2006 SUMMARY REPORT
of
Wooster Lake

Lake County, Illinois

Prepared by the

LAKE COUNTY HEALTH DEPARTMENT
ENVIRONMENTAL HEALTH SERVICES
LAKES MANAGEMENT UNIT

3010 Grand Avenue
Waukegan, Illinois 60085

Shaina Keseley
Michael Adam
Leonard Dane
Adrienne Orr

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LAKE FACTS

Lake Name:	Wooster Lake
Historical Name:	None
Nearest Municipality:	Round Lake, Fox Lake
Location:	T45N, R9E, Section 23
Elevation:	742.0 feet
Major Tributaries:	None
Watershed:	Fox River
Sub-watershed:	Fish Lake Drainage
Receiving Water body:	Duck Lake
Surface Area:	98.5 acres
Shoreline Length:	2.0 miles
Maximum Depth:	28.0 feet
Average Depth:	16.3 feet
Lake Volume:	1,634.9 acre-feet
Lake Type:	Glacial
Watershed Area:	4,657.0 acres
Major Watershed Land uses:	Agriculture, forest and grassland
Bottom Ownership:	Village of Round Lake and Private
Management Entities:	Village and Private
Current and Historical uses:	Fishing, swimming and boating
Description of Access:	No public access

In 2005, Wooster Lake was chosen to be one of seven "sentinel" lakes in the county that the Lakes Management Unit (LMU) will monitor annually for five years. This report summarizes the water quality sampling results and aquatic plant surveys conducted in 2006 on Wooster Lake. Similar reports have been written on data collected in 1999, 2003 and 2005 and are available from the LMU. The following report does not cover lake history and discussion of the watershed, as the previous reports have.

SUMMARY OF WATER QUALITY

Water samples were taken monthly from April through October at the deepest location in the lake (Figure 1). Two samples were taken; one from the upper water layer (epilimnion) and one from the lower water layer (hypolimnion). They were analyzed for nutrients, solids concentration, and other physical parameters. The epilimnion sample was taken from three feet each month, while the hypolimnion sample varied from 24-28 feet deep, as these samples are always taken three feet above the bottom, and the water level fluctuated throughout the season (Appendix A). Wooster Lake was stratified from May until September, with the strongest thermal stratification occurring in July and August. In 2006, all the lakes in the Fish Lake Drain (FLD) watershed were sampled including Duck Lake, Wooster Lake, Fischer Lake, Lake Christa, and Fish Lake. The results for all but Lake Christa will be referred to throughout this report (Appendix C).

Two swimming beaches were tested by the Lakes Management Unit (LMU) this summer. Both Holiday Park and Camp Henry Horner beaches received no closure recommendations (i.e. *E. coli* concentrations >235 colony forming units/100 mL). These beaches have been on the beach sampling program since 1988.

The average epilimnetic dissolved oxygen (DO) concentration was 8.45 mg/L (Table 1), with the highest reading in April (11.57 mg/L) and the lowest in September (5.80 mg/L). The average hypolimnetic DO concentration was 2.38 mg/L, with the highest reading in October (8.43 mg/L) and the lowest in September (0.08 mg/L). The hypoxic layer (where DO concentrations fall below 5.0 mg/L) went from non-existent in April to approximately 15 feet in May and then to it's lowest at approximately 11 feet in July (Appendix B). DO concentrations above 5.0 mg/L are recommended by the IDNR in order to sustain a healthy bass/sunfish fishery. Anoxic conditions (DO < 1.0 mg/L) were at 19 feet in May, and then peaked at 13 feet in June and stayed at that depth through July.

The average epilimnetic total suspended solids (TSS) concentration for Wooster Lake was 5.1 mg/L. This was below the county median of 7.9 mg/L (Appendix D), but was an increase from the 2005 value of 2.9 mg/L. In May, as stratification was setting up, TSS was highest (15.0 mg/L), while the TSS concentration in October was 1.6 mg/L. Directly upstream from Wooster Lake is Fischer Lake, which had a 2006 TSS concentration of 28.0 mg/L (Table 2). Fish Lake sits above Fischer Lake at the top of the watershed and had a 2006 TSS concentration of 11.0 mg/L. It was likely that the increase in TSS in Wooster Lake was the result of upstream sources. The FLD is currently undergoing significant land use changes, and it is strongly recommended that these be monitored to minimize degradation to the watershed's water quality.

Due to low TSS, Secchi depth (water clarity) in Wooster Lake was good (Figure 2). The average Secchi depth in 2006 was 7.87 feet, which was a decrease of nearly two feet since the 2005 sampling season (9.54 feet), but was similar to the Secchi depth average in 2003 (7.83 feet). From 1995 to 2006, the TSS concentration has almost tripled. The median county Secchi depth in 2006 was 3.27 feet; more than two times shallower than that of Wooster Lake. Considerable differences in Secchi depth were found throughout the 2006 season with the deepest Secchi reading found in October (13.29 feet) and the lowest reading in May (1.60 feet). This poor May reading correlates with the highest TSS concentration in May that was due to the severe algal bloom that occurred. Based on LMU data, an algal bloom like that which occurred in 2006 happens every spring on Wooster Lake. In 2005/06, this bloom consisted of the blugreen algae *Aphanizomenon* sp. In 2006, the FLD experienced decreases in Secchi depths from the previous Lake County Health Department (LCHD) sampling, with the exception of Duck Lake. Fischer Lake had a Secchi depth of 1.96 feet and Fish Lake had a Secchi depth of 3.47 feet, while Duck Lake had a Secchi depth of 3.49 feet (Table 2). The Volunteer Lake Monitoring Program (VLMP) has been continuously active on the lake since 1995 (data was also recorded in 1992) (Figure 3). The VLMP average Secchi depth in 2006 was 8.4 feet, which was deeper than the LCHD average. Differences between VLMP and LCHD data can be attributed to discrepancies between samplers, as well as date and time samples were taken.

Average conductivity in 2006 was 0.7388 mS/cm. This was an increase from the 2005 value of 0.6945 mS/cm and from the 2003 value of 0.6437 mS/cm. Since 1995, the conductivity concentration has increased by 43%. While this was an increase for Wooster Lake, it was still below the county median (0.7948 mS/cm). Conductivity concentrations vary slightly throughout the FLD. In 2006, Fish Lake had an average value of 0.8688 mS/cm, Fischer Lake had an average value of 0.8524 mS/cm, and Duck Lake had an average value of 0.7807 mS/cm (Table 2). Lakes throughout the FLD have experienced increases since the previous LMU sampling. The road salts used in winter road management runoff into our water supplies and build up in lakes and increase both conductivity and chloride ion (Cl^-) concentrations, which are correlated (Figure 4). The median Cl^- concentration in the county is 171 mg/L, however Wooster Lake contains less than this concentration (112 mg/L). Almost all of the lakes in the county are experiencing similar increases in conductivity for the same reason.

In 2006, the average epilimnetic total phosphorus (TP) concentration in Wooster Lake was 0.043 mg/L, which was less than the county median (0.060 mg/L). TP conditions have risen since sampling was performed in 2005 (0.032 mg/L) and 2003 (0.032 mg/L), and have doubled since 1995. In 2006, Fish Lake had an average TP concentration of 0.096 mg/L, and Duck Lake had an average of 0.100 mg/L. Fischer Lake had the highest value within the FLD, with an average TP concentration of 0.228 mg/L (Table 2). Wooster Lake has a low TP concentration due in part to both its extensive plant population, which competes with algae for phosphorus, and its greater water volume. The trophic state of Wooster Lake in terms of its phosphorus concentration in 2006 was eutrophic, with a TSIp score of 58.5. This indicated a decrease in water quality from 2005 when the TSIp score was 54.0. In 2006, Wooster Lake was 51st out of 162 lakes in Lake County based on TP concentrations, which was a drop from being ranked 43rd in 2005 (Table 3).

TSI values along with other water quality parameters can be used to make other analyses based on use impairment indexes established by the Illinois Environmental Protection Agency (IEPA). Most water quality standard impairment assessments were listed as *None*. However, widespread aquatic vegetation was the source of impairments based on excessive plant growth (*High* use impairment), and exotic species (*Slight* use impairment). Furthermore, based on IEPA indices, Wooster Lake has *Partial* support for recreational and swimming use and *Full* support for aquatic life use. Based on these indices, this lake was listed as providing *Partial* overall use support. This was a drop from 2005 when the lake was listed in *Full* overall use support.

Figure 1. Water quality sampling point on Wooster Lake, 2006.

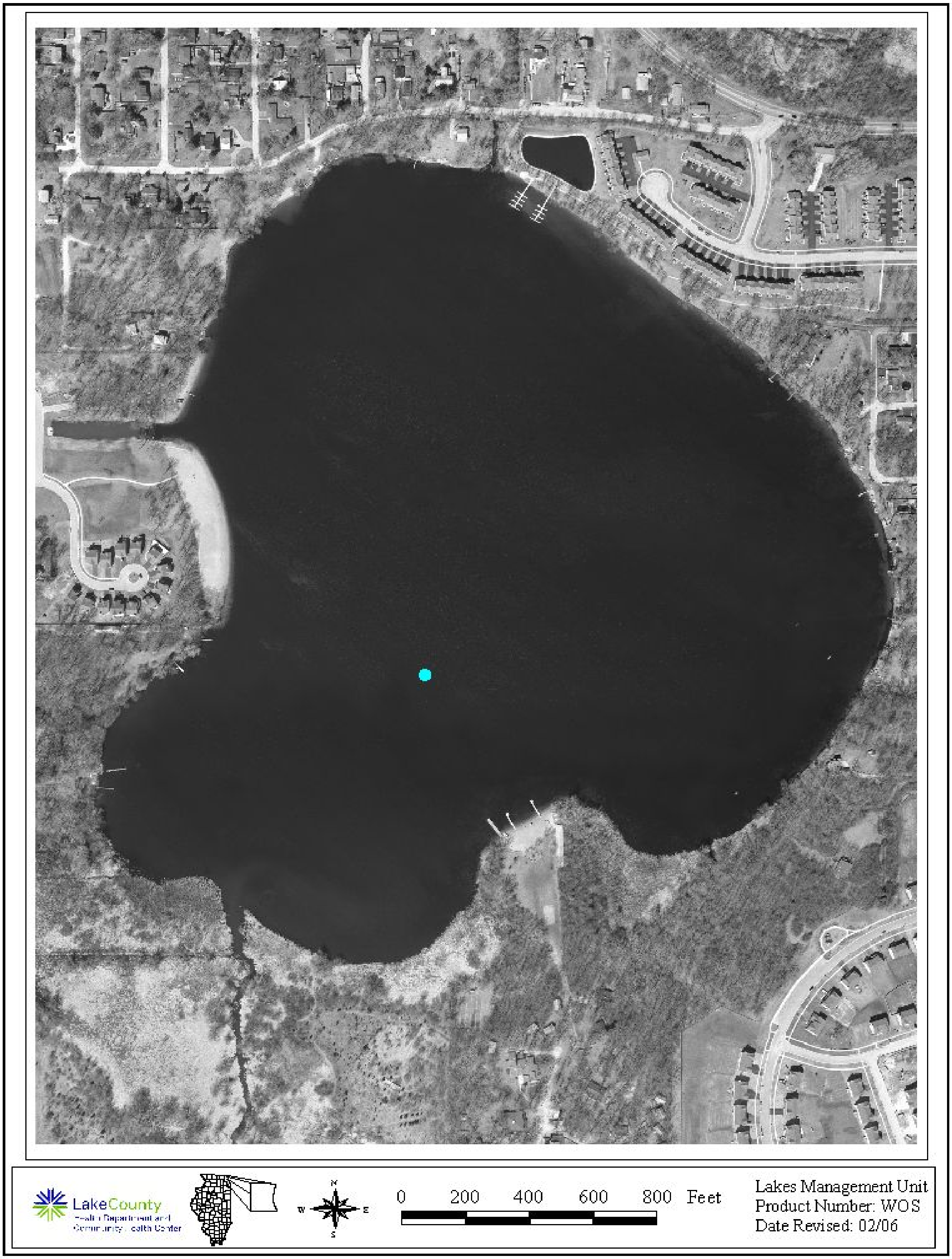

Table 1. Water quality data for Wooster Lake, 2003, 2005 and 2006.

2006 DATE	Epilimnion DEPTH	ALK	TKN	NH_3-N	NO2+NO3*	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
11-Apr	3	180	1.37	<0.1	0.148	0.090	<0.005	NA	104	9.1	459	121	3.61	0.7292	8.46	11.57
10-May	3	164	2.09	<0.1	<0.05	0.049	<0.005	NA	108	15.0	454	124	1.60	0.7207	8.71	10.90
14-Jun	3	148	1.38	<0.1	<0.05	0.027	<0.005	NA	111	3.7	472	147	5.41	0.7222	8.84	9.34
12-Jul	3	150	1.32	<0.1	<0.05	0.023	<0.005	NA	114	2.0	478	150	11.48	0.7404	8.57	6.00
9-Aug	3	150	1.27	<0.1	<0.05	0.020	<0.005	NA	117	2.4	490	161	10.17	0.7591	8.55	6.86
13-Sep	3	153	1.21	<0.1	<0.05	0.021	<0.005	NA	116	2.1	461	133	9.51	0.7431	8.20	5.80
31-Oct	3	172	1.83	0.728	<0.05	0.073	0.039	NA	113	1.6	473	129	13.29	0.7571	7.40	8.69
	Average	160	1.50	NA	0.148[k]	0.043	0.039[k]	NA	112	5.1	470	138	7.87	0.7388	8.39	8.45

2005 DATE	Epilimnion DEPTH	ALK	TKN	NH_3-N	NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
11-Apr	3	180	1.43	<0.1	0.200	0.050	<0.005	NA	90.2	3.7	431	117	6.00	0.6662	8.67	11.95
17-May	3	173	1.40	<0.1	0.058	0.035	<0.005	NA	92.1	3.2	412	114	9.02	0.6633	8.16	10.03
21-Jun	3	163	1.30	<0.1	<0.05	0.016	<0.005	NA	97.2	<1.0	421	115	17.45	0.6761	8.18	8.23
19-Jul	3	163	1.24	<0.1	<0.05	0.021	<0.005	NA	103.0	1.0	472	160	13.45	0.7094	8.05	6.53
16-Aug	3	167	1.34	<0.1	<0.05	0.038	<0.005	NA	101.0	3.3	458	151	5.90	0.7055	8.86	7.79
20-Sep	3	174	1.32	<0.1	<0.05	0.027	<0.005	NA	105.0	3.0	448	130	8.53	0.7232	8.28	6.12
18-Oct	3	180	1.46	0.209	<0.05	0.040	<0.005	NA	101.0	2.9	432	117	6.40	0.7181	8.08	5.58
	Average	171	1.36	NA	0.130[k]	0.032	<0.005	NA	98.5	2.9[k]	439	129	9.54	0.6945	8.33	8.03

2003 DATE	Epilimnion DEPTH	ALK	TKN	NH_3-N	NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
27-May	3	181	1.06	<0.1	<0.05	0.026	<0.005	388	NA	1.3	409	133	14.08	0.6628	8.68	9.67
24-Jun	3	165	1.38	<0.1	<0.05	0.051	<0.005	362	NA	6.9	426	136	4.33	0.6392	8.78	10.40
29-Jul	3	149	1.13	<0.1	<0.05	0.023	<0.005	361	NA	3.7	401	121	6.69	0.6341	8.81	7.02
26-Aug	3	143	1.03	<0.1	<0.05	0.023	<0.005	332	NA	2.5	390	122	6.89	0.6228	8.96	7.46
30-Sep	3	167	1.06	0.115	<0.05	0.035	<0.005	362	NA	2.4	380	102	7.15	0.6597	8.47	6.32
	Average	161	1.13	NA	<0.05	0.032	<0.005	361	NA	3.4	401	123	7.83	0.6437	8.74	8.17

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
NO2+NO3 = Nitrite and 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
* = Prior to 2006 only Nitrate was analyzed

Table 1. Continued

2006	Hypolimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO2+NO3*	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
11-Apr	24	180	1.53	<0.1	0.188	0.066	<0.005	NA	103	5.8	438	109	NA	0.7340	8.08	7.72
10-May	24	179	1.93	0.498	<0.05	0.104	0.039	NA	105	5.6	446	113	NA	0.7560	7.33	0.13
14-Jun	25	218	4.15	3.02	<0.05	0.428	0.336	NA	105	3.7	485	141	NA	0.7930	6.93	0.09
12-Jul	25	229	5.04	3.53	<0.05	0.467	0.394	NA	106	5.8	483	137	NA	0.8004	6.84	0.10
9-Aug	24	230	5.06	3.65	<0.05	0.439	0.358	NA	109	4.8	484	139	NA	0.8209	6.96	0.13
13-Sep	24	263	7.18	6.25	<0.05	0.724	0.652	NA	108	4.6	497	137	NA	0.8293	6.97	0.08
31-Oct	25	172	1.89	0.735	<0.05	0.074	0.033	NA	113	2.0	469	129	NA	0.7587	7.55	8.43
	Average	210	3.83	2.95[k]	0.188[k]	0.329	0.302[k]	NA	107	4.6	472	129	NA	0.7846	7.24	2.38

2005	Hypolimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
11-Apr	26	186	2.09	0.95	0.133	0.065	0.022	NA	87.2	2.7	421	111	NA	0.6717	7.56	2.51
17-May	24	186	2.00	0.77	0.063	0.137	0.099	NA	89.8	<1.0	420	111	NA	0.6914	7.32	0.34
21-Jun	24	194	2.58	1.07	<0.05	0.210	0.129	NA	90.0	4.8	442	122	NA	0.7062	6.85	0.05
19-Jul	24	198	2.97	<0.1	<0.05	0.245	0.140	NA	91.4	8.4	456	132	NA	0.7297	6.87	0.06
16-Aug	23	225	4.60	3.10	<0.05	0.649	0.544	NA	91.0	5.2	476	156	NA	0.7413	6.85	0.10
20-Sep	24	173	1.48	<0.1	<0.05	0.041	0.000	NA	104.0	3.0	447	135	NA	0.7787	6.75	0.19
18-Oct	23	237	5.42	4.49	<0.05	0.713	0.617	NA	92.0	4.0	437	101	NA	0.7592	7.24	0.11
	Average	200	3.02	1.47[k]	0.098[k]	0.294	0.222	NA	93.7	4.68[k]	452	124	NA	0.7430	6.91	0.48

2003	Hypolimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
27-May	26	192	1.63	0.552	<0.05	0.181	0.111	386	NA	1.3	411	128	NA	0.6754	7.53	0.12
24-Jun	27	213	3.40	1.760	<0.05	0.448	0.361	398	NA	5.9	425	141	NA	0.6926	7.22	0.06
29-Jul	26	220	3.42	2.180	<0.05	0.377	0.270	418	NA	5.5	430	138	NA	0.7248	7.30	0.14
26-Aug	25	231	4.54	3.080	<0.05	0.468	0.365	386	NA	7.6	437	164	NA	0.7207	7.23	0.07
30-Sep	25	211	3.43	2.440	<0.05	0.328	0.248	388	NA	7.5	408	113	NA	0.7600	7.14	0.24
	Average	213	3.28	2.002	<0.05	0.360	0.271	395	NA	5.6	422	137	NA	0.7147	7.28	0.13

Glossary

ALK = Alkalinity, mg/L $CaCO_3$
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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
* = Prior to 2006 only Nitrate was analyzed

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

	Fish Lake	Fish Lake	Fish Lake	Fischer Lake	Fischer Lake	Wooster Lake	Wooster Lake	Wooster Lake	Wooster Lake	Wooster Lake	Duck Lake	Duck Lake	Duck Lake
Year	**1997**	**2002**	**2006**	**2001**	**2006**	**1995**	**1999**	**2003**	**2005**	**2006**	**1997**	**2001**	**2006**
Secchi (feet)	3.53	4.02	3.47	2.72	1.96	10.13	8.00	7.83	9.54	7.87	3.12	2.01	3.49
TSS (mg/L)	8.9	11.3	11.0	15.4	28.0	1.8	4.3	3.4	3.2	5.1	8.5	20.6	9.1
TP (mg/L)	0.134	0.102	0.096	0.198	0.228	0.024	0.027	0.032	0.03	0.043	0.047	0.100	0.100
Conductivity (milliSiemens/cm)	0.6984	0.6629	0.8688	0.6687	0.8524	0.5160	0.5744	0.6437	0.7100	0.7388	0.6544	0.6071	0.7807

Direction of Watershed Flow

Figure 2. Total suspended solid (TSS) concentrations vs. Secchi depth for Wooster Lake, 2006.

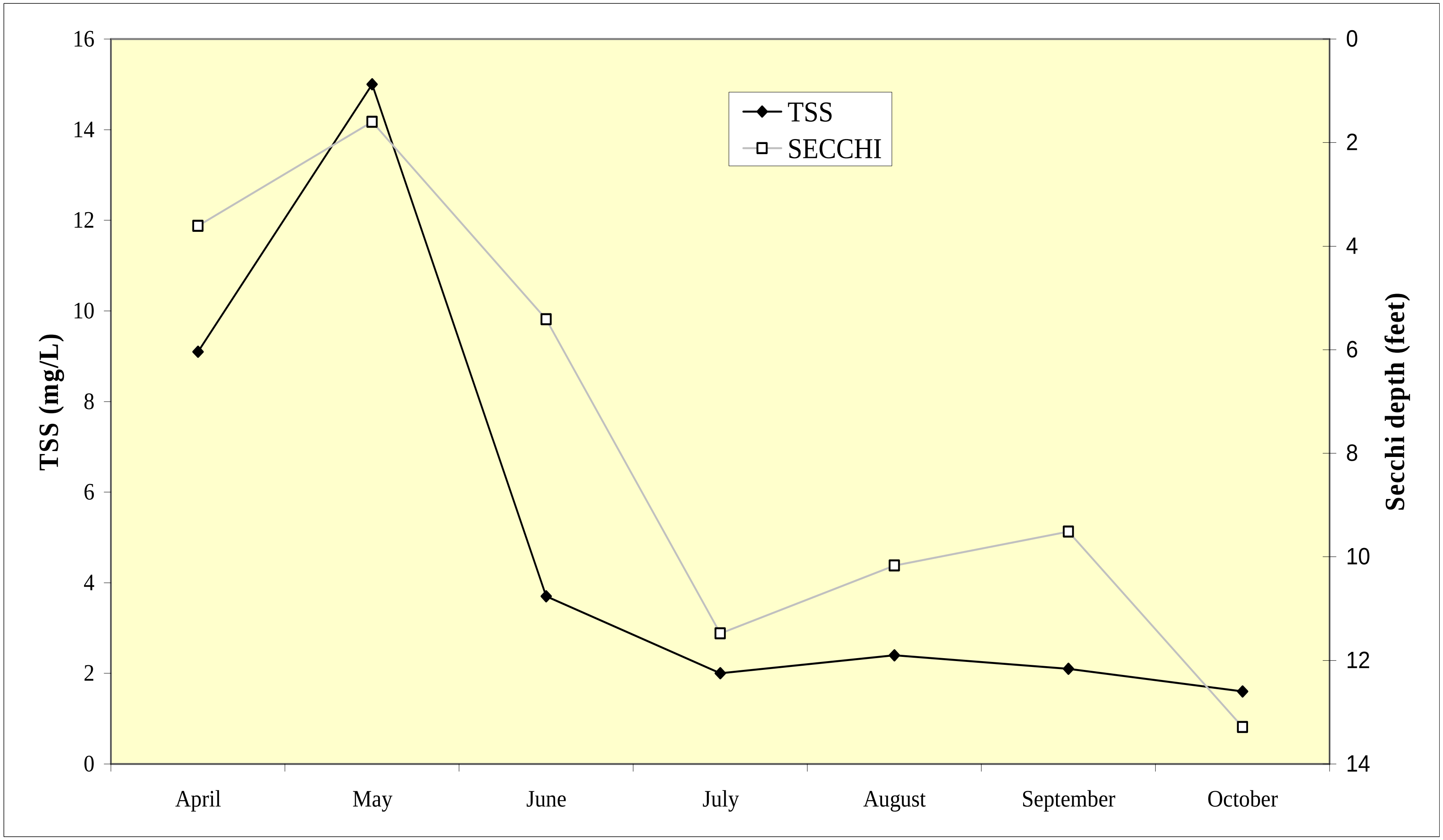

Figure 3. Comparison of average Secchi disk depths between VLMP records and LCHD records from 1992-2006 for Wooster Lake.

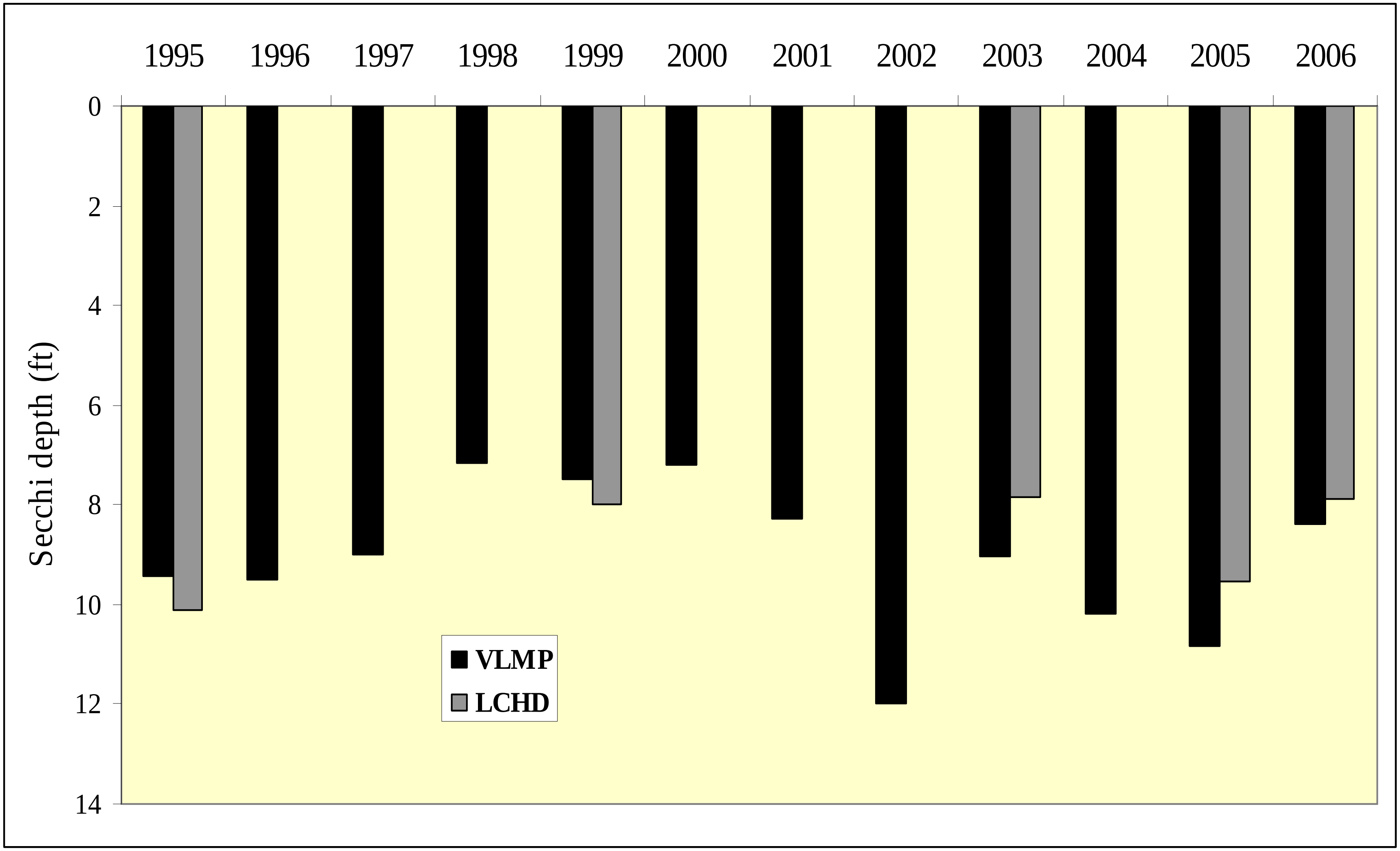

Figure 4. Chloride vs. conductivity concentrations in Wooster Lake, 2006.

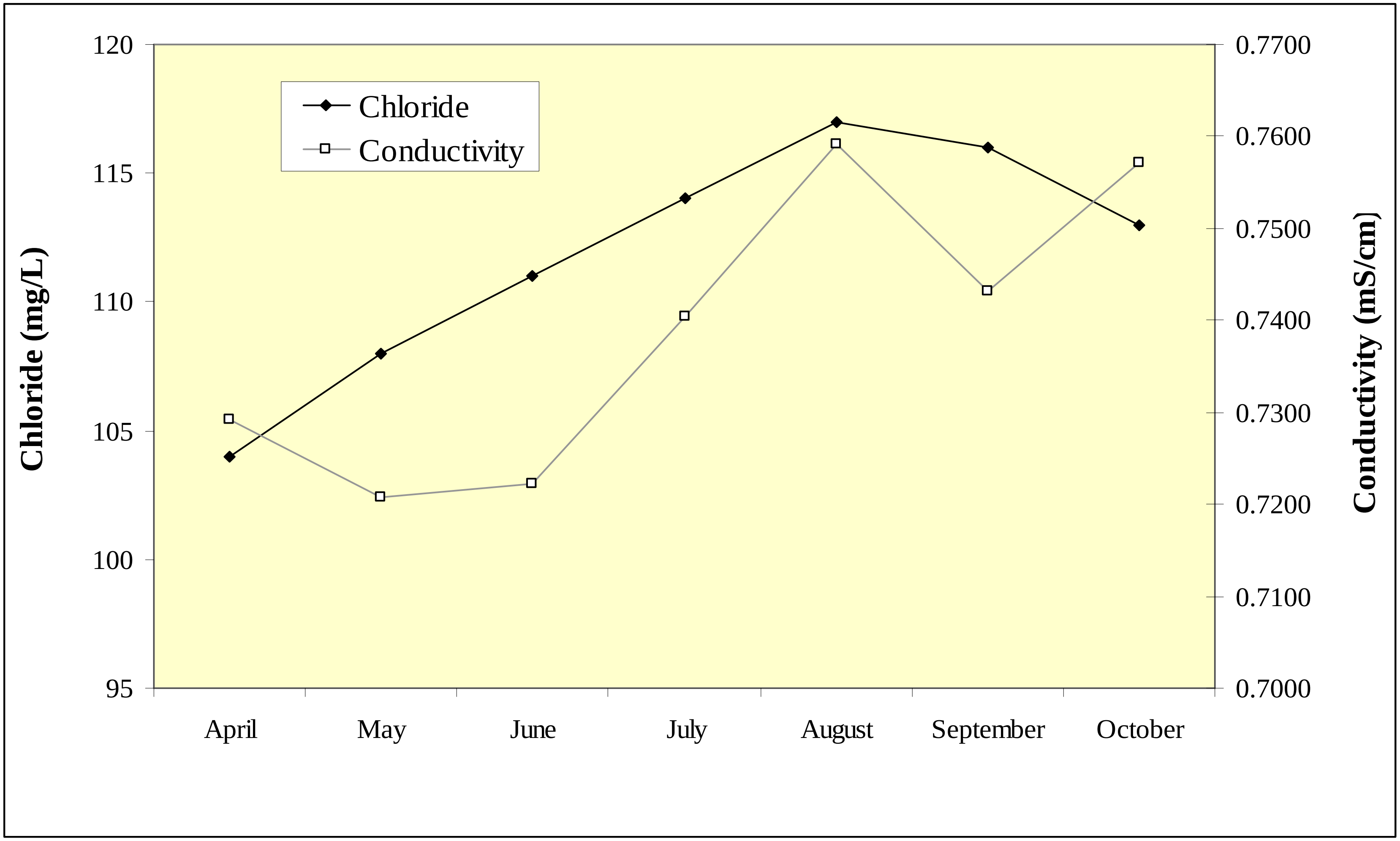

Table 3. Lake County average TSI phosphorus (TSIp) ranking, 2000-2006.

RANK	LAKE NAME	TP AVE	TSIp
1	Cedar Lake	0.0154	43.61
2	Windward Lake	0.0158	43.95
3	Sterling Lake	0.0162	44.31
4	Lake Minear	0.0165	44.57
5	Pulaski Pond	0.0180	45.83
6	Timber Lake	0.0180	45.83
7	Fourth Lake	0.0182	45.99
8	West Loon Lake	0.0182	45.99
9	Lake Carina	0.0193	46.86
10	Independence Grove	0.0194	46.91
11	Lake Kathyrn	0.0200	47.35
12	Lake of the Hollow	0.0200	47.35
13	Banana Pond	0.0202	47.49
14	Bangs Lake	0.0220	48.72
15	Cross Lake	0.0220	48.72
16	Third Lake	0.0221	48.82
17	Dog Pond	0.0222	48.85
18	Sand Pond	0.0230	49.36
19	Stone Quarry Lake	0.0230	49.36
20	Cranberry Lake	0.0240	49.98
21	Deep Lake	0.0240	49.98
22	Druce Lake	0.0244	50.22
23	Little Silver Lake	0.0246	50.33
24	Round Lake	0.0254	50.80
25	Lake Leo	0.0256	50.91
26	Dugdale Lake	0.0274	51.89
27	Peterson Pond	0.0274	51.89
28	Lake Miltmore	0.0276	51.99
29	Ames Pit	0.0278	52.10
30	East Loon Lake	0.0280	52.20
31	Lake Zurich	0.0282	52.30
32	Lake Fairfield	0.0296	53.00
33	Gray's Lake	0.0302	53.29
34	Highland Lake	0.0302	53.29
35	Hook Lake	0.0302	53.29
36	Lake Catherine (Site 1)	0.0308	53.57
37	Lambs Farm Lake	0.0312	53.76
38	Old School Lake	0.0312	53.76
39	Sand Lake	0.0316	53.94
40	Sullivan Lake	0.0320	54.13
41	Lake Linden	0.0326	54.39
42	Gages Lake	0.0338	54.92
43	Hendrick Lake	0.0344	55.17
44	Diamond Lake	0.0372	56.30

Table 3. Continued.

RANK	LAKE NAME	TP AVE	TSIp
45	Channel Lake (Site 1)	0.0380	56.60
46	White Lake	0.0408	57.63
47	Sun Lake	0.0410	57.70
48	Potomac Lake	0.0424	58.18
49	Duck Lake	0.0426	58.25
50	Old Oak Lake	0.0428	58.32
51	Wooster Lake	0.0433	58.48
52	Deer Lake	0.0434	58.52
53	Schreiber Lake	0.0434	58.52
54	Nielsen Pond	0.0448	58.98
55	Turner Lake	0.0458	59.30
56	Seven Acre Lake	0.0460	59.36
57	Willow Lake	0.0464	59.48
58	Lucky Lake	0.0476	59.85
59	Davis Lake	0.0476	59.85
60	East Meadow Lake	0.0478	59.91
61	College Trail Lake	0.0496	60.45
62	Lake Lakeland Estates	0.0524	61.24
63	Butler Lake	0.0528	61.35
64	West Meadow Lake	0.0530	61.40
65	Heron Pond	0.0545	61.80
66	Little Bear Lake	0.0550	61.94
67	Lucy Lake	0.0552	61.99
68	Lake Christa	0.0576	62.60
69	Lake Charles	0.0580	62.70
70	Crooked Lake	0.0608	63.38
71	Waterford Lake	0.0610	63.43
72	Lake Naomi	0.0616	63.57
73	Lake Tranquility S1	0.0618	63.62
74	Werhane Lake	0.0630	63.89
75	Liberty Lake	0.0632	63.94
76	Countryside Glen Lake	0.0642	64.17
77	Leisure Lake	0.0648	64.30
78	St. Mary's Lake	0.0666	64.70
79	Long Lake	0.0680	65.00
80	Mary Lee Lake	0.0682	65.04
81	Hastings Lake	0.0684	65.08
82	Honey Lake	0.0690	65.21
83	North Tower Lake	0.0718	65.78
84	Lake Fairview	0.0724	65.90
85	Spring Lake	0.0726	65.94
86	ADID 203	0.0730	66.02
87	Bluff Lake	0.0734	66.10
88	Harvey Lake	0.0766	66.71

Table 3. Continued.

RANK	LAKE NAME	TP AVE	TSIp
89	Broberg Marsh	0.0782	67.01
90	Countryside Lake	0.0788	67.12
91	Echo Lake	0.0792	67.19
92	Sylvan Lake	0.0794	67.23
93	Big Bear Lake	0.0806	67.45
94	Petite Lake	0.0834	67.94
95	Lake Marie (Site 1)	0.0850	68.21
96	North Churchill Lake	0.0872	68.58
97	Grandwood Park, Site II, Outflow	0.0876	68.65
98	South Churchill Lake	0.0896	68.97
99	Rivershire Pond 2	0.0900	69.04
100	McGreal Lake	0.0914	69.26
101	International Mine and Chemical Lake	0.0948	69.79
102	Eagle Lake (Site I)	0.0950	69.82
103	Dunns Lake	0.0952	69.85
104	Fish Lake	0.0956	69.91
105	Lake Barrington	0.0956	69.91
106	Lochanora Lake	0.0960	69.97
107	Owens Lake	0.0978	70.23
108	Woodland Lake	0.0986	70.35
109	Island Lake	0.0990	70.41
110	McDonald Lake 1	0.0996	70.50
111	Tower Lake	0.1000	70.56
112	Longview Meadow Lake	0.1024	70.90
113	Redwing Slough, Site II, Outflow	0.1072	71.56
114	Lake Forest Pond	0.1074	71.59
115	Bittersweet Golf Course #13	0.1096	71.88
116	Fox Lake (Site 1)	0.1098	71.90
117	Bresen Lake	0.1126	72.27
118	Round Lake Marsh North	0.1126	72.27
119	Timber Lake S	0.1128	72.29
120	Deer Lake Meadow Lake	0.1158	72.67
121	Taylor Lake	0.1184	72.99
122	Grand Avenue Marsh	0.1194	73.11
123	Columbus Park Lake	0.1226	73.49
124	Nippersink Lake (Site 1)	0.1240	73.66
125	Grass Lake (Site 1)	0.1288	74.21
126	Lake Holloway	0.1322	74.58
127	Lakewood Marsh	0.1330	74.67
128	Summerhill Estates Lake	0.1384	75.24
129	Redhead Lake	0.1412	75.53
130	Forest Lake	0.1422	75.63
131	Antioch Lake	0.1448	75.89
132	Valley Lake	0.1470	76.11

Table 3. Continued.

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

SUMMARY OF AQUATIC MACROPHYTES

An aquatic plant (macrophyte) survey was conducted in June and August of 2006. These sample times allowed the determination of plant growth at the beginning and end of the season. On Wooster Lake, there were 63 sampling sites in June and 57 in August that covered all but the deepest parts of the lake (Figure 5a; Figure 5b). Overall, there were 11 species found in June, with White Water Lily having the highest density (found at 49% of the sites). Coontail, Sago Pondweed and *Chara* spp. (a macroalgae) were also abundant and were found at 44%, 44%, and 43% of the sites respectively (Table 4a). A total of 15 species were found in August, with White Water Lily being the most abundant (found at 60% of the sites). *Chara* spp. (found at 48% of the sites) and Coontail (found at 37% of the sites) were also present at many sites (Table 4c). Plants need at least 1% of surface light levels in order to survive. In June, plants were found down to a depth of 12.7 feet, which relates to the 1% light level depth of 13 feet. In August, the 1% light level depth was around 16 feet, while plants were found at depths of 12.3 feet, which also correlates, but not as well. Out of the 63 June sample sites, plants were found at 52 of them (83%) (Table 4b). In August, plants were found at 53 of the 57 sites (93%) (Table 4d).

Plant coverage did not change much from 2005 when 82% of the lake and 93% of the sample sites were covered in May and August, respectively. These sample sites actually covered 60% of the lake (the remaining area was too deep for plants to grow), and therefore the lake has approximately 48% plant coverage (Figure 6), with approximately 30% topped out (plants reaching and crowding the surface of the lake) (Table 5). Ideally, a lake should have 30-40% plant coverage for a healthy fishery, according to the IDNR. While Wooster has a slightly higher than recommended plant community, the fishery in the lake is good based on surveys conducted by the IDNR. Also, the highly agricultural watershed surrounding the lake inevitably has high nutrient inputs. Wooster's high-density plant community helps utilize these nutrients and keep the water clarity high. If plants were reduced, algal populations may increase and decrease water clarity. Also, the threatened and endangered fish (Starhead Topminnow (*Fundulus dispar*) and Blackchin Shiner (*Notropsis heterodon*), both threatened in Illinois, and the state endangered Blacknose Shiner (*Notropsis heterolepsis*)) in the lake require high densities of plants for proper habitat.

The aquatic plant community in June consisted of 10 species, which was a six species decrease in plant diversity since May, 2005. However, all 10 species found in May 2005 were found again in June 2006. This decrease in plant species may have been due to time of sampling. In May, the plant community is still growing, but by June the plant community is more established. In August 2006 there were 15 species found, which was an increase of three species since sampling in August 2005. Nine species remained the same between August of 2005 and 2006, but six species were found in 2006 that were not observed in 2005 (Table 6). The plant shift could also be attributed to an increase in chemical plant treatments, natural annual variation, competition between species, or sampling bias. The LMU is concerned about the absence of Whitestem Pondweed in 2005 and 2006, which was present in previous years. A detailed effort will be made in 2007 to locate and GPS any remaining beds of this species that may have been missed in our plant sampling grid.

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. A high FQI number indicates there is a large number of sensitive, high quality plant species present in the lake. Non-native species were also included in the FQI calculations for Lake County lakes. The median FQI for 2000-2006 Lake County lakes is 12.7. Wooster Lake had a FQI of 19.8 in 2006, which is a large decrease from 25.2 in 2005. It ranked 14th in 2005 and 29th in 2006 (Table 7). For comparison, Fish Lake, Fischer Lake, and Duck Lake have 2006 FQIs of 19.3, 9.0, and 21.1, respectively.

Figure 5a. Aquatic plant sampling grid that illustrates plant density in June on Wooster Lake, 2006.

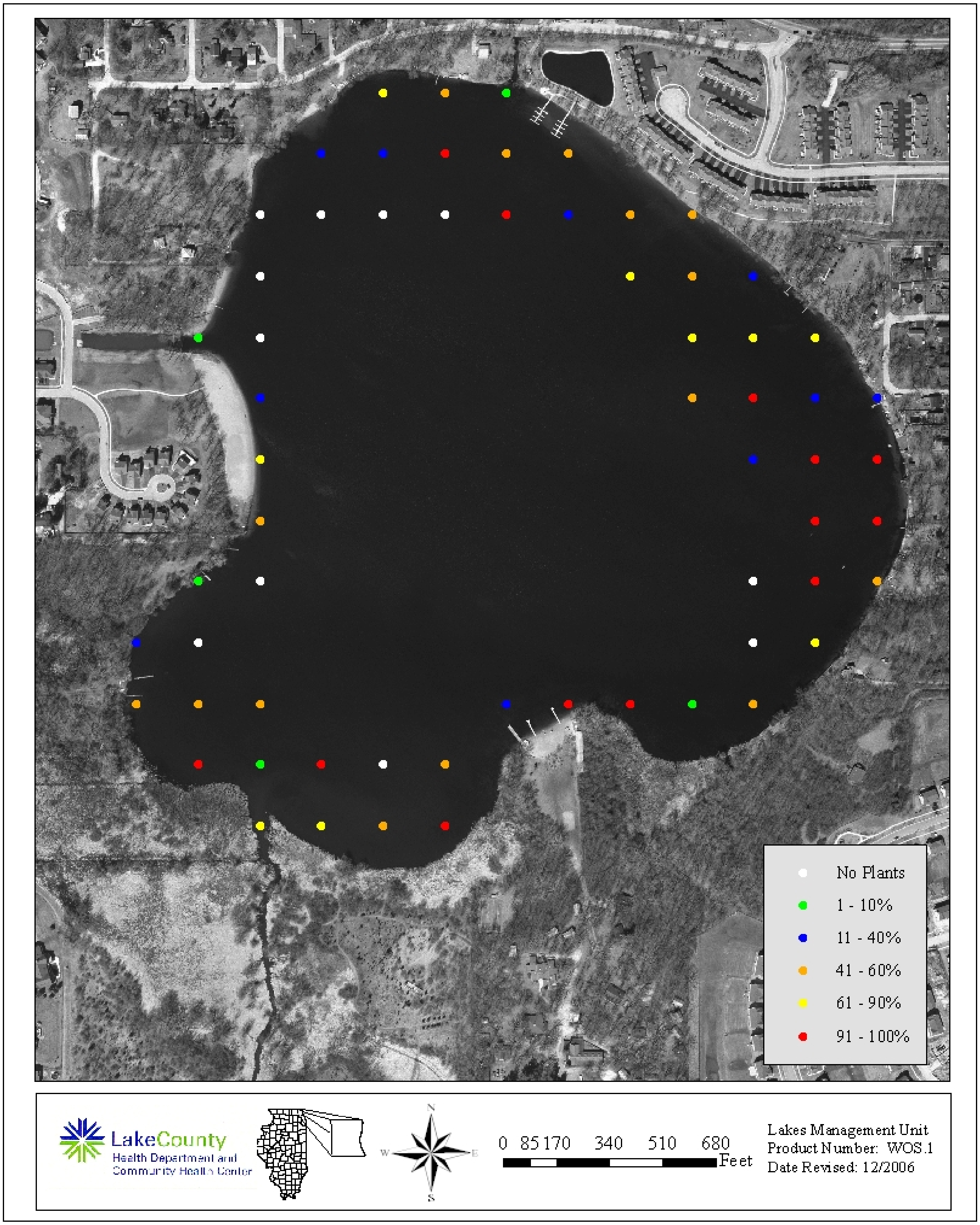

Figure 5b. Aquatic plant sampling grid that illustrates plant density in August on Wooster Lake, 2006.

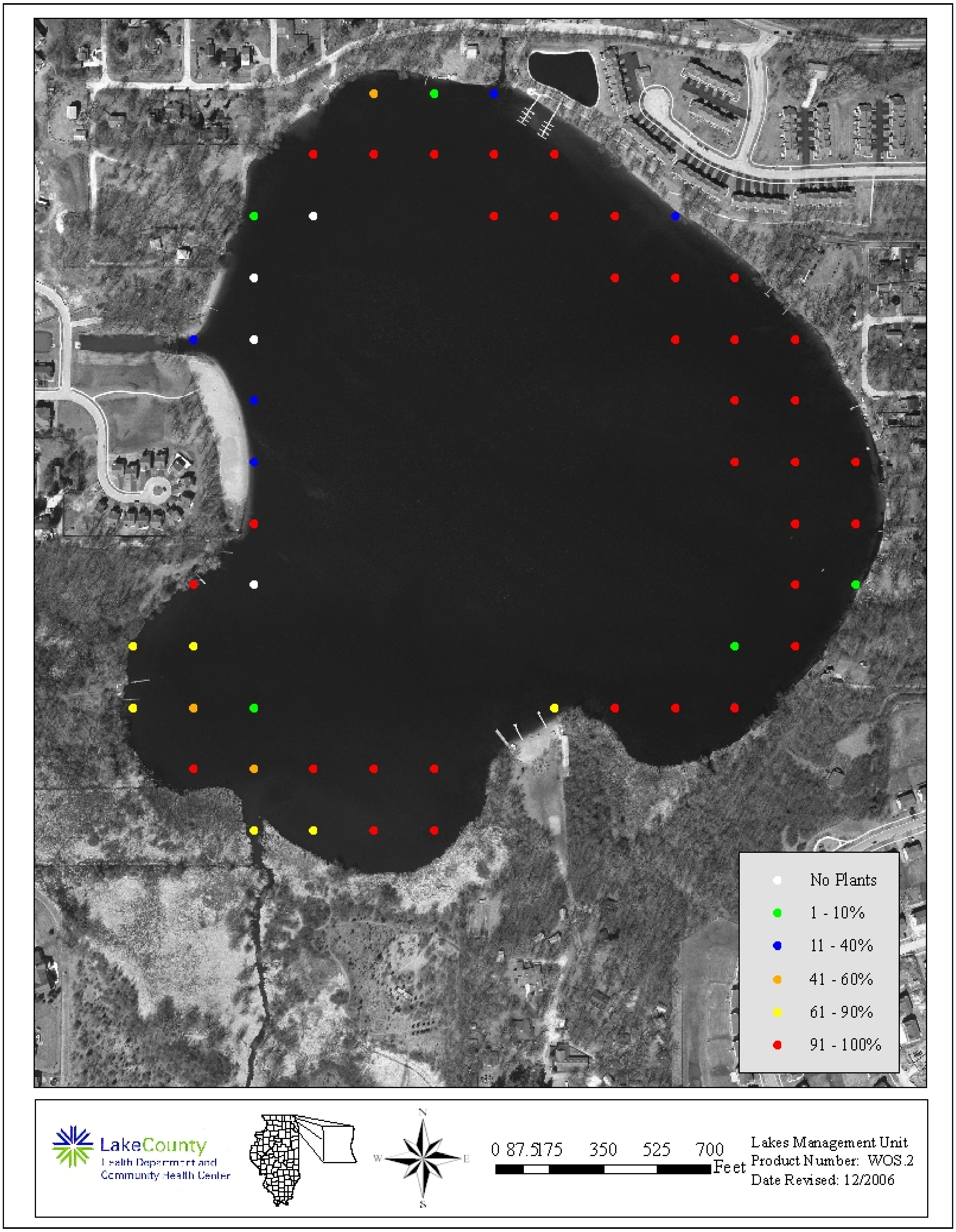

Table 4a. Aquatic plant species found at the sampling sites in June on Wooster Lake, 2006. Maximum depth that plants were found was 12.7 feet.

Plant Density	Chara	Coontail	Curlyleaf Pondweed	Duckweed	Eurasian Watermilfoil	Sago Ponweed	Star Duckweed	Vallisneria	Watermeal	White Water Lily
Absent	36	35	39	59	55	35	56	61	57	32
Present	3	14	17	4	5	21	6	2	6	17
Common	7	8	5	0	1	5	1	0	0	8
Abundant	9	5	1	0	2	2	0	0	0	2
Dominant	8	1	1	0	0	0	0	0	0	4
% Plant Occurrence	43	44	38	6	13	44	11	3	10	49

Table 4b. Distribution of rake density across all sampling sites in June.

Rake Density (coverage)	# of Sites	% of Sites
No Plants	11	17
>0-10%	5	8
10-40%	10	16
40-60%	15	24
60-90%	9	14
>90%	13	21
Total Sites with Plants	52	83
Total # of Sites	63	100

Table 4c. Aquatic plant species found at the sampling sites in August on Wooster Lake, 2006. Maximum depth that plants were found was 12.3 feet.

Plant Density	Chara	Coontail	Curlyleaf Pondweed	Duckweed	Eurasian Watermilfoil	Flatstem Pondweed	Illinois Pondweed	Sago Pondweed	Southern Naiad	Spatterdock
Absent	27	34	54	51	35	54	56	36	52	54
Present	2	8	3	6	17	3	1	11	3	3
Common	0	6	0	0	4	0	0	7	2	0
Abundant	2	5	0	0	1	0	0	2	0	0
Dominant	26	4	0	0	0	0	0	1	0	0
% Plant Occurrence	48	37	5	10	35	5	2	33	8	5

Plant Density	Spiny Naiad	Star Duckweed	Vallisneria	Watermeal	White Water Lily
Absent	54	50	47	53	19
Present	3	6	5	4	12
Common	0	1	4	0	8
Abundant	0	0	1	0	8
Dominant	0	0	0	0	10
% Plant Occurrence	5	11	16	6	60

Table 4d. Distribution of rake density across all sampling sites in August.

Rake Density (coverage)	# of Sites	% of Sites
No Plants	4	7
>0-10%	5	9
10-40%	5	9
40-60%	3	5
60-90%	6	11
>90%	34	60
Total Sites with Plants	53	93
Total # of Sites	57	100

Figure 6. Approximate plant cover on Wooster Lake, 2006.

Table 5. Aquatic plant species found in Wooster Lake, 2006.

Coontail	*Ceratophyllum demersum*
Chara (Macro algae)	*Chara spp.*
Small Duckweed	*Lemna minor*
Star Duckweed	*Lemna trisulca*
Eurasian Watermilfoil^	*Myriophyllum spicatum*
Southern Naiad	*Najas guadalupensis*
Spiny Naiad	*Najas marina*
Spatterdock	*Nuphar variegata*
White Water Lily	*Nymphaea tuberosa*
Curlyleaf Pondweed^	*Potamogeton crispus*
Illinois Pondweed	*Potamageton illinoensis*
Sago Pondweed	*Potamogeton pectinatus*
Flatstem Pondweed	*Potamogeton zosteriformis*
Vallisineria (Eel Grass)	*Vallisineria americana*
Watermeal	*Wolffia columbiana*

^ **Exotic species**

Table 6. Plant community changes in Wooster Lake between 2005 and 2006.

Common Name (*Scientific name*)	2005		2006	
	May	**August**	**June**	**August**
Coontail (*Ceratophyllum demersum*)	X	X	X	X
Chara sp. (Macroalgae) (*Chara spp.*)	X	X	X	X
American Elodea (*Elodea canadensis*)	X	X		
Water Stargrass (*Heteranthera dubia*)		X		
Small Duckweed (*Lemna minor*)	X	X	X	X
Star Duckweed (*Lemna trisulca*)	X	X	X	X
Northern Watermilfoil (*Myriophyllum sibiricum*)	X			
Eurasian Watermilfoil^ (*Myriophyllum spicatum*)	X		X	X
Milfoil sp. (*Myriophyllum sp.*)	X			
Slender Naiad (*Najas flexilis*)		X		
Southern Naiad (*Najas guadalupensis*)				X
Spiny Naiad (*Najas marina*)				X
Spatterdock (*Nuphar variegata*)				X
White Water Lily (*Nymphaea tuberosa*)	X	X	X	X
Curlyleaf Pondweed^ (*Potamogeton crispus*)	X		X	X
Illinois Pondweed (*Potamogeton illinoensis*)				X
Sago Pondweed (*Potamogeton pectinatus*)	X	X	X	X
Small Pondweed (*Potamogeton pusillus*)	X			
Flatstem Pondweed (*Potamogeton zosteriformis*)	X			X
Grass-leaved Arrowhead (*Sagittaria gramminea*)		X		
Vallisineria (Eel Grass) (*Vallisineria americana*)	X	X	X	X
Watermeal (*Wolffia columbiana*)	X	X	X	X
Horned Pondweed (*Zannichellia palustrus*)	X			
Total number of species	**16**	**12**	**10**	**15**

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

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

Table 7. Continued.

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

Table 7. Continued.

Rank	Lake Name	FQI (w/A)	FQI (native)
86	Lake Matthews	12.0	12.0
87	Flint Lake	11.8	13.0
88	Harvey Lake	11.8	13.0
89	Rivershire Pond 2	11.5	13.3
90	Antioch Lake	11.3	13.4
91	Lake Charles	11.3	13.4
92	Lake Linden	11.3	11.3
93	Lake Naomi	11.2	12.5
94	Pulaski Pond	11.2	12.5
95	Redwing Marsh	11.0	11.0
96	West Meadow Lake	11.0	11.0
97	Nielsen Pond	10.7	12.0
98	Lake Holloway	10.6	10.6
99	Lake Carina	10.2	12.5
100	Crooked Lake	10.2	12.5
101	Lake Lakeland Estates	10.0	11.5
102	College Trail Lake	10.0	10.0
103	Werhane Lake	9.8	12.0
104	Big Bear Lake	9.5	11.0
105	Little Bear Lake	9.5	11.0
106	Loch Lomond	9.4	12.1
107	Sand Pond (IDNR)	9.4	12.1
108	Columbus Park Lake	9.2	9.2
109	Sylvan Lake	9.2	9.2
110	Fischer Lake	9.0	11.0
111	Grandwood Park Lake	9.0	11.0
112	Lake Fairfield	9.0	10.4
113	McDonald Lake 1	8.9	10.0
114	East Meadow Lake	8.5	8.5
115	South Churchill Lake	8.5	8.5
116	Lake Christa	8.5	9.8
117	Lake Farmington	8.5	9.8
118	Lucy Lake	8.5	9.8
119	Bittersweet Golf Course #13	8.1	8.1
120	Woodland Lake	8.1	9.9
121	Albert Lake	7.5	8.7
122	Lake Eleanor	7.5	8.7
123	Fairfield Marsh	7.5	8.7
124	Lake Louise	7.5	8.7
125	Banana Pond	7.5	9.2
126	Patski Pond	7.1	7.1
127	Rasmussen Lake	7.1	7.1
128	Slough Lake	7.1	7.1
129	Lucky Lake	7.0	7.0

Table 7. Continued.

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

APPENDIX A. METHODS FOR FIELD DATA COLLECTION AND LABORATORY ANALYSES

Water Sampling and Laboratory Analyses

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

Plant Sampling

In order to randomly sample each lake, mapping software (ArcMap 9.1) overlaid a grid pattern onto a 2006 aerial photo of Lake County and placed points 60 or 30 meters apart, depending on lake size. Plants were sampled using a garden rake fitted with hardware cloth. The hardware cloth surrounded the rake tines and is tapered two feet up the handle. A rope was tied to the end of the handle for retrieval. At designated sampling sites, the rake was tossed into the water, and using the attached rope, was dragged across the bottom, toward the boat. After pulling the rake into the boat, plant coverage was assessed for overall abundance. Then plants were individually identified and placed in categories based on coverage. Plants that were not found on the rake but were seen in the immediate vicinity of the boat at the time of sampling were also recorded. Plants difficult to identify in the field were placed in plastic bags and identified with plant keys after returning to the office. The depth of each sampling location was measured either by a hand-held depth meter, or by pushing the rake straight down and measuring the depth along the rope or rake handle. One-foot increments were marked along the rope and rake handle to aid in depth estimation.

Plankton Sampling

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

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

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

Shoreline Assessment

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

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

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

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

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

Wildlife Assessment

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

Table A1. Analytical methods used for water quality parameters.

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

APPENDIX B. MULTI-PARAMETER DATA FOR WOOSTER LAKE, 2006.

Wooster Lake 2006 Multiparameter data

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 Average	Extinction Coefficient
												0.74
41106	90003	0.25	0.37	9.92	11.43	104.0	0.7286	8.45	1515	Surface		
41106	90057	1	1.06	9.92	11.40	103.6	0.7284	8.45	1426	Surface	100%	
41106	90204	2	2.01	9.90	11.47	104.3	0.7289	8.45	418	0.26	29%	4.72
41106	90310	3	3.01	9.88	11.57	105.1	0.7289	8.46	249	1.26	17%	0.41
41106	90446	4	3.97	9.87	11.50	104.5	0.7286	8.47	149	2.22	10%	0.23
41106	90549	6	5.99	9.83	11.42	103.7	0.7286	8.47	72	4.24	5%	0.17
41106	90837	8	8.03	9.49	11.04	99.4	0.7301	8.41	36	6.28	3%	0.11
41106	91013	10	10.01	9.45	10.92	98.2	0.7302	8.40	14	8.26	1.0%	0.11
41106	91156	12	12.00	8.90	10.39	92.2	0.7308	8.32	4	10.25	0.3%	0.12
41106	91407	14	14.03	8.50	9.56	84.1	0.7319	8.26	2	12.28	0%	0.06
41106	91509	16	15.99	8.25	9.34	81.7	0.7318	8.24	0	14.24		
41106	91645	18	18.01	8.00	9.09	79.0	0.7314	8.22	0	16.26		
41106	91736	20	20.03	7.63	8.68	74.7	0.7318	8.17	0	18.28		
41106	91840	22	22.02	7.49	8.40	72.1	0.7320	8.15	0	20.27		
41106	92007	24	24.05	7.35	7.72	66.0	0.7343	8.08	0	22.3		
41106	92053	26	26.06	7.32	6.94	59.3	0.7373	8.02	0	24.31		

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 Average	Extinction Coefficient
												0.83
51006	83549	0.25	0.25	17.51	10.97	119.4	0.7192	8.68	2508	Surface		
51006	83649	1	1.02	17.45	11.00	119.5	0.7195	8.70	2297	Surface	100%	
51006	83805	2	1.99	17.32	11.15	120.8	0.7206	8.71	722	0.24	31%	4.82
51006	84055	3	3.03	17.22	10.90	117.9	0.7206	8.71	316	1.28	14%	0.65
51006	84225	4	4.01	17.17	10.81	116.8	0.7216	8.70	140	2.26	6%	0.36
51006	84432	6	6.03	17.14	10.70	115.6	0.7225	8.68	38	4.28	2%	0.30
51006	84600	8	8.06	16.96	10.23	110.1	0.7298	8.64	9	6.31	0.4%	0.23
51006	84834	10	10.02	15.42	8.30	86.5	0.7328	8.57	3	8.27	0.1%	0.13
51006	84949	12	12.01	14.11	6.62	67.0	0.7356	8.45	1	10.26	0%	0.11
51006	85109	14	14.05	13.19	5.94	58.9	0.7362	8.37	1	12.3	0%	0.00
51006	85218	16	15.99	12.61	4.41	43.2	0.7397	8.19	0	14.24		
51006	85336	18	18.03	11.70	1.21	11.6	0.7464	7.80	0	16.28		
51006	85443	20	19.99	10.42	0.19	1.7	0.7499	7.56	0	18.24		
51006	85541	22	22.01	9.78	0.15	1.4	0.7498	7.49	0	20.26		
51006	85645	24	24.07	8.84	0.13	1.2	0.7560	7.33	0	22.32		
51006	85726	26	26.02	8.31	0.13	1.1	0.7635	7.19	0	24.27		

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 Average	Extinction Coefficient
												0.36
61406	84759	0.25	0.40	22.01	9.40	110.3	0.7227	8.82	3407	Surface		
61406	84901	1	1.00	22.02	9.50	111.6	0.7224	8.83	3242	Surface	100%	
61406	85121	2	2.06	21.99	9.50	111.5	0.7223	8.85	1303	0.31	40%	2.94
61406	85238	3	3.02	21.92	9.34	109.4	0.7222	8.84	994	1.27	31%	0.21
61406	85338	4	4.01	21.78	9.16	107.1	0.7221	8.84	722	2.26	22%	0.14
61406	85514	6	6.03	21.53	9.25	107.6	0.7222	8.83	356	4.28	11%	0.17
61406	85656	8	8.04	20.88	9.23	106.0	0.7240	8.81	188	6.29	6%	0.10
61406	85942	10	10.03	20.50	8.52	97.2	0.7252	8.75	97	8.28	3%	0.08
61406	90057	12	12.00	19.19	6.71	74.5	0.7334	8.42	50	10.25	1.5%	0.06
61406	90255	14	14.03	16.89	1.83	19.3	0.7399	7.81	22	12.28	0.7%	0.07
61406	90550	16	16.04	14.10	0.14	1.4	0.7388	7.58	11	14.29	0.3%	0.05
61406	90826	18	18.00	12.46	0.10	1.0	0.7468	7.46	5	16.25	0%	0.05
61406	90922	20	20.01	11.53	0.10	1.0	0.7510	7.38	1	18.26	0%	0.09
61406	91035	22	22.00	10.24	0.09	0.8	0.7648	7.16	0	20.25		
61406	91150	24	24.01	9.35	0.09	0.8	0.7930	6.93	0	22.26		
61406	91240	26	25.99	9.06	0.08	0.7	0.8042	6.86	0	24.24		
61406	91328	28	27.97	8.67	0.09	0.8	0.8232	6.77	0	26.22		

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 Average	Extinction Coefficient
												0.49
71206	84752	0.25	0.51	24.63	5.98	74.1	0.7406	8.54	1235	Surface		
71206	84906	1	1.06	24.64	5.97	74.0	0.7409	8.55	763	Surface	100%	
71206	85002	2	2.01	24.64	5.97	74.1	0.7406	8.56	332	0.26	44%	3.20
71206	85131	3	3.03	24.64	6.00	74.4	0.7404	8.57	216	1.28	28%	0.34
71206	85319	4	4.00	24.64	5.88	73.0	0.7404	8.57	151	2.25	20%	0.16
71206	85458	6	6.02	24.65	5.97	74.0	0.7405	8.58	111	4.27	15%	0.07
71206	85607	8	8.03	24.64	5.96	73.9	0.7407	8.58	74	6.28	10%	0.06
71206	85844	10	10.08	24.60	5.96	73.9	0.7407	8.58	70	8.33	9%	0.01
71206	90014	12	12.02	22.84	4.48	53.7	0.7445	8.32	46	10.27	6%	0.04
71206	90129	14	14.05	18.65	3.10	34.3	0.7409	7.99	31	12.30	4%	0.03
71206	90355	16	15.94	15.92	0.61	6.3	0.7430	7.64	18	14.19		
71206	90634	18	18.00	13.01	0.10	1.0	0.7539	7.36	8	16.25		
71206	90844	20	20.05	11.49	0.10	1.0	0.7681	7.13	1	18.30		
71206	90947	22	21.99	10.44	0.10	0.9	0.7803	6.99	1	20.24		
71206	91125	24	23.96	9.65	0.10	0.9	0.8004	6.84	0	22.21		
71206	91309	26	26.00	9.14	0.10	0.9	0.8308	6.67	0	24.25		

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 Average	Extinction Coefficient
												0.64
80906	83224	0.25	0.43	26.82	6.97	89.5	0.7601	8.54	3216	Surface		
80906	83427	1	0.97	26.84	6.92	89.0	0.7595	8.55	3161	Surface	100%	
80906	83528	2	2.00	26.84	6.92	88.9	0.7591	8.55	1046	0.25	33%	4.42
80906	83639	3	3.01	26.84	6.86	88.2	0.7591	8.55	858	1.26	27%	0.16
80906	83738	4	4.08	26.81	6.86	88.1	0.7586	8.55	490	2.33	16%	0.24
80906	83923	6	6.07	26.80	6.87	88.2	0.7584	8.55	419	4.32	13%	0.04
80906	84126	8	8.06	26.79	6.86	88.1	0.7582	8.54	226	6.31	7%	0.10
80906	84420	10	10.01	26.67	6.39	81.9	0.7592	8.48	157	8.26	5%	0.04
80906	84639	12	12.03	25.90	5.05	63.8	0.7582	8.30	85	10.28	3%	0.06
80906	84826	14	14.01	21.60	7.64	89.1	0.7441	8.56	56	12.26	2%	0.03
80906	85010	16	16.04	18.31	4.30	46.9	0.7481	8.18	29	14.29	0.9%	0.05
80906	85218	18	18.02	15.26	0.85	8.7	0.7596	7.76	10	16.27	0.3%	0.07
80906	85348	20	19.94	12.82	0.16	1.6	0.7736	7.34	4	18.19	0%	0.05
80906	85503	22	22.03	10.85	0.13	1.2	0.7936	7.12	0	20.28		
80906	85612	24	24.02	9.95	0.13	1.1	0.8209	6.96	1	22.27		
80906	85736	26	26.08	9.33	0.11	1.0	0.8641	6.77	0	24.33		

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 Average	Extinction Coefficient
												0.38
91306	83918	0.25	0.29	20.12	6.01	68.7	0.7427	8.19	177	Surface		
91306	84022	1	0.95	20.12	5.90	67.4	0.7425	8.20	150	Surface	100%	
91306	84122	2	2.08	20.13	5.90	67.5	0.7432	8.20	45	0.33	30%	3.65
91306	84205	3	3.04	20.15	5.80	66.3	0.7431	8.20	39	1.29	26%	0.11
91306	84254	4	4.00	20.15	5.73	65.5	0.7431	8.20	34	2.25	23%	0.06
91306	84343	6	5.98	20.14	5.76	65.9	0.7434	8.21	24	4.23	16%	0.08
91306	84454	8	7.96	20.13	5.78	66.1	0.7435	8.21	17	6.21	11%	0.06
91306	84637	10	10.03	20.12	5.65	64.7	0.7438	8.21	10	8.28	7%	0.06
91306	84747	12	12.06	20.13	5.65	64.7	0.7441	8.22	9	10.31	6%	0.01
91306	84904	14	13.99	20.12	5.57	63.7	0.7439	8.21	6	12.24	4%	0.03
91306	85050	16	15.97	20.08	5.34	61.0	0.7445	8.19	4	14.22	3%	0.03
91306	85215	18	17.97	18.24	0.30	3.3	0.7523	7.82	3	16.22	2%	0.02
91306	85404	20	20.01	14.27	0.12	1.2	0.7737	7.39	1	18.26	0.7%	0.06
91306	85521	22	22.00	12.10	0.11	1.0	0.8012	7.14	1	20.25	0.7%	
91306	85647	24	23.99	10.99	0.08	0.8	0.8293	6.97	0	22.24		
91306	85759	26	26.04	9.97	0.08	0.7	0.8691	6.82	0	24.29		

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 Average	Extinction Coefficient
												0.45
103106	93730	0.25	0.32	8.65	9.12	80.7	0.7573	6.63	3296	Surface		
103106	93830	1	0.98	8.62	8.82	78.2	0.7574	7.18	3666	Surface	100%	
103106	93933	2	2.07	8.62	8.75	77.5	0.7571	7.32	649	0.32	18%	5.41
103106	94035	3	3.05	8.63	8.69	77.1	0.7577	7.41	492	1.30	13%	0.21
103106	94119	4	4.00	8.61	8.66	76.8	0.7575	7.46	304	2.25	8%	0.21
103106	94206	6	6.03	8.62	8.63	76.5	0.7575	7.48	161	4.28	4%	0.15
103106	94253	8	8.03	8.60	8.62	76.4	0.7573	7.51	128	6.28	3%	0.04
103106	94353	10	10.00	8.60	8.55	75.7	0.7571	7.50	71	8.25	2%	0.07
103106	94441	12	12.00	8.59	8.57	75.9	0.7573	7.53	42	10.25	1%	0.05
103106	94525	14	14.03	8.59	8.56	75.8	0.7573	7.54	24	12.28	1%	0.05
103106	94628	16	16.01	8.60	8.57	75.9	0.7575	7.54	17	14.26	0.5%	0.02
103106	94728	18	17.99	8.59	8.56	75.9	0.7578	7.54	11	16.24	0%	0.03
103106	94813	20	20.01	8.55	8.54	75.6	0.7579	7.55	6	18.26	0%	0.03
103106	94921	22	22.03	8.59	8.48	75.1	0.7576	7.56	4	20.28	0%	0.02
103106	95033	24	24.00	8.57	8.48	75.1	0.7578	7.56	3	22.25	0%	0.01
103106	95153	26	26.04	8.53	8.38	74.1	0.7583	7.56	1	24.29		0.05
103106	95310	28	28.05	8.53	7.78	68.8	0.7581	7.53	1	26.30		

APPENDIX C. INTERPRETING YOUR LAKES WATER QUALITY DATA

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

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

Temperature and Dissolved Oxygen:

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

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

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

Nutrients:

Phosphorus:

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

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

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

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

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

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

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

Solids:

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

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

Water Clarity:

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

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

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

Alkalinity, Conductivity, Chloride, pH:

Alkalinity:

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

Conductivity and Chloride:

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

pH:

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

Eutrophication and Trophic State Index:

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

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

Table 1. Trophic State Index (TSI).

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

APPENDIX D. WATER QUALITY STATISTICS FOR ALL LAKE COUNTY LAKES

2000 - 2006 Water Quality Parameters, Statistics Summary

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

No 2002 IEPA Chain Lakes

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

No 2002 IEPA Chain Lakes.

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

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

LakeCounty
Health Department and
Community Health Center