LPL-458

Middle McKenzie Lake near Spooner,WI
Water-Quality Data Summary

This summary covers the period June 1997 to September 1998, which is the period of water-quality monitoring of Middle 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:

Middle McKenzie Lake is classified as a drainage lake, with one inlet and one outlet. Flow in the inlet is primarily outflow from McKenzie Lake, about 0.5 miles southof Middle McKenzie Lake. The average depth of the lake is 6.1 meters and the surface area is 530 acres (0.83 square miles). The water-quality sampling site is located at the deepest point in the lake at a depth of about 10 meters. Lake stage was monitored near the outlet, which is located on the northeast side of the lake. The locations of the monitoring sites are shown in Figure 1.

Hydrologic conditions during water years 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 warmer than normal for the period December 1997 through March 1998; April and May was 3.9 ° F warmer than normal; and the period June through August was 0.5 ° F warmer than normal (National Oceanic and Atmospheric Administration "Climatological Data--Wisconsin"). Precipitation during water year 1997 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 Middle 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 Middle 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. Observed stages ranged from 91.83 feet on June 10, 1998 to 92.36 feet on April 15, 1998. Owing to the infrequency of measurements, actual range in stage may have been greater that the observed range. Stage values are listed shown in the table in 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 in Figure 2. During the June 1997 through August 1998 sampling period, complete water-column mixing was observed on April 16, 1998. The lake became thermally stratified through the summer. In June the lower 1 meter of water was anoxic (devoid of oxygen), and by August the lower 2-3 meters were anoxic. The anoxic zone is unable to support fish. The pH, which ranged between 7.3 and 8.8, is common for northwestern Wisconsin lakes and poses no problems for aquatic life.

Chemical constituents:

Analyses of water samples collected on April 15, 1998 for selected chemical constituents for chemical characterization of the lake are shown in Figure 2. Samples collected at 0.5 and 8.0-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, total nitrogen, 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 ratio of dissolved nitrogen to dissolved phosphorus was 26:1, based on the surface concentrations on April 15. 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. At the center sampling site, total phosphorus concentrations ranged from <0.005 mg/L on March 3,1998 to 0.040 mg/L on April 19,1997, chlorophyll a ranged from 2.2 µg/L on June 24,1997 to 8.11 µg/L on August 21, 1998, and Secchi depths ranged from 2.5 m on June 24, 1997 to 4.0 m on July 14, 1998.

Surface total phosphorus and chlorophyll a concentrations, and Secchi depths for the 1996-98 period are shown on Figure 3. The generally higher phosphorus concentrations in 1997 are similar to what was observed at McKenzie Lake where 13 years (1986-98) of data are availible

Total phosphorus concentration 0.5 meters above the lake bottom ranged from 0.033 mg/L on June 10, 1998 to 0.099 mg/L on August 19,1997. These phosphorus concentrations observed during anoxic periods 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. The phosphorus index showed "fair" water quality in Middle McKenzie Lake in 1997 and "good" water quality in 1998. The chlorophyll a concentrations and Secchi depths indicate "very good" water quality.

Lillie and Mason (1983) also provided a means of comparing the condition of Middle 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 Middle 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 Middle McKenzie Lake during the 2-year study period. The TSI show the lake to be lower eutrophic with respect to phosphorus , and mesotrophic with respect to chlorophyll a and Secchi depth.

Table 1. Lake -depth profiles for Middle Mckenzie Lake near Spooner, 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	23.0	8.4	136	10.2
24...	1.5	23.0	8.4	137	9.9
24...	2.5	23.0	8.4	136	9.5
24...	3.5	23.0	8.4	137	9.5
24...	4.5	20.5	8.1	136	9.0
24...	5.5	16.0	7.7	134	8.7
24...	6.5	14.5	7.6	136	7.1
24...	7.5	13.5	7.3	136	3.6
24...	8.5	13.0	7.3	139	3.2
24...	9.5	12.5	7.2	141	1.9
24...	10.5	12.5	7.2	148	1.2
JUL					
21...	0.5	24.0	8.9	146	9.4
21...	1.0	24.5	8.9	146	9.2
21...	1.5	24.5	8.9	145	9.0
21...	2.0	24.5	8.9	145	9.0
21...	2.5	24.5	8.9	145	8.9
21...	3.0	24.5	8.9	146	8.9
21...	3.5	24.5	8.9	145	8.9
21...	4.0	24.5	8.9	146	8.9
21...	4.5	24.0	8.8	145	7.8
21...	5.0	20.5	8.2	146	7.5
21...	5.5	20.0	7.9	145	6.4
21...	6.0	18.5	7.7	150	5.1
21...	6.5	17.5	7.4	152	2.8
21...	7.0	16.5	7.3	153	1.6
21...	7.5	15.0	7.2	157	0.3
21...	8.0	14.5	7.2	157	0.2
21...	8.5	14.0	7.1	158	0.2
21...	9.0	14.0	7.1	162	0.1
21...	9.5	13.5	7.1	166	0.1
21...	10.0	--	--	--	--
AUG					
19...	0.5	20.5	8.8	132	8.8
19...	1.0	20.5	8.8	133	8.4
19...	2.0	20.5	8.8	133	8.3
19...	4.0	20.5	8.7	133	8.2
19...	5.0	20.5	8.7	134	7.9
19...	6.0	20.5	8.6	133	7.3
19...	7.0	19.0	7.6	140	1.6
19...	8.0	15.0	7.3	141	0.2
19...	9.0	13.5	7.2	163	0.2
19...	10.0	--	--	--	--

Table 1. Lake-depth profiles for Middle 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					
03...	0.5	3.3	147	7.9	11.7
03...	1.0	3.8	154	7.8	11.3
03...	2.0	4.0	151	7.8	11.1
03...	3.0	4.0	150	7.7	11.0
03...	4.0	4.1	150	7.7	10.8
03...	5.0	4.2	154	7.6	9.7
03...	6.0	4.3	152	7.5	7.2
03...	7.0	4.4	154	7.4	7.0
03...	8.0	4.5	159	7.3	6.9
03...	9.0	4.5	160	7.3	5.6
03...	9.5	--	--	--	--
APR					
15...	0.5	8.6	143	7.8	13.2
15...	1.0	8.6	142	7.8	12.6
15...	1.5	8.6	142	7.8	12.3
15...	2.0	8.5	142	7.8	12.2
15...	2.5	8.6	142	7.8	12.1
15...	3.0	8.5	142	7.8	12.1
15...	3.5	8.6	142	7.8	12.1
15...	4.0	8.5	141	7.9	12.0
15...	4.5	8.5	141	7.9	12.0
15...	5.0	8.5	141	7.8	12.0
15...	6.0	8.5	142	7.8	11.9
15...	7.0	8.5	141	7.9	11.9
15...	8.0	8.5	141	7.8	11.8
15...	9.0	--	--	--	--
JUN					
10...	0.5	17.2	155	8.8	10.3
10...	1.0	17.2	155	8.5	10.0
10...	2.0	17.2	155	8.4	9.9
10...	3.0	17.2	155	8.3	9.8
10...	4.0	17.2	155	8.3	9.6
10...	5.0	17.1	155	8.2	9.3
10...	6.0	17.0	155	8.2	9.2
10...	7.0	16.9	155	8.1	8.6
10...	8.0	16.4	155	8.0	6.3
10...	9.0	14.2	164	7.8	0.7
10...	10.0	12.9	175	7.6	0.4
10...	11.0	--	--	--	--

Table 1. Lake-depth profiles for Middle McKenzie Lake near Spooner, Wiscsonsin, 1998 water year - continued

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)
JUL					
14...	0.5	26.5	156	8.3	9.9
14...	1.0	26.5	156	8.4	9.6
14...	2.0	26.5	155	8.4	9.6
14...	3.0	26.2	155	8.5	9.6
14...	4.0	24.8	156	8.5	10.1
14...	4.5	24.5	156	8.5	9.7
14...	5.0	23.5	158	8.4	9.3
14...	5.5	22.1	160	8.1	8.6
14...	6.0	20.7	161	8.1	7.8
14...	6.5	19.2	161	8.0	6.5
14...	7.0	18.6	161	7.9	4.8
14...	7.5	17.5	164	7.7	1.5
14...	8.0	16.8	165	7.6	1.3
14...	9.0	15.1	184	7.5	0.6
14...	9.5	--	--	--	--
AUG					
21...	0.5	23.5	153	8.2	9.5
21...	1.0	23.5	153	8.5	9.4
21...	2.0	23.5	153	8.6	9.3
21...	3.0	23.2	153	8.6	9.0
21...	3.5	23.1	153	8.7	8.5
21...	4.0	23.0	153	8.7	8.2
21...	4.5	22.9	154	8.6	7.7
21...	5.0	22.8	154	8.6	7.5
21...	5.5	22.6	155	8.6	6.8
21...	6.0	22.4	155	8.5	6.3
21...	6.5	21.9	157	8.3	3.6
21...	7.0	21.2	159	8.1	1.4
21...	7.5	19.6	162	7.9	0.6
21...	8.0	17.8	168	7.8	0.5
21...	9.0	16.8	174	7.7	0.5
21...	9.5	16.2	184	7.6	0.5
21...	10.0	--	--	--	--

Table 2.--Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Middle 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	2.5	8.2	47	0.5	0.030	30	55	2.19	41	--
	-	-	-	10	0.052	52	--	-	-	--
07/21/97	3.1	10.2	44	0.5	0.034	34	55	2.15	41	--
	-	-	-	9.5	0.043	43	--	-	-	--
08/19/97	2.6	8.5	46	0.5	0.040	40	57	5.76	48	--
--	--	--	--	9	0.099	99	--	-	-	--
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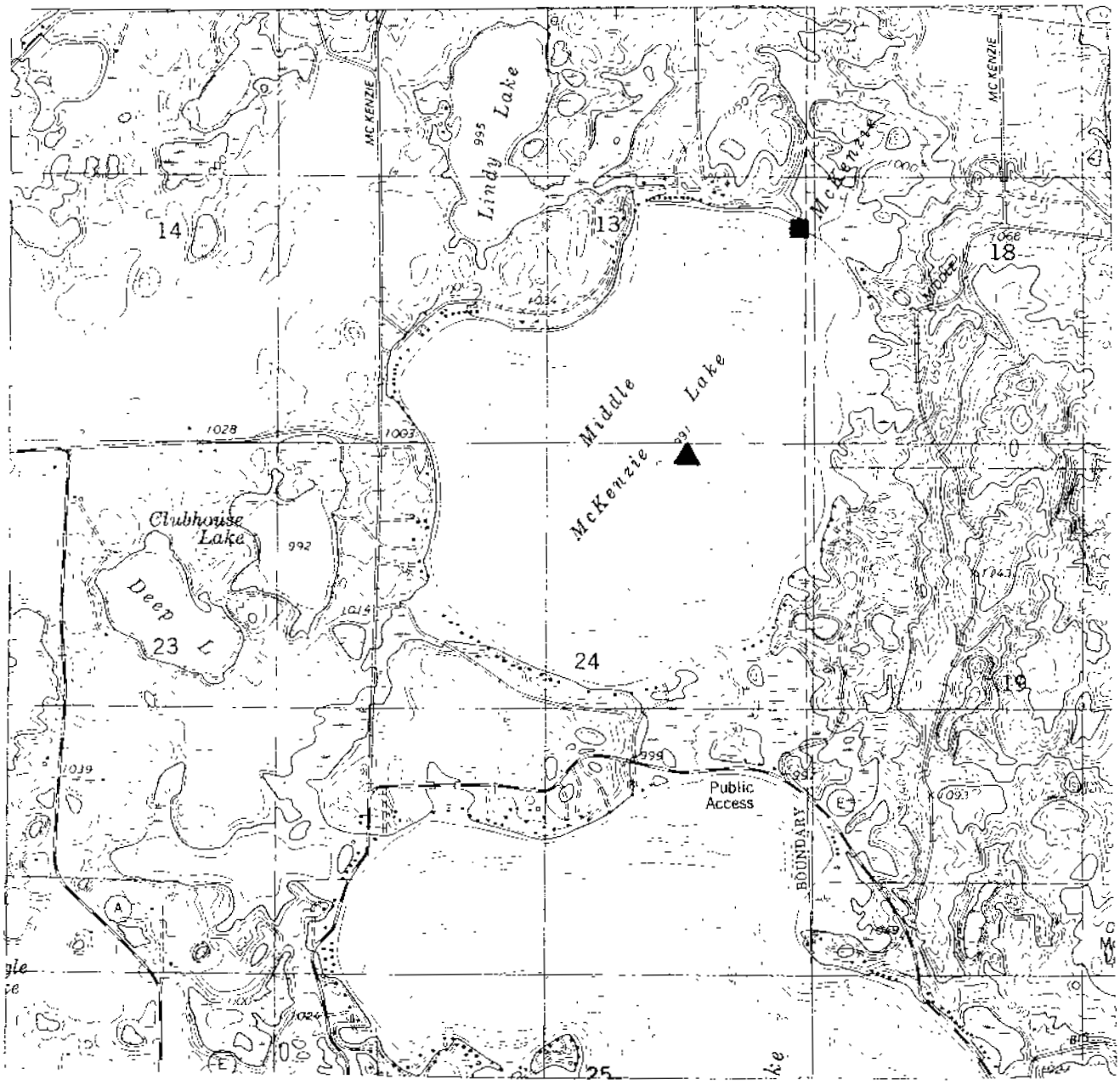
Table 2c. Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Middle McKenzie Lake, 1998 water year

[- 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)
04/15/98	3.5	11.5	42	0.5	0.031	31	55	5.08	47	<0.002
	-	-	-	8.0	0.032	-	-	-	-	<0.002
06/10/98	3.4	11.2	42	0.5	0.016	16	50	4.87	47	--
	-	-	-	10.0	0.033	-	-	-	-	--
07/10/98	4	13.1	40	0.5	0.014	14	49	2.27	41	--
	-	-	-	9.0	0.059	59	-	-	-	--
08/21/98	2.6	8.5	46	0.5	0.021	21	52	8.11	51	--
	-	-	-	9.5	0.052	52	-	-	-	--

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

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

LOCATION.--Lat 45°56'35", long 92°02'18", in SW 1/4 SE 1/4 sec.13, T.40 N., R.14 W., Burnett County, Hydrologic Unit 07030002, 11.2 mi northwest of Spooner.
PERIOD OF RECORD --June to August 1997.
REMARKS.--Lake sampled near center at deep hole. 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)	---		91.94		93.00	
Secchi-depth (meters)	2.5		3.1		2.6	
Chlorophyll a, phytoplankton (µg/L)	2.2		2.3		5.6	
Depth of sample (m)	0.5	10	0.5	9.5	0.5	9.0
Water temperature (°C)	23.0	12.5	24.0	13.5	20.5	13.5
Specific conductance (µS/cm)	136	148	146	166	132	163
pH (units)	8.4	7.2	8.9	7.1	8.8	7.2
Dissolved oxygen	10.2	1.2	9.4	0.1	8.8	0.2
Phosphorus, total (as P)	0.030	0.052	0.034	0.043	0.040	0.099

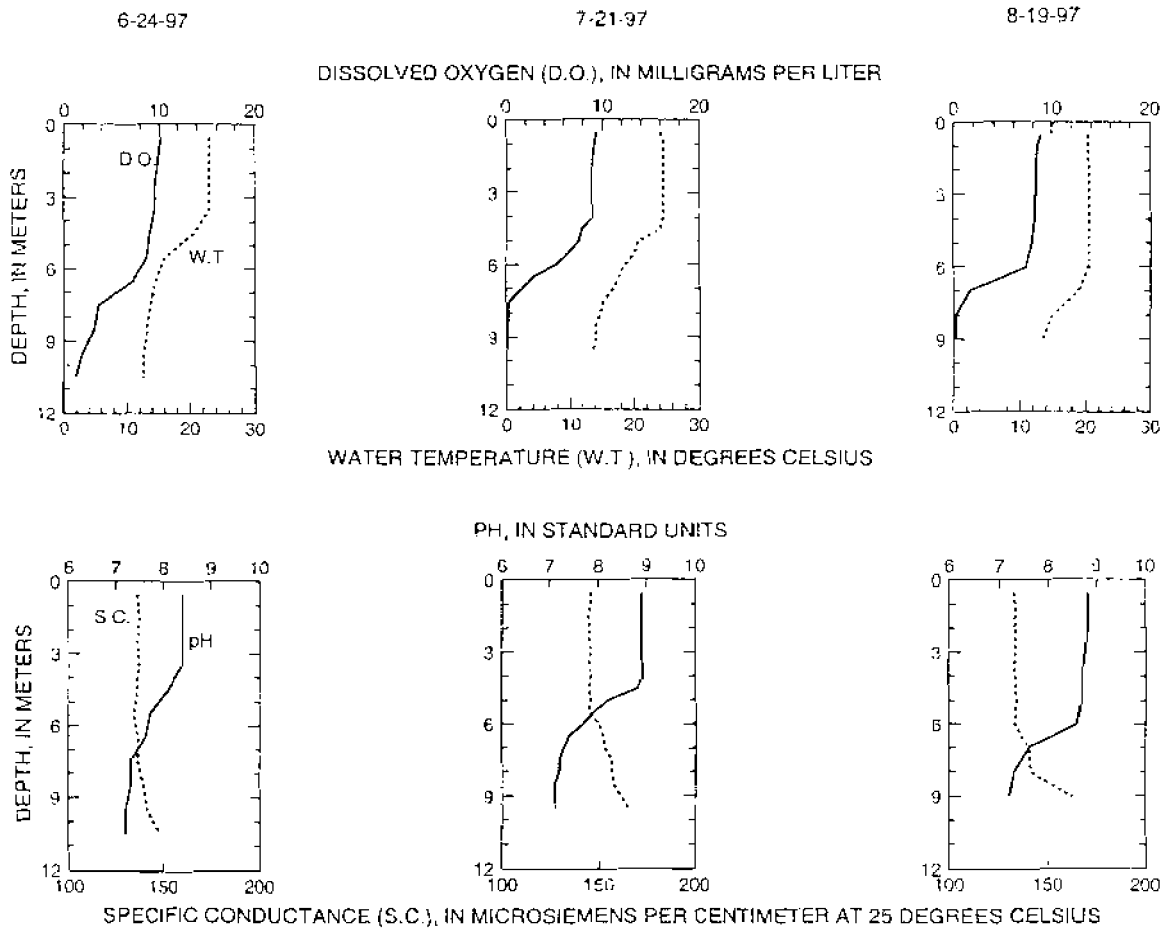


Figure 2. Water-quality data and depth profiles for Middle McKenzie Lake near Spooner, Wisconsin, 1997 water year

LOCATION.--Lat 45°56'35", long 92°02'18", in SW 1/4 SE 1/4 sec.13, T.40 N., R.14 W., Burnett County, Hydrologic Unit 07030002, 11.2 mi northwest of Spooner.

PERIOD OF RECORD.--June 1997 to current year.

REMARKS.--Lake sampled near center at deep hole. Water-quality analyses done by Wisconsin State Laboratory of Hygiene.

WATER-QUALITY DATA, MARCH 03 TO AUGUST 21, 1998
(Milligrams per liter unless otherwise indicated)

	Mar. 03	Apr. 15		June 10		July 14		Aug 21	
Lake stage (ft)	---	92.36		91.83		91.94		91.87	
Secchi-depth (meters)	---	3.5		3.4		4.0		2.6	
Chlorophyll a, phytoplankton (µg/L)	---	5.08		4.87		2.27		9.11	
Depth of sample (m)	0.5	0.5	8.0	0.5	10.0	0.5	9.0	0.5	9.5
Water temperature (°C)	3.5	8.6	8.5	17.2	12.9	26.5	15.1	23.5	16.2
Specific conductance (µS/cm)	147	143	141	155	175	156	184	183	184
pH (units)	7.9	7.8	7.8	8.8	7.6	8.3	7.5	8.2	7.6
Dissolved oxygen	12.7	13.2	11.8	10.3	0.4	9.9	0.6	9.5	0.5
Phosphorus, total (as P)	<0.005	0.031	0.032	0.016	0.033	0.014	0.059	0.021	0.052
Phosphorus, ortho, dissolved (as P)	---	<0.002	<0.002	---	---	---		---	---
Nitrogen, NO2 + NO3, diss. (as N)	---	0.040	0.039	---	---	---	---	---	---
Nitrogen, ammonia, dissolved (as N)	---	<0.013	<0.013	---	---	---	---	---	---
Nitrogen, amm + org, total (as N)	---	0.28	0.29	---	---	---	---	---	---
Nitrogen, total (as N)		0.32	0.33	---	---	---	---		---
Color (Pt-Co. scale)	---	10	10	---	---	---	---	---	
Turbidity (NTU)	---	2.8	3	---	---	---	---	---	---
Hardness, as CaCO3	---	74	74	---	---	---	---	---	
Calcium, dissolved (Ca)	---	20	20	---	---	---	---	---	---
Magnesium, dissolved (Mg)	---	5.8	5.8	---	---	---	---	---	---
Sodium, dissolved (Na)	---	2.9	2.9	---	---	---	---	---	
Potassium, dissolved (K)	---	0.7	0.5		---	---	---	---	---
Alkalinity, as CaCO3	---	72	73	---	---	---		---	---
Sulfate, dissolved (SO4)	---	2.6	2.7	---	---	---	---	---	---
Chloride, dissolved (Cl)	---	2.9	3.0	---	---	---	---	---	---
Silica, dissolved (SiO2)	---	17	17	---	---	---		---	
Solids, dissolved, at 180°C	---	100	100	---	---	---	---	---	---
Iron, dissolved (Fe) µg/L	---	10	10	---		---	---	---	---
Manganese, dissolved (Mn) µg/L	---	50	49	---	---	---		---	

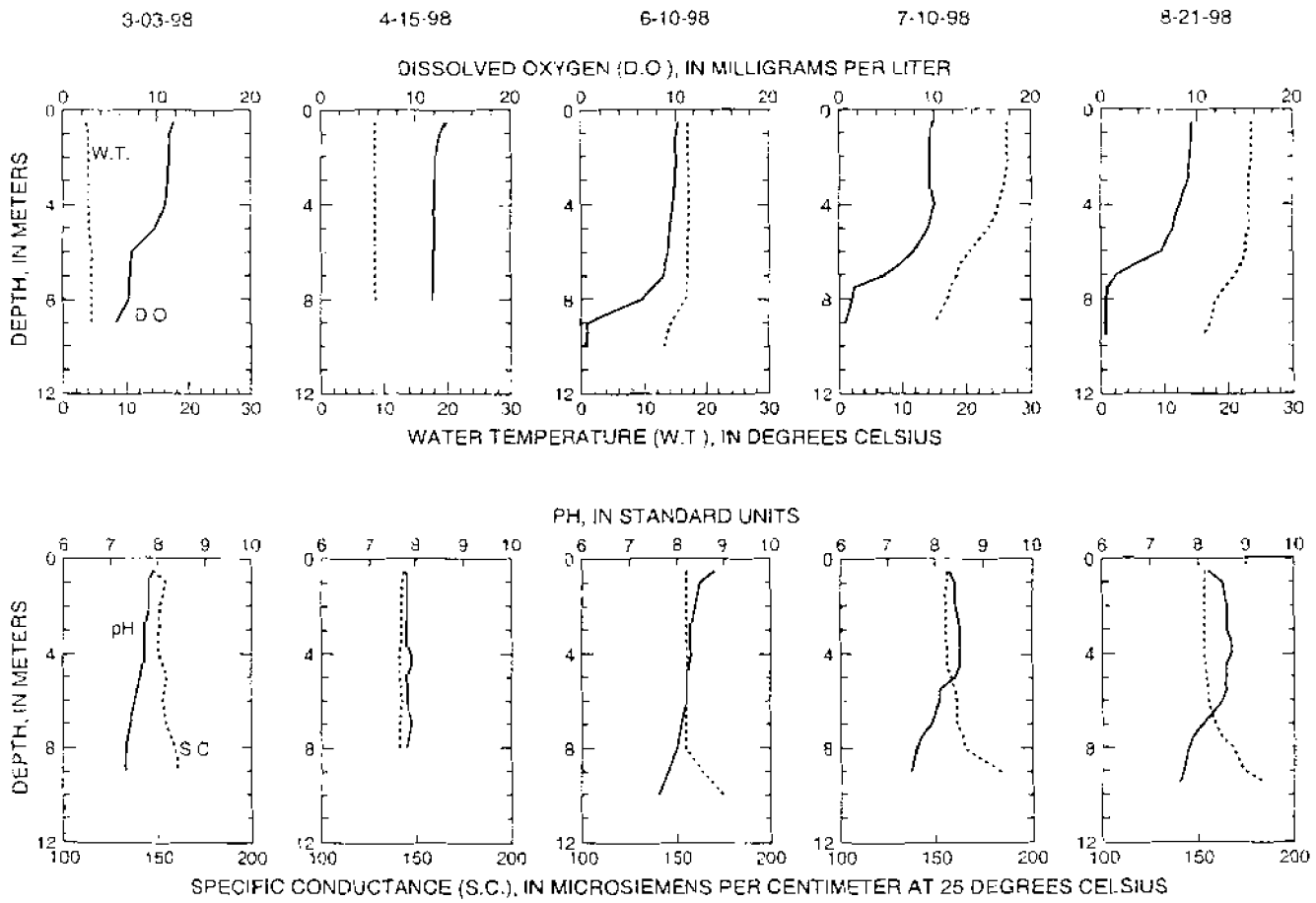


Figure 2. Water-quality data and depth profiles for Middle McKenzie Lake near Spooner, Wisconsin, 1998 water year

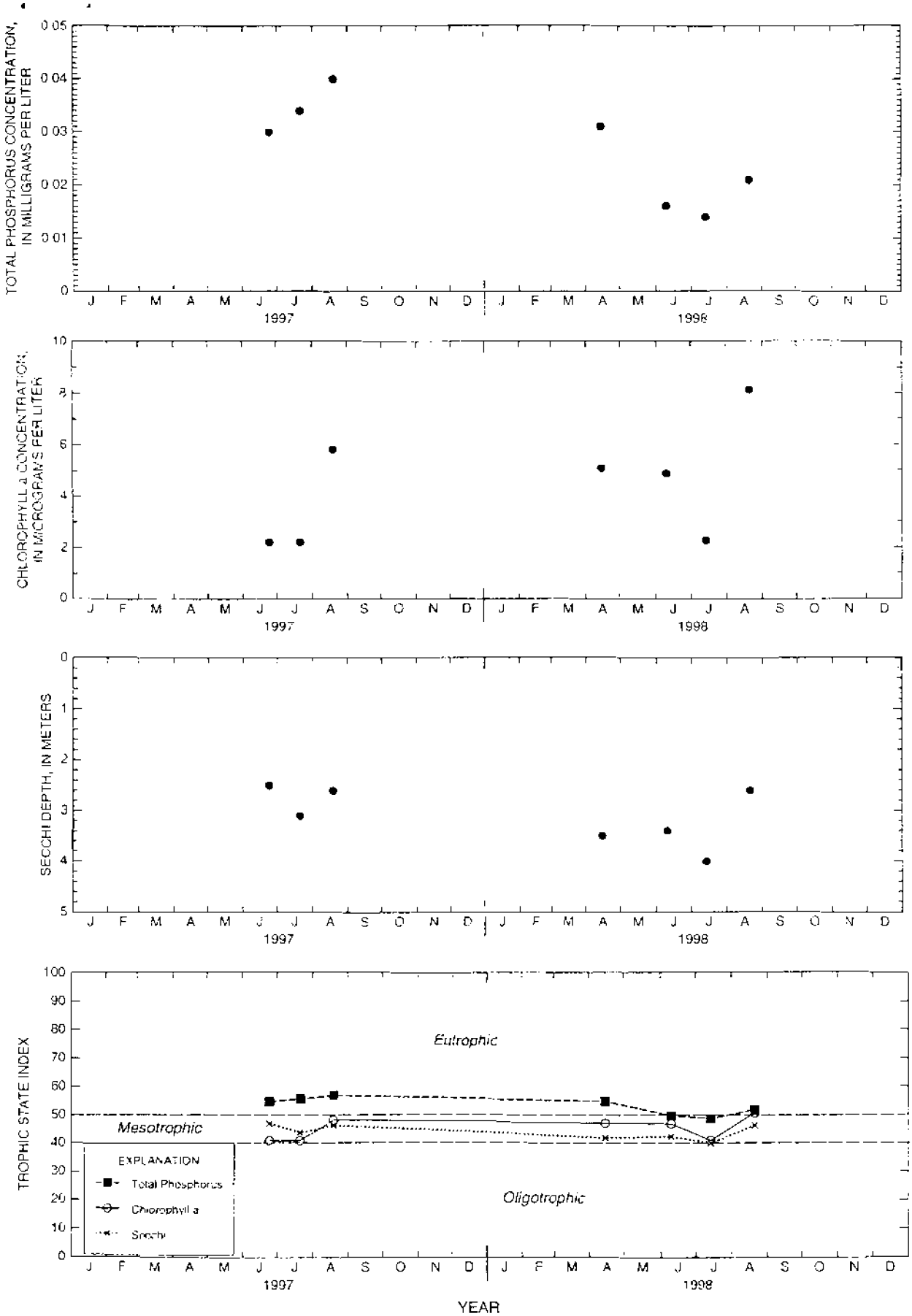


Figure 3. Surface total phosphorus, chlorophyll a concentrations, Secchi depths, and TSI data for Middle McKenzie Lake near Spooner, Wisconsin.