WATER QUALITY OF ROGERS LAKE, DAKOTA COUNTY, MINNESOTA

U. S. GEOLOGICAL SURVEY

Water-Resources Investigations 80-5

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Construction of an interstate highway is planned near Rogers Lake in Dakota County, Minn. Samples of water and bed material were collected at six sites during March 1976 to April 1978 to determine selected physical, chemical, and biological characteristics before construction. Samples were collected at least twice during each season of the year. Data derived from these samples will provide baseline information to aid in assessing the impact of highway construction on the water quality of the lake. Rogers Lake is separated into an upper and lower lake by a culvert; both were eutrophic and dominated by blue-green algae year around.

Analyses of water from Rogers Lake suggest that sodium and chloride concentrations were higher than in ground water or in water in some surrounding lakes. Sodium ranged from 7.2 to 55 milligrams per liter, and chloride ranged from 15 to 30 milligrams per liter. Concentrations were highest in March 1978, when most of the lake water was frozen. Much of the sodium and chloride may have been derived from road salts used for deicing.

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DAKOTA COUNTY, MINNESOTA

By M. R. Have

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Minnesota Department of Transportation

January 1980

UNITED STATES DEPARTMENT OF THE INTERIOR

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GEOLOGICAL SURVEY

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CONVERSION FACTORS

Multiply inch-pound unit	By	To obtain SI units
acre	0.4047	hectare (ha)
foot (ft)	.3048	meter (m)
inch (in)	25.4	millimeter (mm)

WATER QUALITY OF ROGERS LAKE, DAKOTA COUNTY, MINNESOTA

By M. R. Have

ABSTRACT

Construction of an interstate highway is planned near Rogers Lake in Dakota County, Minn. Samples of water and bed material were collected at six sites during March 1976 to April 1978 to determine selected physical, chemical, and biological characteristics before construction. Samples were collected at least twice during each season of the year. Data derived from these samples will provide baseline information to aid in assessing the impact of highway construction on the water quality of the lake.

Rogers Lake is separated into an upper and lower lake by a culvert; both were eutrophic and dominated by blue-green algae year around. The upper lake is a closed basin; it is shallower and contains less water than the lower lake and had higher concentrations of dissolved solids, nitrogen, and phosphorus. Phytoplankton cell counts were also higher in the upper lake.

Analyses of water from Rogers Lake suggest that sodium and chloride concentrations were higher than in ground water or in water in some surrounding lakes. Sodium ranged from 7.2 to 55 milligrams per liter, and chloride ranged from 15 to 130 milligrams per liter. Concentrations were highest in March 1978, when most of the lake water was frozen. Much of the sodium and chloride may have been derived from road salts used for deicing.

INTRODUCTION

Construction of Interstate Highway I-35E near Rogers Lake in Dakota County, Minn. (fig. 1) has been proposed by the Minnesota Department of Transportation. As part of an environmental impact study, a water-quality assessment during preconstruction, construction, and post-construction phases is planned. The purpose of this study is to provide preconstruction water-quality data for Rogers Lake.

ENVIRONMENTAL SETTING

Rogers Lake is in the Twin Cities Metropolitan Area in the municipality of Mendota Heights. The lake fills an ice-block depression in till of the St. Croix moraine formed during Wisconsin Glaciation (Bray, 1977).

Rogers Lake has a surface area of 116 acres and is divided into an upper and lower lake by Dakota County Road 16 (fig. 1). A culvert under the road connects the lakes, but it was plugged during the time of the study. Rogers Lake is, in effect, two separate lakes (hereafter Rogers Lake or "the lake" refers to both).

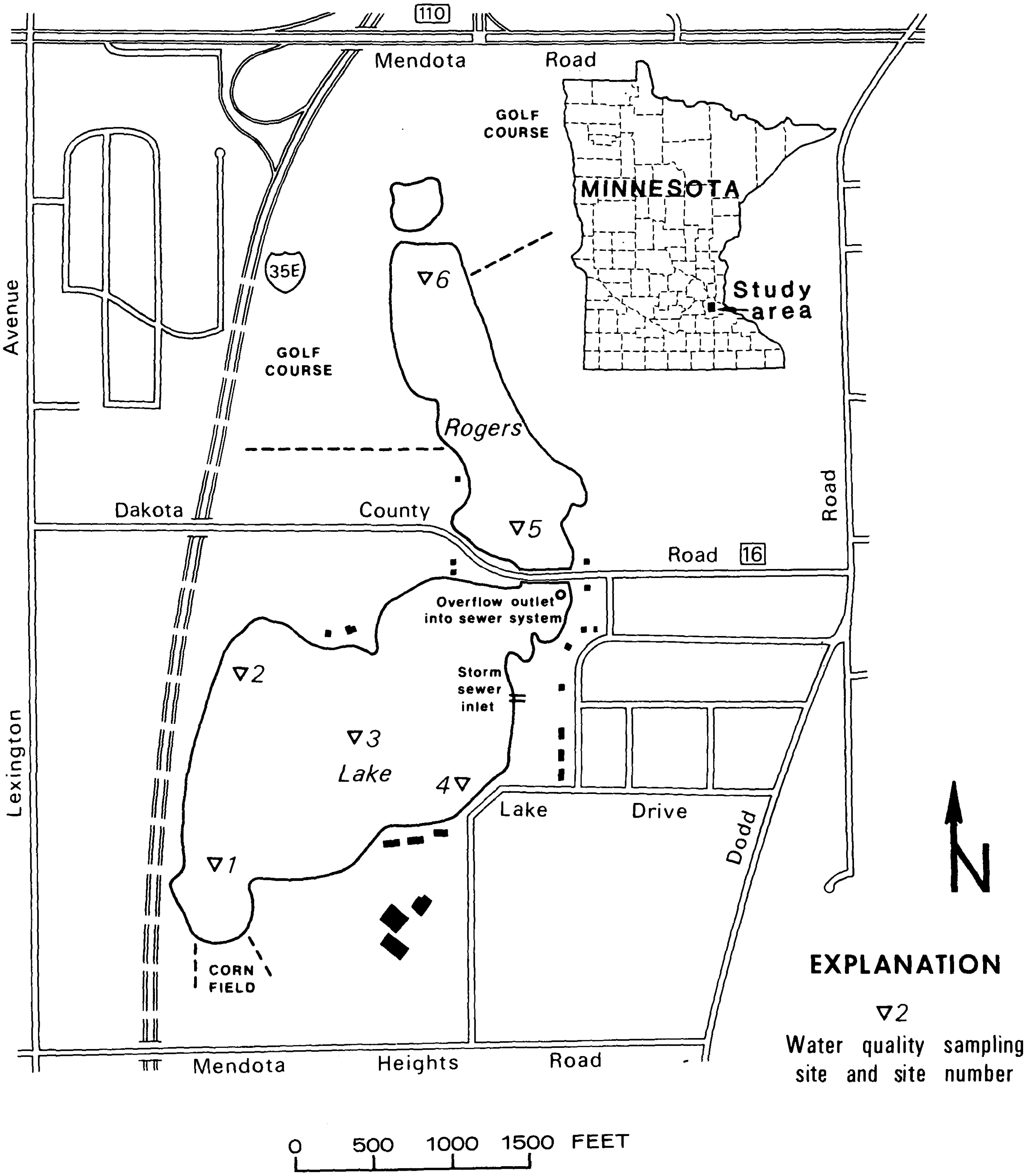

Figure 1.--Sampling sites at Rogers Lake, Dakota County

Rogers Lake has no natural surface-water inlets or outlets; however, the lower lake receives water from a storm-sewer inlet on the east side (fig. 1). This storm sewer drains the residential area immediately east of the lake. An overflow at the northeast corner of the lower lake empties into the municipal sewer system.

The area around Rogers Lake is moderately developed (fig. 1). A golf course borders most of the upper lake; the remaining area around the upper lake is swampland. The intersection of State Highway 110 and Interstate I-35E is about 1,300 feet from the upper lake. Several houses and an apartment complex are on the east side of the lower lake. When completed, Interstate I-35E will border the western edge of the lower lake.

DESCRIPTION OF SAMPLING

Samples were collected at the six sampling sites shown in figure 1 in late winter, spring, summer, and autumn. Grab samples were collected near the water surface at each site.

When sampling began in March 1976, characteristics determined in the field included depth at sampling site, pH, specific conductance, DO (dissolved oxygen), water and air temperatures, and Secchi-disk transparency. Fecal coliform and fecal Streptococci bacteria, phytoplankton, major cations and anions, nutrients, oil and grease, turbidity, suspended solids, and dissolved solids were measured in the laboratory. During the autumn sampling, additional determinations were made for selected trace metals in the water, and selected trace metals, nutrients, and oil and grease were determined in the bottom sediments. The bottom sediments were collected with a U.S. BMH-60 scoop-type sampler that collects sediment to a depth of 1.7 inches.

In July 1977, detergents, selenium, cyanide, fluoride, BOD (biochemical oxygen demand), and COD (chemical oxygen demand) were added to the sampling schedule. Barium and boron were added to the trace-metals schedule, and alkalinity as carbonate and bicarbonate was determined in the field instead of in the laboratory.

The physical and chemical characteristics were determined by methods of Brown and others (1970), and Goerlitz and Brown (1972). Percentage saturation of DO was calculated according to American Public Health Association and others (1971, p. 480). Secchi-disk transparency was determined by lowering a standard-sized Secchi disk into the water until it disappeared from view. The point of disappearance was recorded. The disk was then raised until it reappeared. The point of reappearance was recorded. The mean of the two readings was then recorded as the true reading.

Fecal coliform and fecal Streptococci bacteria were determined by the membrane-filter technique described by Greeson and others (1977). Phytoplankton concentration was also determined by the methods described by Greeson and others (1977).

RESULTS AND DISCUSSION

Major Chemical Constituents

The water in Rogers Lake is a mixed calcium bicarbonate type that contains significant amounts of sodium and chloride (fig. 2). The chloride concentrations are relatively high compared with concentrations in surrounding lakes, including lakes with storm-sewer inlets (Have, 1975, p. 21).

Sampling sites 5 and 6 in the upper lake (fig. 1) have significantly higher concentrations of calcium, magnesium, sodium, and chloride than sites 1 to 4 in the lower lake. The higher concentrations in the upper lake may be caused by (1) runoff of highway deicing salt into the upper lake from State Highway 110, (2) runoff from irrigation of the adjacent golf course, and (3) smaller volume of water in the upper lake and, therefore, less dilution.

As seen in figure 1, sites 5 and 6 are the closest sites to State Highway 110 and to the major intersection near the northwest corner of the lake. More road salt consisting of sodium chloride is used per mile on roads of four or more lanes and on four-lane intersections than on smaller two-lane roads (Minnesota Pollution Control Agency, 1978). The upper lake is the lowest point in a closed basin that is intersected by State Highway 110; it is approximately 30 feet lower than the major intersection. Thus, overland runoff from the highway to the lake may account for the high sodium and chloride concentrations.

The higher concentrations of calcium and magnesium at sites 5 and 6 may be partly due to cation exchange in the soil with the sodium in the road salt, although some of the calcium probably originates from the road salt itself. Divalent cations, such as calcium and magnesium, are generally held more tightly to soils (mainly clay particles) than monovalent cations, such as sodium, but the exchange process is a reversible chemical reaction that obeys the law of mass action (Hem, 1959). Hence, the massive amounts of sodium from road salt in the runoff can displace some of the calcium and magnesium ions in the soil, thereby increasing the calcium and magnesium concentrations in the water.

The golf course at the north end of the upper lake is irrigated and fertilized. Runoff from irrigation tends to be more concentrated in dissolved salts and, therefore, is a likely contributor of major ions, particularly those associated with nutrients, to the upper lake.

The higher concentrations of dissolved salts in the upper lake may also result from its being a closed basin, the smaller water volume, and the shallower depths. Much of the mineral content entering the upper lake is retained except for the amount that seeps into the ground-water system. Most dissolved minerals are concentrated in the lake water by evaporation and freezing. An example can be seen in table 1. The highest conductances and dissolved solids for sites 5 and 6 occurred in March 1978, when the average water depth of 3.5 feet at the two sites was frozen for approximately

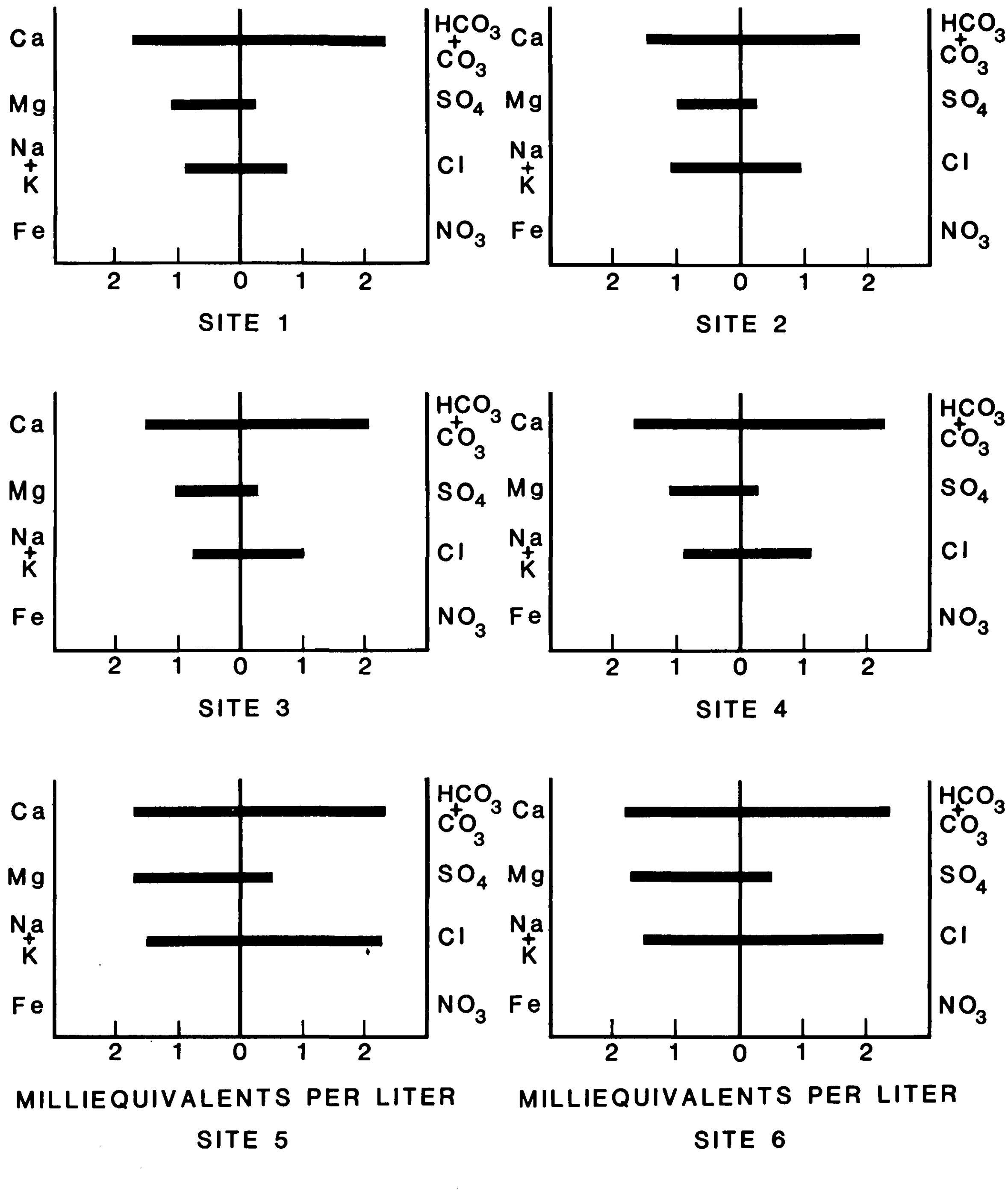

Figure 2.--Water type for each sampling site at Rogers Lake

Table 1.--Selected physical, chemical, and biological analyses from Rogers Lake, March 1976 to April 1978

[Letter B indicates nonideal colony count]

Date	Temperature (°C)	Depth at sampling point (m)	Transparency (Secchi disk) (m)	Turbidity (JTU)	Solids, susp. total res. at 110 C° (mg/L)	Specific conductance (micromhos)	Solids, res. at 180 C° dissolved (mg/L)	Oxygen, dissolved (mg/L)	Oxygen, dissolved (percent saturation)	pH (units)	Carbonate (mg/L as CO3)	Bicarbonate (mg/L as HCO3)
Rogers Lake, site 1												
Mar. 09, 1976...	3.0	1.52	---	1	0	405	230	4.3	33	7.5	0	148
Apr. 12.........	12.0	1.52	1.40	3	3	248	156	12.6	126	8.6	2	107
Aug. 04.........	22.5	1.68	.30	15	30	288	176	2.3	27	9.3	6	91
Oct. 19.........	5.0	.70	.70	4	9	352	206	7.4	60	7.8	0	139
Mar. 02, 1977...	1.0	1.00	.20	5	7	503	319	8.4	61	7.5	0	204
Apr. 12.........	14.5	.91	---	7	12	329	189	11.5	115	8.4	0	130
July 13.........	23.0	.70	.70	2	3	265	168	6.3	75	8.9	10	76
Nov. 16.........	3.5	1.46	1.10	2	1	290	202	12.6	97	8.1	0	126
Mar. 06, 1978...	.5	1.22	---	3	4	450	301	1.1	8	7.2	0	97
Apr. 26.........	11.0	1.52	1.52	2	2	300	184	10.8	100	8.0	0	120
Rogers Lake, site 2												
Mar. 09, 1976...	3.5	2.13	---	1	0	216	129	2.6	20	8.3	0	84
Apr. 12.........	11.5	1.98	1.40	2	4	267	160	11.9	112	8.5	1	108
Aug. 04.........	22.5	1.68	.27	15	16	288	177	3.9	45	9.5	10	84
Oct. 19.........	5.5	1.31	.90	2	19	350	201	9.2	75	7.8	0	135
Mar. 01, 1977...	2.0	1.40	.90	4	3	309	200	12.0	89	8.0	0	106
Apr. 12.........	14.5	1.19	---	6	12	328	190	11.6	116	8.4	0	130
July 13.........	23.0	1.19	.80	4	8	261	164	7.5	89	9.2	12	72
Nov. 08.........	10.0	1.98	1.00	2	4	295	181	9.4	85	7.7	0	120
Mar. 08, 1978...	3.0	1.98	---	4	3	424	295	.6	5	7.1	0	190
Apr. 26.........	11.0	1.98	1.98	2	2	300	185	10.4	96	8.0	0	118

Table 1.--Selected physical, chemical, and biological analyses from Rogers Lake, March 1976 to April 1978--Continued

Date	Temperature (°C)	Depth at sampling point (m)	Transparency (Secchi disk) (m)	Turbidity (JTU)	Solids, susp. total res. at 110 C° (mg/L)	Specific conductance (micromhos)	Solids, res. at 180 C° dissolved (mg/L)	Oxygen, dissolved (mg/L)	Oxygen, dissolved (percent saturation)	pH (units)	Carbonate (mg/L as CO3)	Bicarbonate (mg/L as HCO3)
Rogers Lake, site 3												
Mar. 09, 1976...	2.0	2.29	---	1	0	285	173	11.6	86	8.4	0	105
Apr. 12.........	11.0	2.29	1.50	2	0	262	165	11.9	110	8.6	2	107
Aug. 04.........	22.5	1.83	.27	15	15	282	173	4.5	52	9.4	7	90
Oct. 19.........	6.0	1.49	.85	2	9	342	203	9.0	74	7.7	0	136
Mar. 01, 1977...	2.0	1.64	1.00	4	7	342	238	18.7	139	8.5	0	133
Apr. 12.........	15.0	1.71	---	7	12	325	183	11.8	119	8.5	0	130
July 14.........	25.5	1.49	.80	3	6	277	163	8.8	109	9.4	18	60
Nov. 16.........	3.0	2.13	1.00	2	4	295	200	12.6	95	8.0	0	124
Mar. 08, 1978...	2.5	2.29	---	3	1	425	298	.9	7	7.2	0	190
Apr. 26.........	11.0	2.44	1.90	2	1	298	204	10.7	99	8.0	0	120
Rogers Lake, site 4												
Mar. 09, 1976...	2.0	1.68	---	1	0	155	82	6.1	45	7.9	0	50
Apr. 12.........	12.0	1.98	1.20	4	3	262	165	11.7	111	8.6	2	106
Aug. 04.........	23.0	1.52	.27	15	12	285	175	5.2	62	9.5	12	77
Oct. 20.........	5.0	1.16	1.00	2	7	345	196	8.6	69	7.8	0	137
Mar. 02, 1977...	1.0	1.31	.70	8	7	490	298	14.0	101	8.3	0	191
Apr. 12.........	14.0	1.31	---	6	13	329	183	11.1	110	8.4	0	130
July 14.........	25.5	1.19	.80	3	2	261	164	9.2	114	9.4	20	56
Nov. 16.........	4.0	1.52	1.00	2	1	290	206	12.4	97	8.0	0	126
Mar. 09, 1978...	2.0	1.19	---	2	1	440	289	.3	2	7.2	0	192
Apr. 26.........	11.0	1.68	1.68	1	1	298	194	10.4	96	8.0	0	1

Table 1.--Selected physical, chemical, and biological analyses from Rogers Lake,

March 1976 to April 1978--Continued

Date	Temperature (°C)	Depth at sampling point (m)	Transparency (Secchi disk) (m)	Turbidity (JTU)	Solids, susp. total res. at 110 C° (mg/L)	Specific conductance (micromhos)	Solids, res. at 180 C° dissolved (mg/L)	Oxygen, dissolved (mg/L)	Oxygen, dissolved (percent saturation)	pH (units)	Carbonate (mg/L as CO3)	Bicarbonate (mg/L as HCO3)
Rogers Lake, site 5												
Mar. 09, 1976...	2.0	1.07	---	4	18	660	364	.2	1	7.2	0	213
Apr. 12.........	10.0	.91	.55	10	17	423	258	13.6	124	8.5	1	206
Aug. 04.........	26.0	.61	.30	15	27	458	329	15.5	194	9.9	23	116
Oct. 20.........	3.0	.40	.30	8	50	697	452	12.3	94	8.5	0	177
Apr. 13, 1977...	14.0	.85	---	7	21	409	285	11.2	111	9.6	0	110
June 09.........	20.0	.70	.70	2	10	458	323	3.1	35	8.1	0	140
July 12.........	23.0	---	---	3	8	435	308	7.8	93	8.5	4	130
Nov. 16.........	3.5	.98	1.00	2	1	395	273	13.1	101	8.4	1	191
Mar. 09, 1978...	.0	1.22	---	10	10	1270	823	.2	1	7.2	0	632
Apr. 27.........	15.0	1.19	.90	3	4	390	237	122.9	130	8.6	6	160
Rogers Lake, site 6												
Mar. 09, 1976...	1.0	.91	---	3	14	510	281	.7	5	7.2	0	195
Apr. 12.........	10.0	.91	.64	10	19	451	263	13.9	126	8.7	6	209
Aug. 04.........	27.0	.46	.27	10	34	440	324	19.2	246	9.9	16	126
Oct. 20.........	3.0	.18	.30	10	86	660	461	11.8	90	8.3	0	180
Apr. 13, 1977...	14.0	.49	---	10	27	407	294	13.6	135	9.6	0	110
June 09.........	20.0	.49	.49	3	4	454	331	3.0	34	7.9	0	140
July 12.........	23.0	---	---	4	4	420	318	12.0	143	9.4	38	68
Nov. 16.........	2.0	.79	>2.60	2	4	392	259	13.8	102	8.4	1	190
Mar. 09, 1978...	.0	.91	---	65	75	1650	1020	.4	3	7.1	0	860
Apr. 27.........	14.5	.88	.88	3	2	387	337	14.4	144	8.7	7	160

Table 1.--Selected physical, chemical, and biological analyses from Rogers Lake,

March 1976 to April 1978--Continued

Date	Calcium dis-solved (mg/L as CA)	Magne-sium, dis-solved (mg/L as MG)	Sodium, dis-solved (mg/L as NA)	Potas-sium, dis-solved (mg/L as K)	Chlo-ride, dis-solved (mg/L as CL)	Sulfate dis-solved (mg/L as SO4)	Fluo-ride, dis-solved (mg/L as F)	Nitrogen ammonia & organic total (mg/L as N)	Nitrogen ammonia & organic dis. (mg/L as N)	Nitro-gen NO2+NO3 total (mg/L as N)	Nitro-gen, ammonia total (mg/L as N)	Phos-phorus, total (mg/L as P)
Rogers Lake, site 1												
Mar. 09, 1976...	36	---	14	---	35	---	---	1.6	0.98	0.02	---	0.05
Apr. 12.........	26	---	11	---	26	---	---	1.2	.86	.04	---	.05
Aug. 04.........	25	12	14	3.5	34	4.3	---	3.9	1.1	.00	---	.37
Oct. 19.........	33	14	16	4.9	37	9.6	---	1.5	1.3	.30	---	.18
Mar. 02, 1977...	53	20	23	7.0	56	19	---	3.0	1.5	.07	---	.28
Apr. 12.........	32	12	14	4.4	31	15	---	2.0	.72	.02	---	.13
July 13.........	21	11	14	3.9	33	4.7	.2	1.3	---	.00	.20	.26
Nov. 16.........	32	12	13	4.2	31	11	.2	1.1	---	.07	.03	.04
Mar. 08, 1978...	46	18	18	5.9	43	18	.2	2.1	---	.09	.73	.06
Apr. 26.........	31	11	12	3.9	29	15	.1	.88	---	.04	.05	.02
Rogers Lake, site 2												
Mar. 09, 1976...	20	---	8.5	---	20	---	---	1.7	.48	.15	---	.10
Apr. 12.........	26	---	11	---	26	---	---	1.1	.89	.01	---	.04
Aug. 04.........	25	12	14	3.5	34	4.8	---	4.7	1.2	.00	---	.38
Oct. 19.........	32	14	16	4.7	37	8.6	---	1.9	.98	.26	---	.10
Mar. 01, 1977...	31	12	14	4.6	34	18	---	1.5	1.0	.30	---	.08
Apr. 12.........	32	13	14	4.4	30	16	---	1.5	.73	.01	---	.10
July 13.........	24	11	14	3.9	34	4.4	.2	1.2	---	.01	.14	.27
Nov. 08.........	30	12	13	4.3	33	13	.1	.90	---	.03	.01	.04
Mar. 08, 1978...	46	18	17	5.8	43	18	.2	2.5	---	.10	.77	.06
Apr. 26.........	31	11	11	4.0	29	15	.1	.93	---	.04	.08	.09

Table 1.--Selected physical, chemical, and biological analyses from Rogers Lake,

March 1976 to April 1978--Continued

Date	Calcium dis-solved (mg/L as CA)	Magne-sium, dis-solved (mg/L as MG)	Sodium, dis-solved (mg/L as NA)	Potas-sium, dis-solved (mg/L as K)	Chlo-ride, dis-solved (mg/L as CL)	Sulfate dis-solved (mg/L as SO4)	Fluo-ride, dis-solved (mg/L as F)	Nitrogen ammonia & organic total (mg/L as N)	Nitrogen ammonia & organic dis. (mg/L as N)	Nitro-gen NO2+NO3 total (mg/L as N)	Nitro-gen, ammonia total (mg/L as N)	Phos-phorus, total (mg/L as P)
Rogers Lake, site 3												
Mar. 09, 1976...	26	---	12	---	28	---	---	1.2	.97	.03	---	.02
Apr. 12.........	26	---	11	---	27	---	---	1.1	.88	.01	---	.03
Aug. 04.........	25	11	13	3.4	34	4.8	---	4.3	1.0	.01	---	.36
Oct. 19.........	32	14	17	4.8	37	10	---	1.6	.87	.19	---	.08
Mar. 01, 1977...	38	14	17	5.2	41	17	---	2.6	1.8	.10	---	.52
Apr. 12.........	32	12	14	4.5	30	16	---	1.4	.75	.00	---	.09
July 14.........	21	11	14	3.9	35	4.2	0.2	1.5	---	.00	.11	.26
Nov. 16.........	31	12	13	4.3	30	10	.2	.97	---	.07	.03	.04
Mar. 08, 1978...	46	17	17	5.9	43	18	.2	2.1	---	.09	.72	.04
Apr. 26.........	32	11	12	3.8	30	16	.1	1.0	---	.09	.10	.03
Rogers Lake, site 4												
Mar. 09, 1976...	13	---	7.2	---	14	---	---	1.2	.71	.41	---	.08
Apr. 12.........	25	---	11	---	26	---	---	1.3	.90	.01	---	.04
Aug. 04.........	24	12	13	3.4	34	5.2	---	4.1	1.1	.00	---	.33
Oct. 20.........	32	14	16	4.8	37	8.3	---	1.4	.79	.15	---	.08
Mar. 02, 1977...	47	18	24	6.6	54	21	---	2.1	1.3	.15	---	.11
Apr. 12.........	32	13	14	4.4	30	16	---	1.6	.78	.00	---	.08
July 14.........	21	11	14	3.9	35	4.2	.2	1.4	---	.00	.08	.25
Nov. 16.........	32	12	13	4.3	30	11	.2	.90	---	.08	.06	.04
Mar. 09, 1978...	45	17	17	5.9	39	17	.2	2.3	---	.07	.75	.04
Apr. 26.........	32	12	11	3.9	30	16	.1	.87	---	.04	.18	.03

Table 1.--Selected physical, chemical, and biological analyses from Rogers Lake,

March 1976 to April 1978--Continued

Date	Calcium dis-solved (mg/L as CA)	Magne-sium, dis-solved (mg/L as MG)	Sodium, dis-solved (mg/L as NA)	Potas-sium, dis-solved (mg/L as K)	Chlo-ride, dis-solved (mg/L as CL)	Sulfate dis-solved (mg/L as SO4)	Fluo-ride, dis-solved (mg/L as F)	Nitrogen ammonia & organic total (mg/L as N)	Nitrogen ammonia & organic dis. (mg/L as N)	Nitro-gen NO2+NO3 total (mg/L as N)	Nitro-gen, ammonia total (mg/L as N)	Phos-phorus, total (mg/L as P)
Rogers Lake, site 5												
Mar. 09, 1976...	50	---	38	---	80	---	---	4.3	2.1	.01	---	.51
Apr. 12.........	41	---	18	---	40	---	---	2.1	1.1	.00	---	.13
Aug. 04.........	38	22	28	4.8	72	4.8	---	4.7	2.0	.00	---	.35
Oct. 20.........	52	28	41	7.6	120	34	---	5.9	3.0	.02	---	.25
Apr. 13, 1977...	26	19	29	5.6	57	39	---	4.6	2.3	.09	---	.25
June 09.........	33	21	31	4.4	74	14	---	2.8	2.3	.05	---	.12
July 12.........	31	18	30	3.9	69	4.2	.3	2.2	---	.02	.39	.34
Nov. 16.........	41	21	17	3.4	37	10	.2	.99	---	.01	.08	.06
Mar. 09, 1978...	140	75	55	8.7	130	16	.2	3.9	---	.01	.44	1.5
Apr. 27.........	40	17	14	2.2	34	16	.1	.99	---	.01	.02	.05
Rogers Lake, site 6												
Mar. 09, 1976...	47	---	21	---	49	---	---	4.4	1.7	.01	---	.54
Apr. 12.........	43	---	19	---	42	---	---	2.3	.97	.00	---	.17
Aug. 04.........	38	21	28	4.7	72	6.0	---	1.4	1.4	.01	---	.45
Oct. 20.........	52	28	42	7.6	120	33	---	5.4	3.2	.03	---	.24
Apr. 13, 1977...	25	20	29	5.6	58	38	---	4.5	2.5	.10	---	.26
June 09.........	36	20	30	3.5	71	18	---	2.2	1.9	.01	---	.08
July 12.........	36	18	30	2.8	66	5.3	.2	1.6	---	.01	.04	.44
Nov. 16.........	40	21	16	3.3	36	10	.1	.91	---	.03	.08	.06
Mar. 09, 1978...	200	80	55	6.8	130	18	.2	7.3	---	.01	1.0	3.2
Apr. 27.........	41	17	15	2.0	35	16	.1	.73	---	.01	.02	.04

Table 1.—Selected physical, chemical, and biological analyses from Rogers Lake,

March 1976 to April 1978—Continued

Date	Phosphorus, dissolved (mg/L as P)	Carbon, organic total (mg/L as C)	BOD 5 day (mg/L)	COD (high level) (mg/L)	Silica, dissolved (mg/L as SIO2)	Oil and grease (mg/L)	Methylene blue active substance (mg/L)	Cyanide total (mg/L as CN)	Selenium, total (ug/L as SE)	Coliform, fecal, 0.45 um-mf (cols./100 mL)	Streptococci fecal (cols./100 mL)
Rogers Lake, site 1											
Mar. 09, 1976...	0.00	13	---	---	0.5	1	---	---	---	<1	<1
Apr. 12.........	.00	6.9	---	---	.3	0	---	---	---	1	<1
Aug. 04.........	.03	30	---	---	2.4	---	---	---	---	<1	B4
Oct. 19.........	.01	16	---	---	2.9	0	---	---	---	12	12
Mar. 02, 1977...	.02	18	---	---	2.8	0	---	---	---	<1	B8
Apr. 12.........	.02	9.1	---	---	.7	0	---	---	---	1	3
July 13.........	.15	11	5.4	50	3.7	0	0.10	0.00	0	B130	B470
Nov. 16.........	.02	---	---	42	5.4	0	.10	.00	0	<1	4
Mar. 08, 1978...	.03	13	2.7	34	7.7	0	.00	.00	0	<1	1
Apr. 26.........	.01	9.3	1.7	25	1.5	0	5.1	.00	0	1	<1
Rogers Lake, site 2											
Mar. 09, 1976...	0.01	8.8	---	---	0.4	1	---	---	---	<1	<1
Apr. 12.........	.00	7.3	---	---	.2	0	---	---	---	<1	B1
Aug. 04.........	.03	25	---	---	2.2	0	---	---	---	B4	<1
Oct. 19.........	.01	11	---	---	3.7	3	---	---	---	<1	5
Mar. 01, 1977...	.01	9.7	---	---	2.3	0	---	---	---	<1	5
Apr. 12.........	.02	9.1	---	---	.8	0	---	---	---	<1	8
July 13.........	.16	12	5.8	46	3.5	0	0.10	0.00	0	B1	260
Nov. 08.........	.01	---	---	33	5.8	---	.10	.00	0	<1	3
Mar. 08, 1978...	.03	14	1.8	47	7.6	1	.00	.00	0	<1	<1
Apr. 26.........	.01	2.9	1.9	20	1.7	0	3.6	.00	0	3	2

Table 1.--Selected physical, chemical, and biological analyses from Rogers Lake,

March 1976 to April 1978--Continued

Date	Phosphorus, dissolved (mg/L as P)	Carbon, organic total (mg/L as C)	BOD 5 day (mg/L)	COD (high level) (mg/L)	Silica, dissolved (mg/L as SIO2)	Oil and grease (mg/L)	Methylene blue active substance (mg/L)	Cyanide total (mg/L as CN)	Selenium, total (ug/L as SE)	Coliform, fecal, 0.45 um-mf (cols./100 mL)	Streptococci fecal (cols./100 mL)
Rogers Lake, site 3											
Mar. 09, 1976...	0.00	10	---	---	0.2	0	---	---	---	<1	B19
Apr. 12.........	.00	6.4	---	---	.1	0	---	---	---	B1	B1
Aug. 04.........	.03	27	---	---	2.3	0	---	---	---	<1	B4
Oct. 19.........	.01	15	---	---	3.7	0	---	---	---	830	B10
Mar. 01, 1977...	.43	12	---	---	2.9	0	---	---	---	<1	3
Apr. 12.........	.02	8.9	---	---	.7	0	---	---	---	1	3
July 14.........	.13	12	6.5	53	3.0	0	.10	.00	0	<1	B480
Nov. 16.........	.03	---	---	53	5.4	0	.00	.00	0	<1	0
Mar. 08, 1978...	.02	12	1.4	35	7.4	0	.00	.00	0	<1	4
Apr. 26.........	.01	7.0	2.7	20	1.6	0	3.6	.00	0	<1	1
Rogers Lake, site 4											
Mar. 09, 1976...	0.02	7.2	---	---	0.3	0	---	---	---	<1	<1
Apr. 12.........	.00	6.6	---	---	.2	0	---	---	---	B3	B3
Aug. 04.........	.02	21	---	---	2.3	0	---	---	---	<1	<1
Oct. 20.........	.00	13	---	---	4.1	1	---	---	---	3	7
Mar. 02, 1977...	.01	12	---	---	4.1	0	---	---	---	<1	87
Apr. 12.........	.02	9.4	---	---	.8	0	---	---	---	<1	9
July 14.........	.12	12	6.1	45	2.9	0	.10	.00	0	B2	B340
Nov. 16.........	.02	---	---	33	5.4	0	.00	.00	0	---	---
Mar. 09, 1978...	.02	13	1.1	30	7.7	0	.00	.00	0	<1	<1
Apr. 26.........	.01	7.4	2.4	20	1.6	1	3.7	.00	0	1	2

Table 1.--Selected physical, chemical, and biological analyses from Rogers Lake,

March 1976 to April 1978--Continued

Date	Phos-phorus, dis-solved (mg/L as P)	Carbon, organic total (mg/L as C)	BOD 5 day (mg/L)	COD (high level) (mg/L)	Silica, dis-solved (mg/L as SIO2)	Oil and grease (mg/L)	Methylene blue active sub-stance (mg/L)	Cyanide total (mg/L as CN)	Sele-nium, total (ug/L as SE)	Coliform, fecal, 0.45 um-mf (cols./100 mL)	Strep-tococci fecal (cols./100 mL)
Rogers Lake, site 5											
Mar. 09, 1976...	0.27	26	---	---	8.5	1	---	---	---	<1	B28
Apr. 12.........	.00	10	---	---	.4	0	---	---	---	B3	<1
Aug. 04.........	.04	37	---	---	27	3	---	---	---	<1	<1
Oct. 20.........	.02	26	---	---	20	1	---	---	---	1	B244
Apr. 13, 1977...	.07	23	---	---	11	0	---	---	---	<1	B8
June 09.........	.08	22	---	---	3.8	0	---	---	---	B3	130
July 12.........	.32	23	1.8	73	18	0	.10	.01	0	B17	B12
Nov. 16.........	.05	---	---	51	1.5	0	.10	.00	0	<1	2
Mar. 09, 1978...	1.5	32	9.9	84	19	---	1.0	.00	0	<1	<1
Apr. 27.........	.01	8.2	4.0	25	2.0	0	4.5	.00	0	<1	2
Rogers Lake, site 6											
Mar. 09, 1976...	0.17	24	---	---	6.8	1	---	---	---	<1	B24
Apr. 12.........	.00	10	---	---	.6	0	---	---	---	B1	B2
Aug. 04.........	.07	37	---	---	28	2	---	---	---	<1	B4
Oct. 20.........	.02	36	---	---	20	7	---	---	---	B6	B245
Apr. 13, 1977...	.08	23	---	---	11	0	---	---	---	B20	B33
June 09.........	.05	22	---	---	5.7	0	---	---	---	<1	B3
July 12.........	.41	18	3.3	81	18	0	.10	.01	0	B1	B8
Nov. 16.........	.05	---	---	61	1.4	0	.10	.00	0	<1	6
Mar. 09, 1978...	2.8	27	19	130	38	1	.10	.00	0	2	<1
Apr. 27.........	.01	9.5	4.1	20	1.9	2	6.4	.00	0	<1	<1

2.5 feet. The lowest conductances and dissolved solids occurred in April 1978 after dilution by melted ice and snow and runoff of precipitation in spring.

The higher mineralization at sites 5 and 6 is clearly shown in table 2. Average specific conductance and dissolved-solids concentrations are almost two times higher at sites 5 and 6 than in samples from sites in the lower lake. The ranges are also much greater at sites 5 and 6, mainly resulting from winter conditions.

The mean equivalent proportions of calcium, magnesium, sodium, and chloride for the six sites are shown in table 3. Mean equivalent proportion is the percentage of the total cations or anions represented by a particular cation or anion, calculated through the use of milliequivalents per liter. Sites 5 and 6 have a slightly higher proportion of magnesium and a much lower proportion of calcium than sites 1 to 4. The difference in calcium may be partly related to the higher organic content and the higher productivity of aquatic plants at sites 5 and 6. The organic content and productivity of Rogers Lake are discussed in more detail later in the report. Organic substances in water can complex calcium, and biological activity, such as shell construction and plant precipitation of calcium carbonate, tends to decrease the calcium-ion content dissolved in the water (Hutchinson, 1957, p. 664; Reid and Wood, 1976, p. 231). Therefore, even though calcium concentrations are higher in the upper lake, its proportion of the dissolved-solids content is lower.

Table 3 also shows the mean equivalent proportions of sodium and chloride to be higher for sites 5 and 6. These data tend to support the hypothesis that the upper lake receives runoff that contains road salt.

Chloride concentration increased throughout the open-water period of 1976 as shown by the April, August, and October samples (fig. 3). During 1976, 16.5 inches of precipitation was recorded at the Twin Cities Airport weather station, which was 9.4 inches below normal (National Oceanic and Atmospheric Administration, 1976). Because of the below-normal rainfall in 1976, it was observed that the lake level (that is, lake volume) decreased throughout this period, thereby increasing chloride concentrations.

Due to the low-water levels at the beginning of the 1977 winter sampling period, the chloride concentrations measured in the lower lake in March 1977 were generally higher than those measured in March 1976. The lake was frozen to the bottom at sites 5 and 6 during the March 1977 sampling period, which, of course, prevented sample collection.

During the open-water season of 1977, rainfall was above normal; a total of 34.88 inches of precipitation was recorded for the year (National Oceanic and Atmospheric Administrations, 1977). The dilution effect from this amount of precipitation in 1977 had decreased the chloride concentrations considerably by autumn, as shown by the November 1977 chloride concentration.

Table 2.--Averages and ranges of specific conductance and dissolved solids for each sampling site at Rogers Lake

Site	Number of samples	Specific conductance, in micromhos per centimeter at 25°C		Dissolved solids, in milligrams per liter	
		Average	Range	Average	Range
1	10	343	248-503	213	156-319
2	10	304	216-424	188	129-295
3	10	313	262-425	200	163-298
4	10	316	155-490	195	82-298
5	10	560	390-1270	380	237-823
6	10	577	387-1650	378	227-1020

Table 3.—Mean equivalent proportions of calcium, magnesium, sodium, and chloride for each sampling site at Rogers Lake

Site	Calcium	Magnesium	Sodium	Chloride
1	46	31	19	30
2	46	32	19	30
3	46	31	19	30
4	46	32	19	30
5	39	35	24	38
6	39	35	24	38

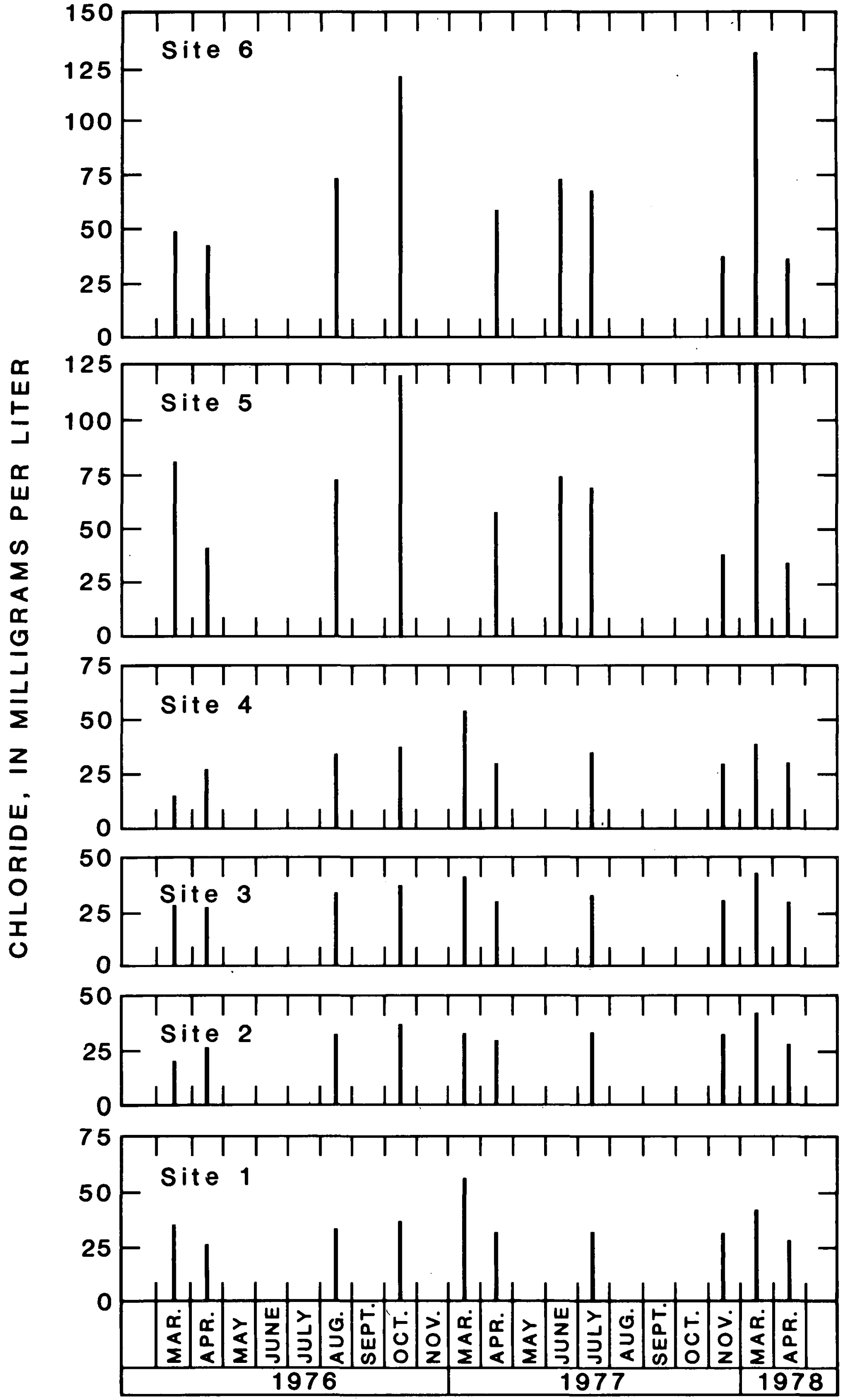

Figure 3.--Chloride concentrations for each sampling site at Rogers Lake

DO and pH

DO in water is essential for sustaining life. Not only fish and other animal life need oxygen, but plants, which produce oxygen through photosynthesis, need it for respiration.

The amount of DO in eutrophic lakes, such as Rogers Lake, varies widely with time (fig. 4) because of the high production of algae and vascular plants. The lowest DO values for all sampling sites occurred in March 1978 when the lake was frozen. During the ice and snow-cover period, photosynthesis and reaeration are normally at a minimum. Even though respiration and oxidation of organic material continues, DO concentations are generally low. However, relatively high DO concentrations can occur under ice cover. For example, during the March 1977 sampling (table 1) the DO concentration at site 3 was 18.7 mg/L (139 percent saturation), the highest DO for site 3. A lack of snow cover on the ice may have permitted sufficient light penetration for significant photosynthesis. The DO produced was trapped and concentrated under the ice. Similar situations of supersaturated conditions under ice are reported by Ficke and Ficke (1977) in their review of the effects of ice on rivers and lakes.

Values of pH normally increase and decrease with DO concentration as both are related to photosynthesis. Removal of carbon dioxide by photosynthesis causes a decrease of the hydrogen ion concentration or an increase in pH and an increase in DO concentration. pH was lowest under ice during the March 1978 sampling (fig. 4). pH was usually highest in summer, when biological activity was normally at a maximum.

Selected Trace Metals

Samples of bottom material collected in March and October 1976 and in November 1977 were analyzed for selected trace metals. Water samples collected in October 1976 and November 1977 were analyzed for the same trace metals (tables 4 and 5).

Aluminum and iron were the predominant metals determined in analyses of the bottom-sediment samples. Concentration ranges were 3,300 to 9,600 and 7,900 to 15,000 ug/g (micrograms per gram), respectively. The metals in the sediment occurred at concentrations comparable with those found in other lakes in the area (Payne, 1977).

Concentrations of trace metals in the water samples collected in October 1976 and November 1977 were low (table 5). The ranges indicated that concentrations of the metals were less than the limits recommended for public water supplies (U.S. Environmental Protection Agency, 1977). Concentrations of most of the metals were slightly higher in October 1976 than in November 1977. Because of the drought in the latter part of 1976, lake volume was smaller when the 1976 samples were collected, thereby concentrating the metals.

Table 4.--Oil and grease, nutrients, and selected trace metals in bottom sediments for each sampling site at Rogers Lake

Date	Time	Organic carbon in bottom material (g/kg)	Total nitrogen in bottom material (mg/kg)	Oil and grease in bottom material (mg/kg)	Total phosphorus in bottom material (mg/kg)	Total aluminum in bottom material (ug/g)	Total arsenic in bottom material (ug/g)	Total barium in bottom material (ug/g)	Total boron in bottom material (ug/g)
				Rogers Lake site 1					
Mar., 1976									
09...	1430	112	3800	0.0	210	9600	13	---	---
Oct. 19...	1030	110	11,900	.0	110	5300	10	---	---
Nov., 1977									
16...	1230	82	201	.0	490	4000	16	80	170
				Rogers Lake site 2					
Mar., 1976									
09...	1500	138	3000	0.0	250	8500	12	---	---
Oct. 19...	1215	137	15,200	.0	130	5100	8	---	---
Nov., 1977									
08...	1230	116	36	.0	440	5000	10	100	180
				Rogers Lake site 3					
Mar., 1976									
09...	1330	111	2800	0.0	420	8000	12	---	---
Oct. 19...	1330	118	13,000	.0	130	4700	6	---	---
Nov., 1977									
16...	1330	140	173	.0	500	4900	21	100	450
				Rogers Lake site 4					
Mar., 1976									
09...	1230	56	2400	0.0	290	6900	10	---	---
Oct 20...	0950	82	9900	.0	150	5000	4	---	---
Nov., 1977									
16...	1400	50	76	.0	680	3500	10	90	61
				Rogers Lake site 5					
Mar., 1976									
09...	0930	153	2900	---	350	6600	13	---	---
Oct. 19...	1130	229	23,300	0.0	150	5000	14	---	---
Nov., 1977									
16...	1000	241	277	.0	800	3300	15	120	450
				Rogers Lake site 6					
Mar., 1976									
09...	1030	178	3200	---	300	7800	18	---	---
Oct. 20...	1145	243	24,300	0.0	160	3700	14	---	---
Nov., 1977									
16...	1030	251	56	.0	310	3800	8	120	510

Table 4.--Oil and grease, nutrients, and selected trace metals in bottom sediments for each sampling site at Rogers Lake--Continued

Date	Total cadmium in bottom material (ug/g)	Total chromium in bottom material (ug/g)	Total copper in bottom material (ug/g)	Total iron in bottom material (ug/g)	Total lead in bottom material (ug/g)	Total manganese in bottom material (ug/g)	Total mercury in bottom material (ug/g)	Total nickel in bottom material (ug/g)	Total zinc in bottom material (ug/g)
				Rogers Lake site 1					
2	26	26	---	68	---	0.3	---	115	
1	15	20	11,000	75	240	.1	15	80	
1	16	19	9000	70	240	.0	15	160	
				Rogers Lake site 2					
1	25	25	---	84	---	0.4	---	166	
1	15	24	11,000	95	340	.1	15	101	
1	16	23	9000	70	320	.0	15	74	
				Rogers Lake site 3					
1	22	25	---	90	---	0.5	---	110	
1	14	21	10,000	80	280	.1	15	84	
1	44	26	9000	90	260	.0	20	80	
				Rogers Lake site 4					
1	21	19	---	64	---	0.5	---	110	
<1	14	22	11,000	80	280	.2	15	82	
1	12	18	7900	60	240	.0	10	56	
				Rogers Lake site 5					
2	17	25	---	80	---	0.7	---	94	
1	14	22	11,000	80	280	.8	15	94	
1	16	18	9200	50	640	---	15	58	
				Rogers Lake site 6					
2	21	32	---	100	---	1.0	---	175	
1	14	24	15,000	80	300	1.0	20	93	
1	36	14	8900	30	280	.1	10	48	

Table 5.—Selected trace metals in water for each sampling site at Rogers Lake

Date	Time	Total aluminum (ug/L)	Total arsenic (ug/L)	Dissolved arsenic (ug/L)	Total barium (ug/L)	Total boron (ug/L)	Total cadmium (ug/L)	Dissolved cadmium (ug/L)	Total chromium (ug/L)	Dissolved chromium (ug/L)	Total copper (ug/L)	Dissolved copper (ug/L)
					Rogers Lake site 1							
Oct. 19, 1976	1030	80	2	1	---	---	<10	1	0	0	<10	0
Nov. 16, 1977	1230	20	1	---	300	90	1	---	8	---	1	---
					Rogers Lake site 2							
Oct. 19, 1976	1215	60	2	2	---	---	<10	0	0	0	<10	1
Nov. 08, 1977	1230	50	1	---	300	70	<10	---	8	---	<10	---
					Rogers Lake site 3							
Oct. 19, 1976	1330	10	2	1	---	---	<10	1	0	0	<10	3
Nov. 16, 1977	1330	20	1	---	400	90	1	---	8	---	1	---
					Rogers Lake site 4							
Oct. 19, 1976	0950	80	1	1	---	---	<10	1	0	0	<10	0
Nov. 16, 1977	1400	20	1	---	500	90	0	---	8	---	2	---
					Rogers Lake site 5							
Oct. 19, 1976	1130	190	9	6	---	---	<10	1	0	0	<10	2
Nov. 16, 1977	1000	20	1	---	500	80	1	---	4	---	2	---
					Rogers Lake site 6							
Oct. 19, 1976	1145	280	8	6	---	---	<1	1	0	0	<10	8
Nov. 16, 1977	1030	10	1	---	300	0	1	000	4	---	2	---

Table 5.—Selected trace metals in water for each sampling site at Rogers Lake—Continued

Date	Total iron (ug/L)	Dis-solved iron (ug/L)	Total lead (ug/L)	Dis-solved lead (ug/L)	Total man-ganese (ug/L)	Total mercury (ug/L)	Dis-solved mercury (ug/L)	Total nickel (ug/L)	Dis-solved nickel (ug/L)	Total zinc (ug/L)	Dis-solved zinc (ug/L)
Rogers Lake site 1											
Oct. 19, 1976...	270	20	<100	0	110	0.0	0.0	<50	1	10	10
Nov. 16, 1977...	70	---	7	---	40	.0	---	4	---	6	---
Rogers Lake site 2											
Oct. 19, 1976...	190	10	<100	0	60	0.0	0.0	<50	1	10	0
Nov. 08, 1977...	70	---	<100	---	30	.0	---	<50	---	50	---
Rogers Lake site 3											
Oct. 19, 1976...	190	30	<100	3	40	0.0	0.0	<50	1	10	0
Nov. 16, 1977...	30	---	4	---	20	.0	---	4	---	6	---
Rogers Lake site 4											
Oct. 20, 1976...	160	20	<100	0	40	0.0	0.0	<50	1	0	0
Nov. 16, 1977...	30	---	11	---	20	---	---	4	---	2	---
Rogers Lake site 5											
Oct. 20, 1976...	670	40	<100	2	250	0.0	0.0	<50	2	10	10
Nov. 16, 1977...	130	---	10	---	30	.0	---	4	---	10	---
Rogers Lake site 6											
Oct. 20, 1976...	990	90	<100	3	300	0.0	0.0	<50	2	20	10
Nov. 16, 1977...	80	---	6	---	20	.0	---	4	---	4	---

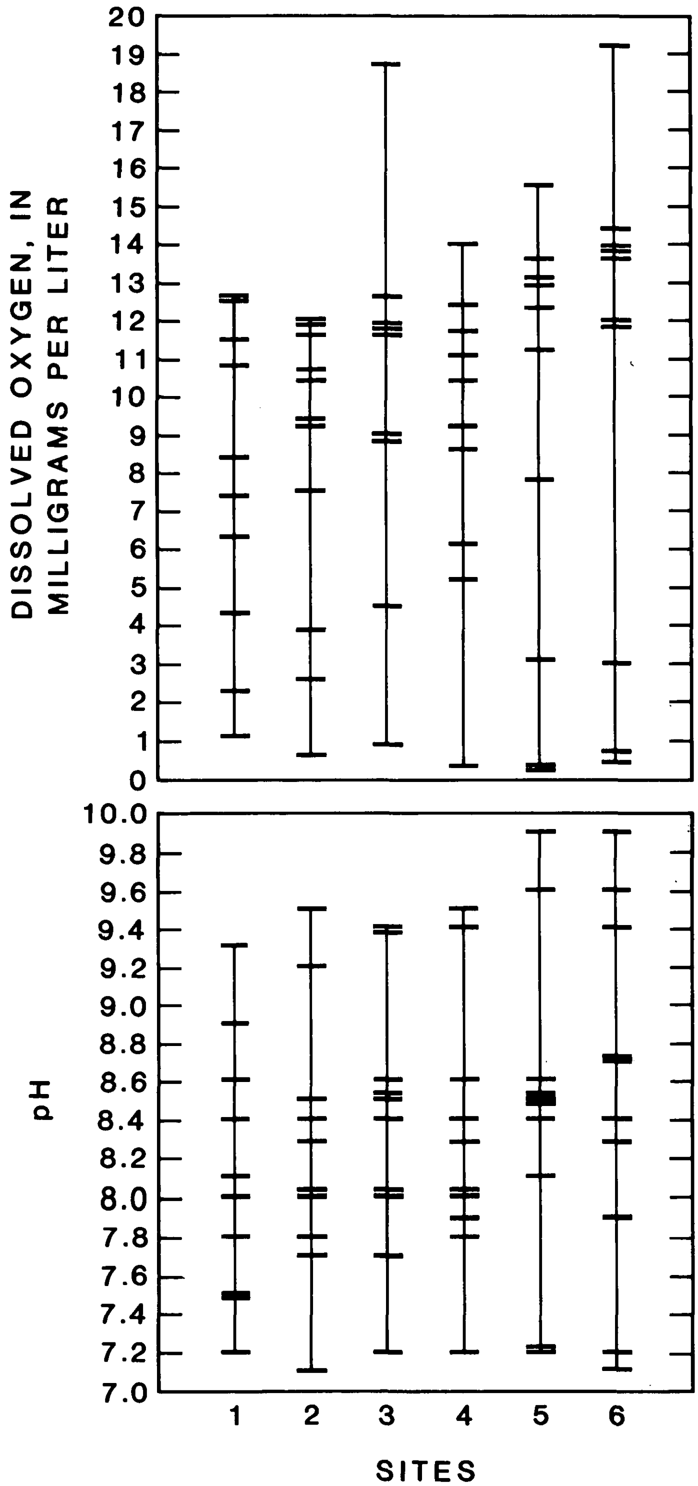

Figure 4.--Dissolved-oxygen concentrations and pH for each sampling site at Rogers Lake. Span indicates range between maximum and minimum values. Each mark across the vertical lines represents a sampled value

Total concentrations of aluminum, iron, and manganese were much higher at sites 5 and 6 in October 1976 than they were at the other sites. The shallower depths (<2 ft) in the upper lake during that time probably permitted a greater amount of sediment to be stirred up and mixed with the overlying water.

Nutrients

Nutrients are necessary for growth, repair of tissue, or reproduction of aquatic flora. Nitrogen and phosphorus are considered to be key nutrients required by aquatic flora. Phosphorus is frequently considered to be a limiting factor in phytoplankton production, but Carroll (1962) and Voight (1960) have shown that its concentration in rainfall alone have been more than adequate for supporting algal blooms. The minimum concentrations of nitrogen and phosphorus required for active plant growth (that is, an algal bloom) have not been firmly established; a wide range of minimum requirements is reported in the literature. For example, Greeson and Myers (1969, p. 11-12) list ranges for nitrogen from trace quantities to 5.3 mg/L and phosphorus from 0.002 to 0.09 mg/L.

Data indicate that Rogers Lake is highly enriched with nitrogen and phosphorus and can support large algal populations. Figure 5 shows the phosphorus concentrations for the six sites.

Phosphorus content at all sites changes concurrently as shown in figure 5. Sites 5 and 6 consistently have the highest concentrations. The dissolved phosphorus values were zero or near zero in many samples collected during the study, which is typical of a eutrophic lake with prolific algal growth.

Phosphorus concentrations in March 1977 at site 3, the deepest part of the lake, were considerably higher than at any of the other sites. A possible explanation for this is that conditions at the water-mud interface produced free phosphorus in excess of the amount utilized by algae. There also were fewer submerged macrophytes utilizing the available phosphorus at site 3.

In July 1977, the dissolved phosphorus concentrations were unusually high at all sites when compared to other open-water sampling periods. The moderately high ammonium-nitrogen concentrations (table 1) suggest that a significant amount of decomposition was taking place, hence, a possible excess of dissolved phosphorus existed at that time. Furthermore, bacteria can convert inorganic phosphates to organic phosphorus that can be released to the water in a form unavailable to plants (Mackenthun and Ingram, 1967, p. 118).

Table 6 shows the average nitrogen, phosphorus, silica, and organic carbon concentrations for all sites. Except for the nitrite plus nitrate-nitrogen values, concentrations for the rest of the constituents in table 6 were significantly higher at sites 5 and 6. The Kjeldahl nitrogen, total phosphorus, and total organic carbon reflect, in part, the more intense

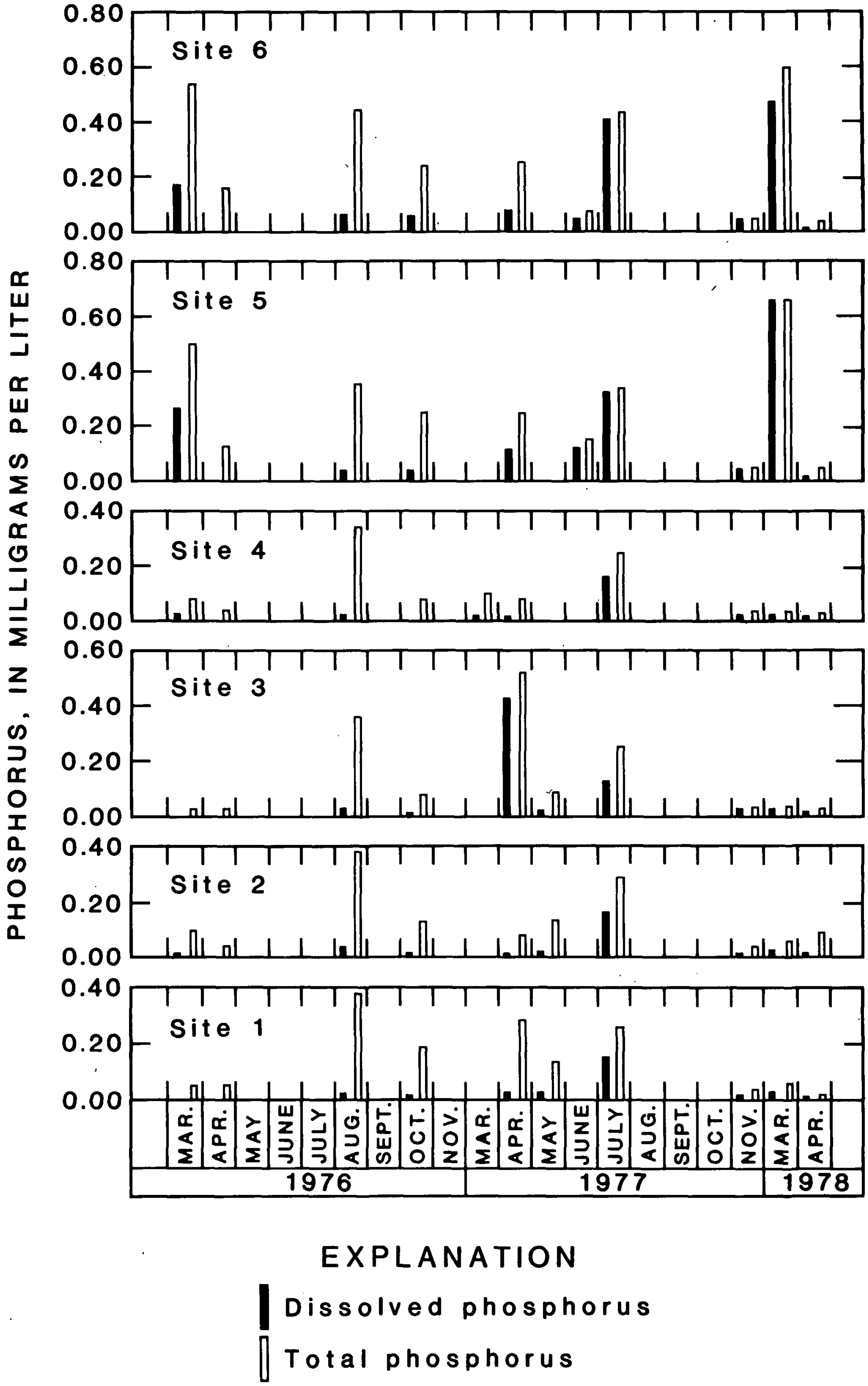

Figure 5.--Total and dissolved-phosphorus concentrations for each sampling site at Rogers Lake

Table 6.—Average nitrogen, phosphorus, silica, and organic carbon concentrations, in milligrams per liter, for each sampling site at Rogers Lake

Site	Total Kjeldahl nitrogen	Dissolved Kjeldahl nitrogen	Nitrite plus nitrate-nitrogen	Total phosphorus	Dissolved phosphorus	Silica	Total organic carbon
1	2.0	1.1	0.08	0.17	0.03	2.3	15
2	1.8	.88	.10	.14	.03	2.4	12
3	1.8	1.0	.05	.18	.08	2.3	13
4	1.7	.93	.09	.11	.02	2.9	11
5	3.2	2.1	.02	.36	.24	11	23
6	3.1	1.9	.02	.55	.37	13	23

biological activity at those two sites. The Kjeldahl nitrogen is largely organic nitrogen. Plants convert inorganic nitrogen (mainly in the form of nitrite plus nitrate-nitrogen) to organic nitrogen in the synthesis of protoplasm, which is reflected in the Kjeldahl nitrogen values. Therefore, Kjeldahl nitrogen is an indicator of the flora part of the biomass in a body of water. The phytoplankton concentrations (table 7) confirm that the cell counts were indeed generally higher at sites 5 and 6. The higher values of most constituents at sites 5 and 6 (table 6) also reflect the more pronounced concentration effect from evaporation during the summer months and from ice during the winter months at those shallow-water sites.

Organic carbon, nitrogen, and phosphorus concentrations in bottom sediments at each Rogers Lake site (table 4) are comparable to those found in other shallow eutrophic lakes sampled in Eagan and Apple Valley, Minn., in 1974 (Have, 1975, p. 21-24). These lakes are also in northern Dakota County, and therefore geologic and climatic conditions are similar. Nutrients probably cycle between bottom sediments and the lake water. Mechanical mixing of the bottom sediments by wave action, diving birds, and aquatic rodents recycles nutrients to the water for algal growth. Nutrients are returned to the sediments as algal growth dies off and settles to the lake bottom.

Biological Characteristics

Blue-green and green algae and diatoms were present in Rogers Lake throughout the year. Blue-green algae were dominant in 66 percent of the samples and had cell concentrations typically in the thousands per milliliter (table 7). Lee (1970) proposed that a concentration of 500 to 1,000 cells per milliliter indicated an excessive amount of phytoplankton production or an algal bloom. The high cell counts are, therefore, characteristic of algal blooms.

Table 8 lists the occurrences of blue-green algae that were dominant in Rogers Lake. <u>Oscillatoria</u> was dominant more frequently at sites 5 and 6, usually occurring in the winter and autumn. <u>Anacystis</u> was the more frequent in the winter and autumn at sites 1 to 4. In the spring and summer, the blue-green algae genera were more diverse at all the sites.

Blooms of blue-green algae are particularly obnoxious. The genus <u>Anacystis</u>, which was one of the more frequently occurring genera, has been reported several times as the cause of fatalities among horses, cattle, hogs, sheep, dogs, rabbits, and poultry (Palmer, 1962, p. 53). In their review of algae related toxicity, Ingram and Prescott (1954) found that algae responsible for mammalian, avarian, and fish deaths were all to be found in the blue-green algal group.

In general, the representative genera in Rogers Lake are typical genera found in a highly enriched environment. Palmer (1968) assigned a pollution-tolerant rating to each alga reported by 165 authors in 269 reports. Most of the algae found in Rogers Lake, including the green algae and diatoms, are listed in Palmer's report as being pollution-tolerant genera.

Table 7.--Phytoplankton concentrations and dominant and codominant genera for each sampling site at Rogers Lake

[BG, blue-green algae; D, Diatoms; DF, dinoflagellates; E, euglenoids; G, green algae]

			Dominant genera			Codominant genera			Codominant genera		
Date	Site	Number of cells per mL	Genus	Type	Percent of total cells	Genus	Type	Percent of total cells	Genus	Type	Percent of total cells
03-09-76	1	850,000	Oscillatoria	BG	98	---	---	---	---	---	---
04-12-76	1	5,600	Cyclotella	D	49	Ankistrodesmus	G	26	---	---	---
08-04-76	1	250,000	Anabaena	BG	74	Agmenellum	BG	23	---	---	---
10-19-76	1	150,000	Dictyosphaerium	G	50	Scenedesmus	G	17	---	---	---
03-02-77	1	62,000	Anacystis	BG	46	Oscillatoria	BG	22	---	---	---
07-13-77	1	22,000	Anabaena	BG	29	Dictyosphaerium	G	27	---	---	---
11-16-77	1	26,000	Anacystis	BG	79	Ankistrodesmus	G	18	---	---	---
03-08-78	1	32	Navicula	D	40	Diatoma	D	20	Cocconeis	D	20
04-26-78	1	2,900	Anacystis	BG	78	---	---	---	---	---	---
03-09-76	2	3,100	Peridinium	DF	36	Chlamydomonas	G	22	Trachelomonas	E	16
04-12-76	2	12,000	Ankistrodesmus	G	41	Cyclotella	D	22	---	---	---
08-04-76	2	300,000	Anabaena	BG	98	---	---	---	---	---	---
10-19-76	2	110,000	Anacystis	BG	56	Oscillatoria	BG	18	---	---	---
03-01-77	2	30,000	Oscillatoria	BG	89	---	---	---	---	---	---
04-12-77	2	200,000	Scenedesmus	G	37	Anacystis	BG	20	---	---	---
07-13-77	2	52,000	Anacystis	BG	36	Anabaena	BG	34	Agmenellum	BG	21
11-08-77	2	9,100	Anacystis	BG	80	---	---	---	---	---	---
03-08-78	2	7	Navicula	D	100	---	---	---	---	---	---
04-26-78	2	17,000	Anacystis	BG	86	---	---	---	---	---	---
03-09-76	3	1,600	Chlamydomonas	G	91	---	---	---	---	---	---
04-12-76	3	180,000	Raphidiopsis	BG	96	---	---	---	---	---	---
08-04-76	3	320,000	Anabaena	BG	72	Agmenellum	BG	26	---	---	---
10-19-76	3	200,000	Dictyosphaerium	G	40	Anacystis	BG	43	---	---	---
03-01-77	3	13,000	Anacystis	BG	50	Oscillatoria	BG	24	---	---	---
04-12-77	3	180,000	Scenedesmus	G	32	Anacystis	BG	22	Ankistrodesmus	G	17
07-14-77	3	36,000	Anabaena	BG	53	Anacystis	BG	24	---	---	---
03-08-78	3	5	Synedra	D	100	---	---	---	---	---	---
04-26-78	3	13,000	Anacystis	BG	83	---	---	---	---	---	---

Table 7.--Phytoplankton concentrations and dominant and codominant genera for each sampling site at Rogers Lake--Continued

[BG, blue-green algae; D, diatoms; DF, dinoflagellates; E, euglenoids; G, green algae]

			Dominant genera			Codominant genera			Codominant genera		
Date	Site	Number of cells per mL	Genus	Type	Percent of total cells	Genus	Type	Percent of total cells	Genus	Type	Percent of total cells
03-09-76	4	8,400	Chlamydomonas	G	95	---	---	---	---	---	---
04-12-76	4	150,000	Raphidiopsis	BG	96	---	---	---	---	---	---
08-04-76	4	250,000	Anabaena	BG	75	Agmenellum	BG	24	---	---	---
10-20-76	4	110,000	Anacystis	BG	68	---	---	---	---	---	---
03-02-77	4	28,000	Oscillatoria	BG	87	---	---	---	---	---	---
04-12-77	4	230,000	Anacystis	BG	45	Scenedesmus	G	35	---	---	---
07-14-77	4	90,000	Anacystis	BG	41	Anabaena	BG	36	---	---	---
11-16-77	4	11,000	Ankistrodesmus	G	85	---	---	---	---	---	---
03-09-78	4	360	Anacystis	BG	69	Melosira	D	16	---	---	---
04-26-78	4	26,000	Anacystis	BG	90	---	---	---	---	---	---
03-09-76	5	340,000	Oscillatoria	BG	51	Gomphosphaeria	BG	34	Anacystis	BG	15
04-12-76	5	49,000	Cyclotella	D	26	Scenedesmus	G	17	Anacystis	BG	16
08-04-76	5	690,000	Dictyosphaerium	G	19	Kirchneriella	G	18	---	---	---
10-20-76	5	1,500,000	Oscillatoria	BG	68	Anacystis	BG	16	---	---	---
04-13-77	5	640,000	Micractinium	G	44	Dictyosphaerium	G	32	---	---	---
06-09-77	5	3,200	Lyngbya	BG	34	Agmenellum	BG	32	---	---	---
07-12-77	5	4,100	Oscillatoria	BG	35	Anacystis	BG	23	---	---	---
11-16-77	5	6,100	Chroomonas	E	87	---	---	---	---	---	---
03-09-78	5	4,300	Oscillatoria	BG	88	---	---	---	---	---	---
04-27-78	5	5,100	Anacystis	BG	66	---	---	---	---	---	---
03-09-76	6	960	Peridinum	DF	42	Trachelomonas	E	16	Oscillatoria	BG	16
04-12-76	6	180,000	Cyclotella	D	84	---	---	---	---	---	---
08-04-76	6	1,700,000	Agmenellum	BG	44	Gloeoactinium	G	17	---	---	---
10-20-76	6	5	Oscillatoria	BG	57	Anacystis	BG	27	---	---	---
04-13-77	6	530,000	Anacystis	BG	76	---	---	---	---	---	---
06-09-77	6	4,500	Lyngbya	BG	29	Oscillatoria	BG	18	Agmenellum	BG	16
07-12-77	6	81,000	Oscillatoria	BG	44	---	---	---	---	---	---
11-16-77	6	4,200	Chroomonas	BG	42	Anacystis	BG	18	---	---	---
03-09-78	6	32,000	Oscillatoria	BG	70	---	---	---	---	---	---
04-27-78	6	44,000	Anacystis	BG	98	---	---	---	---	---	---

Table 8.--Number of occurrences of blue-green algae for each sampling site at Rogers Lake, March 1976 to April 1978

[Sp-spring, S-summer, A-autumn, W-winter]

Site	Oscillatoria	Lyngbya	Anabaena	Anacystis	Raphidiopsis	Agmenellum
1	1	0	2	3	0	0
2	1	0	1	4	0	0
3	0	0	2	2	1	0
4	1	0	1	5	1	0
5	3	1	0	1	0	0
6	3	1	0	2	0	1
Time of year most commonly found	A,W	Sp	S	A,W	Sp	S

Fecal coliform and fecal *Streptococci* bacteria counts were usually quite low at all sites (table 1). There were several bacteria samples that had reported values of less than one colony per 100 milliliters. Only nine samples, or 8 percent, had bacteria counts greater than 100 colonies. The highest fecal coliform count was 830 colonies per 100 milliliters of lake water at site 3 on October 19, 1976. This exceeded the recreational standard of 400 colonies per 100 milliliters at any one time for body-contact recreation (U.S. Environmental Protection Agency, 1977). The highest fecal *Streptococci* count was 480 colonies per 100 milliliters and also occurred at site 3 on October 19, 1976.

Other Characteristics

Other characteristics tested for in Rogers Lake were Secchi-disk transparency, turbidity, suspended solids, COD, oil and grease, cyanide, and detergents. The determination of some of these characteristics was started later in the study.

Most of the high turbidities, high suspended-solids concentrations, and lowest Secchi-disk transparencies occurred in August 1976 (table 1). Some of the high phytoplankton counts also occurred during this period. In July 1977, however, when phytoplankton counts were much lower, turbidity and suspended solids were lower and light transparencies higher. This suggests that these three physical characteristics are at least partly dependent upon phytoplankton concentrations and that all these characteristics can vary greatly even during the same season.

No significant amounts of oil and grease were detected in the lake water (table 1). Their concentrations ranged from 0 to 7 mg/L. Oil and grease were detected in 8 of 19 samples at sites 5 and 6 and in 6 of 38 samples at sites 1 through 4. This higher frequency in the upper lake suggests some overland runoff to the lake from State Highway 110. Conceivably, this could happen during heavy rains. No oil and grease were found in the bottom material at any of the sites (table 4).

Cyanide, highly toxic to aquatic animals, was detected only at sites 5 and 6. The concentrations found at both sites were 0.01 mg/L and can affect the respiratory process of aquatic animals (Minnesota Pollution Control Agency, 1978). In the presence of ultraviolet light, sodium ferrocyanide, an anticaking agent used in deicing chemicals, can be reduced to cyanide. Because of the proximity of sites 5 and 6 to State Highway 110 and its intersection with Interstate I-35E, it may be possible that some sodium ferrocyanide is reaching the lake and is being reduced to cyanide.

COD is a measure of the quantity of oxidizable compounds (mainly organic) present in water. Like TOC (total organic carbon) it would partly reflect the degree of biomass, which is mostly organic. COD concentrations were much higher at sites 5 and 6 than at sites 1 to 4 (table 3). The average COD concentrations for sites 1 to 6 are 38, 37, 40, 32, 58, and 73 mg/L, respectively.

SUMMARY

Selected physical, chemical, and biological characteristics were determined to assess the quality of Rogers Lake. These data will serve as baseline information to detect and evaluate water-quality changes during highway construction.

Rogers Lake is divided by a county road. The upper lake has less area and depth than the lower lake. A golf course surrounds much of the upper lake and a four-lane highway lies near its north end. These characteristics contribute to the difference in chemical and biological quality between the upper and lower lakes. The lower lake has more residential development, an inlet for storm sewers, and an outlet for overflow.

Rogers Lake had relatively high concentrations of sodium and chloride compared with many other lakes in the area. The sodium and chloride values ranged from 7.2 to 55 and 15 to 130 mg/L, respectively, with the upper lake having higher concentrations than the lower lake. A possible major source of the sodium and chloride is State Highway 110 north of the upper lake. This source, together with the smaller volume of water in the upper lake, resulted in the relatively high concentrations.

The upper lake also contained greater concentrations of many other compounds. For example, total nitrogen and phosphorus were higher in the upper lake. Fertilization and irrigation of the golf course may have contributed part of the nutrient load to the upper lake.

Both the upper and lower lakes were eutrophic and were mainly dominated by blue-green algae year around. The highest cell counts occurred in the upper lake.

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