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## **Elizabeth Lake near Twin Lakes, Wisconsin Water-Quality Data Summary**

This summary covers the period October 1994 to September 1997, which is the period of water-quality monitoring of Elizabeth Lake by the U.S. Geological Survey (USGS). Emphasis in this summary is on data collected during 1997. All data collected during 1997 is included. Data from 1995 and 1996 are included in graphs to illustrate changes or trends.

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 1997" and to Shaw and others (1994) "Understanding Lake Data."

### **Lake description and sampling locations:**

Elizabeth Lake is classified as a drainage lake, with one major inlet from Mary lake, 5 intermittent inlets, and one outlet. The average depth of the lake is 3.4 meters, and the surface area is 638 acres (0.997 square miles). The water-quality sampling site is located at the deepest point in the lake at a depth of about 9.5 meters. Lake stage was monitored at the outlet, which is located on the southeastern side of the lake, and also at Judy Jooss' property on the northwestern side of the lake. The locations of the monitoring sites are shown in Figure 1.

### **Hydrologic conditions during water year 1997:**

Annual variability in lake condition often reflects variability in climatic and hydrologic conditions. Air temperature in southeastern Wisconsin was, on the average, 0.8 °F warmer than normal for the period December 1996 through March 1997; April and May was 4.0 °F cooler than normal; and the period June through August was 1.6 °F cooler than normal (National Oceanic and Atmospheric Administration "Climatological Data--Wisconsin"). Precipitation during water year 1997 was 101 percent of normal precipitation for southeastern Wisconsin (Pamela Naber-Knox, UW-Extension, Geological and Natural History Survey, written commun., 1997). Watershed runoff in the region of Elizabeth Lake was between 80 and 100 percent of long-term average runoff (Holmstrom and others, 1998. "Water Resources Data--Wisconsin").

### **Lake Data for 1997:**

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

#### Lake-stage fluctuations:

Observed lake stage ranged from 10.71 to 11.93 ft (local datum) and are similar to those observed during the water year 1996. Lake stages were measured by Judy Jooss at her residence and by the USGS on sampling dates. The altitude of the local gage datum (corner of Baxa seawall next to Judy Jooss' property) is 795.88 (MSL; +/- 0.1 ft). Stage values are listed in Table 4 and on the top of Figure 2.

#### Lake-depth profiles:

Vertical profiles of water temperature, dissolved oxygen, pH, and specific conductance exhibit a pattern that is typical for thermally stratified lakes and are similar to those for 1995 and 1996 except for the August 18, 1997 profiles. These profiles, which were measured over the deepest point in the lake, are listed in Table 1 and shown in Figure 2. During the February through August sampling period, complete water-column mixing was observed on April 14. The lake became thermally stratified through the summer. It appears that between the July 14 and August 18 sampling dates stratification broke down, as evidenced by the near vertical temperature profile and absence of a significant anoxic zone on August 18. No anoxic (devoid of oxygen) regions developed by June, but in July the lower 1.5 meters of water were anoxic. The anoxic zone is unable to support fish. The pH, which ranged between 7.2 and 8.4, is common for southeastern Wisconsin lakes and poses no problems for aquatic life.

#### Chemical constituents:

Analyses of water samples collected on April 14 for selected chemical constituents for chemical characterization of the lake are shown in Figure 2. Samples collected at 0.5 and 9-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 72:1, based on the surface concentrations on April 14. 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 <0.005 mg/L on July 14 to 0.024 mg/L on August 18, chlorophyll *a* ranged from 4.0 µg/L on June 2 and July 14 to 9.5 µg/L on August 18, and Secchi depths ranged from 2.3 m on August 18 to 3.4 m on June 2. The significant increase in total phosphorus and chlorophyll *a* concentrations in August are what would be expected as a result of a breakdown of stratification. That is, the more phosphorus-rich water from the hypolimnion got mixed throughout the lake, resulting in larger concentrations in the epilimnion. Surface total phosphorus and chlorophyll *a* concentrations, and Secchi depths for the 1995-97 period are shown on Figure 3. Values for 1997 are similar to those for 1996.

Total phosphorus concentration 0.5 meters above the lake bottom ranged from <0.008 mg/L on April 14 to 0.072 mg/L on July 14. The total 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 1997," 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 Elizabeth Lake indicate "good" water quality.

Lillie and Mason (1983) also provided a means of comparing the condition of Elizabeth Lake with other lakes in southeastern Wisconsin. The comparison in Table 3 shows the percentage distribution of southeastern Wisconsin lakes within each condition group and the relative position of Elizabeth 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 1997 TSI data are listed in Table 2. Figure 4 is a graphical illustration of the variation in Trophic State Indices for Elizabeth Lake during the 3 year study period. The data from 1997 show the lake to be mesotrophic, or a lake with moderate nutrient levels.

Table 1. Lake -depth profiles for Elizabeth Lake near Twin Lakes, Wisconsin, 1997 water year.

WATER QUALITY DATA					
DATE	SAM- PLING DEPTH (M) (00003)	TEMPER- ATURE WATER (DEG C) (00010)	PH WATER WHOLE FIELD (STAND- ARD UNITS) (00095)	SPE- CIFIC CON- DUCT- ANCE (US/CM) (00400)	OXYGEN, DIS- SOLVED (MG/L) (00300)
FEB					
10...	0.5	1.5	8.4	573	15.6
10...	1.0	3.0	8.4	599	14.9
10...	2.0	3.5	8.5	595	14.3
10...	3.0	3.5	8.4	600	14.3
10...	4.0	3.5	8.3	603	13.3
10...	5.0	3.5	8.2	605	12.3
10...	6.0	4.0	8.1	611	9.5
10...	7.0	4.0	7.9	618	6.1
10...	8.0	4.0	7.8	629	4.8
10...	9.0	4.0	7.6	636	2.0
10...	9.5	--	--	--	--
APR					
14...	0.5	6.5	8.4	550	11.5
14...	1.0	6.0	8.4	548	11.4
14...	2.0	6.0	8.4	550	11.3
14...	3.0	6.0	8.4	551	11.7
14...	4.0	6.0	8.4	553	12.0
14...	5.0	6.0	8.4	552	11.6
14...	6.0	6.0	8.4	554	11.4
14...	7.0	5.5	8.4	554	11.1
14...	8.0	5.5	8.4	553	11.1
14...	9.0	5.5	8.4	552	11.0
14...	9.5	--	--	--	--
JUN					
02...	0.5	16.5	8.3	567	9.9
02...	1.0	16.5	8.3	567	9.9
02...	2.0	16.0	8.3	569	9.9
02...	3.0	16.0	8.3	569	10.5
02...	4.0	16.0	8.3	568	10.5
02...	5.0	15.5	8.3	567	9.9
02...	6.0	15.5	8.2	565	8.9
02...	7.0	14.5	8.1	568	7.7
02...	8.0	14.5	8.1	570	7.4
02...	9.0	14.5	8	573	6.1
02...	10.0	14.0	7.9	576	4.4
02...	10.5	--	--	--	--

Table 1. Lake -depth profiles for Elizabeth Lake near Twin Lakes, Wisconsin, 1997 water year continued.

WATER QUALITY DATA

DATE	SAM- PLING DEPTH (M) (00003)	TEMPER- ATURE WATER (DEG C) (00010)	PH WATER WHOLE FIELD (STAND- ARD UNITS) (00095)	SPE- CIFIC CON- DUCT- ANCE (US/CM) (00400)	OXYGEN, DIS- SOLVED (MG/L) (00300)
JUL					
14...	0.5	26.5	8.3	543	9.0
14...	1.0	26.5	8.3	543	9.0
14...	2.0	26.5	8.3	543	9.2
14...	3.0	26.5	8.3	544	9.5
14...	4.0	24.5	8.3	546	9.4
14...	5.0	23.5	8.5	546	8.3
14...	6.0	22.5	8	553	5.0
14...	7.0	21.5	7.6	563	2.0
14...	8.0	19.5	7.5	582	0.1
14...	9.0	17.0	7.4	600	0.1
14...	9.5	16.5	7.4	603	0.1
14...	10.0	--	--	--	--
AUG					
18...	0.5	22.5	8.2	536	7.9
18...	1.0	23.0	8.2	531	7.8
18...	2.0	23.0	8.2	534	7.9
18...	3.0	23.0	8.2	534	7.8
18...	4.0	22.5	8.2	534	7.5
18...	5.0	22.5	8.2	534	7.4
18...	6.0	22.5	8.2	534	7.2
18...	7.0	22.5	8.2	534	6.9
18...	8.0	22.5	8.1	534	6.1
18...	9.0	20.5	7.2	600	0.1
18...	9.5	--	--	--	--

Table 2.--Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Elizabeth Lake, 1997 water year

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

Date	Secchi Disk		Sampling Depth (feet)	Total Phosphorus		Chlorophyll a		Dissolved Orthophosphate Phosphorus Conc. (mg/L)	
	Depth (meters)	Depth (feet)		Conc. (mg/L)	T.S.I.	Conc. (µg/L)	T.S.I.		
04/14/97	2.5	8.2	0.5	0.010	10	46	6.37	49	<0.002
	-	-	9	<.008	<8	-	-	-	<0.002
06/02/97	3.4	11.2	0.5	0.016	16	50	4	45	--
	-	-	10	0.059	59	-	-	-	--
07/14/97	2.7	8.9	0.5	<.005	<5	41	3.96	45	--
	-	-	9.5	0.072	72	-	-	-	--
08/18/97	2.3	7.5	0.5	0.024	24	53	9.53	52	--
	-	-	9	--	--	-	-	-	--

**Table 3. Regional lake condition and percentage distribution of southeastern lakes**

	Parameter	Percentage distribution of lakes in southeast Wisconsin within parameter ranges	
	<u>Total Phosphorus (mg/L)</u>		
Elizabeth Lake values	<0.010	best condition	7
	0.010-0.020	↓	21
	0.020-0.030		15
	0.030-0.050		21
	0.050-0.100		21
	0.100-0.150		3
	>0.150	worst condition	12
	<u>Chlorophyll a (µg/L)</u>		
Elizabeth Lake values	0-5	best condition	22
	5-10	↓	31
	10-15		14
	15-30		12
	>30	worst condition	22
	<u>Secchi depth (feet)</u>		
Elizabeth Lake values	>6.0	best condition	1
	3.0-6.0	↓	9
	2.0-3.0		26
	1.0-2.0		31
	<1.0		worst condition

**Table 4. 1995-1997 water year observer stage values for Elizabeth Lake at Twin Lakes, WI**

LOCATION.--Lat 42°30'51", long 88°15'53", in NW 1/4 SW 1/4 sec.28, T.1 N., R.19 E., Kenosha County, Hydrologic Unit 07120006, near Twin Lakes.

LAKE-STAGE RECORDS

PERIOD OF RECORD.--April 1995 to current year.

GAGE.--Staff gage read by Judy Jooss. Datum of gage is 782.31 ft above sea level.

EXTREMES FOR PERIOD OF RECORD.--Maximum gage height observed, 12.13 ft, June 7 and 10, 1996; minimum observed, 10.71 ft, Oct. 28, 1996.

EXTREMES FOR CURRENT YEAR.--Maximum gage height observed, 11.93 ft, June 16; minimum observed, 10.71, Oct. 28.

GAGE HEIGHT, FEET, WATER YEAR OCTOBER 1994 TO SEPTEMBER 1995

DATE	GAGE HEIGHT	DATE	GAGE HEIGHT	DATE	GAGE HEIGHT	DATE	GAGE HEIGHT
Apr. 22	11.31	June 24	11.21	July 22	11.05	Aug. 17	11.29
May 07	11.70	29	11.25	29	11.05	18	11.30
09	11.59	July 04	11.21	31	11.04	21	11.31
15	11.66	06	11.21	Aug. 01	11.08	29	11.27
22	11.58	10	11.17	04	11.09	Sept. 16	11.03
June 01	11.56	14	11.14	10	11.19	28	11.02
12	11.37	15	11.13	13	11.19		

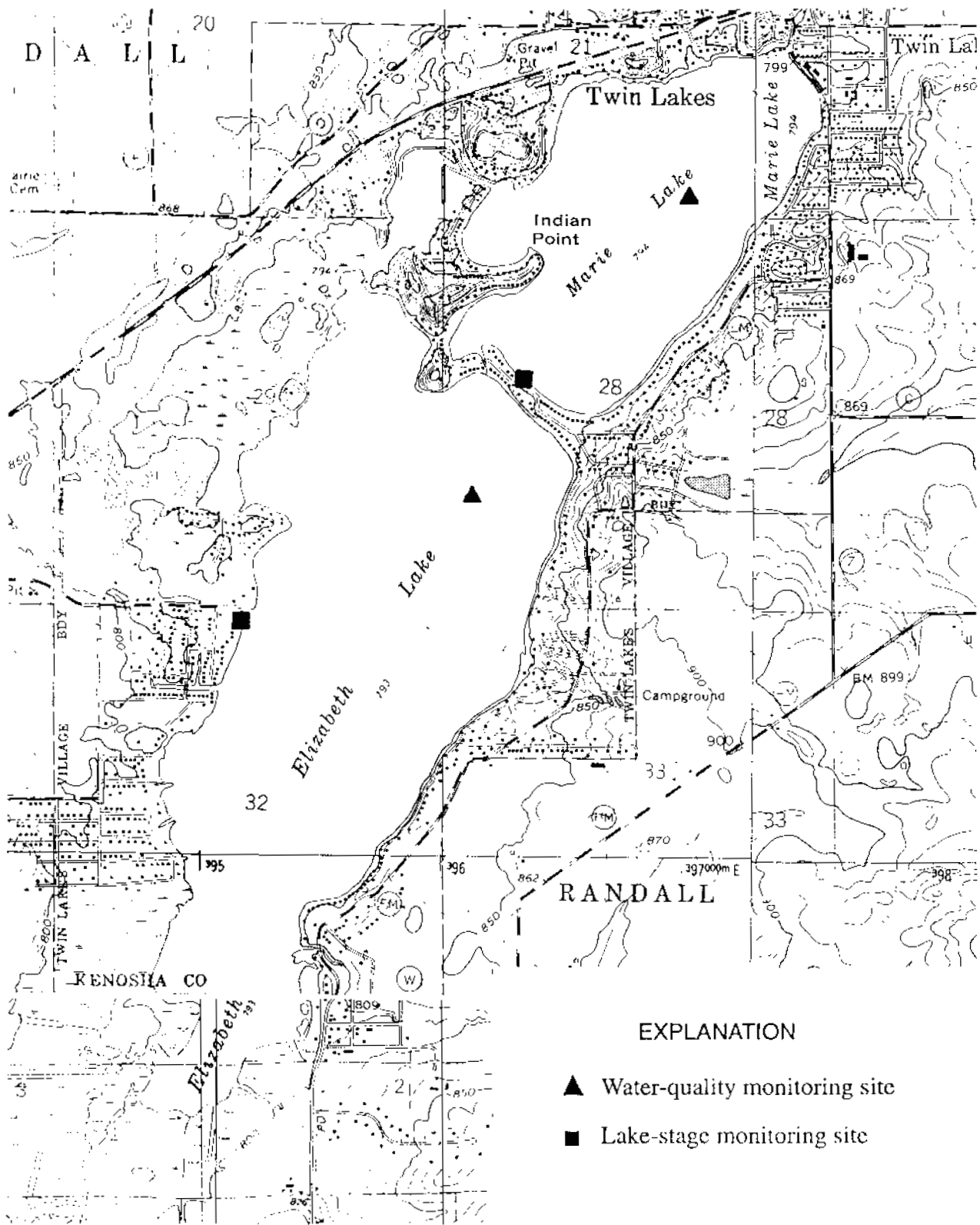
GAGE HEIGHT, FEET, WATER YEAR OCTOBER 1995 TO SEPTEMBER 1996

DATE	GAGE HEIGHT	DATE	GAGE HEIGHT	DATE	GAGE HEIGHT	DATE	GAGE HEIGHT
Oct. 18	11.06	June 02	11.86	June 17	11.97	Aug. 02	11.55
May 03	10.87	03	11.89	18	12.09	12	11.50
13	11.14	06	11.91	24	11.98	21	11.43
20	11.31	07	12.13	July 03	11.71	Sept. 04	11.30
21	11.79	10	12.13	13	11.50	19	11.05
22	11.81	12	12.09	23	11.69		

GAGE HEIGHT, FEET, WATER YEAR OCTOBER 1996 TO SEPTEMBER 1997

DATE	GAGE HEIGHT	DATE	GAGE HEIGHT	DATE	GAGE HEIGHT	DATE	GAGE HEIGHT
Oct. 13	10.73	Apr. 18	10.86	June 15	11.43	July 22	11.71
28	10.71	28	10.81	16	11.93	Aug. 26	11.59
Nov. 10	10.79	May 04	10.98	24	11.88	Sept. 14	11.33
20	10.78	13	11.11	July 12	11.67	28	11.38





**Figure 1.** Locations of water-quality and lake-stage monitoring sites on Elizabeth and Marie Lakes at Twin Lakes, Wisconsin.

PERIOD OF RECORD.--February 1995 to August 1997 (discontinued).

REMARKS.--Lake sampled at the deepest point near north side of lake. Lake was ice-covered during February measurements. Water-quality analyses done by Wisconsin State Laboratory of Hygiene.

WATER-QUALITY DATA, FEBRUARY 10 TO AUGUST 18, 1997

(Milligrams per liter unless otherwise indicated)

	Feb. 10		Apr. 14		June 02		July 14		Aug. 18	
Lake stage (ft)	10.69		10.93		---		11.68		11.67	
Secchi-depth (meters)	---		2.5		3.4		2.7		2.3	
Chlorophyll a, phytoplankton (µg/L)	---		6.4		4.0		4.0		9.5	
Depth of sample (m)	0.5	9.0	0.5	9.0	0.5	10	0.5	9.5	0.5	9.0
Water temperature (°C)	1.5	4.0	6.5	5.5	16.5	14.0	26.5	16.5	22.5	20.5
Specific conductance (µS/cm)	573	636	550	552	567	576	543	603	536	600
pH (units)	8.4	7.6	8.4	8.4	8.3	7.9	8.3	7.4	8.2	7.2
Dissolved oxygen	15.6	2.0	11.5	11.0	9.9	4.4	9.0	0.1	7.9	0.1
Phosphorus, total (as P)	0.011	0.018	0.010	<0.008	0.016	0.059	<0.005	0.072	0.024	0.053
Phosphorus, ortho, dissolved (as P)	---	---	<0.002	<0.002	---	---	---	---	---	---
Nitrogen, NO2 + NO3, diss. (as N)	---	---	0.13	0.13	---	---	---	---	---	---
Nitrogen, ammonia, dissolved (as N)	---	---	<0.013	<0.013	---	---	---	---	---	---
Nitrogen, amm. + org., total (as N)	---	---	0.50	0.70	---	---	---	---	---	---
Nitrogen, total (as N)	---	---	0.62	0.82	---	---	---	---	---	---
Color (Pt-Co. scale)	---	---	15	15	---	---	---	---	---	---
Turbidity (NTU)	---	---	1.4	1.6	---	---	---	---	---	---
Hardness, as CaCO3	---	---	240	240	---	---	---	---	---	---
Calcium, dissolved (Ca)	---	---	40	40	---	---	---	---	---	---
Magnesium, dissolved (Mg)	---	---	34	34	---	---	---	---	---	---
Sodium, dissolved (Na)	---	---	21	21	---	---	---	---	---	---
Potassium, dissolved (K)	---	---	2	2	---	---	---	---	---	---
Alkalinity, as CaCO3	---	---	190	190	---	---	---	---	---	---
Sulfate, dissolved (SO4)	---	---	36	36	---	---	---	---	---	---
Chloride, dissolved (Cl)	---	---	48	48	---	---	---	---	---	---
Silica, dissolved (SiO2)	---	---	3.3	3.3	---	---	---	---	---	---
Solids, dissolved, at 180°C	---	---	306	306	---	---	---	---	---	---
Iron, dissolved (Fe) µg/L	---	---	<10	<10	---	---	---	---	---	---
Manganese, dissolved (Mn) µg/L	---	---	<0.4	<0.4	---	---	---	---	---	---

2-10-97

4-14-97

6-02-97

7-14-97

8-18-97

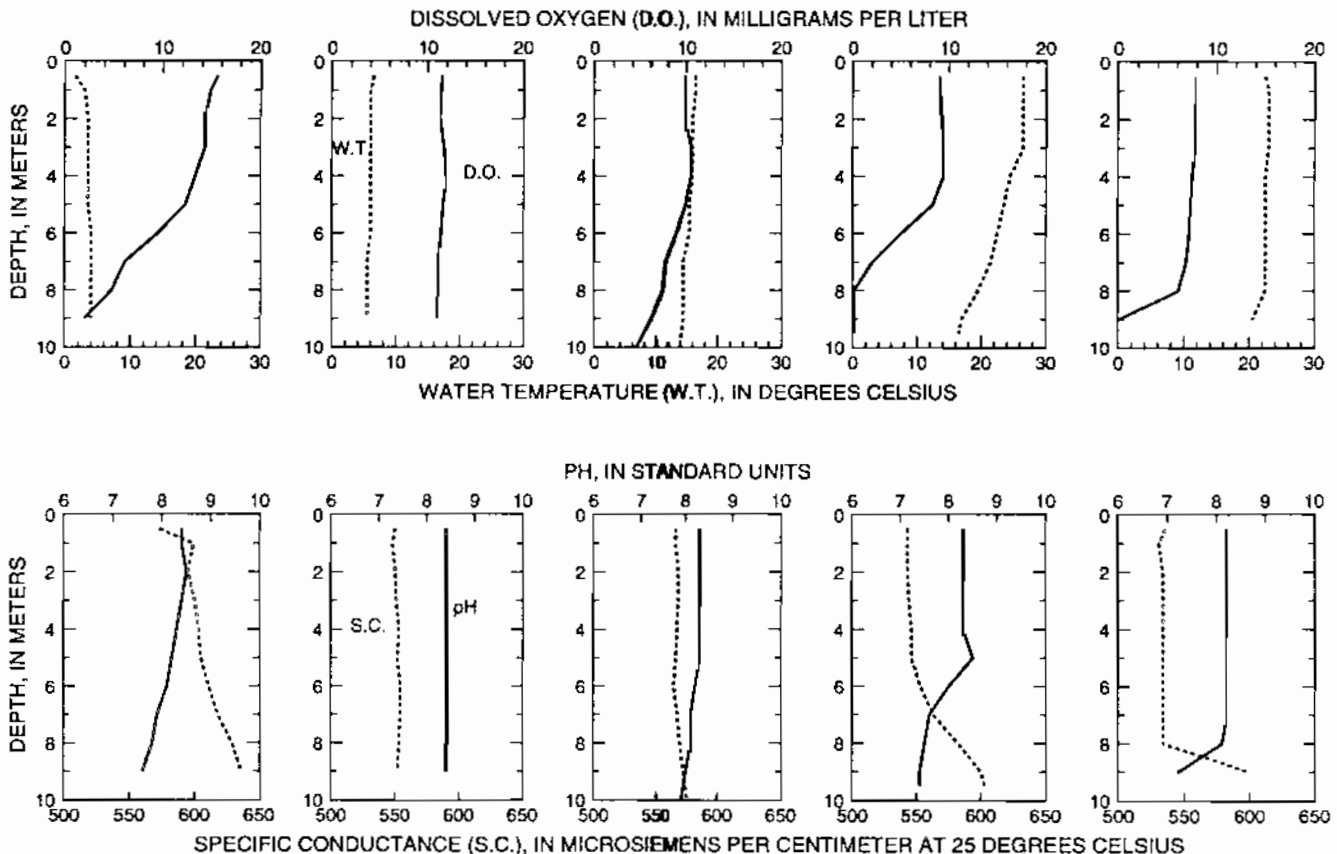


Figure 2. Water-quality data and depth profiles for Elizabeth Lake near Twin Lakes, Wisconsin, 1997 water year

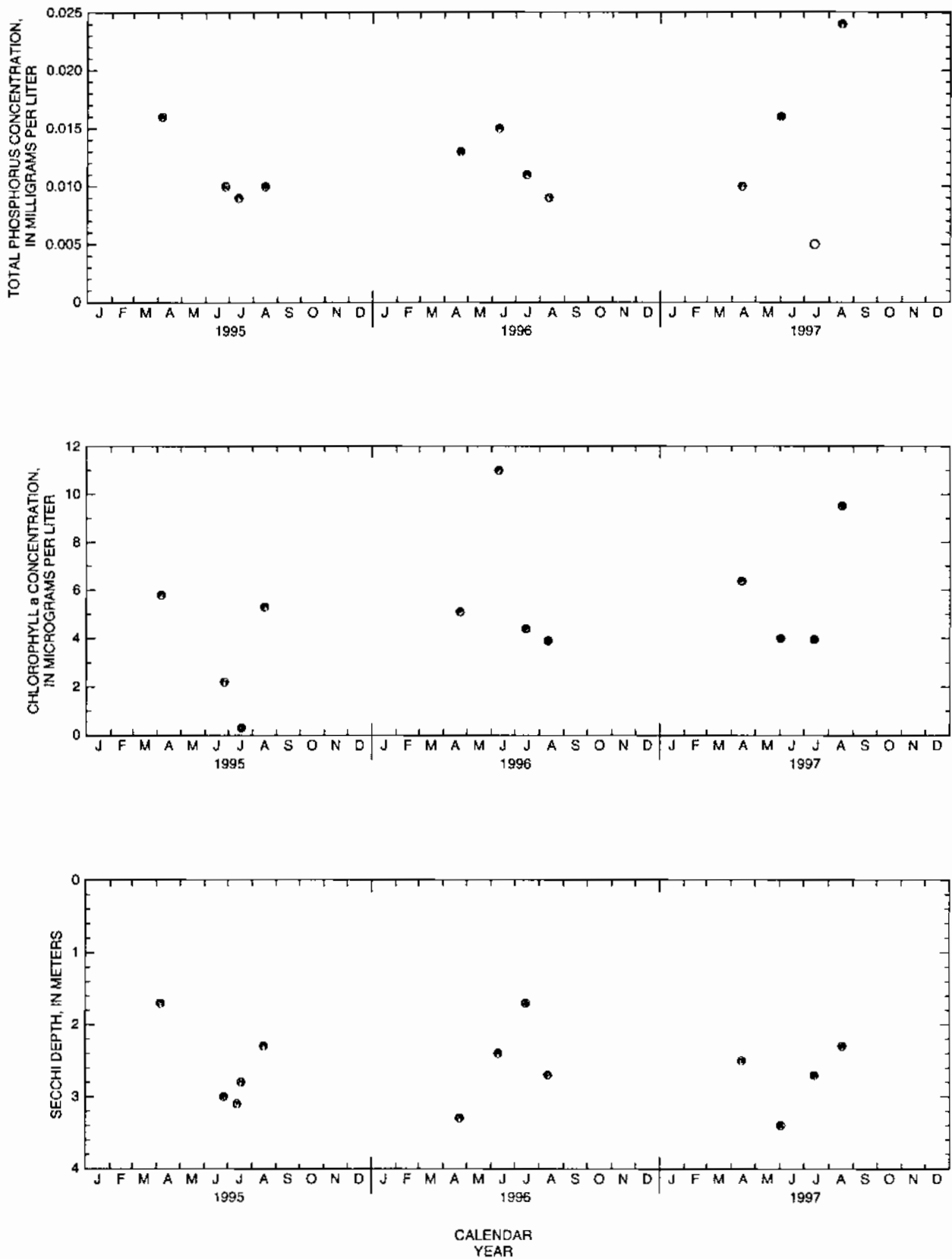


Figure 3. Surface total phosphorus and chlorophyll a concentrations, and Secchi depths for Elizabeth Lake near Twin Lakes, Wisconsin.

(Circles indicate laboratory detection limit for selected analyses. Actual concentrations for these particular analyses are less than the plotted circles.)

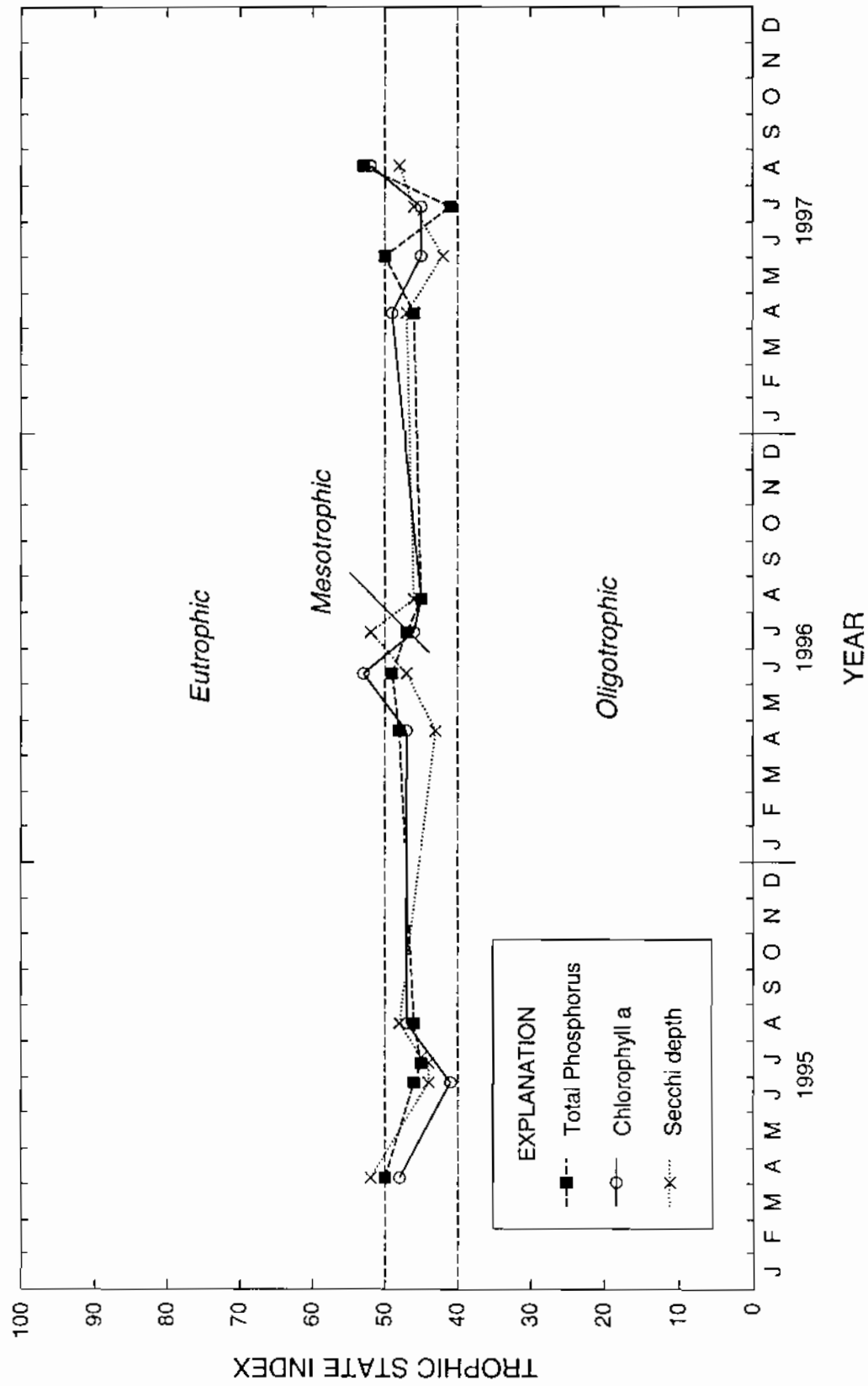


Figure 4. Trophic state indices for Elizabeth Lake near Twin Lakes, Wisconsin