

## **Wolf Lake near Mt. Calvary, WI Water-Quality Data Summary**

This summary covers the period 1984 to 1996, which is the period of water-quality monitoring of Wolf Lake by the U.S. Geological Survey. Emphasis in this summary is on data collected during 1996. All data collected during 1996 is included. Data from previous years is 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 1996" and to Shaw and others (1994) "Understanding Lake Data."

The data that have been collected for Wolf Lake from 1984 to 1986 and 1992 to 1996 are useful for understanding the lake's water quality, and for managing the lake. These data define the lake's present water quality and provide a basis for assessing the trends or changes in water quality in the future.

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

Wolf Lake is a drainage lake, with an inlet and an outlet. The average depth of Wolf Lake is 19 feet, the surface area is 76 acres (0.12 square miles), and the lake's watershed area is 3.51 square miles. The water-quality sampling site is located at the deepest point in the lake at a depth of about 47 feet. Lake stage was monitored near the outlet, which is located on the south side of the lake. The locations of the monitoring sites are shown in Figure 1.

### **Hydrologic conditions during water year 1996:**

Annual variability in lake condition often reflects variability in climatic and hydrologic conditions. Air temperature in east central Wisconsin was, on the average, 3.1 °F cooler than normal for the period December 1995 through March 1996; April and May was 4.0 °F cooler than normal; and the period June through August was 1.2 °F cooler than normal (National Oceanic and Atmospheric Administration "Climatological Data--Wisconsin"). Precipitation during water year 1996 was 103 percent of normal precipitation for east central Wisconsin (Pamela Naber-Knox, UW-Extension, Geological and Natural History Survey, written commun., 1996). Watershed runoff in the region of Wolf Lake was between 64 and 100 percent of long-term average runoff (Holmstrom and others, 1997, "Water Resources Data--

Wisconsin").

#### **Lake Data for 1996:**

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

##### Lake-stage fluctuations:

Lake stages were measured by Alan Depies intermittently, and by the USGS on sampling dates. The stages ranged from 4.72 feet on October 1 to 6.14 feet on June 26. This range of fluctuation is similar to average fluctuation during the previous 6 years of monitoring. However, owing to the infrequency of measurements, actual range of fluctuation may have been greater than observed. Stage values are listed in Table 1.

##### Lake-depth profiles:

Vertical profiles of water temperature, dissolved oxygen, pH, and specific conductance exhibit no abnormalities and are similar to those from the previous years. These profiles, which were measured over the deepest point in the lake, are listed in Table 2 and shown in Figure 2. During the February through August sampling period, complete water-column mixing was observed on May 1. The lake became thermally stratified through the summer. In June the lower 17.0 feet of water were anoxic (devoid of oxygen), and by August the lower 28.0 feet were anoxic. The anoxic zone is unable to support fish. The pH, which ranged between 7.3 and 8.4, is common for southeastern Wisconsin lakes and poses no problems for aquatic life.

##### Chemical constituents:

Analyses of water samples collected on May 1 for selected chemical constituents for chemical characterization of the lake are shown in Figure 2. Samples collected at 1.5 and 46-foot 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 130:1, based on the surface concentrations on May 1. This ratio suggests the lake is phosphorus limited, which means algal growth is dependent on the amount of available phosphorus rather than 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 0.024 mg/L on July 23 to 0.037 mg/L on May 1, chlorophyll *a* ranged from 4.3 µg/L on June 26 to 11 µg/L on August 21, and Secchi depths ranged from 1.7 m on August 21 to 3.8 m on May 1.

Surface total-phosphorus and chlorophyll *a* concentrations, and Secchi depths for the 1984-96 period are shown on Figure 3. Although there is year-to-year variation in the magnitude of these parameters, there does not appear to be an increasing or decreasing trend. There is a general seasonal pattern of declining phosphorus concentrations from spring through summer.

Total-phosphorus concentration 1.5 feet above the lake bottom at the center site ranged from 0.038 mg/L on May 1 to 0.559 mg/L on August 21. The high total-phosphorus concentrations observed during anoxic periods are indicative of large phosphorus release from the bottom sediments, and probably accounts for the high surface concentrations of phosphorus at spring turnover.

**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 12 of "Water-Quality and Lake-Stage data for Wisconsin Lakes, Water Year 1996," 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 Wolf Lake indicate "good" water quality.

Lillie and Mason (1983) also provided a means of comparing the condition of Wolf Lake with other lakes in southeastern Wisconsin. The comparison on page 4 shows the percentage distribution of southeastern Wisconsin lakes within each condition group and the relative position of Wolf Lake.

	Parameter	Percentage distribution of lakes in southeast Wisconsin within parameter ranges	
	<b>Total-phosphorus (mg/L)</b>		
	<0.010	best condition	7
	0.010-0.020	↓	21
Wolf Lake values	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
	<b>Chlorophyll a (µg/L)</b>		
	0-5	best condition	22
	5-10	↓	31
Wolf Lake values	10-15		14
	15-30		12
	>30		worst condition
	<b>Secchi depth (feet)</b>		
	>19.7	best condition	1
	9.8-19.7	↓	9
Wolf Lake values	6.6-9.8		26
	3.3-6.6		31
	<3.3		worst condition

Trophic status:

Another means of assessing the nutrient, or trophic, status of a lake is to use Carlson's Trophic State Index (TSI). The 1996 TSI data is listed in Table 3. Figure 4 is a graphical illustration of the variation in Trophic State Indices for Wolf Lake during the 7 year study period. The data from 1996 show the lake to be meso-eutrophic, or a lake with moderate to high nutrient levels.



Table 2. Lake-depth profiles for Wolf Lake near Mt. Calvary, Wisconsin, 1996 water year

WATER-QUALITY DATA					
DATE	SAMPLING DEPTH (FEET) (00003)	TEMPERATURE WATER (DEG C) (00010)	SPECIFIC CONDUCTANCE (US/CM) (00095)	PH WATER WHOLE FIELD (STANDARD UNITS) (00400)	OXYGEN, DIS-SOLVED (MG/L) (00300)
FEB 1996					
15...	3.00	3.5	522	8.0	11.6
15...	6.00	3.5	527	8.1	11.6
15...	9.00	3.5	526	8.1	11.3
15...	12.0	3.5	528	8.1	12.3
15...	15.0	3.5	528	8.1	12.7
15...	18.0	3.5	527	8.0	11.7
15...	21.0	3.5	531	7.9	9.1
15...	24.0	3.5	534	7.9	7.6
15...	27.0	4.0	539	7.8	6.2
15...	30.0	4.0	546	7.6	1.8
15...	33.0	4.0	550	7.5	0.6
15...	36.0	4.0	547	7.5	1.1
15...	39.0	4.5	557	7.4	0.9
15...	42.0	4.5	573	7.4	0.4
15...	45.0	4.5	616	7.3	0.2
15...	47.0	--	--	--	--
MAY					
01...	1.50	8.0	501	8.1	9.9
01...	3.00	8.0	501	8.1	9.8
01...	6.00	8.0	501	8.1	9.7
01...	9.00	8.0	501	8.1	10.2
01...	12.0	8.0	504	8.1	10.9
01...	15.0	8.0	503	8.1	10.6
01...	18.0	8.0	502	8.1	10.1
01...	21.0	8.0	502	8.1	9.9
01...	24.0	8.0	501	8.1	9.8
01...	27.0	8.0	502	8.1	9.8
01...	30.0	8.0	502	8.1	9.8
01...	33.0	8.0	502	8.1	9.8
01...	36.0	8.0	501	8.1	9.7
01...	39.0	8.0	501	8.1	9.7
01...	42.0	7.5	501	8.1	9.6
01...	45.5	7.5	502	8.1	9.3
01...	47.0	--	--	--	--
JUN					
26...	1.50	22.5	518	8.1	8.8
26...	3.00	22.0	519	8.1	8.8
26...	6.00	22.0	517	8.2	8.9
26...	9.00	20.5	520	8.1	7.4
26...	12.0	19.0	539	7.8	4.8
26...	15.0	16.5	529	8.1	5.1
26...	18.0	14.0	536	8.0	4.7
26...	21.0	12.0	538	7.9	4.0
26...	24.0	10.5	538	7.8	3.2
26...	27.0	9.5	540	7.8	1.4
26...	30.0	9.5	542	7.7	0.2
26...	33.0	9.0	543	7.7	0.1
26...	36.0	8.5	546	7.7	0.1
26...	39.0	8.5	551	7.7	0.1
26...	42.0	8.5	553	7.7	0.1
26...	44.0	8.5	553	7.7	0
26...	45.5	8.5	554	7.7	0
26...	47.0	--	--	--	--

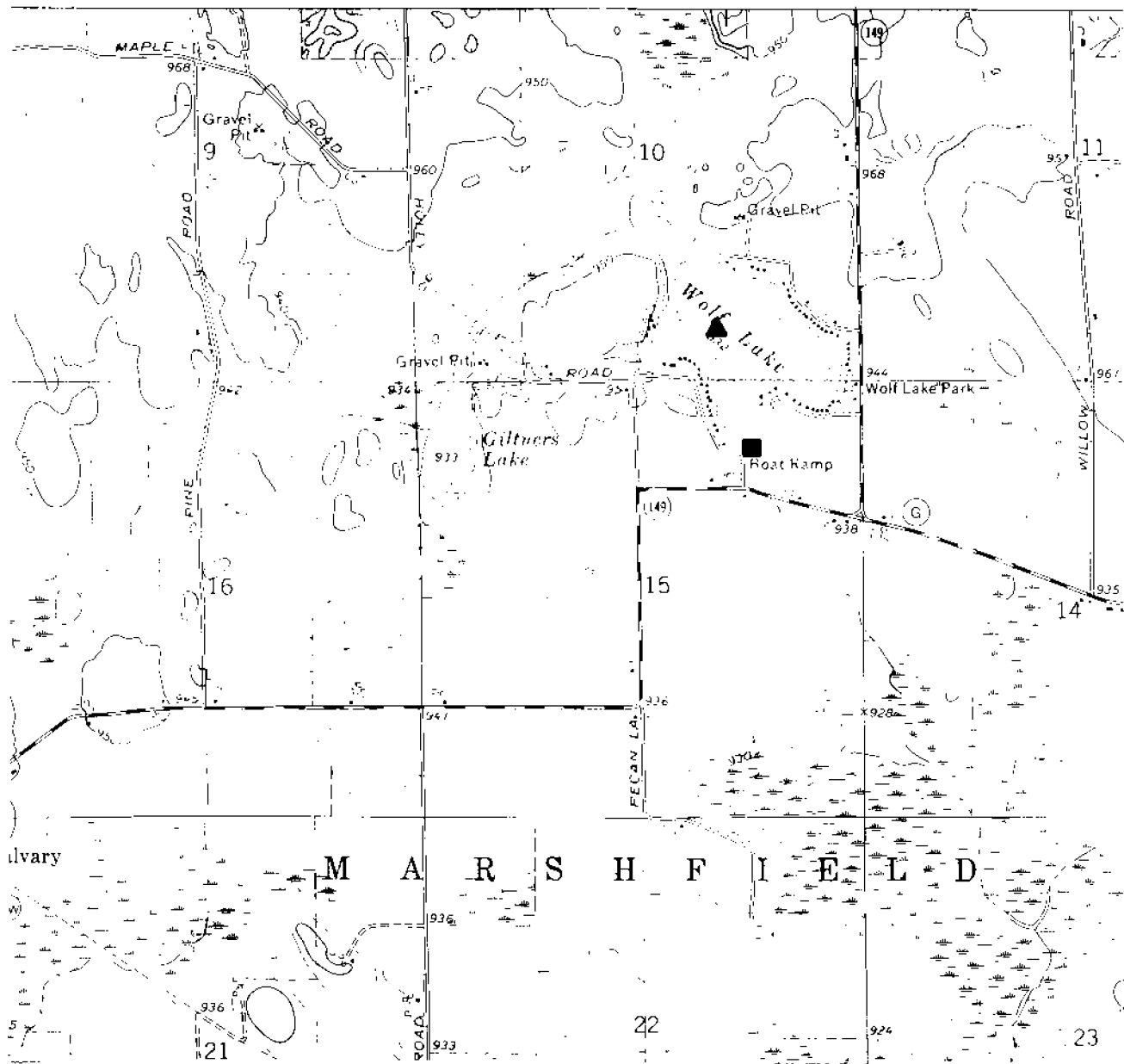
Table 2. Lake-depth profiles for Wolf Lake near Mt. Calvary, Wisconsin, 1996 water year--  
continued

WATER-QUALITY DATA					
DATE	SAM- PLING DEPTH (FEET) (00003)	TEMPER- ATURE WATER (DEG C) (00010)	SPE- CIFIC CON- DUCT- ANCE (US/CM) (00095)	PH WATER FIELD (STAND- ARD UNITS) (00400)	OXYGEN, DIS- SOLVED (MG/L) (00300)
JUL 1996					
23...	1.50	23.0	530	8.4	8.8
23...	3.00	23.0	530	8.4	8.9
23...	6.00	23.0	528	8.4	9.1
23...	9.00	22.5	531	8.4	9.4
23...	12.0	22.5	533	8.2	8.2
23...	15.0	18.0	533	7.5	1.1
23...	18.0	14.0	530	7.6	0.7
23...	21.0	11.5	527	7.6	0.4
23...	24.0	11.0	526	7.6	0.3
23...	27.0	10.0	525	7.6	0.3
23...	30.0	9.5	529	7.6	0.3
23...	33.0	9.0	532	7.6	0.1
23...	36.0	9.0	535	7.6	0.2
23...	39.0	9.0	534	7.6	0.2
23...	42.0	8.5	539	7.6	0.2
23...	45.0	8.5	543	7.5	0.2
23...	46.5	--	--	--	--
AUG					
21...	1.50	26.0	520	8.3	9.0
21...	3.00	25.0	521	8.4	8.9
21...	6.00	24.5	521	8.4	8.9
21...	9.00	24.0	526	8.3	8.0
21...	12.0	23.0	533	8.0	4.5
21...	15.0	20.0	536	7.6	2.0
21...	18.0	16.0	527	7.5	0.3
21...	21.0	12.5	528	7.5	0
21...	24.0	11.0	532	7.5	0
21...	27.0	10.0	533	7.5	0
21...	30.0	9.5	536	7.5	0
21...	33.0	9.0	537	7.5	0
21...	36.0	9.0	543	7.5	0
21...	39.0	9.0	545	7.4	0
21...	42.0	8.5	550	7.4	0
21...	44.5	8.5	550	7.4	0
21...	46.0	--	--	--	--



Table 3.--Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Wolf Lake,  
 1996 water year  
 [ - indicates not applicable; -- indicates no data available]

Date	Secchi Disk			Sampling Depth (feet)	Total Phosphorus			Chlorophyll a		Dissolved Ortho- phosphate Phosphorus Conc. (mg/L)
	Depth (meters)	Depth (feet)	T.S.I.		Conc. (mg/L)	Conc. (µg/L)	T.S.I.	Conc. (µg/L)	T.S.I.	
05/15/96	3.8	12.5	41	1.5	0.037	37	56	5.6	48	0.002
	-	-	-	46	0.038	38	-	-	-	0.007
06/26/96	3.1	10.2	44	1.5	0.034	34	55	4.3	46	--
	-	-	-	46	0.350	350	-	-	-	--
07/23/96	3.0	9.8	44	1.5	0.024	24	53	7.2	50	--
	-	-	-	45	0.538	538	-	-	-	--
08/21/96	1.7	5.6	52	1.5	0.032	32	55	11	53	--
	-	-	-	45	0.559	559	-	-	-	--



**EXPLANATION**

- ▲ Water-quality monitoring site
- Lake-stage monitoring site

**Figure 1.** Locations of water-quality and lake-stage monitoring sites on Wolf Lake near Mt. Calvary, Wisconsin.

WATER-QUALITY RECORDS

PERIOD OF RECORD.--February 1984 to September 1987, February 1993 to current year.

REMARKS.--Lake sampled near center at the deep hole. Lake ice-covered during February measurements. Water-quality analyses done by Wisconsin State Laboratory of Hygiene.

WATER-QUALITY DATA, FEBRUARY 15 TO AUGUST 21, 1996  
(Milligrams per liter unless otherwise indicated)

	Feb. 15		May 01		June 26		July 23		Aug. 21	
Depth of sample (ft)	3.0	45	1.5	46	1.5	46	1.5	45	1.5	45
Lake stage (ft)	5.87		5.89		6.14		5.48		5.47	
Specific conductance (µS/cm)	522	616	501	502	518	554	530	543	520	550
pH (units)	8.0	7.3	8.1	8.1	8.1	7.7	8.4	7.5	8.3	7.4
Water temperature (°C)	1.5	4.5	8.0	7.5	22.5	8.5	23.0	8.5	26.0	8.5
Color (Pt-Co. scale)	---	---	25	25	---	---	---	---	---	---
Turbidity (NTU)	---	---	0.80	0.90	---	---	---	---	---	---
Secchi-depth (meters)	---	---	3.8		3.1		3.3		1.7	
Dissolved oxygen	11.0	0.2	9.9	9.3	8.8	0.0	8.9	0.2	9.0	0.0
Hardness, as CaCO <sub>3</sub>	---	---	250	250	---	---	---	---	---	---
Calcium, dissolved (Ca)	---	---	41	42	---	---	---	---	---	---
Magnesium, dissolved (Mg)	---	---	35	35	---	---	---	---	---	---
Sodium, dissolved (Na)	---	---	6.5	6.4	---	---	---	---	---	---
Potassium, dissolved (K)	---	---	5	5	---	---	---	---	---	---
Alkalinity, as CaCO <sub>3</sub>	---	---	200	200	---	---	---	---	---	---
Sulfate, dissolved (SO <sub>4</sub> )	---	---	34	36	---	---	---	---	---	---
Chloride, dissolved (Cl)	---	---	28	28	---	---	---	---	---	---
Fluoride, dissolved (F)	---	---	0.1	0.1	---	---	---	---	---	---
Silica, dissolved (SiO <sub>2</sub> )	---	---	2.6	2.8	---	---	---	---	---	---
Solids, dissolved, at 180°C	---	---	304	308	---	---	---	---	---	---
Nitrogen, NO <sub>2</sub> + NO <sub>3</sub> , diss. (as N)	---	---	0.08	0.08	---	---	---	---	---	---
Nitrogen, ammonia, dissolved (as N)	---	---	0.16	0.16	---	---	---	---	---	---
Nitrogen, organic, total (as N)	---	---	0.92	0.94	---	---	---	---	---	---
Nitrogen, amm. + org., total (as N)	---	---	1.1	1.1	---	---	---	---	---	---
Nitrogen, total (as N)	---	---	1.2	1.2	---	---	---	---	---	---
Phosphorus, total (as P)	---	---	0.031	0.038	0.034	0.350	0.024	0.538	0.032	0.559
Phosphorus, ortho, dissolved (as P)	---	---	0.002	0.007	---	---	---	---	---	---
Iron, dissolved (Fe) µg/L	---	---	<10	<10	---	---	---	---	---	---
Manganese, dissolved (Mn) µg/L	---	---	5	16	---	---	---	---	---	---
Chlorophyll a, phytoplankton (µg/L)	---	---	5.6	---	4.3	---	7.2	---	11	---

2-15-96

5-1-96

6-26-96

7-23-96

8-21-96

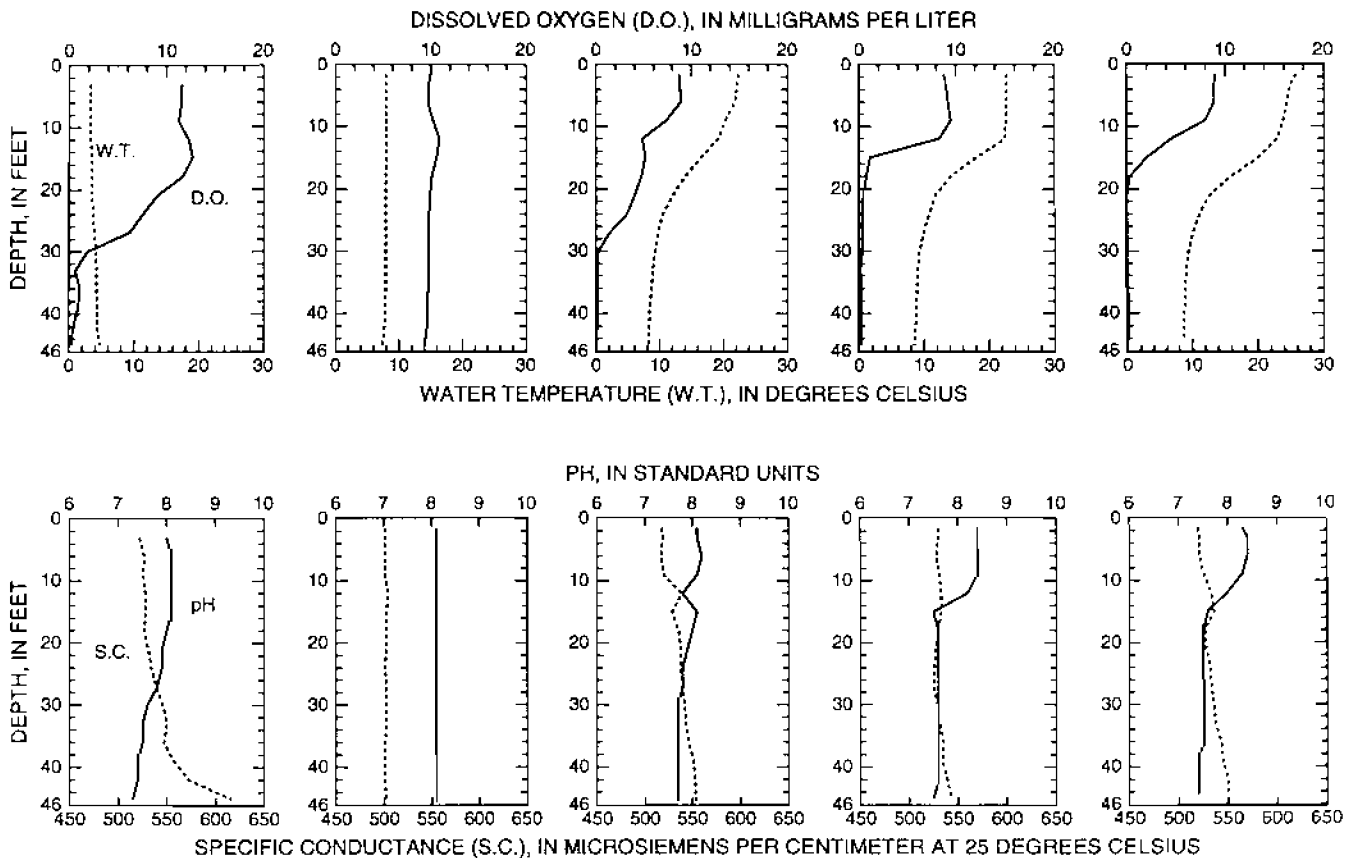


Figure 2. Water-quality data and depth profiles for Wolf Lake near Mt. Calvary, Wisconsin, 1996 water year

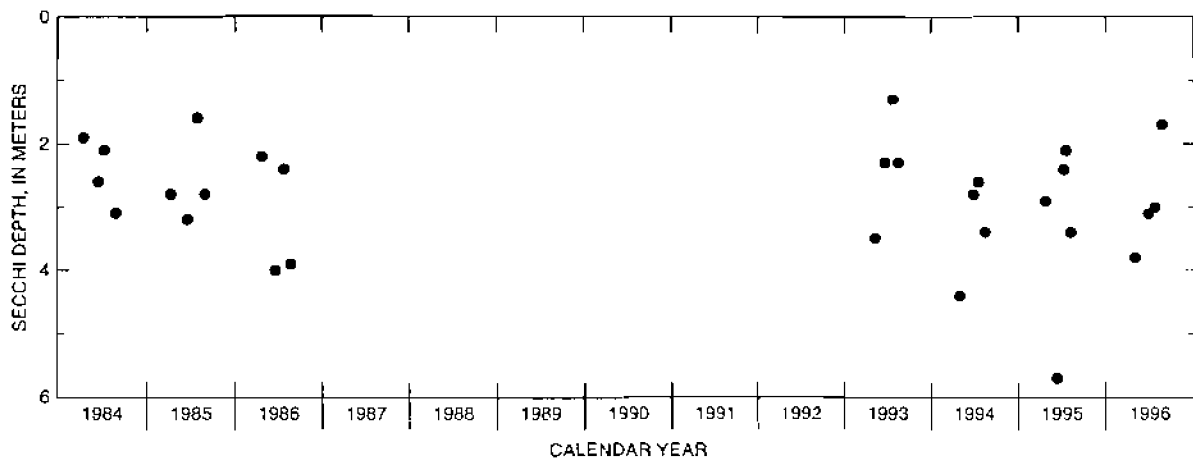
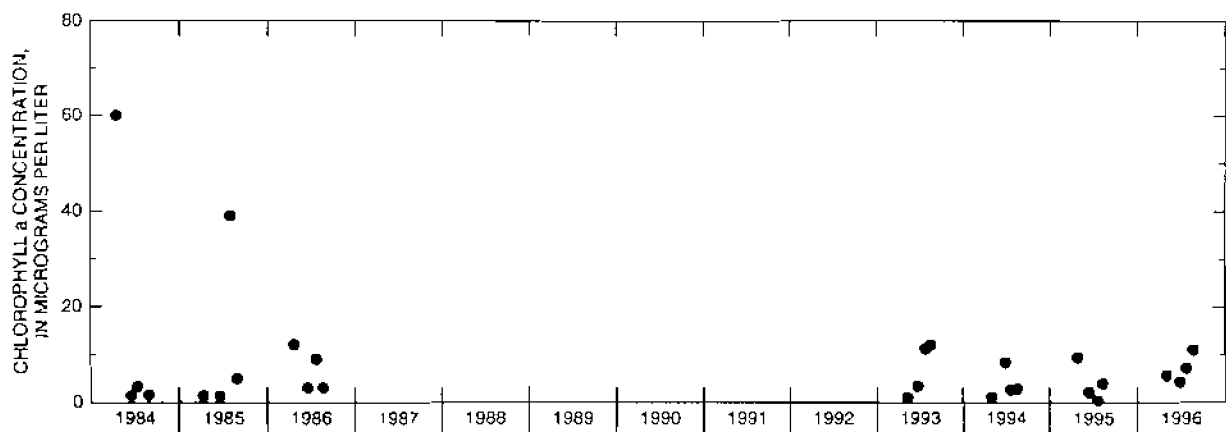
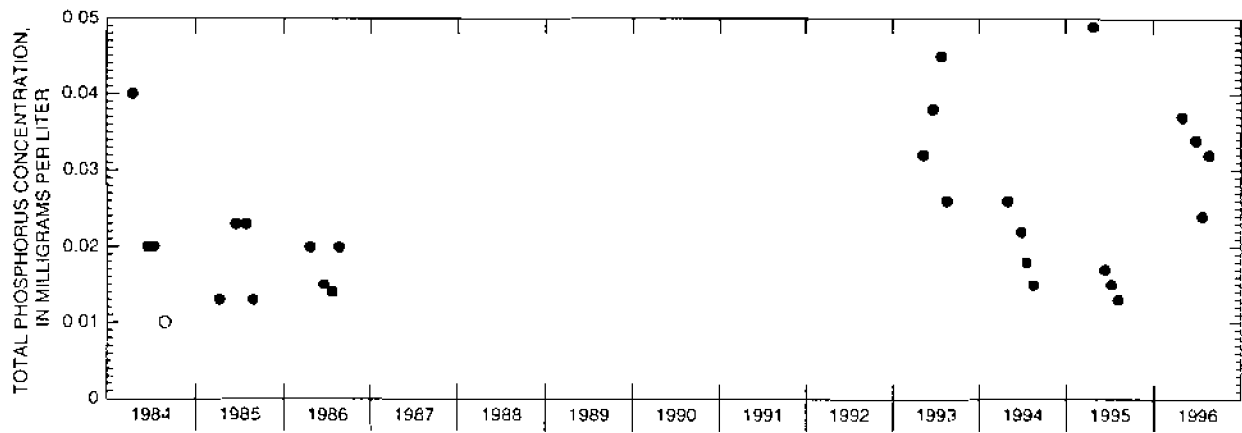


Figure 3. Surface total phosphorus and chlorophyll a concentrations, and Secchi depths for Wolf Lake near Mt. Calvary, Wisconsin.

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

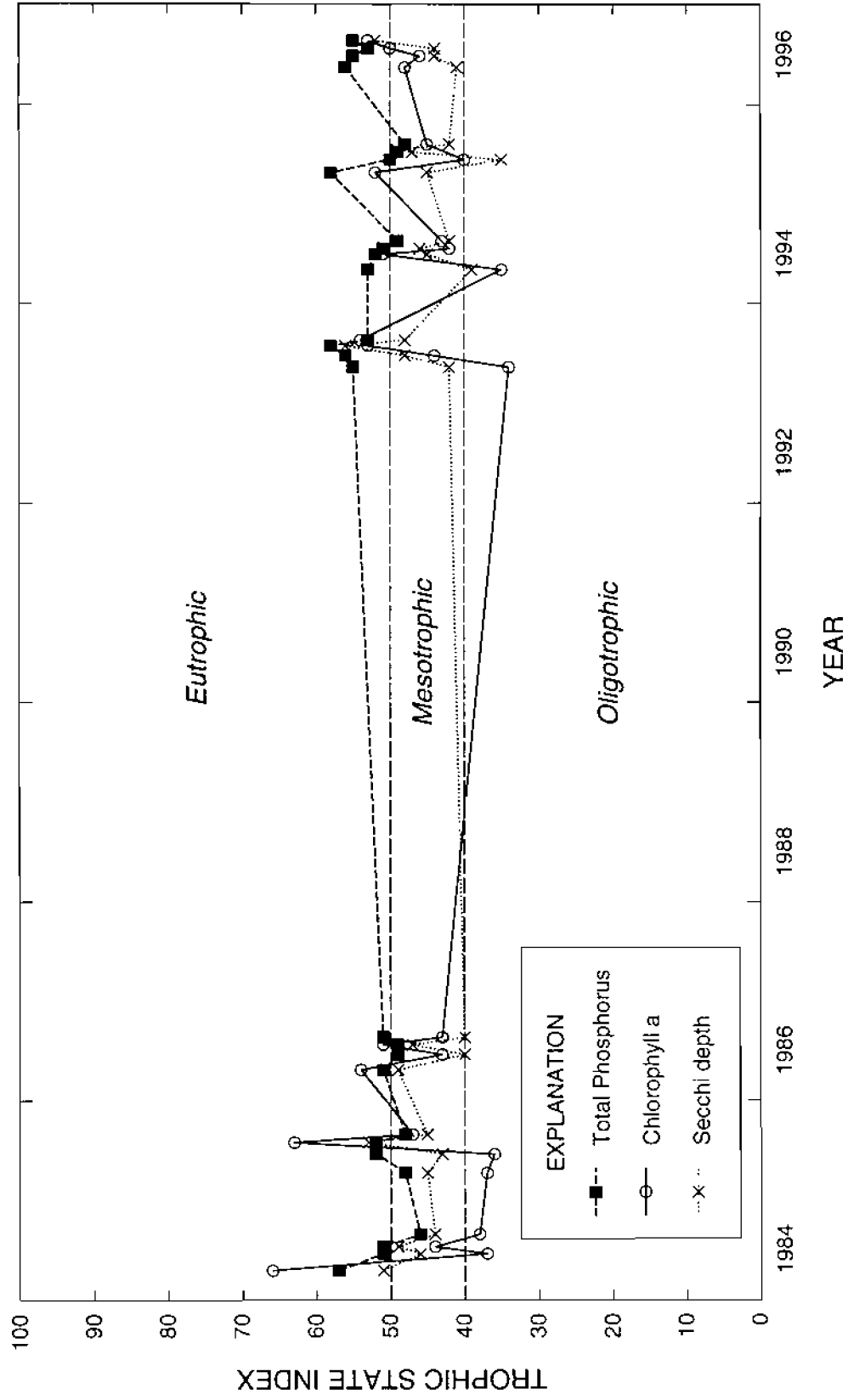


Figure 4. Trophic state indices for Wolf Lake near Mt. Calvary, Wisconsin