TOWN OF WATERFORD
WATERWAYS COMMITTEE

FINAL REPORT
WATER MANAGEMENT PLANNING GRANT
GRANT # LPL 173

OVERVIEW

The Lake Management planning grant allowed for three major studies to be completed. A community survey, an aquatic plant study and comprehensive water quality testing. Information from these three studies is essential to aid in future planning for the management of our considerable water resources. Since the Fox River within our township is considered an impoundment, it could be included in these studies along with Tichigan Lake. The public was kept informed, as work progressed, through posted meetings as well as press releases to local newspapers.

COMMUNITY SURVEY

Our committee **worked** with Aron & Associates in formulating questions for this survey. Aron & Associates prepared this survey and mailed it to all residents within the sanitary sewer district which included all households surrounding our waterways. The results of this survey were presented in a booklet which is available at the town halt for residents to review. The Waterways Committee has, and continues to use **this** survey **as a** guide whenever questions regarding waterways management arise.

AQUATIC PLANT SURVEY

We hired Aron & Associates to **complete** an aquatic plant survey on our waterways. The study was completed and results printed in a booklet. This booklet is available at the town hall for residents to review. Samples of aquatic plants were also collected, identified and preserved. This survey serves as a baseline study and will be used for comparison for future studies and/or **plant** management plans.

WATER QUALITY TESTING

Comprehensive water quality testing was done over a three year period by the

(more)

United States Geological Survey. This sampling was done during the calendar years 7994, 1995 and 1996. Results of this sampling are published in the USGS Water-Quality and Lake-Stage Data **reports** for Wisconsin Lakes. This report is published each **year.** Data from this testing can be compared to results of former testing as well as future testing to determine any changing condition of the water in our waterways. This data is essential in formulating future management **plans.**

CONCLUSION

The information accumulated through this lake management planning grant is an extremely valuable tool. It has provided essential information necessary as we move ahead in planning and managing our water resources in the future.

We wish to thank all who helped to **make** this project a success through their dedication and hard work. We are grateful to the Department of Natural Resources and the United States Geological Survey for their assistance and the monetary grants which made this project possible.

Respectfully submitted **by:**

Jill G. Mitchell

Jill A. Mitchell, Chairperson
Town of Waterford Waterways Committee

Tichigan Lake near Waterford, Wisconsin
Water-Quality Data Summary

This summary covers the period October 1993 to September 1996, which is the period of water-quality monitoring of Tichigan Lake by the U.S. Geological Survey (USGS). 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."

Lake description and sampling locations:

Tichigan Lake is classified as a drainage lake which is part of an impoundment of the Fox River at Waterford. A "narrows" (about 400 feet wide) connects the lake to the Fox River. Water exchange through the narrows between Tichigan Lake and the Fox River probably fluctuates with stage fluctuations of the river. That is, as the river increases, water flows into Tichigan **Lake; and** as the river stage decreases, water flows from the lake into the river. The lake's surface area is 282 acres (.44 square miles), and the lake's watershed area is 2.09 square miles. The water-quality sampling site is located at the deepest point in the lake at a depth of about 62 feet. Lake stage was monitored at a reference point which is located on the southeast 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 southeastern Wisconsin was, on the average, 2.2 ^{o} F cooler than normal for the period December 1995 through March 1996; April and May was 4.0 ^{o} F cooler than normal; and the period June through August was 1.3 ^{o} F cooler than normal (National Oceanic and Atmospheric Administration "Climatological Data--Wisconsin"). Precipitation during water year 1996 was 103 percent of normal precipitation for southeastern Wisconsin (Pamela Naber-Knox, UW-Extension, Geological and Natural History Survey, written commun., 1996). Watershed runoff in the region of Tichigan Lake was between

100 and 120 percent of long-term average runoff (Holmstrom and others, 1997, "Water Resources Data--Wisconsin").

Lake Data for 1996:

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

Lake-staae fluctuations:

Lake stages were measured by the USGS on sampling dates. The stages ranged from 4.12 feet on August 13 to 5.04 feet on June 12. This **range** of fluctuation is less than the average from the previous 2 years of monitoring. Stage values are listed in the table on the top half of Figure 2.

Lake-denth profiles:

Vertical profiles of water temperature, dissolved oxygen, pH, and specific conductance exhibit a pattern typical of thermally-stratified lakes 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 1 and shown in Figure 2. During the February through August sampling period, complete water-column mixing was observed on April 23. The lake became thermally stratified through the summer. fn June **the** lower 23 feet of water were anoxic (devoid of oxygen), and by August the lower 37 feet were anoxic. The anoxic zone is unable lo support fish. The pH, which ranged between 7.3 **and** 8.5, is common for southeastern Wisconsin lakes and poses no problems for aquatic life.

Chemical constituents:

Analyses of water samples collected on April 23 for selected chemical constituents for chemical characterization of the lake are shown in Figure 2. Samples collected at 1.5 and 61-foot **depths** show similar constituent concentrations, as would be expected **under** mixed water column condilions. The constituent values for color, chlorophyll a, 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 value for chloride is greater than regional values.

The ratio of dissolved nitrogen to dissolved phosphorus was 440:1, based on the surface concentrations on April 23. 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 0.015 mg/L on August 13 to 0.052 mg/L on April 23, chlorophyll a ranged from 5.9 µg/L on August 13 to 22.0 µg/L on April 23, and Secchi depths ranged from 1.3 m on April 23 to 2.7 m on June 12 and August 13. Surface total phosphorus and chlorophyll a concentrations, and Secchi depths for the 1994-96 period are shown on Figure 3. No trends are apparent from the previous data.

Total phosphorus concentration 1.5 feet above the lake bottom at the center site ranged from 0.071 mg/L on April 23 to 0.817 mg/L on August 13. These total phosphorus concentrations observed during anoxic periods are indicative of large 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 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, chlorophyll a concentrations and Secchi depths in Tichigan Lake indicate "good water quality.

Lillie and Mason (1983) also provided a means of comparing the condition of Tichigan 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 Tichigan 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 1996 TSI data is listed in Table 2. Figure 4 is a graphical illustration of the variation in Trophic State Indices for Tichigan Lake during the 3 year study period. The data from 1996 show the lake to be meso-eutrophic, or a lake with moderate to high nutrient levels.

Table 1. Lake-depth profiles for Tichigan Lake near Waterford, 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) 100400	OXYGEN, DISSOLVED (MG/L) (00300)
FEB 1996					
W...	3.00	3.5	829	8.1	11.2
W...	6.00	3.0	841	8.2	11.0
W...	9.00	3.0	845	8.2	11.4
09...	12.0	3.0	847	8.1	12.8
W...	15.0	3.0	855	8.1	12.9
09...	18.0	3.0	859	8.0	11.8
09...	21.0	3.0	865	8.0	11.0
09...	24.0	3.0	873	8.0	10.7
m...	27.0	3.0	887	8.0	10.6
07...	30.0	2.5	900	7.9	10.2
09...	33.0	2.5	903	7.9	9.6
09...	36.0	2.5	913	7.8	9.5
w...	39.0	2.5	934	7.8	8.9
09...	42.0	2.5	947	7.8	9.1
09...	45.0	2.5	963	7.8	8.8
W...	48.0	2.5	976	7.7	8.6
09...	51.0	2.5	982	7.7	8.3
W...	54.0	2.5	997	7.6	6.9
09...	57.0	2.5	1010	7.6	3.8
W...	60.0	2.5	1010	7.5	1.8
09...	61.0	--	--	--	--
APR					
23...	1.50	11.0	837	8.4	11.6
23...	3.00	11.0	835	8.4	11.5
23...	6.00	11.0	835	8.4	11.8
23...	9.00	11.0	838	8.4	12.7
23...	12.0	11.0	838	8.4	13.3
23...	15.0	11.0	839	8.4	13.0
23...	18.0	10.5	834	8.4	12.3
23...	21.0	10.5	836	8.4	11.9
23...	24.0	10.5	829	8.4	11.6
23...	27.0	10.0	833	8.3	11.4
23...	30.0	9.5	828	8.3	11.0
23...	33.0	9.0	828	8.3	10.9
23...	36.0	8.5	831	8.3	10.8
23...	39.0	8.5	832	8.3	10.8
23...	42.0	8.0	835	8.3	10.7
23...	45.0	8.0	834	8.2	10.5
23...	48.0	7.5	832	8.2	10.4
23...	51.0	7.5	835	8.2	10.4
23...	54.0	7.5	837	8.2	10.4
23...	57.0	7.0	836	8.2	10.2
23...	60.5	7.0	840	8.1	9.2
23...	62.0	--	--	--	--
JUN					
12...	1.50	18.5	781	8.5	11.2
12...	3.00	18.5	778	8.5	11.2
12...	6.00	18.0	779	8.5	11.8
12...	9.00	17.5	784	8.5	11.5
12...	12.0	17.0	785	8.4	11.0
12...	15.0	16.5	786	8.3	9.6
12...	18.0	16.0	789	8.3	8.5
12...	21.0	15.0	816	8.1	6.5
12...	24.0	14.0	822	8.1	5.5
12...	27.0	13.5	827	8.0	4.6
12...	30.0	12.5	829	7.9	2.9
12...	33.0	11.5	834	7.8	2.2
12...	36.0	10.5	836	7.7	1.2
12...	39.0	10.0	836	7.7	0.7
12...	42.0	9.5	839	7.7	0.7
12...	45.0	9.5	846	7.6	0.6
12...	48.0	9.0	846	7.6	0.7
12...	51.0	9.0	847	7.6	0.8
12...	54.0	9.0	850	7.6	0.8
12...	57.0	9.0	854	7.5	0.8
12...	60.5	8.5	862	7.5	0.8
12...	62.0	--	--	--	

Table 1. Lake-depth profiles for Tichigan Lake near Waterford, Wisconsin, 1996 water year -- continued

WATER-QUALITY DATA

DATE	SAMPLING DEPTH (FEET) (00003)	TEMPERATURE WATER (DEG C) (00010)	SPECIFIC CONDUCTAYCE (US/CM) (00095)	PH WATER WHOLE FIELD (STANDARD UNITS) (00400)	OXYGEN, DISSOLVED (MG/L) (00300)
JUL 1996					
29...	1.50	23.5	692	8.5	9.7
29...	3.00	23.5	689	8.6	9.6
29...	6.00	23.5	690	8.6	9.8
29...	9.00	23.5	690	8.6	10.2
29...	12.0	23.5	692	8.6	10.6
29...	15.0	22.5	718	8.2	5.8
29...	18.0	21.0	742	7.9	2.8
29...	21.0	18.5	774	7.7	0.5
29...	24.0	15.0	817	7.7	0.4
29...	27.0	13.5	823	7.7	0.6
29...	30.0	12.5	829	7.7	0.5
29...	33.0	12.0	829	7.7	0.5
29...	36.0	11.0	838	7.7	0.5
29...	39.0	10.0	844	7.6	0.4
29...	42.0	10.0	847	7.6	0.4
29...	45.0	9.5	844	7.6	0.5
29...	48.0	9.0	849	7.5	0.5
29...	51.0	9.0	857	7.5	0.5
29...	54.0	9.0	860	7.5	0.4
29...	57.0	9.0	864	7.4	0.6
29...	60.0	9.0	867	7.4	0.5
29...	61.5	--	--	--	--
AUG					
13...	1.50	25.5	690	8.5	9.4
13...	3.00	25.5	690	8.5	9.4
13...	6.00	25.5	688	8.5	9.7
13...	9.00	25.5	689	8.5	10.1
13...	12.0	25.0	698	8.5	9.6
13...	15.0	24.0	720	8.2	5.1
13...	18.0	21.5	743	7.8	1.6
13...	21.0	19.0	768	7.7	0.6
13...	24.0	16.0	817	7.6	0.5
13...	27.0	14.0	832	7.6	0.5
13...	30.0	12.5	834	7.6	0.5
13...	33.0	12.0	837	7.7	0.5
13...	36.0	11.0	842	7.6	0.5
13...	39.0	10.5	843	7.6	0.5
13...	42.0	10.0	847	7.6	0.4
13...	45.0	9.5	849	7.5	0.4
13...	48.0	9.5	856	7.5	0.4
13...	51.0	9.0	861	7.4	0.4
13...	54.0	9.0	869	7.4	0.3
13...	57.0	9.0	875	7.4	0.3
13...	59.5	8.5	883	7.3	0.4
13...	61.0	--	--	--	--

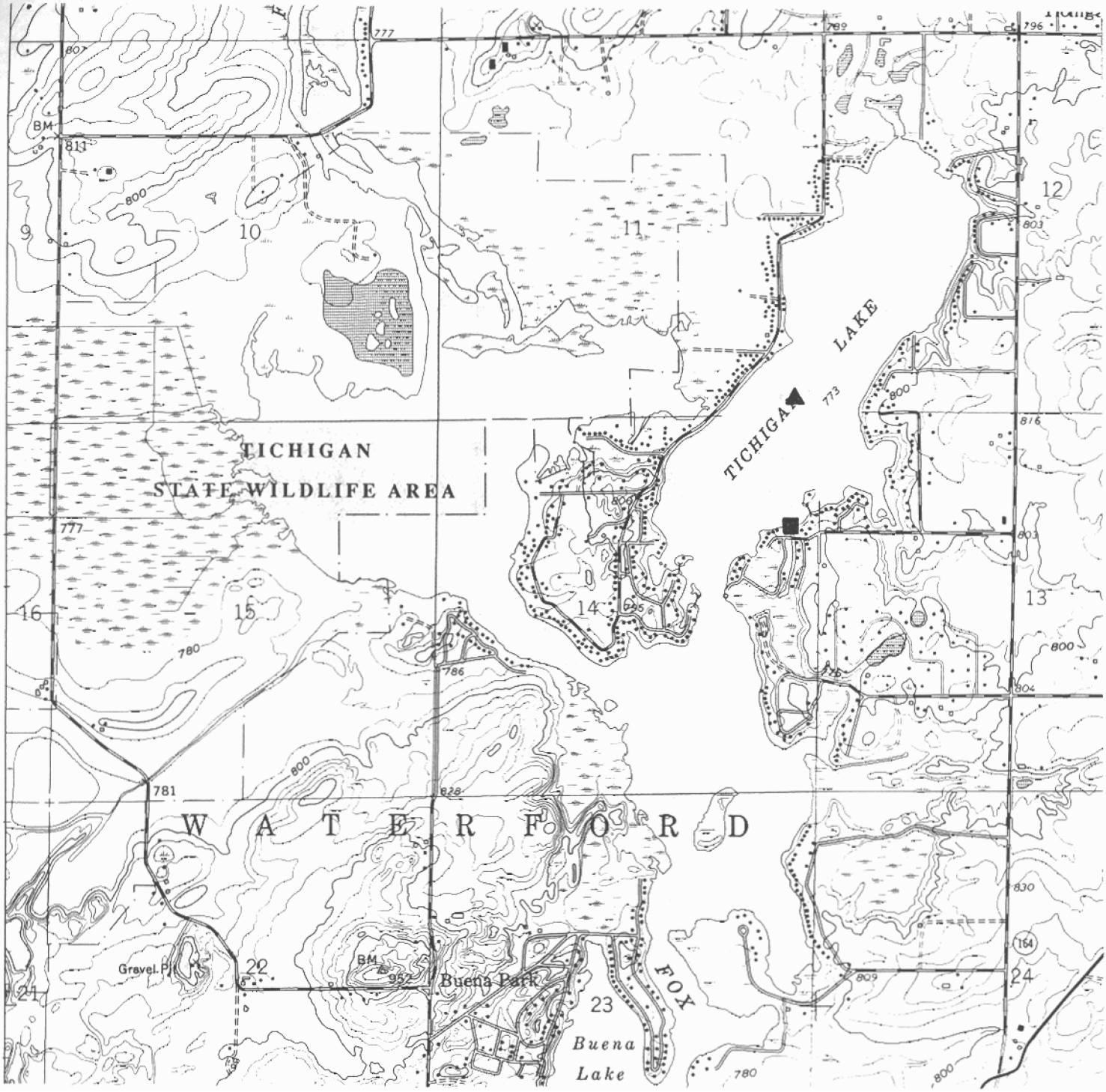
Table 2.--Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Tichigan Lake, 1996 water year

[- 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)
04/23/96	1.3	4.3	56	1.5	0.052	52	59	22	58	<0.002
				61	0.071	71				0.004
06/12/96	2.7	8.9	46	1.5	0.027	27	54	6.7	49	--
	-			61	0.358	358				--
07/29/96	2.4	7.9	47	1.5	0.021	21	52	6.7	49	--
				60	0.629	629				--
08/13/96	2.7	8.9	46	1.5	0.015	15	49	5.9	48	--
				60	0.817	817				--

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

	Parameter		Percentage distribution of lakes in southeast Wisconsin within **parameter** ranges
	Total Phosphorus (mg/L)		
Tichigan 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
	Chlorophyll a (µg/L)		
Tichigan Lake Values	0-5	best condition	22
	5-10	↓	31
	10-15	↓	14
	15-30	↓	12
	>30	worst condition	22
	Secchi depth (feet)		
Tichigan Lake Values	>19.7	**best** condition	1
	9.8-19.7	↓	9
	6.6-9.8	↓	*26*
	3.3-6.6	↓	31
	<3.3	worst condition	33



EXPLANATION

▲ Water-quality monitoring site

Lake-stage monitoring site

Figure 1. **Locations** of water-quality and lake-stage monitoring **sites** on Tichigan **Lake** near Waterford, **Wisconsin.**

LOCATION.--Lat 42°48'54" long 88°12'33", in SE 1/4 SE 1/4 sec.11, T.4N., R.19 E., Racine County, Hydrologic Unit 07120006, 3 5 mi north of Waterford.

PERIOD OF RECORD.--March 1994 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 09 *TO* AUGUST 13, 1996

(Milligrams per liter unless otherwise indicated)

	Feb 09		Apr. 23		June 12		July 29		Aug. 13	
Depth of sample (ft)	3.0	60	1.5	61	1.5	61	1.5	60	1 5	60
Lake stage (ft)	---		4.77		5.04		4.96		4.12	
specific conductance (µS/cm)	829	1010	837	840	781	862	692	867	690	883
pH (units)	8.1	7 5	8 4	8.1	8.5	7.5	8.5	7.4	8 5	7.3
Water temperature (°C)	3 5	2 5	1 0	7.0	18.5	8.5	23.5	9.0	25.5	8.5
Color (Pt-Co. scale)	---	---	30	25	---	---	---	---	---	---
Turbidity (NTU)	---	---	2 7	2.1	---	---	---	---	---	---
Secchi-depth (meters)	---		1 3		2.7		2.4		2.7	
Dissolved oxygen	11.2	1.8	11.6	9 2	11.2	0.4	9.7	0.5	9.4	0.4
Hardness, as CaCO3	---	---	280	280	---	---	---	---	---	---
Calcium, dissolved (Ca)	---	---	57	58	---	---	---	---	---	---
Magnesium, dissolved (Mg)	---	---	34	34	---	---	---	---	---	---
Sodium, dissolved (Na)	---	---	55	57	---	---	---	---	---	---
Potassium, dissolved (K)	---	---	3	3	---	---	---	---	---	---
Alkalinity, as CaCO3	---	---	230	230	---	---	---	---	---	---
Sulfate, dissolved (SO4)	---	---	47	48	---	---	---	---	---	---
Chloride, dissolved (Cl)	---	---	100	100	---	---	---	---	---	---
Fluoride, dissolved (F)	---	---	0.2	0.2	---	---	---	---	---	---
Silica, dissolved (SiO2)	---		0.0	0.3	---	---	---	---	---	---
Solids, dissolved, at 180°C	---	---	472	476	---	---	---	---	---	---
Nitrogen, NO2 + NO3, diss. (as N)	---	---	0.85	0.76	---	---	---	---	---	---
Nitrogen, ammonia, dissolved (as N)	---	---	<0.03	0.32	---	---	---	---	---	---
Nitrogen, organic, total (as N)	---	---	1.1	0.98	---	---	---	---	---	---
Nitrogen, amm + org, total (as N)	---	---	1.1	1.3	---	---	---	---	---	---
Nitrogen, total (as N)	---	---	1.9	2 1	---	---	---	---	---	---
Phosphorus, total (as PI	---	---	0.052	0 071	D 027	0.358	0.021	0.629	0.015	0.817
Phosphorus, ortho, dissolved (as P)	---	---	<0.002	0.004	---	---	---	---	---	---
Iron, dissolved (Fe) µg/L	---	---	<10	<lo	---	---	---	---	---	---
Hanganese, dissolved Inn) µg/L	---	---	0.4	47	---	---	---	---	---	---
Chlorophyll a, phytoplankton (µg/L)	---	---	22	---	6.7	---	6.7	---	5.9	---

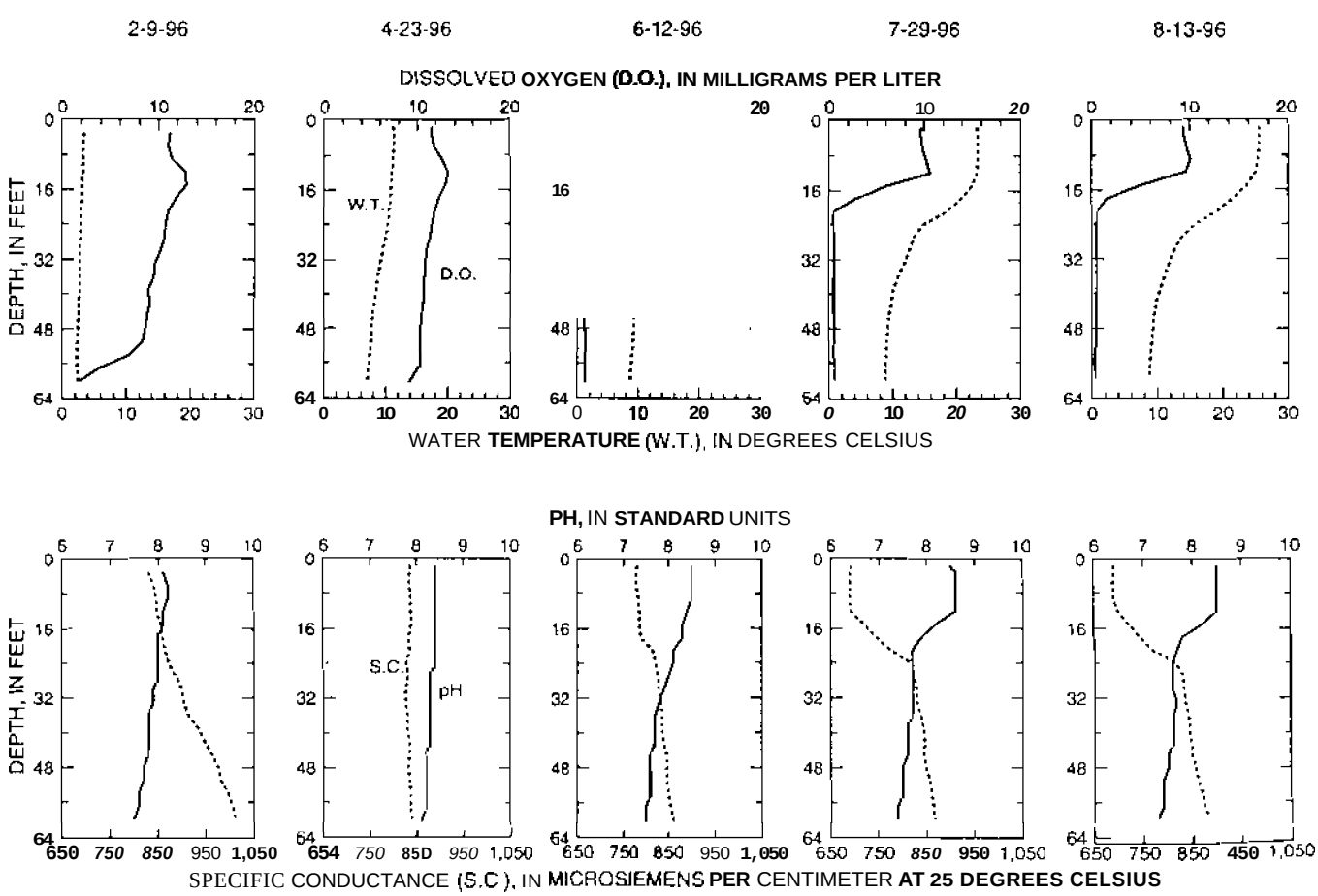


Figure 2. Water-quality data and depth profiles for Tichigan Lake near Waterford, Wisconsin, 1996 water year

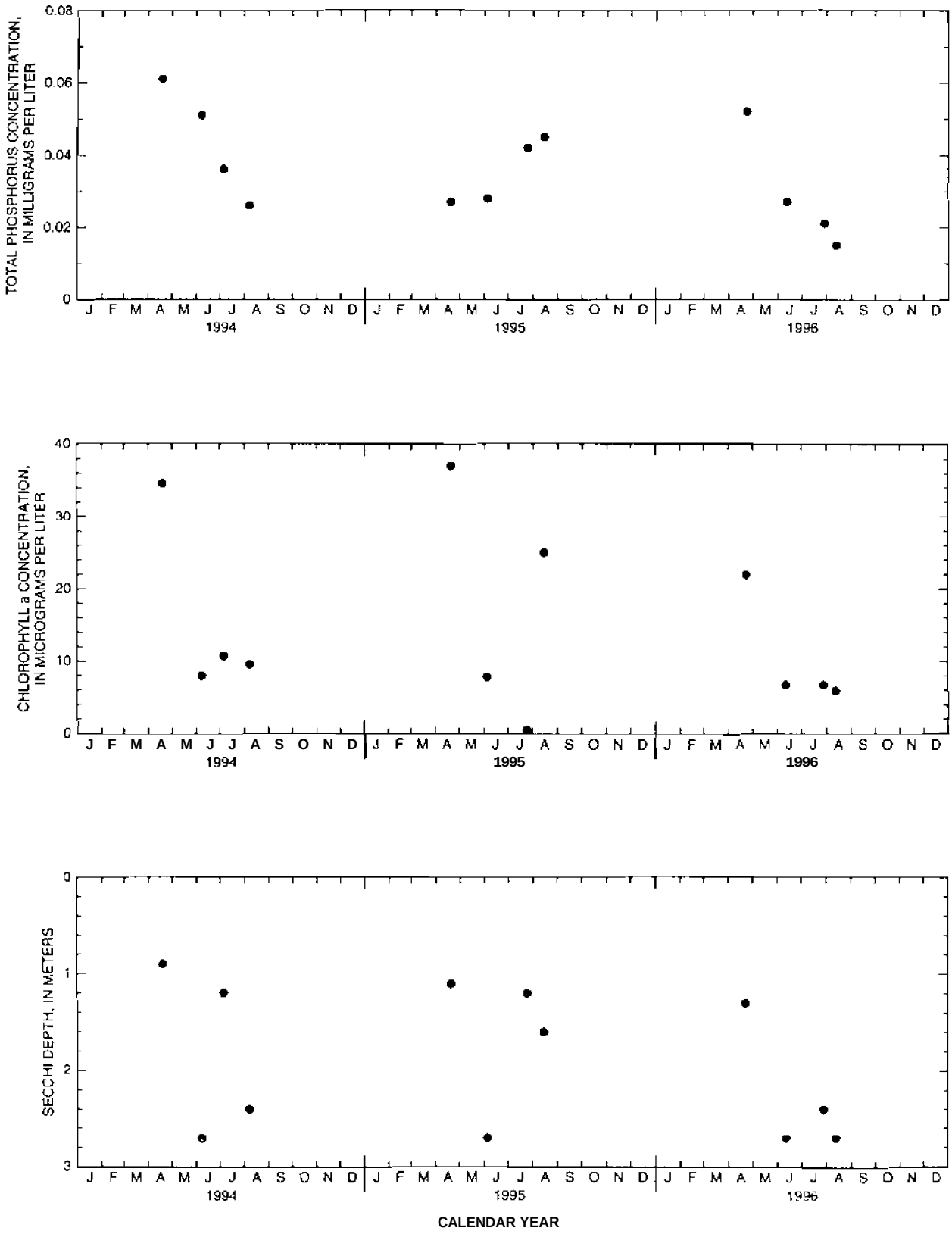


Figure 3. Surface total phosphorus and chlorophyll a concentrations, and Secchi depths for Tichigan Lake near Waterford, Wisconsin.

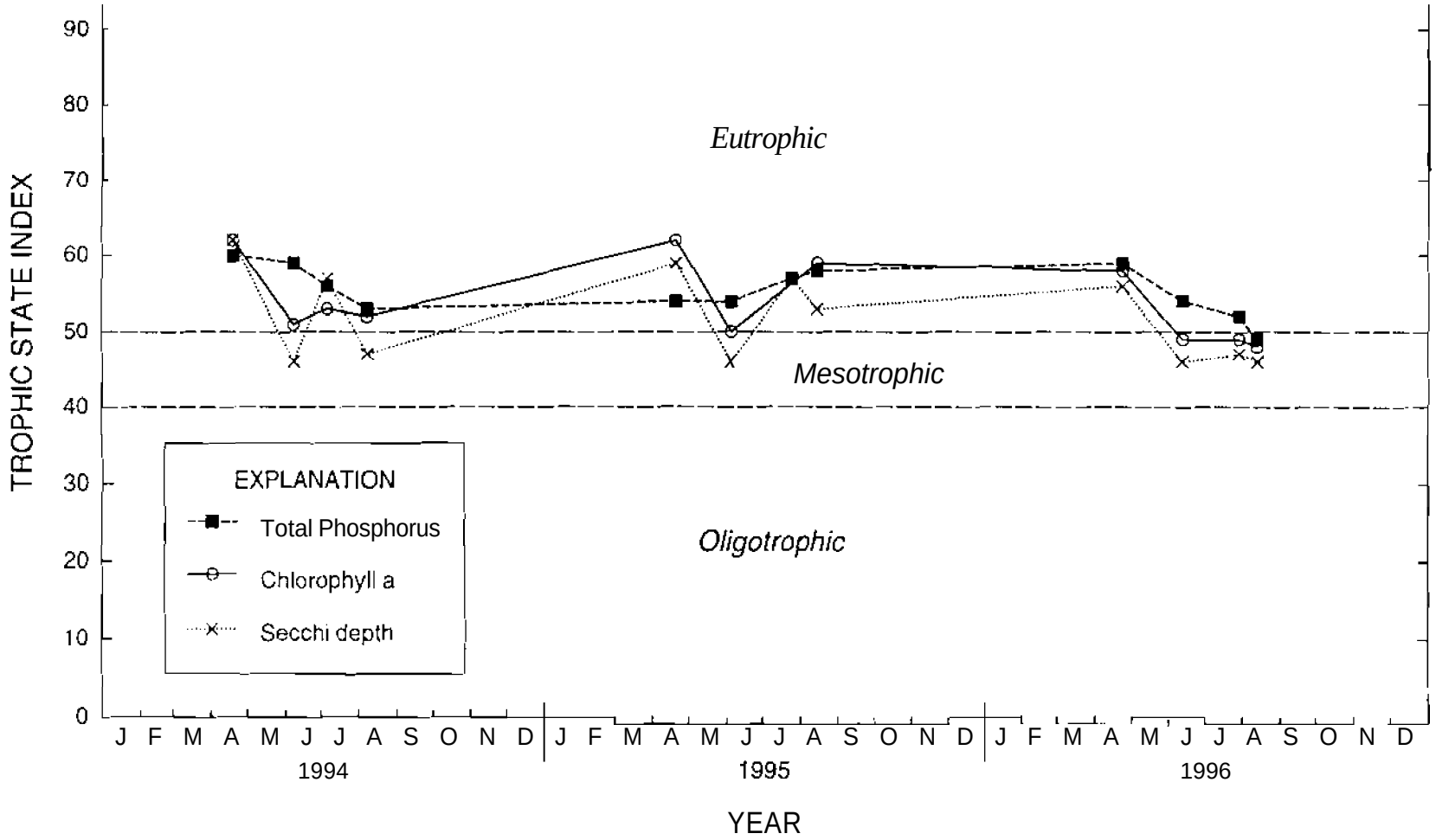


Figure **4.** Trophic state indices for Tichigan Lake near Waterford, Wisconsin