2005 SUMMARY REPORT
of
Bangs Lake

Lake County, Illinois

Prepared by the

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EXECUTIVE SUMMARY

Bangs Lake is a natural glacial lake, encompassing approximately 306 acres and a shoreline length of 6.32 miles. Bangs Lake is part of the Slocum Lake drainage of the Fox River watershed. Water clarity, as measured by Secchi disk transparency readings, averaged 13.76 feet for the 2005 season, which is significantly above the county median (where 50% of the lakes are above and below this value) of 3.17 feet. The 2005 average is a 71% increase from the 2002 average of 8.05 feet. The May reading (29.23 feet) was the deepest recorded since the Lake County Health Department-Lakes Management Unit (LMU) has been measuring this parameter. This increase in clarity is most likely the result of the increase in zebra mussels in the lake.

Total phosphorus (TP) concentrations have remained relatively stable, with the 2005 eplimnetic average concentration (0.023 mg/L), slightly lower than the averages of 2002 (0.027 mg/L), 1997 (0.026 mg/L) and 1990 (0.029 mg/L). Bangs Lake has the lowest TP concentrations in the Slocum Lake watershed.

Conductivity readings in Bangs Lake have increased slightly compared to past years. The 2005 epilimnetic average for conductivity was 0.6064 milliSiemens/cm, which is 9.5% higher than the 2002 average (0.5538 milliSiemens/cm), however still below the county median of 0.7748 milliSiemens/cm. The most likely cause for these increases in conductivity readings is input from dissolved solids washed into the lake from storm events.

In 2005, LMU reassessed the 2002 shoreline erosion survey and found some eroded areas had been remediated, but identified new areas of erosion around the lake. These 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.

LAKE FACTS

Lake Name:	Bangs Lake
Historical Name:	None
Nearest Municipality:	Village of Wauconda
Location:	T44N, R9E, Sections 24,25, and 26
Elevation:	766.2 feet above mean sea level
Major Tributaries:	Slocum Lake Drain
Watershed:	Fox River
Sub-watershed:	Slocum Lake Drain
Receiving Waterbody:	Slocum Lake
Surface Area:	306.1 acres
Shoreline Length:	6.32 miles
Maximum Depth:	32 feet
Average Depth:	10.9 feet
Lake Volume:	3,323.6 acre-feet
Lake Type:	Glacial
Watershed Area:	3,027 acres
Major Watershed Land Uses:	Single Family and Agricultural
Bottom Ownership:	Private, Public (Village of Wauconda)
Management Entities:	Village of Wauconda
Current and Historical Uses:	Swimming, fishing, motorized and non-motorized boating.
Description of Access:	All access locations are private, open to the public (with a permit sticker).

SUMMARY OF WATER QUALITY

Bangs Lake has been previously studied by the Lake County Health Department-Lakes Management Unit (LMU) in 1990, 1997 and 2002. A thorough review of these studies and the history of the lake were given in the 2002 Summary Report for Bangs Lake (available from LMU or on the web site: http://www.co.lake.il.us/health/ehs/lmureports.asp). In 2005, Bangs Lake was chosen to be one of seven "sentinel" lakes in the county, meaning LMU will be monitoring annually for five years, beginning with the 2005 season.

Water quality data was collected at the deep hole location from May through September in (Figure 1, See Appendix A for water sampling methods). In 2005, samples were collected from April through October. In all years, samples were collected at a depth of 3 feet and between 23-28 feet, depending on water level. See Table 1 for the Bangs Lake water quality data from 2002 and 2005. Appendix C explains the various water quality parameters measured, how these parameters relate to each other, and why the measurement of each parameter is important.

In 2005, water clarity, measured by Secchi disk transparency readings, averaged 13.76 feet for the season, which is above the county median (where 50% of the lakes are above and below this value) of 3.17 feet. The clarity increased 71% from 2002 when the seasonal average was 8.05 feet. Water clarity in 2005 was best in May (29.23 feet) and June (18.41 feet) in the season, with poor readings during August (7.05 feet) and September (5.60 feet). The May reading, the deepest recorded since LMU has been measuring this parameter, and the overall increase in clarity is most likely the result of the presence of zebra mussels in the lake. These exotic mussels were first documented in Bangs Lake in 2003 and were found in large numbers in the lake in 2005. Zebra mussels were frequently found attached to plants during the season. While improved clarity is often viewed as a positive aspect, the filter feeding zebra mussel may have negative long-term impacts on the food chain. The poor clarity in August and September was attributed to algae blooms occurring at the time of sampling. In August, *Gloeobotrys* and *Ceratium* were the dominant plankton, while in September unidentified green algae and the blue-green algae *Microcytis* were dominant. The Secchi results of the Volunteer Lake Monitoring Program (VLMP) were similar with a 2005 seasonal average of 11.9 feet.

Correlated with the good clarity readings from 2002 to 2005 were low concentrations of total suspended solids (TSS). Both the 2002 and 2005 epilimnetic averages were the same (3.4 mg/L) and were less than two times the county median for oxic samples (7.9 mg/L), although the 2005 average was probably lower since concentrations were below laboratory detection limits in May, June, and July.

Similarly total phosphorus (TP) concentrations have declined slightly, with the 2005 epilimnetic average concentration (0.023 mg/L), lower than the 2002 average (0.027 mg/L). However, TP concentrations have remained relatively stable over the past 15 years (1997=0.026 mg/L, 1990=0.029 mg/L). While zebra mussels may likely be the reason for the slight decline in TP, watershed contribution of phosphorus are still a threat to the water quality of the lake. One source of phosphorus in the watershed is fertilizers. It is recommended that all homeowners in the watershed use no-phosphorus fertilizers on their properties unless it is determined through a soil test that additional phosphorus is needed.

Nutrient concentrations were much higher in the hypolimnion than in the epilimnion, which is expected in a stratified lake. The lake was not stratified in April or May, but a thermocline was observed in June at approximately 12 feet and in July and August at approximately 18 feet. By September the stratification had eroded and the lake turned over. This turnover explains the increase in TP, total Kjeldahl nitrogen (TKN), and TSS and the decrease in water clarity in September as the influx of nutrients from the hypolimnion into the upper waters triggered an algae bloom. Dissolved oxygen (DO) concentrations also became anoxic in the hypolimnion in June through September. The maximum volume experiencing anoxia was approximately 3.5% (DO concentrations <1.0 mg/L below 20 feet in July and August), thus there are no apparent DO problems in Bangs Lake.

High nutrient concentrations are usually indicative of water quality problems. Algae need light and nutrients, most importantly carbon, nitrogen (N) and phosphorus (P), to grow. Light and carbon are not normally in short supply (limiting). This means that nutrients (N&P) are usually the limiting factors in algal growth. Nitrogen, as well as carbon, naturally occur in high concentrations and come from a variety of sources (soil, air, etc.) that are more difficult to control than sources of phosphorus. To compare the availability of these nutrients, a ratio of total nitrogen to total phosphorus is used (TN: TP). Ratios < 10:1 indicate nitrogen is limiting. Ratios of >15:1 indicate phosphorus is limiting. Ratios >10:1, <15:1 indicate that there is enough of both nutrients for excessive algal growth. The average ratio between total nitrogen and total phosphorus for Bangs Lake in 2005 was 37:1, indicating a strongly phosphorus-limited system. Lakes that are phosphorus-limited may be easier to manage, since controlling phosphorus is more feasible than controlling nitrogen or carbon.

Based on data collected in 2005, standard classification indices compiled by the Illinois Environmental Protection Agency (IEPA) were used to determine the current condition of Bangs Lake. A general overall index that is commonly used is called a trophic state index or TSI. 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 total phosphorus values obtained at or near the surface. The TSIp for Bangs Lake in 2005 classified it as a eutrophic lake (TSIp = 52.6). Although the lake falls into the eutrophic category, it does not exhibit many of the characteristics of eutrophic lakes mentioned above. This is likely the result of a diverse and healthy plant community. When the Secchi depth TSI (TSIsd) is calculated (39.3), Bangs Lake falls into the oligotrophic category, indicating a poorly enriched system with relatively good water quality. Eutrophic lakes are the most common types of lakes throughout the lower Midwest, and they are particularly common among manmade lakes. See Table 2 in Appendix A for a ranking of average TSIp values for Lake County lakes (Bangs Lake is currently #18 of 162 lakes based on average TP concentrations). This ranking is only a relative assessment of the lakes in the county. The current rank of a lake is dependent upon many factors including lake origin, water source, nutrient loads, and morphometric features (volume, depth, substrate, etc.).

In Bangs Lake, the IEPA aquatic life impairment index was low, indicating a full degree of support for all aquatic organisms in the lake. Similarly, the good water clarity in the lake helped classify the swimming index as a full degree of support. Due to the extensive aquatic plant

growth, the recreation index was classified as partial support. The overall use index was classified as full use.

Conductivity readings in Bangs Lake have increased slightly compared to past years. The 2005 epilimnetic average for conductivity was 0.6064 milliSiemens/cm, which is 9.5% higher than the 2002 average (0.5538 milliSiemens/cm), however still below the county median of 0.7748 milliSiemens/cm. The most likely cause for these increases in conductivity readings is input from dissolved solids washed into the lake from storm events. One of the most common dissolved solids is road salt used in winter road maintenance. Because of the high conductivity readings, one additional parameter, chlorides, was collected beginning in 2005. Chloride concentrations help determine if road salt is the primary chloride source as most road salt is sodium chloride, calcium chloride, potassium chloride, magnesium chloride or ferrocyanide salts. The seasonal average for chlorides in Bangs Lake in 2005 was 99 mg/L in the epilimnion and 97 mg/L in the hypolimnion. The IEPA standard for chloride is 500 mg/L. Once values exceed this standard the water body is deemed to be impaired, thus impacting aquatic life. It appears that the road salt is compounding in Bangs Lake and other lakes in the county. Some lakes in the county have seen a doubling of conductivity readings in the past 5-10 years. In a study by Environment Canada (equivalent to our USEPA), it was estimated that 5% of aquatic species such as fish, zooplankton and benthic invertebrates would be affected at chloride concentrations of about 210 mg/L. Additionally, shifts in algae populations in lakes were associated with chloride concentrations as low as 12 mg/L. The current concentrations of chlorides in Bangs Lake may be adversely affecting aquatic life in the lake.

Bangs Lake water quality is directly linked to precipitation events and the quality of the resulting runoff. This is due to the very large watershed (3,027 acres; Figures 2 and 3, Table 3) that drains into Bangs Lake. Lakes such as Bangs Lake, that have a high watershed to lake area ratio (>40:1) are very difficult to manage. The two predominant land uses in the watershed are public and private open space (45.5%) and single family (20.2%). Transportation, although accounting for 6.3% of the land use in the watershed, accounts for approximately 28% of the total runoff. Single family land use accounts for approximately 31% of the total runoff.

Plankton are microscopic plants and animals that are free-floating within the water column. Samples were collected during water quality testing and analyzed for species content (See Appendix A for methods). Diatoms were the dominant plankton in April (mainly *Tabellaria*) and again in June (mainly *Fragilaria*) (Figure 4). The September algae bloom, which reduced the water clarity, was comprised mostly of unidentified green algae, although some blue-green algae were present (specifically *Microcystis*, *Anabaena* and *Oscillatoria*).

Figure 1. Water quality sampling site (blue) and access locations (green) on Bangs Lake, 2005.

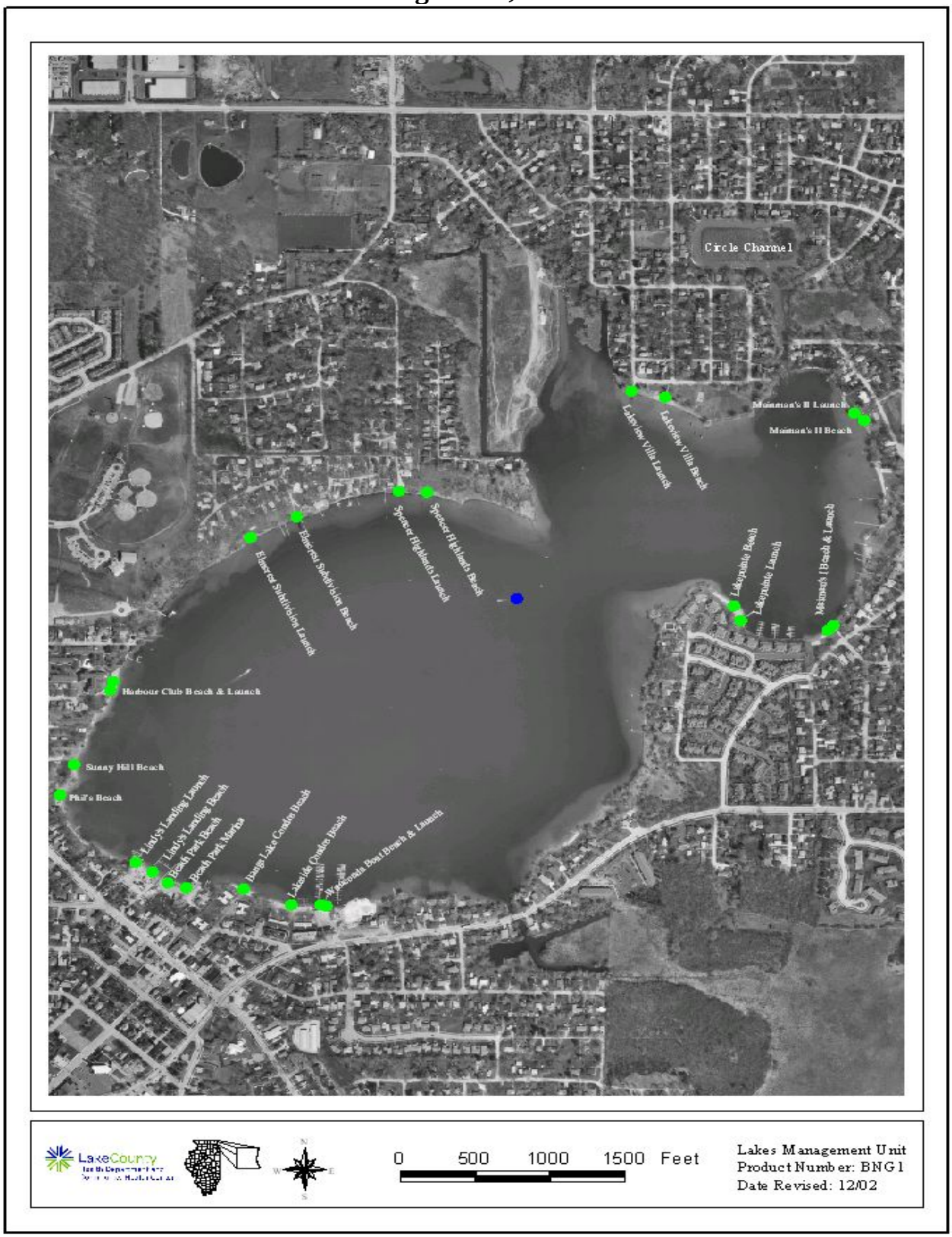

Table 1. Water quality data for Bangs Lake, 2002 and 2005.

2005	Epilimnion															
DATE	DEPTH	ALK	TKN	NH3-N	NO3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
12-Apr	3	142	0.726	<0.1	<0.05	<0.010	<0.005	NA	90.4	3.2	350	85	10.50	0.5874	8.09	9.96
18-May	3	139	0.726	<0.1	<0.05	0.012	<0.005	NA	92.5	<1.0	344	72	29.23	0.5948	7.61	9.92
22-Jun	3	128	0.844	<0.1	<0.05	0.016	<0.005	NA	97.6	<1.0	349	95	18.41	0.5823	8.19	7.62
20-Jul	3	130	0.794	<0.1	<0.05	0.010	<0.005	NA	102.0	<1.0	372	102	16.34	0.6089	8.07	7.36
18-Aug	3	134	0.800	<0.1	<0.05	0.031	<0.005	NA	102.0	3.0	370	102	7.05	0.6099	8.67	7.67
21-Sep	3	139	1.000	<0.1	<0.05	0.044	<0.005	NA	105.0	4.9	371	91	5.60	0.6211	8.67	7.18
19-Oct	3	141	0.900	<0.1	<0.05	0.027	<0.005	NA	105.0	2.6	359	76	9.22	0.6405	8.37	8.16
	Average	136	0.827	<0.1	<0.05	0.023[k]	<0.005	NA	99.2	3.4[k]	359	89	13.76	0.6064	8.24	8.27

2002	Epilimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
20-May	3	158	0.772	<0.1	<0.05	0.029	<0.005	306	NA	1.3	335	87	15.26	0.5744	8.31	9.34
24-Jun	3	144	0.842	<0.1	<0.05	0.018	<0.005	324	NA	2.1	341	105	10.24	0.5676	8.43	7.68
29-Jul	3	137	0.974	<0.1	<0.05	0.020	<0.005	290	NA	2.8	332	97	6.43	0.5528	8.63	7.10
26-Aug	3	133	1.130	<0.1	<0.05	0.031	<0.005	308	NA	5.2	339	93	3.94	0.5307	8.71	8.30
23-Sep	3	136	1.100	<0.1	<0.05	0.037	<0.005	320	NA	5.4	332	102	4.40	0.5435	8.28	6.89
	Average	142	0.964	<0.1	<0.05	0.027	<0.005	310	NA	3.4	336	97	8.05	0.5538	8.47	7.86

Glossary

ALK = Alkalinity, mg/L $CaCO_3$
TKN = Total Kjeldahl nitrogen, mg/L
NH_3-N = Ammonia nitrogen, mg/L
NO_3-N = Nitrate nitrogen, mg/L
TP = Total phosphorus, mg/L
SRP = Soluble reactive phosphorus, mg/L
TDS = Total dissolved solids, mg/L
Cl^- = Chloride ions, 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

Note: "k" denotes that the actual value is known to be less than the value presented.
NA = Not Applicable

Table 1. Continued.

2005	Hypolimnion															
DATE	DEPTH	ALK	TKN	NH3-N	NO3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
12-Apr	28	145	0.822	<0.1	<0.05	<0.010	<0.005	NA	91.2	3.1	356	81	NA	0.6040	7.54	2.98
18-May	28	140	0.700	<0.1	<0.05	0.021	<0.005	NA	93.0	1.0	348	74	NA	0.5969	7.72	8.25
22-Jun	28	161	0.856	<0.1	<0.05	0.062	0.019	NA	94.2	5.2	362	80	NA	0.6155	7.19	0.08
20-Jul	24	167	0.848	<0.1	<0.05	0.054	0.010	NA	94.8	8.0	367	82	NA	0.6298	7.23	0.05
18-Aug	27	180	2.020	0.878	<0.05	0.505	0.114	NA	94.6	18.0	386	91	NA	0.6705	7.68	0.11
21-Sep	26	144	1.460	0.416	<0.05	0.174	0.083	NA	104.0	5.5	368	84	NA	0.6364	7.83	0.19
19-Oct	23	141	0.944	<0.1	<0.05	0.029	<0.005	NA	105.0	2.7	363	79	NA	0.6406	8.42	7.39
	Average	154	1.093	0.647[k]	<0.05	0.141[k]	0.057	NA	96.7	6.2	364	82	NA	0.6277	7.66	2.72

2002	Hypolimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
20-May	27	159	0.892	<0.1	<0.05	0.016	<0.005	338	NA	1.4	335	86	NA	0.5745	8.32	9.29
24-Jun	28	173	1.080	0.116	<0.05	0.045	<0.005	318	NA	4.0	367	104	NA	0.6042	7.54	0.06
29-Jul	27	177	1.500	0.329	<0.05	0.068	0.007	318	NA	7.4	356	103	NA	0.6134	7.23	0.05
26-Aug	25	176	2.170	1.140	<0.05	0.146	0.015	322	NA	9.9	361	110	NA	0.6284	7.21	0.20
23-Sep	26	136	1.060	<0.1	<0.05	0.034	<0.005	323	NA	5.4	341	108	NA	0.5435	8.30	6.98
	Average	164	1.340	0.530[k]	<0.05	0.062	0.011[k]	324	NA	5.6	352	102	NA	0.5928	7.72	3.32

Glossary

ALK = Alkalinity, mg/L $CaCO_3$
TKN = Total Kjeldahl nitrogen, mg/L
NH_3-N = Ammonia nitrogen, mg/L
NO_3-N = Nitrate nitrogen, mg/L
TP = Total phosphorus, mg/L
SRP = Soluble reactive phosphorus, mg/L
TDS = Total dissolved solids, mg/L
Cl^- = Chloride ions, 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

Note: "k" denotes that the actual value is known to be less than the value presented.
NA = Not Applicable

Figure 2. Approximate watershed delineation for Bangs Lake, 2005.

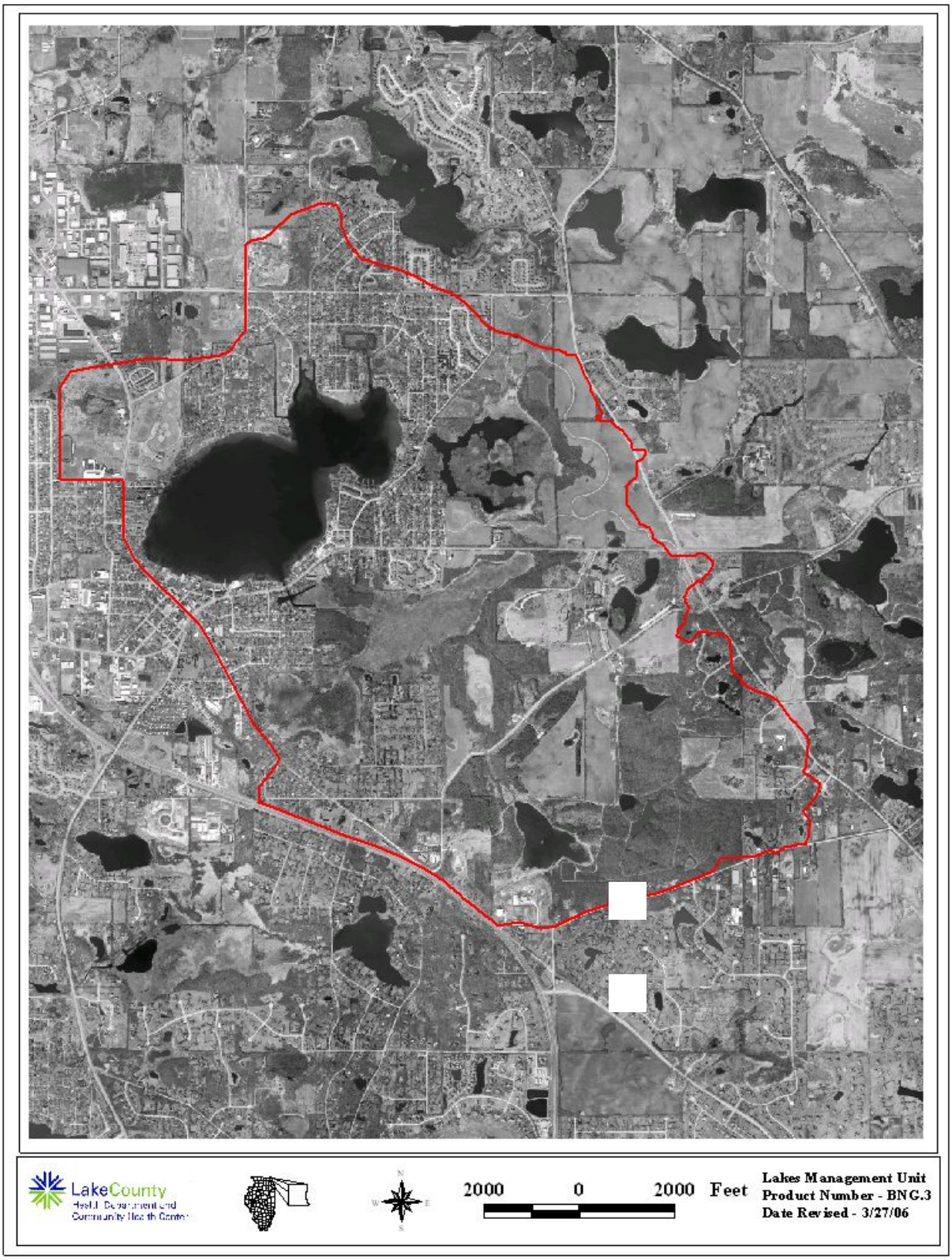

Figure 3. Approximate land use within the Bangs Lake watershed, 2005.

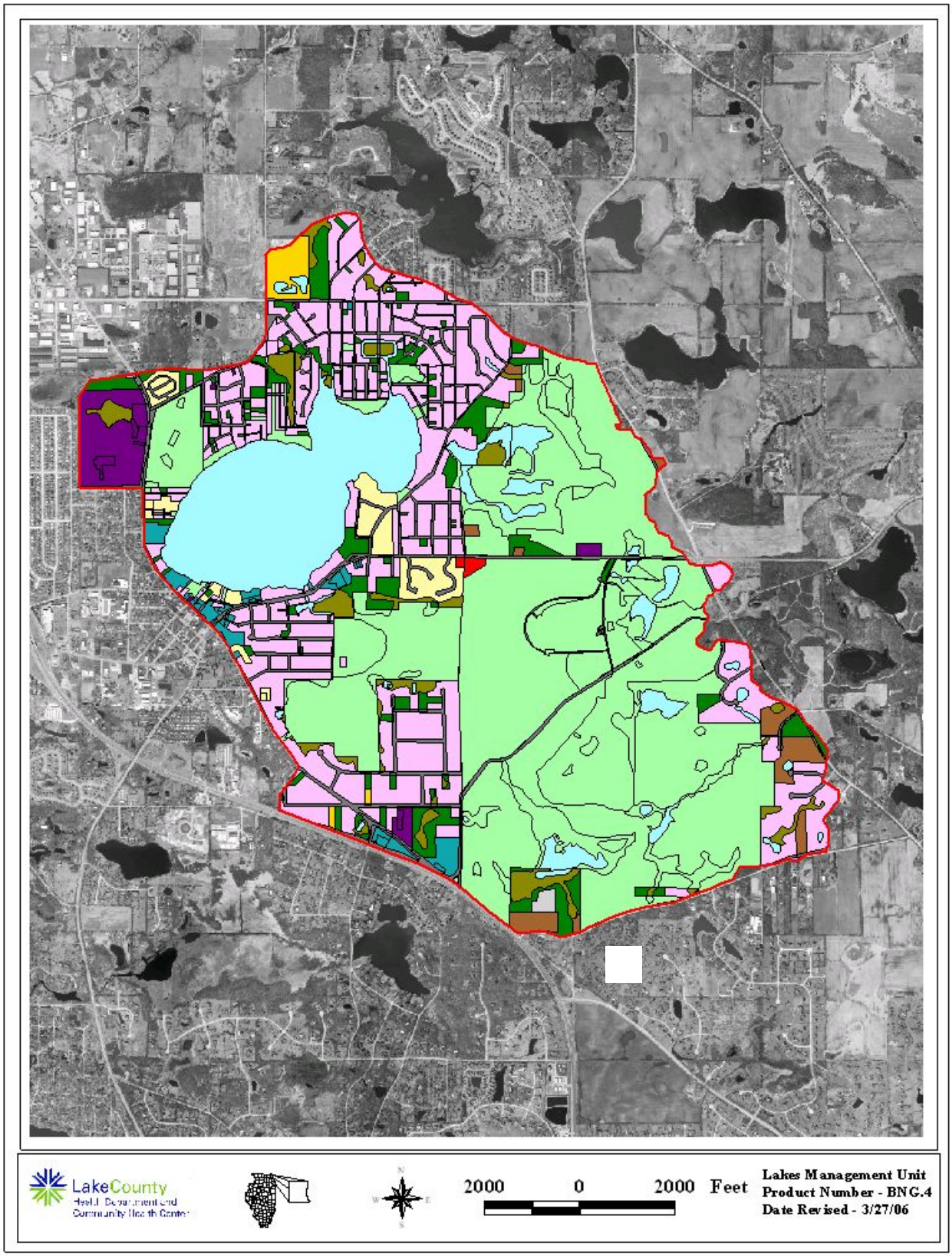

Figure 4. Plankton counts for Bangs Lake, 2005.

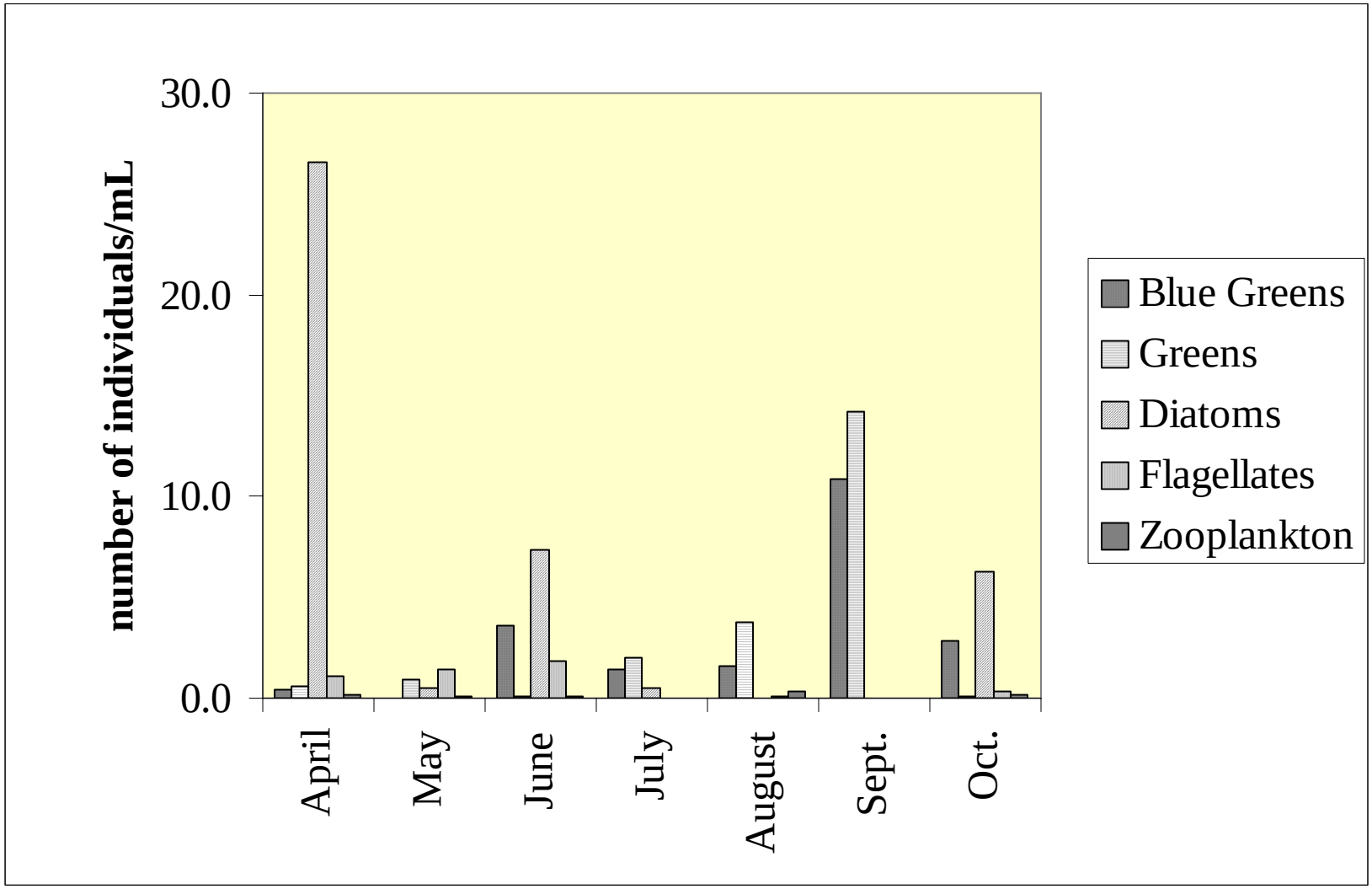

Table 2. Lake County average TSI phosphorous (TSIp) ranking 2000-2005.

RANK	LAKE NAME	TP AVE	TSIp
1	Windward Lake	0.0158	43.9
2	Sterling Lake	0.0162	44.3
3	Lake Minear	0.0165	44.6
4	Pulaski Pond	0.0180	45.8
5	Fourth Lake	0.0182	46.0
6	West Loon Lake	0.0182	46.0
7	Cedar Lake	0.0183	46.1
8	Third Lake	0.0190	46.6
9	Lake Carina	0.0193	46.9
10	Independence Grove	0.0194	46.9
11	Lake Kathyrn	0.0200	47.3
12	Lake of the Hollow	0.0200	47.3
13	Banana Pond	0.0202	47.5
14	Cross Lake	0.0220	48.7
15	Dog Pond	0.0222	48.9
16	Sand Pond	0.0230	49.4
17	Stone Quarry Lake	0.0230	49.4
18	**Bangs Lake**	**0.0233**	**49.6**
19	Cranberry Lake	0.0236	49.7
20	Deep Lake	0.0240	50.0
21	Druce Lake	0.0244	50.2
22	Little Silver Lake	0.0246	50.3
23	Round Lake	0.0254	50.8
24	Lake Leo	0.0256	50.9
25	Timber Lake	0.0270	51.7
26	Dugdale Lake	0.0274	51.9
27	Peterson Pond	0.0274	51.9
28	Lake Miltmore	0.0276	52.0
29	Ames Pit	0.0278	52.1
30	East Loon Lake	0.0280	52.2
31	Lake Zurich	0.0282	52.3
32	Lake Fairfield	0.0296	53.0
33	Gray's Lake	0.0302	53.3
34	Highland Lake	0.0302	53.3
35	Hook Lake	0.0302	53.3
36	Lake Catherine (Site 1)	0.0308	53.6
37	Lambs Farm Lake	0.0312	53.8
38	Old School Lake	0.0312	53.8
39	Sand Lake	0.0316	53.9
40	Waterford Lake	0.0318	54.0
41	Potomac Lake	0.0318	54.0
42	Sullivan Lake	0.0320	54.1
43	Wooster Lake	0.0324	54.3
44	Gages Lake	0.0338	54.9
45	Hendrick Lake	0.0356	55.7

Table 2. Continued.

RANK	LAKE NAME	TP AVE	TSIp
46	Diamond Lake	0.0372	56.3
47	Channel Lake (Site 1)	0.0380	56.6
48	Sun Lake	0.0410	57.7
49	Lake Linden	0.0420	58.0
50	Old Oak Lake	0.0428	58.3
51	Schreiber Lake	0.0434	58.5
52	Nielsen Pond	0.0448	59.0
53	Turner Lake	0.0458	59.3
54	Seven Acre Lake	0.0460	59.4
55	Willow Lake	0.0464	59.5
56	Lucky Lake	0.0476	59.9
57	Davis Lake	0.0476	59.9
58	East Meadow Lake	0.0478	59.9
59	College Trail Lake	0.0496	60.4
60	Countryside Lake	0.0512	60.9
61	Lake Lakeland Estates	0.0524	61.2
62	Butler Lake	0.0528	61.3
63	Lake Christa	0.0530	61.4
64	West Meadow Lake	0.0530	61.4
65	Deer Lake	0.0542	61.7
66	Heron Pond	0.0545	61.8
67	Little Bear Lake	0.0550	61.9
68	Lucy Lake	0.0552	62.0
69	Lake Charles	0.0580	62.7
70	White Lake	0.0588	62.9
71	Lake Naomi	0.0616	63.6
72	Lake Tranquility S1	0.0618	63.6
73	Werhane Lake	0.0630	63.9
74	Liberty Lake	0.0632	63.9
75	Countryside Glen Lake	0.0642	64.2
76	Leisure Lake	0.0648	64.3
77	Hastings Lake	0.0664	64.7
78	St. Mary's Lake	0.0666	64.7
79	Mary Lee Lake	0.0682	65.0
80	Honey Lake	0.0690	65.2
81	Redwing Slough, Site II, Outflow	0.0718	65.8
82	North Tower Lake	0.0718	65.8
83	Lake Fairview	0.0724	65.9
84	Spring Lake	0.0726	65.9
85	ADID 203	0.0730	66.0
86	Bluff Lake	0.0734	66.1
87	Long Lake	0.0761	66.6
88	Harvey Lake	0.0766	66.7
89	Broberg Marsh	0.0782	67.0
90	Echo Lake	0.0792	67.2
91	Sylvan Lake	0.0794	67.2

Table 2. Continued.

RANK	LAKE NAME	TP AVE	TSIp
92	Big Bear Lake	0.0806	67.4
93	Petite Lake	0.0834	67.9
94	Lake Marie (Site 1)	0.0850	68.2
95	North Churchill Lake	0.0872	68.6
96	Grandwood Park, Site II, Outflow	0.0876	68.6
97	South Churchill Lake	0.0896	69.0
98	Rivershire Pond 2	0.0900	69.0
99	McGreal Lake	0.0914	69.3
100	International Mine and Chemical Lake	0.0948	69.8
101	Eagle Lake (Site I)	0.0950	69.8
102	Dunns Lake	0.0952	69.8
103	Lake Barrington	0.0956	69.9
104	Lochanora Lake	0.0960	70.0
105	Owens Lake	0.0978	70.2
106	Woodland Lake	0.0986	70.4
107	Island Lake	0.0990	70.4
108	Duck Lake	0.0996	70.5
109	Tower Lake	0.1000	70.6
110	Crooked Lake	0.1014	70.8
111	Fish Lake	0.1022	70.9
112	Longview Meadow Lake	0.1024	70.9
113	Lake Forest Pond	0.1074	71.6
114	Bittersweet Golf Course #13	0.1096	71.9
115	Fox Lake (Site 1)	0.1098	71.9
116	Bresen Lake	0.1126	72.3
117	Round Lake Marsh North	0.1126	72.3
118	Timber Lake S	0.1128	72.3
119	Deer Lake Meadow Lake	0.1158	72.7
120	Taylor Lake	0.1184	73.0
121	Grand Avenue Marsh	0.1194	73.1
122	Columbus Park Lake	0.1226	73.5
123	Nippersink Lake (Site 1)	0.1240	73.7
124	Grass Lake (Site 1)	0.1288	74.2
125	Lake Holloway	0.1322	74.6
126	Lakewood Marsh	0.1330	74.7
127	Summerhill Estates Lake	0.1384	75.2
128	Redhead Lake	0.1412	75.5
129	Antioch Lake	0.1448	75.9
130	Forest Lake	0.1470	76.1
131	Valley Lake	0.1470	76.1
132	Slocum Lake	0.1496	76.4
133	Drummond Lake	0.1510	76.5
134	Pond-a-Rudy	0.1514	76.5
135	Lake Matthews	0.1516	76.6
136	Buffalo Creek Reservoir	0.1550	76.9
137	Pistakee Lake (Site 1)	0.1592	77.3

Table 2. Continued.

RANK	LAKE NAME	TP AVE	TSIp
138	Salem Lake	0.1650	77.8
139	Half Day Pit	0.1690	78.1
140	McDonald Lake 1	0.1722	78.4
141	Lake Eleanor Site II, Outflow	0.1812	79.1
142	Lake Farmington	0.1848	79.4
143	ADID 127	0.1886	79.7
144	Lake Louise Inlet	0.1938	80.1
145	Grassy Lake	0.1952	80.2
146	Fischer Lake	0.1978	80.4
147	Dog Bone Lake	0.1990	80.5
148	Redwing Marsh	0.2072	81.1
149	Stockholm Lake	0.2082	81.1
150	Bishop Lake	0.2156	81.6
151	Hidden Lake	0.2236	82.2
152	Lake Napa Suwe (Outlet)	0.2304	82.6
153	Patski Pond (outlet)	0.2512	83.8
154	Slough Lake	0.2634	84.5
155	McDonald Lake 2	0.2706	84.9
156	Oak Hills Lake	0.2792	85.4
157	Loch Lomond	0.2954	86.2
158	Fairfield Marsh	0.3264	87.6
159	ADID 182	0.3280	87.7
160	Flint Lake Outlet	0.4996	93.8
161	Rasmussen Lake	0.5025	93.8
162	Albert Lake, Site II, outflow	1.1894	106.3

Table 3. Approximate land uses and retention time for the Bangs Lake watershed, 2005.

Land Use	Acreage	% of Total
Agricultural	40.3	1.3
Disturbed Land	22.3	0.7
Forest and Grassland	146.6	4.8
Government and Institutional	66.9	2.2
Industrial	4.5	0.1
Multi Family	62.0	2.0
Public and Private Open Space	1364.1	45.1
Retail/Commercial	38.1	1.3
Single Family	610.5	20.2
Transportation	190.3	6.3
Utility and Waste Facilities	3.8	0.1
Water	392.5	13.0
Wetlands	85.5	2.8
	3027.58	100.0

Land Use	Acreage	Runoff Coeff.	Estimated Runoff, acft.	% total of Estimated Runoff
Agricultural	40.27	0.05	5.5	0.3%
Disturbed Land	22.33	0.05	3.1	0.2%
Forest and Grassland	146.65	0.5	201.6	12.6%
Government and Institutional	66.95	0.5	92.1	5.7%
Industrial	4.5	0.85	10.6	0.7%
Multi Family	62.0	0.3	51.1	3.2%
Public and Private Open Space	1364.1	0.05	187.6	11.7%
Retail/Commercial	38.1	0.85	88.9	5.5%
Single Family	610.5	0.3	503.7	31.4%
Transportation	190.3	0.85	444.9	27.7%
Utility and Waste Facilities	3.8	0.3	3.2	0.2%
Water	392.5	0	0.0	0.0%
Wetlands	85.5	0.05	11.8	0.7%
TOTAL	**3027.6**		**1603.9**	**100.0%**

Lake volume	3323.6	acre-feet
Retention Time (years)= lake volume/runoff	2.07	years
	756.33	days

SUMMARY OF AQUATIC MACROPHYTES

Aquatic plant species presence and distribution in Bangs Lake were assessed in June and August 2005 (see Appendix A for methods). Sixteen aquatic submersed and floating plant species were found (see Table 4, below).

Bangs Lake has a good diversity of aquatic plants. In May, Curlyleaf Pondweed was the most common species, being found in 49.4% of the sample sites (Table 5a, 5b). Flatstem Pondweed (28.6 %), *Chara* (24.7%), and Eurasian Watermilfoil (EWM) (24.3 %) were the next most common species. Both Curlyleaf and EWM are exotic species. In August, EWM was the most common species (39.0%), followed by Flatstem Pondweed (31.3%) and *Chara* (25.7%). The approximate plant densities (total density, including all species) are shown in Figures 5 (May) and 6 (August).

Aquatic plant harvesting has been carried out for removal of EWM and Curlyleaf Pondweed since the 1990's. In 2005, the Village of Wauconda provided LMU with weekly maps of the areas harvested. Harvesting began in late-May and ended by mid-September and was concentrated in areas where EWM and Curlyleaf Pondweed are the densest, which tended to be the deeper areas of the lake. Many of the native pondweeds were found in greater densities in the shallow littoral zones. The harvesting technique appears to be an acceptable form of plant management, at this time.

To maintain a healthy sunfish/bass fishery, the optimal aquatic plant (macrophyte) coverage is 30% to 40% across the lake bottom. The maximum depth that plants were found in Bangs Lake was 18.3 feet in May (Curlyleaf Pondweed), which theoretically calculates to approximately 94% bottom coverage, although this was likely not the case because Curlyleaf was not founding all areas of the lake. Due to concern over the amount of aquatic plant coverage in the lake and the potential impact plants they were having on recreational opportunities, LMU mapped the "navigational impairment" area of the lake or the area were motor boat activity was negatively impacted by plants (i.e. excessive plant material on the boat prop). On July 14, 2005 approximately 102 acres (30%) of the lake was classified as having some form of navigational impairment (Figure 7). Most of this impairment is in the shallow areas of the lake within the "no-wake" buoys and is not adversely impacting operation motor boats at higher speeds in the main body of the lake. There may be some impairment near shore by piers and beaches. At this time the overall density of aquatic plants in Bangs Lake is adequate.

Water clarity and depth are the major limiting factors in determining the maximum depth at which aquatic plants will grow in a specific lake. Aquatic plants will not photosynthesize at water depths with less than 1% of the available sunlight at the surface. During 2005, the depth of the 1% light level ranged from 10 feet (September) to the bottom (May). The poor light penetration in September was due to the algae bloom occurring at that time.

The Floristic Quality Index (FQI) is a rapid assessment tool designed to evaluate the closeness of the flora of an area to that of undisturbed conditions. It can be used to: 1) identify natural areas, 2) compare the quality of different sites or different locations within a single site, 3) monitor long-term floristic trends, and 4) monitor habitat restoration efforts (Nichols, 1999). Each

floating or submersed aquatic plant is assigned a number between 1 and 10 (10 indicating the plant species most sensitive to disturbance). An FQI is calculated by multiplying the average of these numbers by the square root of the number of these plant species found in the lake. A high FQI number indicates that there are 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. Bangs Lake had a FQI of 19.6 in 2005, which is a slight decline from 2002 (FQI of 26.9), however, annual variation in plant abundance and the implementation of a new plant survey technique may account for this decline. The median FQI for 2000-2005 Lake County lakes is 13.1.

Table 4: Aquatic plant species found in Bangs Lake in 2005.

Chara	*Chara* spp.
Coontail	*Ceratophyllum demersum*
Elodea	*Elodea canadensis*
Water Stargrass	*Heteranthera dubia*
Duckweed	*Lemna minor*
Eurasian Watermilfoil	*Myriophyllum spicatum*
Northern Watermilfoil	*Myriophyllum sibiricum*
Southern Naiad	*Najas guadalupensis*
White Water Lily	*Nymphaea tuberosa*
Largeleaf Pondweed	*Potamogeton amplifolius*
Curlyleaf Pondweed	*Potamogeton crispus*
Illinois Pondweed	*Potamogeton illinoensis*
Flatstem Pondweed	*Potamogeton zosterifomis*
Sago Pondweed	*Potamogeton pectinatus*
Eel Grass	*Vallisneria americana*
Watermeal	*Wolffia columbiana*

^ Exotic plant

SUMMARY OF SHORELINE CONDITION

In 2002, an assessment was conducted to determine the condition of the shoreline at the water/land interface. Approximately 71% of Bangs Lake's shoreline is developed and the majority of the developed shoreline is comprised of seawall (30.5%) and buffer (21%). The remainder of the developed shoreline consists of beach (19.8%), manicured lawn (15.5%), rip rap (6.9%), woodland (3.2%), shrub (1.7%) and wetland (1.3%). The undeveloped portions of the lake are made up of wetland, woodland and buffer. As a result of the dominance of wetland and buffered shorelines, 93.1% of Bangs Lake's shoreline exhibited no erosion.

The shoreline was reassessed for shoreline erosion in August 2005. No severe erosion was noted. However there were two parcels classified as moderately eroding (0.6% of the total shoreline) and several more classified as slightly eroding (21.9% of the total shoreline) (Figure

8). The moderately erosion should be remediated immediately to prevent additional shoreline degradation and input of sediment into the lake.

SUMMARY OF WILDLIFE AND HABITAT

Wildlife habitat around Bangs Lake was variable. Good habitat was found on the undeveloped sections of the eastern and southwestern shorelines, and along the northwest section of the lake near the spillway. The maintenance of wetland and buffered shorelines and the establishment of additional buffer strips (especially along the shoreline of newly developed areas) is very important and strongly recommended to provide the appropriate habitat for birds and other animals in the future. While the manicured lawns on the lake do not provide good habitat, many of the lots had a mature tree canopy at the shoreline, which harbored numerous wildlife species. Improvements to the wildlife habitat on Bangs Lake may include the placement of artificial nesting structures (i.e., bird and bat boxes), leaving deadfall and creating buffer strips along shorelines, and boating restrictions.

Table 5a. Aquatic vegetation species found at the 259 (May) and 261 (August) sampling sites on Bangs Lake, 2005. Maximum depth plants were found was 18.3 feet in May, 15.4 feet in August.

Plant Density	Chara	Coontail	Curlyleaf Pondweed	Duckweed	Elodea	Eurasian Watermilfoil	Flatstem Pondweed	Illinois Pondweed	Largeleaf Pondweed	Northern Watermilfoil	Sago Pondweed	Southern Naiad	Watermeal	Water Stargrass
Present	36	8	44	5	2	32	41	1	12	1	13	1	6	3
Common	9	2	23	1	3	15	18	0	6	0	3	0	0	1
Abundant	9	2	19	0	1	6	14	0	3	0	0	0	0	1
Dominant	10	2	42	1	2	10	1	0	16	0	0	0	1	0
% Plant Occurrence	24.7	5.4	49.4	2.7	3.1	24.3	28.6	0.4	14.3	0.4	6.2	0.4	2.7	1.9

Plant Density	Chara	Coontail	Curlyleaf Pondweed	Duckweed	Eurasian Watermilfoil	Flatstem Pondweed	Illinois Pondweed	Largeleaf Pondweed	Sago Pondweed
Present	38	26	31	1	57	44	18	15	18
Common	12	11	1	2	25	23	4	6	1
Abundant	12	6	0	1	12	17	1	6	1
Dominant	8	1	0	0	12	1	0	2	0
% Plant Occurrence	25.7	16.2	11.8	1.5	39.0	31.3	8.5	10.7	7.4

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

May

Rake Density (coverage)	# of Sites	% of Sites
No Plants	37	14.3
>0-10%	68	26.3
10-40%	43	16.6
40-60%	59	22.8
60-90%	30	11.6
>90%	22	8.5
Total Sites with Plants	222	85.7
Total # of Sites	259	100.0

August

Rake Density (coverage)	# of Sites	% of Sites
No Plants	55	21.1
>0-10%	84	32.2
10-40%	22	8.4
40-60%	20	7.7
60-90%	29	11.1
>90%	51	19.5
Total Sites with Plants	206	78.9
Total # of Sites	261	100.0

Figure 5. Aquatic plant grid illustrating plant on Bangs Lake, May 2005.

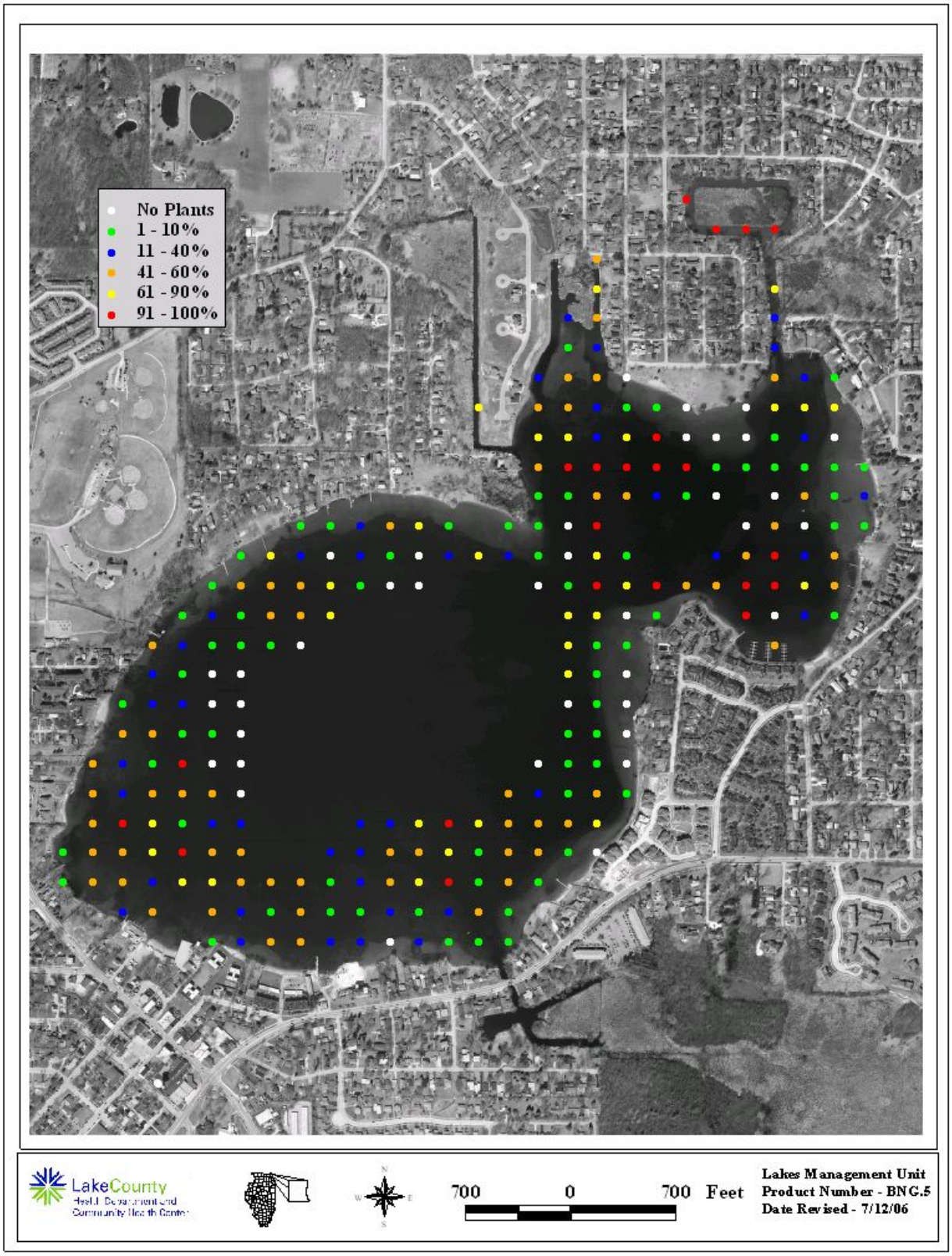

Figure 6. Aquatic plant sampling grid illustrating plant density on Bangs Lake, August 2005.

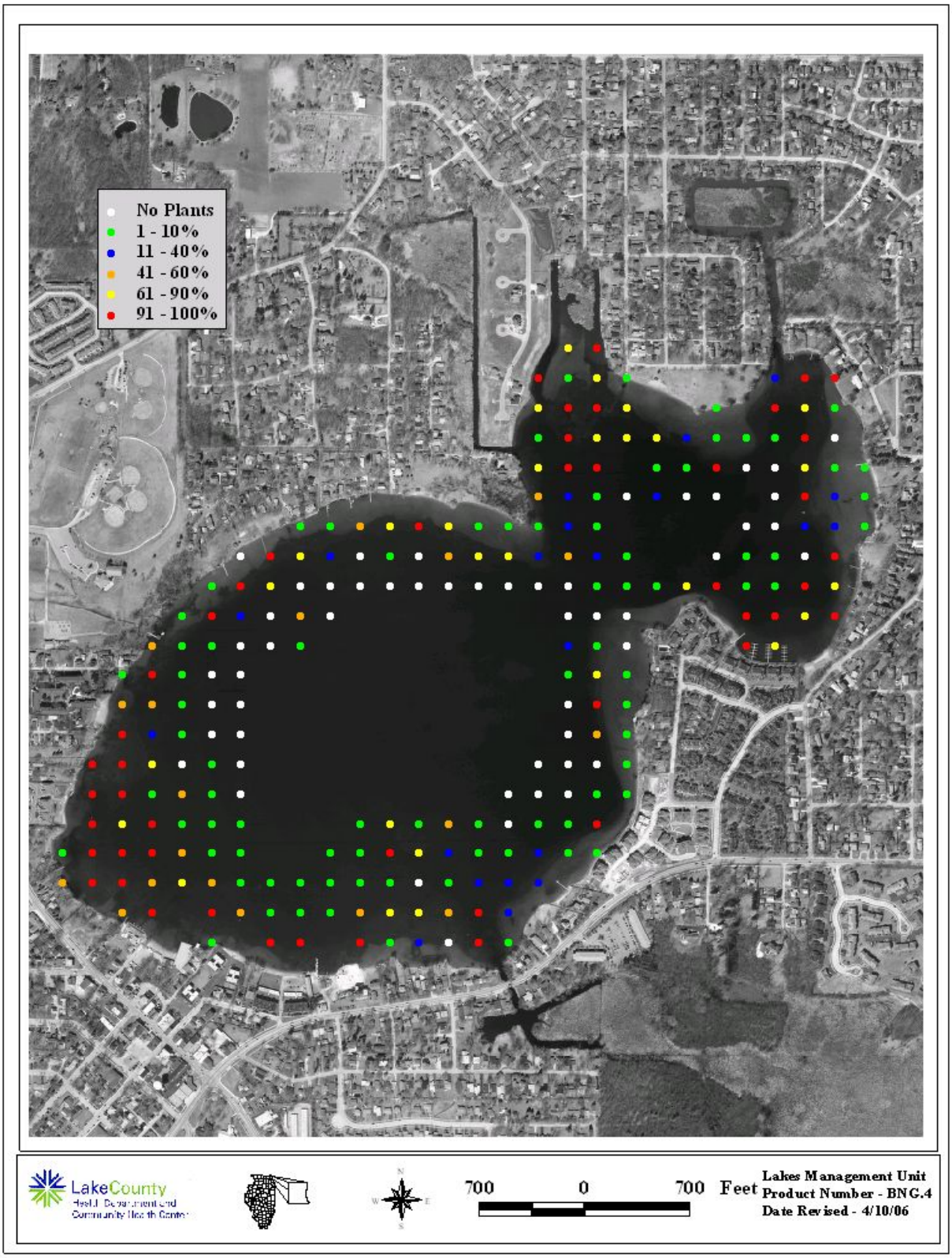

Figure 7. Extent of the navigational impairment on Bangs Lake July 2005.

Figure 8. Shoreline erosion on Bangs Lake, 2005.

LAKE MANAGEMENT RECOMMENDATIONS

Overall Bangs Lake's water clarity has remained stable in recent years and in fact as increased, most likely due to the zebra mussels in the lake. Dissolved oxygen concentrations are good and nuisance algae blooms are minimal. The state of the lake's fishery appears well balanced. However, there are several of recommendations that will aid in improving the overall quality of Bangs Lake (see Appendix D for more details).

Shoreline erosion

There are still some areas around the lake with erosion, including areas not previously identified in 2002. These eroded areas should be remediated to prevent additional loss of shoreline and continued degradation of the water quality through sediment inputs. When possible, the shorelines should be repaired using natural vegetation instead of riprap or seawalls.

Increasing conductivity readings

Conductivity readings in Bangs Lake have increased slightly compared to past years. The 2005 epilimnetic average for conductivity was 0.6064 milliSiemens/cm, which is 9.5% higher than the 2002 average (0.5538 milliSiemens/cm), however still below the county median of 0.7748 milliSiemens/cm. The most likely cause for these increases in conductivity readings is input from dissolved solids washed into the lake from storm events.

Monitor zebra mussel populations

Zebra mussels were first documented in Bangs Lake in 2003 and were found in large numbers in the lake in 2005. Zebra mussels were frequently found attached to plants during the season. While improved clarity is often viewed as a positive aspect, the filter feeding zebra mussel may have negative long-term impacts on the food chain. Efforts should be made to prevent their spread to other area lakes.

Wildlife habitat

With the lake being in a residential setting with the majority of the shoreline as riprap, seawall, or lawn, wildlife habitat is limited. Enhancing habitat for terrestrial wildlife such as birds and small mammals can be accomplished through the addition of shoreline buffer zones, which were noted on some lots, and are recommended as one aspect of shoreline protection. Most of the birds observed were those common to residential settings.

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 (ArcGIS 3.2) overlaid a grid pattern onto a 2004 aerial photo of Lake County and placed points 60 meters apart. Plants were sampled using a garden rake fitted with hardware cloth. The hardware cloth surrounded the rake tines and is tapered two feet up the handle. A rope was tied to the end of the handle for retrieval. At designated sampling sites, the rake was tossed into the water, and using the attached rope, was dragged across the bottom, toward the boat. After pulling the rake into the boat, plant coverage was assessed for overall abundance. Then plants were individually identified and placed in categories based on coverage. Plants that were not found on the rake but were seen in the immediate vicinity of the boat at the time of sampling were also recorded. Plants difficult to identify in the field were placed in plastic bags and identified with plant keys after returning to the office. The depth of each sampling location was measured either by a hand-held depth meter, or by pushing the rake straight down and measuring the depth along the rope or rake handle. One-foot increments were marked along the rope and rake handle to aid in depth estimation.

Plankton Sampling

Plankton was sampled at the same location as water quality samples. Using the Hydrolab DataSonde® 4a 1% light level depth (depth where the water light is 1% of the surface irradiance) was determined. A plankton net/tow, with 80μm mesh, was then lowered to the pre-determined 1% light level depth and retrieved vertically. On the way up the water column, plankton are collected within a small cup on the bottom of the tow. The collected sample was then emptied into a pre-labeled brown plastic bottle. The net was rinsed with deionized water into the bottle in order to ensure all the plankton were collected. The sample was then transferred to a graduated cylinder to measure the amount of milliliters (mL) that the sample was. The sample was then returned to the bottle and preserved with Lugol's iodine solution (5 drops/mL). The sample bottle was then closed and stored in a cooler until returning to the lab, where it was transferred to the refrigerator until enumeration. Enumeration was performed within three months, but ideally

within one month, under a microscope. Sample bottle was inverted several times to ensure proper homogenization. An automated pipette was used to retrieve 1 mL of sample, which was then placed on a Sedgewick Rafter slide. This is a microscope slide on which a rectangular chamber has been constructed, measuring 50 mm x 20 mm in area and with a depth of 1 mm. The slide was then placed under the microscope and counted at a 20X magnification. Twenty fields of view were randomly counted with all species within each field counted. Through calculations, it was determined how many of each species were in 1 mL of lake water.

Shoreline Assessment

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

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

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

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

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

Wildlife Assessment

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

Table A1. Analytical methods used for water quality parameters.

Parameter	***Method***
Temperature	Hydrolab DataSonde® 4a or YSI 6600 Sonde®
Dissolved oxygen	Hydrolab DataSonde ®4a or YSI 6600 Sonde®
Nitrate nitrogen	Brucine method Standard Methods (SM) 14th ed 419D 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 BANGS LAKE IN 2005

Date MMDDYY	Time HHMMSS	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission	Extinction Coefficient
											Average	0.77
41205	84529	0.25	0.52	12.87	10.12	99.10	0.5871	8.08	262	Surface		
41205	84710	1	1.06	12.89	10.03	98.20	0.5870	8.09	215	Surface	100%	
41205	84832	2	1.96	12.88	9.97	97.70	0.5871	8.10	55	0.21	26%	6.49
41205	84913	3	3.04	12.90	9.96	97.60	0.5874	8.09	46	1.29	21%	0.17
41205	85004	4	4.05	12.88	10.08	98.70	0.5875	8.09	54	2.3	25%	-0.16
41205	85057	6	6.04	12.89	10.05	98.40	0.5875	8.09	23	4.29	11%	0.43
41205	85141	8	8.04	12.90	10.06	98.60	0.5876	8.09	20	6.29	9%	0.07
41205	85305	10	10.03	12.90	10.01	98.10	0.5876	8.10	12	8.28	6%	0.26
41205	85413	12	12.05	12.90	9.90	97.00	0.5875	8.10	6	10.3	3%	0.34
41205	85457	14	14.09	12.90	9.90	97.00	0.5876	8.10	2	12.34	1%	0.54
41205	85832	16	15.99	12.89	9.83	96.30	0.5880	8.14	1	14.24	0%	0.36
41205	90322	18	17.98	12.88	9.79	95.90	0.5876	8.15	1	16.23	0%	0.00
41205	90506	20	19.97	12.72	9.35	91.20	0.5877	8.12	1	18.22	0%	0.00
41205	90654	22	22.02	11.69	8.08	77.00	0.5910	7.97	0	20.27	0%	
41205	90808	24	23.99	11.44	7.38	69.90	0.5928	7.88	0	22.24	0%	
41205	90918	26	26.00	10.98	5.70	53.50	0.5950	7.70	0	24.25		
41205	91200	28	28.07	9.86	2.98	27.20	0.6040	7.54	0	26.32		
41205	91331	30	30.01	9.76	2.46	22.40	0.6049	7.49	0	28.26		

Date MMDDYY	Time HHMMSS	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission	Extinction Coefficient
											Average	0.57
51805	91616	0	0.35	14.95	10	101.9	0.5947	6.98	1790	Surface		
51805	91741	1	1.12	14.93	10.05	102.3	0.595	7.35	1891	Surface	100%	
51805	91907	2	1.93	14.93	10.01	101.9	0.5951	7.51	463	0.18	24%	7.82
51805	92037	3	3.04	14.93	9.92	101	0.5948	7.61	599	1.29	32%	-0.23
51805	92148	4	4.04	14.93	9.9	100.8	0.5948	7.67	784	2.29	41%	-0.27
51805	92250	6	6.03	14.93	9.85	100.2	0.5948	7.7	799	4.28	42%	-0.01
51805	92359	8	7.95	14.92	9.85	100.2	0.5947	7.73	505	6.2	27%	0.24
51805	92513	10	10.03	14.91	9.81	99.8	0.5944	7.77	387	8.28	20%	0.13
51805	92622	12	11.98	14.84	9.8	99.6	0.5945	7.79	322	10.23	17%	0.09
51805	92722	14	14	14.55	9.75	98.4	0.5942	7.8	135	12.25	7%	0.43
51805	92816	16	15.98	13.95	9.49	94.6	0.5946	7.78	97	14.23	5%	0.17
51805	92937	18	17.99	13.88	9.32	92.7	0.5949	7.77	76	16.24	4%	0.12
51805	93055	20	20.02	13.81	9.11	90.7	0.5954	7.77	57	18.27	3%	0.14
51805	93151	22	22	13.74	9.27	91.9	0.5944	7.78	50	20.25	3%	0.07
51805	93256	24	23.98	13.66	9.2	91.1	0.595	7.78	42	22.23	2%	0.09
51805	93402	26	25.98	13.62	8.93	88.2	0.5956	7.76	32	24.23	2%	0.14
51805	93513	28	28.01	13.6	8.25	81.6	0.5969	7.72	25	26.26	1%	0.12
51805	93746	30	30.04	13.53	7.47	73.7	0.5987	7.66	22	28.29	1%	0.06

Date MMDDYY	Time HHMMSS	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission	Extinction Coefficient
											Average	0.39
62205	110437	0.25	0.51	24.56	7.72	94.9	0.583	8.17	3739	Surface		
62205	110538	1	0.96	24.57	7.71	94.7	0.5825	8.18	3744	Surface	100%	
62205	110630	2	2.04	24.58	7.67	94.3	0.5827	8.19	1657	0.29	44%	2.81
62205	110712	3	3.01	24.58	7.62	93.4	0.5824	8.19	1539	1.26	41%	0.08
62205	110757	4	3.95	24.57	7.57	93	0.5825	8.19	856	2.2	23%	0.62
62205	110848	6	5.98	24.52	7.49	92	0.5828	8.19	1107	4.23	30%	-0.13
62205	110933	8	7.85	24.43	7.51	92.1	0.5826	8.18	649	6.1	17%	0.29
62205	111048	10	9.99	23.94	6.88	83.6	0.5833	8.13	456	8.24	12%	0.16
62205	111150	12	11.99	22.88	6.19	73.7	0.582	8.07	351	10.24	9%	0.13
62205	111248	14	14.03	22.11	4.88	57.2	0.5855	7.92	285	12.28	8%	0.10
62205	111421	16	16.01	20.22	2.79	31.5	0.5926	7.62	197	14.26	5%	0.19
62205	111530	18	18.05	17.69	2.54	27.3	0.5986	7.52	140	16.3	4%	0.17
62205	111723	20	19.99	16.45	0.92	9.6	0.606	7.34	97	18.24	3%	0.19
62205	111829	22	22.03	16.09	0.5	5.2	0.6078	7.28	72	20.28	2%	0.15
62205	111926	24	24.04	15.71	0.23	2.4	0.6081	7.24	35	22.29	1%	0.36
62205	112018	26	26.03	14.72	0.09	0.9	0.6131	7.22	17	24.28	0%	0.36
62205	112144	28	28	14.55	0.08	0.8	0.6156	7.2	9	26.25	0%	0.32
62205	112237	30	29.98	14.45	0.07	0.7	0.6164	7.18	4	28.23	0%	0.41

Date MMDDYY	Time HHMMSS	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission	Extinction Coefficient
											Average	0.49
72005	103505	0.25	0.44	27.46	7.38	96.1	0.6092	7.99	4285	Surface		
72005	103614	1	1.02	27.47	7.39	96.2	0.6091	8.03	3741	Surface	100%	
72005	103732	2	2	27.46	7.41	96.5	0.609	8.06	1772	0.25	47%	2.99
72005	103845	3	2.89	27.47	7.36	95.9	0.6089	8.07	1294	1.14	35%	0.35
72005	104017	4	3.96	27.47	7.23	94.2	0.6089	8.08	662	2.21	18%	0.63
72005	104138	6	6.03	27.46	7.38	96.2	0.6089	8.09	489	4.28	13%	0.15
72005	104245	8	8.05	27.45	7.37	95.9	0.6088	8.09	398	6.3	11%	0.10
72005	104423	10	9.86	27.46	7.52	97.9	0.6091	8.09	305	8.11	8%	0.15
72005	104528	12	11.93	27.42	7.19	93.6	0.609	8.09	162	10.18	4%	0.31
72005	104631	14	14.03	27.41	7.26	94.4	0.6088	8.09	100	12.28	3%	0.23
72005	104741	16	15.96	27.27	7.11	92.3	0.6091	8.07	64	14.21	2%	0.23
72005	105000	18	18.17	26.56	4.51	57.9	0.6077	7.82	48	16.42	1%	0.13
72005	105134	20	20	20.96	0.19	2.2	0.615	7.43	43	18.25	1%	0.06
72005	105309	22	21.86	18.82	0.06	0.7	0.6234	7.29	20	20.11	1%	0.41
72005	105417	24	23.98	16.41	0.05	0.5	0.6298	7.23	5	22.23	0%	0.65
72005	105528	26	25.92	15.52	0.04	0.4	0.6376	7.15	1	24.17	0%	0.83

Date MMDDYY	Time HHMMSS	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission	Extinction Coefficient
											Average	0.57
81805	145944	0.25	0.29	26.02	7.69	98.3	0.6108	8.6	3436	Surface		
81805	150041	1	1.01	26.01	7.66	97.9	0.6104	8.61	3484	Surface	100%	
81805	150146	2	2.15	26	7.63	97.6	0.6102	8.64	677	0.4	19%	4.10
81805	150250	3	2.94	25.99	7.67	98	0.61	8.67	313	1.19	9%	0.98
81805	150342	4	3.97	25.97	7.5	95.8	0.6099	8.72	219	2.22	6%	0.35
81805	150607	6	6	25.96	7.55	96.4	0.6101	8.8	210	4.25	6%	0.02
81805	150738	8	8.06	25.89	7.43	94.8	0.6099	8.85	160	6.31	5%	0.13
81805	150902	10	10.01	25.87	7.56	96.3	0.6098	8.88	135	8.26	4%	0.09
81805	151057	12	12.01	25.84	7.57	96.5	0.6088	8.88	86	10.26	2%	0.23
81805	151249	14	14.12	25.77	7.53	95.8	0.6087	8.88	54	12.37	2%	0.22
81805	151357	16	16.02	25.6	6.26	79.5	0.6106	8.72	34	14.27	1%	0.24
81805	151528	18	17.94	24.66	2.23	27.9	0.6201	8.06	22	16.19	1%	0.23
81805	151805	20	20.05	24.07	0.13	1.7	0.6225	7.82	11	18.3	0%	0.33
81805	151931	22	22.01	23.07	0.09	1.1	0.6304	7.75	4	20.26	0%	0.52
81805	152102	24	24.01	18.09	0.11	1.2	0.6539	7.7	4	22.26	0%	0.00
81805	152216	26	26.05	16.97	0.11	1.1	0.6678	7.69	1	24.3	0%	0.68
81805	152312	28	28	16.44	0.1	1.1	0.6739	7.66	0	26.25	0%	

Date MMDDYY	Time HHMMSS	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission	Extinction Coefficient
											Average	0.61
92105	94414	0.25	0.33	22.52	7.59	90	0.6216	8.64	3445	Surface		
92105	94515	1	1.03	22.52	7.5	88.9	0.6213	8.65	3352	Surface	100%	
92105	94620	2	2.01	22.54	7.4	87.7	0.6211	8.66	1218	0.26	36%	3.89
92105	94715	3	3	22.54	7.18	85.1	0.6211	8.67	689	1.25	21%	0.58
92105	94825	4	3.96	22.51	7.1	84.2	0.6213	8.69	523	2.21	16%	0.29
92105	94934	6	5.98	22.51	7.44	88.2	0.6214	8.7	222	4.23	7%	0.42
92105	95029	8	7.99	22.45	7.17	84.9	0.6215	8.71	126	6.24	4%	0.28
92105	95123	10	10	22.39	6.98	82.5	0.6216	8.71	70	8.25	2%	0.29
92105	95240	12	11.97	22.37	6.94	82	0.6214	8.73	33	10.22	1%	0.38
92105	95336	14	13.99	22.36	6.83	80.7	0.6213	8.72	19	12.24	1%	0.27
92105	95426	16	15.99	22.2	6.14	72.3	0.6229	8.62	11	14.24	0%	0.27
92105	95529	18	18.02	22.05	5.54	65.1	0.6242	8.56	6	16.27	0%	0.30
92105	95633	20	19.95	21.88	4.25	49.7	0.6265	8.32	3	18.2	0%	0.36
92105	95742	22	22.01	21.75	2.65	31.1	0.6284	8.12	1	20.26	0%	0.53
92105	95839	24	24.02	21.68	2.11	24.6	0.6293	8.05	1	22.27	0%	0.00
92105	95936	26	25.96	21.12	0.19	2.2	0.6364	7.83	1	24.21	0%	0.00
92105	100032	28	27.96	20.79	0.1	1.2	0.6416	7.78	1	26.21	0%	0.00

Date MMDDYY	Time HHMMSS	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission	Extinction Coefficient
											Average	0.59
101905	104902	0.25	0.39	15.28	8.28	85.4	0.641	8.33	3815	Surface		
101905	104934	1	1.01	15.28	8.26	85.1	0.6408	8.35	3764	Surface	100%	
101905	105015	2	2	15.29	8.18	84.3	0.6406	8.37	1078	0.25	29%	5.00
101905	105100	3	2.97	15.28	8.16	84.1	0.6405	8.37	1031	1.22	27%	0.05
101905	105146	4	4.02	15.29	8.09	83.4	0.6403	8.38	677	2.27	18%	0.40
101905	105253	6	6.01	15.26	8.08	83.2	0.6401	8.38	430	4.26	11%	0.23
101905	105351	8	7.88	15.28	8.08	83.3	0.64	8.4	296	6.13	8%	0.20
101905	105524	10	10.03	15.22	8.03	82.7	0.6396	8.43	174	8.28	5%	0.25
101905	105624	12	11.96	15.2	8.02	82.5	0.6399	8.45	119	10.21	3%	0.20
101905	105737	14	13.95	15.16	7.99	82.2	0.6399	8.45	66	12.2	2%	0.30
101905	105839	16	15.96	15.15	7.87	80.8	0.6401	8.46	34	14.21	1%	0.33
101905	105939	18	17.84	15.14	7.97	81.9	0.6404	8.46	32	16.09	1%	0.03
101905	110027	20	19.92	15.13	7.77	79.8	0.6403	8.46	20	18.17	1%	0.23
101905	110139	22	21.92	15.11	7.7	79.1	0.6404	8.44	13	20.17	0%	0.22
101905	110303	24	23.95	15.02	7.37	75.5	0.6408	8.4	8	22.2	0%	0.24
101905	110459	26	25.96	15.02	7.41	75.9	0.6408	8.39	6	24.21	0%	0.14

APPENDIX C. INTERPRETING YOUR LAKE'S WATER QUALITY DATA

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

The following pages will discuss the different water quality parameters measured by Lake County Health Department staff, how these parameters relate to each other, and why the measurement of each parameter is important. The median values (the middle number of the data set, where half of the numbers have greater values, and half have lesser values) of data collected from Lake County lakes from 2000-2005 will be used in the following discussion.

Temperature and Dissolved Oxygen:

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

Monthly temperature profiles were established on each lake by measuring water temperature every foot (lakes $\leq$ 15 feet deep) or every two feet (lakes > 15 feet deep) from the lake surface to the lake bottom. These profiles are important in understanding the distribution of chemical/biological characteristics and because increasing water temperature and the establishment of thermal stratification have a direct impact on dissolved oxygen (DO) concentrations in the water column. If a lake is shallow and easily mixed by wind, the DO concentration is usually consistent throughout the water column. However, shallow lakes are typically dominated by either plants or algae, and increasing water temperatures during the summer speeds up the rates of photosynthesis and decomposition in surface waters. When many of the plants or algae die at the end of the growing season, their decomposition results in heavy oxygen consumption and can lead to an oxygen crash. In deeper, thermally stratified lakes, oxygen production is greatest in the top portion of the lake, where sunlight drives photosynthesis, and oxygen consumption is greatest near the bottom of a lake, where sunken organic matter accumulates and decomposes. The oxygen difference between the top and bottom water layers can be dramatic, with plenty of oxygen near the surface, but practically none near the bottom. The oxygen profiles measured during the water quality study can illustrate if

this is occurring. This is important because the absence of oxygen (anoxia) near the lake bottom can have adverse effects in eutrophic lakes resulting in the chemical release of phosphorus from lake sediment and the production of hydrogen sulfide (rotten egg smell) and other gases in the bottom waters. Low oxygen conditions in the upper water of a lake can also be problematic since all aquatic organisms need oxygen to live. Some oxygen may be present in the water, but at too low a concentration to sustain aquatic life. Oxygen is needed by all plants, virtually all algae and for many chemical reactions that are important in lake functioning. Most adult sport-fish such as largemouth bass and bluegill require at least 3 mg/L of DO in the water to survive. However, their offspring require at least 5 mg/L DO as they are more sensitive to DO stress. When DO concentrations drop below 3 mg/L, rough fish such as carp and green sunfish are favored and over time will become the dominant fish species.

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

Nutrients:

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

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

it moves into the sunlit surface water at that time. Accordingly, many of the lakes in Lake County are plagued by dense algae blooms and excessive, exotic plant coverage, which negatively affect DO levels, fish communities and water clarity.

Lakes with an average phosphorus concentration greater than 0.05 mg/L are considered nutrient rich. The median near surface total phosphorus (TP) concentration in Lake County lakes from 2000-2005 is 0.063 mg/L and ranged from a non-detectable minimum of <0.010 mg/L on five lakes to a maximum of 3.880 mg/L on Albert Lake. The median anoxic TP concentration in Lake County lakes from 2000-2005 was 0.174 mg/L and ranged from a minimum of 0.012 mg/L in West Loon Lake to a maximum of 3.880 mg/L in Taylor Lake.

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

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

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

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

Solids:

Although several forms of solids (total solids, total suspended solids, total volatile solids, total dissolved solids) were measured each month by the Lakes Management Staff, total suspended solids (TSS) and total volatile solids (TVS) have the most impact on other variables and on the lake as a whole. TSS are particles of algae or sediment suspended in the water column. High TSS concentrations can result from algae blooms, sediment resuspension, and/or the inflow of turbid water, and are typically associated with low water clarity and high phosphorus concentrations in many lakes in Lake County. Low water clarity and high phosphorus concentrations, in turn, exacerbate the high TSS problem by leading to reduced plant density (which stabilize lake sediment) and increased occurrence of algae blooms. The median TSS value in epilimnetic waters in Lake County is 7.9 mg/L, ranging from below the 1 mg/L detection limit (10 lakes) to 165 mg/L in Fairfield Marsh.

TVS represents the fraction of total solids that are organic in nature, such as algae cells, tiny pieces of plant material, and/or tiny animals (zooplankton) in the water column. High TVS values indicate that a large portion of the suspended solids may be made up of algae cells. This is important in determining possible sources of phosphorus to a lake. If much of the suspended material in the water column is determined to be resuspended sediment that is releasing phosphorus, this problem would be addressed differently than if the suspended material was made up of algae cells that were releasing phosphorus. The median TVS value was 132 mg/L, ranging from 34 mg/L in Pulaski Pond to 298 mg/L in Fairfield Marsh.

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

Water Clarity:

Water clarity (transparency) is not a chemical property of lake water, but is often an indicator of a lake's overall water quality. It is affected by a lake's water color, which is a reflection of the amount of total suspended solids and dissolved organic chemicals. Thus, transparency is a measure of particle concentration and is measured with a Secchi disk. Generally, the lower the clarity or Secchi depth, the poorer the water quality. A decrease in Secchi depth during the summer occurs as the result of an increase in suspended solids (algae or sediment) in the water column. Aquatic plants play an important role in the level of water clarity and can, in turn, be negatively affected by low clarity levels. Plants increase clarity by competing with algae for

resources and by stabilizing sediments to prevent sediment resuspension. A lake with a healthy plant community will almost always have higher water clarity than a lake without plants. Additionally, if the plants in a lake are removed (through herbicide treatment or the stocking of grass carp), the lake will probably become dominated by algae and Secchi depth will decrease. This makes it very difficult for plants to become re-established due to the lack of available sunlight and the lake will, most likely, remain turbid. Turbidity will be accelerated if the lake is very shallow and/or common carp are present. Shallow lakes are more susceptible to sediment resuspension through wind/wave action and are more likely to experience clarity problems if plants are not present to stabilize bottom sediment.

Common Carp are prolific fish that feed on invertebrates in the sediment. Their feeding activities stir up bottom sediment and can dramatically decrease water clarity in shallow lakes. As mentioned above, lakes with low water clarity are, generally, considered to have poor water quality. This is because the causes and effects of low clarity negatively impact the plant and fish communities, as well as the levels of phosphorus in a lake. The detrimental impacts of low Secchi depth to plants has already been discussed. Fish populations will suffer as water clarity decreases due to a lack of food and decreased ability to successfully hunt for prey. Bluegills are planktivorous fish and feed on invertebrates that inhabit aquatic plants. If low clarity results in the disappearance of plants, this food source will disappear too. Largemouth Bass and Northern Pike are piscivorous fish that feed on other fish and hunt by sight. As the water clarity decreases, these fish species find it more difficult to see and ambush prey and may decline in size as a result. This could eventually lead to an imbalance in the fish community. Phosphorus release from resuspended sediment could increase as water clarity and plant density decrease. This would then result in increased algae blooms, further reducing Secchi depth and aggravating all problems just discussed. The average Secchi depth for Lake County lakes is 3.17 feet. From 2000-2005, Fairfield Marsh and Patski Pond had the lowest Secchi depths (0.33 feet) and Bangs Lake had the highest (29.23 feet). As an example of the difference in Secchi depth based on plant coverage, South Churchill Lake, which had no plant coverage and large numbers of Common Carp in 2003 had an average Secchi depth of 0.73 feet (over four times lower than the county average), while Deep Lake, which had a diverse plant community and few carp had an average 2003 Secchi depth of 12.48 feet (almost four times higher than the county average).

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

Alkalinity, Conductivity, Chloride, pH:

Alkalinity:

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

Conductivity and Chloride:

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

pH:
pH is the measurement of hydrogen ion (H^+) activity in water. The pH of pure water is neutral at 7 and is considered acidic at levels below 7 and basic at levels above 7. Low pH levels of 4-5 are toxic to most aquatic life, while high pH levels (9-10) are not only toxic to aquatic life but may also result in the release of phosphorus from lake sediment. The presence of high plant densities can increase pH levels through photosynthesis, and lakes dominated by a large amount of plants or algae can experience large fluctuations in pH levels from day to night, depending on the rates of photosynthesis and respiration. Few, if any pH problems exist in Lake County lakes. Typically, the flooded gravel mines in the county are more acidic than the glacial lakes as they have less biological activity, but do not usually drop below pH levels of 7. The median near surface pH value of Lake County lakes is 8.30, with a minimum of 7.06 in Deer Lake and a maximum of 10.28 in Round Lake Marsh North.

Eutrophication and Trophic State Index:

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

The Trophic State Index (TSI) is an index which attaches a score to a lake based on its average

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

Table 1. Trophic State Index (TSI).

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

APPENDIX D. LAKE MANAGEMENT OPTIONS.

D1. 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.

D2. Options for Watershed Nutrient Reduction

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

Option 1. Buffer Strips

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

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

a. Compost yard waste instead of burning. Ashes from yard waste contain nutrients and are easily washed into a lake.
b. Avoid dumping yard waste along or into a ditch, pond, lake, or stream. As yard waste decomposes, the nutrients are released directly into the water, or flushed to the lake via the ditch.
c. Avoid applying fertilizer up to the water's edge. Leave a buffer strip of at least 25 feet of unfertilized yard before the shoreline.

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

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

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

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

Option 3. Street Sweeping

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

Option 4: Reduce Stormwater Volume from Impervious Surfaces

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

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

Option 5: Required Practices for Construction

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

Option 6. Organize a Local Watershed Organization

A watershed organization can be instrumental in circulating educational information about watersheds and how to care for them. Often a galvanized organization can be a stronger working unit and a stronger voice than a few individuals. Watershed residents are the first to notice problems in the area, such as a lack of erosion control at construction sites. This organization would be an advocate for the watershed, and

members could voice their concerns about future development impacts to local officials. This organization could educate the community about how phosphorus (and other pollutants) affect lakes and can help people implement watershed controls. Several types of educational outreaches can be used together for best results. These include: community newsletters, newspaper articles, local cable and radio station announcements. In some cases fundraising may be utilized to secure more funding for a project.

Option 7. Motor Boat Restrictions for Shallow Lakes

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

Option 8. Discourage Waterfowl from Congregating

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

D3. Options for Watershed Sediment Reduction

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

Option 1. Municipal Street Sweeping

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

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

Please refer to the Watershed Development Ordinance for requirements.

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

Option 3. Agricultural Practices

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

D4. Options to Enhance Wildlife Habitat Conditions on a Lake

Option 1: Increase Habitat Cover

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

Brush piles also make excellent wildlife habitat. They provide cover as well as food resources for many species. Brush piles are easy to create and will last for several years. They should be place at least 10 feet away from the shoreline to prevent any debris from

washing into the lake. Trees that have fallen on the ground or into the water are beneficial by harboring food and providing cover for many wildlife species. In a lake, fallen trees provide excellent cover for fish, basking sites for turtles, and perches for herons and egrets. Increasing habitat cover should not be limited to the terrestrial environment. Native aquatic vegetation, particularly along the shoreline, can provide cover for fish and other wildlife. Finally, by increasing habitat, wildlife is attracted to and uses the area as a place to raise their young. However, if vegetation is allowed to grow, lake access and visibility may be limited. If this occurs, a small path can be made to the shoreline.

Option 2: Increase Natural Food Supply

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

Option 3: Limit Disturbance

Since most species of wildlife are susceptible to human disturbance, any action to curtail disturbances is beneficial. Limiting disturbance can include posting signs in areas of the lake where wildlife may live (e.g., nesting waterfowl), establish a "no wake" area, boat horsepower or speed limits, or establish restricted boating hours. These are examples of time and space zoning for lake usage. Enforcement and public education are needed if this option is to be successful. In some areas, off-duty law enforcement officers can be hired to patrol the lake.
Limiting disturbance will increase the chance that wildlife will use the lake, particularly for raising their young. Many wildlife species have suffered population declines due to loss of habitat and poor breeding success. This is due in part to their sensitivity to disturbance. Recreation activities such as canoeing and paddleboating may be enhanced by the limited disturbance.

One of the strongest opponents to this option would probably be the powerboat users and water skiers. However, this problem may be solved if a significant portion of the daylight hours and the use of the middle part of the lake (assuming the lake is deep enough) are allowed for powerboating. For example, powerboating could be allowed between 9 AM and 6 PM within the boundaries established by "no wake" restricted area buoys.

D5. Zebra Mussels

Zebra Mussels get their name from the alternating black and white stripped pattern on their shells. They have spread extensively in the Great Lakes region in the past decade. They attach themselves to any solid underwater object such as boat hulls, piers, intake pipes, plants, other bivalves (mussels), and even other Zebra Mussels. Zebra Mussels originated from Eastern Europe, specifically the Black and Caspian Seas. By the mid 18th and 19th centuries they had spread to most of Europe. The mussels were believed to have been spread to this country in the mid 1980s by cargo ships that discharged their ballast water into the Great Lakes. They were first discovered in Lake St. Clair (the body of water that connects lakes Erie and Huron) in June of 1988. The mussels then spread to the rest of the Great Lakes. The first sighting in Lake Michigan was in June 1989. By 1990, Zebra Mussels had been found in all of the Great Lakes. By 1991 they had made their way into the adjacent waters of the Great Lakes such as the Illinois River, which eventually led to their spread into the Mississippi River and all the way down to the Gulf of Mexico. Other states in the Midwest have also experienced Zebra Mussel infestations of their inland lakes. Southeastern Wisconsin has about a dozen lakes infested and Michigan has about 100 infested lakes. Even though they are a fresh water mussel they have also been found in brackish (slightly saline) water and they can even live out of the water for up to 10 days at high humidity and cool temperatures. At average summer temperatures, Zebra Mussels can survive out of water for an average of five days.

The Zebra Mussels reproductive cycle allows for rapid expansion of the population. A mature female can produce up to 40,000 eggs in a cycle and up to one million in a season. Eggs hatch within a few days and young larvae (called veligers) are free floating for up to 33 days, carried along on water currents. This allows for the distribution of larvae to uninfected areas, which accelerates their spread. The larvae attach themselves by a filamentous organ (called a byssus) near their foot. Once attached to a solid surface, larvae develop into a double shelled adult within three weeks and are capable of reproduction in a year. Zebra Mussels can live as long as five years and have an average life span of about 3.5 years. The adults are typically about the size of a thumb nail but can grow as large as 2 inches in diameter. Colonies can reach densities of 30,000 - 70,000 mussels per square meter.

Due to their quick life cycle and explosive growth rate, Zebra Mussels can quickly edge out native mussel species. Negative impacts on native bivalve populations include interference with feeding, habitat, growth, movement, and reproduction. Some native species of bivalves have been found with 10,000 Zebra Mussels attached to them. Many of these native, rare, threatened and endangered bivalve species may not be able to survive if Zebra Mussels populations continue to expand. The impact that the mussels have on fish populations is not fully understood. However, they feed on phytoplankton (algae), which is also a major food source for planktivorous fish, such as Bluegill. These fish, in turn, are a food source for piscivorus fish (fish eating fish), such as Largemouth Bass and Northern Pike. Concern has also arisen over the concentration of pollutants found in Zebra Mussels. Mussels are filter feeders, taking up water and sediment containing pollutants, which then builds to high concentrations in their tissue

(bioaccumulation). Due to the large number of mussels that are consumed by fish, concentrations of pollutants are even higher in the fish (biomagnification), which are potentially consumed by humans.

In addition to the ecological impacts, there are also many economical concerns. Zebra Mussels have caused major problems for industrial complexes located on the Great Lakes and associated bodies of water. Mussels can clog water intakes of power plants, public water supplies, and other industrial facilities. This can reduce water flow (by as much as two-thirds) to heat exchangers, condensers, fire fighting equipment, and air conditioning systems. Zebra Mussels can infest inboard motor intakes and can actually grow inside the motor, causing considerable damage. Navigational buoys have sunk due to the weight of attached mussels. Corrosion of concrete and steel, which can lead to loss of structural integrity, can occur from long-term mussel attachment. A Michigan-based paper company recently reported that it had spent 1.4 million dollars in removing only 400 cubic yards of Zebra Mussels. It has been estimated that billions of dollars have been incurred in removal efforts and in damage to factories, water supply companies, power plants, ships, and the fishing industry. There are several methods of control, which include both removal and eradication. Many are site specific, so control methods are often dictated by the situation. These control methods include chemical molluscicides, manual removal, thermal irritation, acoustical vibration, toxic and non-toxic coatings, CO_2 injection, and ultraviolet light. Additionally, several biological controls are being investigated. However, there is currently no widespread/whole lake control practice that would be effective without harming other wildlife.

Surprisingly, some positive impacts have been observed from Zebra Mussel infestations. They are capable of filtering one liter of water per day. This water often contains sediment and phytoplankton, which contribute to turbidity. As a result, large infestations have brought about significant improvements in water clarity in some lakes. Due to severe mussel infestations, Lake Erie water clarity has increased four to six times what it was before Zebra Mussels invaded the lake (in addition to improvements as a result of pollution control measures). This has resulted in deeper penetration of light and an expansion of aquatic plant populations, something that has not been seen for decades. In turn, the increased plant growth is providing better fish habitat and better fishing. Unfortunately, the negative ecological and economical impacts associated with Zebra Mussels far outweigh any positive benefits.

Here are some tips from the Great Lakes Sea Grant Network that can help prevent the spread of Zebra Mussels:

- Flush clean water (tap) through the cooling system of your motor to rinse out any larvae.

- Drain all bilge water, live wells, bait buckets, and engine compartments. Make sure water is not trapped in your trailer.

- Always inspect your boat and boat trailer carefully before transporting.

- In their earlier stages, attached Zebra Mussels may not be easily seen. Pass your hand across the bottom of the boat - if it feels grainy, it is probably covered with mussels. Don't take a chance; clean them off by scraping or blasting.

- Full grown Zebra Mussels can be easily seen but cling stubbornly to surfaces. Carefully scrape the hull (or trailer), or use a high pressure spray (250 psi) to dislodge them. Or leave your boat out of the water for at least 10-14 days, preferably two weeks. The mussels will die and drop off.

- Dispose of the mussels in a trash barrel or other garbage container. Don't leave them on the shore where they could be swept back into the lake or foul the area.

- Before you leave the boat launch site, remove from the boat trailer any plant debris where tiny Zebra Mussels may be entangled.

- Always use extra caution when transporting bait fish from one lake to another. You could be carrying microscopic veligers. To be safe, do not take water from one lake to another.

- Certain polymer waxes discourage zebra Mussels from attaching. But check your hull periodically because the mussels cling to drain holes and speedometer brackets.

APPENDIX E. WATER QUALITY STATISTICS FOR ALL LAKE COUNTY LAKES

2000 - 2005 Water Quality Parameters, Statistics Summary

	ALK (oxic) <=3ft 2000-2005	
Average	**167.0**	
Median	**162.0**	
Minimum	**64.9**	**IMC**
Maximum	**330.0**	**Flint Lake**
STD	**42.2**	
n =	**803**	

	ALK (anoxic) 2000-2005	
Average	**205**	
Median	**194**	
Minimum	**103**	**Heron Pond**
Maximum	**470**	**Lake Marie**
STD	**53**	
n =	**265**	

	Cond (oxic) <=3ft 2000-2005	
Average	**0.8536**	
Median	**0.7748**	
Minimum	**0.2305**	**White Lake**
Maximum	**6.8920**	**IMC**
STD	**0.5203**	
n =	**808**	

	Cond (anoxic) 2000-2005	
Average	**0.9606**	
Median	**0.8210**	
Minimum	**0.3031**	**White Lake**
Maximum	**7.4080**	**IMC**
STD	**0.7611**	
n =	**265**	

	NO3-N (oxic) <=3ft 2000-2005	
Average	**0.480**	
Median	**0.116**	
Minimum	**<0.05**	***ND**
Maximum	**9.670**	**South Churchill Lake**
STD	**1.019**	
n =	**808**	

*ND = Many lakes had non-detects (69%)
Only compare lakes with detectable
concentrations to the statistics above

	NH3-N (anoxic) 2000-2005	
Average	**2.296**	
Median	**1.560**	
Minimum	**<0.1**	***ND**
Maximum	**18.400**	**Taylor Lake**
STD	**2.483**	
n =	**265**	

*ND = 21% Non-detects from 32 different lakes

	pH (oxic) <=3ft 2000-2005	
Average	**8.31**	
Median	**8.30**	
Minimum	**7.06**	**Deer Lake**
Maximum	**10.28**	**Round Lake Marsh North**
STD	**0.46**	
n =	**807**	

	pH (anoxic) 2000-2005	
Average	**7.11**	
Median	**7.13**	
Minimum	**5.80**	**Third Lake**
Maximum	**8.48**	**Heron Pond**
STD	**0.41**	
n =	**265**	

	All Secchi 2000-2005	
Average	**4.39**	
Median	**3.17**	
Minimum	**0.33**	**Fairfield Marsh, Patski Pond**
Maximum	**29.23**	**Bangs Lake**
STD	**3.65**	
n =	**740**	

81 of 161 lakes had anoxic conditions
Anoxic conditions are defined <=1 mg/l D.O.
pH Units are equal to the -Log of [H] ion activity
Conductivity units are in MilliSiemens/cm
Secchi Disk depth units are in feet
All others are in mg/L

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2000 - 2005 Water Quality Parameters, Statistics Summary continued

TKN (oxic)
<=3ft 2000-2005

Average	**1.457**	
Median	**1.220**	
Minimum	**<0.5**	***ND**
Maximum	**10.300**	**Fairfield Marsh**
STD	**0.831**	
n =	**808**	

*ND = 5% Non-detects from 19 different lakes

TKN (anoxic)
2000-2005

Average	**3.067**	
Median	**2.270**	
Minimum	**<0.5**	***ND**
Maximum	**21.000**	**Taylor Lake**
STD	**2.467**	
n =	**265**	

*ND = 5% Non-detects from 7 different lakes

TP (oxic)
<=3ft 2000-2005

Average	**0.098**	
Median	**0.063**	
Minimum	**<0.01**	**From 5 Lakes**
Maximum	**3.880**	**Albert Lake**
STD	**0.168**	
n =	**795**	

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

TP (anoxic)
2000-2005

Average	**0.320**	
Median	**0.174**	
Minimum	**0.012**	**West Loon Lake**
Maximum	**3.800**	**Taylor Lake**
STD	**0.412**	
n =	**265**	

TSS (all)
<=3ft 2000-2005

Average	**15.3**	
Median	**7.9**	
Minimum	**<0.1**	***ND**
Maximum	**165.0**	**Fairfield Marsh**
STD	**20.3**	
n =	**815**	

*ND = 2% Non-detects from 10 different lakes

TVS (oxic)
<=3ft 2000-2005

Average	**136.0**	
Median	**132.0**	
Minimum	**34.0**	**Pulaski Pond**
Maximum	**298.0**	**Fairfield Marsh**
STD	**40.4**	
n =	**758**	

No 2002 IEPA Chain Lakes

TDS (oxic)
<=3ft 2000-2004

Average	**470**	
Median	**454**	
Minimum	**150**	**Lake Kathryn, White**
Maximum	**1340**	**IMC**
STD	**169**	
n =	**745**	

No 2002 IEPA Chain Lakes, Data from 00-04.

CL (anoxic)
2004-2005

Average	**277**	
Median	**102**	
Minimum	**53**	**Banana Pond**
Maximum	**2390**	**IMC**
STD	**489**	
n =	**66**	

CL (oxic)
<=3ft 2004-2005

Average	**243.8**	
Median	**183.0**	
Minimum	**51.7**	**Heron Pond**
Maximum	**2760.0**	**IMC**
STD	**339.4**	
n =	**197**	

LakeCounty
Health Department and
Community Health Center

APPENDIX F. GRANT PROGRAM OPPORTUNITES

Table F1. A list of potential grant opportunities

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

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

Table F2. Grant Contacts

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

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

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

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

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

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

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

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

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

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

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

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

Other Related Contacts

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

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

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

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

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