



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)

June 28, 1994

Ms. Mary Hele
3550 Edmund Boulevard
Minneapolis, Minnesota 55406

Dear Ms. Hele:

This letter describes the progress on the evaluation of the water quality of Red Cedar Lake according to the data collected from October 1992 to September 1993 as stated in our agreement. Please read the enclosure, "U.S. Geological Survey Lake Monitoring Program in Wisconsin", before proceeding with this letter.

In a brief summary, based on the 1993 data:

- The water quality of Red Cedar Lake ranges from poor to good and can be classified as a meso-eutrophic lake or one with moderate to many nutrients.
- Algal growth appears to be dependent upon the amount of available phosphorus rather than nitrogen.
- In June, July, and August, during summer stratification, oxygen disappears from the bottom portion of the lake at the deep hole site which is then unable to support a fish population.
- During the summer anoxic (devoid of oxygen) period, there are moderate amounts of phosphorus being released from the bottom sediments at the deep hole site.
- The data enclosed herein are provisional until published.

Red Cedar Lake has a surface area of 1,841 acres (2.88 square miles) and a drainage area at the outlet of 151 square miles for a drainage area/lake size ratio of 52:1. Lakes with drainage area/lake size ratios of greater than 10:1 tend to develop water-quality problems. (Uttomark, Paul D., and Mark L. Hutchins, 1978, Input/output models as decision criteria for lake restoration. University of Wisconsin-Madison, Wisconsin, Water Resources Center technical report No. 78-03, 61 pp.).

Two sites were sampled in Red Cedar Lake. One was located approximately at the deepest spot in the lake at a depth of about 48 feet and the other was located at the south end of the lake at an approximate depth of 27 feet. Both sites are shown in figure 1.

The data for this report are found in the following tables and figures:

Table 1. Lake stages for Red Cedar Lake, 1993 water year

Table 2a. Lake-depth profiles for Red Cedar Lake (deep hole) near Mikana, Wisconsin, 1993 water year

Table 2b. Lake-depth profiles for Red Cedar Lake (south end) at Mikana, Wisconsin, 1993 water year

Table 3a. Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Red Cedar Lake (deep hole), 1993 water year

Table 3b. Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Red Cedar Lake (south end), 1993 water year

Figure 1. Location of water-quality sampling sites and lake staff gage for Balsam, Red Cedar, and Hemlock Lakes

Figure 2a. Lake water-quality data for Red Cedar Lake (deep hole) near Mikana, Wisconsin, 1993 water year

Figure 2b. Lake water-quality data for Red Cedar Lake (south end) at Mikana, Wisconsin, 1993 water year

Figure 3a. Trophic state indices for Red Cedar Lake (deep hole) near Mikana, Wisconsin

Figure 3b. Trophic state indices for Red Cedar Lake (south end) at Mikana, Wisconsin

All the water-quality samples collected were analyzed by the Wisconsin State Laboratory of Hygiene at Madison, Wisconsin. The water-quality data are published in our annual publication, "Water Resources Data for Wisconsin, 1993".

LAKE-STAGE FLUCTUATIONS

Lake stages were read at the dam of Red Cedar Lake by Robert Quillen. Lake-stage data are listed in table 1. Lake stages fluctuated 1.21 feet and ranged from 9.69 feet on March 8 to 10.9 feet on June 11, 25, and 28.

LAKE-DEPTH PROFILES

Profiles of water temperature, dissolved oxygen, pH, and specific conductance at the deep hole and south end are listed in tables 2a and 2b and shown in figures 2a and 2b. No abnormalities in the data are apparent. Complete water-column mixing was not observed on any sampling dates. The lake thermally stratifies during summer. During July and August, the bottom 19 feet of water at the deep hole site became anoxic (devoid of oxygen) and were unable to support fish. During June, the bottom 7.5 feet of water became anoxic. The water at the bottom of the

lake at the south site was oxygenated on all sampling dates. The levels of pH are within acceptable limits to support aquatic life. Because of the buffering capacity of the lake water, Red Cedar Lake is not susceptible to the effects of acid rain.

SELECTED ANALYSES

Analyses of selected constituents for May 11 for samples collected at 1.5 and 27-foot depths for the south site are listed in figure 2b. The water-quality values for color, chlorophyll a, chlorides, 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.

To compute the nitrogen-phosphorus ratio, only the sample collected for May from the 1.5-foot sampling depth at the south site was used. This depth was used because algae grow in the upper part of the lake rather than at the bottom. The ratio of total nitrogen to phosphorus was calculated as approximately 25:1 and suggests the lake is phosphorus-limited. This means algal growth appears to be dependent on the amount of available phosphorus rather than nitrogen.

MAY, JUNE, JULY AND AUGUST WATER QUALITY

The data for total phosphorus, chlorophyll a, and Secchi-depth readings, are listed in tables 3a and 3b and on figures 2a and 2b.

Red Cedar Lake (deep hole)

Total phosphorus: Total phosphorus concentrations sampled at a 1.5-foot depth range from 0.014 mg/L in June to 0.020 mg/L in May and July. All values fall within the regional values previously referenced.

Concentration of total phosphorus 1.5 feet above the lake bottom ranged from 0.150 mg/L in June and July to 0.370 mg/L in August. These concentrations are indicative of moderate phosphorus release from the bottom sediments during anoxic (absence of oxygen) periods.

Chlorophyll a: Chlorophyll a concentrations, which indicate algal biomass, ranged from 8.03 µg/L in June to 28.1 µg/L in July. These data are within the regional values.

Secchi disc: Secchi-disc depths, which indicate water clarity, ranged from 4.9 feet in July and August to 6.9 feet in June. These data are within the regional values.

Red Cedar Lake (south site)

Total phosphorus: Total phosphorus concentrations sampled at a 1.5-foot depth range from 0.017 mg/L in June to 0.020 mg/L in July and August. All values fall within the regional values previously referenced.

Concentration of total phosphorus 1.5 feet above the lake bottom ranged from <0.020 mg/L in July to 0.095 mg/L in June.

Chlorophyll a: Chlorophyll a concentrations, which indicate algal biomass, ranged from 7.12 µg/L in June to 25.2 µg/L in July. These data are within the regional values.

Secchi disc: Secchi-disc depths, which indicate water clarity, ranged from 3.9 feet in August to 8.9 feet in June. These data are within the regional values.

TROPHIC STATUS

Lillie and Mason (1983) classified Wisconsin lakes using a random data set (summer, July and August) according to total phosphorus and chlorophyll a concentrations, and Secchi-disc depth. This evaluation is shown below:

Water quality index	Approximate total phosphorus equivalent (mg/L)	Approximate chlorophyll <u>a</u> equivalent (µg/L)	Approximate water clarity equivalent (Secchi-disc depth in ft)
Excellent	<0.001	<1	<19.7
Very good	.001-.010	1-5	9.8-19.7
Good	.010-.030	5-10	6.6-9.8
Fair	.030-.050	10-15	4.9-6.6
Poor	.050-.150	15-30	3.3-4.9
Very poor	>.150	>30	<3.3

Using the above criteria to evaluate the mean summer (July-August) 1993 data shown in tables 3a and 3b for Red Cedar Lake, surface total phosphorus concentrations indicate good water quality, while chlorophyll a concentrations and Secchi-disc depths indicate poor water quality.

Using the data from "Limnological Characteristics of Wisconsin Lakes," 1983, by Lillie and Mason, a comparison of the 1993 mean summer data (July and August) for total phosphorus, chlorophyll a, and Secchi depths for Red Cedar Lake to other lakes in northwest Wisconsin are shown below:

	<u>Parameter</u>	<u>Percentage of distribution of lakes in northwest Wisconsin within these concentrations</u>
	Total phosphorus (mg/L)	
	<.010	Best condition 12
Red Cedar Lake values →	.010-.020	35
	.020-.030	23
	.030-.050	18
	.050-.100	8
	.100-.150	3
	>.150	Worst condition 1
		Chlorophyll <i>a</i> (µg/L)
	0- 5	Best condition 29
	5-10	36
	10-15	14
Red Cedar Lake values →	15-30	14
	>30	Worst condition 9
		Secchi depth (in feet)
	9.8	Best condition 22
	6.6- 9.8	29
Red Cedar Lake values →	3.3- 6.6	30
	<3.3	Worst condition 19

Comparing other lakes in northwest Wisconsin to the 1993 data for Red Cedar Lake, the above data show, during the period 1966 to 1979, 53 percent had higher total phosphorous concentrations, 9 percent had higher chlorophyll *a* concentrations, and 19 percent had less water clarity.

A second approach to assessing the "health" or trophic status of a lake is to use Carlson's Trophic State Index (TSI). Graphic illustrations of the Trophic State Index for Red Cedar Lake are shown on figures 3a and 3b. The data from 1993 show Red Cedar Lake to be meso-eutrophic or one with moderate to many nutrients.

The data that has been collected for Red Cedar Lake from 1993 is extremely important for understanding the lake's water quality and managing the lake. To continue with the monitoring will help to build a very valuable data base.

Table 3a.--Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Red Cedar Lake, Deep Hole, 1993 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)	T.S.I.		Conc. (mg/L)	Conc. (µg/L)	T.S.I.	Conc. (µg/L)	T.S.I.	
05/11/93	2.0	6.6	50	1.5	0.020	20	51	8.94	51	--
	-	-	-	--	--	--	-	-	-	--
06/28/93	2.1	6.9	49	1.5	0.014	14	49	8.03	51	--
	-	-	-	48	0.150	150	-	-	-	--
07/19/93	1.5	4.9	54	1.5	0.020	20	51	28.1	60	--
	-	-	-	50	0.150	20	-	-	-	--
08/11/93	1.5	4.9	54	1.5	0.016	16	50	18	57	--
	-	-	-	48	0.370	370	-	-	-	--

Table 3b.--Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Red Cedar Lake, South End, 1993 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)		Conc. (mg/L)	Conc. (µg/L)	Conc. (µg/L)	T.S.I.	
05/11/93	2.1	6.9	1.5	0.019	19	10.3	52	0.002
	-	-	27	0.031	31	-	-	0.002
06/28/93	2.7	8.9	1.5	0.017	17	7.12	50	--
	-	-	27	0.095	95	-	-	--
07/19/93	1.5	4.9	1.5	0.020	20	25.2	59	--
	-	-	27	<0.020	20	-	-	--
08/11/93	1.2	3.9	1.5	0.020	20	22.8	58	--
	-	-	29	0.030	30	-	-	--

CHIPPEWA RIVER BASIN

453725091345100 RED CEDAR LAKE, DEEP HOLE, NEAR MIKANA, WI

LOCATION.--Lat 45°37'25", long 91°34'51", in NW 1/4 NW 1/4 sec.11, T.36 N., R.10 W., Barron County, Hydrologic Unit 07050007, 2.4 mi northeast of Mikana.

PERIOD OF RECORD.--March to August 1993.

REMARKS.--Lake sampled in northern part of lake at deep hole. Lake ice-covered during March sampling. Water-quality analyses by Wisconsin State Laboratory of Hygiene.

WATER-QUALITY DATA, MARCH 08 TO AUGUST 11, 1993
(Milligrams per liter unless otherwise indicated)

	Mar. 08		May 11		June 28		July 19		Aug. 11	
Depth of sample (ft)	1.5	39	1.5	48	1.5	48	1.5	50	1.5	48
Lake stage (ft)	9.69		10.46		10.90		10.40		10.65	
Specific conductance (μS/cm)	169	201	139	137	132	162	118	177	127	190
pH (units)	8.3	7.5	7.6	7.6	7.7	7.4	8.8	7.7	8.8	7.7
Water temperature (°C)	0.5	5.0	13.5	7.5	19.5	12.0	23.0	12.5	24.5	13.0
Secchi-depth (meters)	---		2.0		2.1		1.5		1.5	
Dissolved oxygen	11.5	0.5	11.0	4.2	9.2	0.1	11.1	0.1	9.6	0.1
Phosphorus, total (as P)	---		0.020		0.014		0.020		0.016	
Chlorophyll a, phytoplankton (μg/L)	---		8.9		8.0		28		18	

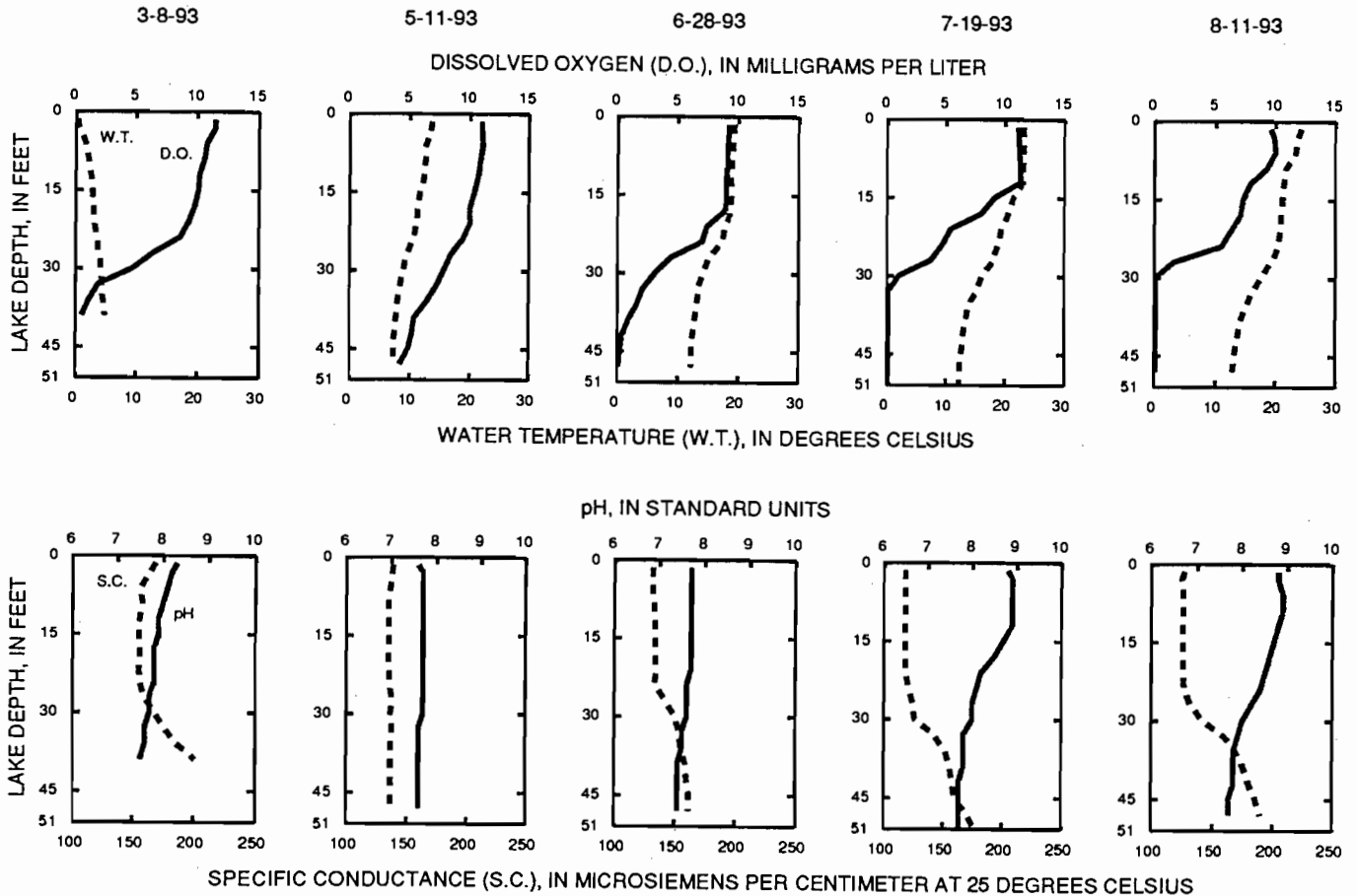


Figure 2a. Lake water-quality data for Red Cedar Lake (deep hole) near Mikana, Wisconsin, 1993 water year

CHIPPEWA RIVER BASIN

453519091352500 RED CEDAR LAKE, SOUTH END, AT MIKANA, WI--CONTINUED

WATER-QUALITY RECORDS

PERIOD OF RECORD.--March to August 1993.

REMARKS.--Lake sampled 0.2 mi northwest of Honeymoon Island. Lake ice-covered during March sampling. Water-quality analyses by Wisconsin State Laboratory of Hygiene.

WATER-QUALITY DATA, MARCH 08 TO AUGUST 11, 1993
(Milligrams per liter unless otherwise indicated)

	Mar. 08		May 11		June 28		July 19		Aug. 11	
Depth of sample (ft)	1.5	18	1.5	27	1.5	27	1.5	27	1.5	29
Lake stage (ft)	9.69		10.46		10.90		10.40		10.65	
Specific conductance (µS/cm)	134	150	134	132	130	130	115	119	125	133
pH (units)	8.2	7.7	7.6	7.6	7.3	7.5	8.8	8.0	8.5	8.0
Water temperature (°C)	0.0	3.5	12.5	11.0	18.5	18.5	23.0	18.5	23.0	19.0
Color (Pt-Co. scale)	---	---	10	10	---	---	---	---	---	---
Turbidity (NTU)	---	---	1.1	1.00	---	---	---	---	---	---
Secchi-depth (meters)	---	---	2.1		2.7		1.5		1.2	
Dissolved oxygen	6.5	9.2	10.5	7.1	9.0	8.9	11.0	3.5	9.6	1.5
Hardness, as CaCO ₃	---	---	66	66	---	---	---	---	---	---
Calcium, dissolved (Ca)	---	---	17	17	---	---	---	---	---	---
Magnesium, dissolved (Mg)	---	---	5.8	5.7	---	---	---	---	---	---
Sodium, dissolved (Na)	---	---	2.5	2.5	---	---	---	---	---	---
Potassium, dissolved (K)	---	---	0.8	0.9	---	---	---	---	---	---
Alkalinity, as CaCO ₃	---	---	66	65	---	---	---	---	---	---
Sulfate, dissolved (SO ₄)	---	---	5.0	5.0	---	---	---	---	---	---
Chloride, dissolved (Cl)	---	---	2.0	2.0	---	---	---	---	---	---
Fluoride, dissolved (F)	---	---	<0.0	0.1	---	---	---	---	---	---
Silica, dissolved (SiO ₂)	---	---	15	15	---	---	---	---	---	---
Solids, dissolved, at 180°C	---	---	96	96	---	---	---	---	---	---
Nitrogen, nitrate, total (as N)	---	---	0.08	0.09	---	---	---	---	---	---
Nitrogen, NO ₂ + NO ₃ , diss. (as N)	---	---	0.08	0.09	---	---	---	---	---	---
Nitrogen, ammonia, dissolved (as N)	---	---	0.01	0.02	---	---	---	---	---	---
Nitrogen, organic, total (as N)	---	---	0.39	0.29	---	---	---	---	---	---
Nitrogen, amm. + org., total (as N)	---	---	0.40	0.30	---	---	---	---	---	---
Nitrogen, total (as N)	---	---	0.48	0.39	---	---	---	---	---	---
Phosphorus, total (as P)	---	---	0.019	0.031	0.017	0.095	0.020	<0.020	0.020	0.030
Phosphorus, ortho, dissolved (as P)	---	---	0.002	0.002	---	---	---	---	---	---
Iron, dissolved (Fe) µg/L	---	---	<50	<50	---	---	---	---	---	---
Manganese, dissolved (Mn) µg/L	---	---	<40	<40	---	---	---	---	---	---
Chlorophyll a, phytoplankton (µg/L)	---	---	10	---	7.1	---	25	---	23	---

3-8-93

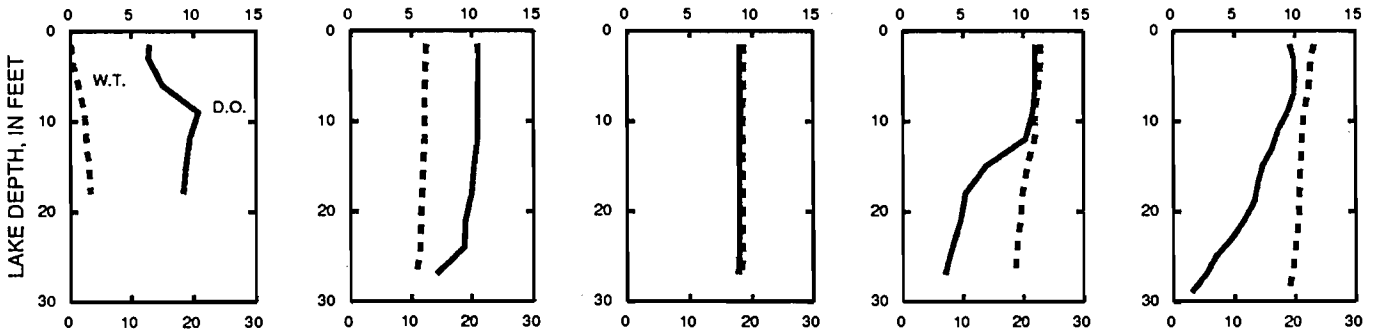
5-11-93

6-28-93

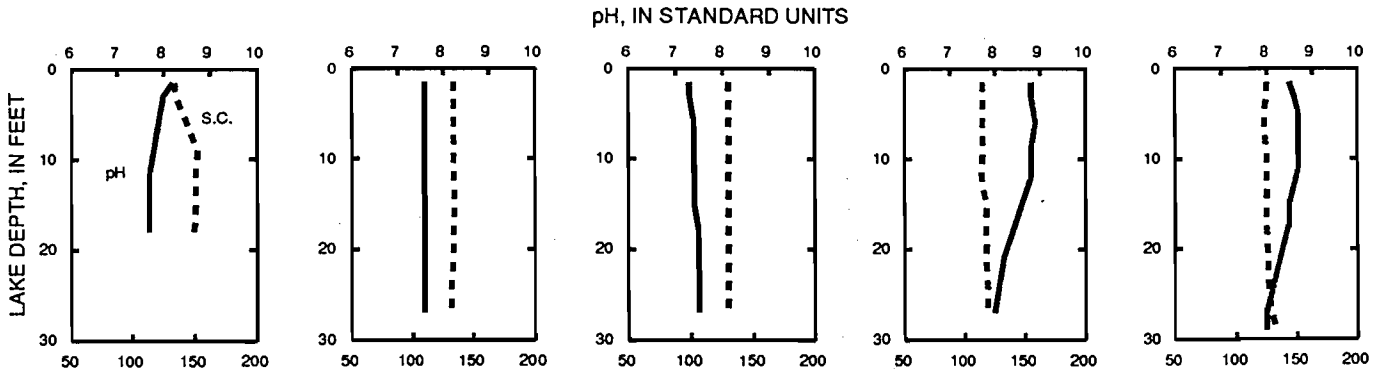
7-19-93

8-11-93

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



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



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

Figure 2b. Lake water-quality data for Red Cedar Lake (south end) at Mikana, Wisconsin, 1993 water year

TROPHIC STATE INDICES
 RED CEDAR LAKE (DEEP HOLE) NEAR MIKANA, WI.
 BARRON COUNTY

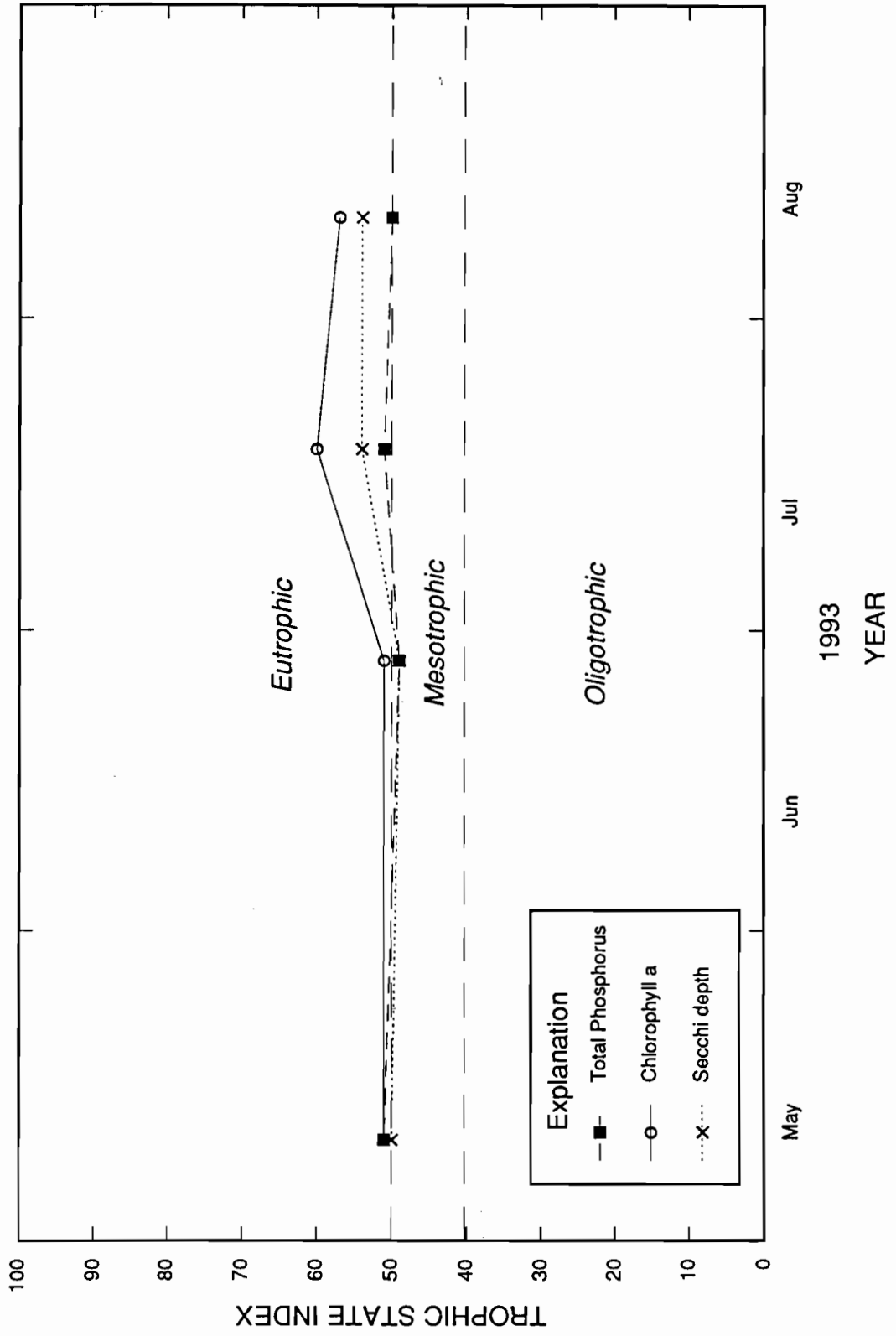


Figure 3a. Trophic state indices for Red Cedar Lake (deep hole) near Mikana, Wisconsin

TROPHIC STATE INDICES
 RED CEDAR LAKE (SOUTH END) AT MIKANA, WI.
 BARRON COUNTY

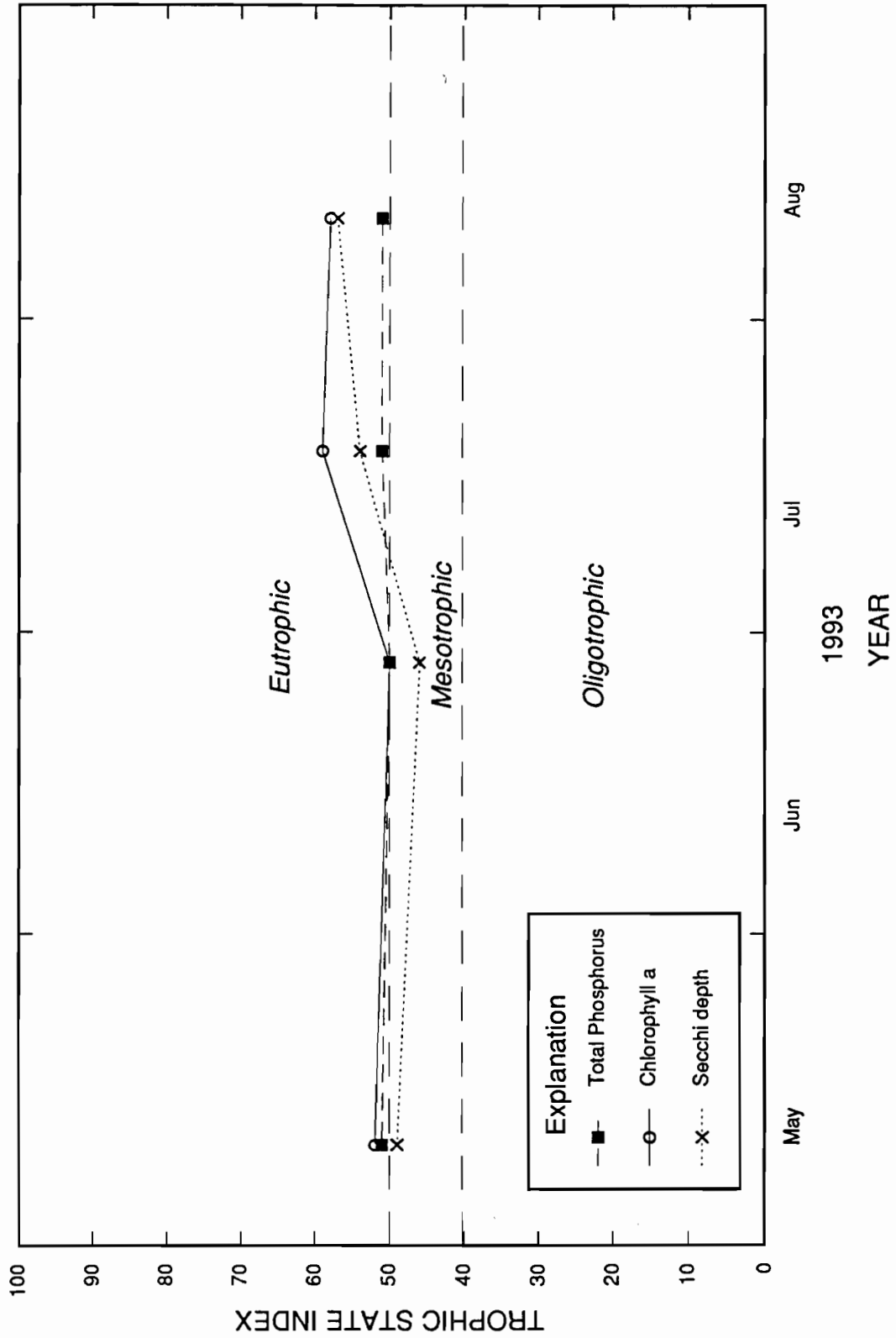


Figure 3b. Trophic state indices for Red Cedar Lake (south end) at Mikana, Wisconsin



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)

June 7, 1995

Ms. Mary Hele
3550 Edmund Boulevard
Minneapolis, Minnesota 55406

Dear Ms. Hele:

This letter describes the progress on the evaluation of the water quality of Red Cedar Lake according to the data collected from October 1993 to September 1994 as stated in our agreement. Please read the "U.S. Geological Survey Lake Monitoring Program in Wisconsin", sent to you previously, before proceeding with this letter.

In a brief summary, based on the 1994 data:

- The water quality of Red Cedar Lake ranges from fair to good and can be classified as a meso-eutrophic lake or one with moderate to many nutrients.
- Surface total-phosphorus and chlorophyll *a* concentrations and Secchi-disc depths in 1994 are similar to those monitored in 1993.
- Algal growth appears to be dependent upon the amount of available phosphorus rather than nitrogen.
- In June, July, and August, during summer stratification, oxygen disappears from the bottom portion of the lake at the deep hole site which is then unable to support a fish population.
- During the summer anoxic (devoid of oxygen) period, there are moderate amounts of phosphorus being released from the bottom sediments at the deep hole site.
- The data enclosed herein are provisional until published.

Red Cedar Lake has a surface area of 1,841 acres (2.88 square miles) and a drainage area at the outlet of 151 square miles for a drainage area/lake size ratio of 52:1. Lakes with drainage area/lake size ratios of greater than 10:1 tend to develop water-quality problems. (Uttormark, Paul D., and Mark L. Hutchins, 1978, Input/output models as decision criteria for lake restoration. University of Wisconsin-Madison, Wisconsin, Water Resources Center technical report No. 78-03, 61 pp.).

Two sites were sampled in Red Cedar Lake. One was located approximately at the deepest spot in the lake at a depth of about 47 feet and the other was located at the south end of the lake at an approximate depth of 28 feet. Both sites are shown in figure 1.

The data for this report are found in the following tables and figures:

Table 1a. Lake-depth profiles for Red Cedar Lake (deep hole) near Mikana, Wisconsin, 1994 water year

Table 1b. Lake-depth profiles for Red Cedar Lake (south end) at Mikana, Wisconsin, 1994 water year

Table 2a. Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Red Cedar Lake (deep hole), 1994 water year

Table 2b. Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Red Cedar Lake (south end), 1994 water year

Figure 1. Location of water-quality sampling sites and lake staff gage for Balsam, Red Cedar, and Hemlock Lakes

Figure 2a. Lake water-quality data for Red Cedar Lake (deep hole) near Mikana, Wisconsin, 1994 water year

Figure 2b. Lake water-quality data for Red Cedar Lake (south end) at Mikana, Wisconsin, 1994 water year

Figure 3a. Trophic state indices for Red Cedar Lake (deep hole) near Mikana, Wisconsin

Figure 3b. Trophic state indices for Red Cedar Lake (south end) at Mikana, Wisconsin

All the water-quality samples collected were analyzed by the Wisconsin State Laboratory of Hygiene at Madison, Wisconsin. The water-quality data are published in our annual publications, "Water Resources Data for Wisconsin, 1994" and "Water-Quality and Lake-Stage Data for Wisconsin Lakes, Water Year 1994".

LAKE-STAGE FLUCTUATIONS

Lake stages were read at the dam of Red Cedar Lake by USGS personnel at the time of sampling. Lake-stage data are listed in figures 2a and 2b. Lake stages fluctuated 0.32 feet and ranged from 10.40 feet on June 16 to 10.72 feet on March 9.

LAKE-DEPTH PROFILES

Profiles of water temperature, dissolved oxygen, pH, and specific conductance at the deep hole and south end are listed in tables 1a and 1b and shown in figures 2a and 2b. No abnormalities in the data are apparent. Among our sampling dates, complete water-column mixing was observed on May 4. The remainder of the profile data show incomplete mixing. The lake thermally stratifies during summer. During June, July and August, the water at the bottom of the lake at the deep hole site became anoxic (devoid of oxygen) and was unable to support fish. The water at the bottom of the lake at the south site was oxygenated on all sampling

dates. The levels of pH are within acceptable limits to support aquatic life. Because of the high buffering capacity of the lake water, Red Cedar Lake is not susceptible to the effects of acid rain.

SELECTED ANALYSES

Analyses of selected constituents for May 4 for samples collected at 1.5 and 45-foot depths are listed in figure 2a. The water-quality values for color, chlorophyll a, chlorides, 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.

To compute the nitrogen-phosphorus ratio, only the sample collected from the 1.5-foot sampling depth for May was used. This depth was used because algae grow in the upper part of the lake rather than at the bottom. The ratio of total nitrogen to phosphorus was calculated as approximately 21:1 for the deep hole site and 18:1 for the south site and suggests the lake is phosphorus-limited. This is consistent with previous data. This means algal growth appears to be dependent on the amount of available phosphorus rather than nitrogen.

MAY, JUNE, JULY AND AUGUST WATER QUALITY

The data for total phosphorus, chlorophyll a, and Secchi-depth readings, are listed in tables 2a and 2b and on figures 2a and 2b.

Red Cedar Lake (deep hole)

Total phosphorus: Total phosphorus concentrations sampled at a 1.5-foot depth range from 0.011 mg/L in June to 0.024 mg/L in May. All values fall within the regional values previously referenced.

Concentration of total phosphorus 1.5 feet above the lake bottom ranged from 0.026 mg/L in May to 0.77 mg/L in August. These concentrations are indicative of moderate phosphorus release from the bottom sediments during anoxic (absence of oxygen) periods.

Chlorophyll a: Chlorophyll a concentrations, which indicate algal biomass, ranged from 3.29 µg/L in June to 17.3 µg/L in August. These data are within the regional values.

Secchi disc: Secchi-disc depths, which indicate water clarity, ranged from 5.2 feet in August to 11.8 feet in June. These data are within the regional values.

Red Cedar Lake (south site)

Total phosphorus: Total phosphorus concentrations sampled at a 1.5-foot depth range from 0.011 mg/L in June to 0.024 mg/L in August. All values fall within the regional values previously referenced.

Concentration of total phosphorus 1.5 feet above the lake bottom ranged from 0.029 mg/L in June to 0.032 mg/L in August.

Chlorophyll a: Chlorophyll a concentrations, which indicate algal biomass, ranged from 3.4 µg/L in June to 22.7 µg/L in August. These data are within the regional values.

Secchi disc: Secchi-disc depths, which indicate water clarity, ranged from 4.9 feet in August to 11.8 feet in June. These data are within the regional values.

TROPHIC STATUS

Lillie and Mason (1983) classified Wisconsin lakes using a random data set (summer, July and August) according to total phosphorus and chlorophyll a concentrations, and Secchi-disc depth. This evaluation is shown below:

Water quality index	Approximate total phosphorus equivalent (mg/L)	Approximate chlorophyll a equivalent (µg/L)	Approximate water clarity equivalent (Secchi-disc depth in ft)
Excellent	<0.001	<1	<19.7
Very good	.001-.010	1-5	9.8-19.7
Good	.010-.030	5-10	6.6-9.8
Fair	.030-.050	10-15	4.9-6.6
Poor	.050-.150	15-30	3.3-4.9
Very poor	>.150	>30	<3.3

Using the above criteria to evaluate the mean summer (July-August) 1994 data shown in tables 2a and 2b for Red Cedar Lake, chlorophyll a concentrations and Secchi-disc depths indicate fair water quality, while surface total phosphorus concentrations indicate good water quality.

Using the data from "Limnological Characteristics of Wisconsin Lakes," 1983, by Lillie and Mason, a comparison of the 1994 mean summer data (July and August) for total phosphorus, chlorophyll a, and Secchi depths for Red Cedar Lake to other lakes in northwest Wisconsin are shown below:

	<u>Parameter</u>	<u>Percentage of distribution of lakes in northwest Wisconsin within these concentrations</u>
	Total phosphorus (mg/L)	
	<.010	Best condition 12
Red Cedar Lake values →	.010-.020	35
	.020-.030	23
	.030-.050	18
	.050-.100	8
	.100-.150	3
	.150-.200	Worst condition 1
	>.150	
	Chlorophyll <i>a</i> (µg/L)	
	0- 5	Best condition 29
Red Cedar Lake values →	5-10	36
	10-15	14
	15-30	14
	>30	Worst condition 9
	Secchi depth (in feet)	
	9.8	Best condition 22
Red Cedar Lake values →	6.6- 9.8	29
	3.3- 6.6	30
	<3.3	Worst condition 19

Comparing other lakes in northwest Wisconsin to the 1994 data for Red Cedar Lake, the above data show, during the period 1966 to 1979, 12 percent had lower total phosphorous concentrations, 65 percent had lower chlorophyll *a* concentrations, and 51 percent had more water clarity.

A second approach to assessing the "health" or trophic status of a lake is to use Carlson's Trophic State Index (TSI). Graphic illustrations of the Trophic State Index for Red Cedar Lake are shown on figures 3a and 3b. The data from 1994 show Red Cedar Lake to be meso-eutrophic or one with moderate to many nutrients.

Surface total-phosphorus and chlorophyll *a* concentrations and Secchi-disc depths for the period of record for Red Cedar Lake are shown in figures 4a and 4b. The 1994 water-quality data are similar to that monitored in 1993.

Table 2a.--Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Red Cedar Lake, Deep Hole,
1994 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.		
05/04/94	2.1	6.9	1.5	0.024	24	53	11.5	53	<0.002
	-	-	45	0.026	26	-	-	-	<0.002
06/16/94	3.6	11.8	1.5	0.011	11	47	3.29	44	--
	-	-	45	0.250	250	-	-	-	--
07/14/94	2.2	7.2	1.5	0.017	17	50	7.29	50	--
	-	-	48	0.350	350	-	-	-	--
08/18/94	1.6	5.2	1.5	0.019	19	51	17.3	56	--
	-	-	45	0.770	770	-	-	-	--

Table 2b.--Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Red Cedar Lake, South End, 1994 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.	
05/04/94	1.8	5.9	52	1.5	0.022	22	52	10.1	52	<0.002
	-	-	-	27	0.030	30	-	-	-	<0.002
06/16/94	3.6	11.8	42	1.5	0.011	11	47	3.4	44	--
	-	-	-	27	0.029	29	-	-	-	--
07/14/94	2.0	6.6	50	1.5	0.017	17	50	9.62	52	--
	-	-	-	27	0.030	30	-	-	-	--
08/18/94	1.5	4.9	54	1.5	0.024	24	53	22.7	58	--
	-	-	-	27	0.032	32	-	-	-	--

453725091345100 RED CEDAR LAKE, DEEP HOLE, NEAR MIKANA, WI

LOCATION.--Lat 45°37'25", long 91°34'51", in NW 1/4 NW 1/4 sec.11, T.36 N., R.10 W., Barron County, Hydrologic Unit 07050007, 2.4 mi northeast of Mikana.

PERIOD OF RECORD.--March 1993 to August 1994 (discontinued).

REMARKS.--Lake sampled in northern part of lake at deep hole. Lake ice-covered during March sampling. Water-quality analyses by Wisconsin State Laboratory of Hygiene.

WATER-QUALITY DATA, MARCH 09 TO AUGUST 18, 1994
(Milligrams per liter unless otherwise indicated)

	Mar. 09		May 04		June 16		July 14		Aug. 18	
Depth of sample (ft)	1.5	42	1.5	45	1.5	45	1.5	48	1.5	45
Lake stage (ft)	10.72		10.66		10.40		10.50		10.50	
Specific conductance (µS/cm)	140	186	136	134	140	163	127	168	128	190
pH (units)	8.4	7.5	8.1	7.8	7.6	7.4	8.0	7.5	8.4	7.5
Water temperature (°C)	1.5	4.5	8.5	8.5	21.5	11.5	22.0	12.0	23.0	12.0
Color (Pt-Co. scale)	---	---	20	15	---	---	---	---	---	---
Turbidity (NTU)	---	---	1.9	2.0	---	---	---	---	---	---
Secchi-depth (meters)	---	---	2.1	---	3.6	---	2.2	---	1.6	---
Dissolved oxygen	11.5	0.3	11.2	10.7	8.6	0.1	8.8	0.1	10.4	0.1
Hardness, as CaCO3	---	---	67	70	---	---	---	---	---	---
Calcium, dissolved (Ca)	---	---	17	18	---	---	---	---	---	---
Magnesium, dissolved (Mg)	---	---	6.0	6.0	---	---	---	---	---	---
Sodium, dissolved (Na)	---	---	3.0	3.0	---	---	---	---	---	---
Potassium, dissolved (K)	---	---	0.5	0.8	---	---	---	---	---	---
Alkalinity, as CaCO3	---	---	67	67	---	---	---	---	---	---
Sulfate, dissolved (SO4)	---	---	4.0	4.0	---	---	---	---	---	---
Chloride, dissolved (Cl)	---	---	2.0	2.1	---	---	---	---	---	---
Fluoride, dissolved (F)	---	---	0.0	0.0	---	---	---	---	---	---
Silica, dissolved (SiO2)	---	---	12	12	---	---	---	---	---	---
Solids, dissolved, at 180°C	---	---	90	90	---	---	---	---	---	---
Nitrogen, NO2 + NO3, diss. (as N)	---	---	0.01	0.06	---	---	---	---	---	---
Nitrogen, ammonia, dissolved (as N)	---	---	0.01	0.02	---	---	---	---	---	---
Nitrogen, amm. + org., total (as N)	---	---	0.50	0.50	---	---	---	---	---	---
Nitrogen, total (as N)	---	---	0.51	0.56	---	---	---	---	---	---
Phosphorus, total (as P)	---	---	0.024	0.026	0.011	0.250	0.017	0.350	0.019	0.770
Phosphorus, ortho, dissolved (as P)	---	---	<0.002	<0.002	---	---	---	---	---	---
Iron, dissolved (Fe) µg/L	---	---	<50	<50	---	---	---	---	---	---
Manganese, dissolved (Mn) µg/L	---	---	81	80	---	---	---	---	---	---
Chlorophyll a, phytoplankton(µg/L)	---	---	12	---	3.3	---	7.3	---	17	---

3-9-94

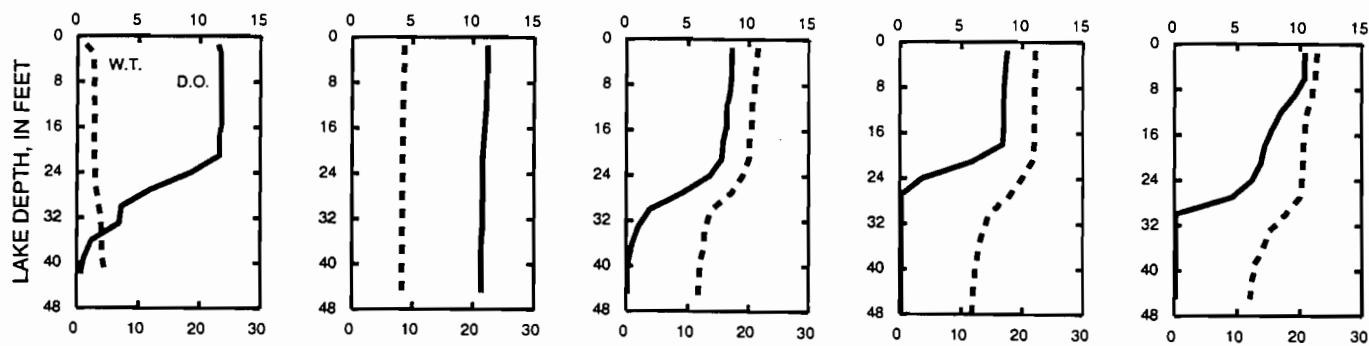
5-4-94

6-16-94

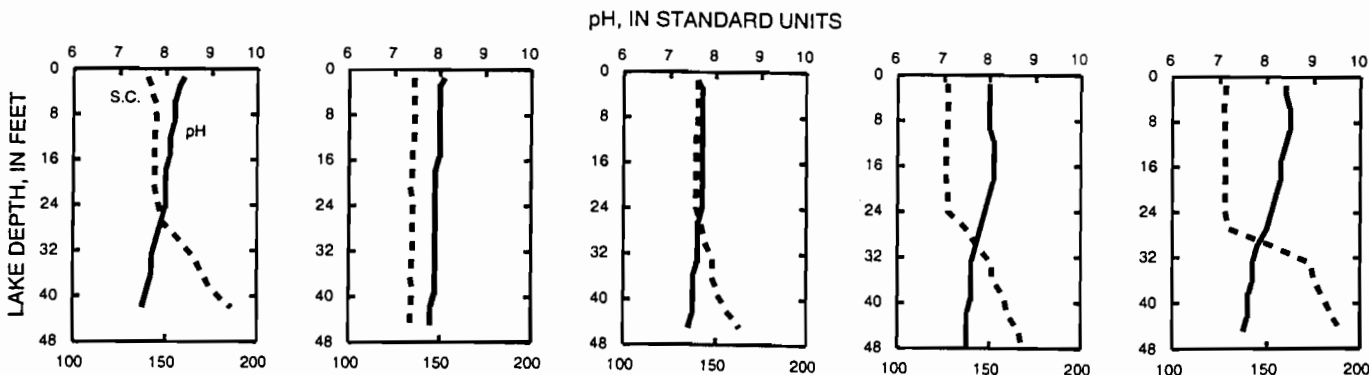
7-14-94

8-18-94

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



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



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

Figure 2a. Lake water-quality data for Red Cedar Lake (deep hole) near Mikana, Wisconsin, 1994 water year

453519091352500 RED CEDAR LAKE, SOUTH END, AT MIKANA, WI

LOCATION.--Lat 45°35'19", long 91°35'25", in SW 1/4 NE 1/4 sec.22, T.36 N., R.10 W., Barron County, Hydrologic Unit 07050007, at Mikana.

PERIOD OF RECORD.--March 1993 to August 1994 (discontinued).

REMARKS.--Lake sampled 0.2 mi northwest of Honeymoon Island. Lake ice-covered during March sampling. Water-quality analyses by Wisconsin State Laboratory of Hygiene.

WATER-QUALITY DATA, MARCH 09 TO AUGUST 18, 1994
(Milligrams per liter unless otherwise indicated)

	Mar. 09		May 04		June 16		July 14		Aug. 18	
Depth of sample (ft)	1.5	24	1.5	27	1.5	27	1.5	27	1.5	27
Lake stage (ft)	10.72		10.66		10.40		10.50		10.50	
Specific conductance (µS/cm)	120	140	131	134	140	144	126	136	126	127
pH (units)	8.9	8.1	8.5	8.0	7.6	7.5	7.8	7.8	8.2	7.9
Water temperature (°C)	2.0	3.0	8.5	8.5	21.0	15.5	22.0	18.0	22.0	20.0
Color (Pt-Co. scale)	---	---	20	20	---	---	---	---	---	---
Turbidity (NTU)	---	---	1.8	1.9	---	---	---	---	---	---
Secchi-depth (meters)	---	---	1.8		3.6		2.0		1.5	
Dissolved oxygen	10.3	9.2	10.8	10.6	8.5	3.6	8.9	0.2	10.3	5.6
Hardness, as CaCO ₃	---	---	67	67	---	---	---	---	---	---
Calcium, dissolved (Ca)	---	---	17	17	---	---	---	---	---	---
Magnesium, dissolved (Mg)	---	---	6.0	6.0	---	---	---	---	---	---
Sodium, dissolved (Na)	---	---	3.0	3.0	---	---	---	---	---	---
Potassium, dissolved (K)	---	---	0.7	0.7	---	---	---	---	---	---
Alkalinity, as CaCO ₃	---	---	63	66	---	---	---	---	---	---
Sulfate, dissolved (SO ₄)	---	---	4.0	5.0	---	---	---	---	---	---
Chloride, dissolved (Cl)	---	---	1.9	2.0	---	---	---	---	---	---
Fluoride, dissolved (F)	---	---	0.0	0.0	---	---	---	---	---	---
Silica, dissolved (SiO ₂)	---	---	12	12	---	---	---	---	---	---
Solids, dissolved, at 180°C	---	---	86	92	---	---	---	---	---	---
Nitrogen, NO ₂ + NO ₃ , diss. (as N)	---	---	<0.01	0.01	---	---	---	---	---	---
Nitrogen, ammonia, dissolved (as N)	---	---	0.03	0.02	---	---	---	---	---	---
Nitrogen, amm. + org., total (as N)	---	---	0.40	0.50	---	---	---	---	---	---
Nitrogen, total (as N)	---	---	0.40	0.51	---	---	---	---	---	---
Phosphorus, total (as P)	---	---	0.022	0.030	0.011	0.029	0.017	0.030	0.024	0.032
Phosphorus, ortho, dissolved (as P)	---	---	<0.002	<0.002	---	---	---	---	---	---
Iron, dissolved (Fe) µg/L	---	---	<50	<50	---	---	---	---	---	---
Manganese, dissolved (Mn) µg/L	---	---	57	64	---	---	---	---	---	---
Chlorophyll a, phytoplankton(µg/L)	---	---	10	---	3.4	---	9.6	---	23	---

3-9-94

5-4-94

6-16-94

7-14-94

8-18-94

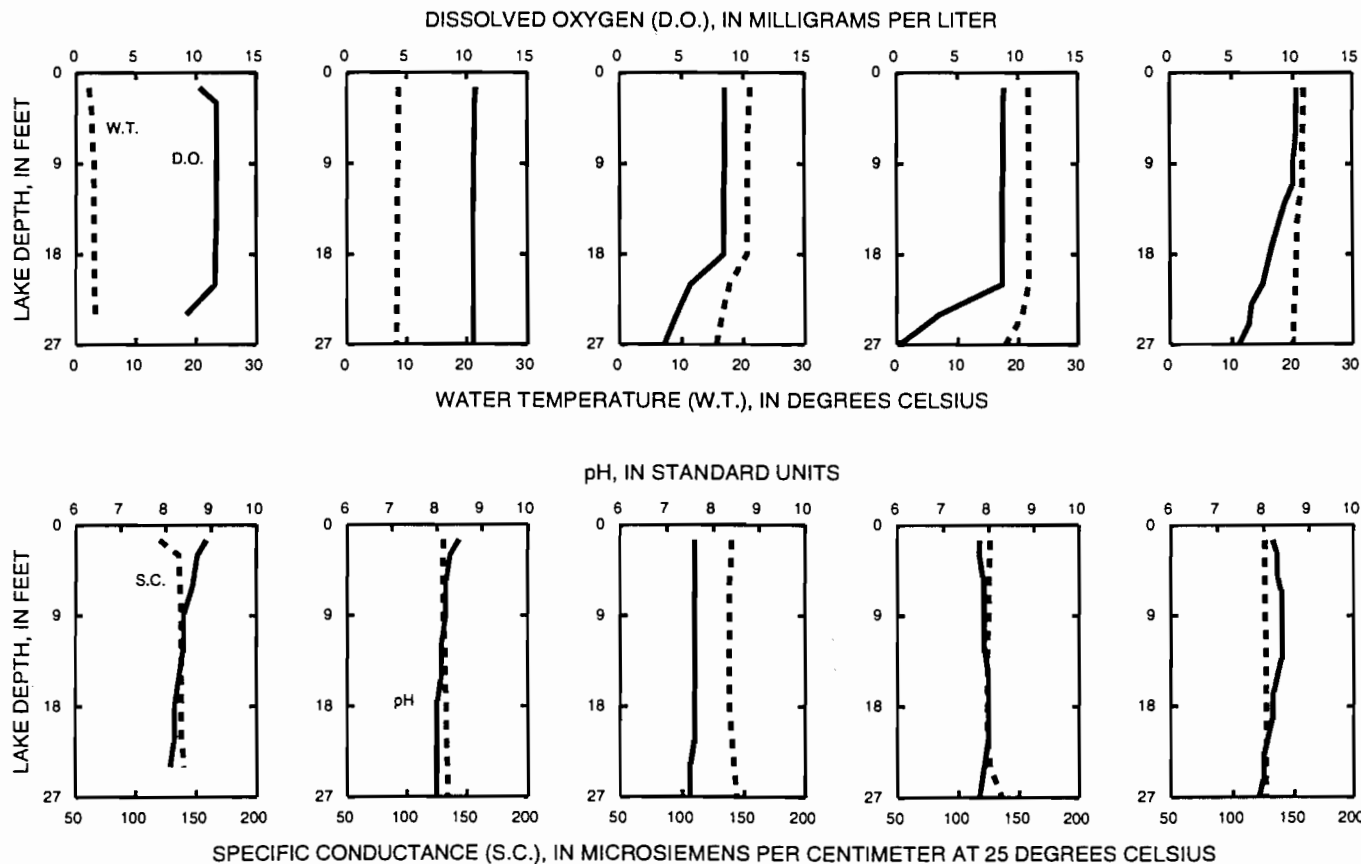


Figure 2b. Lake water-quality data for Red Cedar Lake (south end) at Mikana, Wisconsin, 1994 water year

TROPHIC STATE INDICES
 RED CEDAR LAKE (DEEP HOLE) NEAR MIKANA, WI.
 BARRON COUNTY

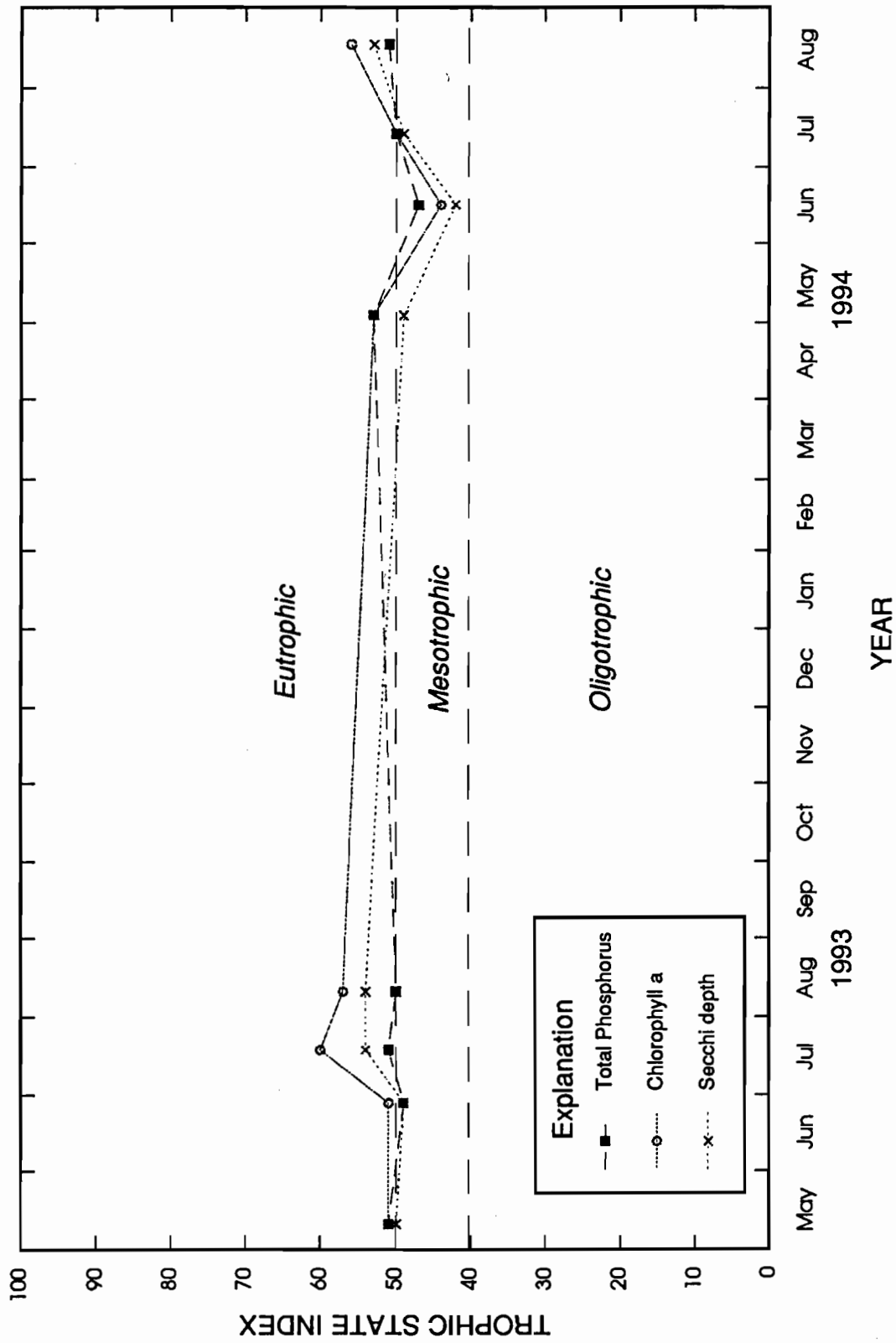


Figure 3a. Trophic state indices for Red Cedar Lake (deep hole) near Mikana, Wisconsin

TROPIC STATE INDICES
 RED CEDAR LAKE (SOUTH END) AT MIKANA, WI.
 BARRON COUNTY

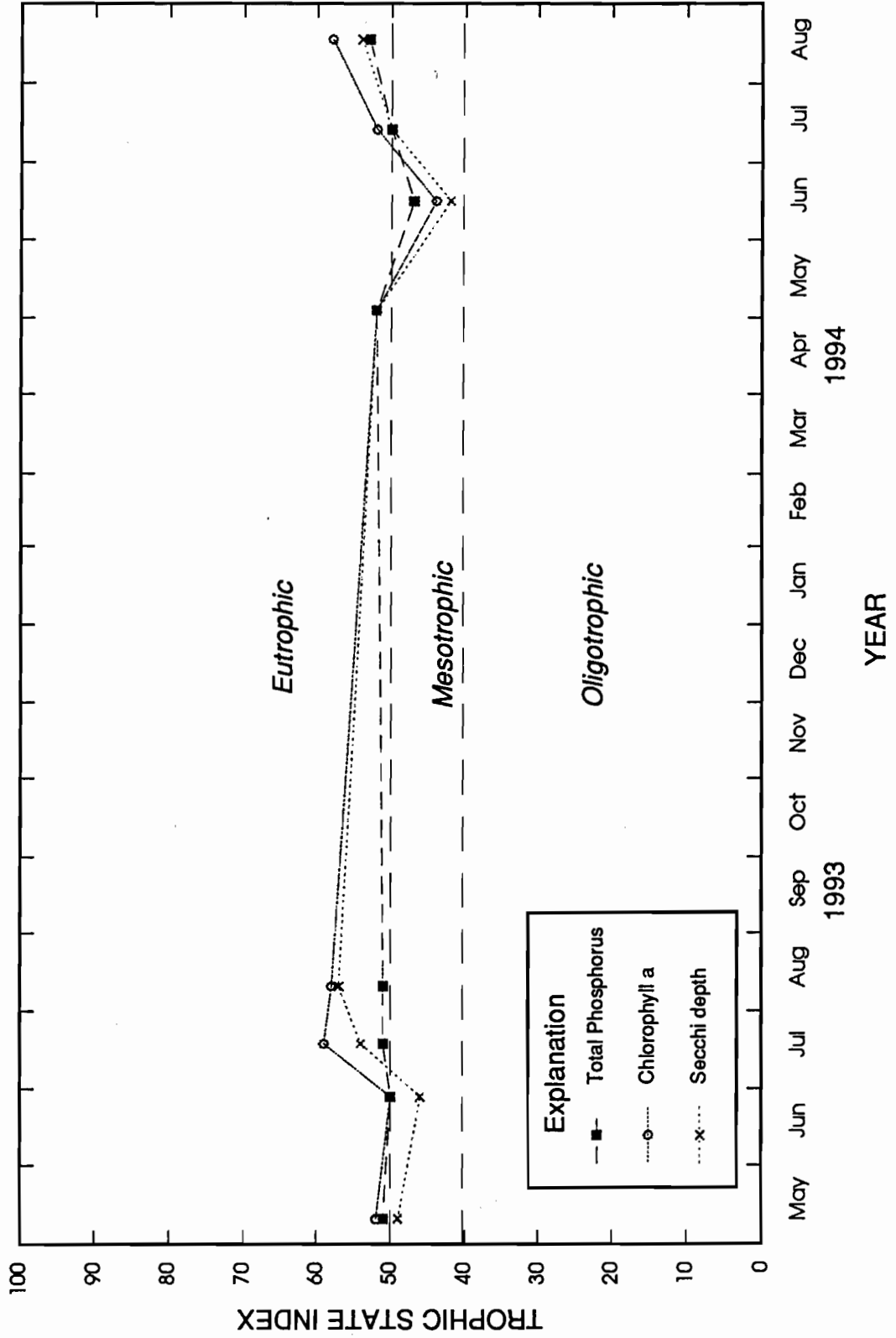


Figure 3b. Trophic state indices for Red Cedar Lake (south end) at Mikana, Wisconsin

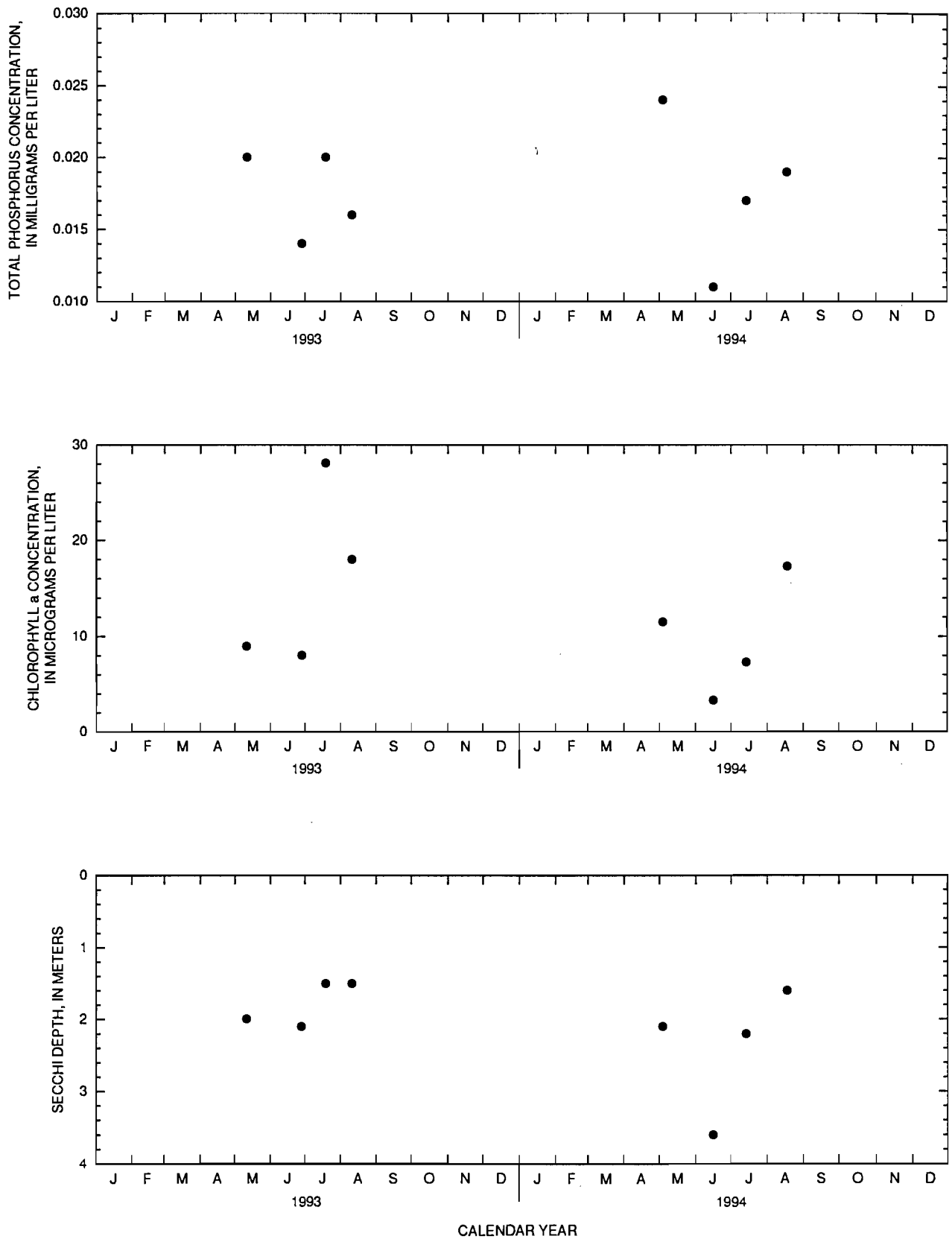


Figure 4a.-- Surface total phosphorus and chlorophyll a concentrations, and Secchi depths for Red Cedar Lake, Deep Hole, near Mikana, Wisconsin.

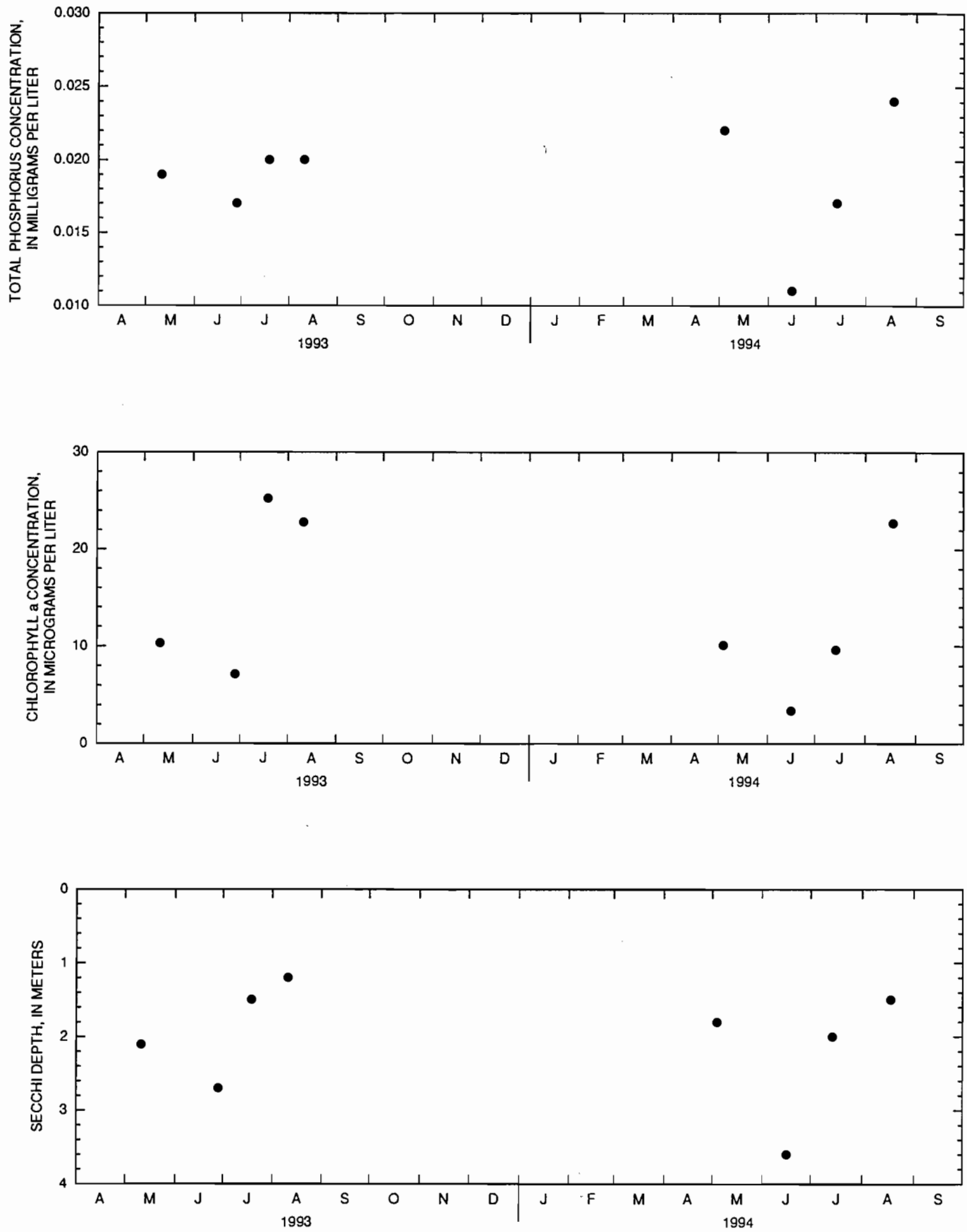


Figure 4b.-- Surface total phosphorus and chlorophyll a concentrations, and Secchi depths for Red Cedar Lake (south end) at Mikana, Wisconsin.



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)

June 28, 1994

Ms. Mary Hele
3550 Edmund Boulevard
Minneapolis, Minnesota 55406

Dear Ms. Hele:

This letter describes the progress on the evaluation of the water quality of Hemlock Lake according to the data collected from October 1992 to September 1993 as stated in our agreement. Please read the enclosure, "U.S. Geological Survey Lake Monitoring Program in Wisconsin", before proceeding with this letter.

In a brief summary, based on the 1993 data:

- The water quality of Hemlock Lake is very poor to fair and can be classified as a eutrophic lake or one with many nutrients.
- In July, during summer stratification, oxygen disappears from the bottom portion of the lake which is then unable to support a fish population.
- During the summer anoxic (devoid of oxygen) period, there are moderate amounts of phosphorus being released from the bottom sediments.
- The data enclosed herein are provisional until published.

Hemlock Lake has a surface area of 357 acres (0.56 square miles) and a drainage area at the outlet of 30.8 square miles.

One site was sampled in Hemlock Lake. It was located approximately at the deepest spot in the lake at a depth of about 21 feet and is shown in figure 1.

The data for this report are found in the following tables and figures:

Table 1. Lake stages for Red Cedar Lake, 1993 water year

Table 2. Lake-depth profiles for Hemlock Lake near Mikana, Wisconsin, 1993 water year

Table 3. Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Hemlock Lake, 1993 water year

Figure 1. Location of water-quality sampling sites and lake staff gage for Balsam, Red Cedar, and Hemlock Lakes

Figure 2. Lake water-quality data for Hemlock Lake near Mikana, Wisconsin, 1993 water year

Figure 3. Trophic state indices for Hemlock Lake near Mikana, Wisconsin

All the water-quality samples collected were analyzed by the Wisconsin State Laboratory of Hygiene at Madison, Wisconsin. The water-quality data are published in our annual publication, "Water Resources Data for Wisconsin, 1993"

LAKE-STAGE FLUCTUATIONS

Lake stages were not read at Hemlock Lake. However, lake stages were read at Red Cedar Lake by Robert Quillen. Hemlock and Red Cedar Lake are connected by a channel; therefore, lake stages at Red Cedar Lake reflect those stages on Hemlock Lake. Lake-stage data are listed in table 1. Lake stages fluctuated 1.21 feet and ranged from 9.69 feet on March 8 to 10.9 feet on June 11, 25, and 28.

LAKE-DEPTH PROFILES

Profiles of water temperature, dissolved oxygen, pH, and specific conductance at the deep hole are listed in table 2 and shown in figure 2. No abnormalities in the data are apparent. The lake thermally stratifies during summer. During July, the bottom 5 feet of water became anoxic (devoid of oxygen) and were unable to support fish. The levels of pH are within acceptable limits to support aquatic life.

MAY, JUNE, JULY AND AUGUST WATER QUALITY

The data for total phosphorus, chlorophyll *a*, and Secchi-depth readings, are listed in table 3 and on figure 2.

Total phosphorus: Total phosphorus concentrations sampled at a 1.5-foot depth range from 0.020 mg/L in May to 0.045 mg/L in July. All values fall within the regional values described by Lillie and Mason in "Limnological Characteristics of Wisconsin Lakes," 1983, Technical Bulletin No. 138, Department of Natural Resources.

Concentration of total phosphorus 1.5 feet above the lake bottom ranged from 0.050 mg/L in August to 0.240 mg/L in July. These concentrations are indicative of moderate phosphorus release from the bottom sediments during anoxic (absence of oxygen) periods.

Chlorophyll *a*: Chlorophyll *a* concentrations, which indicate algal biomass, ranged from 8.12 µg/L in May to 60.7 µg/L in August. These data are within the regional values.

Secchi disc: Secchi-disc depths, which indicate water clarity, ranged from 2.6 feet in August to 5.9 feet in May. These data are within the regional values.

TROPHIC STATUS

Lillie and Mason (1983) classified Wisconsin lakes using a random data set (summer, July and August) according to total phosphorus and chlorophyll a concentrations, and Secchi-disc depth. This evaluation is shown below:

Water quality index	Approximate total phosphorus equivalent (mg/L)	Approximate chlorophyll <u>a</u> equivalent (µg/L)	Approximate water clarity equivalent (Secchi-disc depth in ft)
Excellent	<0.001	<1	<19.7
Very good	.001-.010	1-5	9.8-19.7
Good	.010-.030	5-10	6.6-9.8
Fair	.030-.050	10-15	4.9-6.6
Poor	.050-.150	15-30	3.3-4.9
Very poor	>.150	>30	<3.3

Using the above criteria to evaluate the mean summer (July-August) 1993 data shown in table 3 for Hemlock Lake, chlorophyll a concentrations and Secchi-disc depths indicate very poor water quality, while surface total phosphorus concentrations indicate fair water quality.

Using the data from "Limnological Characteristics of Wisconsin Lakes," 1983, by Lillie and Mason, a comparison of the 1993 mean summer data (July and August) for total phosphorus, chlorophyll a, and Secchi depths for Hemlock Lake to other lakes in northwest Wisconsin are shown below:

	<u>Parameter</u>	<u>Percentage of distribution of lakes in northwest Wisconsin within these concentrations</u>
	Total phosphorus (mg/L)	
	<.010	Best condition 12
	.010-.020	35
	.020-.030	23
Hemlock Lake values →	.030-.050	18
	.050-.100	8
	.100-.150	3
	>.150	Worst condition 1

	<u>Parameter</u>	<u>Percentage of distribution of lakes in northwest Wisconsin within these concentrations</u>	
	Chlorophyll <u>a</u> ($\mu\text{g/L}$)		
	0- 5	Best condition	29
	5-10	↓	36
	10-15	↓	14
	15-30	↓	14
Hemlock Lake values	→ >30	Worst condition	9
	Secchi depth (in feet)		
	>9.8	Best condition	22
	6.6- 9.8	↓	29
	3.3- 6.6	↓	30
Hemlock Lake values	→ <3.3	Worst condition	19

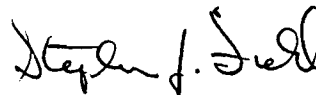
Comparing other lakes in northwest Wisconsin to the 1993 data for Hemlock Lake, the above data show, during the period 1966 to 1979, 70 percent had lower total phosphorous concentrations, 93 percent had lower chlorophyll a concentrations, and 81 percent had better water clarity.

A second approach to assessing the "health" or trophic status of a lake is to use Carlson's Trophic State Index (TSI). A graphic illustration of the Trophic State Index for Hemlock Lake is shown on figure 3. The data from 1993 show Hemlock Lake to be eutrophic or one with many nutrients.

The data that has been collected for Hemlock Lake from 1993 is extremely important for understanding the lake's water quality and managing the lake: To continue with the monitoring will help to build a very valuable data base.

If you have any questions regarding this evaluation, please contact me at 608/276-3842.

Sincerely,



Stephen J. Field
Biologist

Enclosures

CC: Dan Ryan, DNR, Spooner

Table 3.--Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Hemlock Lake, 1993 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.	
05/11/93	1.8	5.9	1.5	0.020	20	8.12	51	--
	-	-	--	--	--	-	-	--
06/28/93	1.1	3.6	1.5	0.044	44	21.5	58	--
	-	-	20	0.069	69	-	-	--
07/19/93	1.2	3.9	1.5	0.045	45	42.1	63	--
	-	-	20	0.240	240	-	-	--
08/11/93	0.8	2.6	1.5	0.036	36	60.7	66	--
	-	-	19	0.050	50	-	-	--

CHIPPEWA RIVER BASIN

453421091333700 HEMLOCK LAKE NEAR MIKANA, WI

LOCATION.--Lat 45°34'21", long 91°33'37", in SE 1/4 SE 1/4 sec.26, T.36 N., R.10 W., Barron County, Hydrologic Unit 07050007, 2.5 mi southeast of Mikana.

PERIOD OF RECORD.--March to August 1993.

REMARKS.--Lake sampled at deep hole near center of lake. Lake ice-covered during March sampling. Water-quality analyses by Wisconsin State Laboratory of Hygiene.

WATER-QUALITY DATA, MARCH 08 TO AUGUST 11, 1993
(Milligrams per liter unless otherwise indicated)

	Mar. 08		May 11		June 28		July 19		Aug. 11	
Depth of sample (ft)	1.5	18	1.5	19	1.5	20	1.5	20	1.5	19
Lake stage (ft)	9.69		10.46		10.90		10.40		10.65	
Specific conductance (μS/cm)	123	128	80	83	68	72	73	98	87	106
pH (units)	8.3	7.7	7.3	7.3	7.2	6.9	8.8	7.5	8.5	7.5
Water temperature (°C)	1.5	4.5	16.5	11.0	19.0	14.5	23.5	15.5	23.0	17.5
Secchi-depth (meters)	---		1.8		1.1		1.2		0.8	
Dissolved oxygen	10.0	1.0	9.4	3.3	8.6	0.9	10.2	0.1	10.4	0.3
Phosphorus, total (as P)	---		0.020	---	0.044	0.069	0.045	0.240	0.036	0.050
Chlorophyll a, phytoplankton (μg/L)	---		8.1	---	22	---	42	---	61	---

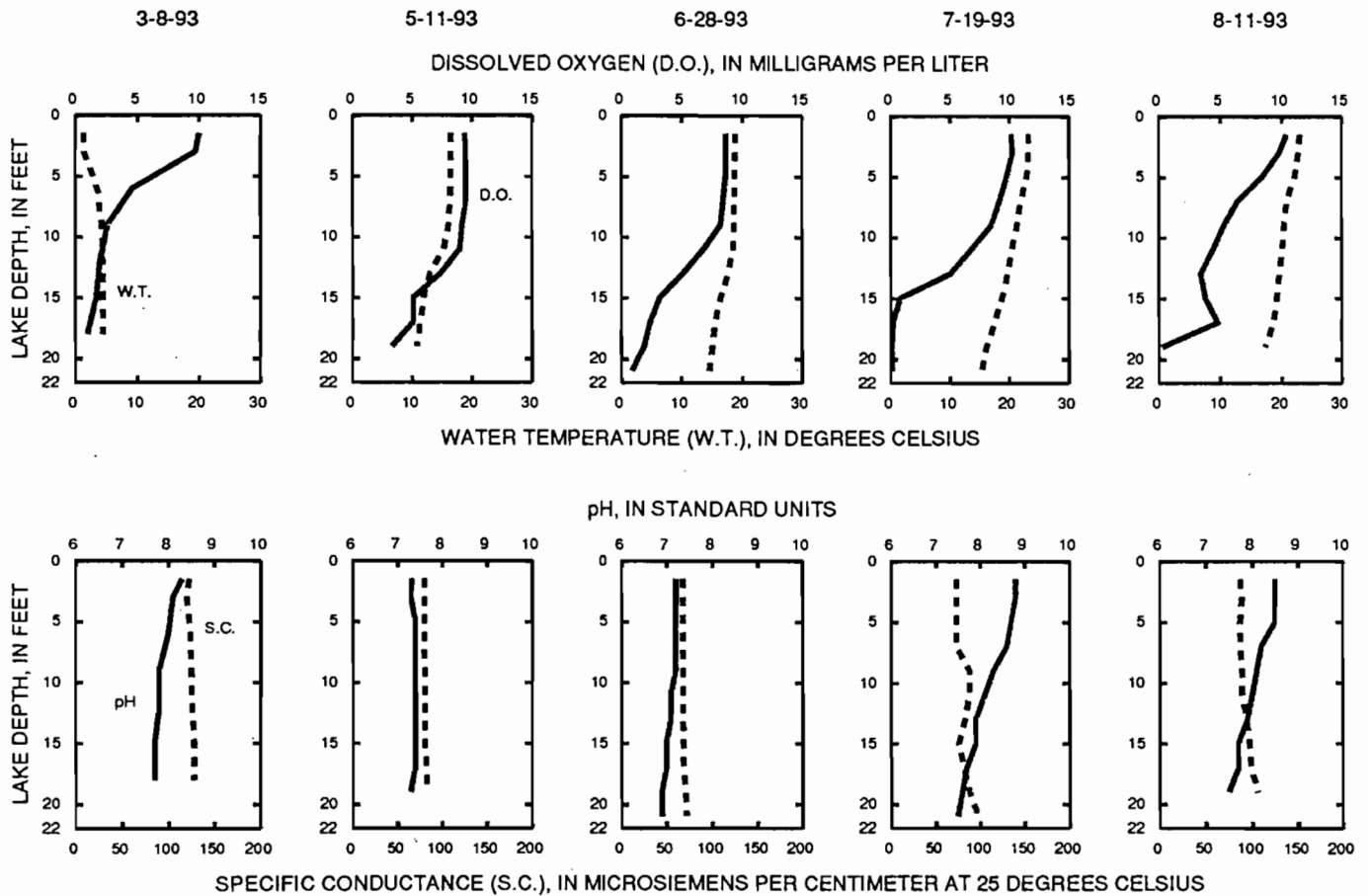


Figure 2. Lake water-quality data for Hemlock Lake near Mikana, Wisconsin, 1993 water year

TROPHIC STATE INDICES
 HEMLOCK LAKE NEAR MIKANA, WI.
 BARRON COUNTY

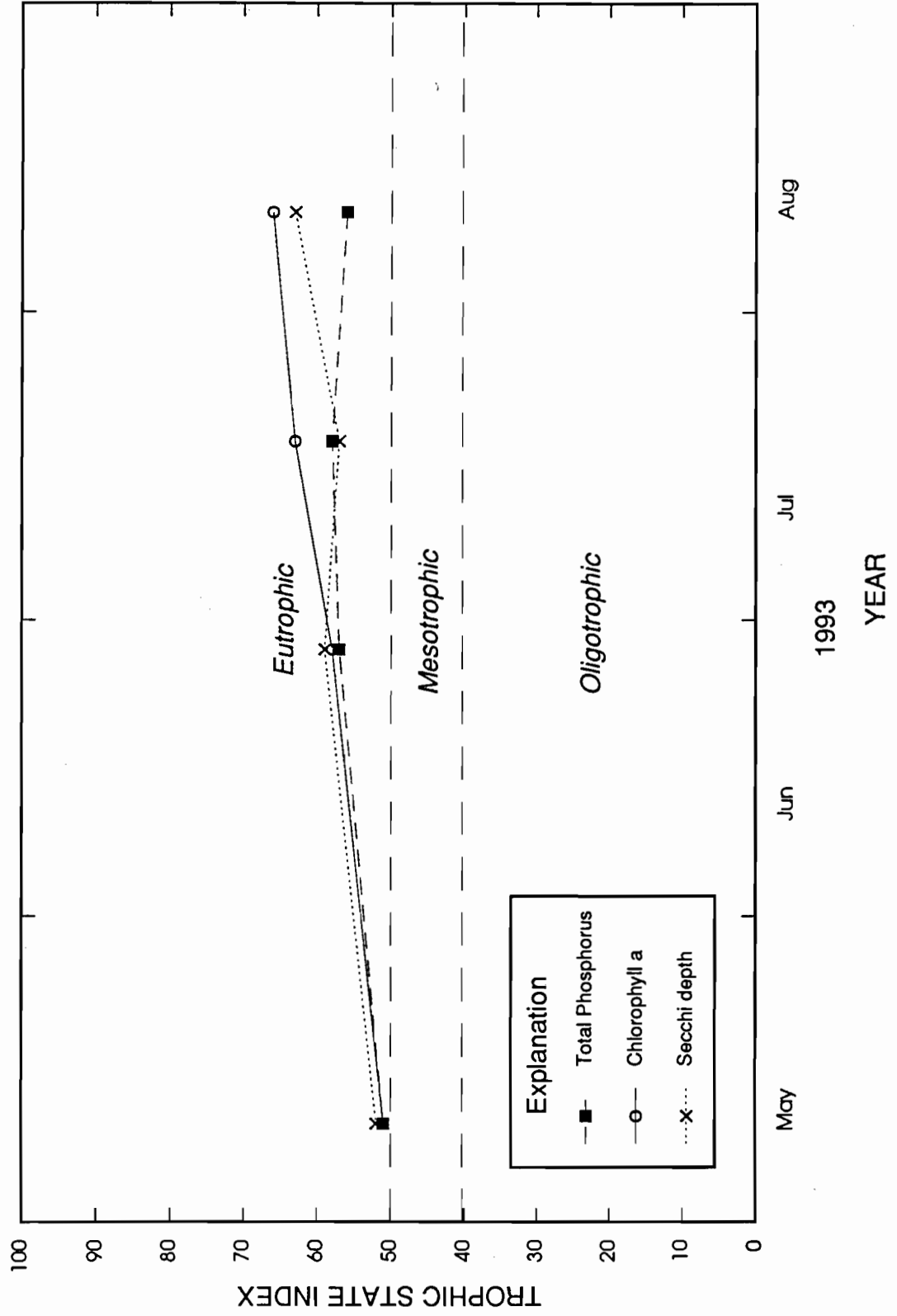


Figure 3. Trophic state indices for Hemlock Lake near Mikana, Wisconsin



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)

June 9, 1995

Ms. Mary Hele
 3550 Edmund Boulevard
 Minneapolis, Minnesota 55406

Dear Ms. Hele:

This letter describes the progress on the evaluation of the water quality of Hemlock Lake according to the data collected from October 1993 to September 1994 as stated in our agreement. Please read the "U.S. Geological Survey Lake Monitoring Program in Wisconsin", sent to you previously, before proceeding with this letter.

In a brief summary, based on the 1994 data:

- The water quality of Hemlock Lake is very poor to fair and can be classified as a mesoeutrophic lake or one with moderate to many nutrients.
- In March, June, July, and August, during summer stratification, oxygen disappears from the bottom portion of the lake which is then unable to support a fish population.
- During the summer anoxic (devoid of oxygen) period, there are moderate amounts of phosphorus being released from the bottom sediments.
- Algal growth appears to be dependent upon the available phosphorus rather than nitrogen.
- Phosphorus and chlorophyll *a* concentrations in 1994 are less than in 1993 and water clarity is greater. However, two years of data are insufficient to determine trends and the improvement in water quality may only reflect annual variability.
- The data enclosed herein are provisional until published.

Hemlock Lake has a surface area of 357 acres (0.56 square miles) and a drainage area at the outlet of 30.8 square miles.

One site was sampled in Hemlock Lake. It was located approximately at the deepest spot in the lake at a depth of about 22 feet and is shown in figure 1.

The data for this report are found in the following tables and figures:

Table 1. Lake-depth profiles for Hemlock Lake near Mikana, Wisconsin, 1994 water year

Table 2. Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Hemlock Lake, 1994 water year

Figure 1. Location of water-quality sampling sites and lake staff gage for Balsam, Red Cedar, and Hemlock Lakes

Figure 2. Lake water-quality data for Hemlock Lake near Mikana, Wisconsin, 1994 water year

Figure 3. Trophic state indices for Hemlock Lake near Mikana, Wisconsin

Figure 4. Surface total phosphorus and chlorophyll a concentrations and Secchi-disc depths for Hemlock Lake near Mikana, Wisconsin

All the water-quality samples collected were analyzed by the Wisconsin State Laboratory of Hygiene at Madison, Wisconsin. The water-quality data are published in our annual publications, "Water Resources Data for Wisconsin, 1994", and "Water-Quality and Lake-Stage Data for Wisconsin Lakes, Water Year 1994".

LAKE-STAGE FLUCTUATIONS

Lake stages were not read at Hemlock Lake. However, lake stages were read at Red Cedar Lake by USGS personnel. Hemlock and Red Cedar Lake are connected by a channel; therefore, lake stages at Red Cedar Lake reflect those stages on Hemlock Lake. Lake-stage data are listed in figure 2. Lake stages fluctuated 0.32 feet and ranged from 10.40 feet on June 16 to 10.72 feet on March 9.

LAKE-DEPTH PROFILES

Profiles of water temperature, dissolved oxygen, pH, and specific conductance at the deep hole are listed in table 1 and shown in figure 2. No abnormalities in the data are apparent. Among our sampling dates, almost complete water-column mixing was observed on May 4. The remainder of the profile data show incomplete mixing. The lake thermally stratifies during summer. During March, June, July, and August, the bottom 7 feet of water became anoxic (devoid of oxygen) and were unable to support fish. The levels of pH are within acceptable limits to support aquatic life. Because of the high buffering capacity of the lake water, Hemlock Lake is not susceptible to the effects of acid rain.

SELECTED ANALYSES

Analyses of selected constituents for May 4 for samples collected at 1.5 and 19-foot depths are listed in figure 2. The water-quality 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.

To compute the nitrogen-phosphorus ratio, only the sample collected from the 1.5-foot sampling depth for May was used. This depth was used because algae grow in the upper part of the lake

rather than at the bottom. The ratio of total nitrogen to phosphorus was calculated as 15:1 and suggests the lake is phosphorus-limited. This means algal growth appears to be dependent on the amount of available phosphorus rather than nitrogen.

MAY, JUNE, JULY AND AUGUST WATER QUALITY

The data for total phosphorus, chlorophyll a, and Secchi-depth readings, are listed in table 2 and on figure 2.

Total phosphorus: Total phosphorus concentrations sampled at a 1.5-foot depth range from 0.022 mg/L in June to 0.037 mg/L in July. All values fall within the regional values previously referenced.

Concentration of total phosphorus 1.5 feet above the lake bottom ranged from 0.036 mg/L in May to 0.251 mg/L in August. These concentrations are indicative of moderate phosphorus release from the bottom sediments during anoxic (absence of oxygen) periods.

Chlorophyll a: Chlorophyll a concentrations, which indicate algal biomass, ranged from 5.7 µg/L in June to 38 µg/L in August. These data are within the regional values.

Secchi disc: Secchi-disc depths, which indicate water clarity, ranged from 3.0 feet in August to 10.2 feet in June. These data are within the regional values.

TROPHIC STATUS

Lillie and Mason (1983) classified Wisconsin lakes using a random data set (summer, July and August) according to total phosphorus and chlorophyll a concentrations, and Secchi-disc depth. This evaluation is shown below:

Water quality index	Approximate total phosphorus equivalent (mg/L)	Approximate chlorophyll <u>a</u> equivalent (µg/L)	Approximate water clarity equivalent (Secchi-disc depth in ft)
Excellent	<0.001	<1	<19.7
Very good	.001-.010	1-5	9.8-19.7
Good	.010-.030	5-10	6.6-9.8
Fair	.030-.050	10-15	4.9-6.6
Poor	.050-.150	15-30	3.3-4.9
Very poor	>.150	>30	<3.3

Using the above criteria to evaluate the mean summer (July-August) 1994 data shown in table 3 for Hemlock Lake, surface total phosphorus concentrations indicate fair water quality, chlorophyll a concentrations indicate very poor water quality, and Secchi-disc depths indicate poor water quality.

Using the data from "Limnological Characteristics of Wisconsin Lakes," 1983, by Lillie and Mason, a comparison of the 1994 mean summer data (July and August) for total phosphorus, chlorophyll *a*, and Secchi depths for Hemlock Lake to other lakes in northwest Wisconsin are shown below:

	<u>Parameter</u>	<u>Percentage of distribution of lakes in northwest Wisconsin within these concentrations</u>	
	Total phosphorus (mg/L)		
	<.010	Best condition	12
	.010-.020		35
	.020-.030		23
Hemlock Lake values	→ .030-.050		18
	.050-.100		8
	.100-.150		3
	>.150	Worst condition	1
	Chlorophyll <i>a</i> (µg/L)		
	0- 5	Best condition	29
	5-10		36
	10-15		14
	15-30		14
Hemlock Lake values	→ >30	Worst condition	9
	Secchi depth (in feet)		
	>9.8	Best condition	22
	6.6- 9.8		29
Hemlock Lake values	→ 3.3- 6.6		30
	<3.3	Worst condition	19

Comparing other lakes in northwest Wisconsin to the 1994 data for Hemlock Lake, the above data show, during the period 1966 to 1979, 70 percent had lower total phosphorous concentrations, 93 percent had lower chlorophyll *a* concentrations, and 51 percent had greater water clarity.

A second approach to assessing the "health" or trophic status of a lake is to use Carlson's Trophic State Index (TSI). A graphic illustration of the Trophic State Index for Hemlock Lake is shown on figure 3. The data from 1994 show Hemlock Lake to be meso-eutrophic or one with moderate to many nutrients.

Ms. Mary Hele, June 9, 1995

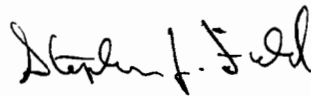
5

Surface total phosphorus and chlorophyll a concentrations and Secchi-disc depths for 1993-1994 for Hemlock Lake are shown in figure 4. Phosphorus and chlorophyll a concentrations in 1994 are less than in 1993 and water clarity is greater. However, two years of data are insufficient to determine trends and the improvement in water quality may only reflect annual variability.

The data that has been collected for Hemlock Lake from 1993 and 1994 is extremely important for understanding the lake's water quality and managing the lake. To continue with the monitoring will help to build a very valuable data base.

If you have any questions regarding this evaluation, please contact me at 608/276-3842.

Sincerely,



Stephen J. Field
Biologist

Enclosures

cc: Dan Ryan, DNR, Spooner

Table 2.--Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Hemlock Lake, 1994 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.	
05/04/94	2.1	6.9	49	1.5	0.027	27	54	6.41	49	0.003
	-	-	-	19	0.036	36	-	-	-	0.005
06/16/94	3.1	10.2	44	1.5	0.022	22	52	5.66	48	--
	-	-	-	19	0.145	145	-	-	-	--
07/14/94	1.1	3.6	59	1.5	0.037	37	56	25.4	59	--
	-	-	-	21	0.230	230	-	-	-	--
08/18/94	0.9	3.0	62	1.5	0.036	36	56	37.6	62	--
	-	-	-	21	0.251	251	-	-	-	--

453421091333700 HEMLOCK LAKE NEAR MIKANA, WI

LOCATION.--Lat 45°34'21", long 91°33'37", in SE 1/4 SE 1/4 sec.26, T.36 N., R.10 W., Barron County, Hydrologic Unit 07050007, 2.5 mi southeast of Mikana.

PERIOD OF RECORD.--March 1993 to August 1994 (discontinued).

REMARKS.--Lake sampled at deep hole near center of lake. Lake ice-covered during March sampling. Water-quality analyses by Wisconsin State Laboratory of Hygiene.

WATER-QUALITY DATA, MARCH 09 TO AUGUST 18, 1994
(Milligrams per liter unless otherwise indicated)

	Mar. 09		May 04		June 16		July 14		Aug. 18	
Depth of sample (ft)	1.5	20	1.5	19	1.5	19	1.5	21	1.5	21
Lake stage (ft)	10.72		10.66		10.40		10.50		10.50	
Specific conductance (µS/cm)	120	162	65	69	96	100	92	131	93	176
pH (units)	8.2	7.5	8.4	7.8	7.6	7.4	7.9	7.2	8.1	7.1
Water temperature (°C)	2.0	4.5	11.5	7.0	22.5	14.5	22.0	15.0	22.0	16.0
Color (Pt-Co. scale)	---	---	50	50	---	---	---	---	---	---
Turbidity (NTU)	---	---	1.5	2.6	---	---	---	---	---	---
Secchi-depth (meters)	---	---	---	2.1	---	3.1	---	1.1	---	0.9
Dissolved oxygen	8.7	0.1	11.2	8.4	9.0	0.1	8.8	0.1	10.4	0.1
Hardness, as CaCO ₃	---	---	30	33	---	---	---	---	---	---
Calcium, dissolved (Ca)	---	---	7.0	8.2	---	---	---	---	---	---
Magnesium, dissolved (Mg)	---	---	3.0	3.0	---	---	---	---	---	---
Sodium, dissolved (Na)	---	---	2.0	2.0	---	---	---	---	---	---
Potassium, dissolved (K)	---	---	0.6	0.8	---	---	---	---	---	---
Alkalinity, as CaCO ₃	---	---	26	31	---	---	---	---	---	---
Sulfate, dissolved (SO ₄)	---	---	7.0	6.0	---	---	---	---	---	---
Chloride, dissolved (Cl)	---	---	0.9	0.9	---	---	---	---	---	---
Fluoride, dissolved (F)	---	---	<0.0	0.0	---	---	---	---	---	---
Silica, dissolved (SiO ₂)	---	---	8.1	9.9	---	---	---	---	---	---
Solids, dissolved, at 180°C	---	---	54	60	---	---	---	---	---	---
Nitrogen, NO ₂ + NO ₃ , diss. (as N)	---	---	<0.01	0.01	---	---	---	---	---	---
Nitrogen, ammonia, dissolved (as N)	---	---	<0.00	0.02	---	---	---	---	---	---
Nitrogen, amm. + org., total (as N)	---	---	0.40	0.40	---	---	---	---	---	---
Nitrogen, total (as N)	---	---	0.40	0.41	---	---	---	---	---	---
Phosphorus, total (as P)	---	---	0.027	0.036	0.022	0.145	0.037	0.230	0.036	0.251
Phosphorus, ortho, dissolved (as P)	---	---	0.003	0.005	---	---	---	---	---	---
Iron, dissolved (Fe) µg/L	---	---	150	170	---	---	---	---	---	---
Manganese, dissolved (Mn) µg/L	---	---	<40	<40	---	---	---	---	---	---
Chlorophyll a, phytoplankton (µg/L)	---	---	6.4	---	5.7	---	25	---	38	---

3-9-94

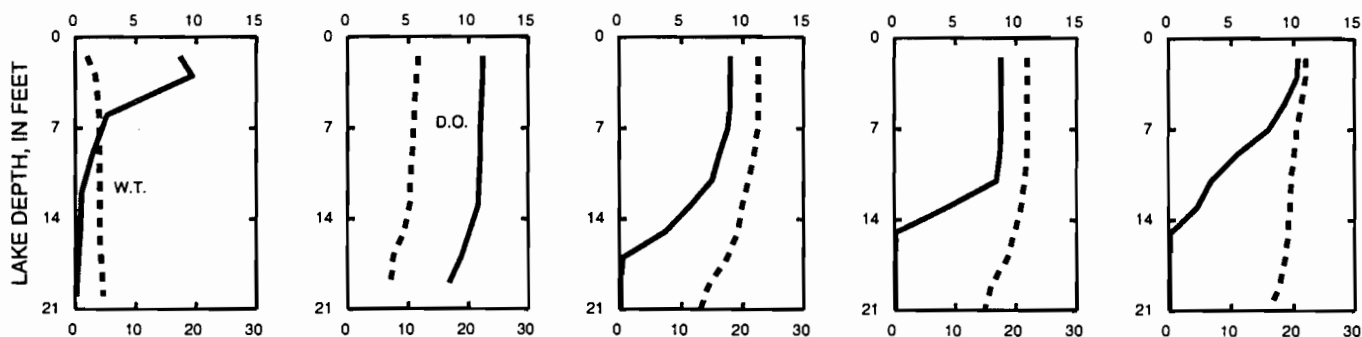
5-4-94

6-16-94

7-14-94

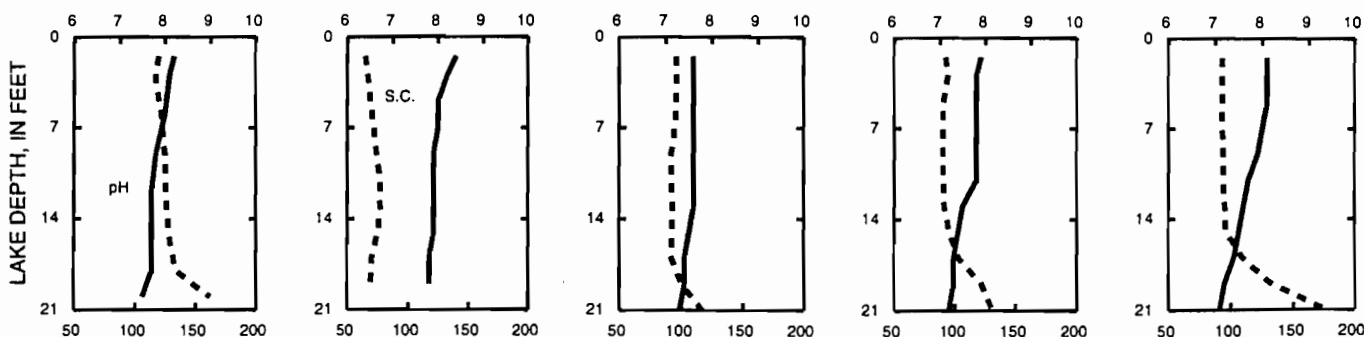
8-18-94

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. Lake water-quality data for Hemlock Lake near Mikana, Wisconsin, 1994 water year

TROPHIC STATE INDICES
 HEMLOCK LAKE NEAR MIKANA, WI.
 BARRON COUNTY

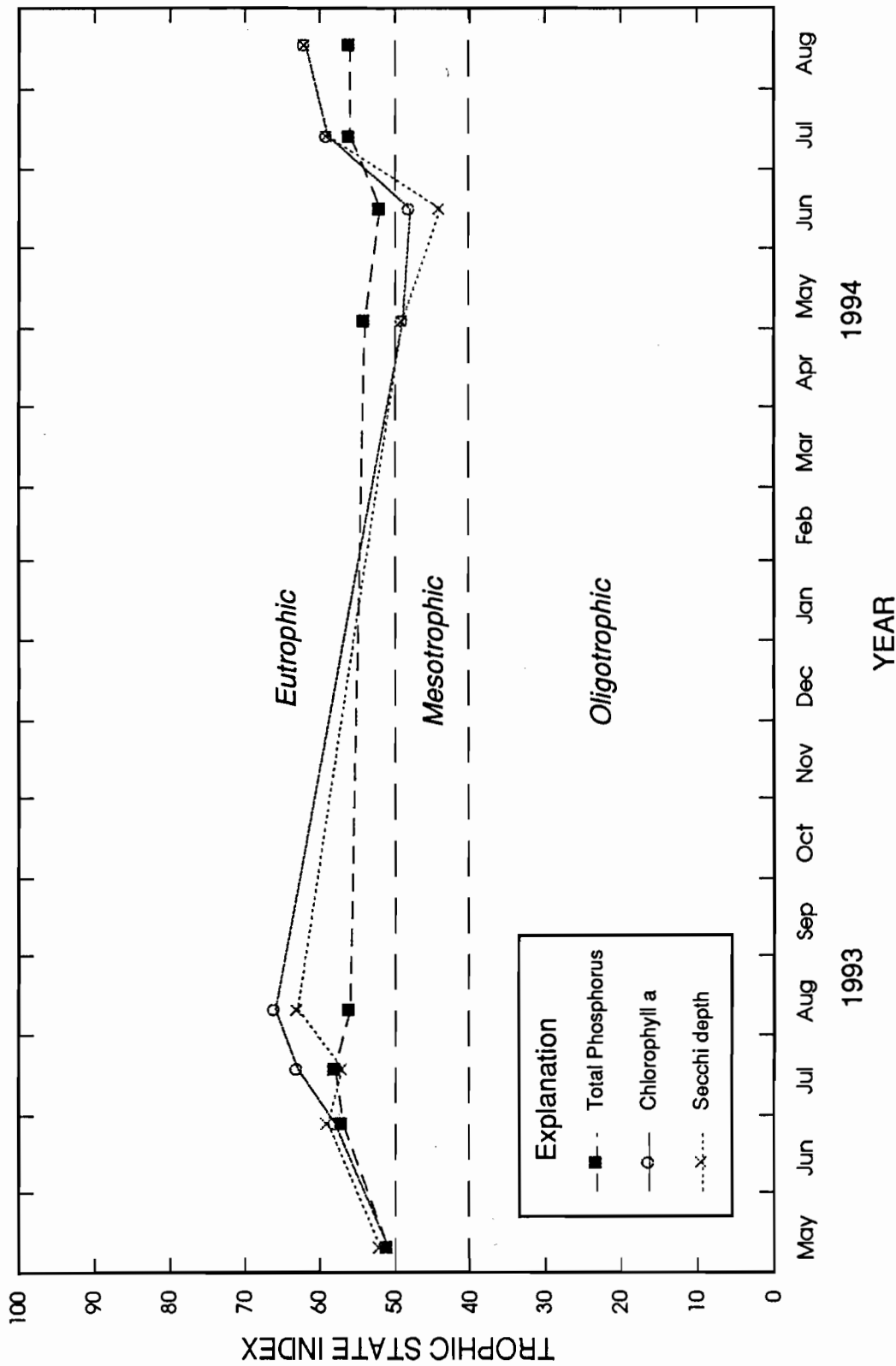


Figure 3. Trophic State Indices for Hemlock Lake near Mikana, Wisconsin

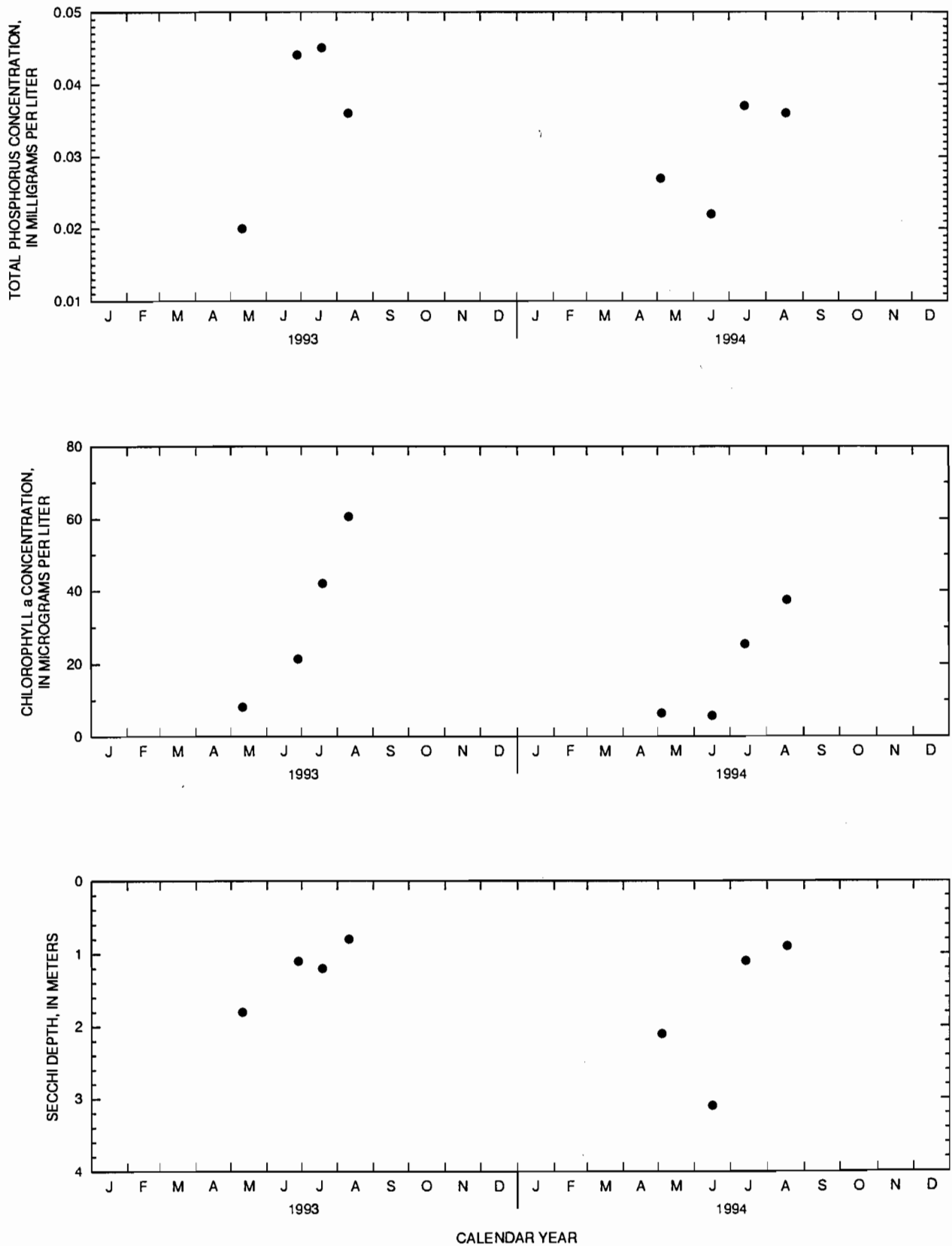


Figure 4. --Surface total phosphorus and chlorophyll a concentrations, and Secchi depths for Hemlock Lake near Mikana, Wisconsin.



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)

June 28, 1994

Ms. Mary Hele
3550 Edmund Boulevard
Minneapolis, Minnesota 55406

Dear Ms. Hele:

This letter describes the progress on the evaluation of the water quality of Balsam Lake according to the data collected from October 1992 to September 1993 as stated in our agreement. Please read the enclosure, "U.S. Geological Survey Lake Monitoring Program in Wisconsin", before proceeding with this letter.

In a brief summary, based on the 1993 data:

- The water quality of Balsam Lake is good and can be classified as a mesotrophic lake or one with moderate nutrients.
- In March, June, July, and August, during summer stratification, oxygen disappears from the bottom portion of the lake which is then unable to support a fish population.
- During the summer anoxic (devoid of oxygen) period, there are moderate amounts of phosphorus being released from the bottom sediments.
- The data enclosed herein are provisional until published.

Balsam Lake has a surface area of 295 acres (0.46 square miles) and a drainage area at State Highway 48 of 50,200 acres (78.5 square miles) for a drainage area/lake size ratio of 171:1. Lakes with drainage area/lake size ratios of greater than 10:1 tend to develop water-quality problems. (Uttomark, Paul D., and Mark L. Hutchins, 1978, Input/output models as decision criteria for lake restoration. University of Wisconsin-Madison, Wisconsin, Water Resources Center technical report No. 78-03, 61 pp.).

One site was sampled in Balsam Lake. It was located approximately at the deepest spot in the lake at a depth of about 42 feet and is shown in figure 1.

The data for this report are found in the following tables and figures:

Table 1. Lake stages for Red Cedar Lake, 1993 water year

Table 2. Lake-depth profiles for Balsam Lake near Birchwood, 1993 water year

Table 3. Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Balsam Lake near Birchwood, 1993 water year

Figure 1. Location of water-quality sampling sites and lake staff gage for Balsam, Red Cedar, and Hemlock Lakes

Figure 2. Lake water-quality data for Balsam Lake near Birchwood, 1993 water year

Figure 3. Trophic state indices for Balsam Lake near Birchwood

All the water-quality samples collected were analyzed by the Wisconsin State Laboratory of Hygiene at Madison, Wisconsin. The water-quality data are published in our annual publication, "Water Resources Data for Wisconsin, 1993".

LAKE-STAGE FLUCTUATIONS

Lake stages were not read on Balsam Lake. However, lake stages were read on Red Cedar Lake by Robert Quillen. Balsam and Red Cedar Lake are connected by a channel; therefore, lake stages at Red Cedar Lake reflect those stages on Balsam Lake. Lake-stage data are listed on table 1. Lake stages fluctuated 1.21 feet and ranged from 9.69 feet on March 8 to 10.9 feet on June 11, 25, and 28.

LAKE-DEPTH PROFILES

Profiles of water temperature, dissolved oxygen, pH, and specific conductance at the deep hole are listed in table 2 and shown in figure 2. No abnormalities in the data are apparent. The lake thermally stratifies during summer. During March, June, July and August, the bottom 19 feet became anoxic (devoid of oxygen) and were unable to support fish. The levels of pH are within acceptable limits to support aquatic life.

MAY, JUNE, JULY AND AUGUST WATER QUALITY

The data for total phosphorus, chlorophyll *a*, and Secchi-depth readings, are listed in table 3 and on figure 2.

Total phosphorus: Total phosphorus concentrations sampled at a 1.5-foot depth range from 0.012 mg/L in August to <0.020 mg/L in May. All values fall within the regional values described by Lillie and Mason in "Limnological Characteristics of Wisconsin Lakes," 1983, Technical Bulletin No. 138, Department of Natural Resources.

Concentration of total phosphorus 1.5 feet above the lake bottom ranged from <0.020 mg/L in July to 0.360 mg/L in August. These concentrations are indicative of moderate phosphorus release from the bottom sediments during anoxic (absence of oxygen) periods.

Chlorophyll *a*: Chlorophyll *a* concentrations, which indicate algal biomass, ranged from 5.07 µg/L in June to 9.42 µg/L in May. These data are within the regional values.

Secchi disc: Secchi-disc depths, which indicate water clarity, ranged from 6.9 feet in July and August to 10.8 feet in June. These data are within the regional values.

TROPHIC STATUS

Lillie and Mason (1983) classified Wisconsin lakes using a random data set (summer, July and August) according to total phosphorus and chlorophyll a concentrations, and Secchi-disc depth. This evaluation is shown below:

Water quality index	Approximate total phosphorus equivalent (mg/L)	Approximate chlorophyll <u>a</u> equivalent (µg/L)	Approximate water clarity equivalent (Secchi-disc depth in ft)
Excellent	<0.001	<1	<19.7
Very good	.001-.010	1-5	9.8-19.7
Good	.010-.030	5-10	6.6-9.8
Fair	.030-.050	10-15	4.9-6.6
Poor	.050-.150	15-30	3.3-4.9
Very poor	>.150	>30	<3.3

Using the above criteria to evaluate the mean summer (July-August) 1993 data shown in table 3 for Balsam Lake, surface total phosphorus and chlorophyll a concentrations and Secchi-disc depths indicate good water quality.

Using the data from "Limnological Characteristics of Wisconsin Lakes," 1983, by Lillie and Mason, a comparison of the 1993 mean summer data (July and August) for total phosphorus, chlorophyll a, and Secchi depths for Balsam Lake to other lakes in northwest Wisconsin are shown below:

	<u>Parameter</u>	<u>Percentage of distribution of lakes in northwest Wisconsin within these concentrations</u>
	Total phosphorus (mg/L)	
	<.010	Best condition 12
Balsam Lake values →	.010-.020	35
	.020-.030	23
	.030-.050	18
	.050-.100	8
	.100-.150	3
	>.150	Worst condition 1

	<u>Parameter</u>	<u>Percentage of distribution of lakes in northwest Wisconsin within these concentrations</u>
	Chlorophyll <i>a</i> ($\mu\text{g/L}$)	
	0- 5	Best condition 29
Balsam Lake values \longrightarrow	5-10	36
	10-15	14
	15-30	14
	>30	Worst condition 9
	Secchi depth (in feet)	
	9.8	Best condition 22
Balsam Lake values \longrightarrow	6.6- 9.8	29
	3.3- 6.6	30
	<3.3	Worst condition 19

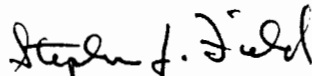
Comparing other lakes in northwest Wisconsin to the 1993 data for Balsam Lake, the above data show, during the period 1966 to 1979, 53 percent had higher total phosphorous concentrations, 37 percent had higher chlorophyll *a* concentrations, and 49 percent had less water clarity.

A second approach to assessing the "health" or trophic status of a lake is to use Carlson's Trophic State Index (TSI). A graphic illustration of the Trophic State Index for Balsam Lake is shown on figure 3. The data from 1993 show Balsam Lake to be mesotrophic or one with moderate nutrients.

The data that has been collected for Balsam Lake from 1993 is extremely important for understanding the lake's water quality and managing the lake. To continue with the monitoring will help to build a very valuable data base.

If you have any questions regarding this evaluation, please contact me at 608/276-3842.

Sincerely,



Stephen J. Field
Biologist

Enclosures

cc: Dan Ryan, DNR, Spooner

Table 3.--Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Balsam Lake near Birchwood, 1993 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)	
05/11/93	2.4	7.9	1.5	<0.02	20	51	9.42	52	--
	-	-	--	--	--	-	-	-	--
06/28/93	3.3	10.8	1.5	0.017	17	50	5.07	47	--
	-	-	43	0.328	328	-	-	-	--
07/19/93	2.1	6.9	1.5	0.013	13	48	8.43	51	--
	-	-	40	<0.02	20	-	-	-	--
08/11/93	2.1	6.9	1.5	0.012	12	47	9.3	52	--
	-	-	38	0.360	360	-	-	-	--

CHIPPEWA RIVER BASIN

453907091345800 BALSAM LAKE NEAR BIRCHWOOD, WI

LOCATION.--Lat 45°39'07", long 91°34'58", in NE 1/4 NE 1/4 sec.34, T.37 N., R.10 W., Washburn County, Hydrologic Unit 07050007, 1.2 mi southwest of Birchwood.

PERIOD OF RECORD.--March to August 1993.

REMARKS.--Lake sampled near southern end of Balsam Lake at a lake depth of about 43 ft. Lake ice-covered during March sampling. Water-quality analyses by Wisconsin State Laboratory of Hygiene.

WATER-QUALITY DATA, MARCH 08 TO AUGUST 11, 1993
(Milligrams per liter unless otherwise indicated)

	Mar. 08		May 11		June 28		July 19		Aug. 11	
Depth of sample (ft)	1.5	39	1.5	39	1.5	43	1.5	40	1.5	38
Lake stage (ft)	9.69		10.46		10.90		10.40		10.65	
Specific conductance (μS/cm)	170	239	143	168	137	203	127	183	143	200
pH (units)	8.4	7.4	7.8	7.7	7.7	7.4	8.5	7.8	8.6	7.8
Water temperature (°C)	1.0	4.5	15.0	6.5	19.5	7.0	24.0	7.5	24.0	8.0
Secchi-depth (meters)	---	---	2.4	---	3.3	---	2.1	---	2.1	---
Dissolved oxygen	12.9	0.2	11.3	3.4	9.4	0.1	10.1	0.1	10.0	0.1
Phosphorus, total (as P)	---	---	<0.020	---	0.017	0.328	0.013	<0.020	0.012	0.360
Chlorophyll a, phytoplankton(μg/L)	---	---	9.4	---	5.1	---	8.4	---	9.3	---

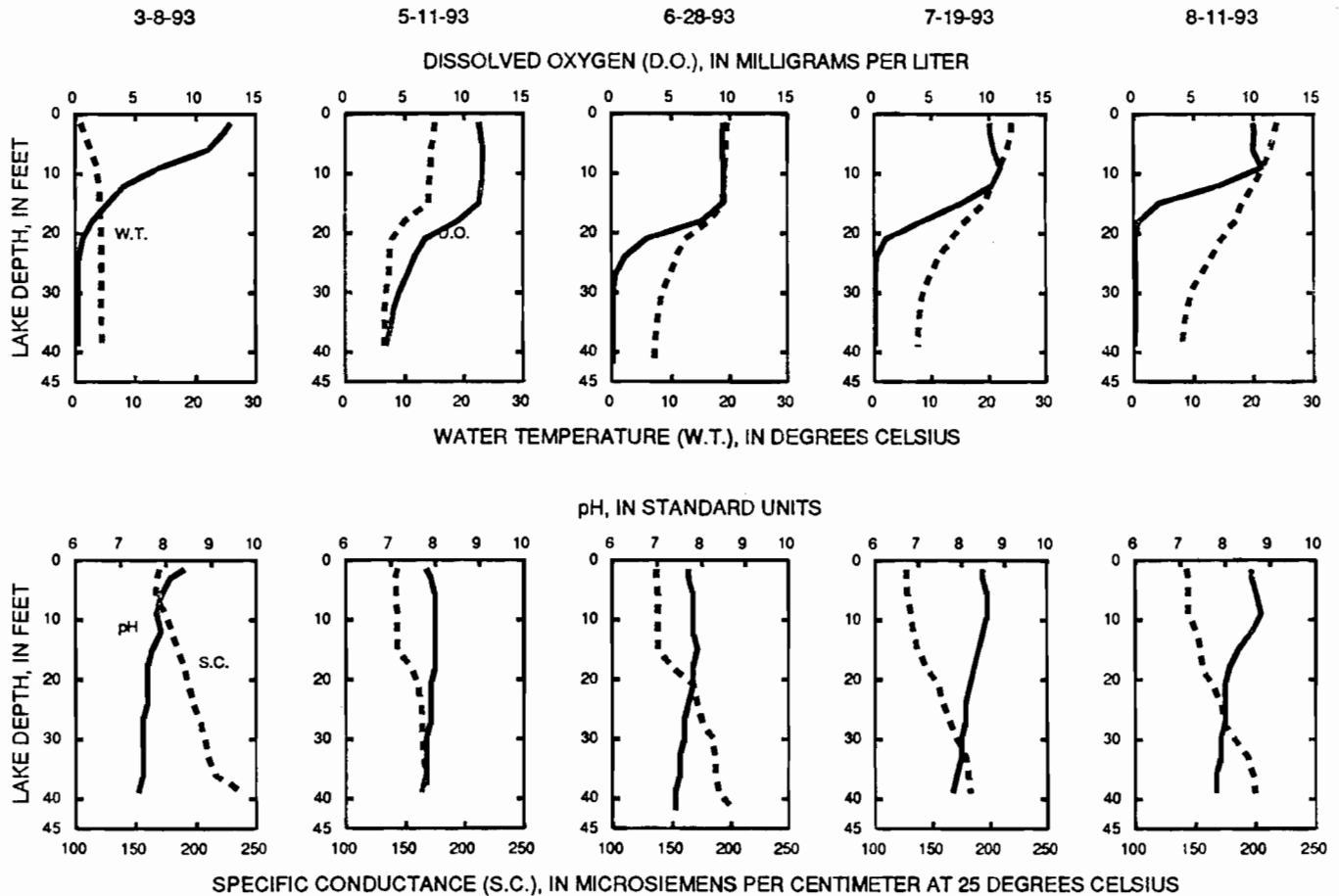


Figure 2. Lake water-quality data for Balsam Lake near Birchwood, 1993 water year

TROPHIC STATE INDICES
 BALSAM LAKE NEAR BIRCHWOOD, WI.
 WASHBURN COUNTY

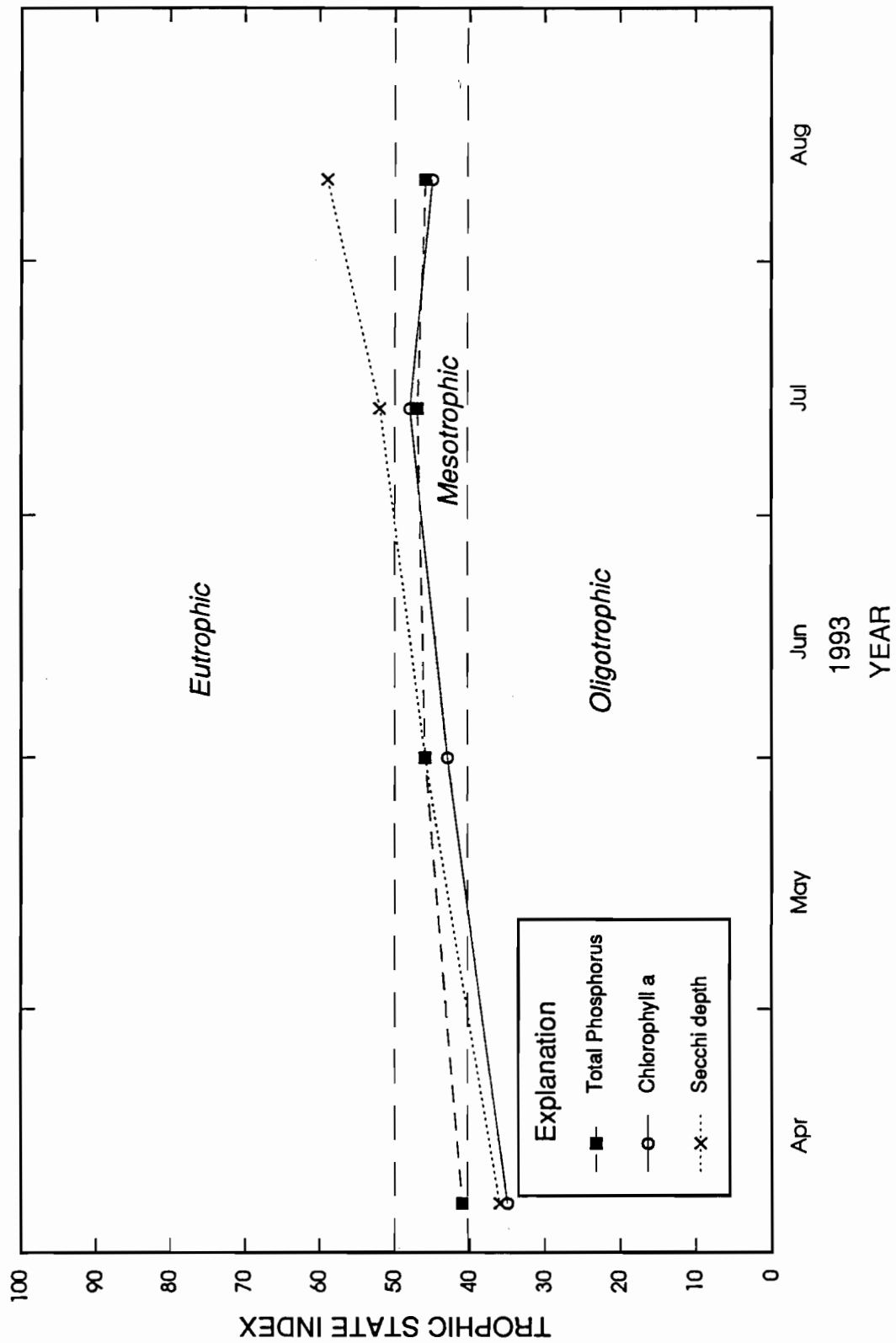


Figure 3. Trophic state indices for Balsam Lake near Birchwood, Wisconsin



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)

June 7, 1995

Ms. Mary Hele
3550 Edmund Boulevard
Minneapolis, Minnesota 55406

Dear Ms. Hele:

This letter describes the progress on the evaluation of the water quality of Balsam Lake according to the data collected from October 1993 to September 1994 as stated in our agreement. Please read the "U.S. Geological Survey Lake Monitoring Program in Wisconsin", sent to you previously, before proceeding with this letter.

In a brief summary, based on the 1994 data:

- The water quality of Balsam Lake is good to fair and can be classified as a mesoeutrophic lake or one with moderate to many nutrients. The water quality in 1994 is similar to 1993 based on Secchi-disc depths and total phosphorus and chlorophyll *a* concentrations.
- In March, June, July, and August, during summer stratification, oxygen disappears from the bottom portion of the lake which is then unable to support a fish population.
- During the summer anoxic (devoid of oxygen) period, there are moderate amounts of phosphorus being released from the bottom sediments.
- Algal growth appears to be dependent upon the amount of available phosphorus rather than nitrogen.
- The data enclosed herein are provisional until published.

Balsam Lake has a surface area of 295 acres (0.46 square miles) and a drainage area at State Highway 48 of 50,200 acres (78.5 square miles) for a drainage area/lake size ratio of 171:1. Lakes with drainage area/lake size ratios of greater than 10:1 tend to develop water-quality problems. (Uttomark, Paul D., and Mark L. Hutchins, 1978, Input/output models as decision criteria for lake restoration. University of Wisconsin-Madison, Wisconsin, Water Resources Center technical report No. 78-03, 61 pp.).

One site was sampled in Balsam Lake. It was located approximately at the deepest spot in the lake at a depth of about 42 feet and is shown in figure 1.

The data for this report are found in the following tables and figures:

Table 1. Lake-depth profiles for Balsam Lake near Birchwood, 1994 water year

Table 2. Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Balsam Lake near Birchwood, 1994 water year

Figure 1. Location of water-quality sampling sites and lake staff gage for Balsam, Red Cedar, and Hemlock Lakes

Figure 2. Lake water-quality data for Balsam Lake near Birchwood, 1994 water year

Figure 3. Trophic state indices for Balsam Lake near Birchwood

Figure 4. Surface total phosphorus and chlorophyll *a* concentrations and Secchi-disc depths for Balsam Lake near Birchwood, Wisconsin

All the water-quality samples collected were analyzed by the Wisconsin State Laboratory of Hygiene at Madison, Wisconsin. The water-quality data are published in our annual publications, "Water Resources Data for Wisconsin, 1994", and "Water-Quality and Lake-Stage Data for Wisconsin Lakes, Water Year 1994".

LAKE-STAGE FLUCTUATIONS

Lake stages were not read on Balsam Lake. However, lake stages were read on Red Cedar Lake by USGS personnel at the time of sampling. Balsam and Red Cedar Lake are connected by a channel; therefore, lake stages at Red Cedar Lake reflect those stages on Balsam Lake. Lake-stage data are listed on figure 2. Lake stages fluctuated 0.32 feet and ranged from 10.40 feet on June 16 to 10.72 feet on March 9.

LAKE-DEPTH PROFILES

Profiles of water temperature, dissolved oxygen, pH, and specific conductance at the deep hole are listed in table 1 and shown in figure 2. No abnormalities in the data are apparent. Among our sampling dates, almost complete water-column mixing was observed on May 4. The remainder of the profile data show incomplete mixing. The lake thermally stratifies during summer. During March, June, July and August, the water at the bottom of the lake became anoxic (devoid of oxygen) and was unable to support fish. The levels of pH are within acceptable limits to support aquatic life. Because of the high buffering capacity of the lake water, Balsam Lake is not susceptible to the effects of acid rain.

SELECTED ANALYSES

Analyses of selected constituents for May 4 for samples collected at 1.5 and 39-foot depths are listed in figure 2. The water-quality values for color, chlorophyll *a*, chlorides, 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.

To compute the nitrogen-phosphorus ratio, only the sample collected from the 1.5-foot sampling depth for May was used. This depth was used because algae grow in the upper part of the lake rather than at the bottom. The ratio of total nitrogen to phosphorus was calculated as 21:1 and suggests the lake is phosphorus-limited. This means algal growth appears to be dependent on the amount of available phosphorus rather than nitrogen.

MAY, JUNE, JULY AND AUGUST WATER QUALITY

The data for total phosphorus, chlorophyll a, and Secchi-depth readings, are listed in table 2 and on figure 2.

Total phosphorus: Total phosphorus concentrations sampled at a 1.5-foot depth range from 0.012 mg/L in June to 0.023 mg/L in May. All values fall within the regional values previously referenced.

Concentration of total phosphorus 1.5 feet above the lake bottom ranged from 0.030 mg/L in May to 0.448 mg/L in August. These concentrations are indicative of moderate phosphorus release from the bottom sediments during anoxic (absence of oxygen) periods.

Chlorophyll a: Chlorophyll a concentrations, which indicate algal biomass, ranged from 3.17 $\mu\text{g/L}$ in June to 11 $\mu\text{g/L}$ in August. These data are within the regional values.

Secchi disc: Secchi-disc depths, which indicate water clarity, ranged from 7.2 feet in August to 11.8 feet in June. These data are within the regional values.

TROPHIC STATUS

Lillie and Mason (1983) classified Wisconsin lakes using a random data set (summer, July and August) according to total phosphorus and chlorophyll a concentrations, and Secchi-disc depth. This evaluation is shown below:

Water quality index	Approximate total phosphorus equivalent (mg/L)	Approximate chlorophyll <u>a</u> equivalent ($\mu\text{g/L}$)	Approximate water clarity equivalent (Secchi-disc depth in ft)
Excellent	<0.001	<1	<19.7
Very good	.001-.010	1-5	9.8-19.7
Good	.010-.030	5-10	6.6-9.8
Fair	.030-.050	10-15	4.9-6.6
Poor	.050-.150	15-30	3.3-4.9
Very poor	>.150	>30	<3.3

Using the above criteria to evaluate the mean summer (July-August) 1994 data shown in table 3 for Balsam Lake, surface total-phosphorus concentrations and Secchi-disc depths indicate good water quality, while chlorophyll a concentrations indicate fair water quality.

Using the data from "Limnological Characteristics of Wisconsin Lakes," 1983, by Lillie and Mason, a comparison of the 1994 mean summer data (July and August) for total phosphorus, chlorophyll *a*, and Secchi depths for Balsam Lake to other lakes in northwest Wisconsin are shown below:

	<u>Parameter</u>	<u>Percentage of distribution of lakes in northwest Wisconsin within these concentrations</u>
	Total phosphorus (mg/L)	
	<.010	Best condition 12
Balsam Lake values →	.010-.020	35
	.020-.030	23
	.030-.050	18
	.050-.100	8
	.100-.150	3
	>.150	Worst condition 1
	Chlorophyll <i>a</i> (µg/L)	
	0- 5	Best condition 29
	5-10	36
Balsam Lake values →	10-15	14
	15-30	14
	>30	Worst condition 9
	Secchi depth (in feet)	
	9.8	Best condition 22
Balsam Lake values →	6.6- 9.8	29
	3.3- 6.6	30
	<3.3	Worst condition 19

Comparing other lakes in northwest Wisconsin to the 1994 data for Balsam Lake, the above data show, during the period 1966 to 1979, 53 percent had higher total phosphorous concentrations, 23 percent had higher chlorophyll *a* concentrations, and 49 percent had less water clarity.

A second approach to assessing the "health" or trophic status of a lake is to use Carlson's Trophic State Index (TSI). A graphic illustration of the Trophic State Index for Balsam Lake is shown on figure 3. The data from 1994 show Balsam Lake to be mesoeutrophic or one with moderate to many nutrients.

Ms. Mary Hele, June 7, 1995

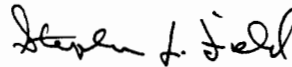
5

Surface total phosphorus and chlorophyll a concentrations and Secchi-disc depths for the period of record for Balsam Lake are shown in figure 4. The water quality is similar for both years.

The data that has been collected for Balsam Lake from 1993 and 1994 is extremely important for understanding the lake's water quality and managing the lake. To continue with the monitoring will help to build a very valuable data base.

If you have any questions regarding this evaluation, please contact me at 608/276-3842.

Sincerely,



Stephen J. Field
Biologist

Enclosures

cc: Dan Ryan, DNR, Spooner

Table 2.--Water clarity and water-quality analyses and their associated Trophic State Indices (TSI) for Balsam Lake near Birchwood, 1994 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)	T.S.I.		Conc. (mg/L)	Conc. (µg/L)	T.S.I.	Conc. (µg/L)	T.S.I.	
05/04/94	2.4	7.9	47	1.5	0.023	23	52	10.6	53	<0.002
	-	-	-	39	0.030	30	-	-	-	<0.002
06/16/94	3.6	11.8	42	1.5	0.012	12	47	3.17	44	--
	-	-	-	39	0.320	320	-	-	-	--
07/14/94	2.4	7.9	47	1.5	0.016	16	50	9.28	52	--
	-	-	-	39	0.330	20	-	-	-	--
08/18/94	2.2	7.2	49	1.5	0.017	17	50	11	53	--
	-	-	-	39	0.448	448	-	-	-	--

LOCATION.--Lat 45°39'07", long 91°34'58", in NE 1/4 NE 1/4 sec.34, T.37 N., R.10 W., Washburn County, Hydrologic Unit 07050007, 1.2 mi southwest of Birchwood.

PERIOD OF RECORD.--March 1993 to August 1994 (discontinued).

REMARKS.--Lake sampled near southern end of Balsam Lake at a lake depth of about 43 ft. Lake ice-covered during March sampling. Water-quality analyses by Wisconsin State Laboratory of Hygiene.

WATER-QUALITY DATA, MARCH 09 TO AUGUST 18, 1994
(Milligrams per liter unless otherwise indicated)

	Mar. 09		May 04		June 16		July 14		Aug. 18	
Depth of sample (ft)	1.5	42	1.5	39	1.5	39	1.5	39	1.5	39
Lake stage (ft)	10.72		10.66		10.40		10.50		10.50	
Specific conductance (µS/cm)	167	234	160	162	161	180	143	169	141	179
pH (units)	8.1	7.4	8.4	7.8	7.8	7.7	8.3	7.8	8.4	7.7
Water temperature (°C)	1.5	4.5	8.5	7.0	22.5	9.0	22.5	9.0	23.0	9.5
Color (Pt-Co. scale)	---	---	10	10	---	---	---	---	---	---
Turbidity (NTU)	---	---	1.1	1.3	---	---	---	---	---	---
Secchi-depth (meters)	---	---	2.4	---	3.6	---	2.4	---	2.2	---
Dissolved oxygen	12.8	0.1	11.5	8.8	9.1	0.1	10.8	0.1	10.5	0.1
Hardness, as CaCO3	---	---	81	81	---	---	---	---	---	---
Calcium, dissolved (Ca)	---	---	21	21	---	---	---	---	---	---
Magnesium, dissolved (Mg)	---	---	7.0	7.0	---	---	---	---	---	---
Sodium, dissolved (Na)	---	---	3.0	3.0	---	---	---	---	---	---
Potassium, dissolved (K)	---	---	0.8	0.8	---	---	---	---	---	---
Alkalinity, as CaCO3	---	---	81	82	---	---	---	---	---	---
Sulfate, dissolved (SO4)	---	---	4.0	4.0	---	---	---	---	---	---
Chloride, dissolved (Cl)	---	---	2.4	2.4	---	---	---	---	---	---
Fluoride, dissolved (F)	---	---	0.0	0.0	---	---	---	---	---	---
Silica, dissolved (SiO2)	---	---	15	15	---	---	---	---	---	---
Solids, dissolved, at 180°C	---	---	108	108	---	---	---	---	---	---
Nitrogen, NO2 + NO3, diss. (as N)	---	---	0.08	0.12	---	---	---	---	---	---
Nitrogen, ammonia, dissolved (as N)	---	---	0.04	0.10	---	---	---	---	---	---
Nitrogen, amm. + org., total (as N)	---	---	0.40	0.40	---	---	---	---	---	---
Nitrogen, total (as N)	---	---	0.48	0.52	---	---	---	---	---	---
Phosphorus, total (as P)	---	---	0.023	0.030	0.012	0.320	0.016	0.330	0.017	0.448
Phosphorus, ortho, dissolved (as P)	---	---	<0.002	<0.002	---	---	---	---	---	---
Iron, dissolved (Fe) µg/L	---	---	<50	<50	---	---	---	---	---	---
Manganese, dissolved (Mn) µg/L	---	---	<40	140	---	---	---	---	---	---
Chlorophyll a, phytoplankton (µg/L)	---	---	11	---	3.2	---	9.3	---	11	---

3-9-94

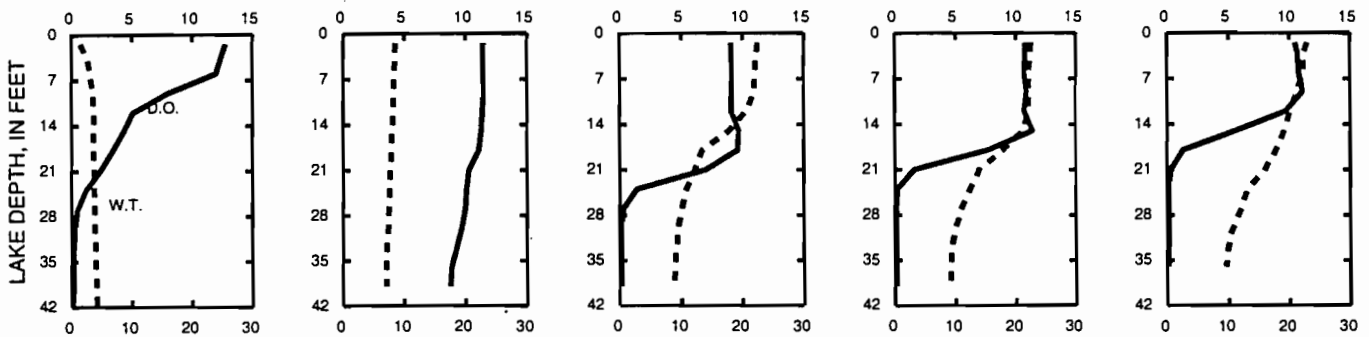
5-4-94

6-16-94

7-14-94

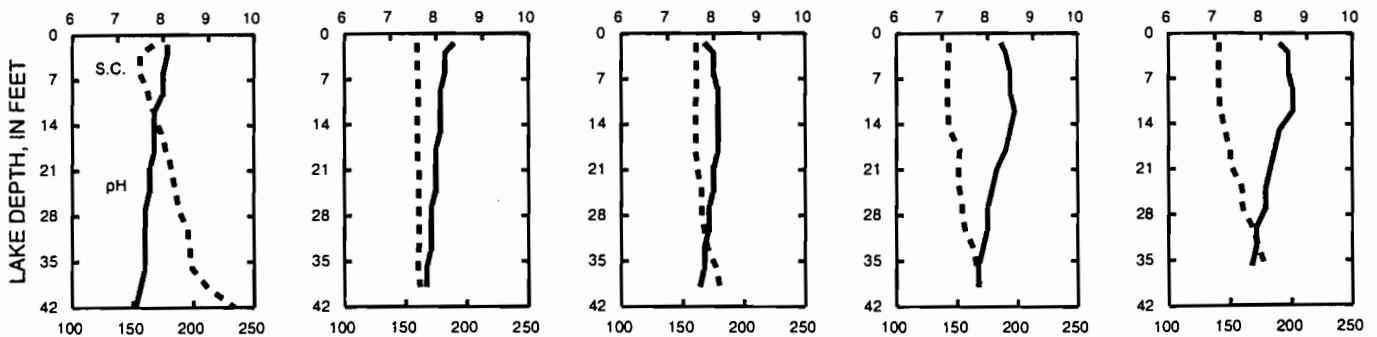
8-18-94

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. Lake water-quality data for Balsam lake near Birchwood, 1994 water year

TROPIC STATE INDICES
 BALSAM LAKE NEAR BIRCHWOOD, WI.
 WASHBURN COUNTY

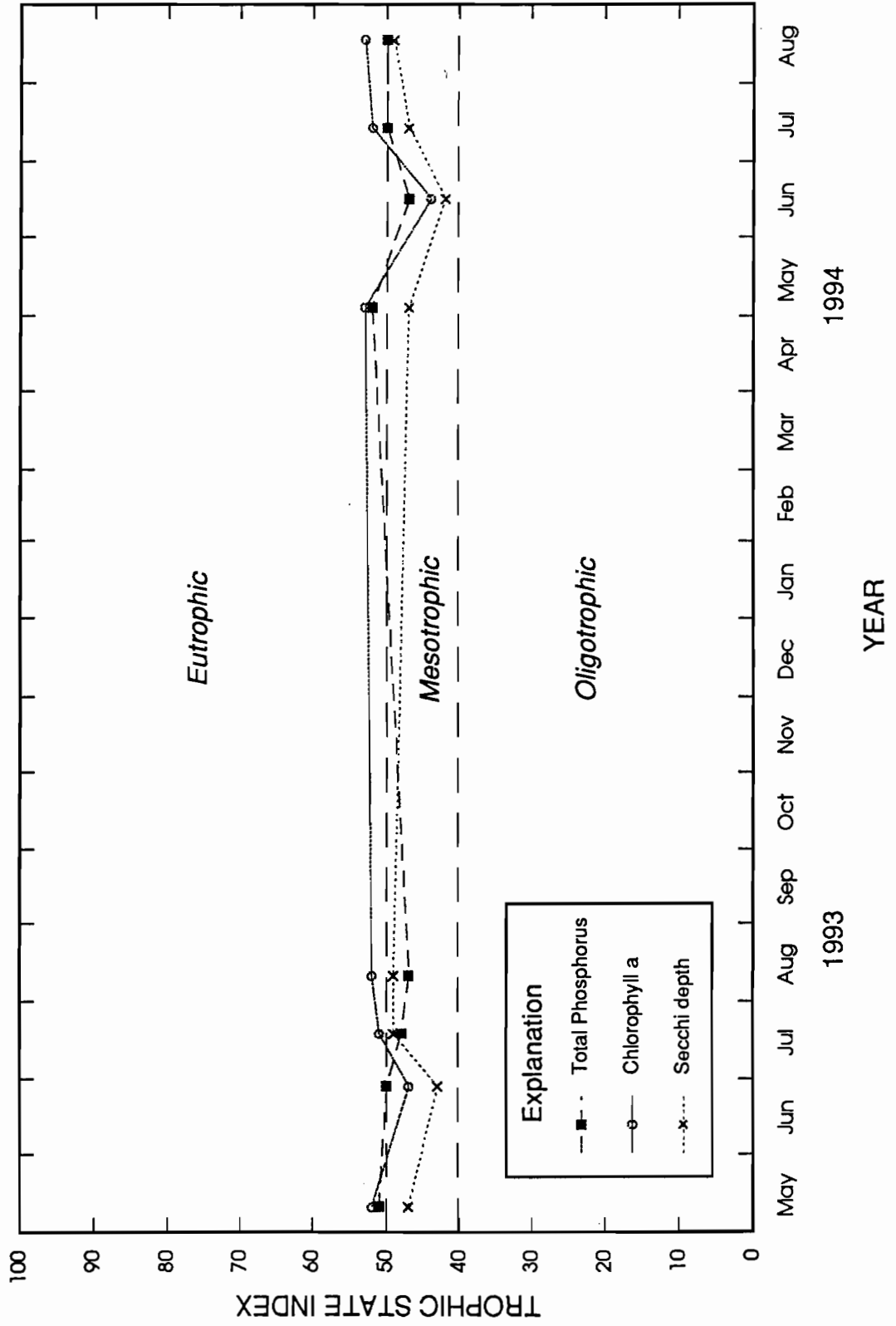


Figure 3. Trophic state indices for Balsam lake near Birchwood

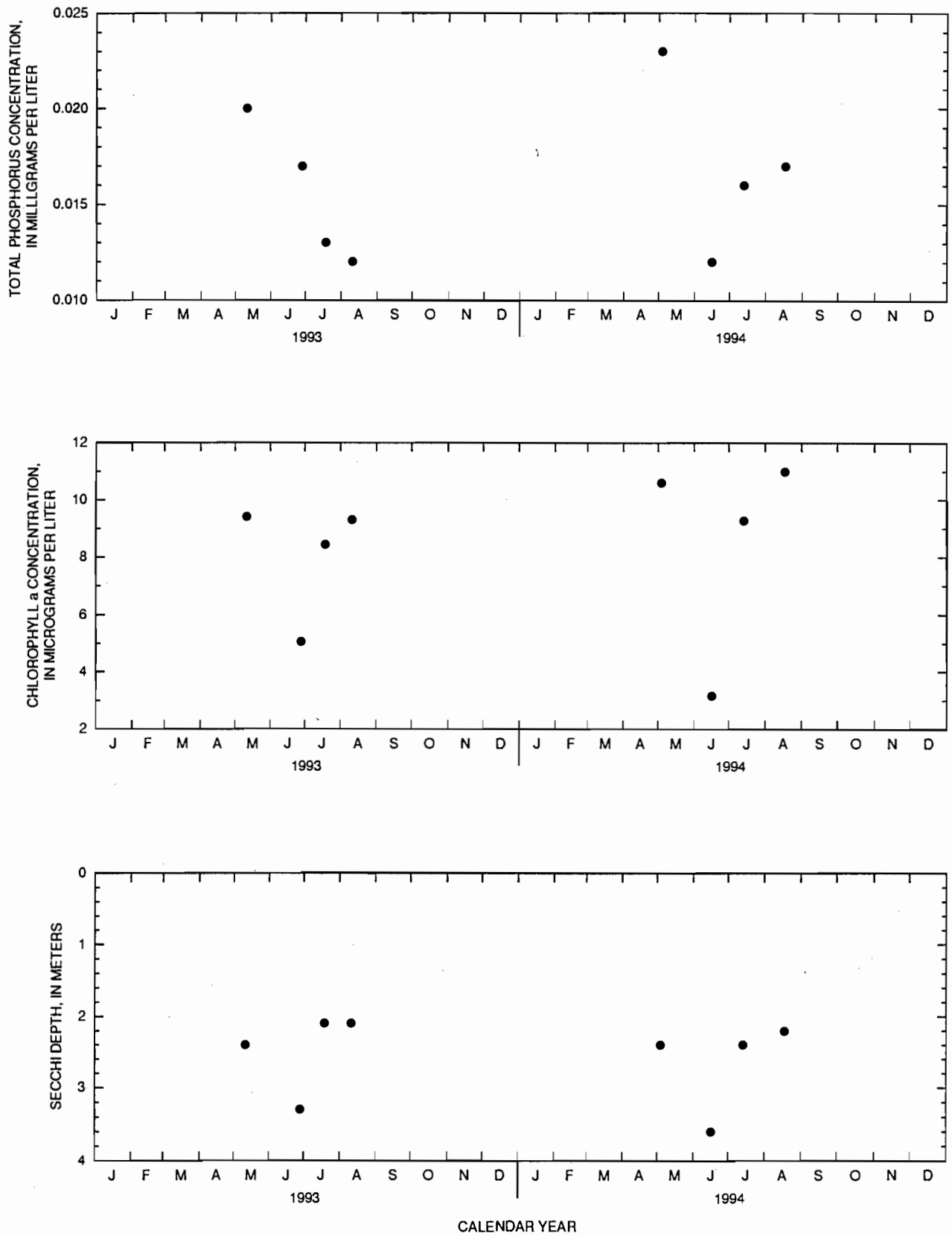


Figure 4.-- Surface total phosphorus and chlorophyll a concentrations, and Secchi depths for Balsam Lake near Birchwood, Wisconsin.