

# **Minocqua and Kawaguesaga Lakes, Oneida County, WI**

## **Water-Quality Data Summary-2003**

U. S. Geological Survey, May 2004

This data summary covers the period May to September 2003, which is the period of water-quality monitoring by the U.S. Geological Survey (USGS). All data presented will be published in the USGS annual lake data report "Water-Quality and Lake-Stage Data for Wisconsin Lakes, Water Year 2003," which will be available in late May 2004. Data from previous years collected by others are included in graphs for comparison and to illustrate changes or trends.

The goals of the 2003 Phase 1 study were to:

- **Review and summarize pertinent existing documents and reports about the hydrology, water quality, and management plans for the lake system.**
- **Evaluate current and historical lake water quality and trophic state relative to longer-term trends.**
- **Use results and information from the above to design Phase 2, a proposal for a comprehensive diagnostic/feasibility study, to be submitted as part of a Lake Protection Grant application.**

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

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

Minocqua and Kawaguesaga Lakes are a complex chain of drainage lakes in Oneida County in the northeastern lakes region of Wisconsin. The surface areas of the lakes are 1,360 and 670 acres, respectively, with maximum depths of 60 and 44 feet. Minocqua Lake receives inflows from upstream chain of lakes through the Tomahawk and Minocqua Thoroughfares and flows directly into Kawaguesaga Lake. Lake levels of both lakes are controlled by a dam at the outlet of Kawaguesaga Lake, which flows into the Tomahawk River. The dam and lake levels are managed by Wisconsin Valley Improvement Company for storage to augment the flow of the Wisconsin River. The total drainage area at the outlet dam is 72.5 square miles. The rapidly growing urban area of Minocqua is on the shore of these lakes.

**Phase 1** consisted of lake water-quality monitoring beginning in May 2003 through September 2003 to identify and characterize current lake conditions and problems. Included in this phase is a review and summary of available historical water-quality data (WDNR long-term monitoring, Self-Help data, and previous studies that may have been conducted on the lakes. Results and information from this phase will be used to design phase 2, a comprehensive study to assess the hydrology and nutrient loading of the lakes, and model the effects of different potential loading scenarios.

Lake water-quality monitoring was done at three locations in Minocqua Lake; a main sampling site over the deepest location in the lake, and at additional auxiliary sites in the northwestern basin of the lake and in the bay near the outlet (fig. 1). Land uses within the immediate watersheds of the lakes are shown in figure 2. Two locations were sampled in Kawaguesaga Lake: the main sampling site over the deepest part of the lake and at one auxiliary site in the southern basin of the lake. Lake stage was monitored at the dam outlet. The sites were sampled according to the schedules shown in tables 1 and 2. Basic chemical characterization of the water was determined by analyzing a water sample for 19 constituents. This sample was taken from the main sampling site during spring turnover. Vertical profiles of

temperature, dissolved oxygen, specific conductance, and pH were measured at all sampling locations during each sampling visit. The trophic state index (TSI) parameters of total phosphorus and chlorophyll *a* concentrations and Secchi depth, were measured or sampled at all sites at all open-water sampling visits. Samples for phosphorus and nitrogen species were collected to determine the nitrogen/phosphorus ratio, which is an indication of nitrogen or phosphorus limitation and the propensity for blue-green algal blooms.

The WDNR and Lake Association have conducted various studies of the lakes and watershed over the past ten years or more. The extensive amount of technical information and reports available about the system are generally not in a form that is easily used by the Lake Association, Town, other local governments, and residents for decision-making. Past lake water-quality data collected by the WDNR and Lake Association were summarized and evaluated. Self-Help data collection began in 2000 and is continuing, but no comprehensive chemical sampling has been done for the past several years.

### **Summary of past studies**

Lake-bottom sediment cores were collected in 1991 and 1992 from Minocqua Lake by WDNR for analysis of the historical record (Garrison, written comm., 2003; Young, 1994). Development since about 1890 has caused a doubling of the sedimentation rate, with greater increases in rate since about 1965. The phosphorus accumulation rate remained relatively constant until about 1950, but has increased significantly since then to the present. Since 1920, the phosphorus accumulation rate has more than tripled, with the greatest rates occurring after about 1980. The southwestern basin had experienced more rapid impacts from shoreline and watershed development than the main basin.

The WDNR conducted macrophyte surveys in 1989, 1993, and 1996 as part of the long-term trend lake monitoring program (WDNR, written comm., 1996). The most common species found were coontail, which had increased in frequency of occurrence since 1989. The percentage of littoral area vegetated also increased from 87% in 1989 to 92% in 1996. The macrophyte community is characterized by high diversity and primarily submergent species. Related to this topic, soil fertility of the littoral zone sediments was surveyed in 2002 (Steve McComas, BlueWater Science, written comm.) to evaluate the potential to support nuisance Eurasian watermilfoil growth. Currently, Eurasian watermilfoil was found only in several small patches in Lake Minocqua covering several acres or less. Nitrogen levels in littoral soils were found to be low to moderate and the potential for supporting nuisance growths was limited to only a few small areas totaling less than 20 acres.

An evaluation of the impacts from septic systems on ground water and surface water was conducted in 1996 (Lindemann and others, 1997). The study included about half of the 160 homes on Lake Minocqua that have on-site sewage disposal systems. The presence of high groundwater tables and highly permeable sandy soils can cause incomplete on-site wastewater treatment and loading of nutrients to be a concern. The study found increased amounts of ammonium, nitrate, phosphorus and chloride entering the lake by groundwater flow. The study did not, however, attempt to quantify the nutrient loading contributed by septic systems. A number of sites had one or more nutrients at elevated concentrations at the lake edge and most of these were associated with developed areas using septic systems. The majority of septic systems studied were older than 25 years and any problems associated with them are likely to become greater in the future as they age further. Other areas having elevated concentrations may be associated with wetland seepage or stormwater runoff from urban areas.

## Hydrologic conditions during 2003 water year

Annual variability in lake condition often reflects variability in climatic and hydrologic conditions. Air temperature in Northcentral Wisconsin was, on the average, cooler than normal for June and July, and warmer than normal in August (National Oceanic and Atmospheric Administration "Climatological Data--Wisconsin"). Precipitation during water year 2003 was 90 percent of normal for Northcentral Wisconsin (Ed Hopkins, State Climatology Office, Univ. of Wisconsin, written commun., 2004). Following a wet spring, monthly precipitation during summer was 78 percent of average for June, 73 percent for July, 50 percent for August, and 71 percent for September. May precipitation was above average with 143 percent. Annual watershed runoff in the region of Minocqua was 96 percent of long-term average runoff (Waschbusch and others, 2004, "Water Resources Data—Wisconsin, Water Year 2003").

### Lake Data for 2003:

The following is a summary of highlights from the data given in the tables and shown in the figures.

#### Lake-stage fluctuations:

Lake stages were obtained at Minocqua Dam from WVIC on sampling dates. The stages ranged from 1584.16 feet on May 8 to 1584.56 feet on June 18. Stage values are shown in the table on the top half of Figure 3.

#### Lake-depth profiles:

Vertical profiles of water temperature, dissolved oxygen, pH, and specific conductance. These profiles, which were measured over the deepest point in the lakes, are shown in Figure 3. During the May through September sampling period, water-column mixing was observed on May 8. The lake became thermally stratified through the summer. By June 18 the column of water became anoxic (devoid of oxygen) below a depth of 13 meters (43 feet) in Minocqua L. and below 9 meters (29.5 feet) in Kawaguesaga; by August, depths below 9 meters in Minocqua and 7 meters in Kawaguesaga were anoxic. The anoxic zone is unable to support fish. The pH, which ranged between 6.4 and 8.1, is common for northern Wisconsin lakes and poses no problems for aquatic life. Specific conductance increased while pH decreased in the anoxic zone during the summer.

#### Chemical constituents:

Analyses of water samples collected on May 8 for selected chemical constituents for characterization of the lake are shown in Figure 3. 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 total nitrogen to total phosphorus is 15 for Minocqua and 13 for Kawaguesaga based on the surface concentrations on May 8. These ratios suggest the lakes are phosphorus limited, which means phosphorus is the most likely nutrient controlling algal growth.

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 for Minocqua Lake ranged from 0.012 mg/L to 0.037 mg/L, chlorophyll a ranged from 1.78 ug/L to 21ug/L, and Secchi depths ranged from 1.6 to 4.6 m. Total phosphorus concentrations for Kawaguesaga Lake ranged from 0.011 mg/L to 0.028 mg/L, chlorophyll a ranged from 2.9 ug/L to 16.8ug/L, and Secchi depths ranged from 1.6 to 3.6 m.

Surface total phosphorus and chlorophyll a concentrations, and Secchi depths for 2003 and the historical period from 1973 are shown on time plots, Figure 4. No trends are apparent from these data for Kawaguesaga Lake. For Minocqua Lake, there appears to be an upward trend in total phosphorus data from about 1990-2003, but no apparent trend in chlorophyll a or Secchi data.

Total phosphorus concentrations 0.5 meters above the lake bottom at the deep sampling sites ranged from 0.02 mg/L on May 8 to 0.273 mg/L on August 12 for Minocqua Lake, and 0.033 mg/L on May 8 to 0.131 mg/L on August 12 for Kawaguesaga Lake. These total phosphorus concentrations observed during anoxic periods are indicative of moderate 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 in "Water-Quality and Lake-Stage data for Wisconsin Lakes," 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 Minocqua and Kawaguesaga Lakes generally indicate "good" water quality.

Trophic status:

Another means of assessing the nutrient, or trophic, status of a lake is to use Carlson's Trophic State Index (TSI). The bottom plot of the time plots is a graphical illustration of the variation in Trophic State Indices for Minocqua and Kawaguesaga Lakes from 1973 to 2003. The data from 2003 show the lake to be mesotrophic to borderline eutrophic, or a lake with moderate nutrient levels. The lakes are generally mesotrophic, but reach eutrophic conditions at times with the hypolimnion becoming anoxic. The northwest basin may generally have slightly poorer water quality than the main basin. Kawaguesaga lake has similar TSI's, and both lakes show no apparent trend over the 30-year period. Although water quality is generally good and trophic condition of the lakes is borderline eutrophic, recent increasing trends in total phosphorus and moderately high bottom phosphorus concentrations are of some concern.

**Phase 2 proposal**

A proposal for a possible future diagnostic/feasibility study, entitled "HYDROLOGY, WATER QUALITY, AND RESPONSE TO SIMULATED CHANGES IN PHOSPHORUS LOADING OF MINOCQUA AND KAWAGUESAGA LAKES, ONEIDA COUNTY, WISCONSIN" was presented to the Minocqua/Kawaguesaga Lakes Protection Association in January 2004.

**References**

Garn, H. S., Elder, J. F. and Robertson, D. M., 2003, Why study lakes? An overview of USGS lake studies in Wisconsin: U.S. Geological Survey Fact Sheet 063-03, 8 p.

Lillie, R. A., and Mason, J. W., 1983, Limnological Characteristics of Wisconsin Lakes, Technical Bulletin No. 138, Wisconsin Department of Natural Resources, 116 p.

Lindemann, J., Shaw, B., and McKinney, B., 1997, An evaluation of the impacts septic systems have on groundwater and surface-water quality of Minocqua Lake, Wisconsin: College of Natural Resources, Univ. of Wisconsin-Stevens Point, 34 p.

Minocqua/Kawaguesaga Lakes Protection Assoc., 2003, State of the lakes, 2003, and member user manual, 39 p.

Wisconsin Department of Natural Resources, 1996, Minocqua – Woodruff Priority lakes Project Plan, WDNR Publ. WT-477-96, 89 p.

Young, Robert, 1994, Minocqua-Woodruff priority lake project water resources appraisal: Wisconsin Dept. of Natural Resources, North Central District, 18 p.

455214089412800 MINOCQUA LAKE, DEEP HOLE, AT MINOCQUA, WI

LOCATION.--Lat 45°52'14", long 89°41'28", in SE 1/4 SW 1/4 nw 1/4 sec.13, T.39 N., R.6 E., Oneida County, Hydrologic Unit 07070001, at Minocqua.

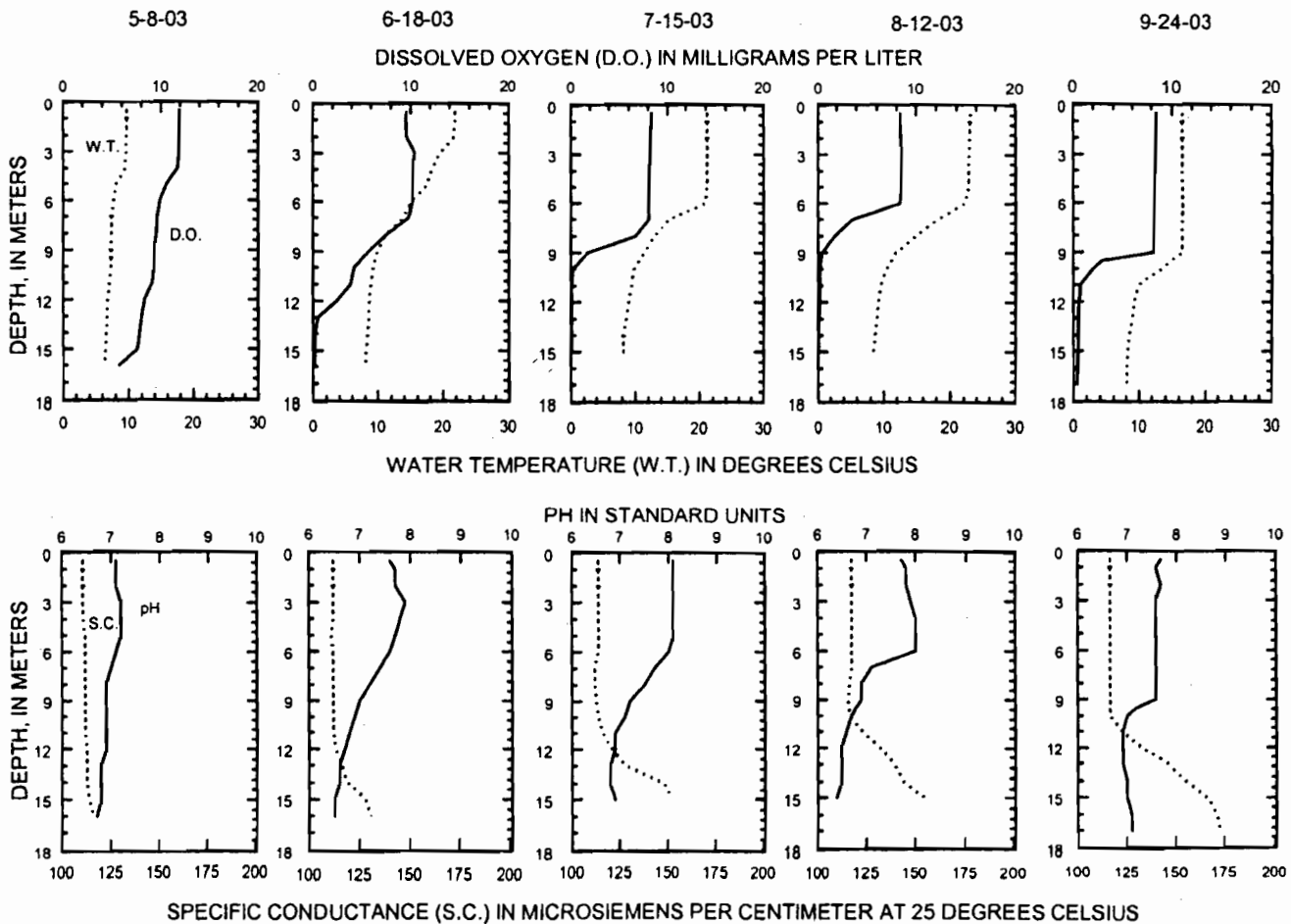
PERIOD OF RECORD.--May to September 2003.

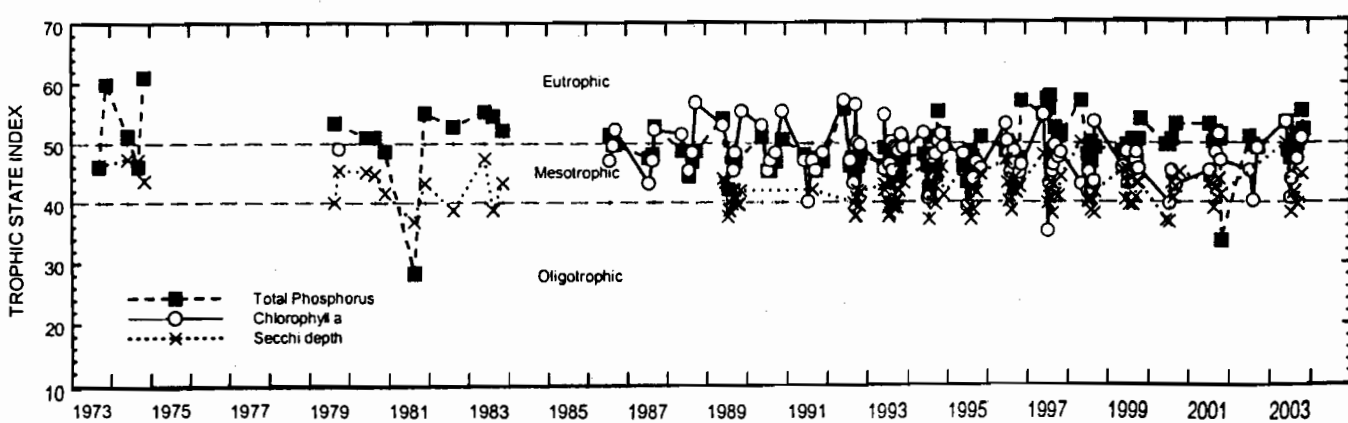
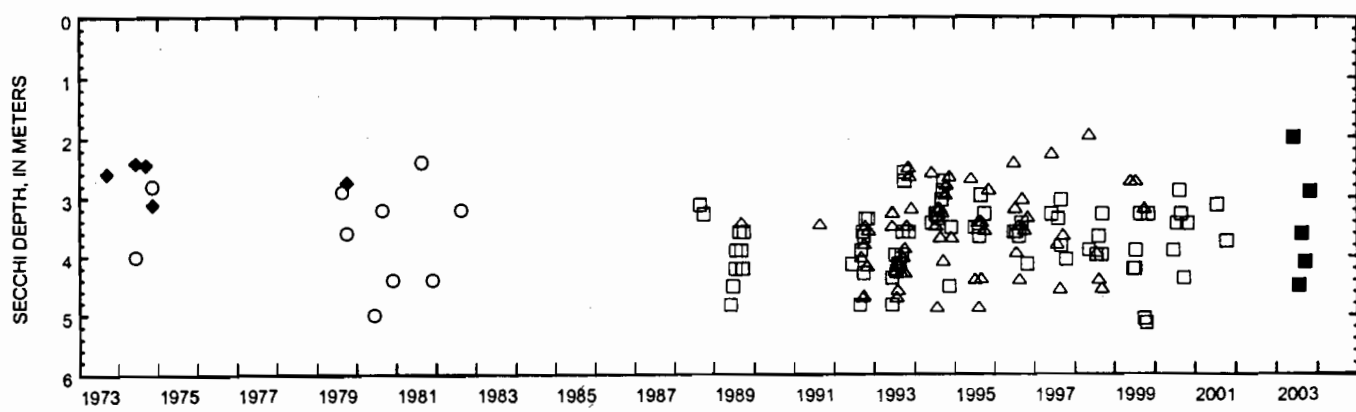
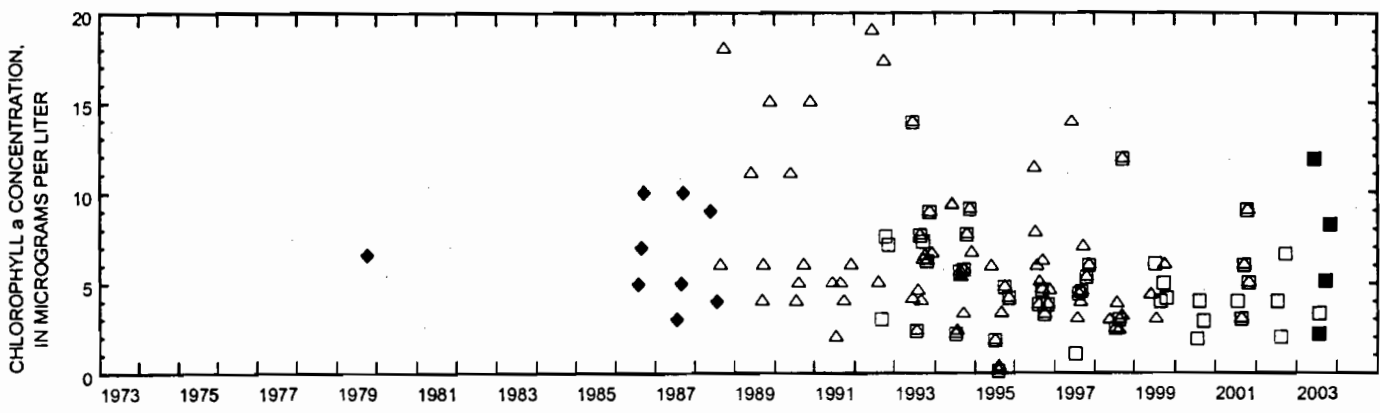
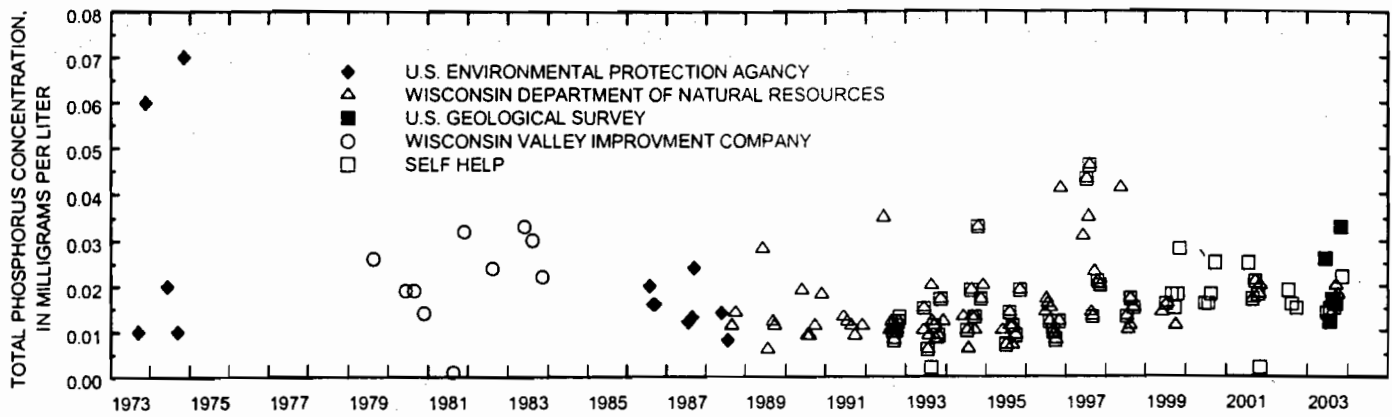
REMARKS.--Lake sampled at deep hole.

Water-quality analyses done by Wisconsin State Laboratory of Hygiene.

WATER-QUALITY DATA, MAY 8 TO September 24, 2003  
(Milligrams per liter unless otherwise indicated)

	May-8		Jun-18		Jul-15		Aug-12		Sep-24		
	1584.16		1584.56		1584.54		1584.55		1584.38		
Lake stage (ft)	2.0		4.5		3.6		4.1		2.9		
Secchi-depth (m)	2.0		4.5		3.6		4.1		2.9		
Depth of sample (m)	0.5	16	0.5	16	0.5	15	0.5	15	0.5	9.5	19
Chlorophyll a, phytoplankton (µg/L)	11.8	--	2.18	--	--	--	5.14	--	8.21	--	--
Water temperature (°C)	9.7	6.4	21.9	8.1	21.2	8.2	23.1	8.4	16.6	14.7	8.1
Specific conductance (µS/cm)	111	116	112	131	114	152	118	155	116	116	173
pH	7.1	6.7	7.6	6.5	8.1	6.9	7.7	6.4	7.7	7.2	7.1
Dissolved oxygen (mg/L)	11.9	5.7	9.6	0.2	8.3	0.1	8.4	0.1	8.5	2.9	0.4
Phosphorus, total (as P)	0.026	0.02	0.012	0.079	0.017	0.237	0.016	0.273	0.033	0.019	0.027
Phosphorus, ortho, dissolved (as P)	0.003	--	--	--	--	--	--	--	--	--	--
Nitrogen, NO <sub>2</sub> + NO <sub>3</sub> , diss. (as N)	<.022	--	--	--	--	--	--	--	--	--	--
Nitrogen, ammonia, dissolved (as N)	<.013	--	--	--	--	--	--	--	--	--	--
Nitrogen, amm. + org., total (as N)	0.37	--	--	--	--	--	--	--	--	--	--
Nitrogen, total (as N)	0.381	--	--	--	--	--	--	--	--	--	--
Color (Pt-Co. scale)	10	--	--	--	--	--	--	--	--	--	--
Turbidity (NTU)	2.9	--	--	--	--	--	--	--	--	--	--
Hardness, as CaCO <sub>3</sub>	48	--	--	--	--	--	--	--	--	--	--
Calcium, dissolved (Ca)	13.1	--	--	--	--	--	--	--	--	--	--
Magnesium, dissolved (Mg)	3.7	--	--	--	--	--	--	--	--	--	--
Sodium, dissolved (Na)	3.6	--	--	--	--	--	--	--	--	--	--
Potassium, dissolved (K)	<1.00	--	--	--	--	--	--	--	--	--	--
Alkalinity, as CaCO <sub>3</sub>	45	--	--	--	--	--	--	--	--	--	--
Sulfate, dissolved (SO <sub>4</sub> )	<4.5	--	--	--	--	--	--	--	--	--	--
Chloride, dissolved (Cl)	6.1	--	--	--	--	--	--	--	--	--	--
Silica, dissolved (SiO <sub>2</sub> )	10.3	--	--	--	--	--	--	--	--	--	--
Solids, dissolved, at 180°C	74	--	--	--	--	--	--	--	--	--	--
Iron, dissolved (Fe) (µg/L)	<100	--	--	--	--	--	--	--	--	--	--





Surface total phosphorus, chlorophyll a concentrations, Secchi depths,  
 and TSI data for Minocqua Lake, Deep Hole, at Minocqua, Wisconsin.

455232089424100 MINOCQUA LAKE, NORTH BAY, AT MINOCQUA, WI

LOCATION.--Lat 45°52'32", long 89°42'41", in NE 1/4 NW 1/4 NW 1/4 sec.14, T.39 N., R.6 E., Oneida County Hydrologic Unit 07070001, at Minocqua.

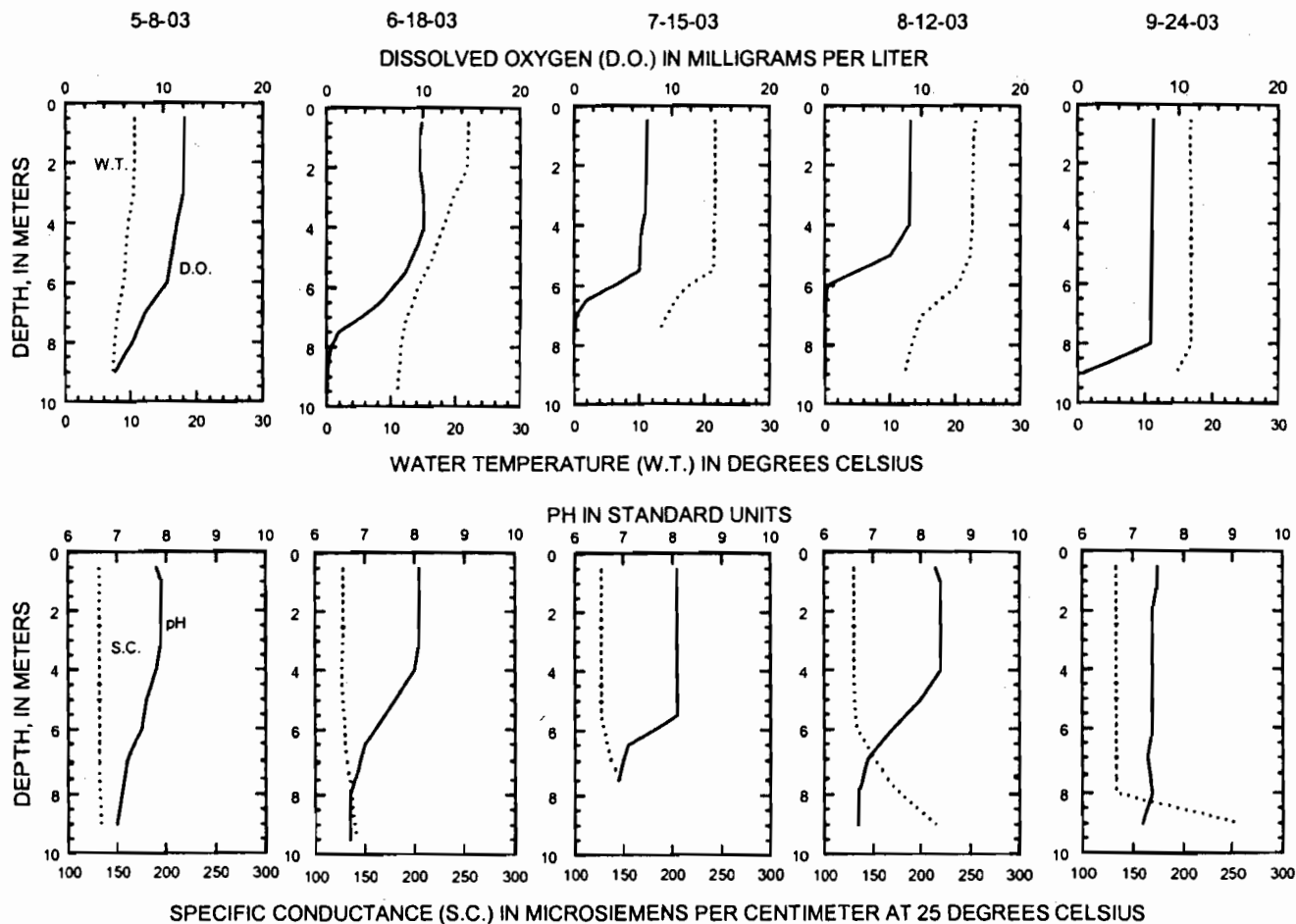
PERIOD OF RECORD.--May to September 2003.

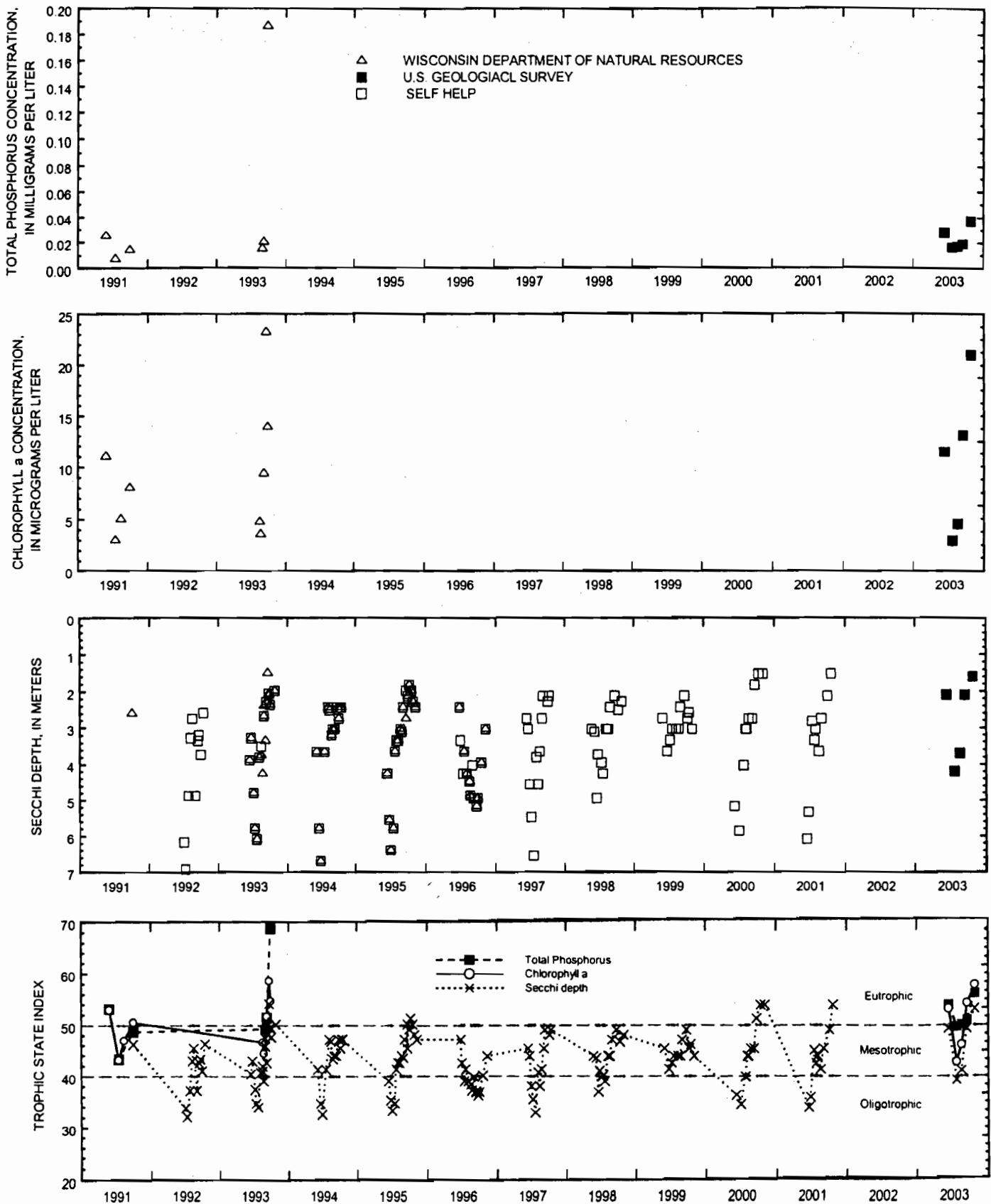
REMARKS.--Lake sampled at North Bay.

Water-quality analyses done by Wisconsin State Laboratory of Hygiene.

WATER-QUALITY DATA, MAY 8 TO September 24, 2003  
(Milligrams per liter unless otherwise indicated)

	May-8		Jun-18		Jul-15		Aug-12		Sep-24	
	1584.16		1584.56		1584.54		1584.55		1584.38	
Lake stage (ft)	2.1		4.2		3.7		2.1		1.6	
Secchi-depth (m)	9		9.5		7.5		9		9	
Depth of sample (m)	0.5		0.5		0.5		0.5		0.5	
Chlorophyll a, phytoplankton (µg/L)	11.4	--	2.89	--	4.5	--	13.1	--	21	--
Water temperature (°C)	10.6	7.3	22	11.1	21.6	13.1	23.2	12.3	16.7	14.6
Specific conductance (µS/cm)	132	134	128	142	128	147	131	216	133	257
pH	7.8	7	8.1	6.7	8.1	6.9	8.3	6.7	7.5	7.2
Dissolved oxygen (mg/L)	12.1	5.1	9.9	0.1	7.5	0.1	8.9	0.1	7.6	0.5
Phosphorus, total (as P)	0.028	0.03	0.016	0.108	0.017	0.043	0.019	0.208	0.037	0.349





Surface total phosphorus, chlorophyll a concentrations, Secchi depths, and TSI data for Minocqua Lake, North Bay, at Minocqua, Wisconsin.



455206089425200 MINOCQUA LAKE, SOUTH BAY, AT MINOCQUA, WI

LOCATION.--Lat 45°52'06", long 89°42'52", in NW 1/4 NW 1/4 SW 1/4 sec.14, T.39 N., R.6 E., Oneida County, Hydrologic Unit 07070001, at Minocqua.

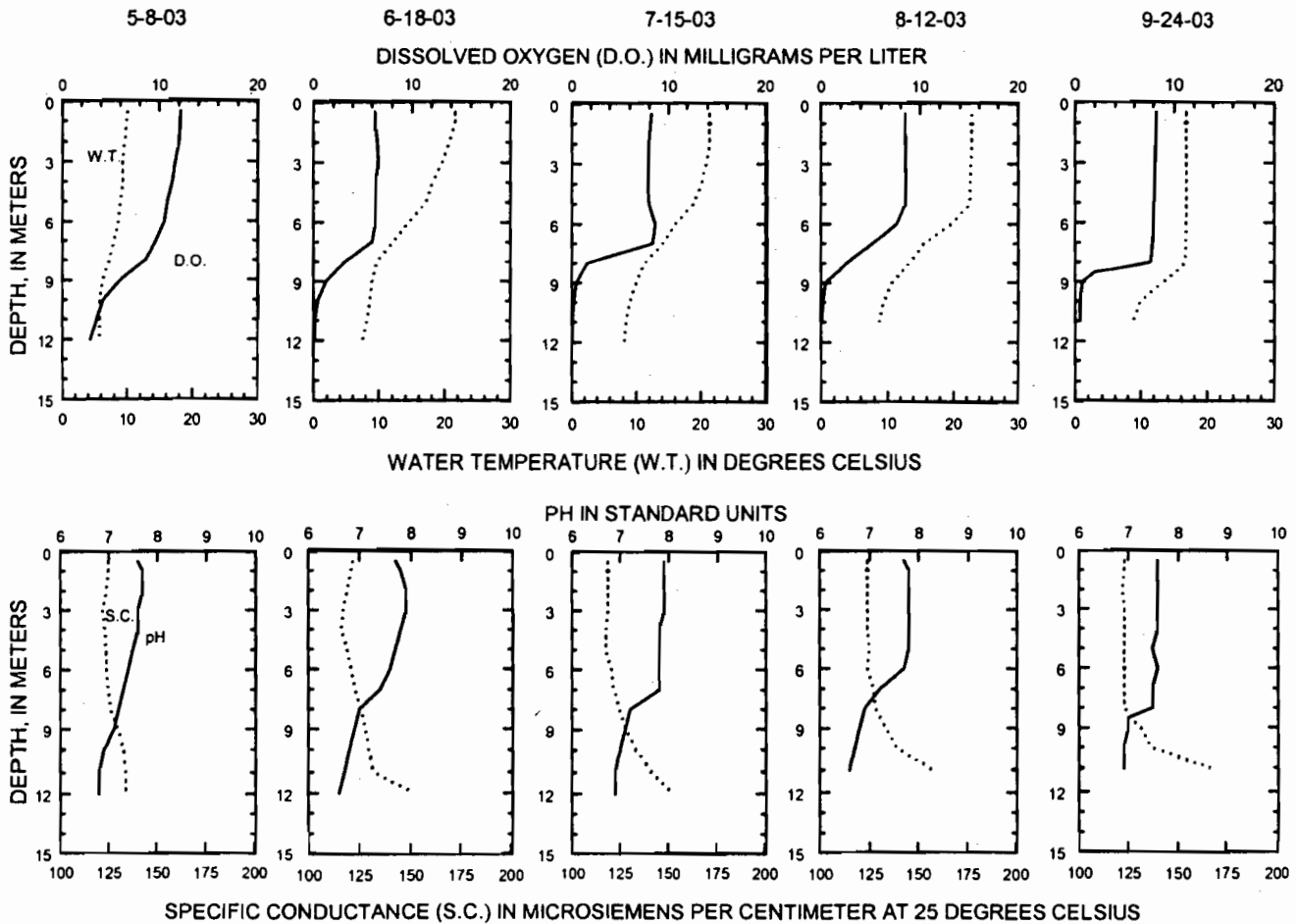
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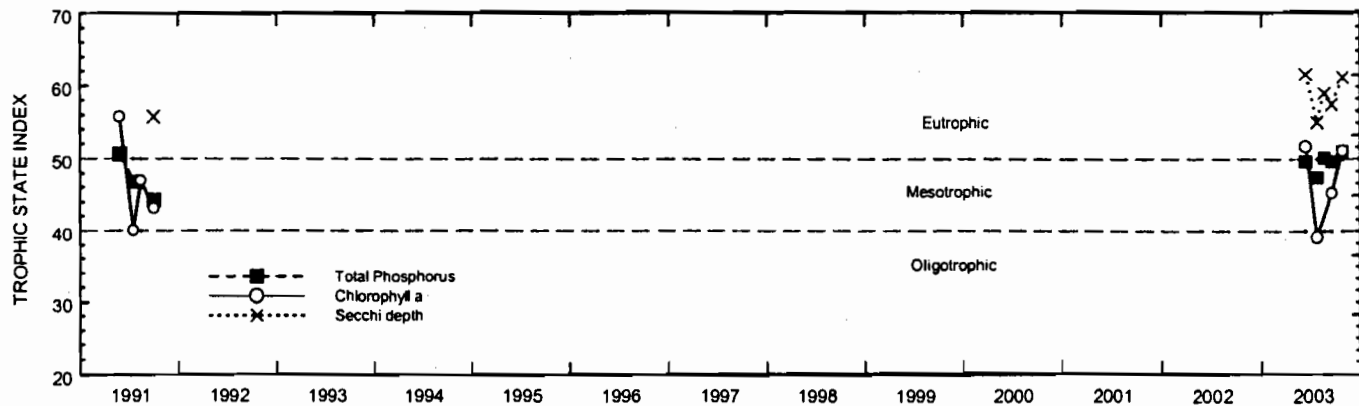
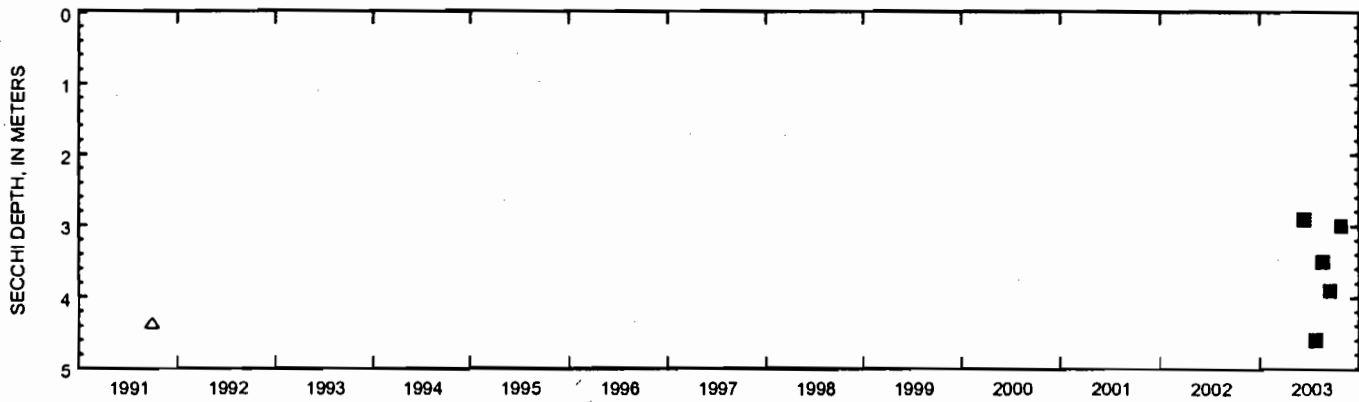
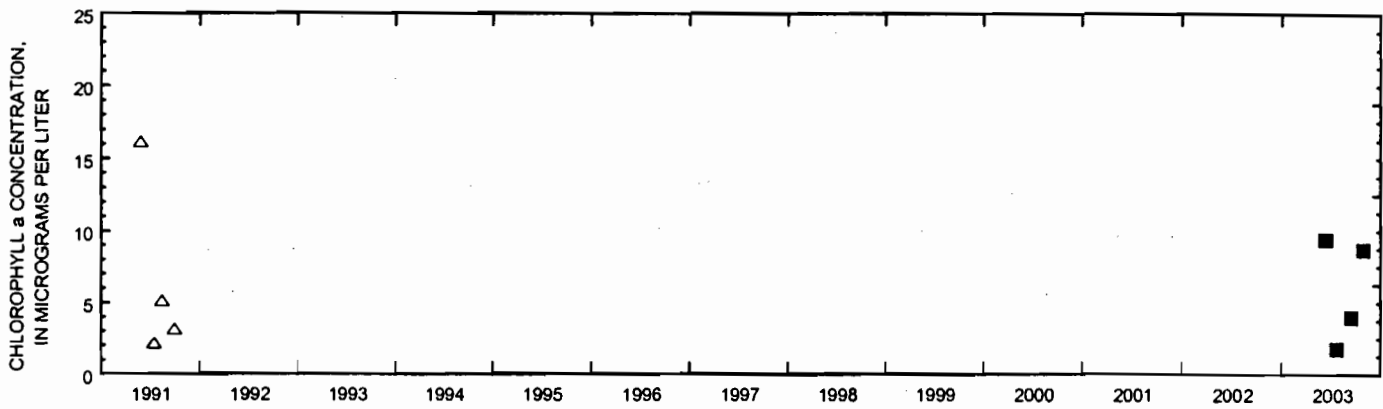
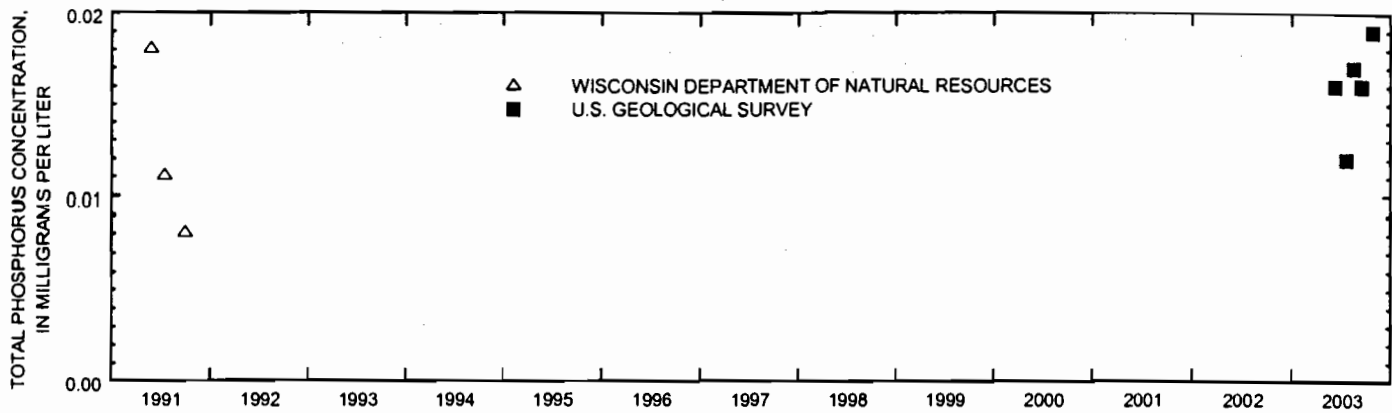
REMARKS.--Lake sampled at South Bay.

Water-quality analyses done by Wisconsin State Laboratory of Hygiene.

WATER-QUALITY DATA, MAY 8 TO September 24, 2003  
(Milligrams per liter unless otherwise indicated)

	May-8		Jun-18		Jul-15		Aug-12		Sep-24	
	1584.16		1584.56		1584.54		1584.55		1584.38	
Lake stage (ft)	2.9		4.6		3.5		3.9		3.0	
Secchi-depth (m)	12		12		12		11		11	
Depth of sample (m)	9.39		1.78		--		4		8.68	
Chlorophyll a, phytoplankton (µg/L)	10.1		21.6		8.2		22.9		16.8	
Water temperature (°C)	5.7		7.5		8.2		8.7		15.2	
Specific conductance (µS/cm)	125		122		153		124		123	
pH	7.6		7.7		6.9		7.7		7.6	
Dissolved oxygen (mg/L)	12.1		9.4		0.1		8.5		8.3	
Phosphorus, total (as P)	0.016		0.012		0.017		0.016		0.019	





Surface total phosphorus, chlorophyll a concentrations, Secchi depths,  
 and TSI data for Minocqua Lake, South Bay, at Minocqua, Wisconsin.

455208089435800 KAWAGUESAGA LAKE, DEEP HOLE, NEAR MIINOCQUA, WI

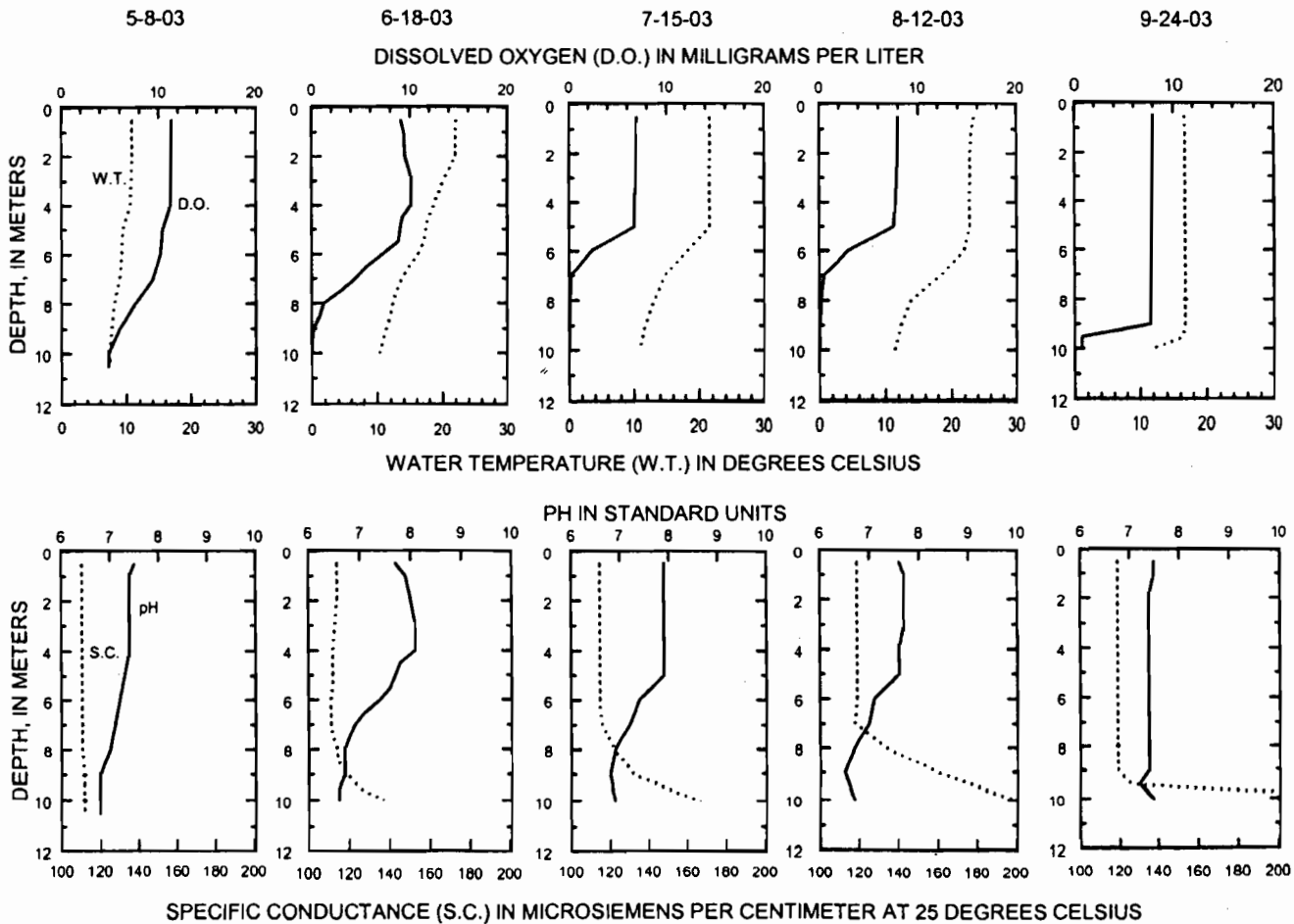
LOCATION.--Lat 45°52'08", long 89°43'58", in NE 1/4 NW 1/4 SW 1/4 sec.15, T.39 N., R.6 E., Oneida County, Hydrologic Unit 07070001, near Minocqua.

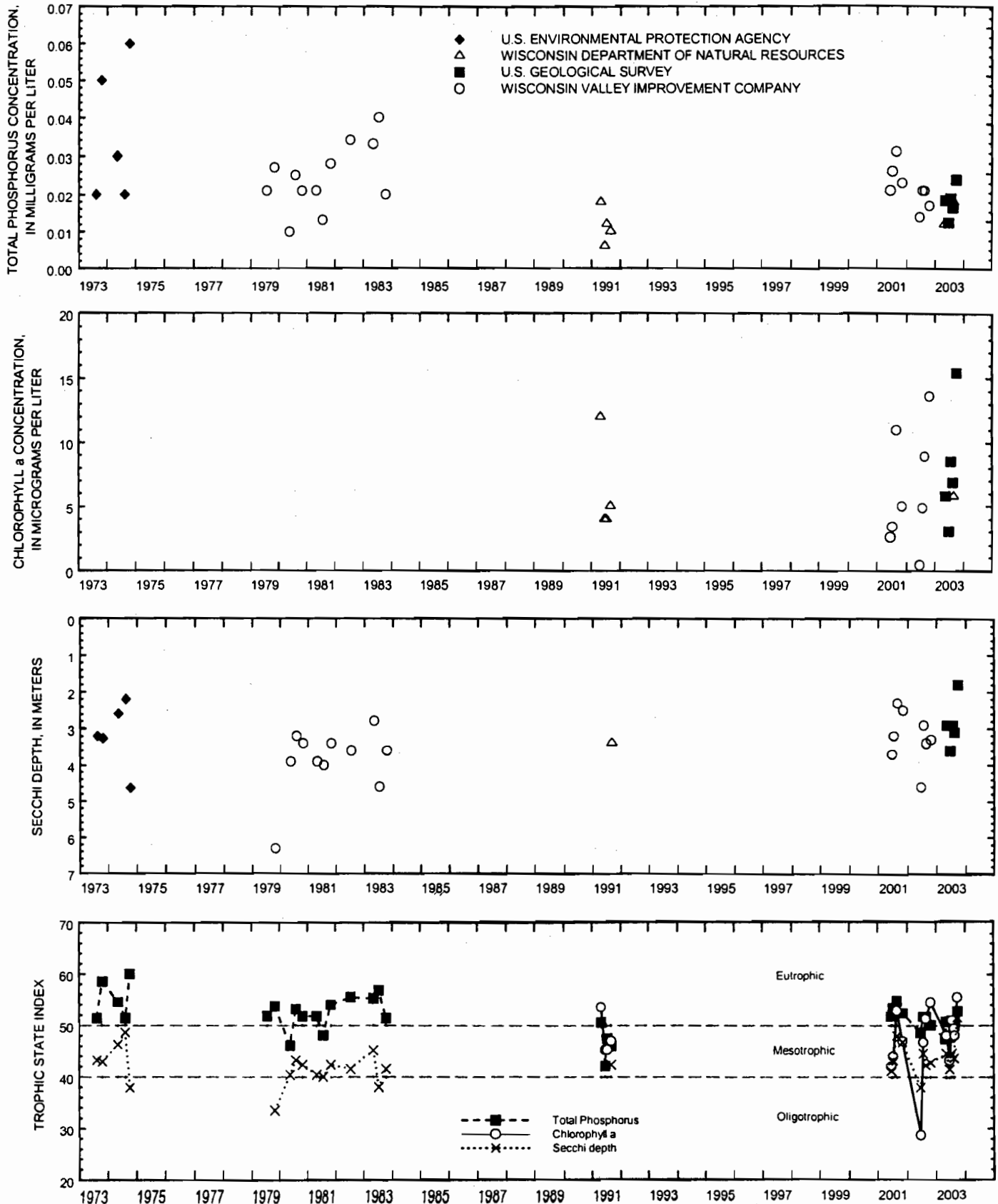
PERIOD OF RECORD.--May to September 2003.

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

WATER-QUALITY DATA, MAY 8 TO September 24, 2003  
(Milligrams per liter unless otherwise indicated)

	May-8		Jun-18		Jul-15		Aug-12		Sep-24	
	1584.16		1584.56		1584.54		1584.55		1584.38	
	2.9		3.6		2.9		3.1		1.8	
Lake stage (ft)										
Secchi-depth (m)	2.9		3.6		2.9		3.1		1.8	
Depth of sample (m)	0.5	10.5	0.5	10	0.5	10	0.5	10	0.5	10
Chlorophyll a, phytoplankton (µg/L)	6.25	--	3.21	--	7.24	--	6.6	--	16.8	--
Water temperature (°C)	10.9	7.4	22.1	10.3	21.7	10.9	23.5	11.4	16.7	11.8
Specific conductance (µS/cm)	111	112	114	137	115	167	119	200	119	249
pH	7.5	6.8	7.7	6.6	7.9	6.9	7.6	6.7	7.5	7.5
Dissolved oxygen (mg/L)	11.3	4.8	9.4	0.1	7	0	7.9	0.1	8	0.7
Phosphorus, total (as P)	0.021	0.033	0.014	0.066	0.018	0.098	0.016	0.131	0.02	0.106
Phosphorus, ortho, dissolved (as P)	0.003	--	--	--	--	--	--	--	--	--
Nitrogen, NO <sup>2</sup> + NO <sup>3</sup> diss. (as N)	<.022	--	--	--	--	--	--	--	--	--
Nitrogen, ammonia, dissolved (as N)	<.013	--	--	--	--	--	--	--	--	--
Nitrogen, amm. + org., total (as N)	0.27	--	--	--	--	--	--	--	--	--
Nitrogen, total (as N)	0.281	--	--	--	--	--	--	--	--	--
Color (Pt-Co. scale)	5	--	--	--	--	--	--	--	--	--
Turbidity (NTU)	1.9	--	--	--	--	--	--	--	--	--
Hardness, as CaCO <sub>3</sub>	47	--	--	--	--	--	--	--	--	--
Calcium, dissolved (Ca)	13	--	--	--	--	--	--	--	--	--
Magnesium, dissolved (Mg)	3.6	--	--	--	--	--	--	--	--	--
Sodium, dissolved (Na)	3.6	--	--	--	--	--	--	--	--	--
Potassium, dissolved (K)	<1.00	--	--	--	--	--	--	--	--	--
Alkalinity, as CaCO <sub>3</sub>	44	--	--	--	--	--	--	--	--	--
Sulfate, dissolved (SO <sub>4</sub> )	<4.5	--	--	--	--	--	--	--	--	--
Chloride, dissolved (Cl)	6.2	--	--	--	--	--	--	--	--	--
Silica, dissolved (SiO <sub>2</sub> )	9.33	--	--	--	--	--	--	--	--	--
Solids, dissolved, at 180°C	74	--	--	--	--	--	--	--	--	--
Iron, dissolved (Fe) (µg/L)	<100	--	--	--	--	--	--	--	--	--
Manganese, dissolved, (Mn) (µg/L)	40	--	--	--	--	--	--	--	--	--





Surface total phosphorus, chlorophyll a concentrations, Secchi depths, and TSI data for Kawagesaga Lake, Deep Hole, near Minocqua, Wisconsin.

455145089442600 KAWAGUESAGA LAKE, SOUTH SITE, NEAR MINOCQUA, WI

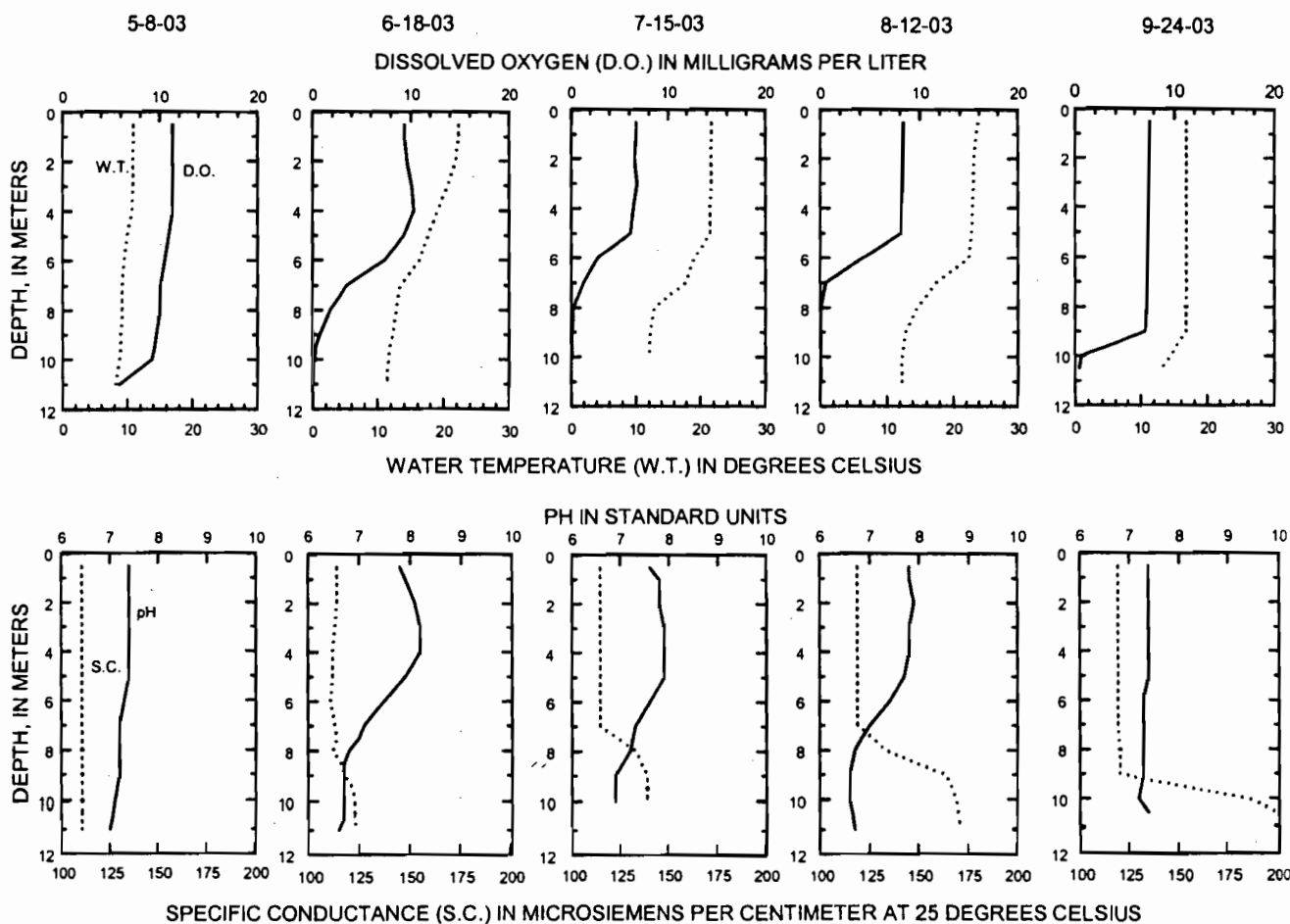
LOCATION.--Lat 45°51'45", long 89°44'26", in SW 1/4 SE 1/4 SE 1/4 sec.16, T.39 N., R.6 E., Oneida County, Hydrologic Unit 07070001, near Minocqua.

PERIOD OF RECORD.--May to September 2003.

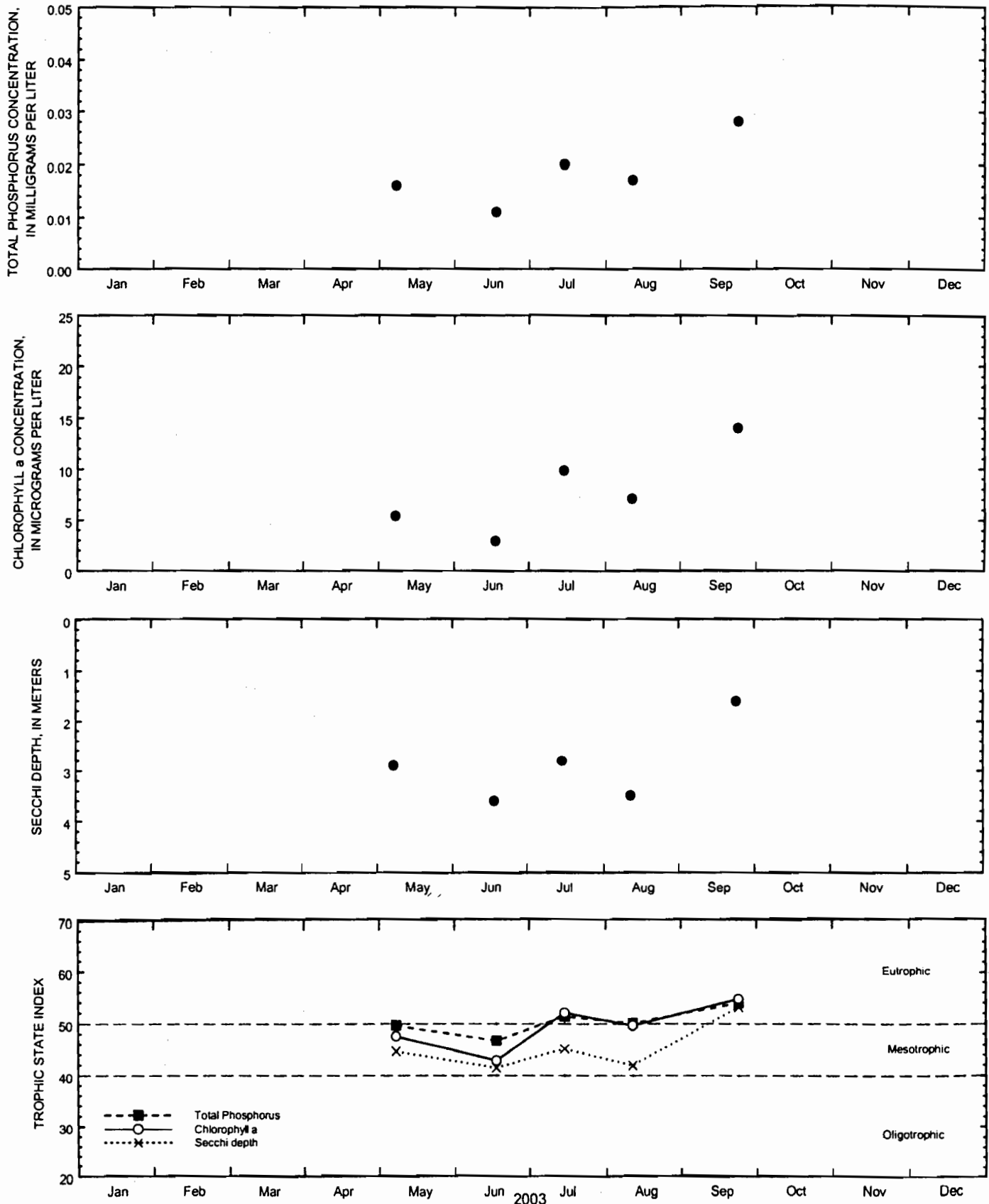
REMARKS.--Lake sampled at South Site. Water-quality analyses done by Wisconsin State Laboratory of Hygiene.

WATER-QUALITY DATA, MAY 8 TO September 24, 2003  
(Milligrams per liter unless otherwise indicated)

	May-8		Jun-18		Jul-15		Aug-12		Sep-24	
Lake stage (ft)	1584.16		1584.56		1584.54		1584.55		1584.38	
Secchi-depth (m)	2.9		3.6		2.8		3.5		1.6	
Depth of sample (m)	0.5	11	0.5	11	0.5	10	0.5	11	0.5	10.5
Chlorophyll a, phytoplankton (µg/L)	5.39	--	2.9	--	9.85	--	7.14	--	14	--
Water temperature (°C)	0.5	8.2	22.3	11.5	21.7	12	23.9	12.3	16.8	13.1
Specific conductance (µS/cm)	111	111	114	124	115	139	119	171	119	199
pH	7.4	7	7.8	6.6	7.6	6.9	7.8	6.7	7.4	7.4
Dissolved oxygen (mg/L)	11.3	5.8	9.4	0.1	6.7	0.1	8.4	0.1	7.6	0.4
Phosphorus, total (as P)	0.016	0.023	0.011	0.064	0.02	0.077	0.017	0.135	0.028	0.11



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



Surface total phosphorus, chlorophyll a concentrations, Secchi depths, and TSI data for Kawaguesaga Lake, South Site, near Minocqua, Wisconsin.

**Table 1. Schedule and parameters for main, deep hole, water-quality monitoring sites in Minocqua and Kawaguesaga Lakes**

Parameter	Approximate date of collection						Remarks
	Feb. or Mar.	Spring, soon after ice-out	Mid-June	Mid-July	Mid-Aug.	Mid-Sep.	
Water chemistry		X					Sample 0.5 meter below surface. <b>19 constituents:</b> NO <sub>2</sub> +NO <sub>3</sub> -N, NH <sub>4</sub> -N, NH <sub>4</sub> +organic-N, P (dissolved), Ca, Cl, Mg, Na, K, pH, total alkalinity, hardness, Fe, Mn, color, turbidity, dissolved solids, SO <sub>4</sub> , and SiO <sub>2</sub>
Dissolved oxygen, temperature, pH, and specific conductance		X	X	X	X	X	Vertical profiles are defined by measuring the four parameters from 0.5 meters below the lake surface to the lake bottom at 0.5-1.0 meter intervals (interval depends on lake depth).
Total phosphorus (Number of samples)		X (2)	X (2)	X (2)	X (3)	X (3)	0.5 meter from surface and 0.5 meter from bottom, except for mid-Aug., Sep. when an additional sample from just below the thermocline will be analyzed.
Chlorophyll a		X	X	X	X	X	0 - 0.5 meter from the surface
Secchi depth		X	X	X	X	X	Index of clarity
Mid-summer dissolved nitrogen and phosphorus species					X		0 - 0.5 meter from the surface. NO <sub>2</sub> +NO <sub>3</sub> -N (dissolved), NH <sub>4</sub> -N (dissolved), NH <sub>4</sub> +organic-N (filtered), and P (dissolved)

**Table 2. Schedule and parameters for auxiliary water-quality monitoring sites in Minocqua and Kawaguesaga Lake**

Parameter	Approximate date of collection						Remarks
	Feb. or Mar.	Spring, right after ice-out	Mid-June	Mid-July	Mid-Aug.	Mid-Sep.	
Dissolved oxygen, temperature, pH, and specific conductance		X	X	X	X	X	Vertical profiles are defined by measuring the four parameters from 0.5 meters below the lake surface to the lake bottom at 0.5-1.0 meter intervals (interval depends on lake depth).
Total phosphorus (Number of samples)		X (2)	X (2)	X (2)	X (3)	X (3)	0.5 meter from surface and 0.5 meter from bottom, except for mid-Aug., Sep. when an additional sample from just below the thermocline will be analyzed.
Chlorophyll a		X	X	X	X	X	0 - 0.5 meter from the surface
Secchi depth		X	X	X	X	X	Index of clarity