ASSESSMENT OF WATER QUALITY IN SYLVAN LAKE

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July, 1999

W9908

Pub. No: T/727
ISBN: 0-7785-3128-7 (Printed Edition)
ISBN: 0-7785-3129-5 (On-Line Edition)
Web Site: http://www3.gov.ab.ca/env/info/infocentre/publist.cfm

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Assessment of Water Quality in Sylvan Lake

Natural Resources Service of Alberta Environment has monitored the water quality of Sylvan Lake each year since 1983, except for 1991 and 1998. This long period of record provides an excellent database from which to determine whether water quality in the lake is changing. Staff of Sylvan Lake/Jarvis Bay Provincial Park collect the samples, Monitoring Branch processes them, and Water Sciences Branch interprets the data. This brief report updates information sent to Alberta Parks in 1996.

General physical characteristics of Sylvan Lake are presented in Table 1, and Figure 1 is a hydrographic survey map. The lake is moderately deep, with a maximum depth of about 18 m. There is no control structure on the outlet, which flows only intermittently; the outlet flows to Cygnet Lake and then to the Red Deer River. Water levels in the lake fluctuate over a range of about 1 m (Figure 2). In the last few years, the water level has been in the upper part of its natural range.

The focus of the water quality monitoring program is on levels of phosphorus, an essential nutrient for plants, and on the amount of algae in the water, as indicated by its chlorophyll *a* content. In most lakes, the greenness of the water is directly related to the amount of phosphorus present, because phosphorus is usually the nutrient in shortest supply. Thus, algae suspended in the water grow in proportion to the amount of phosphorus present. This is also true for rooted aquatic vegetation, but these plants can take nutrients from the bottom sediment, which is often rich in phosphorus, nitrogen and other nutrients. Along with water clarity or transparency, the measurement of phosphorus and chlorophyll *a* concentrations in lake water provides a simple, straightforward way to assess lake water quality for recreation. Lake users associate good water quality with clear water; poor water quality is green, turbid and scummy. They also prefer a lake that is relatively free of "weeds", the submersed or floating aquatic vegetation along the shoreline that are more correctly termed "macrophytes". However, assessment of the amount and density of these plants is difficult - much more so than collecting and analysing a water sample to assess its algal content. Macrophyte surveys are not routinely conducted during lake water quality sampling programs. Recreational water quality also includes a measure of the bacterial content of the water, but bacteria from sewage sources would not show up in samples collected over the whole lake because they would quickly become diluted and dispersed. Results of bacteriological monitoring along provincial park beaches are not reported here.

On several occasions each summer, whole-lake composite samples were collected for analysis of total phosphorus and chlorophyll *a* so that seasonal patterns could be assessed. The transparency of the water was measured with a Secchi disk. As well, quarterly samples were collected to analyse routine water chemistry, e.g., major ions, alkalinity and hardness. Temperature, dissolved oxygen and other variables were measured at one-metre depth intervals from the lake surface to the bottom occasionally during summer and winter.

Routine water chemistry for the lake is listed in Table 2. Levels of major ions in Sylvan Lake are fairly low and within the range of ion levels in many central Alberta lakes. The dominant ions are sodium and bicarbonate. Concentrations of most of the ions did not change between 1989 and 1995, but sulphate levels declined somewhat for unknown reasons. There has been little change in concentrations of ions since 1995.

Lake water quality varies over the summer, but Sylvan Lake is somewhat less variable than what might occur in a more productive lake. Figure 3 shows seasonal variations for two fairly typical years. Sylvan Lake maintains clear water and low concentrations of chlorophyll *a* through most of the summer. For most years sampled, the greatest amount of algae in the water occurred in September. Secchi disk readings were lowest when chlorophyll concentrations were highest, indicating that the main cause of turbidity is suspended algae, rather than sediment stirred up from the bottom.

Figure 4 portrays summer average values for Secchi depths and levels of phosphorus and chlorophyll *a* for the 14 years of data. The lowest recorded individual chlorophyll concentration occurred in June 1994 (0.4 mg/m^3) and the highest in September 1990 (16.9 mg/m^3); the lowest phosphorus concentration occurred in August 1992 (14 mg/m^3) and the highest occurred in May 1996 (36 mg/m^3). Such differences from year to year result largely from natural factors, such as the amount of snowmelt runoff in spring and the amount of phosphorus that is recycled from the bottom sediments in summer. As well, the timing of sample collection, particularly when only three or four samples are collected over the summer, is an important factor in these year-to-year differences. Sylvan Lake was also sampled in 1973 and 1974. Although the phosphorus data collected then are considered unreliable, the chlorophyll *a* data are accurate. Average values for chlorophyll were 4.4 mg/m^3 for 1973 and 4.1 mg/m^3 for 1974, very similar to present-day levels. The Secchi depths measured at that time were 5.0 and 4.4, respectively, which are also similar to present-day values.

Overall average values for chlorophyll *a*, phosphorus and Secchi depth in Sylvan Lake are compared with those from other provincial park lakes in Table 3. The “Trophic Status” column indicates the level of productivity for each of these lakes, with *oligotrophic* being least productive, *hypereutrophic* the most productive. Sylvan Lake falls into the *mesotrophic* or low productivity category. This is an ideal level of productivity for a recreational lake, because the water remains quite clear, but there is usually enough aquatic vegetation to support a good fish population.

Lake surface to bottom measurements of temperature and dissolved oxygen concentrations have been made occasionally in both summer and winter. Figure 5 shows examples of these “profiles” of dissolved oxygen and temperature in Sylvan Lake. The winter profile, in February 1993, shows that there was sufficient dissolved oxygen throughout the water column to overwinter fish populations, although levels declined near the bottom. Winterkills of sportfish have never been recorded in this lake. The temperature was highest near the bottom, which is typical of lake water under ice.

The summer profile for temperature, in August of 1995, suggests that there was weak thermal stratification, although the thermocline (area of maximum temperature difference) was very deep. Profiles from other years suggest that the formation of temperature layers in Sylvan Lake is of short duration. Strong winds from the northwest will mix the lake completely, as occurred in August 1986. Such a mixing event in midsummer may contribute to enhanced growth of algae, because nutrient-rich water from the bottom of the lake would produce a "fertilizing" effect for growing algal populations in the upper layer. This may further explain year to year variability in this lake.

Sylvan Lake has very good water quality. It is one of the best recreational lakes in central Alberta, perhaps because the drainage basin surrounding it is very small compared with its size. There is no evidence that it has deteriorated over the past two decades. However, it is likely that human activities in the watershed have increased the phosphorus supply to the lake. Phosphorus contributed by cottages, agriculture, road building, urban areas, golf courses – any activity that removes natural vegetation – is likely being taken up by the bottom sediments of the lake. Eventually, this excess phosphorus may return to the water from the bottom, degrading water quality in the lake. This could take the form of intense blooms of blue-green algae or dense macrophyte growth. Everyone interested in protecting this valuable resource should make a concerted effort to reduce the nutrient supply. On-going projects along this line are now under way on Pine Lake, Gull Lake, Lac Ste. Anne, Lake Isle and Sandy Lake.

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Table 1. Physical characteristics of Sylvan Lake.	
Surface Area	42.8 km^2
Volume	412 million m^3
Maximum Depth	18.3 m
Average Depth	9.6 m
Drainage Basin Area	102 km^2

Table 2. Average concentrations of major ions and related variables for Sylvan Lake, 1989-1995. Number of samples = 16.	
pH (range)	8.73 -9.00
Specific Conductance, uS/cm	586
Total Dissolved Solids, mg/L	338
Iron, mg/L	0.01
Calcium, mg/L	17
Magnesium, mg/L	37
Total Hardness, mg/L	197
Sodium, mg/L	66
Potassium, mg/L	6.8
Fluoride, mg/L	0.13
Sulphate, mg/L	12
Chloride, mg/L	1.8
Silica, mg/L	1.6
Total Alkalinity, mg/L as CaCO3	330
Bicarbonate, mg/L	353
Carbonate, mg/L	24

Table 3. Mean summer concentrations of phosphorus and chlorophyll *a* and Secchi depth in provincial park lakes, 1983 to 1997-98. Trophic status is based on average level of chlorophyll *a* for summer.

	Trophic Status*	Chlorophyll µg/L	Total Phosphorus µg/L	Secchi Depth m	Average No. of Samples	Years of Data	
Beauvais	ME	8.0	26.1	2.9	5	14	1984-1997
Buffalo Main Bay	E	9.6	68.0	2.2	5	11	1983-1996**
Buffalo Secondary	E	11.0	77.0	1.5	5	8	1983-1996**
Cardinal	HE	82.6	262.2	0.4	5	6	1992-1997
Chain Lakes (avg)	M	7.5	31.5	1.4	2	5	1990-1994
Crimson	M	5.8	20.8	3.0	3	13	1984-1997
Dillberry	M	3.6	17.9	3.7	4	11	1984-1997
Elkwater	M	6.4	39.0	2.6	5	16	1982-1997
Garner	M	7.5	36.5	4.6	4	13	1984-1997
Gregg	O	1.5	8.2	5.8	3	10	1988-1997
Gregoire	E	8.9	29.4	2.4	5	9	1989-1997
Gull	E	8.4	46.0	2.6	4	13	1983-1997
Jarvis	O	1.3	8.7	6.6	3	10	1988-1997
La Biche	HE	17.7	112.1	2.4	4	3	1995-1997
Long	E	22.3	54.3	2.4	5	15	1983-1997
McLeod East	E	9.1	23.6	3.4	4	14	1984-1997
Miquelon	M	2.5	207.0	2.4	3	6	1991-1997
Moonshine	E	23.3	159.5	2.0	4	15	1983-1997
Moose	E	17.4	43.4	2.6	4	15	1983-1997
Newell	M	5.5	19.4	3.5	4	13	1983-1998
North Buck	E	9.4	32.0	2.2	4	7	1991-1997
Pigeon	E	15.4	32.4	2.2	4	15	1983-1997
Police Outpost	M	5.3	28.7	3.0	3	8	1991-1998
Reesor	E	9.9	30.8	3.3	5	16	1982-1997
Saskatoon	HE	35.4	821.2	0.8	4	12	1986-1997
Spruce Coulee	M	5.1	23.0	4.3	5	16	1982-1997
Steele	HE	41.8	110.0	2.1	4	15	1983-1997
Sturgeon Main	HE	32.8	88.7	2.5	4	15	1983-1997
Sylvan	**M**	**4.3**	**21.2**	**4.7**	**4**	**14**	**1983-1997**
Thunder	HE	30.0	68.6	1.7	6	15	1983-1997**
Touchwood	M	3.4	18.2	3.7	4	4	1995-1998
Travers	O	2.5	15.6	3.8	5	15	1983-1997
Wabamun-Main	E	11.8	34.6	2.3	6	14	1983-1996**
Wabamun-Moonlight	M	4.3	28.9	2.1	3	5	1992-1997
Winagami	HE	48.1	151.0	2.0	5	15	1983-1997

*Trophic Status:
- O = Oligotrophic (average summer chlorophyll *a* less than 2.5 µg/L)
- M = Mesotrophic (average summer chlorophyll *a* between 2.5 and 8 µg/L)
- E = Eutrophic (average summer chlorophyll *a* between 8 and 25 µg/L)
- HE = Hypereutrophic (average summer chlorophyll *a* greater than 25 µg/L)

** Includes data from other sampling programs

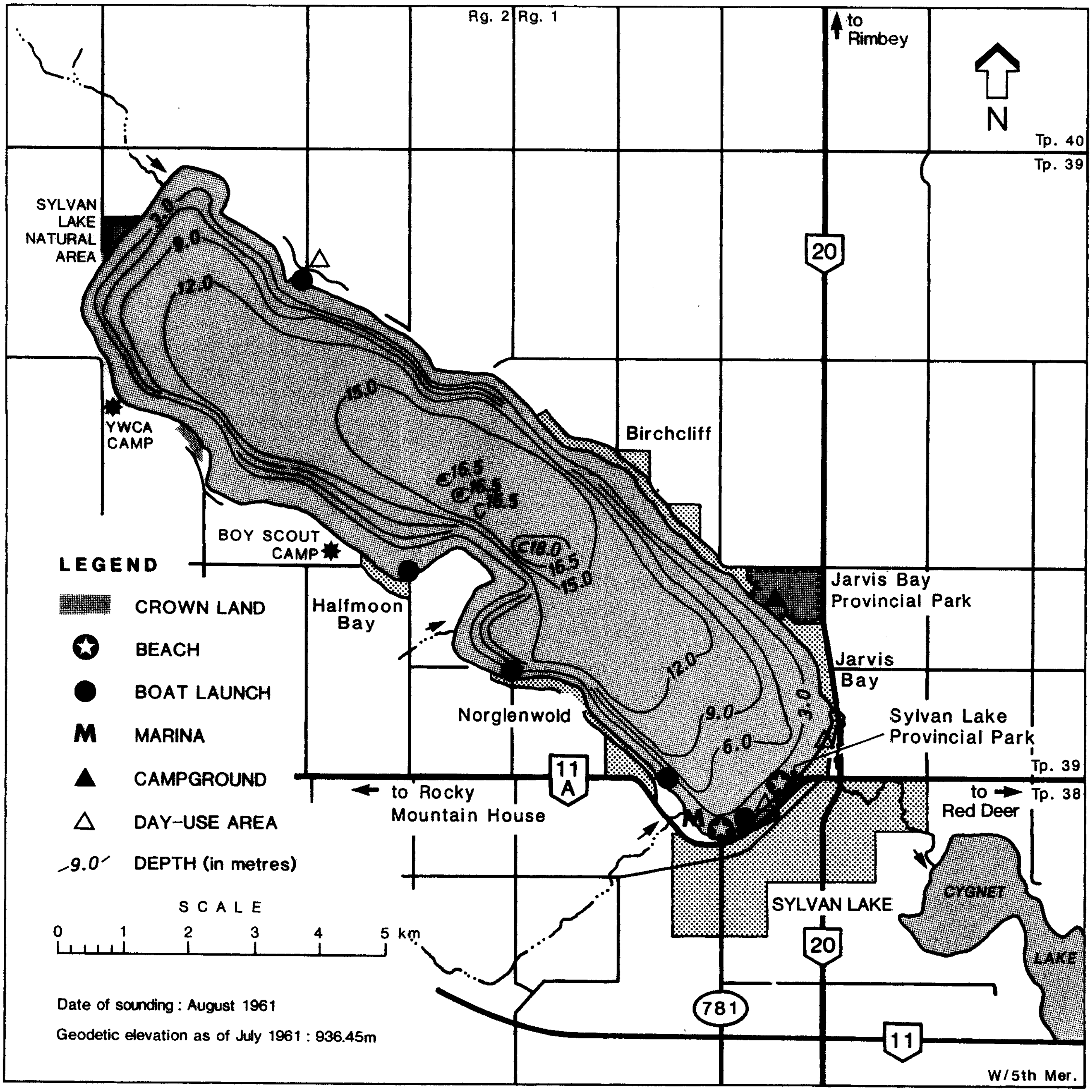

Figure 1. Bathymetric map of Sylvan Lake

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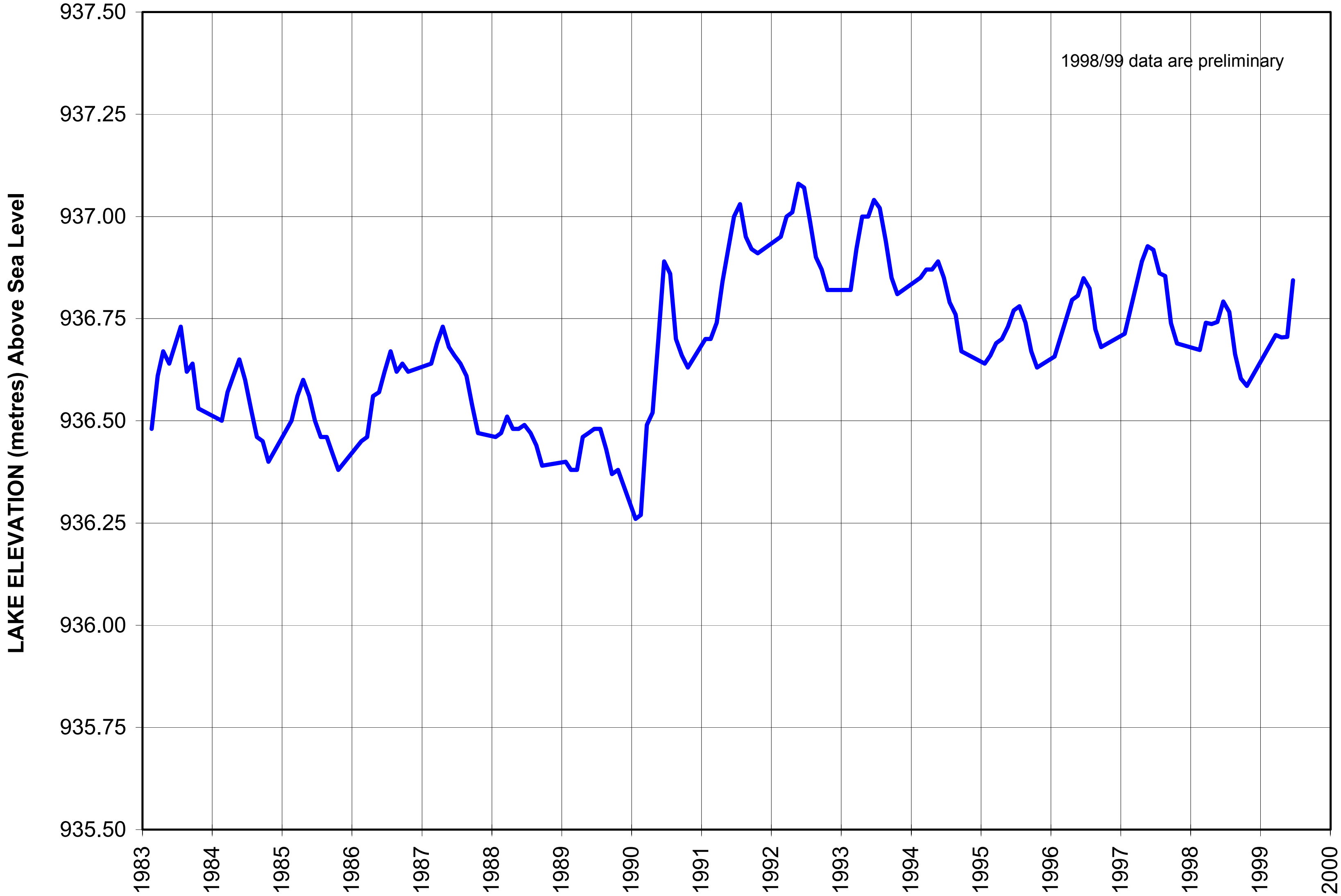

Figure 2. Monthly mean lake level for Sylvan Lake (station no. 05CC003).

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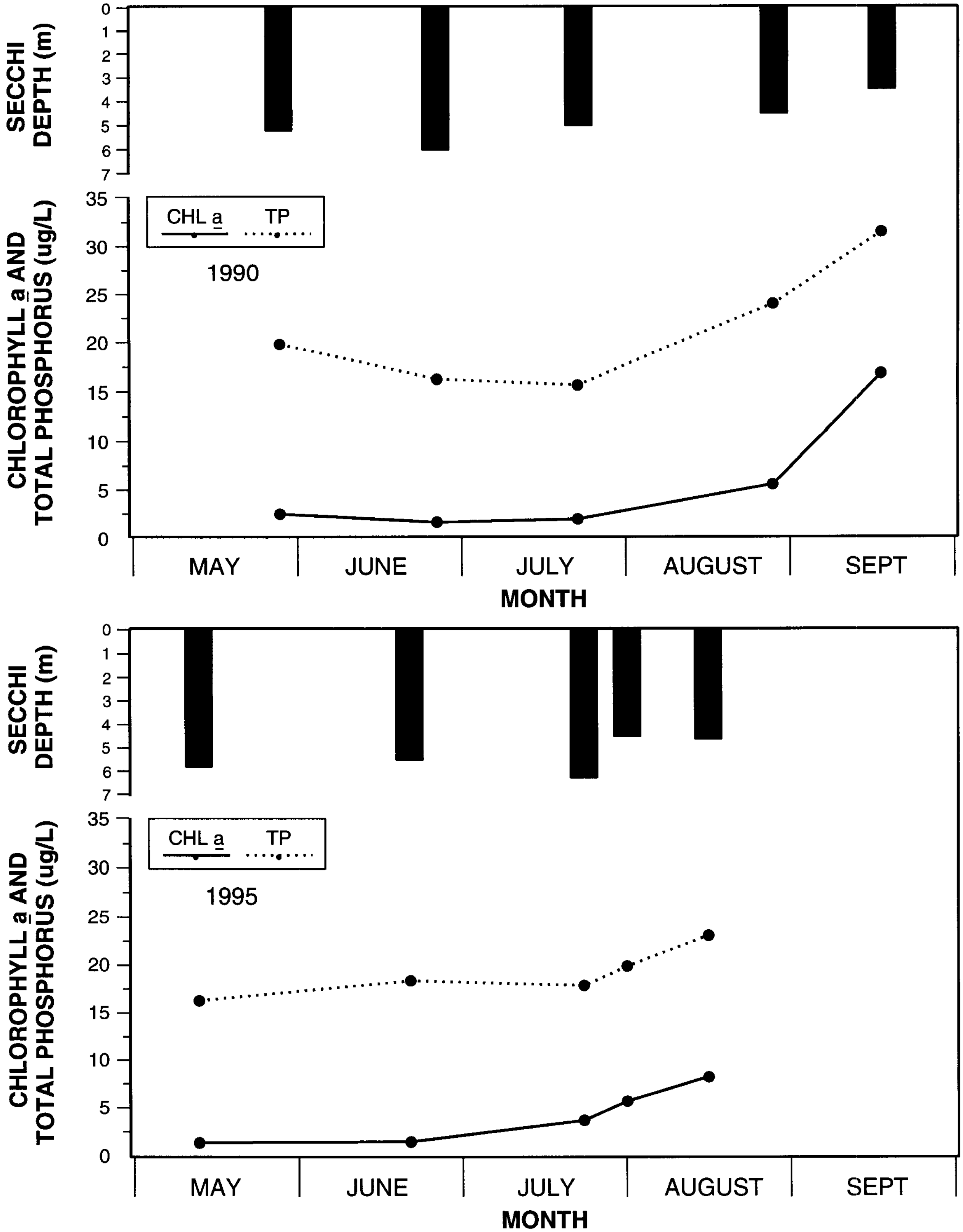

Figure 3. Secchi depth and concentrations of total phosphorus and chlorophyll a in Sylvan Lake, 1990 and 1995.

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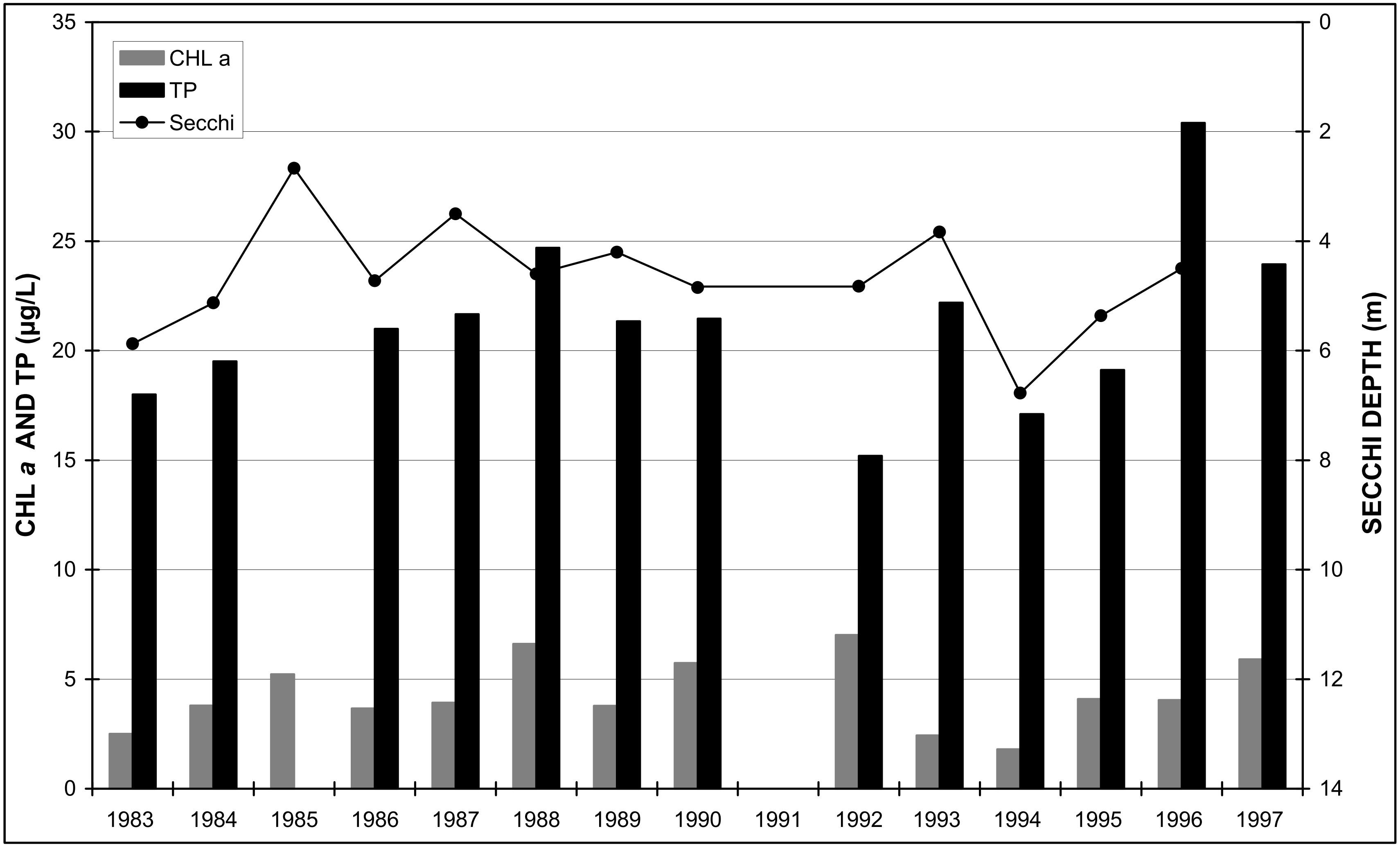

Figure 4. Average open-water Secchi depth and concentrations of chlorophyll *a* and total phosphorus in Sylvan Lake.

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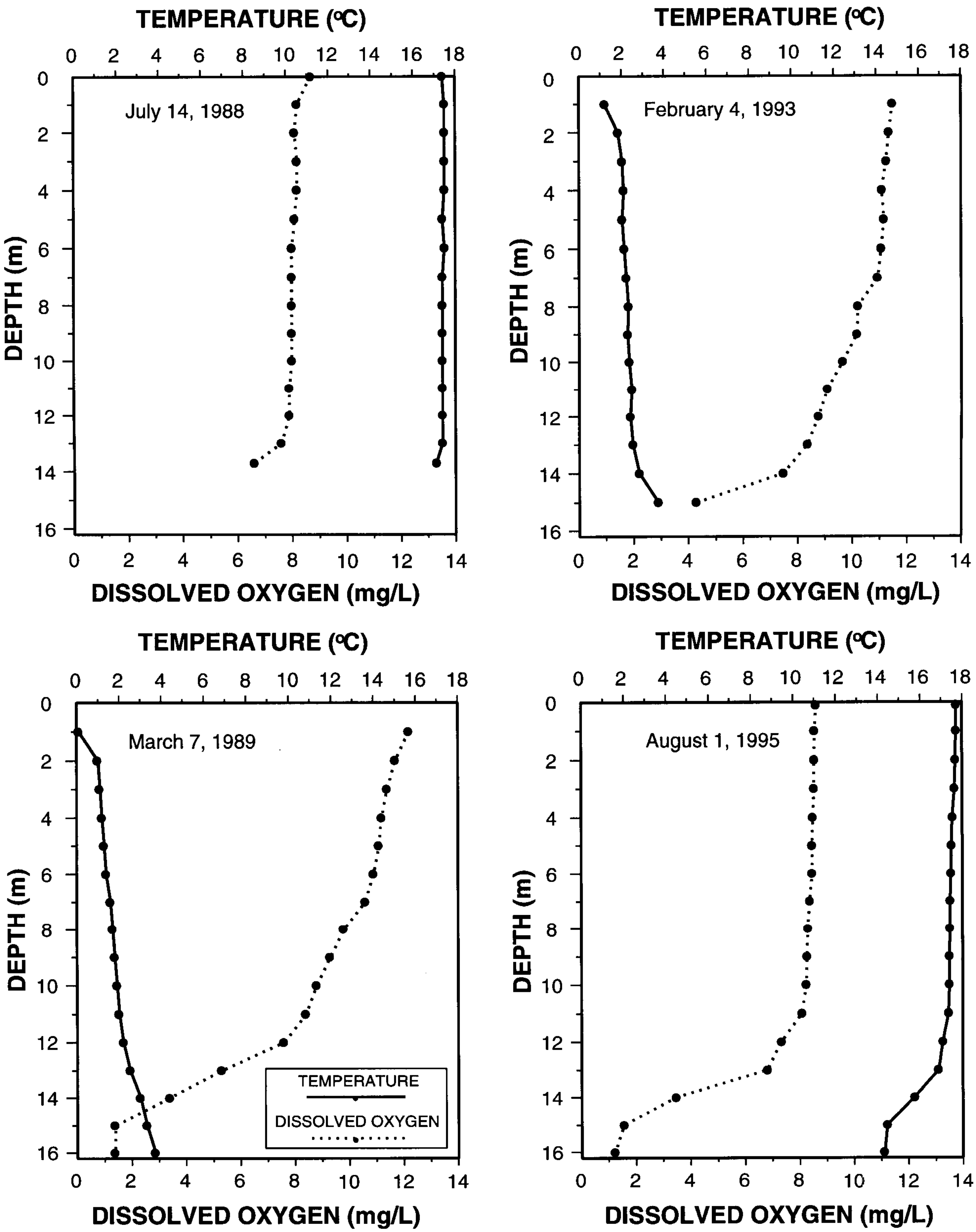

Figure 5. Vertical profiles of temperature and dissolved oxygen in Sylvan Lake, 1988, 1989, 1993 and 1995.

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