LPL-457

Lower McKenzie Lake near Webb Lake, WI
Water-Quality Data Summary

This summary covers the period June 1997 to August 1998, which is the period of water-quality monitoring of Lower McKenzie Lake by the U.S. Geological Survey (USGS). In reviewing the data, it may be helpful to refer to the methods and explanations of physical and chemical characteristics sections in the USGS annual lake data report "Water-Quality and Lake-Stage Data for Wisconsin Lakes, Water Year 1998" and to Shaw and others (1994) "Understanding Lake Data."

Lake description and sampling locations:

Lower McKenzie Lake is classified as a drainage lake, with an inlet and outlet, McKenzie Creek. McKenzie Creek flows from McKenzie into Middle McKenzie Lake and then flows about 3 miles to the south from middle McKenzie Lake before entering Lower McKenzie. The average depth the lake is 2.7 meters, the surface area is 185 acres (0.29 square miles). The water-quality sampling site is located at the deepest point in the lake at a depth of about 5.0 meters. Lake stage was monitored on the north side of the lake at the boat landing. The locations of the monitoring sites are shown in Figure 1.

Hydrologic conditions during water year 1997 and 1998:

Annual variability in lake condition often reflects variability in climatic and hydrologic conditions. Air temperature in northwestern Wisconsin was, on the average, 0.4° F cooler than normal for the period December 1996 through March 1997; April and May was 3.9 ° F cooler than normal; and the period June through August was 0.5 ° F cooler than normal (National Oceanic and Atmospheric Administration "Climatological Data--Wisconsin"). Precipitation during water year 1998 was 100 percent of normal precipitation for northwestern Wisconsin (Pamela Naber-Knox, UW-Extension, Geological and Natural History Survey, written commun., 1997). Watershed runoff in the region of Lower McKenzie Lake was between 120 and 140 percent of long-term average runoff (Holmstrom and others, 1998, "Water Resources Data--Wisconsin").

Air temperature in northwestern Wisconsin was, on the average, 8.68 ° F warmer than normal for the period December 1997 through March 1998; April and May was 5.00 ° F warmer than normal; and the period June through August was 0.37 ° F warmer than normal (National Oceanic and Atmospheric Administration "Climatological Data--Wisconsin"). Precipitation during water year 1998 was 87 percent of normal precipitation for northwestern Wisconsin (Pamela Naber-Knox, UW-Extension, Geological and

Natural History Survey, written commun., 1998). Watershed runoff in the region of Lower McKenzie Lake was between 80 and 100 percent of long-term average runoff (Holmstrom and others, 1999, "Water Resources Data--Wisconsin").

Lake Data:

The following summarizes some highlights of data given in the tables and shown in the figures.

Lake-stage fluctuations:

Lake stages were measured by the USGS on sampling dates. The stages ranged from 92.31 feet on August 21,1998 to 92.58 feet on April 21, 1998. Actual range of stage was probably greater than the observed range, owing to the infrequency of measurements. Stage values are shown in the table on the top half of Figure 2.

Lake-depth profiles:

Vertical profiles of water temperature, dissolved oxygen, pH, and specific conductance, which were measured over the deepest point in the lake, are listed in Table 1 and shown on Figure 2. The profiles exhibit a pattern that is typical for weakly thermally stratified lakes that are subject to wind-driven mixing. The lake was mixed on six of the eight sampling dates. Only on July 21,1997 and March 4, 1998 (under ice cover) was there significant thermal stratification. Significant anoxia (absence of oxygen) in lower waters developed only under ice as shown on the March 4, 1998 profile. The pH, which ranged between 6.3 and 8.6, is common for northwestern Wisconsin lakes and poses no problems for aquatic life.

Chemical constituents:

Analyses of water samples collected on April for selected chemical constituents for chemical characterization of the lake are shown in Figure 2. Samples collected at 0.5 and 4.5-meter depths show similar constituent concentrations, as would be expected under mixed water column conditions. The constituent values for color, chlorophyll a, chloride, calcium, magnesium, pH, alkalinity, and total phosphorus are within regional values for this area as described by Lillie and Mason in "Limnological Characteristics of Wisconsin Lakes," 1983, Technical Bulletin No. 138, Department of Natural Resources. The total nitrogen concentration is below regional values.

The ratio of dissolved nitrogen to dissolved phosphorus was 23:1, based on the surface concentrations on April 21. This ratio suggests the lake is phosphorus limited, which means algal growth is dependent on the amount of available phosphorus rather than available nitrogen.

Three common measures of water quality used as indices are concentrations of near-surface total-phosphorus and chlorophyll a, and Secchi depth. Total phosphorus concentrations ranged from 0.021 mg/L on July 14, 1998 to 0.045 mg/L on August 19, 1997, chlorophyll a ranged from 3.92 µg/L on April 21, 1998 to 15.0 µg/L on August 19,1997 , and Secchi depths ranged from 1.8 m on August 19,1997 and June 10 and August 21, 1998 to 3.5 m on July 14, 1998.

Surface total phosphorus and chlorophyll a concentrations, and Secchi depths for the 1997-98 period are shown on Figure 3. The generally higher concentrations in 1997 are similar to what was observed at McKenzie lake where 13 years (1986-98) of data are available.

Total phosphorus concentration 0.5 meters above the lake bottom at the main site ranged from 0.027 mg/L on March 4 and June 10, 1998 to 0.063 mg/L on August 19,1997. These relatively low phosphorus concentrations for near bottom waters are indicative of minor phosphorus release from the bottom sediments.

Lake condition:

Water-quality index:

Lillie and Mason (1983) classified all Wisconsin lakes using a random data set collected in the summer (July and August). The index, shown on page 14 of "Water-Quality and Lake-Stage data for Wisconsin Lakes, Water Year 1998," is based on surface total-phosphorus and chlorophyll a concentrations, and Secchi depths. According to the index, surface total-phosphorus and chlorophyll a concentrations, and Secchi depths in Lower McKenzie Lake indicate generally "fair" water quality in 1997 and "good" water quality in 1998.

Lillie and Mason (1983) also provided a means of comparing the condition of Lower McKenzie Lake with other lakes in northwestern Wisconsin. The comparison in Table 3 shows the percentage distribution of northwestern Wisconsin lakes within each condition group and the relative position of Lower McKenzie Lake.

Trophic status:

Another means of assessing the nutrient, or trophic, status of a lake is to use Carlson's Trophic State Index (TSI). The 1998 TSI data is listed in Table 2. The last plot on Figure 3 is a graphical illustration of the variation in Trophic State Indices for Lower McKenzie Lake during the 2 year study period. The data show the lake to be meso-eutrophic, or a lake with moderate to high nutrient levels.

Table 1. Lake -depth profiles for Lower Mckenzie Lake near Webb Lake, Wisconsin, 1997 water year.

WATER QUALITY DATA

DATE	SAMPLING DEPTH (M) (00003)	TEMPERATURE WATER (DEG C) (00010)	PH WATER WHOLE FIELD (STANDARD UNITS) (00095)	SPECIFIC CONDUCTANCE (US/CM) (00400)	OXYGEN, DISSOLVED (MG/L) (00300)
JUN					
24..	0.5	24.0	8.4	128	10.8
24...	1.0	24.0	8.4	129	10.4
24...	1.5	24.0	8.4	129	10.0
24..	2.0	24.0	8.4	129	9.9
24...	2.5	24.0	8.4	128	9.8
24...	3.0	23.0	8.3	128	10.6
24...	3.5	21.5	8.1	130	10.0
24..	4.0	20.0	7.4	130	3.7
24...	4.5	19.0	7.1	131	1.3
24..	4.7	--	--	--	--
JUL					
21...	0.5	24.0	8.6	136	9.7
21...	1.0	24.0	8.6	136	9.3
21...	1.5	24.0	8.6	135	9.1
21...	2.0	24.0	8.6	136	8.9
21...	2.5	24.0	8.5	138	7.8
21...	3.0	22.0	7.7	143	7.8
21...	3.5	21.5	7.8	140	8.5
21...	4.0	20.0	7.4	139	4.4
21...	4.5	19.5	7.2	144	0.3
21...	5.0	--	--	--	--
AUG					
19...	0.5	20.0	8.2	124	8.5
19...	1.0	20.0	8.2	124	8.5
19...	1.5	20.0	8.2	124	8.5
19...	2.0	20.0	8.2	124	8.4
19..	2.5	20.0	8.2	124	8.4
19..	3.0	20.0	8.2	124	8.4
19...	3.5	19.5	7.9	125	6.1
19..	4.0	19.5	7.6	124	5.9
19..	4.5	19.0	7.5	127	2.4
19...	5.0	--	--	--	--

Table 1. Lake-depth profiles for Lower McKenzie Lake near Spooner, Wisconsin, 1998 water year

WATER-QUALITY DATA

DATE	SAMPLING DEPTH (M) (00098)	TEMPERATURE WATER (DEG C) (00010)	SPECIFIC CONDUCTANCE (US/CM) (00095)	PH WATER WHOLE FIELD (STANDARD UNITS) (00400)	OXYGEN, DISSOLVED (MG/L) (00300)
MAR					
04...	0.5	2.2	75	6.3	10.6
04...	1.0	3.3	133	6.7	10.3
04...	1.5	4.1	151	6.7	7.9
04...	2.0	4.5	160	6.8	5.2
04...	2.5	4.8	167	6.8	2.2
04...	3.0	4.9	166	6.8	1.5
04...	3.5	5.0	169	6.8	1.2
04...	4.0	5.0	169	6.8	0.8
04...	4.5	5.0	171	6.8	0.6
04...	5.0	--	--	--	--
APR					
21...	0.5	12.0	134	8.0	11.7
21...	1.0	11.7	133	8.0	11.7
21...	1.5	11.3	133	8.0	11.8
21...	2.0	11.2	133	8.0	11.7
21...	2.5	11.2	133	8.0	11.6
21...	3.0	11.1	132	8.0	11.7
21...	3.5	11.0	132	8.0	11.7
21...	4.0	10.7	132	8.0	11.5
21...	4.5	10.7	132	8.0	11.3
21...	5.0	--	--	--	--
JUN					
10...	0.5	17.0	146	8.6	11.0
10...	1.0	17.0	146	8.5	10.9
10...	1.5	16.9	146	8.5	10.4
10...	2.0	16.8	145	8.4	10.5
10...	2.5	16.7	145	8.3	10.0
10...	3.0	16.7	144	8.3	10.1
10...	3.5	16.6	144	8.3	9.6
10...	4.0	16.3	147	8.1	7.7
10...	4.5	15.9	149	7.9	4.8
10...	5.0	--	--	--	--
JUL					
14...	0.5	26.8	143	8.5	9.9
14...	1.0	26.8	143	8.6	9.9
14...	1.5	26.8	142	8.7	9.9
14...	2.0	26.8	143	8.7	9.8
14...	2.5	26.6	146	8.6	9.3
14...	3.0	26.0	148	8.4	9.0
14...	3.5	24.9	152	8.2	9.4
14...	4.0	24.1	150	8.2	8.4
14...	4.5	22.9	156	7.9	5.5
14...	5.0	--	--	--	--
AUG					
21...	0.5	24.5	147	7.9	9.4
21...	1.0	24.3	147	8.0	9.5
21...	1.5	24.0	147	8.0	9.5
21...	2.0	23.7	147	8.1	9.6
21...	2.5	23.0	148	8.0	7.0
21...	3.0	22.6	150	7.8	4.8
21...	3.5	22.4	150	7.6	3.8
21...	4.0	22.0	151	7.5	3.5
21...	4.5	--	--	--	--

Table 2.--Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Lower Mckenzie Lake
1997 water year
[- indicates not applicable; -- indicates no data available]

Date	Secchi Disk			Sampling	Total Phosphorus			Chlorophyll a		Dissolved Ortho-phosphate Phosphorus
	Depth (meters)	Depth (feet)	T.S.I.	Depth (feet)	Conc. (mg/L)	Conc. (µg/L)	T.S.I	Conc. (µg/L)	T.S.I.	Conc. (mg/L)
06/24/97	2.4	7.9	47	0.5	0.031	31	55	5.43	48	--
	-	-	-	4.5	0.032	32	--	-	-	--
07/21/97	2.2	7.2	49	0.5	0.033	33	55	6.12	49	--
	-	-	-	4.5	0.062	62	--	-	-	--
08/19/97	1.8	5.9	52	0.5	0.045	45	58	15.1	55	--
--	--	--	--	4.5	0.063	63	--	-	-	--
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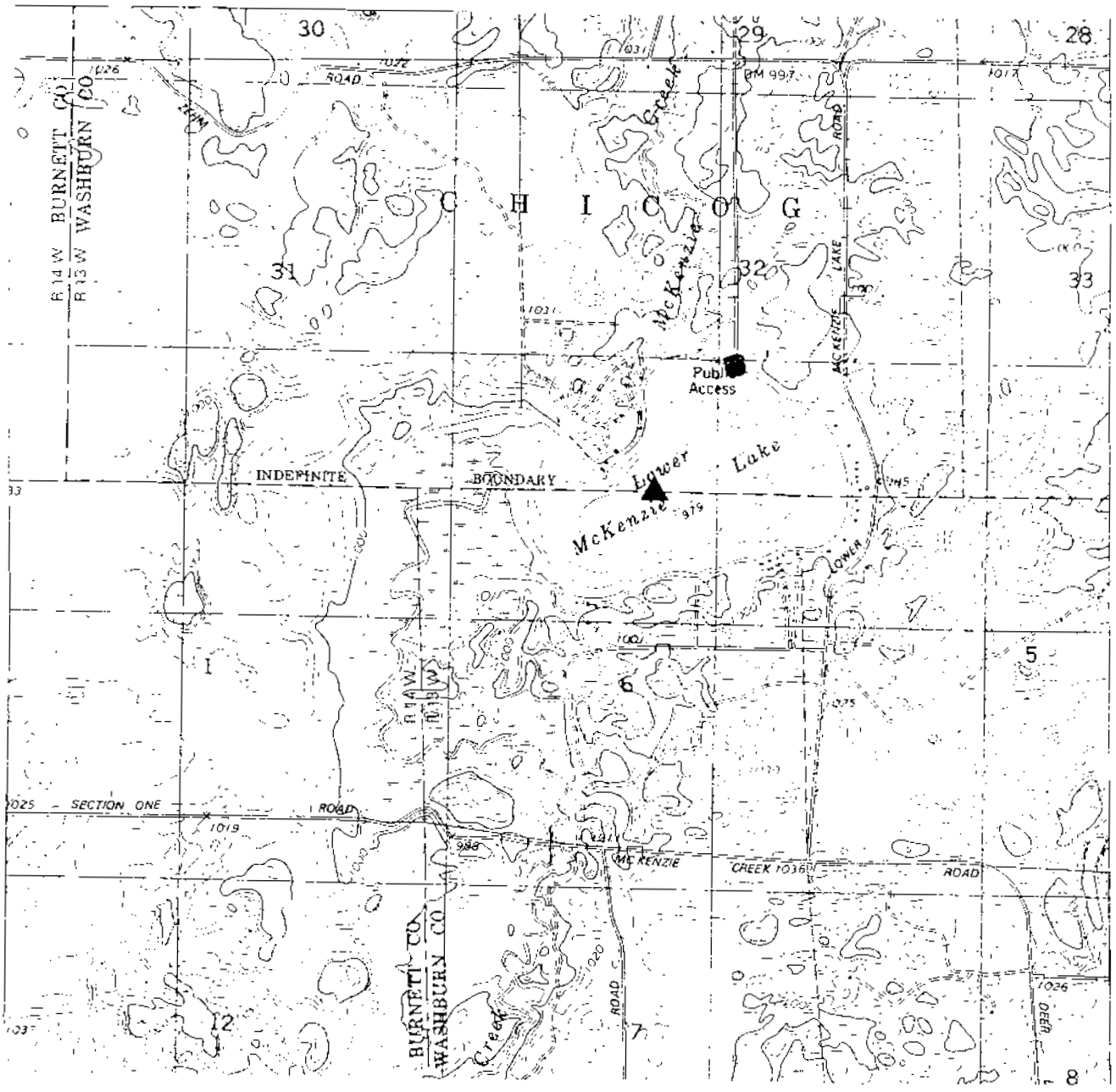
Table 2. Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Lower McKenzie Lake, 1998 water year

[- indicates not applicable; -- indicates no data available]

Date	Secchi Disk			Sampling	Total Phosphorus			Chlorophyll a		Dissolved Ortho-phosphate Phosphorus
	Depth (meters)	Depth (feet)	TSI	Depth (meters)	Conc. (mg/L)	Conc. (ug/L)	TSI	Conc. (ug/L)	TSI	Conc. (mg/L)
04/21/98	3.1	10.2	44	0.5	0.024	24	53	3.92	45	0.001
	-	-	-	4.5	0.031	-	-	-	-	<0.002
06/10/98	1.8	5.9	52	0.5	0.029	29	54	14	55	--
	-	-	-	4.5	0.027	-	-	-	-	--
07/14/98	3.5	11.5	42	0.5	0.021	21	52	4.05	45	--
	-	-	-	4.5	0.035	-	-	-	-	--
08/21/98	1.8	5.9	52	0.5	0.024	24	53	7.06	50	--
	-	-	-	4.0	0.039	-	-	-	-	--

Table 3. Condition of Lower McKenzie Lake relative to other northwestern Wisconsin Lakes

		Parameter	Percentage distribution of lakes in southeast Wisconsin within parameter ranges	
		Total Phosphorus (mg/L)		
Lower McKenzie	1997	<0.010	best condition	12
	1998	0.010-0.020		35
		0.020-0.030		23
		0.030-0.050		18
		0.050-0.100		8
		0.100-0.150		3
		>0.150	worst condition	1
		Chlorophyll a (µg/L)		
		0-5	best condition	29
Lower McKenzie		5-10		36
		10-15		14
		15-30		14
		>30	worst condition	9
		Secchi depth (meters)		
		3.0-6.0	best condition	22
Lower McKenzie		2.0-3.0		29
		1.0-2.0		30
		<1.0	worst condition	19



EXPLANATION

▲ Water-quality monitoring site

■ Lake-stage monitoring site

Figure 1. Locations of water-quality and lake-stage monitoring sites on Lower McKenzie Lake near Webb Lake, Wisconsin.

LOCATION.--Lat 45°59'02", long 92°01'19", in NW 1/4 NE 1/4 sec.6, T.40 N., R.13 W., Washburn County, Hydrologic Unit 07030002, 13.8 mi northwest of Spooner.

PERIOD OF RECORD.--June to August 1997.

REMARKS.--Lake sampled at deepest point. Water-quality analyses done by Wisconsin State Laboratory of Hygiene.

WATER-QUALITY DATA, JUNE 24 TO AUGUST 19, 1997
(Milligrams per liter unless otherwise indicated)

	June 24		July 21		Aug. 19	
Lake stage (ft)	---		92.39		92.41	
Secchi-depth (meters)	2.4		2.2		1.8	
Chlorophyll a, phytoplankton (µg/L)	5.4		6.1		15	
Depth of sample (m)	0.5	4.5	0.5	4.5	0.5	4.5
Water temperature (°C)	24.0	19.0	24.0	19.5	20.0	19.0
Specific conductance (µS/cm)	128	131	136	144	124	127
pH (units)	8.4	7.2	8.6	7.2	8.2	7.5
Dissolved oxygen	10.3	1.3	9.7	0.3	8.5	2.4
Phosphorus, total (as P)	0.031	0.032	0.033	0.052	0.045	0.063

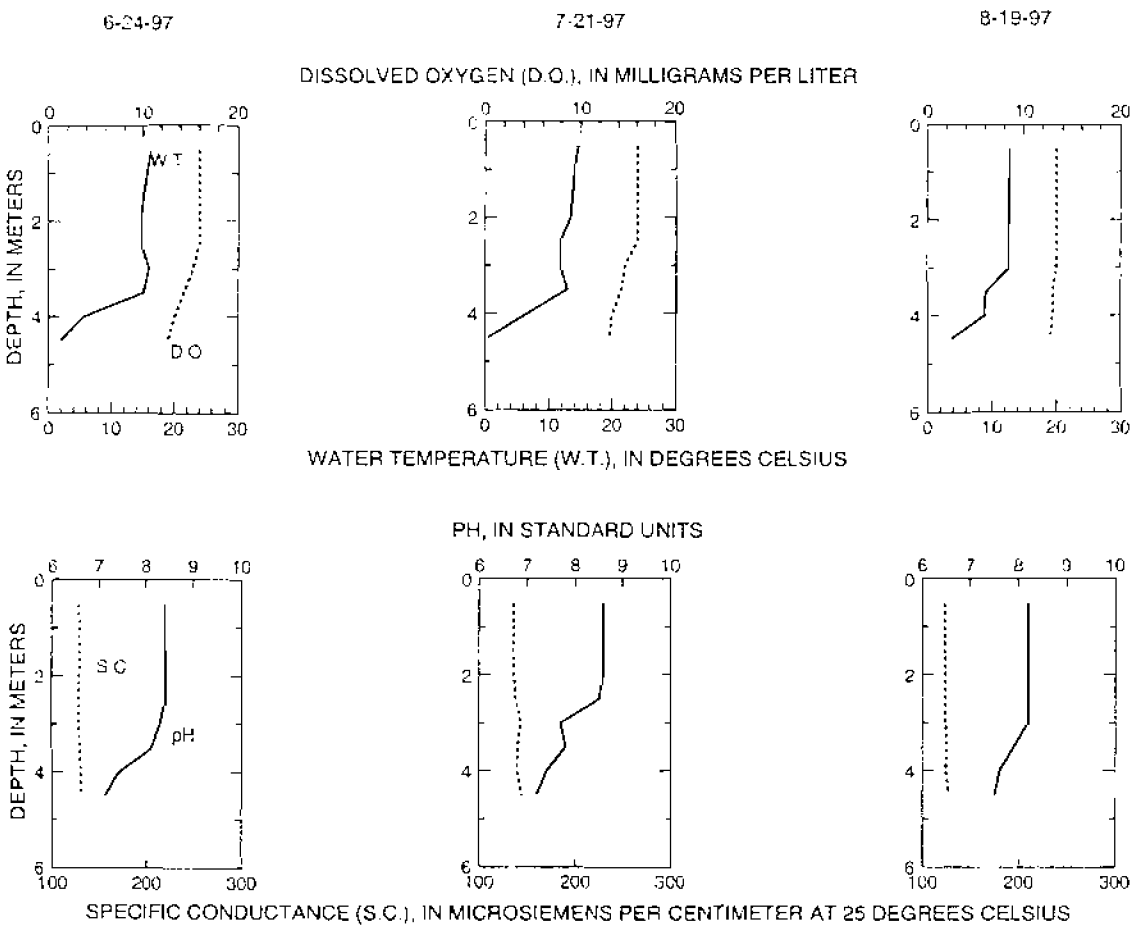


Figure 2. Water-quality data and depth profiles for Lower McKenzie Lake near Webb Lake, Wisconsin, 1997 water year

LOCATION.--Lat 45°59'02", long 92°01'19", in NW 1/4 NE 1/4 sec.6, T.40 N., R.13 W., Washburn County, Hydrologic Unit 07030002, 13.8 mi northwest of Spooner.

PERIOD OF RECORD --June 1997 to current year.

REMARKS.--Lake sampled at deepest point. Water-quality analyses done by Wisconsin State Laboratory of Hygiene.

WATER-QUALITY DATA, MARCH 04 TO AUGUST 21, 1998
(Milligrams per liter unless otherwise indicated)

	Mar. 04		Apr. 21		June 10		July 14		Aug. 21	
Lake stage (ft)	---		92.58		92.53		92.35		92.31	
Secchi-depth (meters)	---		3.1		1.9		3.6		1.8	
Chlorophyll a, phytoplankton (µg/L)	--		3.92		14		4.06		7.56	
Depth of sample (m)	0.5	4.5	0.5	4.5	0.5	4.5	0.5	4.5	0.5	4.0
Water temperature (°C)	2.2	5.0	12.0	10.7	17.0	15.9	26.8	22.9	24.5	22.0
Specific conductance (µS/cm)	75	171	134	132	146	149	143	156	142	152
pH (units)	6.3	6.8	8.0	8.0	8.0	7.9	8.2	7.9	7.9	7.5
Dissolved oxygen	10.5	9.6	11.7	11.3	12.0	4.8	8.9	5.5	9.4	3.5
Phosphorus, total (as P)	0.031	0.027	0.024	0.031	0.029	0.027	0.021	0.035	0.024	0.039
Phosphorus, ortho, dissolved (as P)	--		0.001	<0.002			---	---	---	
Nitrogen, NO2 + NO3, diss. (as N)	--	---	<0.010	<0.010	--	---			---	---
Nitrogen, Ammonia, dissolved (as N)	--	--	<0.013	<0.013	---	--	--	---	---	--
Nitrogen, amm. + org, total (as N)	--	---	0.13	0.27	---	---			--	---
Nitrogen, total (as N)	--		---	---	--			--	--	---
Color (Pt-Co scale)	---	---	25	10	---	---			---	---
Turbidity (NTU)	---	---	1.4	1.8			--			--
Hardness, as CaCO3		---	70	69	---	---			---	---
Calcium, dissolved (Ca)	--		19	19	---		---	---	---	---
Magnesium, dissolved (Mg)		---	5.4	5.3	---	---			---	---
Sodium, dissolved (Na)	---	--	2.2	2.2		--	--	---	--	---
Potassium, dissolved (K)		---	0.7	0.6	---	---	--	---	---	--
Alkalinity, as CaCO3	--	---	68	68	---	---		--	---	--
Sulfate, dissolved (SO4)	---	---	2.8	2.8		---	---	--	--	--
Chloride, dissolved (Cl)		---	2.4	2.4	---	---	--	--	--	---
Silica, dissolved (SiO2)	---	---	14	14	---	---	--	--	---	--
Solids, dissolved, at 180°C	--	---	108	108	---	---	--	--	---	--
Iron, dissolved (Fe) µg/L	---	---	30	20	---	---	---	---	--	
Manganese, dissolved (Mn) µg/L	---		2.4	4.2	---	--	---	--	---	--

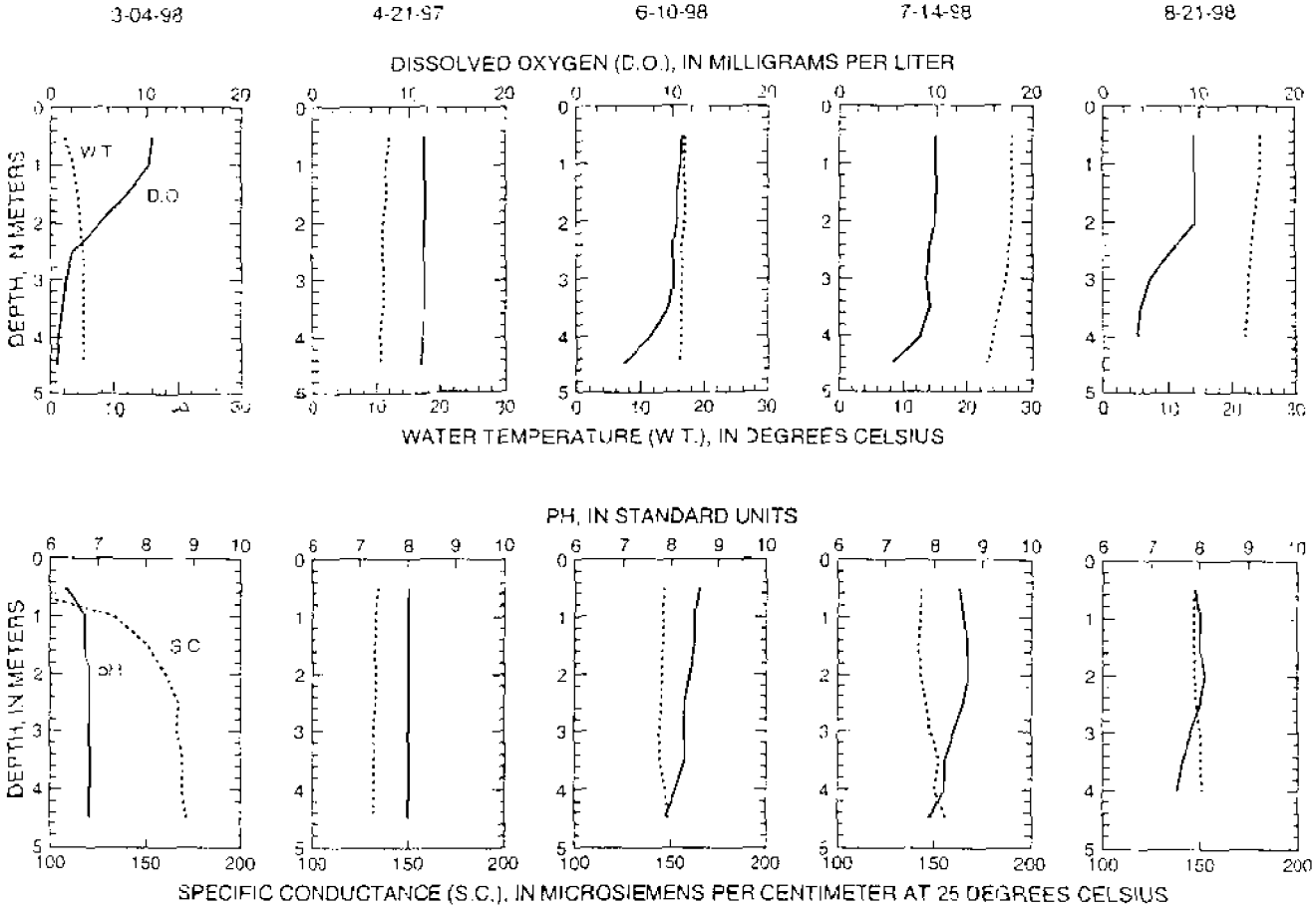


Figure 2. Water-quality data and depth profiles for Lower McKenzie Lake near Spooner, Wisconsin. 1998 water year

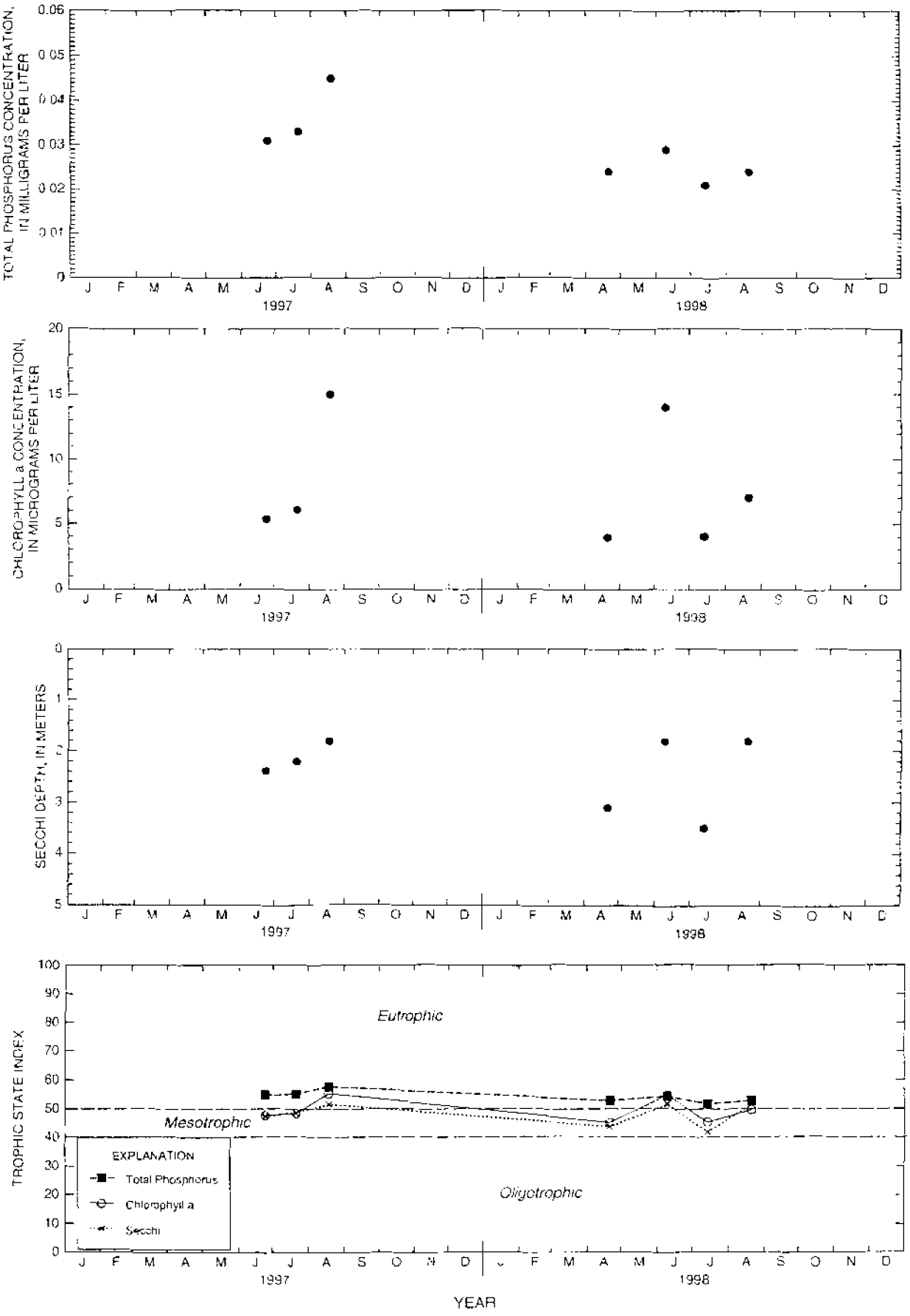


Figure 3. Surface total phosphorus, chlorophyll a concentrations, Secchi depths, and TSI data for Lower McKenzie Lake near Webb Lake, Wisconsin.