake. In 2008 five species was noted, the only exotic being Curlyleaf Pondweed. In 2003 aquatic plants were scarce in Flint Lake, due mostly to the poor water clarity caused by the large carp population in the lake. Sago Pondweed was the dominant plant in Flint Lake in 2003 comprising 42% of all samples. Duckweed (a free floating plant) was the next most common, being found in 19% of all samples. Coontail and Yellow Pond Lily were both found in 12% of the samples. In 2008 Sago Pondweed, Duckweed, and Coontail were also present with the addition of Elodea (Table 6). However American Pondweed and Yellow Pond Lily were not observed.
The absence of yellow pond lily is noteworthy since this lily is uncommon in Lake County. In August a severe occurrence of Duckweed was observed covering 100% of the lake. Duckweed, much like algae, is free floating and buoyant which enables the plant to take advantage of the excessive nutrients resulting in over abundance. To maintain a healthy sunfish/bass fishery, the optimal plant coverage is 30% to 40% across the lake bottom. A healthy aquatic plant population is critical to good lake health. Aquatic vegetation provides important wildlife habitat and food sources. Additionally, aquatic plants provide many water quality benefits such as sediment stabilization and competition with algae for available nutrients which is imperative for Flint Lake.

Floristic quality index (FQI) is an assessment tool designed to evaluate the closeness the flora of an area is to that of undisturbed conditions. It can be used to: 1) identify natural areas, 2) compare the quality of different sites or different locations within a single site, 3) monitor long-term floristic trends, and 4) monitor habitat restoration efforts. Each aquatic plant in a lake is assigned a number between 1 and 10 (10 indicating the plant species most sensitive to disturbance). This is done for every floating and submersed plant species found in the lake. An FQI is calculated by multiplying the average of these numbers by the square root of the number of these plant species found in the lake. A high FQI number indicates that a large number of sensitive, high quality plant species present in the lake. Non-native species were also included in the FQI calculations for Lake County lakes. The average FQI for Lake County lakes from 2000-2008 was 14.9. Flint Lake has an FQI of 11.0 which is only a slight decrease since 2003 (11.8). Flint Lake was below average by Lake County standards ranking 85th of 152 lakes (Table 7).

Table 6. Aquatic plant species found in Flint Lake in 2008.

Coontail	*Ceratophyllum demersum*
American Elodea	*Elodea canadensis*
Small Duckweed	*Lemna minor*
Curlyleaf Pondweed^	*Potamogeton crispus*
Sago Pondweed	*Potamogeton pectinatus*

^ Exotic plant

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

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

Table 7. Continued

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

Table 7. Continued

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

Table 7. Continued

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

SUMMARY OF SHORELINE CONDITION

A shoreline assessment was conducted in July 2003 to determine the condition of the lake shoreline. Of particular interest was the condition of the shoreline at the water/land interface.

Approximately 94% of the shoreline of Flint Lake was classified as developed, with the only undeveloped area being a parcel on the west shoreline. The most common shoreline type was buffer (which is a strip of unmowed vegetation preferably consisting of native plants located at the water's edge), which comprised 58% of the shoreline. Lawn habitat was the next most common at 31%. Riprap and shrub habitat made up the remaining shoreline. While the buffer strips were the dominant shoreline type, the quality of the buffers were poor since most of them were narrow in width and consisted of exotic species, particularly Reed Canary Grass. The buffers should be expanded and exotic species removed and replaced with native plants, since the buffers are beneficial for the water quality of the lake by filtering nutrients and pollutants before they enter the lake and by creating habitat for fish and wildlife.

The shoreline was reassessed in 2008 for significant changes in erosion since 2003. Based on the 2008 assessment, there was an increase in shoreline erosion with 100% of the shoreline having some degree of erosion (Figure 8). Overall, 47% of the shoreline had slight erosion, 24% had moderate erosion, and 29% had severe erosion. The severe and moderately eroded areas should be remediated immediately to prevent additional loss of shoreline and prevent continued degradation of the water quality through sediment inputs. 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. 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.

OBSERVATIONS OF WILDLIFE AND HABITAT

LCHD staff noted the species of wildlife encountered during sampling visits to Flint Lake. While little wildlife was observed during the sampling events a Great Blue Herring was noted using the lake. The undeveloped park on the North West area of the lake provided good habitat for songbirds. Although residential areas usually do not offer good wildlife habitat, the mature trees in the lots surrounding the lake offer some songbird habitat.

Figure 8. Shoreline erosion on Flint Lake, 2008.

LAKE MANAGEMENT RECOMMENDATIONS

Historically Flint Lake's water quality has been one of the poorest of the lakes in Lake County, with all parameters having below average water quality. In 2008, the water quality parameters remained above county medians, however water quality has not deteriorated and has remained the same since 2003. Flint Lake's aquatic plant community had a slight decrease in species diversity; a significant loss is that of the yellow water lily. Flint Lake is located in a residential setting with the shoreline mainly developed and exhibiting 100% shoreline erosion. Although residential areas usually do not offer good wildlife habitat, the mature trees in the lots surrounding the lake offer some songbird habitat.

- **Aquatic Pant Management**

  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 (Appendix D1). Flint Lake's aquatic plant community decreased since the 2003 study when American Pondweed and Yellow Water Lily were present.

- **Lakes with Shoreline Erosion**

  The area on the east side of the lake was severely eroded. This area 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 D2).

- **Reduce Conductivity and Chloride Concentrations**

  Conductivity concentrations in Flint Lake's north inlet (1.0970 mS/cm) and south inlet (1.2780 mS/cm) have decreased since the 2003 south inlet average (1.5818 mS/cm). However these concentrations are still higher than the county median of 0.8195 mS/cm. The chloride concentration averaged 200 mg/L for the north inlet and 223 mg/L for the south inlet and the county median was 166 mg/L. The use of road salts for winter road management is a major contributor to chloride concentrations and conductivity. Proper application procedures and alternative methods can be used to keep these concentrations under control (Appendix D3).

- **<u>Participate in the Volunteer Lake Monitoring Program</u>**

  To track future water quality trends, it is recommended the lake become enrolled in the Volunteer Lake Monitoring Program (VMLP), which trains a volunteer to measure the Secchi disk readings on a bimonthly basis from April to October (Appendix D4). In addition to the VMLP, a staff gauge should be installed to monitor the lake level each month.

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

  Creating a bathymetric map can help with improvements to Flint Lake. A bathymetric map is an essential tool for effective lake management since it provides critical information about the physical features of the lake, such as depth, surface area, volume, etc. This information is particularly important when intensive management techniques (i.e., chemical treatments for plant or algae control, dredging, fish stocking, etc.) are part of the lake's overall management (Appendix D5).

- **<u>Assess Your Lake's Fishery</u>**

  At this time little information about the fishery in Flint Lake is known. A formal fisheries assessment should be conducted to determine the diversity and health of the fish community (Appendix D6).

- **<u>Options for Nuisance Algae Management</u>**

  Algae blooms were common in Flint Lake; algae, is free floating and buoyant which enables the plant to take advantage of the excessive nutrients resulting in over abundance. Without a healthy and diverse aquatic plant community to compete for nutrients the frequency and abundance of algal blooms will likely increase (Appendix D7).

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

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

APPENDIX A. METHODS FOR FIELD DATA COLLECTION AND LABORATORY ANALYSES

Water Sampling and Laboratory Analyses

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

Plant Sampling

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

Shoreline Assessment

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

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

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

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

Wildlife Assessment

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

Table A1. Analytical methods used for water quality parameters.

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

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

Flint Lake 2008 Multiparameter data

North Inlet Date MMDDYY	Text Depth feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units
5/21/2008	0	14.91	13.11	130.2	1.274	8.23

South Inlet Date MMDDYY	Text Depth feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units
5/21/2008	0	14.88	16.81	167.0	1.435	8.18

North Inlet Date MMDDYY	Text Depth feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units
6/18/2008	0	21.10	8.03	90.5	1.120	8.04

South Inlet Date MMDDYY	Text Depth feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units
6/18/2008	0	20.13	8.99	96.4	1.325	8.02

North Inlet Date MMDDYY	Text Depth feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units
7/16/2008	0	26.95	7.09	88.7	1.107	8.24

South Inlet Date MMDDYY	Text Depth feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units
7/16/2008	0	26.35	6.97	86.7	1.220	7.97

North Inlet Date MMDDYY	Text Depth feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units
8/20/2008	0	23.43	12.75	154.6	1.198	8.16

South Inlet Date MMDDYY	Text Depth feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units
8/20/2008	0	22.95	8.19	95.8	1.754	7.96

North Inlet Date MMDDYY	Text Depth feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units
9/17/2008	0	18.47	6.36	67.9	0.786	7.68

South Inlet Date MMDDYY	Text Depth feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units
9/17/2008	0	18.16	5.99	63.1	0.656	7.76

Flint Creek 2008 Multiparameter data

Lake Cook Date MMDDYY	Text Depth feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units
5/21/2008	0	15.49	14.56	146.3	0.918	8.12

Hart Date MMDDYY	Text Depth feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units
5/21/2008	0	15.41	16.11	162.1	1.821	7.97

Kelsey Date MMDDYY	Text Depth feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units
5/21/2008	0	15.58	17.51	176.6	1.393	8.26

Lake Cook Date MMDDYY	Text Depth feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units
6/18/2008	0	17.60	10.63	111.4	0.952	7.79

Hart Date MMDDYY	Text Depth feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units
6/18/2008	0	18.97	9.79	106.8	1.727	7.78

Kelsey Date MMDDYY	Text Depth feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units
6/18/2008	0	21.67	7.98	90.9	1.259	8.08

Lake Cook Date MMDDYY	Text Depth feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units
7/16/2008	0	23.71	6.46	76.6	0.966	8.20

Hart Date MMDDYY	Text Depth feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units
7/16/2008	0	23.72	8.90	103.5	1.527	8.00

Kelsey Date MMDDYY	Text Depth feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units
7/16/2008	0	27.37	7.47	94.7	1.174	8.25

Lake Cook	Text					
Date	Depth	Temp	DO	DO%	SpCond	pH
MMDDYY	feet	øC	mg/l	Sat	mS/cm	Units
8/20/2008	0	16.03	6.08	61.8	0.935	7.92

Hart	Text					
Date	Depth	Temp	DO	DO%	SpCond	pH
MMDDYY	feet	øC	mg/l	Sat	mS/cm	Units
8/20/2008	0	21.16	9.84	111.5	2.286	7.74

Kelsey	Text					
Date	Depth	Temp	DO	DO%	SpCond	pH
MMDDYY	feet	øC	mg/l	Sat	mS/cm	Units
8/20/2008	0	24.81	9.86	119.8	1.575	8.24

Lake Cook	Text					
Date	Depth	Temp	DO	DO%	SpCond	pH
MMDDYY	feet	øC	mg/l	Sat	mS/cm	Units
9/17/2008	0	19.06	9.13	98.1	0.625	7.85

Hart	Text					
Date	Depth	Temp	DO	DO%	SpCond	pH
MMDDYY	feet	øC	mg/l	Sat	mS/cm	Units
9/17/2008	0	17.62	9.01	91.4	0.757	7.69

Kelsey	Text					
Date	Depth	Temp	DO	DO%	SpCond	pH
MMDDYY	feet	øC	mg/l	Sat	mS/cm	Units
9/17/2008	0	18.41	7.62	81.3	0.687	7.83

APPENDIX C. INTERPRETING YOUR LAKE'S WATER QUALITY DATA

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

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

Temperature and Dissolved Oxygen:

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

Monthly temperature profiles were established on each lake by measuring water temperature every foot (lakes $\leq$ 15 feet deep) or every two feet (lakes > 15 feet deep) from the lake surface to the lake bottom. These profiles are important in understanding the distribution of chemical/biological characteristics and because increasing water temperature and the establishment of thermal stratification have a direct impact on dissolved oxygen (DO) concentrations in the water column. If a lake is shallow and easily mixed by wind, the DO concentration is usually consistent throughout the water column. However, shallow lakes are typically dominated by either plants or algae, and increasing water temperatures during the summer speeds up the rates of photosynthesis and decomposition in surface waters. When many of the plants or algae die at the end of the growing season, their decomposition results in heavy oxygen consumption and can lead to an oxygen crash. In deeper, thermally stratified lakes, oxygen production is greatest in the top portion of the lake, where sunlight drives photosynthesis, and oxygen consumption is greatest near the bottom of a lake, where sunken organic matter accumulates and decomposes. The oxygen difference between the top and bottom water layers can be dramatic, with plenty of oxygen near the surface, but practically none near the bottom. The oxygen profiles measured during the water quality study can illustrate if this is occurring. This is important because the absence of oxygen (anoxia) near the lake bottom can have adverse effects in eutrophic lakes resulting in the chemical release of phosphorus from lake sediment and the production of hydrogen sulfide (rotten egg smell) and other gases in the bottom waters. Low oxygen conditions in the upper water of a lake can also be problematic since all aquatic organisms need oxygen to live. Some oxygen may be present in the water, but at too low a concentration to sustain aquatic life. Oxygen is needed by all plants, virtually all algae and for many chemical reactions that are important in lake functioning. Most adult sport-fish such as largemouth bass and bluegill require at least 3 mg/L of DO in the water to survive. However, their offspring require at least 5 mg/L DO as they are more sensitive to DO stress. When DO concentrations drop below 3 mg/L, rough fish such as carp and green sunfish are favored and over time will become the dominant fish species.

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

Nutrients:

Phosphorus:

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

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

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

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

Nitrogen:

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

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

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

Solids:

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

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

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

Water Clarity:

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

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

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

Alkalinity, Conductivity, Chloride, pH:

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

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

pH:

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

Eutrophication and Trophic State Index:

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

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

Table 1. Trophic State Index (TSI).

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

APPENDIX D. LAKE MANAGEMENT OPTIONS.

D1. Options for Aquatic Plant Management

Option 1: Aquatic Herbicides

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

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

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

Option 2: Mechanical Harvesting

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

Mechanical harvesting can be a selective means to reduce stands of nuisance vegetation in a lake. Typically, plants cut low enough to restore recreational use and limit or prevent regrowth. This practice normally improves habitat for fish and other aquatic organisms.
High initial investment, extensive maintenance, and high operational costs have led to decreased use. Mechanical harvesters cannot be used in less than 2-4 feet of water (depending on draft of the harvester) and cannot maneuver well in tight places. The harvested plant material must be

disposed of properly to a place that can accommodate large quantities of plants and prevent any from washing back into the lake. Fish, mussels, turtles and other aquatic organisms are commonly caught in the harvester and injured or even removed from the lake in the harvesting process. After the initial removal, there is a possibility for vegetation regrowth. If complete/over removal does occur several problems can result. One problem is the loss of sediment stabilization by plants, which can lead to increased turbidity and resuspension of nutrients. Another problem with mechanical harvesting, even if properly done, is that it can be a nonselective process.

Option 3: Hand Removal

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

Option 4: Water Milfoil Weevil

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

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

Option 5: Reestablishing Native Aquatic Vegetation

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

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

D2. Options for Lakes with Shoreline Erosion

Option 1: Install a Seawall

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

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

Option 2: Install Rock Rip-Rap or Gabions

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

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

Option 3: Create a Buffer Strip

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

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

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

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

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

Option 5: Install A-Jacks®

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

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

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

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

D3. Options to Reduce Conductivity and Chloride Concentrations

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

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

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

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

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

Option 1. Proper Use on Your Property

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

Option 2. Examples of Alternatives

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

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

Calcium Magnesium Acetate (CMA)

- Mixture of dolomic lime and acetic acid; can also be made from cheese whey and may have even better ice penetration.
- Benefits: low corrosion rates, safe for concrete, low toxicity and biodegradable, stays on surfaces longer (fewer applications necessary).
- Multi-Purpose: use straight, mix with sodium chloride, sand or as a liquid
- Negatives: slow action at low temperatures, higher cost.

Agricultural Byproducts

- Usually mixed with calcium chloride to provide anti-corrosion properties.
- Lower the freezing point of the salt they are added to.

- as a pre-wetting (anti-ice) agent, it's like a Teflon treatment to which ice and snow will not stick.

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

Option 3. Talk to Your Municipality About Using an Alternative

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

D4. Participate in the Volunteer Lake Monitoring Program

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

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

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

For information, please contact:

VLMP Regional Coordinator:
Holly Hudson
Chicago Metropolitan Agency for Planning
233 S. Wacker Drive, Suite 880

Chicago, IL 60606
(312) 386-8700

D5. Option for Creating a Bathymetric Map

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

D6. Options to Assess Your Lake's Fishery

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

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

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

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

D7. Options for Nuisance Algae Management

Option 1: Algaecides

Algaecides are a quick and inexpensive way to temporarily treat nuisance algae. Copper sulfate ($CuSO_4$) and chelated copper products are the two main algaecides in use. There is also a non-copper based algaecide on the market called GreenClean™ from BIOsafe Systems, which contains the active ingredient sodium carbonate peroxyhydrate. Regardless of active ingredient, all forms act as contact killers. This means that the product has to come into contact with the algae to be effective. Algaecides come in two forms: granular and liquid. Granular algaecides are mainly used on filamentous algae where they are spread over their mats. Liquid algaecides are mixed with a known amount of water to achieve a known concentration and sprayed onto/into the water. Liquid forms are used on both filamentous and planktonic algae. When applying an algaecide it is important that the label is completely read and followed. If too much of the lake is treated, an oxygen crash caused by the decomposition of treated algae may cause fish kills. Additionally, treatments should never be applied when blooms/mats are at their fullest extent. It is best to divide the lake into at least two sections depending on the size of the lake, (larger lakes will need to be divided into more sections), and then treat the lake one section at a time allowing at least two weeks between treatments. Furthermore, application of algaecides should never be done in extremely hot weather (>90^oF) or when dissolved oxygen concentrations are low. It is best to treat in spring or when the blooms/mats start to appear.

A properly implemented plan can often provide season long control with minimal applications. The fishery and waterfowl populations of the lake would also benefit due to a decrease in nuisance algal blooms, which would increase water clarity. This in turn would allow the native aquatic plants to return to the lake. Newly established stands of plants would improve spawning habitat and food source availability for fish. Waterfowl population would also benefit from increases in quality food sources. By implementing a good management plan, usage opportunities for the lake would increase. Activities such as boating and swimming would improve due to the removal of thick blooms and/or mats of algae.

The most obvious drawback of using algaecides is the input of chemicals into the lake. Even though the United States Environmental Protection Agency (USEPA) approved these chemicals for use, human error and overuse can make them unsafe and bring about undesired outcomes. As the algae are continuously exposed to copper, some species are becoming more and more tolerant. This results in the use of higher concentrations in order to achieve adequate control, which can be unhealthy for the lake. In other instances, by eliminating one type of algae, lake managers are finding that other species that are even more problematic are showing up. These species can often be more difficult to control due to an inherent resistance to copper products.

Additionally, excessive use of copper products can lead to a build up of copper in lake sediment. This can cause problems for activities such as dredging. Due to a large amount of copper in the sediment, special permits and disposal methods would have to be utilized.

Option 2: Alum Treatment

A possible remedy to excessive algal growth is to eliminate or greatly reduce the amount of phosphorus. This can be accomplished by using aluminum sulfate (alum). Alum binds water-borne phosphorus and forms a flocculent layer that settles on the bottom making it unavailable, thus reducing algal growth. This flocculent layer can then prevent sediment bound phosphorus from entering the water column. Alum treatments typically last 1 to 20 years depending on various parameters. Lakes with low mean depth to surface area ratio benefit more quickly from alum applications, while lakes with high mean depth to surface area ratio (thermally stratified lakes) will see more longevity from an alum application due to isolation of the flocculent layer. Lakes with small watersheds are also better candidates because external phosphorus sources can be limited.

Phosphorus inactivation is a possible long-term solution for controlling nuisance algae and increasing water clarity. This makes alum more cost effective in the long-term compared to continual treatment with algaecides. Effects of alum treatments can be seen in as little as a few days. The increase in clarity can have many positive effects on the lakes ecosystem. With increased clarity, plant populations could expand or reestablish. This in turn would improve fish habitat and provide improved food/habitat sources for other organisms. Recreational activities such as swimming and fishing would be improved due to increased water clarity and healthy plant populations.

There are also several drawbacks to alum. In order for alum to provide long-term effectiveness, external nutrient inputs must also be reduced or eliminated. With larger watersheds this could prove to be physically and financially difficult. Phosphorus inactivation may be shortened by excessive plant growth or motorboat traffic, which can disturb the flocculent layer and allow phosphorus to be released. Also, lakes that are shallow, non-stratified, and wind blown typically do not achieve long term control due to disruption of the flocculent layer. If alum is not properly applied, toxicity problems may occur. Due to these concerns, it is recommended that a lake management professional plans and administers the alum treatment.

Option 3: Revegetation With Native Aquatic Plants

A healthy native plant population can reduce algal growth. Many lakes with long-standing algal problems have a sparse to non-existent plant population. This is due to reduction in light penetration by excessive algal blooms and/or mats. Revegetation should only be done when existing nuisance algal blooms are under control using one of the above management options. If the lake has poor clarity due to excessive algal growth or turbidity, these problems must be addressed before a revegetation plan is undertaken. Planting depth light levels must be greater than 1-5% of the surface light levels for plant growth. If aquatic herbicides are being used to control existing vegetation, their use should be scaled back or abandoned all together. This will allow the vegetation to grow back, which will help in controlling the algae in addition to other positive impacts associated with a healthy plant population.

There are two methods by which reestablishment can be accomplished. The first is use of existing plant populations to revegetate other areas within the lake. Plants from one part of the lake should be allowed to naturally expand into adjacent areas filling the niche left by the nuisance algae. The second method of reestablishment is to import native plants from an outside source. A variety of plants can be ordered from nurseries that specialize in native aquatic plants. These plants are available in several forms such as seeds, roots, and small plants. These two methods can be used in conjunction with each other to increase both quantity and biodiversity of plant populations. Additionally, plantings must be protected from waterfowl and other wildlife. Simple cages made out of wooden or metal stakes and chicken wire should be erected around planted areas for at least one season. The cages are removed once the plants are established and less vulnerable. If large-scale revegetation is needed it would be best to use a consultant to plan and conduct the restoration. A list can be obtained from the Lake Management Unit that lists common, native plants that should be considered when developing a revegetation plan. Included in this list are emergent shoreline vegetation (rushes, cattails, etc) and submersed aquatic plants (pondweeds, *Vallisneria*, etc).

By revegetating opened areas, the lake will benefit in several ways. Once established, native plant populations will help to control growth of nuisance algae by shading and competition for resources. This provides a more natural approach as compared to other management options. Expanded native plant populations will also help with sediment stabilization. This in turn will have a positive effect on water clarity by reducing suspended solids and nutrients that decrease clarity and cause excessive algal growth. Properly revegetating shallow water areas with plants such as cattails, bulrushes, and water lilies can help reduce wave action that can lead to shoreline erosion. Increases in desirable vegetation will increase the plant biodiversity and also provide better quality habitat and food sources for fish and other wildlife. Recreational uses of the lake such as fishing and boating will also improve due to the improvement in water quality and the suppression of weedy species.

One drawback is the possibility of new vegetation expanding to nuisance levels and needing control. Another drawback could be high costs if extensive revegetation is needed using imported plants. If a consultant were used costs would be substantially higher. Additional costs could be associated with constructing proper herbivory protection measures.

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

2000 - 2008 Water Quality Parameters, Statistics Summary

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

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

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

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

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

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

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

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

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

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

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

LakeCounty
Health Department and
Community Health Center

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

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

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

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

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

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

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

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

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

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

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

No 2002 IEPA Chain Lakes

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

No 2002 IEPA Chain Lakes.

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

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

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

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

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

LCHD Lakes Management Unit ~ 12/1/2008

APPENDIX F. GRANT PROGRAM OPPORTUNITES

Table F1. Potential Grant Opportunities

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

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

Table F1. Continued

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

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