



# United States Department of the Interior

## U.S. GEOLOGICAL SURVEY

Water Resources Division  
6417 Normandy Lane  
Madison, Wisconsin 53719-1133  
608 274-3535 (Fax 608 276-3817)

July 23, 1996

Mr. Calvin Gander, President  
Lake Keesus Management District  
W292 N8382 Camp Whitcomb Road  
Hartland, Wisconsin 53029

Dear Mr. Gander:

This letter describes the progress on the evaluation of the water quality of Lake Keesus according to the data collected from October 1994 to September 1995 as stated in our agreement. The format for this progress report is different from that of previous years, but it contains essentially the same type of information.

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 1995" and to Shaw and others (1994) "Understanding Lake Data."

### **Hydrologic conditions during water year 1995:**

Annual variability in lake condition often reflects variability in climatic and hydrologic conditions. Air temperature in southeast Wisconsin was, on the average, 3.2 °F warmer than normal for the period December 1994 through March 1995; April and May was 2.0 °F cooler than normal; and the period June through August was 3.8 °F warmer than normal (National Oceanic and Atmospheric Administration "Climatological Data--Wisconsin"). Precipitation during water year 1995 was 94 percent of normal precipitation for southeast Wisconsin (Pamela Nabor-Knox, UW-Extension, Geological and Natural History Survey, written commun., 1995). Watershed runoff in the region of Lake Keesus was between 80 and 100 percent of long-term average runoff (Holmstrom and others, 1996, "Water Resources Data--Wisconsin").

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

Lake Keesus is classified as a spring lake and has one outlet. It has a surface area of 237 acres (0.37 square miles). Two sites were sampled in Lake Keesus. The primary site is located at the deepest point in the east bay at a depth of about 44 feet. An additional sampling site is located in the north bay at a

depth of about 30 feet. Lake stage was monitored along the western shoreline. The locations of the monitoring sites are shown in Figure 1.

#### **Lake Data for 1995:**

Data collected during the year, as published in the lake data report are **enclosed**. The following summary presents some highlights from the tables and figures.

#### Lake-stage fluctuations:

Lake stages measured on USGS sampling dates ranged from 10.63 feet on August 8 to 11.09 feet on April 24. This range of fluctuation, on average, is similar to the previous 4 years of monitoring. 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 are similar to those from the previous year; with the exception of a larger zone of anoxia seen in both February and August 1995 as compared to 1994. In addition there appears to be a zone of activity present below the thermocline which can be seen in July and August. There is also evidence of this zone in the summer sampling period of the 1994 water year. 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 April 24. The lake became thermally stratified through the summer. In June, water in the lower 7.5 feet was anoxic (devoid of oxygen), and by August the lower 13.0 feet of water were anoxic. In addition, an anoxic layer more than three feet thick occurred approximately at a depth of 21 feet. The anoxic zone is unable to support fish. The pH, which ranged between 7.0 and 8.6, is normal for southeastern Wisconsin lakes and poses no problems for aquatic life.

#### Chemical constituents:

Analyses of water samples collected on April 24 for selected chemical constituents for chemical characterization of the lake are shown in Figure 2. Samples collected at 1.5 and 42-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 30:1, based on the surface concentrations on April 24. 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. At the primary sampling site, total-phosphorus concentrations ranged from 0.011 mg/L on July 12 and August 8 to 0.022 mg/L on April 24, chlorophyll *a* ranged from 0.3 µg/L on July 18 to 15 µg/L on April 24, and Secchi depths ranged from 2.4 m on July 18 to 4.8 m on June 12. At the north bay sampling site, total-phosphorus concentrations ranged from 0.013 mg/L on July 12 and August 8 to 0.022 mg/L on April 24, chlorophyll *a* ranged from 0.2 µg/L on July 18 to 11 µg/L on April 24, Secchi depths ranged from 1.5 m on June 12 to 3.1 m on April 24 and August 8. Total phosphorus and chlorophyll *a* (excluding July) values are within regional values according to Lillie and Mason, (1983), and Secchi depths are within or above regional values.'

Surface total-phosphorus and chlorophyll *a* concentrations and Secchi depths for the 1991-95 period are shown on Figures 3a and 3b for the east and north bays respectively. No general year to year trends are apparent from the data. However, it appears that the highest surface total-phosphorus concentrations, observed during the entire study period, occur in the spring.

Total-phosphorus concentration 1.5 feet above the lake bottom at the primary site ranged from 0.023 mg/L on April 24 to 0.569 mg/L on July 12. The high total-phosphorus concentrations observed during anoxic periods are indicative of a large phosphorus release from the bottom sediments. These high concentrations are then mixed throughout the lake water column during fall turnover and may account for the elevated surface concentrations in the spring.

#### **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 1995,' is based on surface total-phosphorus and chlorophyll *a* concentrations, and Secchi depths. According to the index, surface total-phosphorus concentrations and Secchi depths in

---

1. The extremely low chlorophyll *a* values for July 18 is believed to be erroneous and the result of laboratory error. Abnormally low chlorophyll *a* values were obtained for samples from numerous other lakes during a two week period in July. These low chlorophyll *a* values were not accompanied by corresponding decreases in total-phosphorus or increases in Secchi depth as would generally be expected.

Lake Keesus indicate "good water quality, and chlorophyll a concentrations indicate "very good water quality.

Lillie and Mason (1983) also provided a means of comparing the condition of Lake Keesus with other lakes in southeastern Wisconsin. The comparison on page 5 shows the percentage distribution of southeastern Wisconsin lakes within each condition group and the relative position of Lake Keesus.

	<u>Parameter</u>	<b>Percentage distribution of lakes in southeast Wisconsin within parameter ranges</b>	
	<u>Total-phosphorus (mg/L)</u>		
<b>Lake Keesus values</b>	<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 <u>a</u> (µg/L)</u>		
<b>Lake Keesus values</b>	0-5	best condition	22
	5-10	↓	31
	10-15		14
	15-30		12
	>30	worst condition	22
	<u>Secchi depth (feet)</u>		
<b>Lake Keesus values</b>	>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

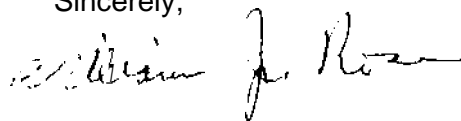
Trophic status:

Another means of assessing the nutrient, or trophic, status of a lake is to use Carlson's Trophic State Index (TSI). The 1995 TSI data for the **east** and north bays is listed in Tables 3a and 3b. Figures 3a and 3b are graphical illustrations of the variation in Trophic State Indices for Lake Keesus, east and north bays respectively, during the **5** year study period. The chlorophyll a value for July 1995 is not included in Figures **4a** and **4b**. The data from 1995 show the lake to be mesotrophic, or a lake with moderate nutrient levels. It can also be seen from the TSI plots that the overall water quality is slightly better in the east bay.

The data that have been collected for Lake Keesus from 1991 through 1995 are useful for understanding the lake's water quality, and for managing the lake. These data define the present water quality of the lake and provide a basis for assessing trends or changes in water quality in the future. Continued monitoring will help to build on this valuable data base.

If you have questions regarding this evaluation, please contact me at (608) 276-3834.

Sincerely,



William Rose  
Hydrologist

Enclosures

cc: Bob Wakeman, DNR, Milwaukee

Table 1. Lake-depth profiles for Lake Keesus, cast bay near Merton, Wisconsin, 1995 water year

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 WHOLE FIELD (STAND- ARD UNITS) (00400)	OXYGEN, DIS- SOLVED (MG/L) (00300)
FEB 1995					
03...	1.50	1.5	402	8.6	10.0
03...	3.00	2.5	400	8.6	13.1
03...	6.00	3.5	403	8.5	12.6
03...	9.00	3.5	403	8.5	12.5
03...	12.0	3.5	402	8.5	12.3
03...	15.0	3.5	403	8.5	11.8
03...	18.0	4.0	403	8.4	11.5
03...	21.0	4.0	407	8.4	11.1
03...	24.0	4.0	405	8.4	10.9
03...	27.0	4.0	407	8.3	10.3
03...	30.0	4.0	410	8.3	9.9
03...	33.0	4.0	416	8.1	6.8
03...	36.0	4.5	421	7.8	1.8
03...	39.0	4.5	421	7.8	1.2
03...	42.0	4.5	425	7.7	1.0
03...	43.5	4.5	428	7.7	1.0
03...	45.0	--	--	--	--
APR					
24...	1.50	8.0	373	8.4	12.0
24...	3.00	8.0	374	8.4	12.0
24...	6.00	8.0	373	8.4	11.9
24...	9.00	8.0	374	8.4	12.1
24...	12.0	8.0	373	8.4	12.3
24...	15.0	8.0	373	8.4	12.1
24...	18.0	8.0	372	8.4	11.8
24...	21.0	8.0	371	8.4	11.7
24...	24.0	8.0	372	8.4	11.6
24...	27.0	8.0	372	8.4	11.5
24...	30.0	7.5	373	8.4	11.4
24...	33.0	7.5	373	8.4	11.3
24...	36.0	7.5	371	8.3	11.2
24...	39.0	7.5	372	8.3	11.0
24...	42.0	7.0	371	8.3	10.9
24...	42.5	7.0	373	8.3	10.8
24...	44.0	--	--	--	--
JUN					
12...	1.50	20.5	370	7.9	9.2
12...	3.00	20.5	370	7.9	9.2
12...	6.00	20.0	371	8.0	9.4
12...	9.00	20.0	371	8.0	9.7
12...	12.0	20.0	372	8.0	9.9
12...	15.0	19.5	370	8.0	9.6
12...	18.0	16.5	379	7.9	8.3
12...	21.0	15.5	384	7.6	5.8
12...	24.0	13.5	385	7.4	4.5
12...	27.0	12.0	383	7.3	4.1
12...	30.0	10.5	390	7.3	3.6
12...	33.0	9.5	391	7.2	1.8
12...	36.0	8.5	402	7.1	0
12...	39.0	8.0	412	7.0	0
12...	42.0	7.5	419	7.0	0
12...	43.5	--	--	--	--

Table I. Lake **depth** profiles for Lake Keesus, east bay near Merton, Wisconsin. 1995 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 WHOLE FIELD (STAND- ARD UNITS) (00400)	OXYGEN, DIS- SOLVED (MG/L) (00300)
JUL					
12...	5	24.0	345	8.2	9.0
12...	3.00	24.0	364	8.2	9.0
12...	6.00	24.0	363	8.2	9.0
12...	9.00	24.0	366	8.2	9.2
12.. .	12.0	23.0	365	8.2	9.4
12...	15.0	22.5	364	8.2	8.7
12.. .	18.0	20.5	375	7.9	5.9
12.. .	21.0	18.5	321	7.4	6.8
12.. .	24.0	14.0	389	7.4	0.2
12.. .	27.0	12.5	389	7.5	0.4
12.. .	30.0	10.5	393	7.5	0
12.. .	33.0	10.0	392	7.5	0
12.. .	36.0	9.0	400	7.5	0
12...	39.0	8.0	428	7.3	0
12.. .	41.5	8.0	440	7.3	0
12...	43.0	--	--	--	--
AUG 1995					
08...	1.50	26.5	344	8.2	8.1
08...	3.00	26.5	345	8.3	8.1
08...	6.00	26.5	344	8.3	8.2
08...	9.00	26.5	344	8.3	8.4
08...	12.0	26.0	345	8.2	8.5
05...	15.0	24.5	360	7.9	5.3
08...	18.0	22.5	372	7.6	2.2
08...	21.0	19.5	383	7.4	0.2
08...	24.0	16.5	383	7.4	0.2
08.. .	27.0	12.5	379	7.7	1.9
08...	30.0	11.0	385	7.5	0
08...	33.0	9.5	397	7.4	0
08...	36.0	9.0	405	7.4	0
08...	39.0	8.0	423	7.3	0
00.. .	41.5	8.0	441	7.2	0
08.. .	43.0	--	--	--	--

Table 2. Water quality data for Lake Keesus, north bay near Mcrton, Wisconsin, 1995 water year

LOCATION.--Lat 43°10'06", long 88°19'10", in NW ~~14~~ SW 1/4 sec.12, T 8 N., R.18 E., Waukesha County, Hydrologic Unit 07090001, 1.4 mi northwest of Mcrton.

PERIOD OF RECORD.-- April 1991 to current year.

LAKE-STAGE GAGE.--Datum of gage is 947.09 ft above sea level.

REMARKS.--Lake sampled in north bay at a lake depth of about 30 ft. Water-quality analyses done by Wisconsin State Laboratory of Hygiene.

WATER-QUALITY DATA, APRIL 24 TO AUGUST 08, 1995  
(Milligrams per liter unless otherwise indicated)

	Apr. 24	June 12	July 12	July 18	Aug. 08
Depth of sample (ft)	1.5	1.5	1.5	1.5	1.5
Lake stage (ft)	11.09	11.02	10.72	-	10.63
Specific conductance (µS/cm)	372	370	368	358	345
pH (units)	8.5	8.1	8.5	8.4	8.4
Water temperature (°C)	8.5	20.0	24.0	26.5	27.0
Secchi-depth (meters)	3.1	1.5	2.9	2.4	3.1
Dissolved oxygen	12.0	9.3	9.2	8.3	8.2
Phosphorus, total (as P)	0.022	0.016	0.013	---	0.013
chlorophyll a, phytoplankton (µg/L)	11	3.6	---	0.2	3.2

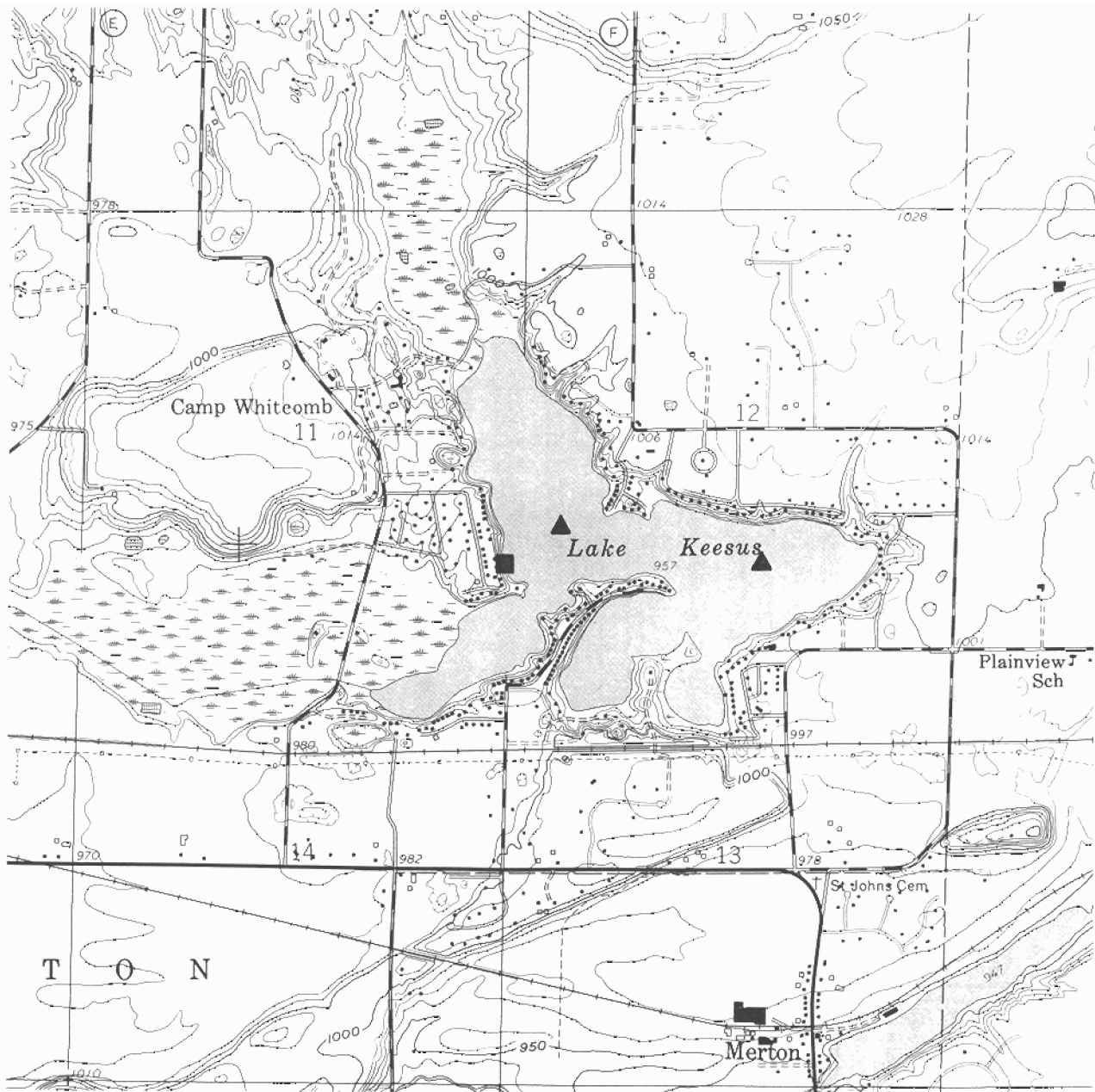


**Table 3a.**--Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Lake Keesus, **east bay**,  
 1995 water year  
 [ - indicates not applicable; -- indicates no data available]

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.	
04124195	3.1	10.2	44	1.5	0.022	22	52	15	55	<0.002
				42	0.023	23				0.002
06112195	4.8	15.7	37	1.5	0.015	15	49	2.9	43	--
				42	0.473	473		-	-	--
07/12195	3.2	10.5	43	1.5	0.011	11	47	--	--	--
				41	0.569	569		-	-	--
07118/95	2.4	7.9	47	1.5	--	--	--	0.3	26	--
08/08/95	2.9	9.5	45	1.5	0.011	11	47	3.3	44	--
				41	0.534	534				--

Table 3b.--Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Lake **Keesus**, north bay,  
**1995 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.	
04/24/95	3.1	10.2	44	1.5	0.022	22	52	11	53	--
				--	--	--				--
06112195	1.5	4.9	54	1.5	0.016	16	50	3.6	45	--
				--	--	--				--
07112195	2.9	9.5	45	1.5	0.013	13	48	--	--	--
				--	--	--				--
<b>07118/95</b>	<b>2.4</b>	<b>7.9</b>	<b>47</b>	<b>1.5</b>	--	--	--	0.2	<b>23</b>	--
08/08/95	3.1	10.2	44	1.5	0.013	13	48	3.2	44	--
				--	--	--				--



**EXPLANATION**

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

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

LOCATION.--Lat 43°09'57", long 88°18'34", in SW 1/4 SE 1/4 sec.12, T.8 N. R.18 B., Waukesha County, Hydrologic Unit 07090001, 1.2 mi north of Merton.

PERIOD OF RECORD.--April 1991 to current year.

LAKE-STAGE GAGE.--Datum of gage is 947.09 ft above sea level.

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

WATER-QUALITY DATA, FEBRUARY 03 TO AUGUST 08, 1995

(Milligrams per liter unless otherwise indicated)

	Feb. 03		Apr. 24		June 12		July 12		July 18	Aug. 08	
Depth of sample (ft)	3.0	44	1.5	42	1.5	42	1.5	41	1.5	1.5	d1
Lake stage (ft)	---	---	11.09	---	11.02	---	10.72	---	---	10.63	---
Specific conductance (µS/cm)	400	42R	373	373	370	419	365	440	358	344	441
pH (units)	8.6	7.7	8.4	8.3	7.9	7.0	8.2	7.3	8.3	8.2	7.2
Water temperature (C)	2.5	4.5	8.0	7.0	20.5	7.5	24.0	8.0	26.5	26.5	8.0
Color (Pt-Co. scale)	---	---	10	10	---	---	---	---	---	---	---
Turbidity (NTU)	---	---	1.5	1.6	---	---	---	---	---	---	---
Secchi-depth (meters)	---	---	3.1	---	4.8	---	3.2	---	2.4	2.9	---
Dissolved oxygen	13.1	1.0	12.1	10.8	9.2	0.0	9.0	0.0	8.0	8.1	0.0
Hardness, as CaCO3	---	---	190	190	---	---	---	---	---	---	---
Calcium, dissolved (Ca)	---	---	39	39	---	---	---	---	---	---	---
Magnesium, dissolved (Mg)	---	---	23	23	---	---	---	---	---	---	---
Sodium, dissolved (Na)	---	---	7.0	7.0	---	---	---	---	---	---	---
Potassium, dissolved (K)	---	---	2	2	---	---	---	---	---	---	---
Alkalinity, as CaCO3	---	---	170	170	---	---	---	---	---	---	---
Sulfate, dissolved (SO4)	---	---	11	11	---	---	---	---	---	---	---
Chloride, dissolved (Cl)	---	---	16	17	---	---	---	---	---	---	---
Fluoride, dissolved (F)	---	---	<0.1	<0.1	---	---	---	---	---	---	---
Silica, dissolved (SiO2)	---	---	0.0	0.1	---	---	---	---	---	---	---
Solids, dissolved, at 180°C	---	---	220	222	---	---	---	---	---	---	---
Nitrogen, NO2 + NO3, diss. [as N]	---	---	0.02	0.02	---	---	---	---	---	---	---
Nitrogen, ammonia, dissolved (as N)	---	---	0.04	0.07	---	---	---	---	---	---	---
Nitrogen, organic, total (as N)	---	---	0.76	0.78	---	---	---	---	---	---	---
Nitrogen, amm. + org.. total (as N)	---	---	0.82	0.82	---	---	---	---	---	---	---
Nitrogen, total (as N)	---	---	0.022	0.023	0.015	0.473	0.011	0.569	---	0.011	0.534
Phosphorus, total (as P)	---	---	<0.002	0.002	---	---	---	---	---	---	---
Phosphorus, ortho, dissolved (as P)	---	---	<10	<10	---	---	---	---	---	---	---
Iron, dissolved (Fe) µg/L	---	---	0.9	4	---	---	---	---	---	---	---
Manganese, dissolved (Mn) µg/L	---	---	15	---	2.9	---	---	---	0.3	3.3	---
Chlorophyll a, phytoplankton (µg/L)	---	---	---	---	---	---	---	---	---	---	---

2-3-95

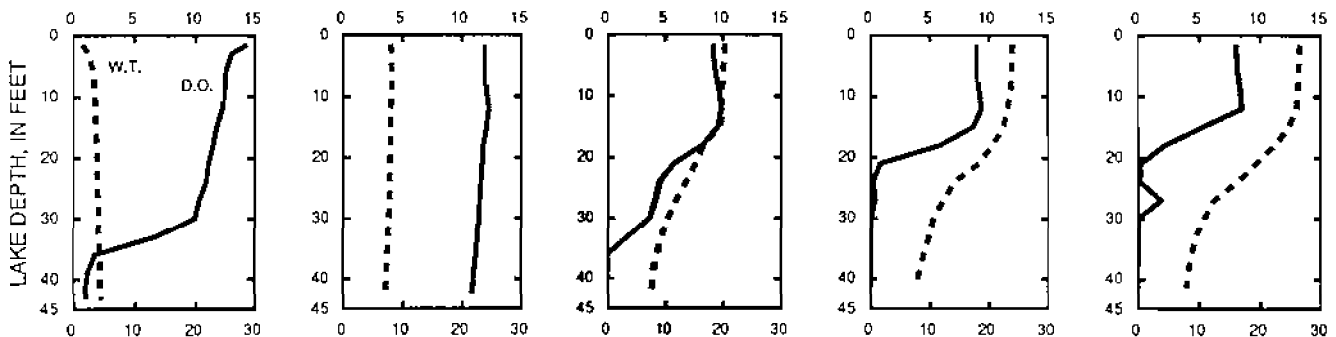
4-24-95

6-12-95

7-12-95

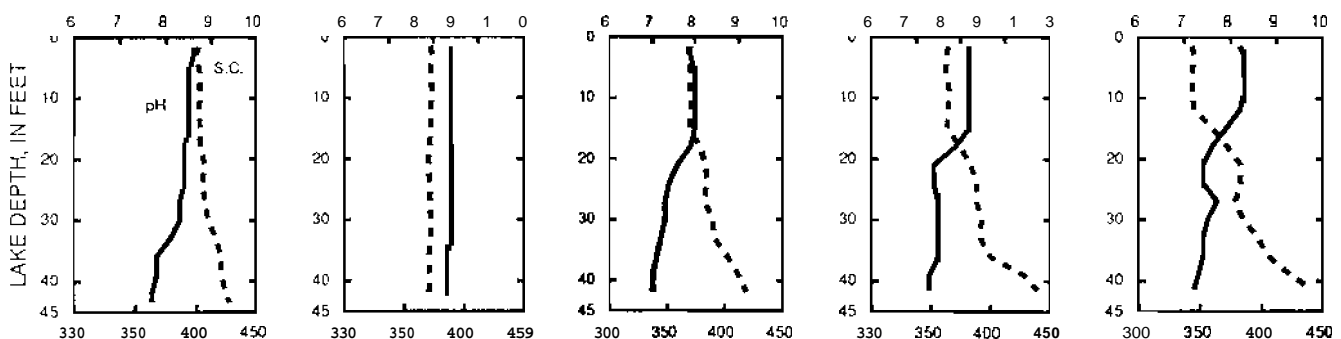
8-8-95

DISSOLVED OXYGEN (D.O.), IN MILLIGRAMS PER LITER



WATER TEMPERATURE (W.T.), IN DEGREES CELSIUS

pH, IN STANDARD UNITS



SPECIFIC CONDUCTANCE (S.C.), IN MICROSIEMENS PER CENTIMETER AT 25 DEGREES CELSIUS

Figure 2. Water quality data and depth profiles for Lake Keesus, east bay near Merton, Wisconsin, 1995 water year





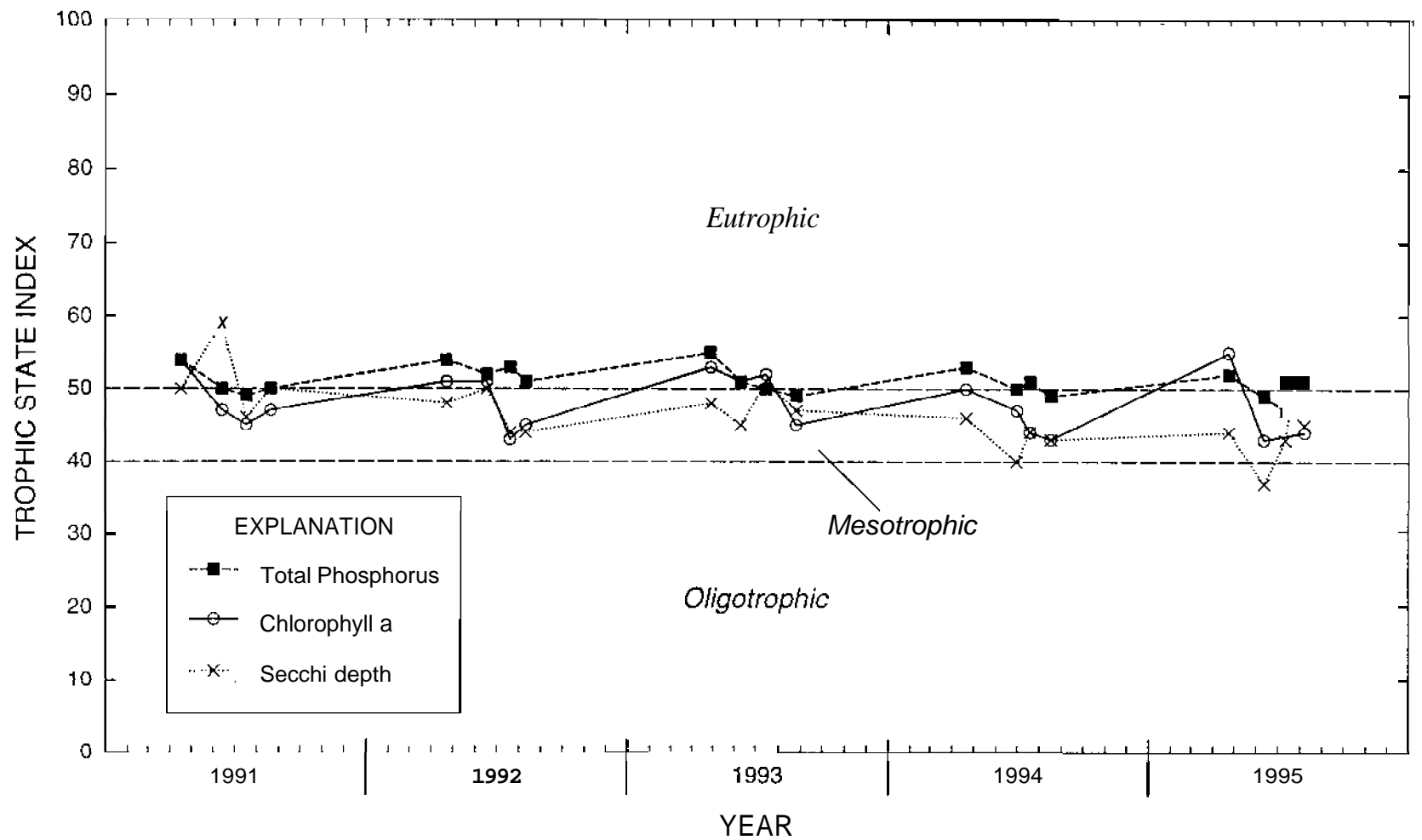


Figure 4a. Trophic state indices *for* Lake Keesus, east bay, near Merton, Wisconsin

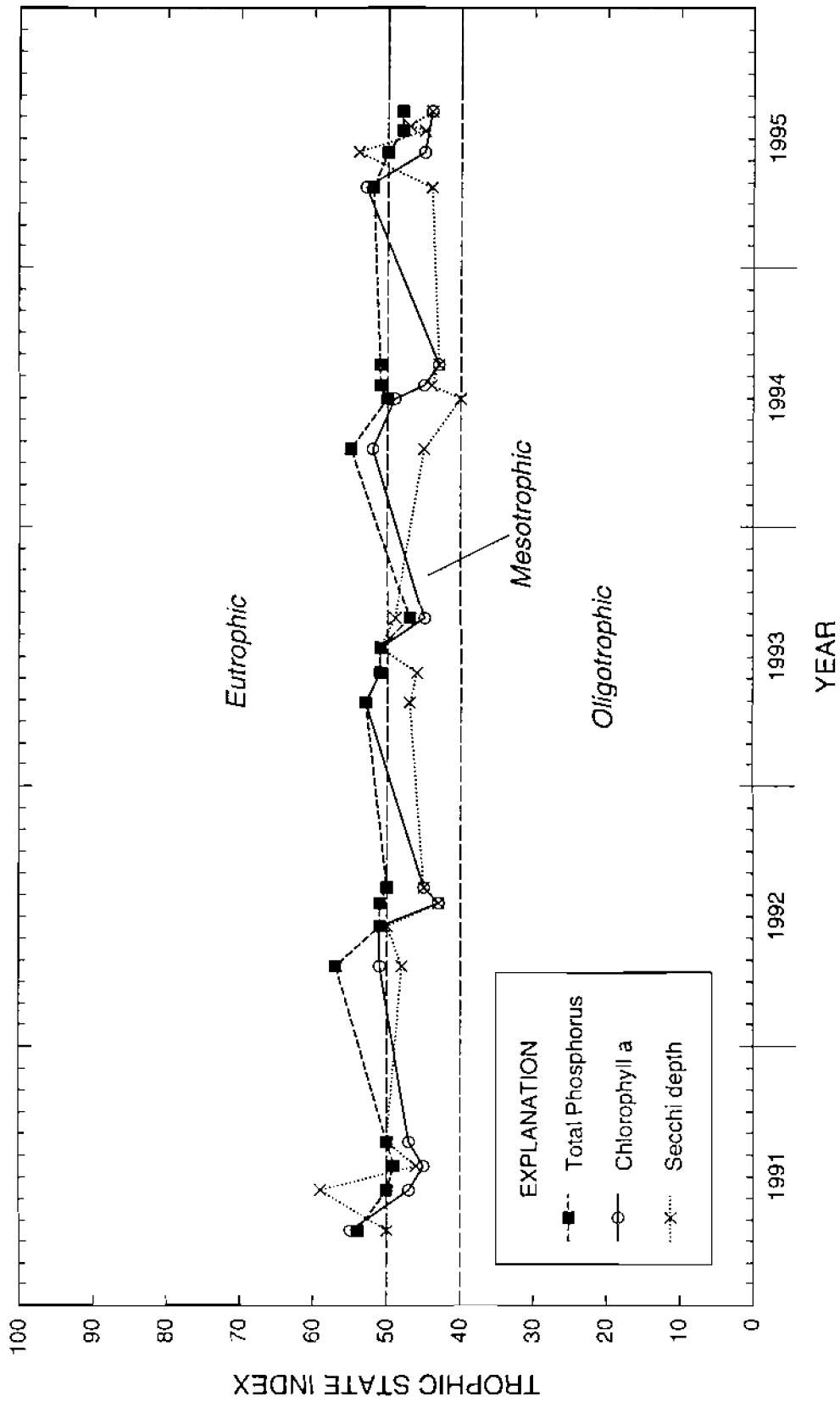


Figure 4b. Trophic state indices for Lake Keesus, north bay, near Merton, Wisconsin