ANALYSIS OF METEOROLOGICAL DATA AND WATER CHEMISTRY OF LATIR LAKES, TAOS COUNTY, NEW MEXICO, 1985-88

By Scott K. Anderholm, Raymond G. Roybal,
Dennis Risser, and Georgene Somers

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
inch	25.40	millimeter
foot	0.3048	meter
mile	1.609	kilometer
mile per hour	1.609	kilometer per hour
acre	0.4047	hectare
square foot	0.0929	square meter
square mile	2.590	square kilometer
gallon	3.785	liter
cubic foot	0.02832	cubic meter
acre-foot	0.001233	cubic hectometer
cubic foot per second	0.02832	cubic meter per second

Temperature in degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) by the equation:

$$°F = 9/5\ (°C) + 32$$

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

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ABSTRACT

Data were analyzed to determine the chemistry of atmospheric deposition and water of the Latir Lakes in Taos County, New Mexico, from 1985 to 1988. The Latir Lakes consist of a series of nine paternoster lakes that range in altitude from 11,061 to 11,893 feet above sea level. The pH of wet precipitation generally ranged from 4.6 to 5.5 and the specific conductance of wet precipitation ranged from 1 to 18 microsiemens per centimeter at 25 degrees Celsius from December 1985 through September 1988.

Snowpack chemistry data indicate a change in the specific conductance, pH, and alkalinity of the snowpack from month to month. The dominant cation in the snowpack is calcium, and the dominant anions are nitrate and sulfate. The samples having the smallest values of specific conductance generally did not contain measurable alkalinity. When the snowpack starts to melt in the spring, specific conductance of the entire snowpack decreases, consistent with the hypothesis that the initial fluid draining from the snowpack transports a large amount of dissolved material out of the snowpack.

Water chemistries in the Latir Lakes are similar although specific conductance increases downstream from lake 9 to lake 1. Calcium is the dominant cation and the ions that produce alkalinity are the dominant anions. Concentrations of sodium, magnesium, chloride, and sulfate do not vary substantially from year to year or during the year in a particular lake. Alkalinity and calcium concentration, however, do vary from year to year and during the year. The pH of outflow from the Latir Lakes varies from lake to lake and from year to year. In 1986, the range in pH in the lakes was less than 1 unit in mid-June, but was greater than 2.5 units by late October. The pH generally was larger than 7.0 in all of the lakes and was as large as 9.9 in several of the lakes during the period of study. The pH of outflow water generally increases from early spring to late summer in the Latir Lakes, and snowmelt does not seem to cause the pH to decrease in the lakes.

Depth profiles of selected lakes indicate that the dissolved-oxygen concentration approaches zero below the thermocline. This suggests biological oxidation of organic matter in the lower zones in these lakes. Because many organisms cannot live in water containing small dissolved-oxygen concentrations, large volumes of water in lakes 9 and 3 probably are not suitable for habitation during the summer months.

INTRODUCTION

Emissions from the combustion of fossil fuels have been extensively studied in connection with acid deposition and the resulting massive chemical and ecosystem changes in Scandinavia, Canada, and the northeastern United States. Recent evidence indicates that acid deposition also is a common occurrence in the Western United States (Lewis and Grant, 1980), including northern New Mexico (Popp and others, 1984).

A current (1987) deficiency in acid-deposition research in the Western States is the scarcity of sampling sites at high altitudes. Only 4 of 64 National Atmospheric Deposition Program/ National Trends Network (NADP/NTS) deposition-monitoring sites in the mountainous Western States are at altitudes higher than 3,000 meters (9,840 feet) above sea level (National Atmospheric Deposition Program, 1986). Popp and others (1984) suggested that deposition collected at low altitudes in New Mexico may not be representative of the amount and chemistry of deposition received by parts of the ecosystem most vulnerable to the effects of acidic precipitation--high-altitude lakes. Precipitation falling at high altitudes may be considerably more acidic than precipitation falling at lower altitudes because terrestrially derived atmospheric particles that neutralize acidity are less available in the mountains.

Acidic precipitation results in substantial seasonal and short-duration episodic changes in the water chemistry of lakes. Episodic changes in water chemistry may occur during rainstorms (Lynch and others, 1986) or during snowmelt (Skartveit and Gjessing, 1979). Snowmelt has the potential to cause significant changes in water chemistry because the concentration of some ionic species can be 5 to 20 times larger in the initial fraction of snowmelt compared to the average concentration in the snowpack (Johannessen and Henriksen, 1978; Suzuki, 1984; Stein and others, 1986). These temporal water-chemistry changes may have adverse effects on aquatic biota if they occur during sensitive periods of an organism's development, such as during the hatching of fish. In 1987, the U.S. Geological Survey, in cooperation with New Mexico Highlands University, began an investigation to determine the chemistry of atmospheric deposition and the water chemistry of the Latir Lakes in Taos County, New Mexico (fig. 1).

Purpose and Scope

This report presents meteorological data and describes the water chemistry of the Latir Lakes. The meteorological data include air temperature; wind speed and direction; precipitation volume; and rainfall, snowpack, and snowmelt chemistry. The description of water chemistry includes lake outflow and depth profiles. All data were collected from 1985 to 1988.

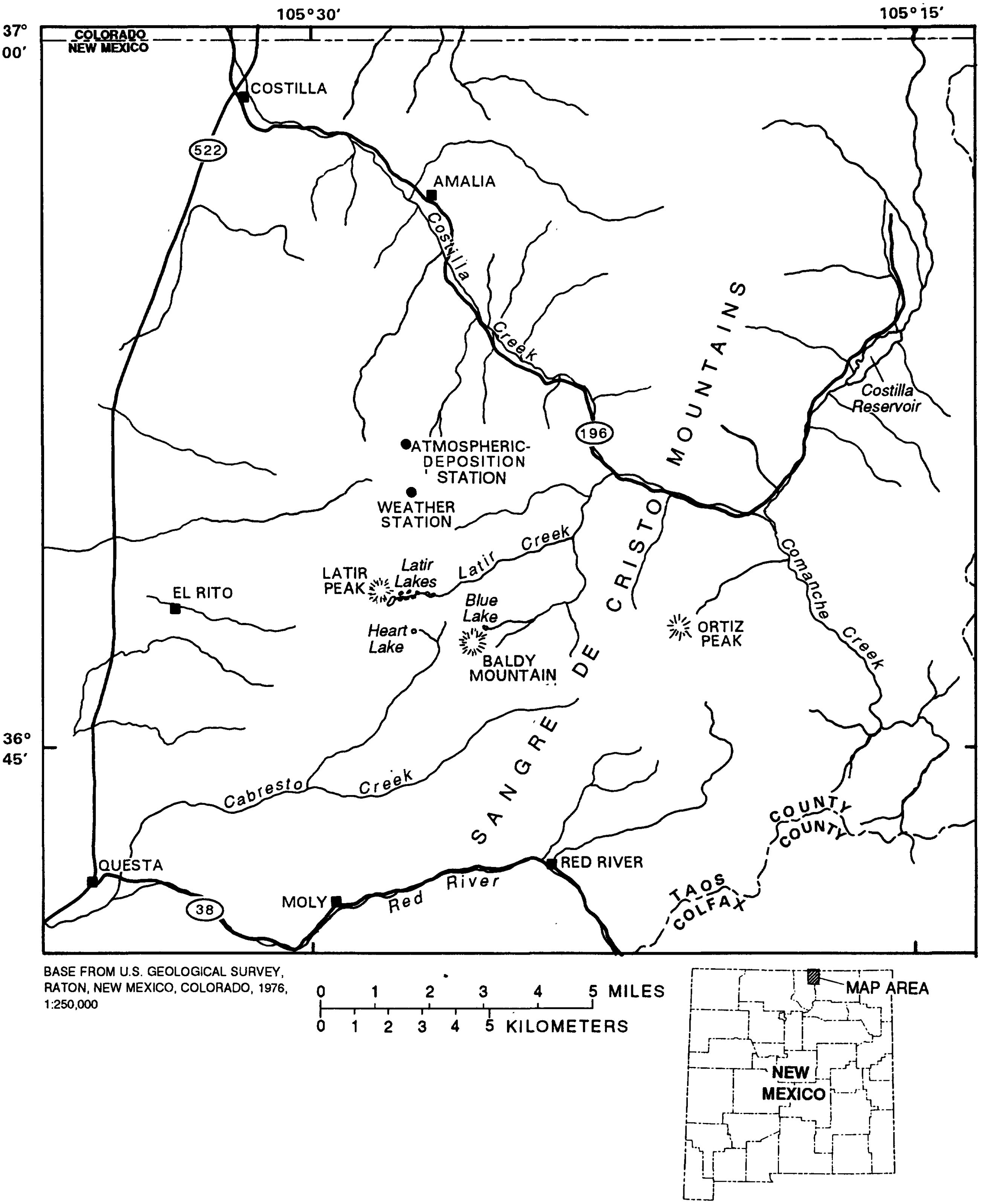


Figure 1.--Location of Latir Lakes, weather station, and atmospheric-deposition station.

Acknowledgments

The Rio Costilla Cooperative Livestock Association allowed access to the Latir Lakes. In particular, Dee Lovato, Lou Lucero, Orlando Romero, Floyd Trujillo, Elias Vigil, and Marvin Arellano of the Association were especially helpful during the course of this study and their assistance and advice are greatly appreciated.

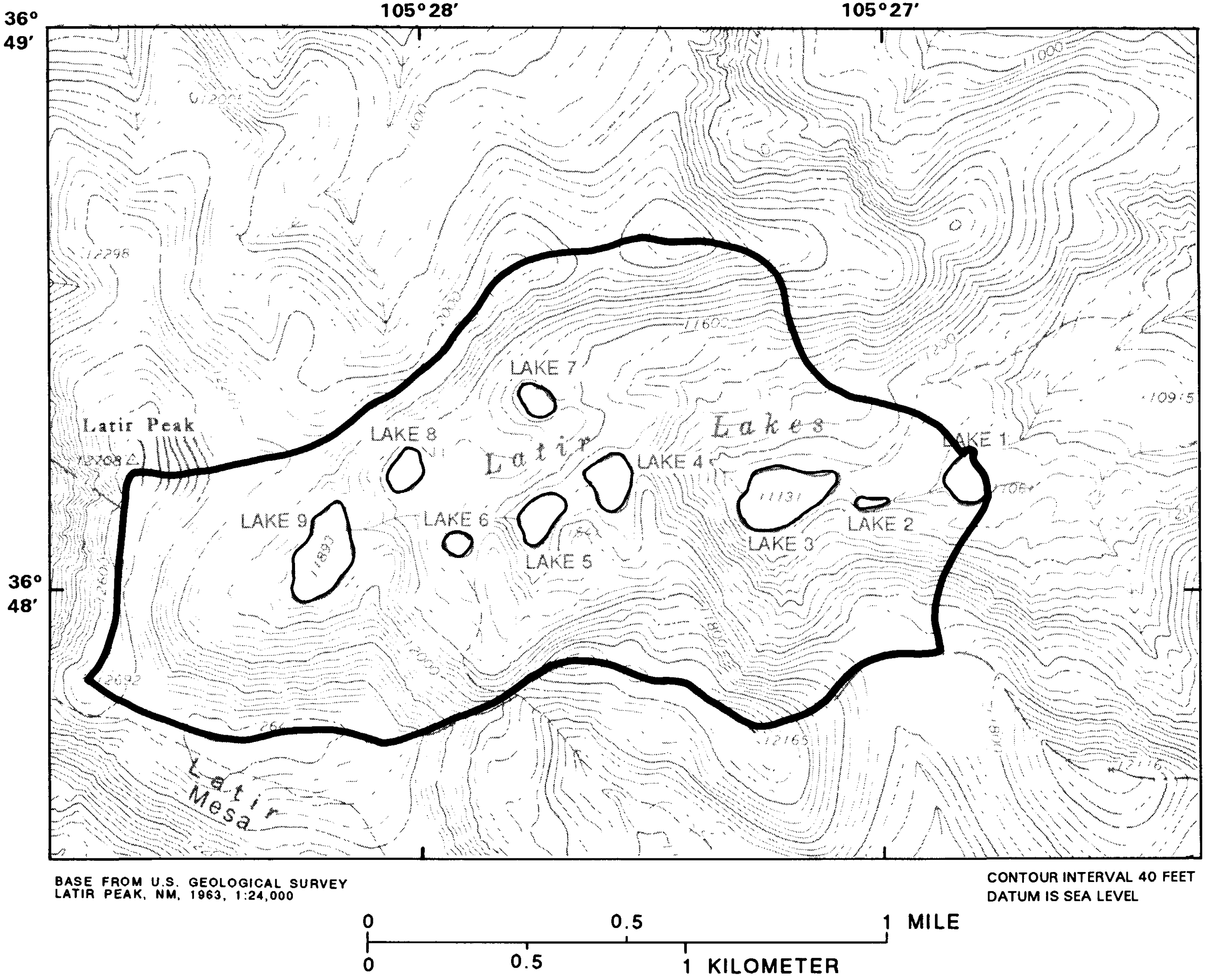
Personnel of Ski Rio helped in the installation of the atmospheric-deposition and weather stations at the ski area. Kevin Beardsley of Ski Rio allowed access to the ski area, allowed personnel to be available to assist the investigators, and loaned equipment to reach the deposition station. Mark Henderson, the observer for the atmospheric-deposition station, collected samples and maintained the equipment. Paul Kunkel also was helpful in assisting with the operation of the deposition station. Kenneth Stevens of the U.S. Geological Survey designed and initiated this study. His efforts to organize and obtain funding for this study made this work possible. John Flager assisted in much of the data collection and organization of this report. His help under less than ideal conditions made much of the data collection possible.

DESCRIPTION OF STUDY AREA

Data were collected at the Latir Lakes, the atmospheric-deposition station, and the weather station in the Sangre de Cristo Mountains of northern New Mexico (fig. 1). The Latir Lakes are a series of nine paternoster lakes carved by glaciers from volcanic bedrock of rhyolite and andesite (McKinlay, 1956). The lakes, numbered from lake 9 to lake 1, range in altitude from 11,893 to 11,061 feet above sea level, respectively (fig. 2).

The Latir Lakes are in a location that is particularly vulnerable to atmospheric deposition of nitrogen and sulfur emissions. The lakes lie in the prevailing downwind pattern of air circulation from copper smelters in southeastern Arizona, southwestern New Mexico, and northern Mexico. Emissions from coal-fired powerplants in the northwest and west-central parts of New Mexico also may be carried over the area.

Because the lakes generally are inaccessible from November through May, a weather station and an atmospheric-deposition station were located at a nearby ski area, which allowed year-round access. The weather station was at the top of the upper chair lift, at an altitude of 11,400 feet (fig. 1). About a mile away, the deposition station, located to assure undisturbed snowpack, was at an altitude of 10,200 feet (fig. 1).



BASE FROM U.S. GEOLOGICAL SURVEY
LATIR PEAK, NM, 1963, 1:24,000

CONTOUR INTERVAL 40 FEET
DATUM IS SEA LEVEL

Figure 2.--Latir Lakes watershed.

Geologic Setting

The geology of the Latir Lakes study area was mapped and described by McKinlay (1956). Most of the following discussion has been summarized from his work.

Three bedrock units of Tertiary age are exposed in the Latir Lakes study area (fig. 3). The oldest bedrock unit consists of red and purple to green andesite flows and pyroclastics (Ta, fig. 3). These rocks are exposed near the upper six Latir Lakes. The andesite flows change thickness from a few feet to several hundred feet in short distances. These flows commonly are interbedded with tuff beds, breccias, and sedimentary rocks, such as conglomerates or siltstones (McKinlay, 1956, p. 13). The andesite flows generally are fine grained. Although some flows are porphyritic and contain phenocrysts of plagioclase and hornblende, much of the aphanitic groundmass is glassy and contains disseminated hematite (McKinlay, 1956, p. 13). Some augite is present; however, the augite generally is altered to chlorite and hematite.

The Latir Peak Formation was named for Latir Peak, where it is exposed (Tlp, fig. 3) (McKinlay, 1956, p. 14). The formation also is exposed on the steep slope between lakes 3 and 4 and south of lakes 1-3 (fig. 3). The Latir Peak Formation consists of light-gray to reddish andesite and latite (porphyry) flows, sills, and dikes. The sills and dikes intrude the andesite flows (Ta, fig. 3). Near this contact with the andesite flows (Ta, fig. 3), the andesite flows have been fractured, sheared, and metamorphosed. The Latir Peak Formation is fine grained near the contacts with the andesite flows and becomes coarser grained outward from the contacts (McKinlay, 1956, p. 14). The formation is composed mainly of latite; however, in some areas the composition is andesitic. The latite contains phenocrysts of plagioclase (35 percent of the rock), which are between oligoclase and andesine; biotite (5 percent); hornblende (2 percent); and quartz. The groundmass consists of feldspars and quartz (McKinlay, 1956, p. 14).

The third Tertiary bedrock unit consists of rhyolite tuffs and flows ranging in thickness from 1,000 to 1,500 feet that crop out east and north of the Latir Lakes (Tr, fig. 3). East of the Latir Lakes, the unit is composed of rhyolite tuffs and breccias. The rhyolite tuff is younger than the andesite flows and pyroclastics of the Latir Formation; however, the age relation between the two units is uncertain (McKinlay, 1956, p. 14).

A Tertiary porphyritic rhyolite dike is exposed south of lakes 8 and 9 (Tri, fig. 3). The dike contains phenocrysts of orthoclase and rounded quartz crystals in an aphanitic groundmass. Quaternary alluvium (Qal, fig. 3) is present in the valleys and on the slopes adjacent to the lakes The alluvium consists of glacial and stream deposits.

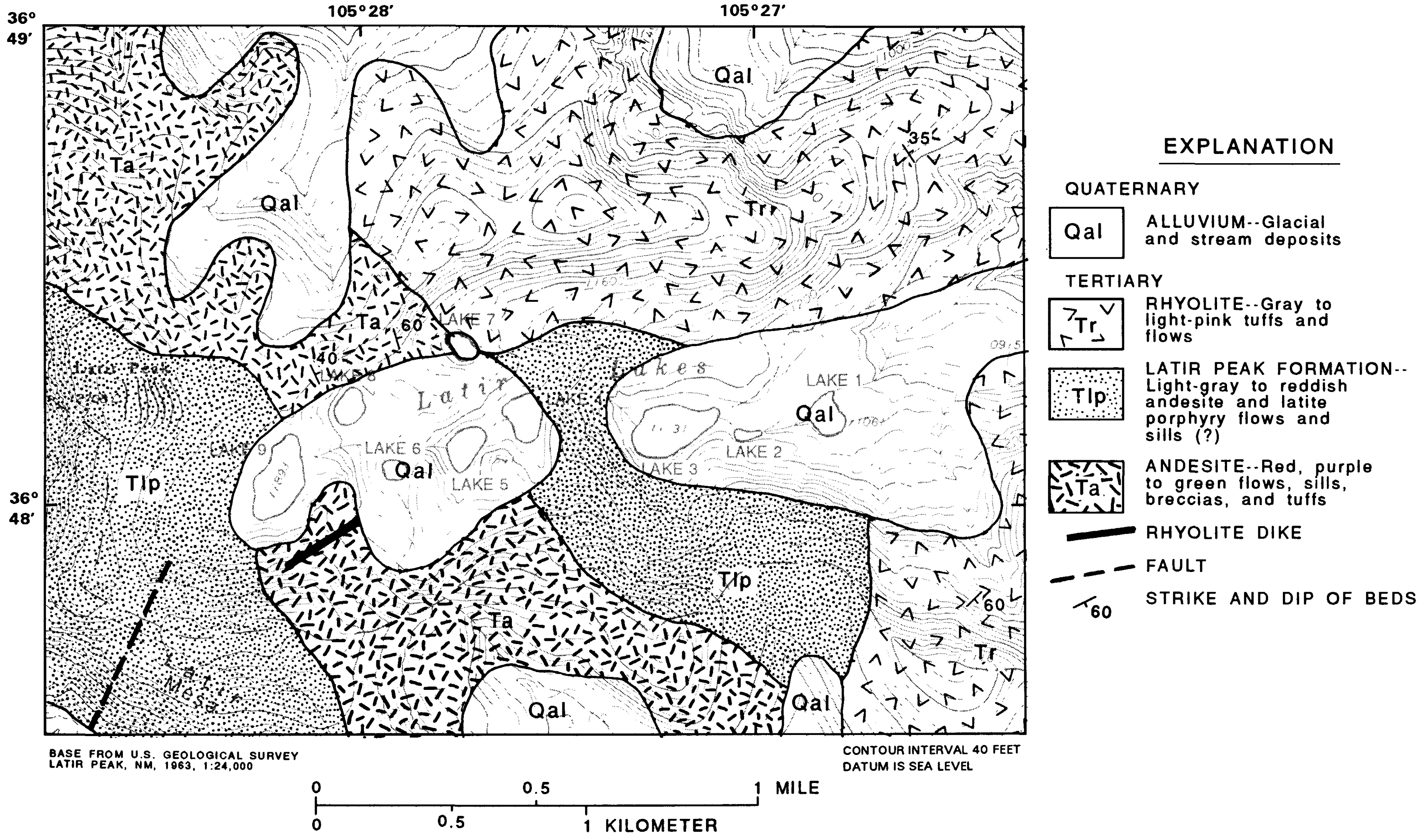


Figure 3.--Geology of the Latir Lakes area (geology from McKinlay, 1956).

Vegetation

The vegetative cover of the Latir Lakes watershed above lake 1 is varied but has been divided into three general categories (fig. 4) on the basis of field reconnaissance and aerial photographs. Some small areas mapped within one category may have another vegetative cover, but because of the map scale these areas cannot be delineated. Dense stands of Engelmann spruce and Douglas fir comprise the most common vegetative cover. In general, the trees are close together and there are few shrubs and little or no grass under the canopy. At higher altitudes, alpine grass and small shrubs comprise the second vegetative cover. Fir and spruce trees are scattered within this category, which also includes marshy areas near the lakes. The third vegetative cover consists of rock outcrops and widely scattered grasses and shrubs on steep slopes and rock outcrops. Many of the areas included in this category are rock glaciers and scree slopes.

METEOROLOGICAL DATA

Meteorological data were collected at two locations at the ski area (fig. 1). Temperature and wind data were collected at the weather station at an altitude of approximately 11,400 feet above sea level. This station is approximately 2.5 miles from the Latir Lakes (fig. 1). Atmospheric-deposition, snowmelt, snowpack, and precipitation-volume data were collected at the atmospheric-deposition station at an altitude of approximately 10,200 feet above sea level. This station is approximately 3.5 miles from the Latir Lakes (fig. 1).

Instrumentation and Data Collection Methods

Weather Station

A recording device and instrumentation for monitoring air temperature, wind direction, and wind speed were installed at the top of the uppermost ski lift. This allowed collection of weather information during the winter months when the Latir Lakes are inaccessible.

Atmospheric-Deposition Station

An Aerochemetrics[1] wet-dry deposition collector was installed to obtain samples of atmospheric deposition. A Belfort recording rain gage was installed to collect data on precipitation volume and time of occurrence. In general, the station was operated according to procedures for sampling and analysis described by Bigelow (1982). Instruments were serviced weekly by a local observer who changed buckets and charts and measured snow depth.

[1] Use of trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

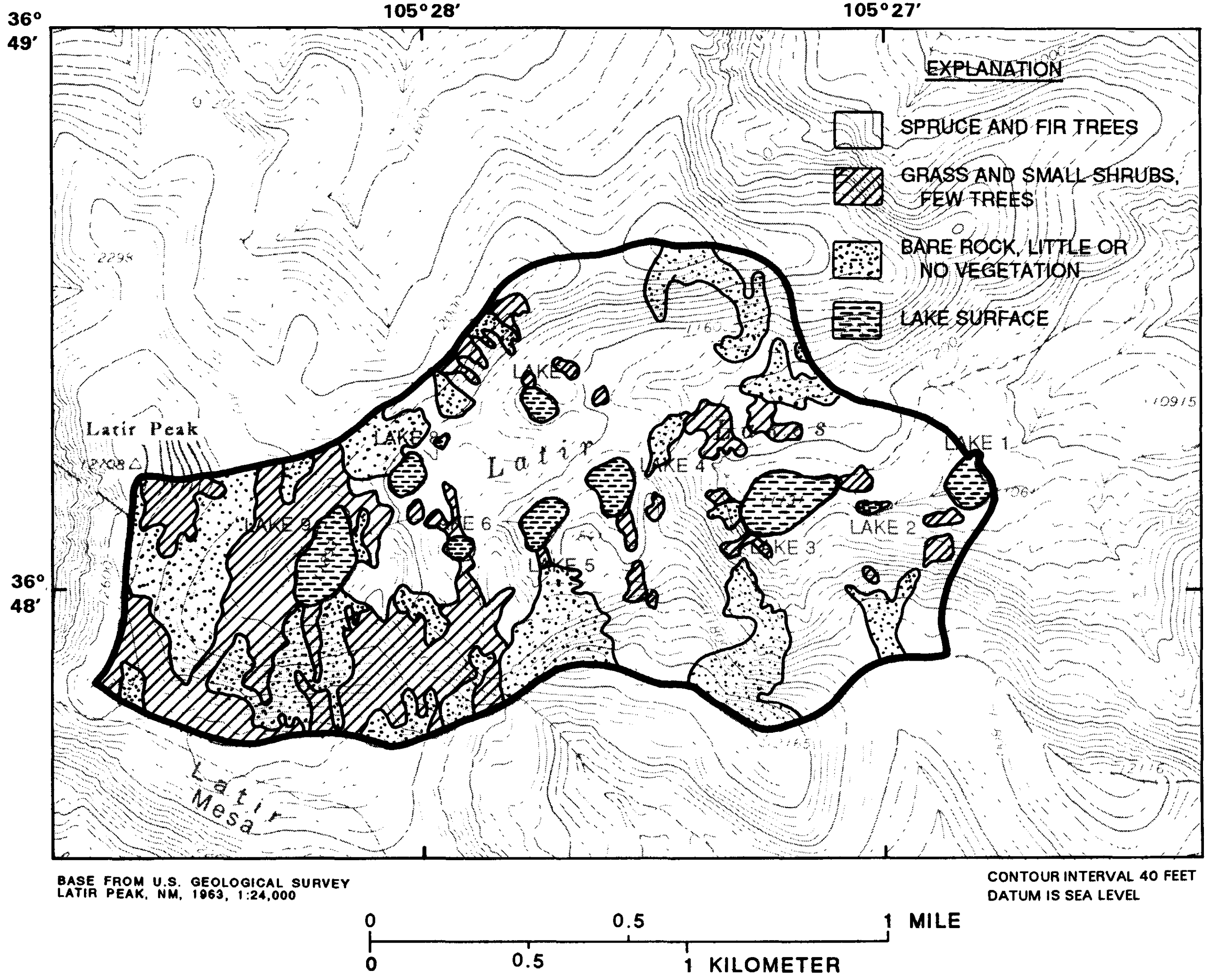


Figure 4.--Vegetative cover in the Latir Lakes watershed.

Atmospheric-deposition samples

Polyethyene buckets containing wetfall precipitation samples from the deposition collector were shipped to Albuquerque (approximately 3 days in the mail) where pH, specific conductance, and alkalinity were measured. The pH was measured using an Orion Model SA250 pH meter and a Ross combination electrode. Orion low ionic strength buffers were used for calibration of the pH meter. Specific conductance was measured using a Myron EP meter, which was calibrated prior to each measurement. Alkalinity was determined by titration with 0.016-normal sulfuric acid and was computed using Gran's technique (Gran, 1952).

Alkalinity is the capacity of a solution to react with and neutralize acid and not the concentration of an individual species (Hem, 1985, p. 106). Bicarbonate and carbonate are the main dissolved species that produce alkalinity in most natural waters; however, hydroxide, ionized silicic acid, borate, and organic ions also produce alkalinity (Drever, 1988, p. 52). In this report alkalinity is expressed in terms of an equivalent concentration of calcium carbonate. To obtain alkalinity in terms of milliequivalents per liter, multiply the milligrams per liter as $CaCO_3$ by 0.02.

If a sample volume was larger than about 500 milliliters, the sample was filtered through a 0.45-micron filter into a polyethyene bottle that had previously been soaked in ultrapure deionized water (water having a specific conductance less than 1 microsiemen per centimeter at 25 degrees Celsius). The sample bottles were soaked until the specific conductance of the deionized water was less than 1 microsiemen (microsiemen per centimeter at 25 degrees Celsius) and then filled with ultrapure deionized water until used. Prior to using a sample bottle, the specific conductance of the deionized water was checked to ensure that it was less than 1 microsiemen. The filter holder and receiver were used only for atmospheric-deposition and snowmelt samples. Prior to filtering the deposition samples, the filter holder and receiver were rinsed with ultrapure deionized water. The filter paper was then inserted into the filter holder and approximately 100 milliliters of ultrapure deionized water was suctioned by vacuum through the filter paper into the receiver. After emptying the receiver, if total sample volume was sufficient, approximately 100 milliliters of the atmospheric-deposition sample was suctioned through the filter paper and discarded. The remainder of the sample was filtered and put into the sample bottles. The sample for cation analysis was then preserved with 1 milliliter of nitric acid. Samples that were to be analyzed for dissolved phosphorus, ammonia, and dissolved organic carbon were preserved with 1 milliliter of sulfuric acid. Samples to be analyzed for anions were preserved by chilling to 4 degrees Celsius in opaque bottles until analysis.

Snowpack samples

Snowpack samples were collected next to the atmospheric-deposition station at the ski area. This area was flat and protected from the wind so little or no drifting of snow would occur. Spacial variation in snowpack depth in this area was small based on monthly measurements. The snowpack was sampled in an undisturbed area by digging a pit in the snow to the ground surface and sampling snow from the walls of the pit. Snow samples of 6 x 6 x 2 inches were collected every 2 vertical inches for the entire depth of the snowpack using a plastic scoop. Each sample was carefully measured for size. Each sample was placed in a plastic bag (which had been rinsed with ultrapure deionized water), sealed, and kept frozen in a cooler to reduce the possibility of evaporation until it was carefully weighed for density determinations at the U.S. Geological Survey laboratory in Albuquerque. The samples were then thawed, and specific conductance, pH, and alkalinity measurements were made. Selected samples were composited, filtered, and sent to another laboratory for chemical analysis.

Snowmelt samples

Snowmelt samples were collected adjacent to the atmospheric-deposition station in spring of 1988. The snowmelt sampler, which was installed in fall 1987 prior to any snowfall, consisted of a 30- x 30-inch epoxy-coated fiberglass shower base. A PVC pipe drained from the drain of the shower base into a bucket enclosed in a larger container, buried in the ground approximately 10 feet from the shower base. The shower base and associated plumbing were rinsed with ultrapure deionized water after installation. The sample bucket, the same type used for atmospheric-deposition sampling, was monitored in the spring when snowmelt was expected to begin; however, snowmelt occurred relatively rapidly in 1988, and some of the water from the earliest snowmelt was lost when the sample bucket overflowed. Thereafter, the sample bucket was removed and replaced with a clean bucket daily. Specific-conductance, pH, and alkalinity measurements were made on snowmelt samples within 3 hours of collection. Procedures for these measurements, sample filtering, and preservation were the same as those described above for the atmospheric-deposition samples.

Chemical Analysis of Samples

Two laboratories were used during the study. The New York State Department of Health Laboratory in Rochester analyzed most samples collected prior to October 24, 1987. This laboratory was under contract with the U.S. Environmental Protection Agency (EPA) and used methods that are EPA-approved for precipitation samples. The U.S. Geological Survey Central Laboratory in Denver, Colorado, analyzed samples collected after October 24, 1987. All cations except sodium were analyzed using inductively coupled plasma techniques. Sodium was analyzed using atomic absorption techniques. All anions were analyzed using ion chromatography techniques.

Data Analysis

Temperature and Wind Data

The collection of temperature, wind-direction, and wind-speed data began in November 1986. Many problems were encountered during the collection of these data, some of which were not quickly resolved. As a result, there are large gaps in the data.

The difference between daily minimum and daily maximum temperatures generally was about 10 to 15 Celsius degrees. Annual temperature ranged from minus 15 to plus 25 degrees Celsius. The temperature data are shown in figure 5.

The wind-direction data are the least complete; however, several observations can be made from the existing data. The predominant wind direction was from the south to southwest (180 to 270 degrees clockwise from north) (fig. 5). When the wind speed was greater than 10 miles per hour, the wind was often from the east or southeast (90 to 180 degrees clockwise from north). Winds from these directions and also from the northwest are associated with precipitation.

Precipitation Volume

Precipitation volume was measured from December 5, 1986, to October 8, 1988. To fill gaps in the data from the recording rain gage, volumes have been calculated from the precipitation collected in the deposition collector (table 1; tables are in the back of the report). Although the deposition-collector efficiency was not as great as the recording rain gage, the data are still useful. Data calculated from the deposition collector are indicated by an asterisk in table 1 and the days they represent are indicated by brackets. When the deposition-collection period included parts of 2 months, the precipitation was arbitrarily assigned to the month that had more days of collection. When the deposition-collection period overlapped 1987-88, the calculated precipitation was divided in half for the period of record; one-half the precipitation was arbitrarily assigned to each year. Total precipitation measured in 1987 was 22.15 inches.

The records indicate a variation in seasonal precipitation from year to year. In 1988, total precipitation measured from January through April was 5.14 inches; during this same period in 1987 total precipitation was 10.34 inches. The only long-term precipitation data were from the Rio Costilla weather station in Costilla (fig. 1) from 1914 to 1921. These data indicate that April, May, July, August, September, and October are the wettest months of the year (table 2).

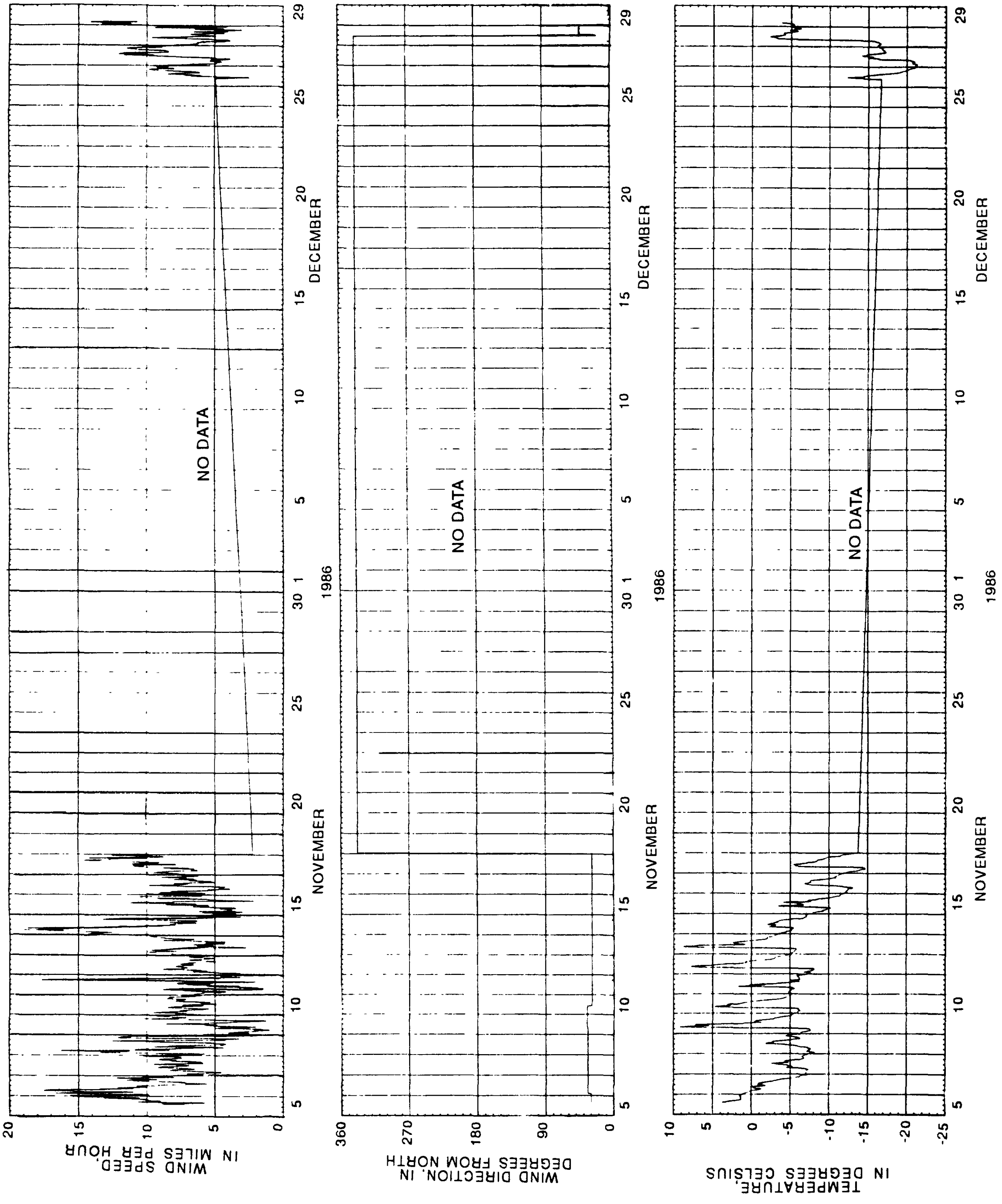


Figure 5.--Temperature, wind direction, and wind speed at the weather station.

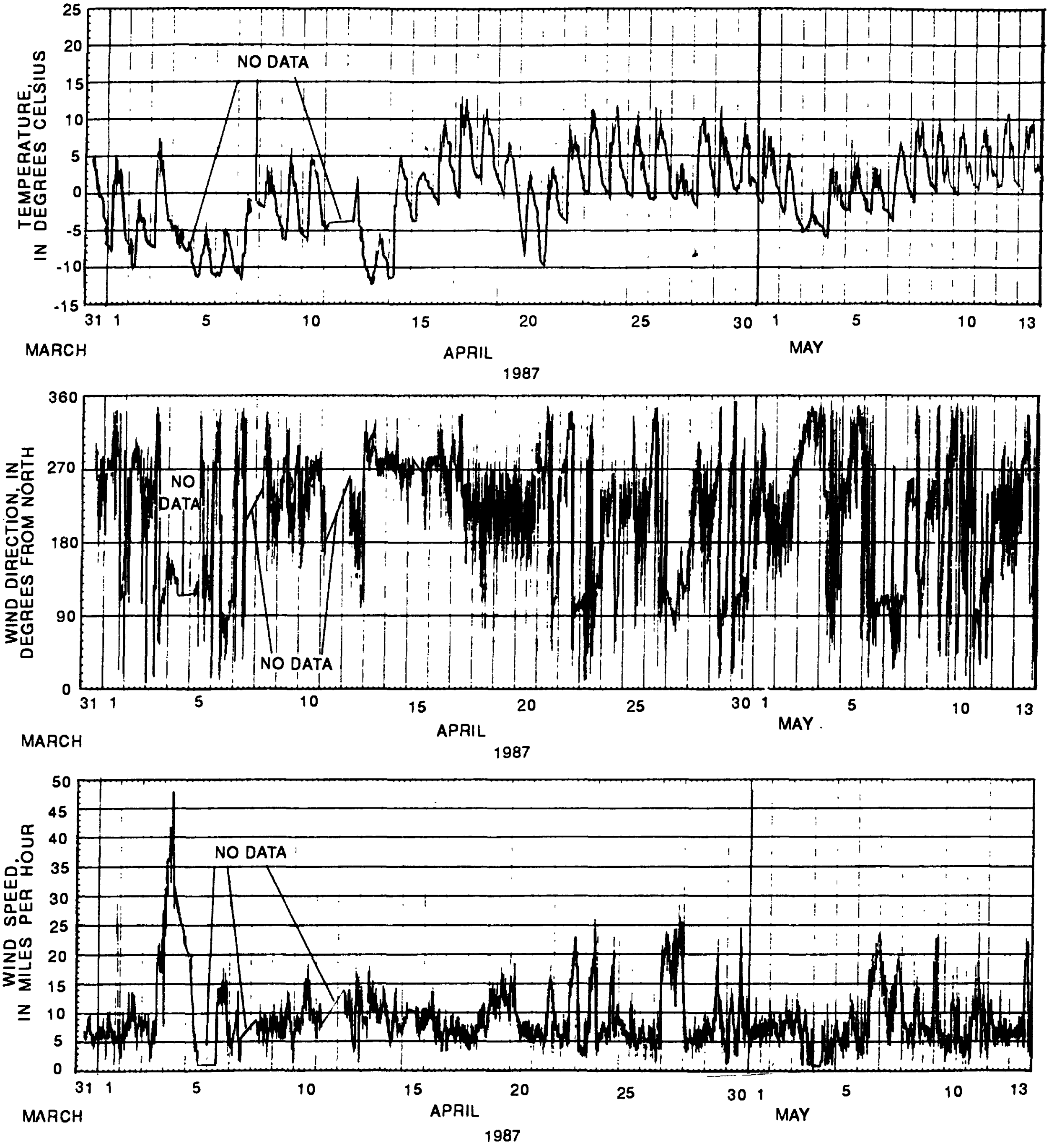
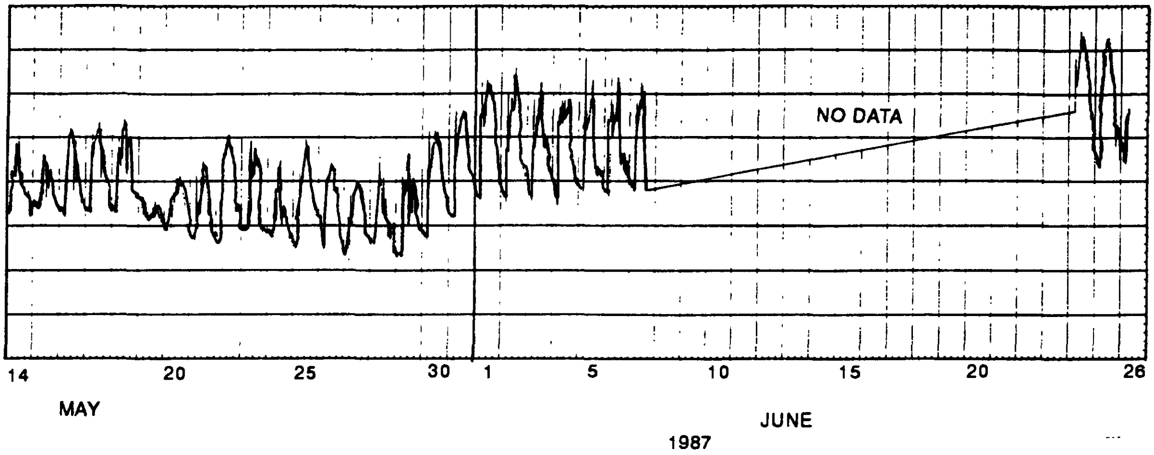
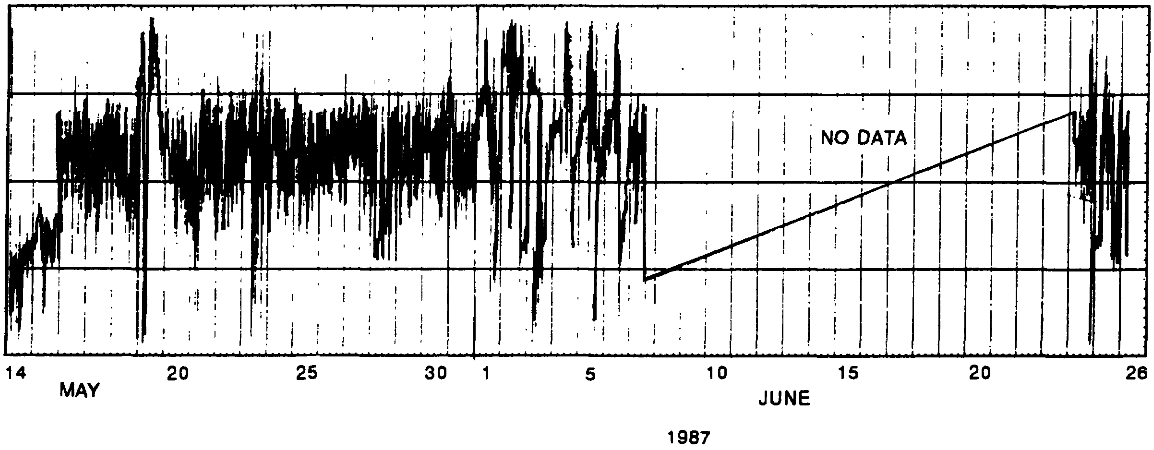


Figure 5.--Temperature, wind direction, and wind speed at the weather station--Continued.


NO DATA
14
20
25
30
1
5
10
15
20
26
MAY
JUNE
1987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20
25
30
1
5
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15
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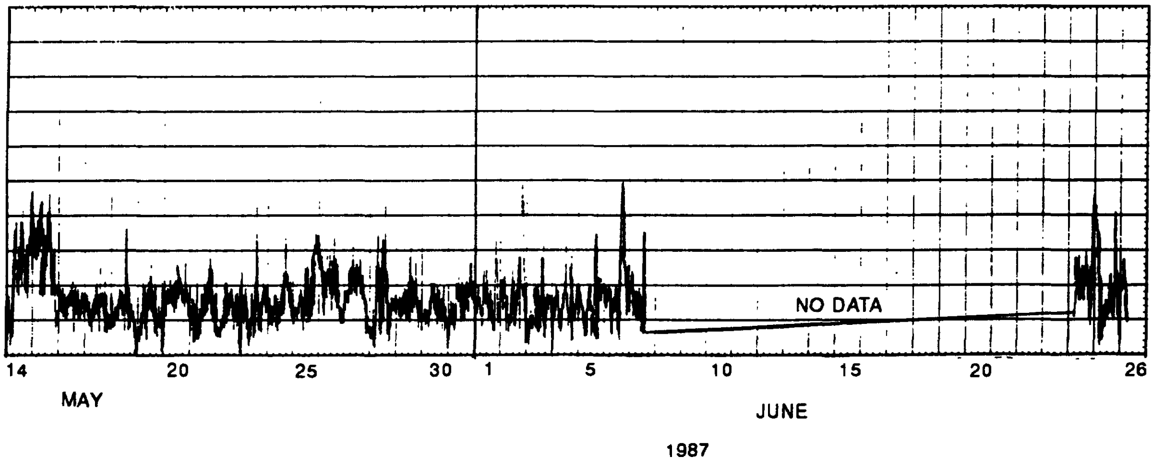
26
MAY
JUNE
1987


NO DATA
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1
5
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MAY
JUNE
1987

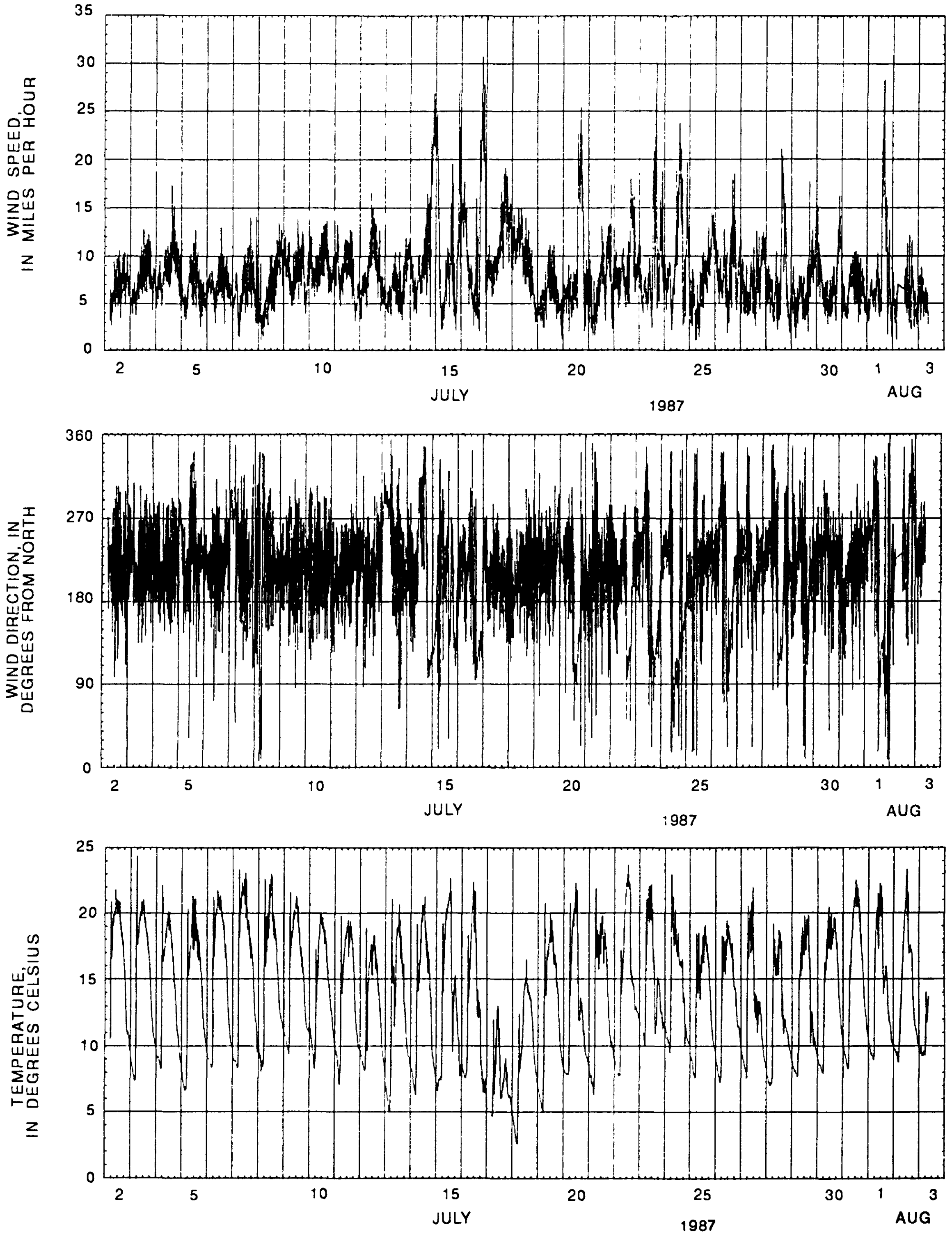
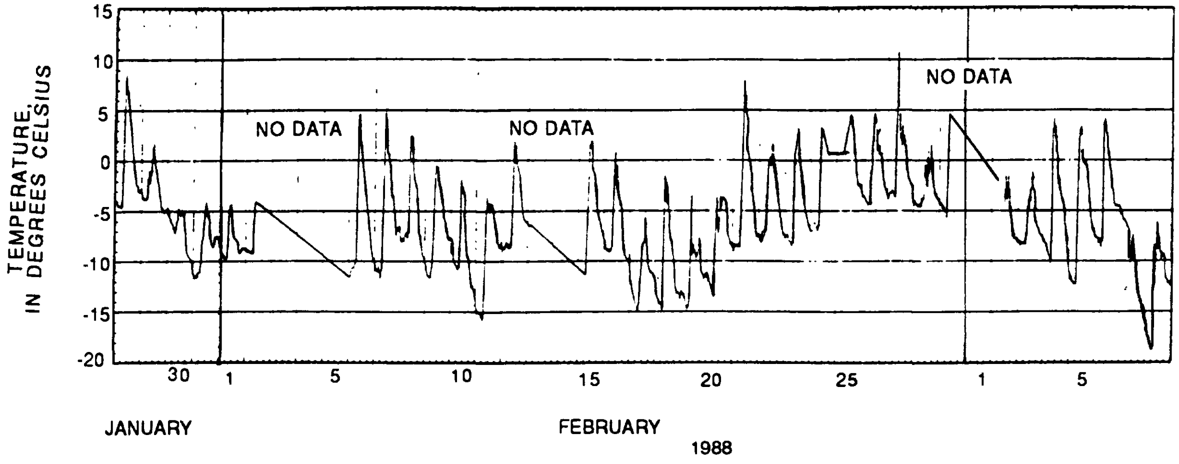
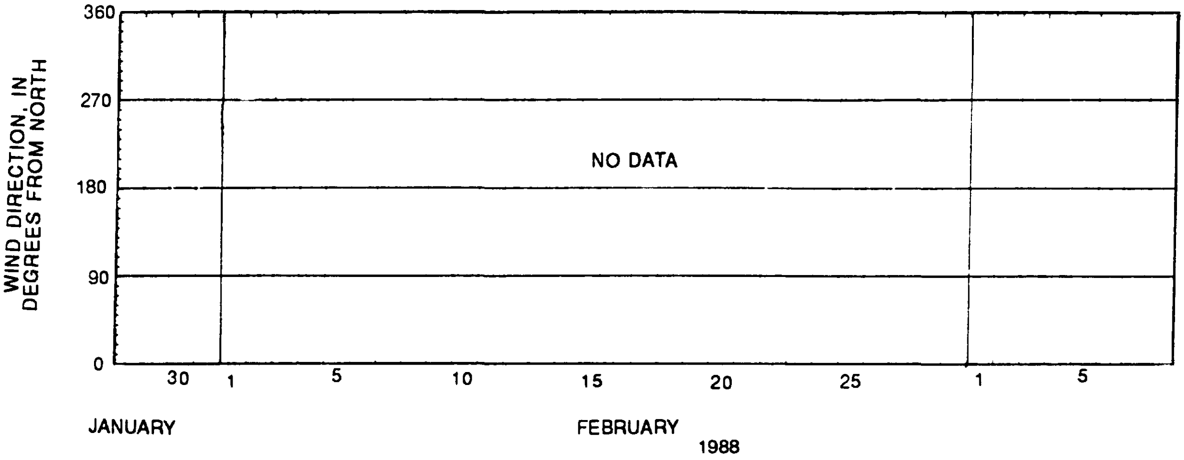


Figure 5.--Temperature, wind direction, and wind speed at the weather station--Continued.


TEMPERATURE, IN DEGREES CELSIUS
15
10
5
0
-5
-10
-15
-20
NO DATA
NO DATA
NO DATA
30
1
5
10
15
20
25
1
5
JANUARY
FEBRUARY
1988


WIND DIRECTION, IN DEGREES FROM NORTH
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270
180
90
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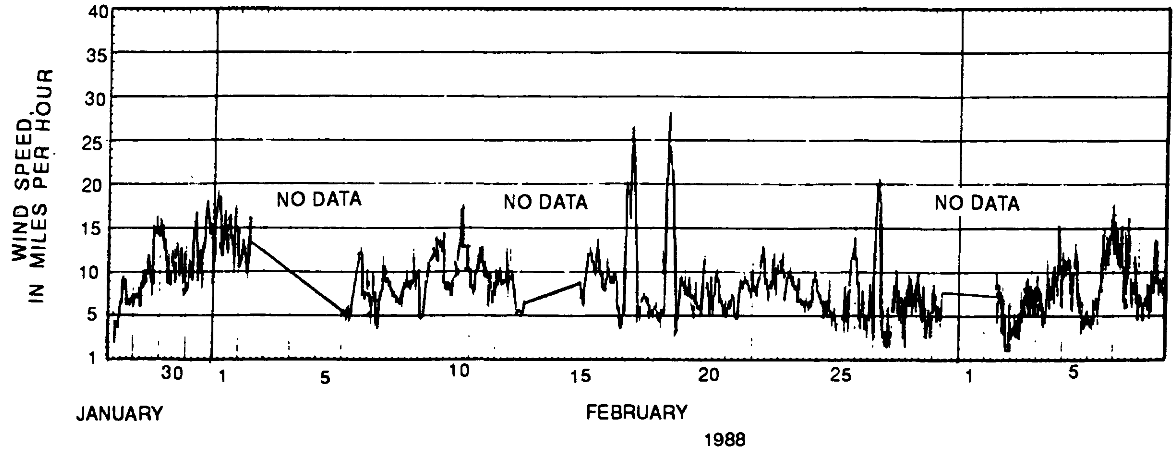
1
5
10
15
20
25
1
5
JANUARY
FEBRUARY
1988


WIND SPEED, IN MILES PER HOUR
40
35
30
25
20
15
10
5
1
NO DATA
NO DATA
NO DATA
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5
10
15
20
25
1
5
JANUARY
FEBRUARY
1988

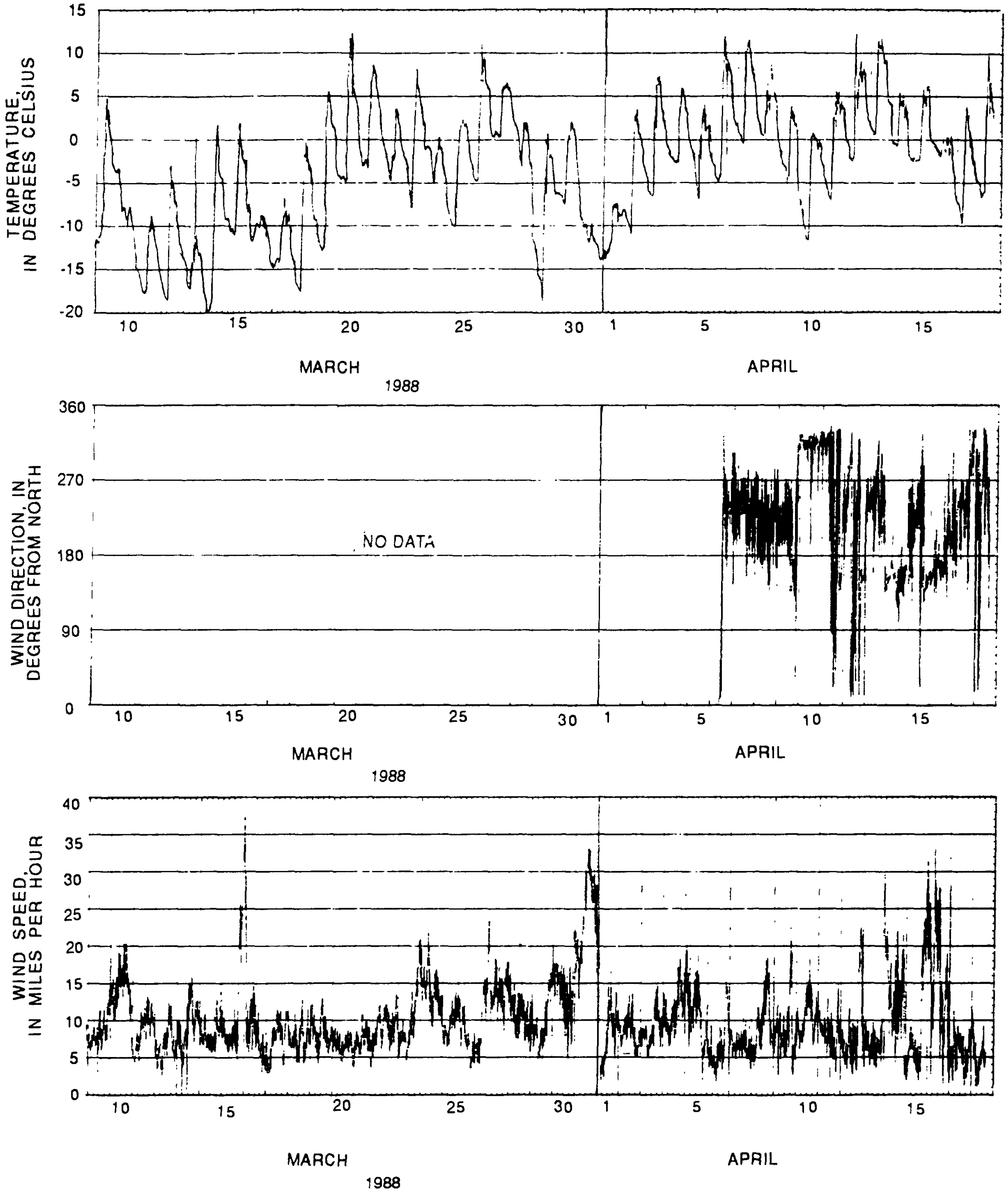


Figure 5.--Temperature, wind direction, and wind speed at the weather station--Concluded.

Precipitation Chemistry

Dissolved constituents in precipitation can come from many sources such as oceanic spray, dust, pollutants, and volcanic ash (Likens and others, 1977). The pH of pure water in equilibrium with atmospheric levels of CO_2 would be about 5.6 (Drever, 1988, p. 209). Precipitation with pH values less than 5.6 could be considered acid rain; however, water is generally not considered acid if the pH is greater than 5.0 (Drever, 1988). Burning of fossil fuels, smelting of nonferrous metals, and various combustion processes result in the addition of sulfur dioxide and nitrogen oxides to the atmosphere. Hydration and oxidation of these sulfur and nitrogen compounds produce sulfuric acid and nitric acid, which can result in decreases in the pH of precipitation (acid rain). These acids combined with precipitation can dissolve calcium carbonate in atmospheric dust, causing the pH of precipitation to increase; however, the concentration of dissolved calcium will also increase.

The precipitation-chemistry data collected from December 1986 to September 1988 are shown in figures 6-11 and listed in table 3. The pH of most of the precipitation was between 4.6 and 5.5, and the median pH is 5.07 (fig. 6 and table 3). Several precipitation samples had a pH of 6.0 or greater. Samples collected in January 1987, March 1987, and mid-March to early May 1988 had pH values greater than 5.8. The specific conductance of precipitation ranged from less than 1 to more than 18 microsiemens (fig. 7). Specific conductance generally decreases with increasing pH (fig. 8), which indicates that water with smaller pH has larger amounts of dissolved ions. There appears to be no relation between sulfate plus nitrate concentrations and pH (fig. 9), sulfate and nitrate concentrations (fig. 10), or calcium plus magnesium and sulfate plus nitrate concentrations (fig. 11).

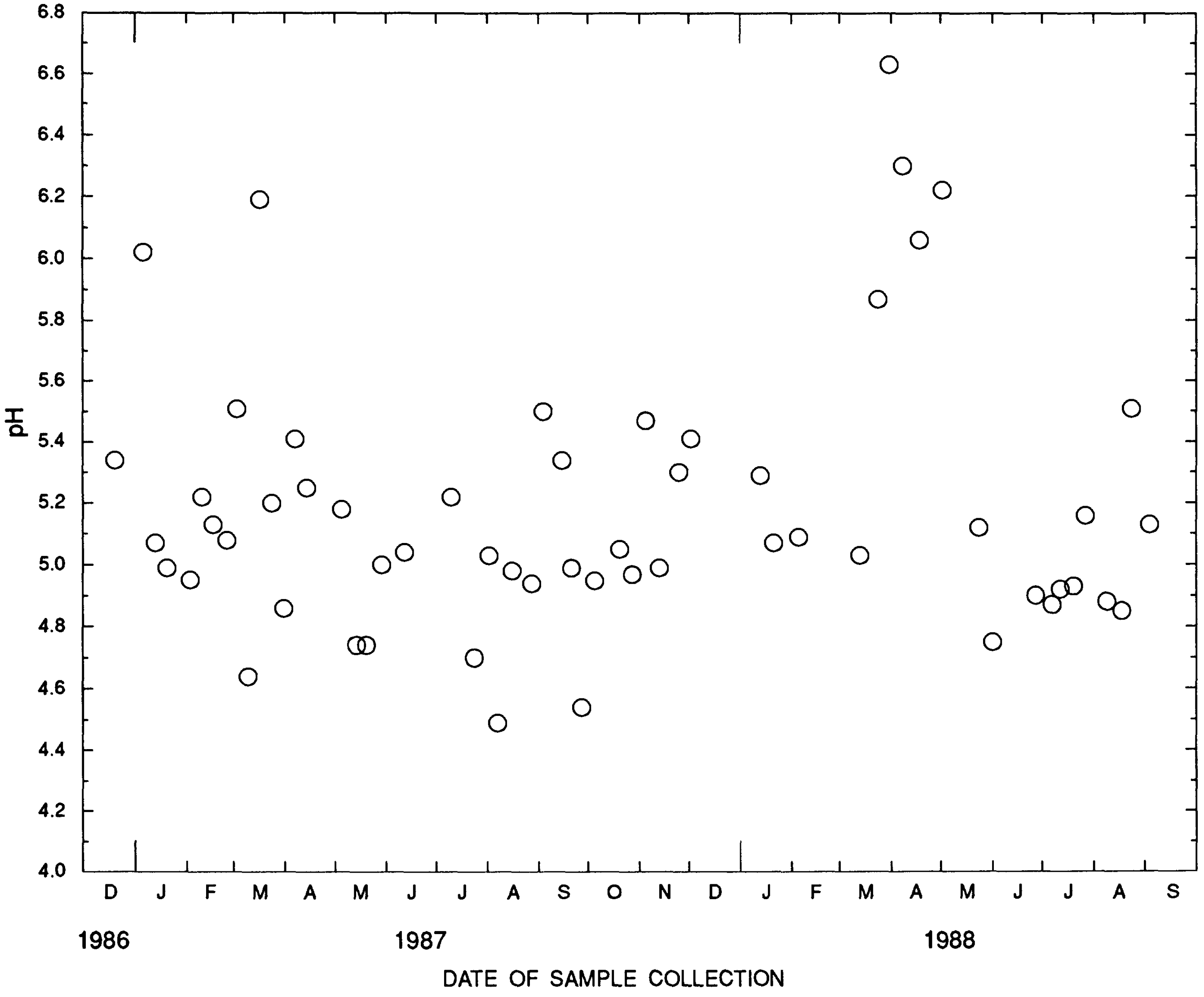


Figure 6.--Variation in pH of precipitation.

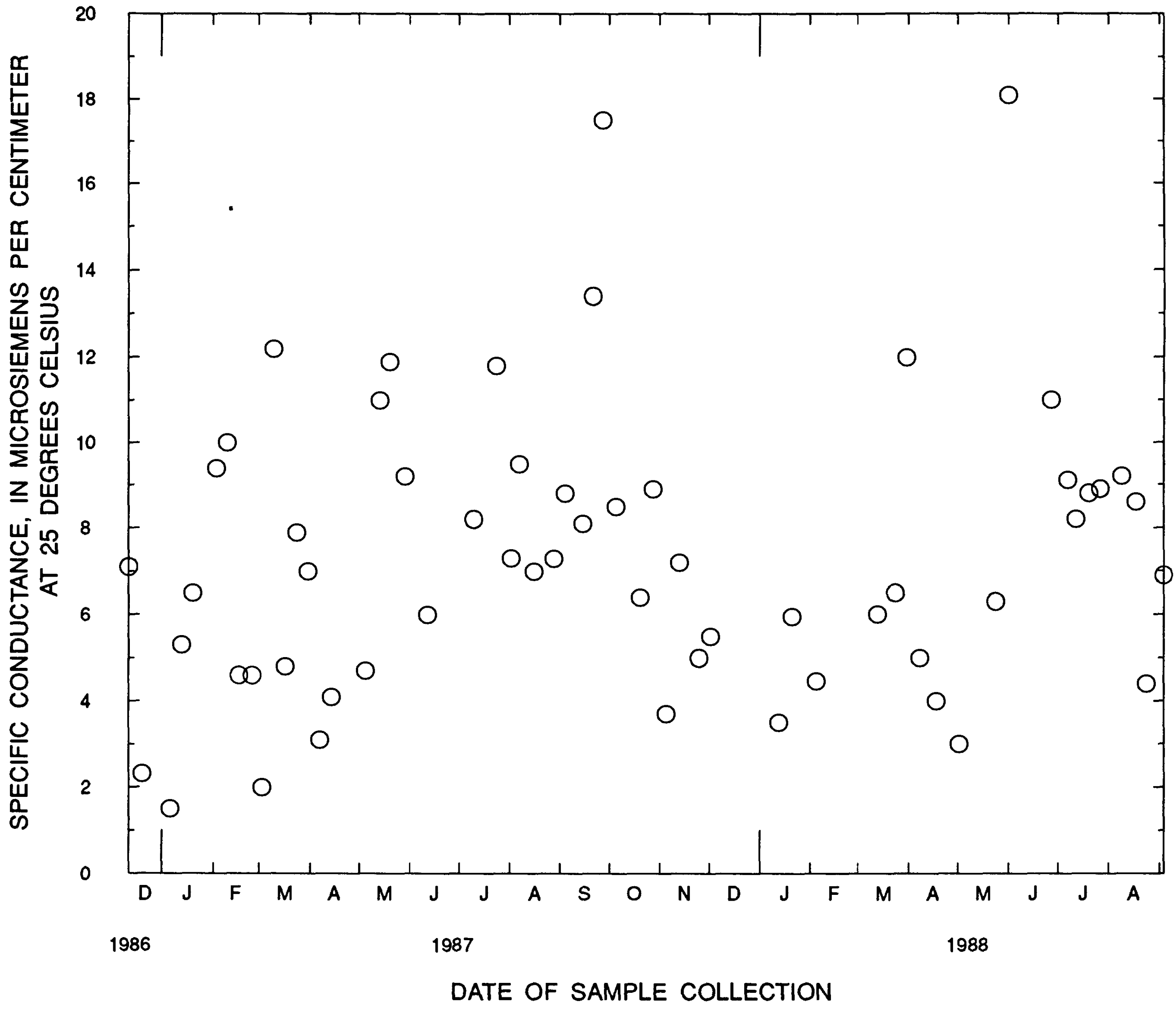


Figure 7.--Variation in specific conductance of precipitation.

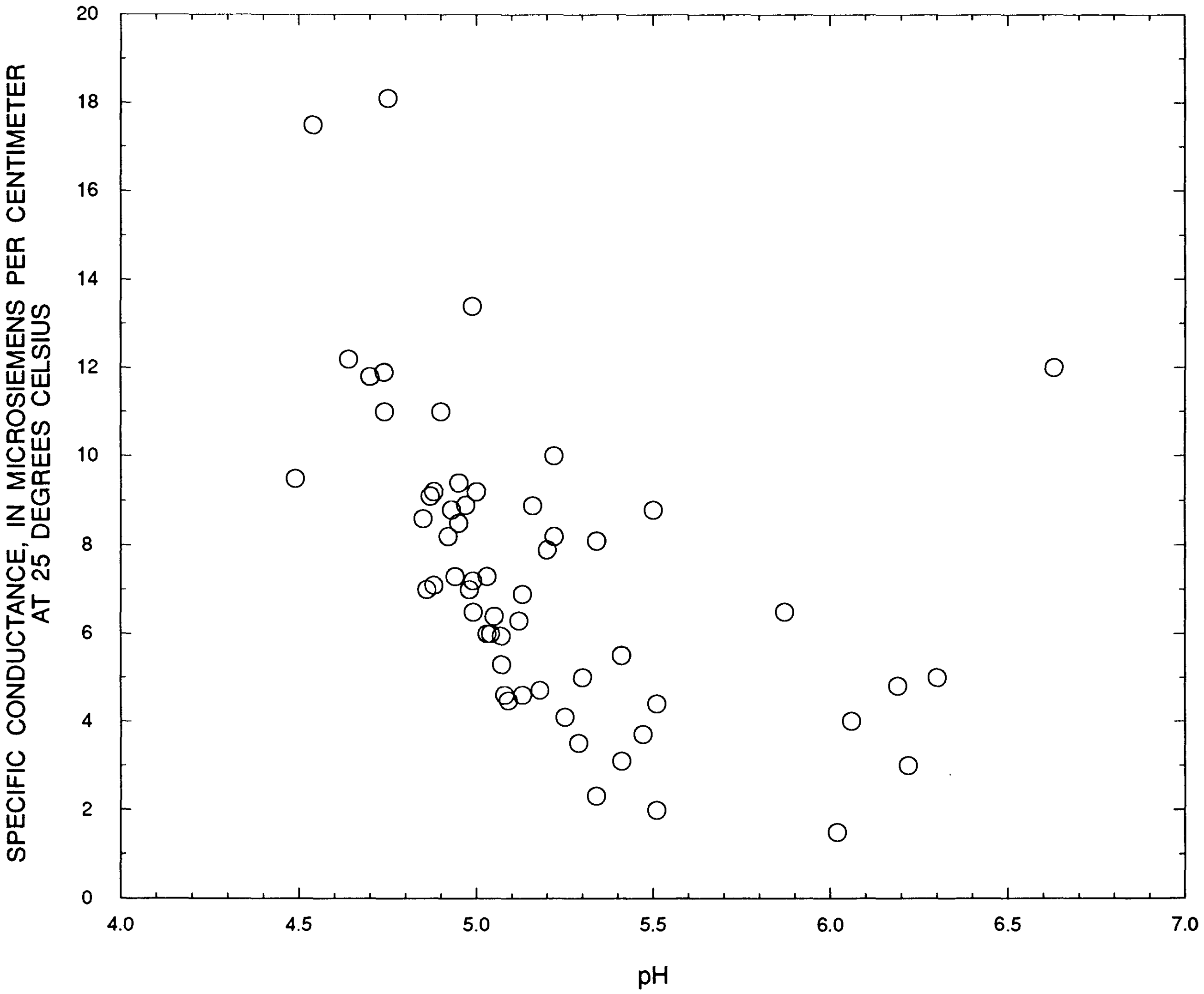


Figure 8.--Relation between pH of precipitation and specific conductance of precipitation.

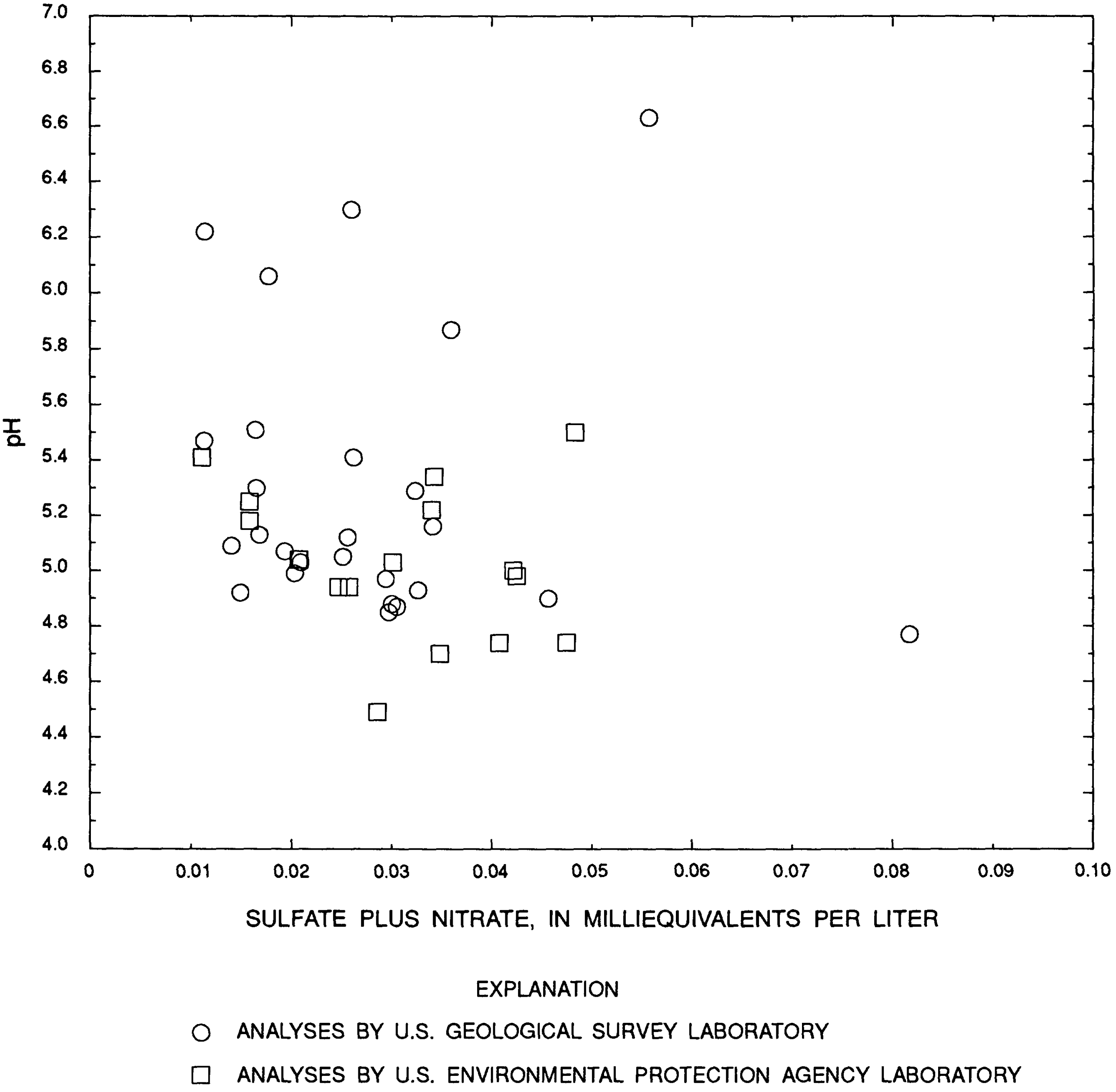
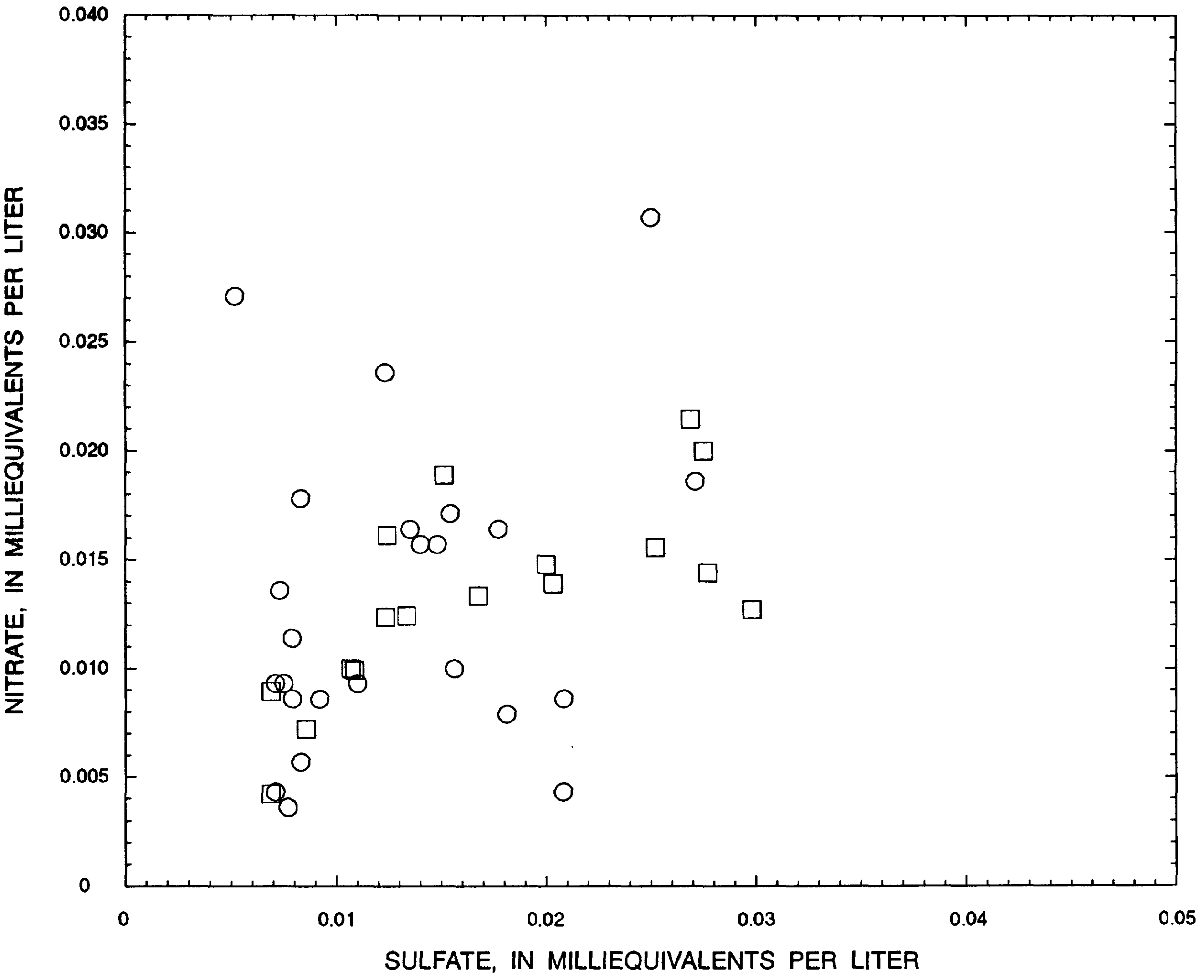


Figure 9.--Relation between sulfate plus nitrate concentration and pH in precipitation.



EXPLANATION

○ ANALYSES BY U.S. GEOLOGICAL SURVEY LABORATORY

☐ ANALYSES BY U.S. ENVIRONMENTAL PROTECTION AGENCY LABORATORY

Figure 10.--Relation between sulfate concentration and nitrate concentration in precipitation.

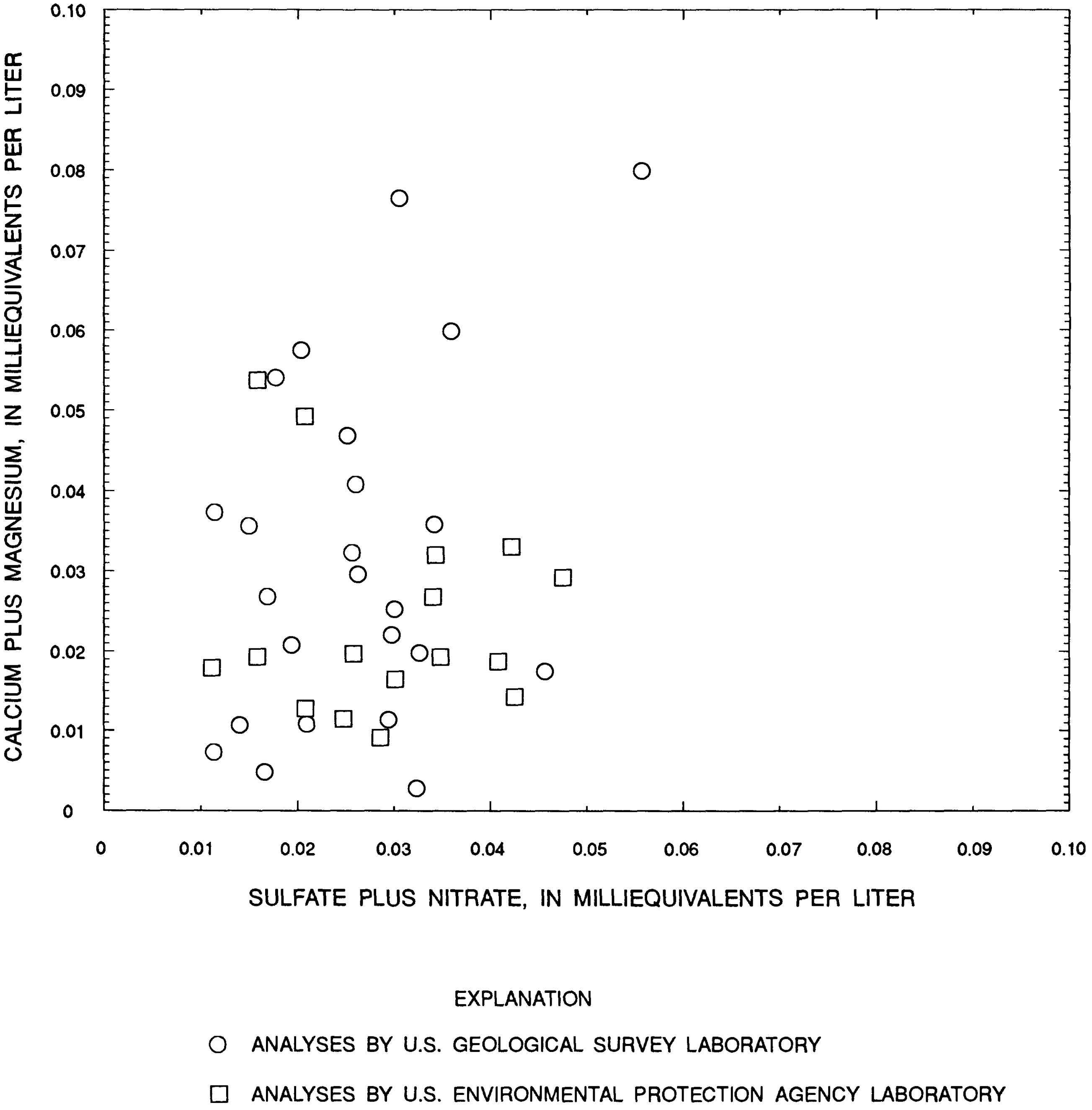


Figure 11.--Relation between sulfate plus nitrate concentration and calcium plus magnesium concentration in precipitation.

Snowpack Chemistry

Snowpack samples were collected in April and May 1987 and in January through April 1988. In 1987, moisture content, specific conductance, and pH were measured for snowpack samples (figs. 12-13); in 1988, these properties plus alkalinity were measured for each sample (figs. 14-17). In addition, composites of snowpack were collected and analyzed for dissolved constituents (table 4).

The chemistry of snowpack samples at a particular level above land surface varies considerably from month to month (table 4; figs. 12-17). Snow samples were collected in a flat area that was protected from the wind, and each monthly set of samples was collected from previously undisturbed snow in an attempt to minimize site-to-site variation. It is recognized that snow from a particular storm may not be at the same distance from land surface from month to month and that there is compaction and redistribution of solutes in the snowpack during the winter. Comparison of the chemistry of snow at particular levels from month to month is useful in better understanding how solutes are redistributed in the snowpack during the winter. On April 1, 1987, the specific conductance of the sample from 10 to 12 inches above ground surface was approximately 13 microsiemens and the specific conductance of the entire snowpack below the 38-inch level generally was larger than 8 microsiemens (fig. 12). The pH generally increased from the top of the snowpack downward. On May 8, 1987, the snowpack had melted or settled to about one-half the depth of April 1 (figs. 12 and 13). Specific conductance of the snowpack generally was less than 5 microsiemens (fig. 13). The layer having the large specific conductance in April (10 to 12 inches) was not present in May. The specific conductance of the entire snowpack decreased from April to May, indicating that large amounts of dissolved ions are transported out of the snowpack during the initial melt of the pack. The pH of the bottom part of the snowpack generally was less in May than in April.

Data collected in 1988 give a better indication of the changes in snowpack chemistry throughout the winter because samples were collected from January through April. The snowpack had melted by mid-April 1988.

Comparison of the snowpack chemistry in January and February 1988 indicates that moisture content and specific conductance generally decreased in February (figs. 14 and 15). The data collected in February for the interval 0 to 2 inches probably are not representative of the snow because some dirt and plant material were in the sample. The pH increased in the bottom 7 inches of the snowpack and remained approximately the same in the rest of the snowpack. In January, samples from 7 to 9 inches above ground surface had large specific conductance, pH, and alkalinity compared with the rest of the snowpack; a layer of similar composition is not evident in the samples collected in February (figs. 14 and 15).

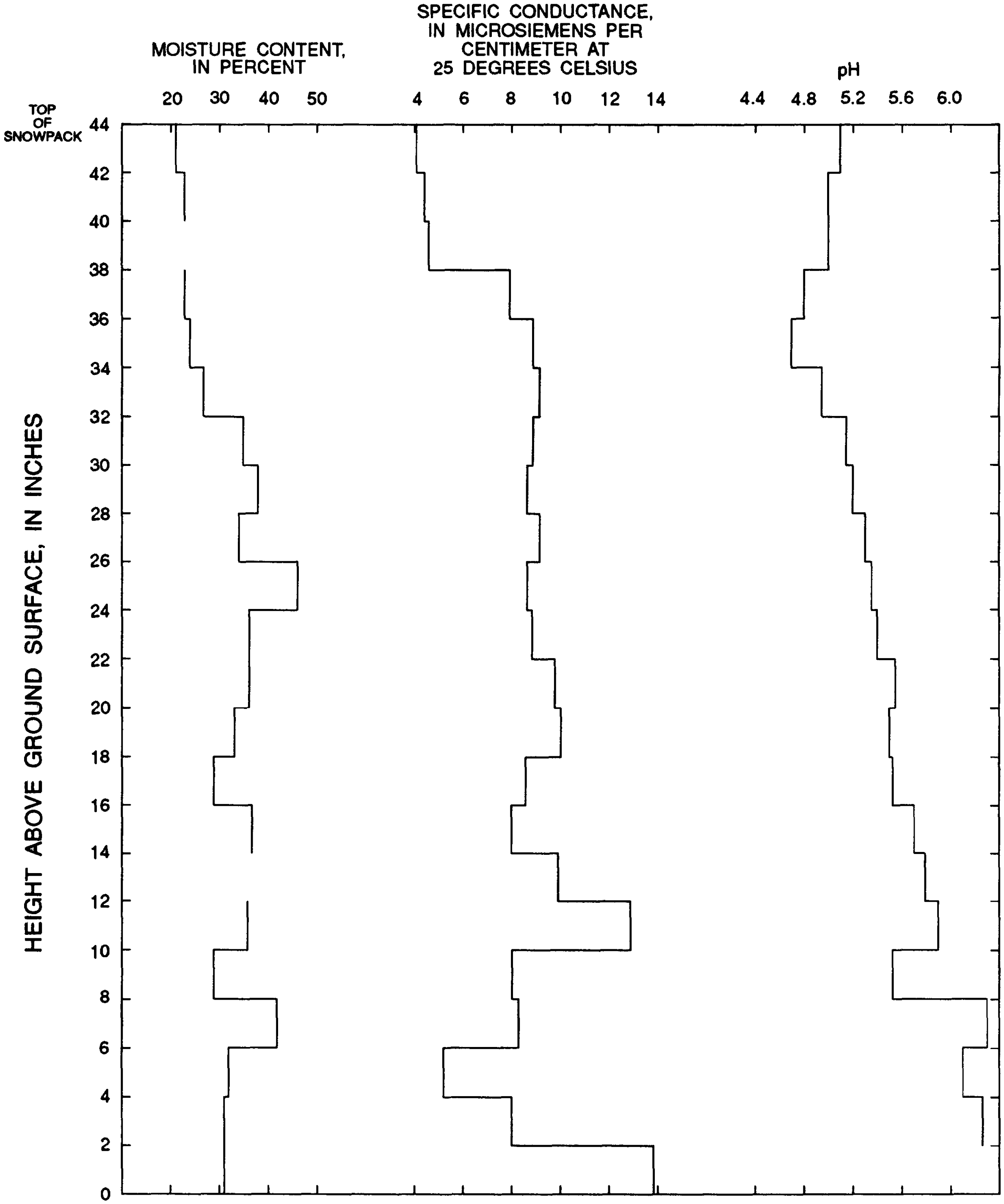


Figure 12.--Moisture content, specific conductance, and pH of snowpack, April 1, 1987.

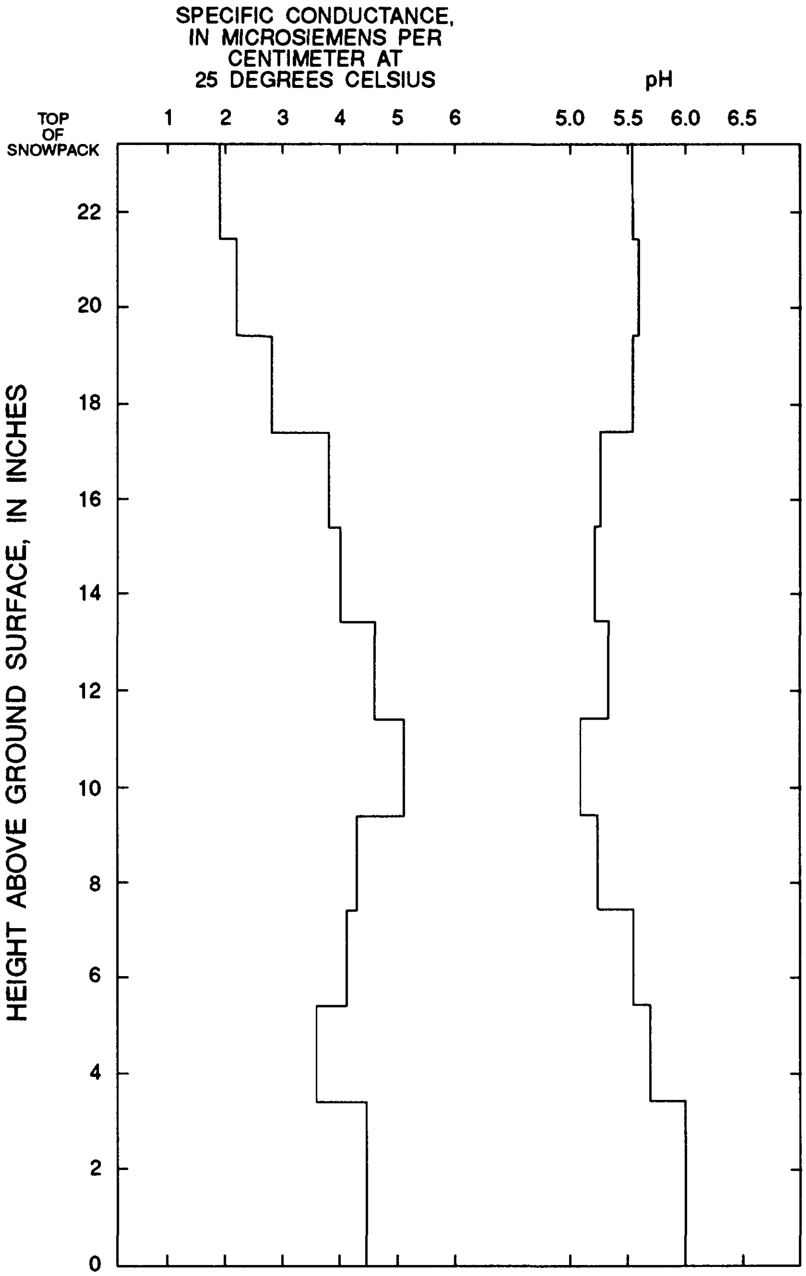


Figure 13.--Specific conductance and pH of snowpack, May 8, 1987.

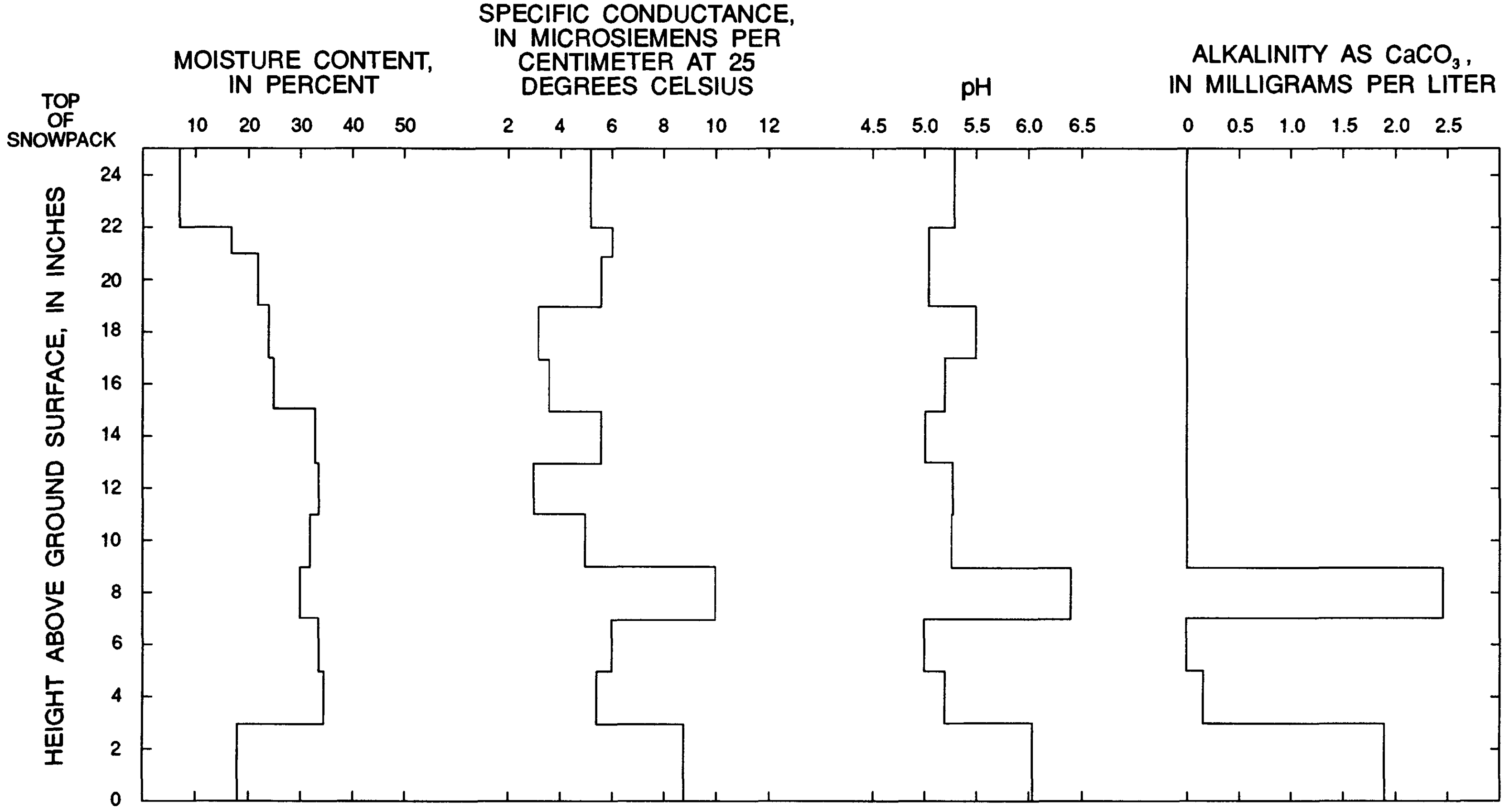


Figure 14.--Moisture content, specific conductance, pH, and alkalinity of snowpack, January 21, 1988.

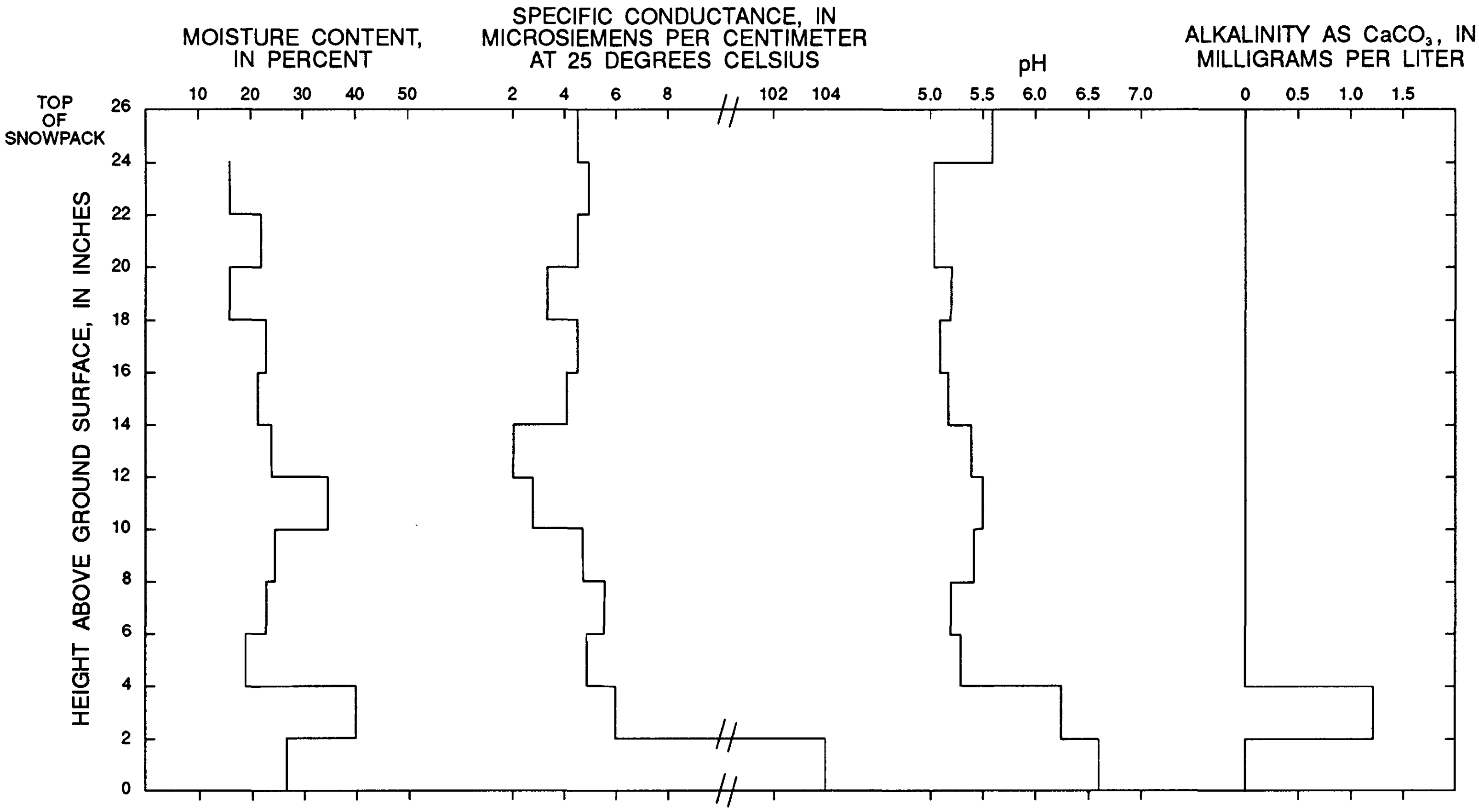


Figure 15.--Moisture content, specific conductance, pH, and alkalinity of snowpack, February 24, 1988.

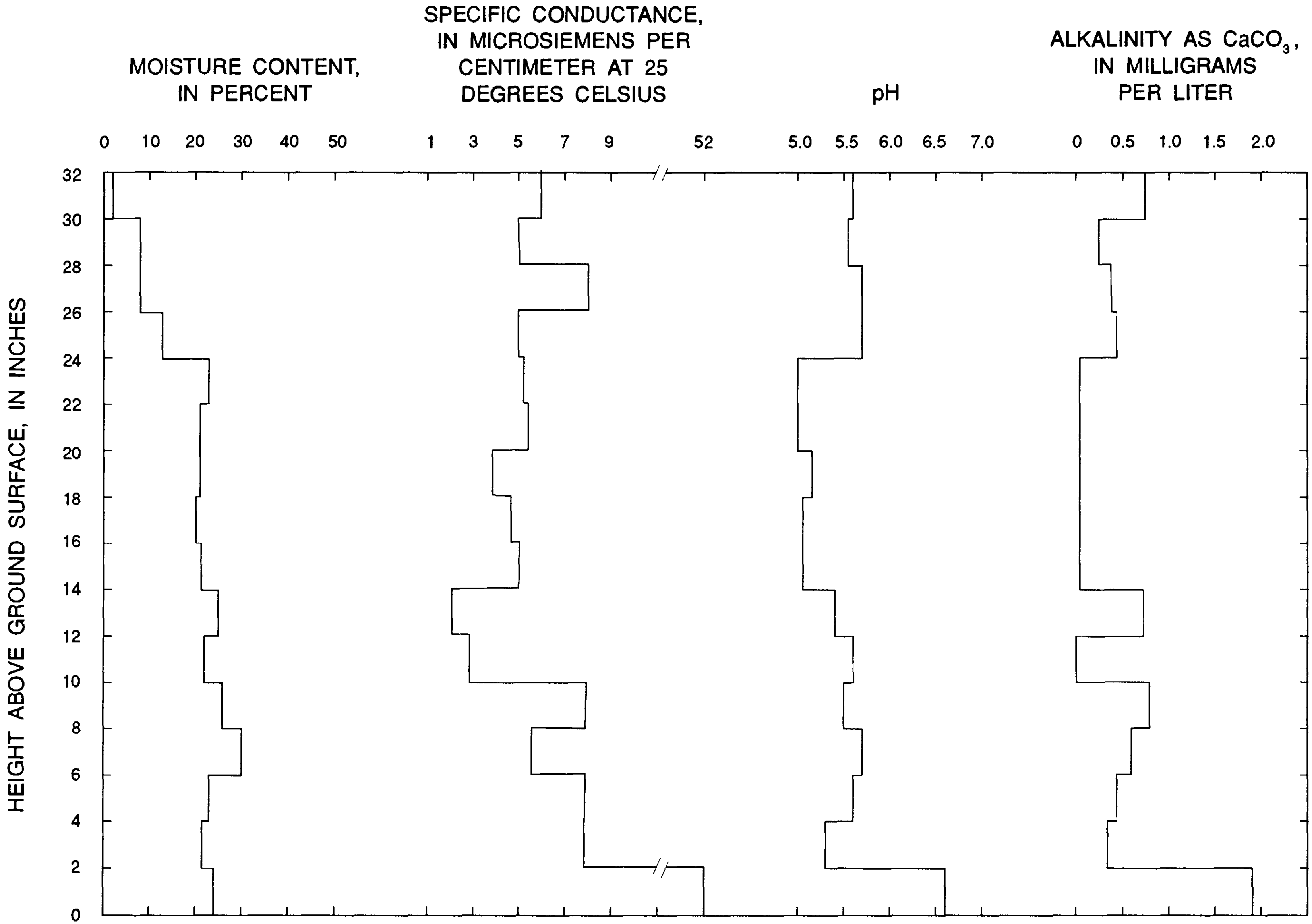


Figure 16.--Moisture content, specific conductance, pH, and alkalinity of snowpack, March 17, 1988.

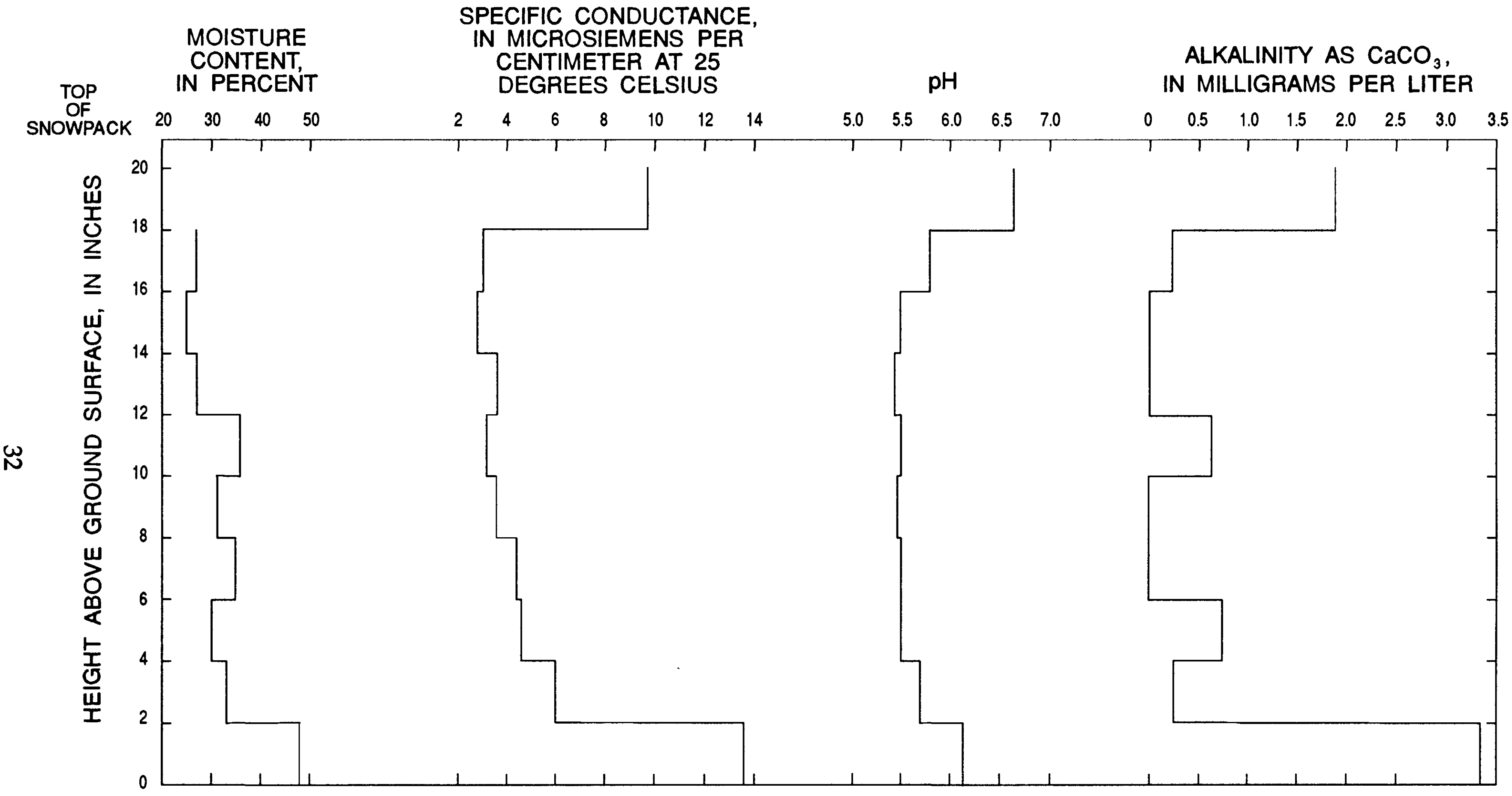


Figure 17.--Moisture content, specific conductance, pH, and alkalinity of snowpack, April 6, 1988.

Comparison of the snowpack chemistry in February and March indicates little change in moisture content, specific conductance, and pH in the interval 8 to 26 inches above ground surface (figs. 15 and 16). Alkalinity expressed as equivalent amount of calcium carbonate was larger than zero in several layers in March, whereas alkalinity had been zero in the same layers in February. This could indicate chemical reactions in the snowpack between the February and March samplings. In the 12- to 14-inch and 24- to 26-inch layers, there was little change in specific conductance and pH between February and March; however, alkalinity increased. In the 8- to 10-inch layer, specific conductance increased, pH was about the same, and alkalinity increased. In the 6- to 8-inch layer, pH increased but specific conductance remained unchanged. In the 4- to 6-inch layer, pH, specific conductance, and alkalinity increased (figs. 15 and 16). The increase in pH and alkalinity in specific layers could indicate chemical reactions in the snowpack that result in the neutralization of acids in the snow.

Snow depth decreased 11 inches from March (32 inches) to April (21 inches) and moisture content generally increased throughout the snowpack (figs. 16 and 17), indicating an increase in the density of the snow and redistribution of water in the pack. Specific conductance decreased in the 2- to 10-inch and 14- to 18-inch intervals and increased in the 18- to 20-inch and 10- to 14-inch intervals from March to April (figs. 16 and 17). The pH increased in the 2- to 4-inch and 12- to 20-inch intervals and decreased in the 4- to 8-inch and 10- to 12-inch intervals during this period. Alkalinity expressed as calcium carbonate ($CaCO_3$) in the 18- to 20-inch interval, which was at the top of the snowpack in April, was almost 2.0 milligrams per liter, possibly indicating that carbonate dust is dissolving in this layer. Specific conductance of the majority of the snowpack decreased from March to April 1988 as was seen in the snowpack in April and May 1987. This indicates that the initial fluid draining from the snowpack transports a large amount of dissolved material out of the snowpack.

Three composites of snowpack were collected and analyzed for major ions each month from January through April 1988. The results of these analyses can be used to examine differences in snowpack chemistry throughout the snowpack on a particular date (table 4), but they are of limited use in comparing changes in snow chemistry on a monthly basis because the depths of the sample intervals varied between months. The three composites collected in February spanned the entire depth of snowpack. The composite samples collected in other months generally were from 2- to 4-inch intervals from three different depths in the snowpack. Sodium and magnesium concentrations in the samples were less than the detection limit of the technique used for the analyses. For these samples, the detection limits set an upper bound for the sodium and magnesium concentrations.

Some general comments regarding the chemistry of the snow can be made by examining the chemical analyses of snowpack composite samples (table 4; figs. 18-21). In general, the pH of the snow was greater than 5.0 in the samples collected. The nitrate and sulfate concentrations, in milliequivalents per liter, in the snowpack generally were about equal. Calcium was the dominant cation. Samples containing larger amounts of dissolved solids generally contained measurable alkalinity; dilute samples, however, generally did not. In general, samples from the upper and lower parts of the snowpack contained larger concentrations of ions than samples from the middle of the pack (figs. 18-21). Samples collected in March and April from near the top of the snowpack generally contained the largest concentrations of ions (figs. 20-21).

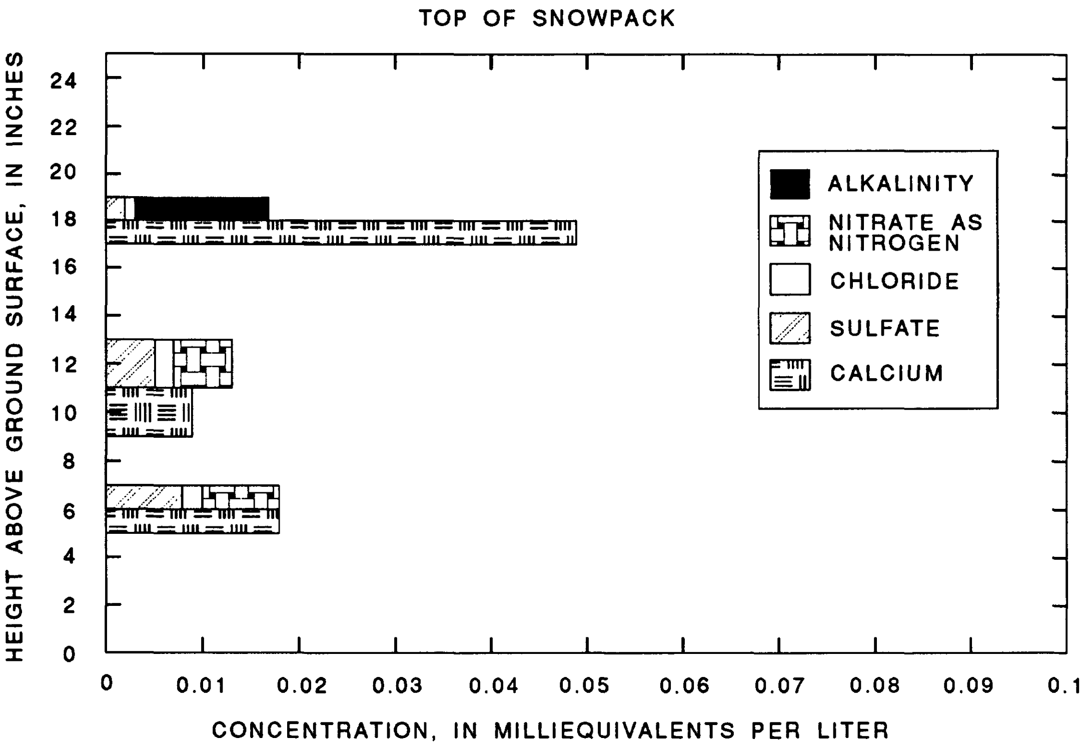


Figure 18.--Chemical analysis of snowpack composite samples, January 21, 1988.

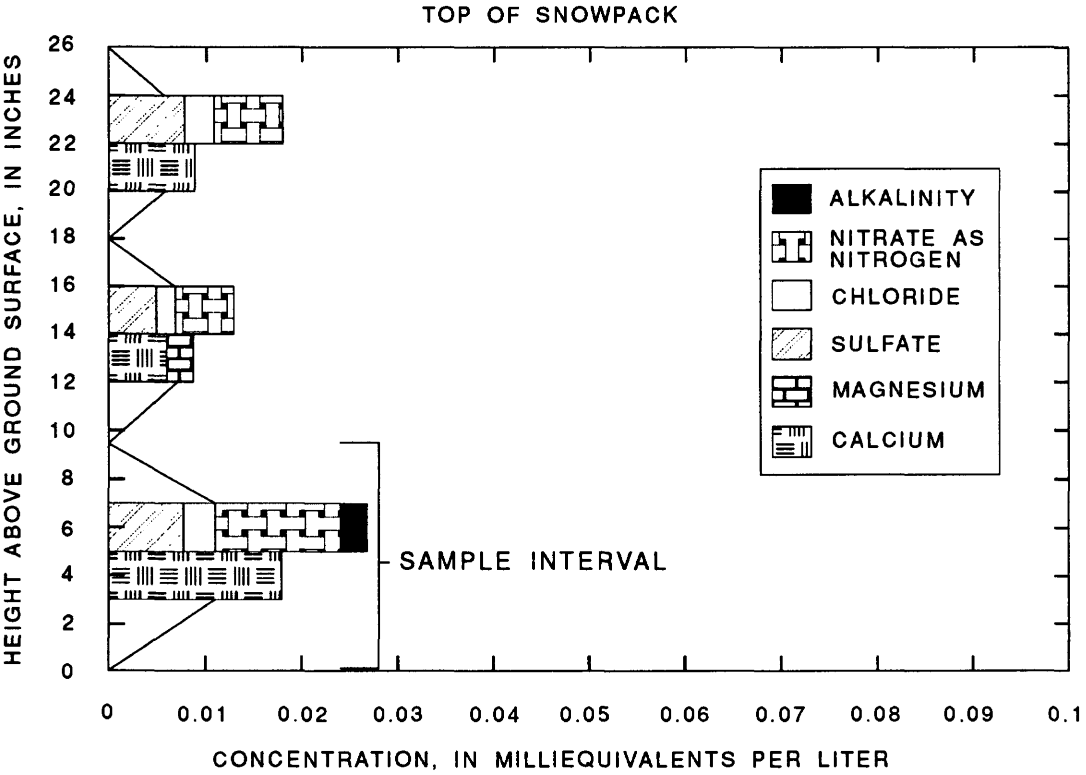


Figure 19.--Chemical analysis of snowpack composite samples, February 24, 1988.

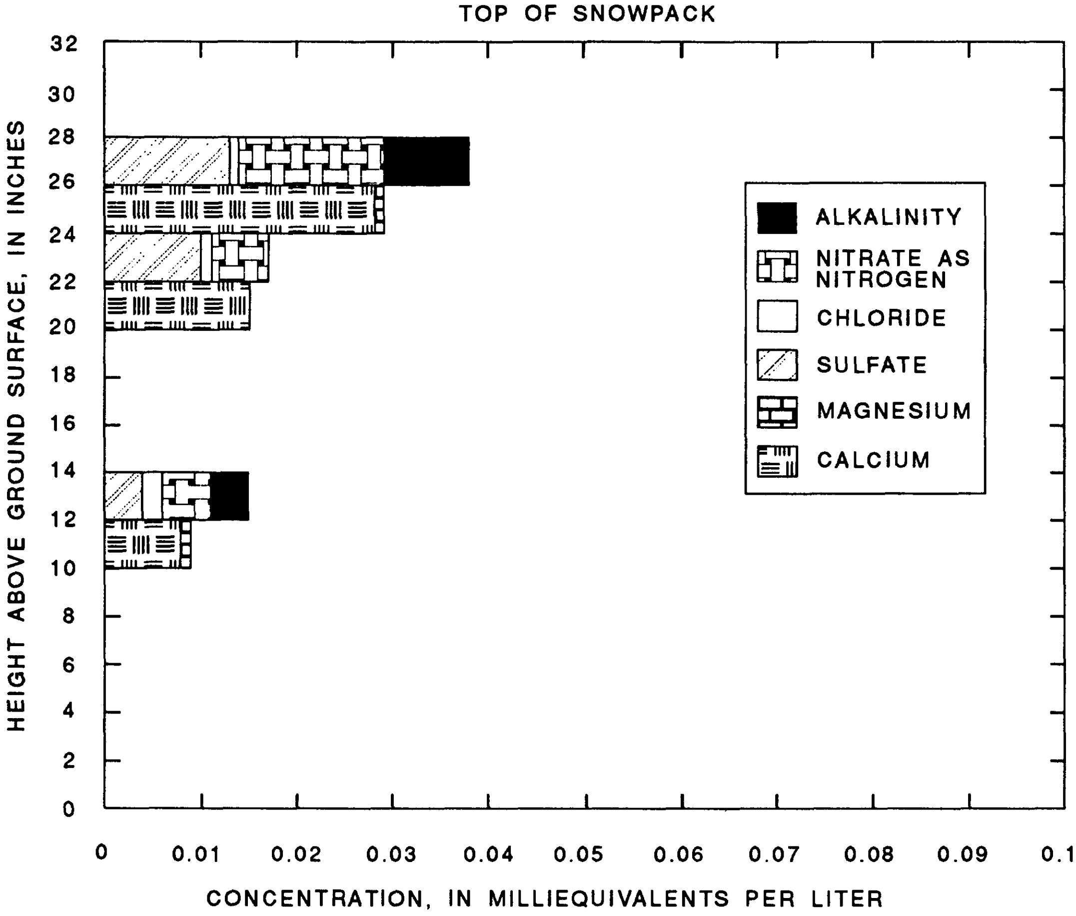


Figure 20.--Chemical analysis of snowpack composite samples, March 17, 1988.

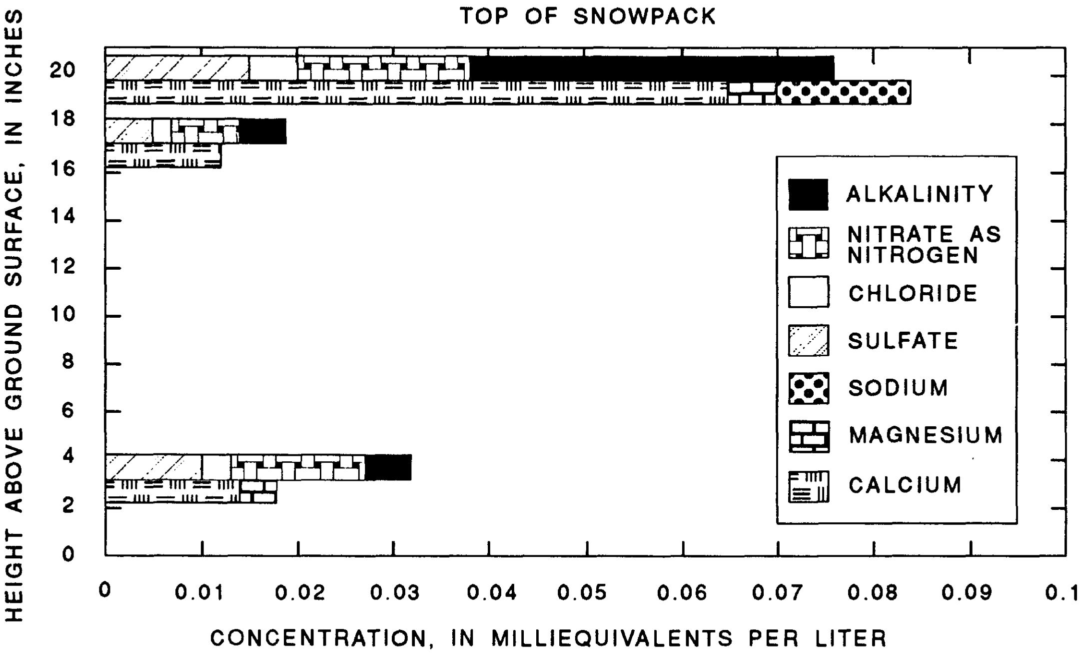


Figure 21.--Chemical analysis of snowpack composite samples, April 6, 1988.

Snowmelt Chemistry

Snowmelt was collected for chemical analysis in 1988. On an April 6 inspection about 100 milliliters of water was found in the sample container, a 3 1/2-gallon bucket in the snowmelt collector. A new sample container was installed at 1000 hours. The sample container was removed at 1700 hours and found to contain about 200 milliliters of water. By the next site visit (April 11 at 1630 hours), the sample container had overflowed. The volume of water that had overflowed the container is not known; however, the snow depth was about one-half of that on April 6. From April 11 to April 15, the sample container was removed from the collector each day. Sample volumes ranged from about 2 1/2 to almost 3 1/2 gallons per 24 hours. The snow depth on April 15 was about 1 1/2 inches. The sample container was checked again on April 18 at 1630 hours. The snow in the collector was less than one-half inch deep and was completely melted in some places. Fresh snow fell on April 18, but because most of the old snowpack had already melted, the decision was made not to monitor the collector until later in the month.

The specific conductance of snowmelt indicates that the sample collected on April 6 contained the largest concentration of dissolved material (table 5). This supports the interpretation that the initial fluid draining from the snowpack transports a large amount of dissolved material out of the snowpack. The pH of the snowmelt sample collected on April 6 was 7.17, specific conductance was 34.2 microsiemens, and alkalinity as calcium carbonate was 11.57 milligrams per liter. In snowmelt samples collected after April 6, pH was greater than 6.4, specific conductance ranged from 3.8 to 13.5 microsiemens, and alkalinity as calcium carbonate ranged from 1.48 to 3.50 (table 5). The large calcium and alkalinity concentrations in the April 6 snowmelt sample could indicate that the initial snowmelt dissolved carbonate dust. The dissolution of carbonate dust would tend to neutralize any acids in the meltwater and result in increased pH. All the snowmelt samples contained alkalinity as calcium carbonate greater than 1 milligram per liter (table 5). The pH, specific conductance, and sulfate plus nitrate are shown in figures 22-24. There appears to be no relation between pH and specific conductance (fig. 25) or between sulfate plus nitrate and calcium plus magnesium (fig. 26).

WATER CHEMISTRY OF LATIR LAKES

Data were collected at the Latir Lakes from July 1985 to October 1988. After 1985 the data collection generally was from June through October when access to the lakes was possible. Because of limited resources, some lakes were studied more intensively than others. This section of the report describes the methods used to collect the data and provides an analysis of the data collected at each of the lakes in descending order from lake 9 to lake 1.

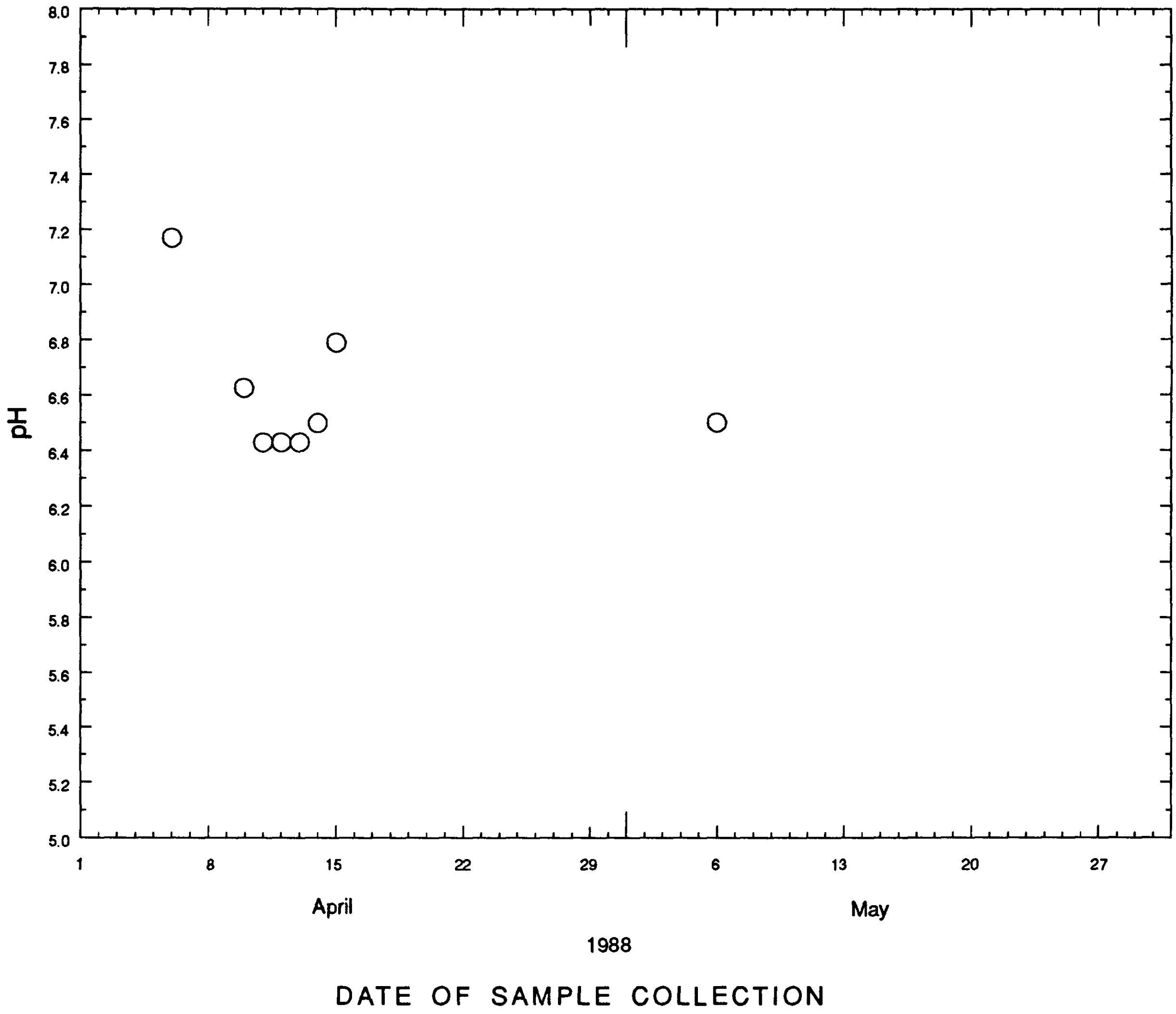


Figure 22.--Variation in pH of snowmelt.

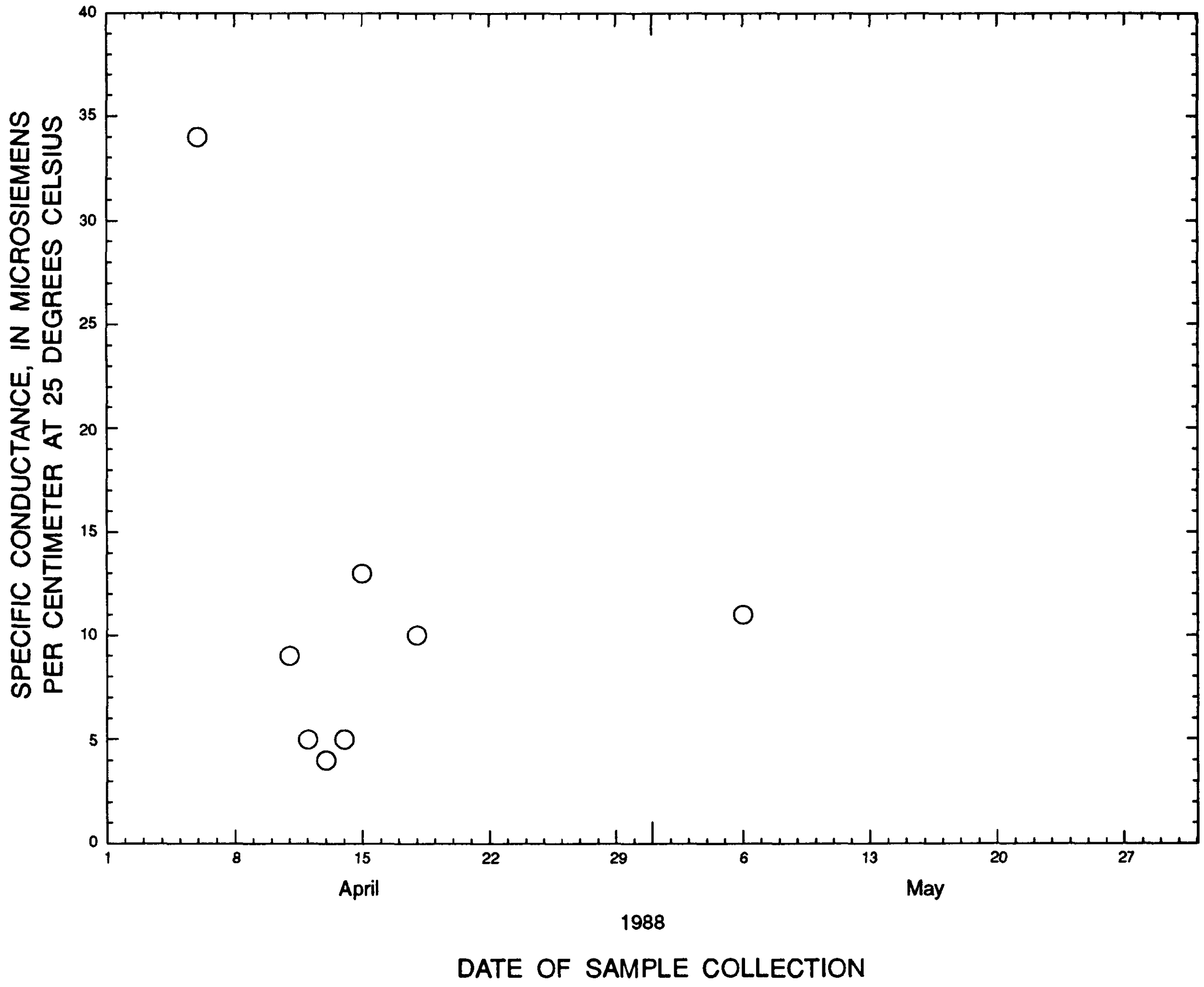


Figure 23.--Variation in specific conductance of snowmelt.

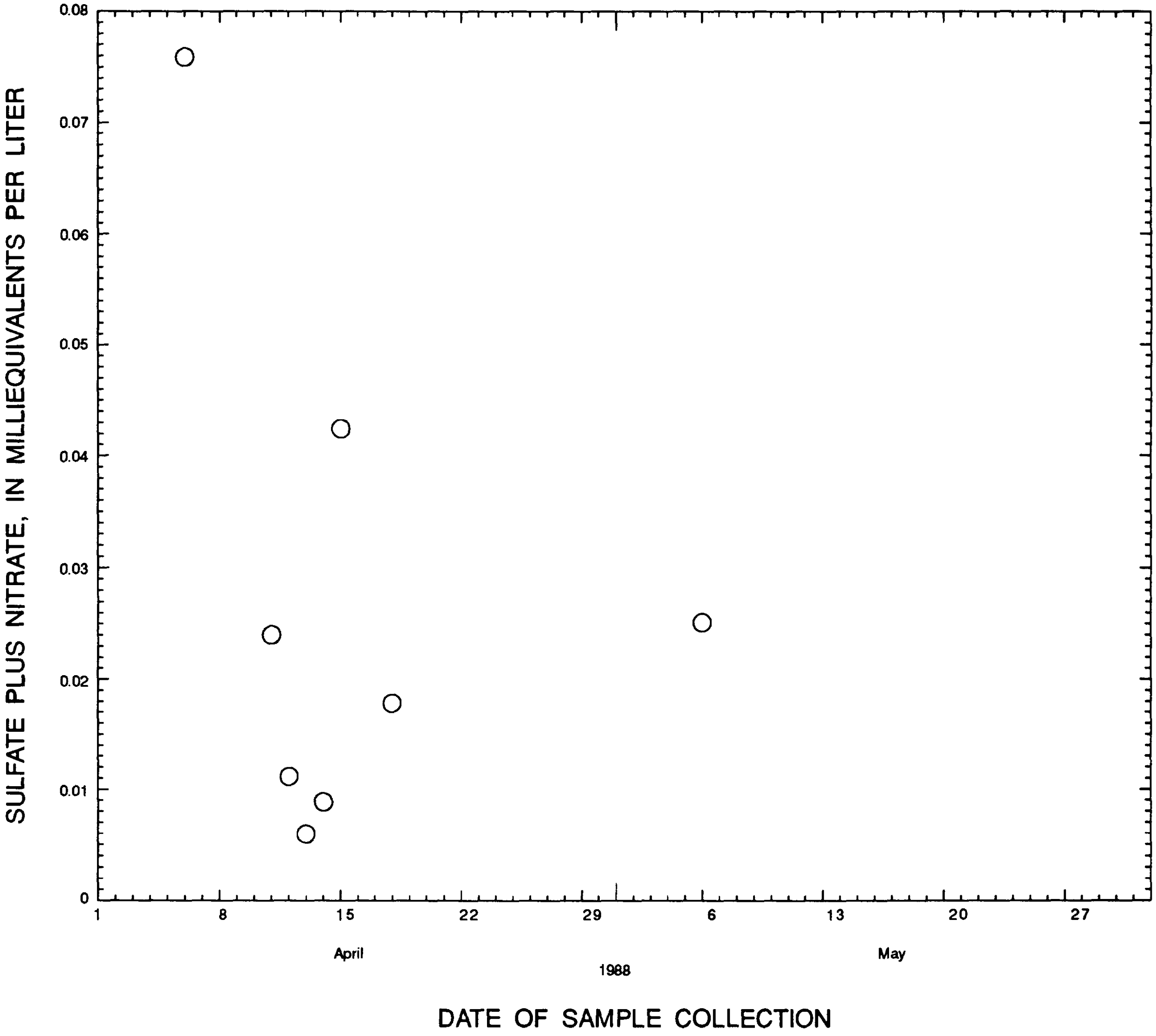


Figure 24.--Variation in sulfate plus nitrate concentration in snowmelt.

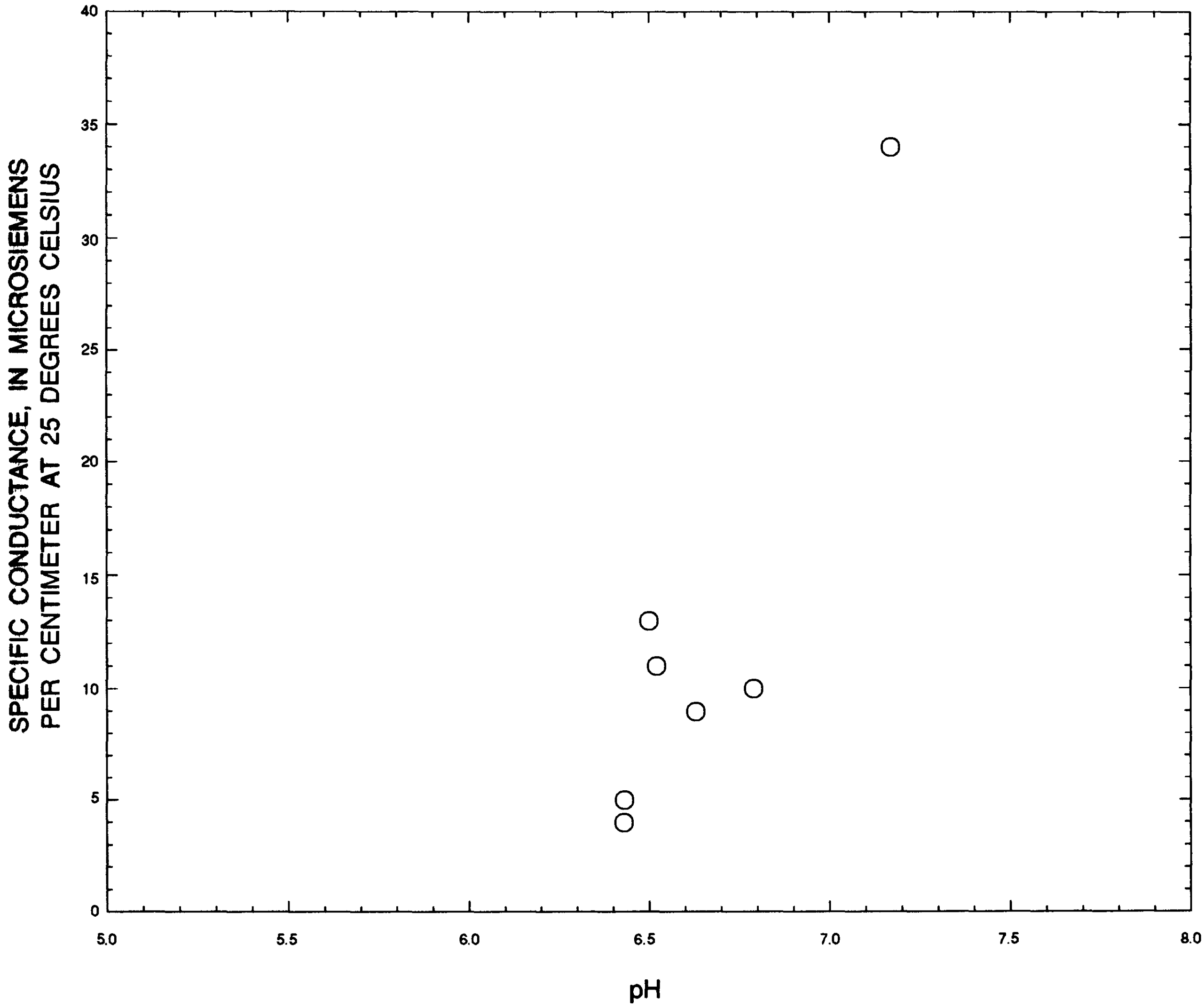


Figure 25.--Relation between pH and specific conductance of snowmelt.

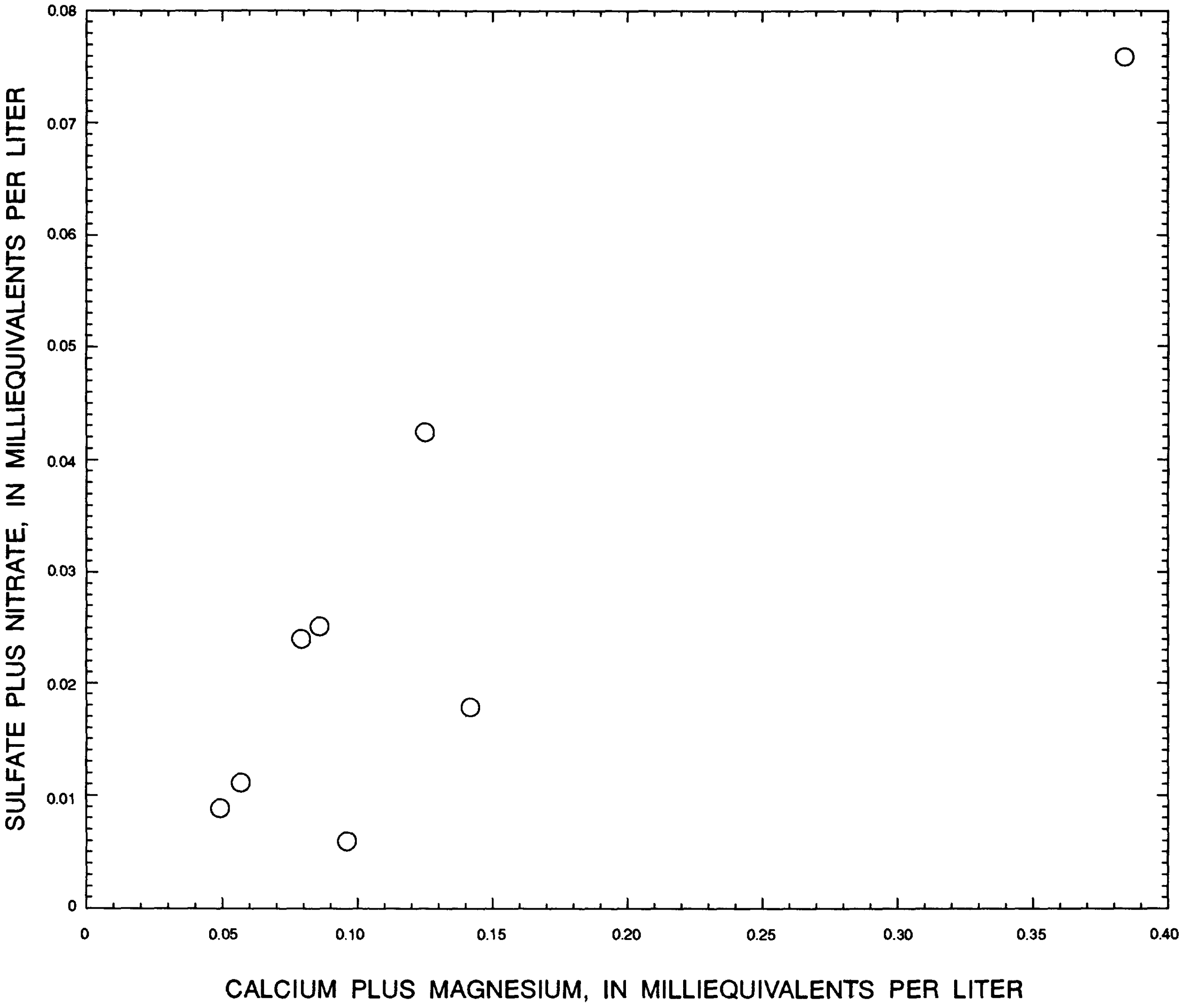


Figure 26.--Relation between sulfate plus nitrate concentration and calcium plus magnesium concentration in snowmelt.

Data Collection Methods

Depth Profiles of Lakes

To estimate the volume of water in each lake and select appropriate locations for determining changes in water chemistry with depth, bathymetric surveys were conducted for each lake. Numerous transects across each lake were made using an inflatable raft, and the depth was recorded by a fathometer. The lake perimeters were determined using a transit and stadia rod. Lakes 3, 5, and 9 were selected for sampling because they are the deepest of the three (lower, intermediate-, and higher altitude) groups of lakes.

At the deepest part of each lake, depth profiles of pH, specific conductance, temperature, and dissolved oxygen were measured from an inflatable raft. Samples for pH and specific conductance were collected using a 2-foot-long Van Dorn sampler. Sample depth was considered to be the depth of the midpoint of the sampler during sample collection. The samples were placed in plastic bottles, which had been rinsed three times with the sample water. The pH and specific conductance were measured with the same instruments used for precipitation measurements. Temperature and dissolved oxygen were measured using a Yellow Springs Instruments Model 57 dissolved-oxygen meter. Except in the early stages of the study, these depth-profile measurements were conducted nearly every month.

Lake-Outflow Measurements

In summer 1986, lake-outflow measurements were made using a pygmy current meter to determine the expected flows for selecting optimally sized flumes and to examine lake stage-discharge relations in individual lakes. The techniques used are described by Buchanan and Somers (1965).

Flumes were installed at the outflows of lake 9 and lake 2 in August 1986. Lake 9 was selected because it is at the highest altitude and is the headwaters of the series of lakes; lake 2 was selected because its outflow could be measured more accurately than lake 1, the lowest lake. The flumes were equipped with automatic-stage recorders set to make hourly readings during the remainder of the 1986 field season and the 1987 and 1988 field seasons. Discharges were calculated on the basis of the stage-discharge rating of the flumes and the recorded stage.

A monitor was installed April 21, 1987, at the outflow of lake 2 to monitor pH, specific conductance, temperature, and dissolved oxygen on an hourly basis. The calibration and operation of the monitor were checked monthly and recalibrated if necessary.

Lake-outflow samples were collected monthly from lakes 9, 5, and 2 during the 1987 and 1988 field seasons. These samples were collected by withdrawing water from the centroid of the outflow using flexible rubber tubing and an electric sampling pump. The samples were filtered using a 0.45-micron filter and put into polyethylene bottles that had been previously washed with ultrapure deionized water. Samples collected for analysis of cations were preserved using 1 milliliter of ultrapure nitric acid. Samples collected for analysis of anions were chilled to 4 degrees Celsius and kept in the dark until analysis. The laboratories that analyzed the deposition samples analyzed the lake-outflow samples. The pH, specific conductance, temperature, and alkalinity were measured on site when samples were collected. In addition to the sampling at lakes 9, 5, and 2, the pH, specific conductance, and temperature were measured monthly at the outflow of lakes 8, 6, 4, 3, and 1 during 1986, 1987, and 1988.

Lake 9

Lake 9, at an altitude of 11,893 feet, is the highest of the Latir series. It is the second largest of the Latir Lakes, having a total surface area of 10.83 acres. However, lake 9 is the largest in volume, containing 11,226,000 cubic feet (258 acre-feet) of water, because it is the deepest of all the lakes. Maximum depth is about 42 feet and average depth is 23.8 feet (fig. 27; table 6). With the exception of a small seep on the western side of lake 9 no surface water flows into the lake. Because no streams flow into lake 9, the water chemistry of the lake is determined by the precipitation and ground-water inflow. Latir Creek begins at lake 9 and flow in maintained by outflow from lake 9.

Outflow water from lake 9 has the smallest specific conductance of any of the Latir Lakes outflows (table 7). The pH of outflow water from lake 9 generally was larger than 8.0; however, in the early fall of 1987 and the late summer of 1988 the pH of outflow water was less than 8.0. Calcium is the predominant cation and the ions that produce alkalinity (mainly bicarbonate and carbonate) are the predominant anions in water from lake 9 (figs. 28-30). Concentrations of dissolved constituents generally did not vary significantly during the year or from year to year. The relatively large volume of water in lake 9 that mixes with relatively small volumes of inflow water resulting from snowmelt or precipitation decreases the variability in water chemistry of lake outflow. Chloride concentrations in outflow water were largest in a sample collected October 24, 1986 (table 8; figs. 28-30).

Depth profiles of temperature, dissolved oxygen, specific conductance, and pH for lake 9 are shown in figure 31. During the 1988 field season data were collected in June, July, August, and September. These data show that in June the thermocline was very near the surface and was poorly developed, specific conductance and dissolved oxygen were approximately the same throughout the water column, and pH was largest near the surface and decreased near the bottom of the lake (fig. 31). Data collected in July indicate that the thermocline was approximately 15 feet below the lake surface, and dissolved oxygen was largest at the thermocline, decreasing to approximately 1 milligram per liter at 28 feet and below (fig. 31). The pH followed a trend similar to those of temperature and dissolved oxygen. Specific conductance was larger near the bottom of the lake. By August, the same trends can be seen, but the thermocline had moved downward to approximately 22 feet below the lake surface (fig. 31). The lake apparently had "turned over" by September because the properties measured were approximately the same throughout the entire water column (fig. 31). During the late summer months the dissolved-oxygen concentration in water from the deeper parts of the lake generally is small (less than 1.5 milligrams per liter).

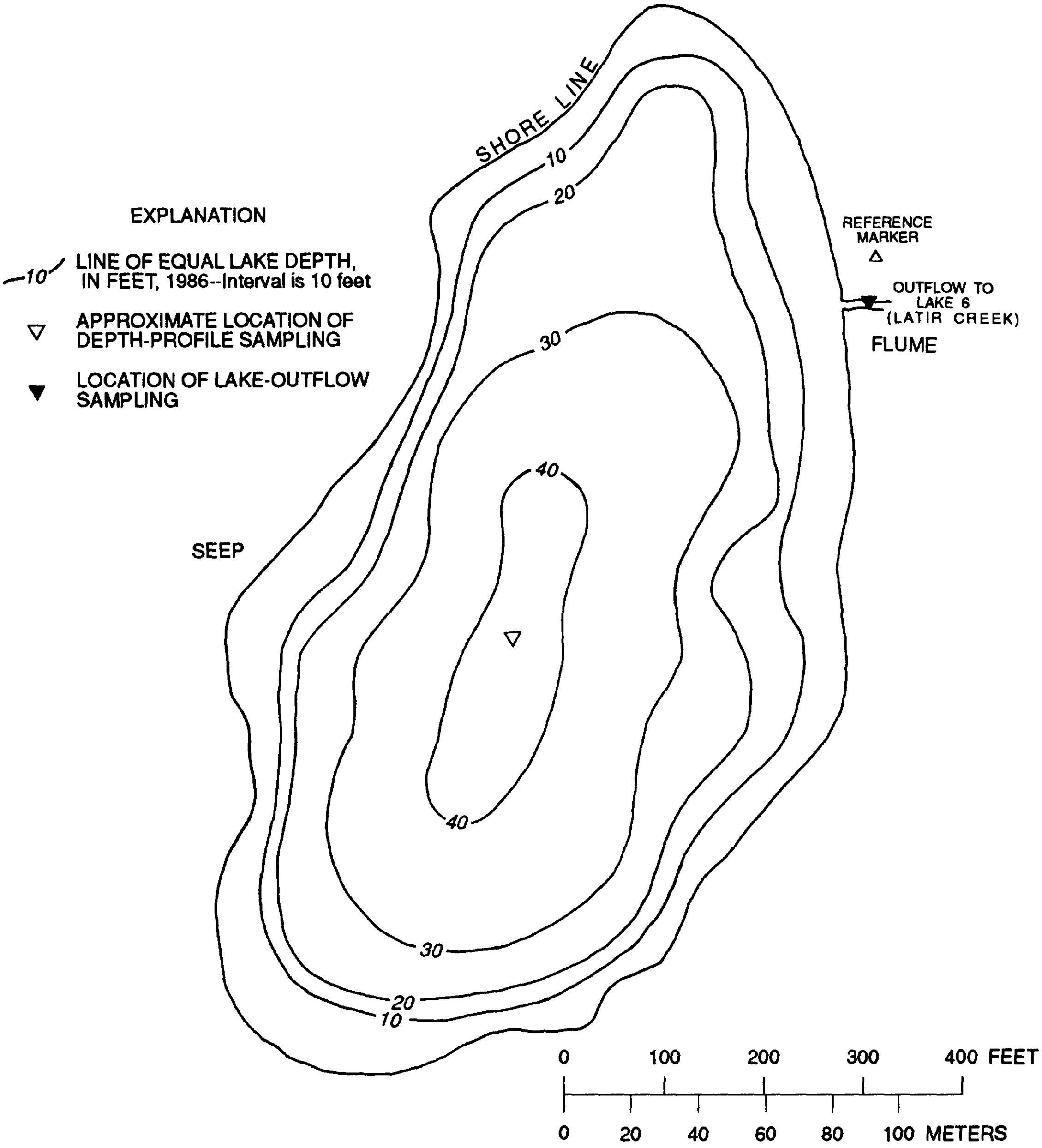


Figure 27.--Bathymetric map of lake 9.

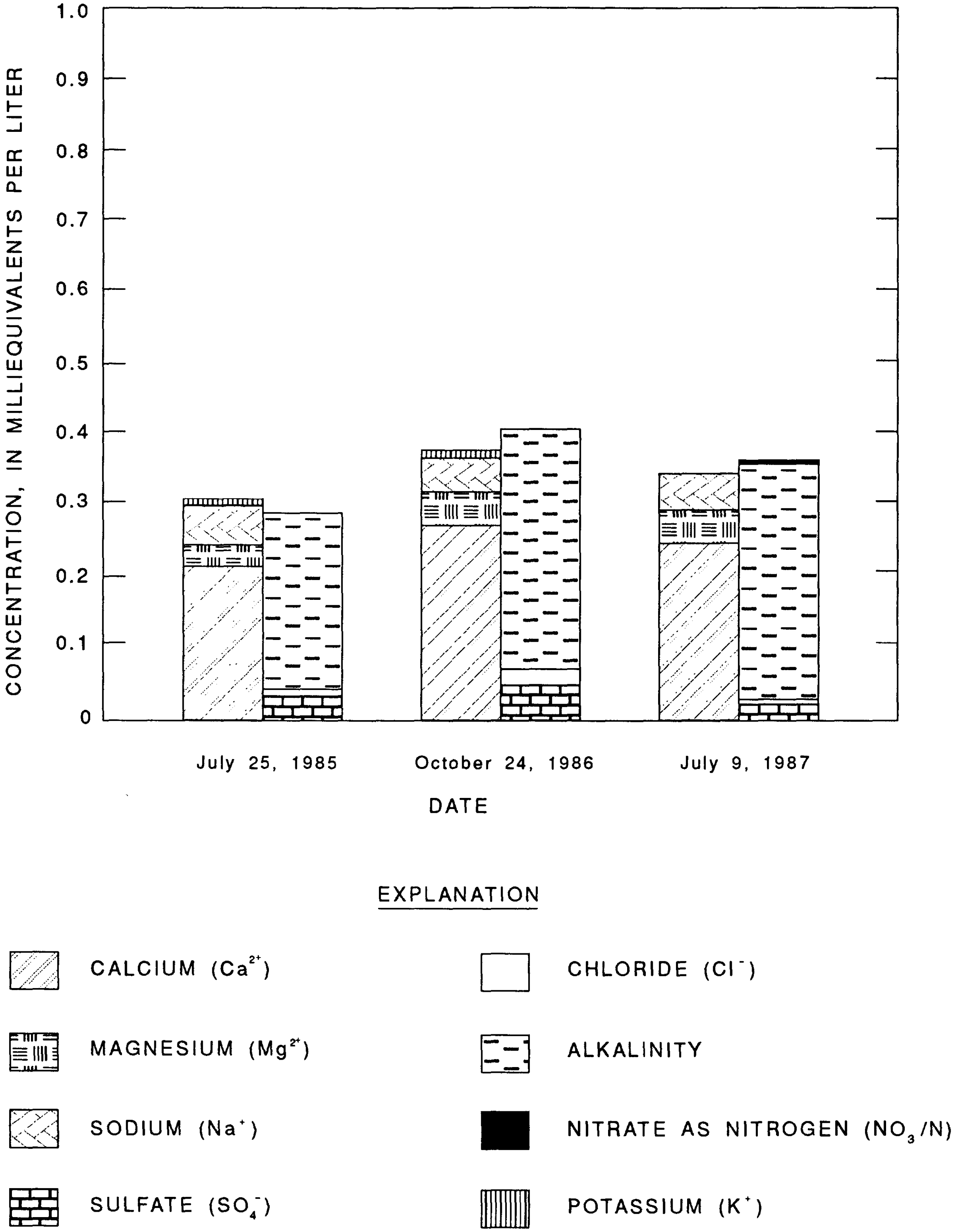


Figure 28.--Chemical composition of lake 9 outflow water, 1985-87.

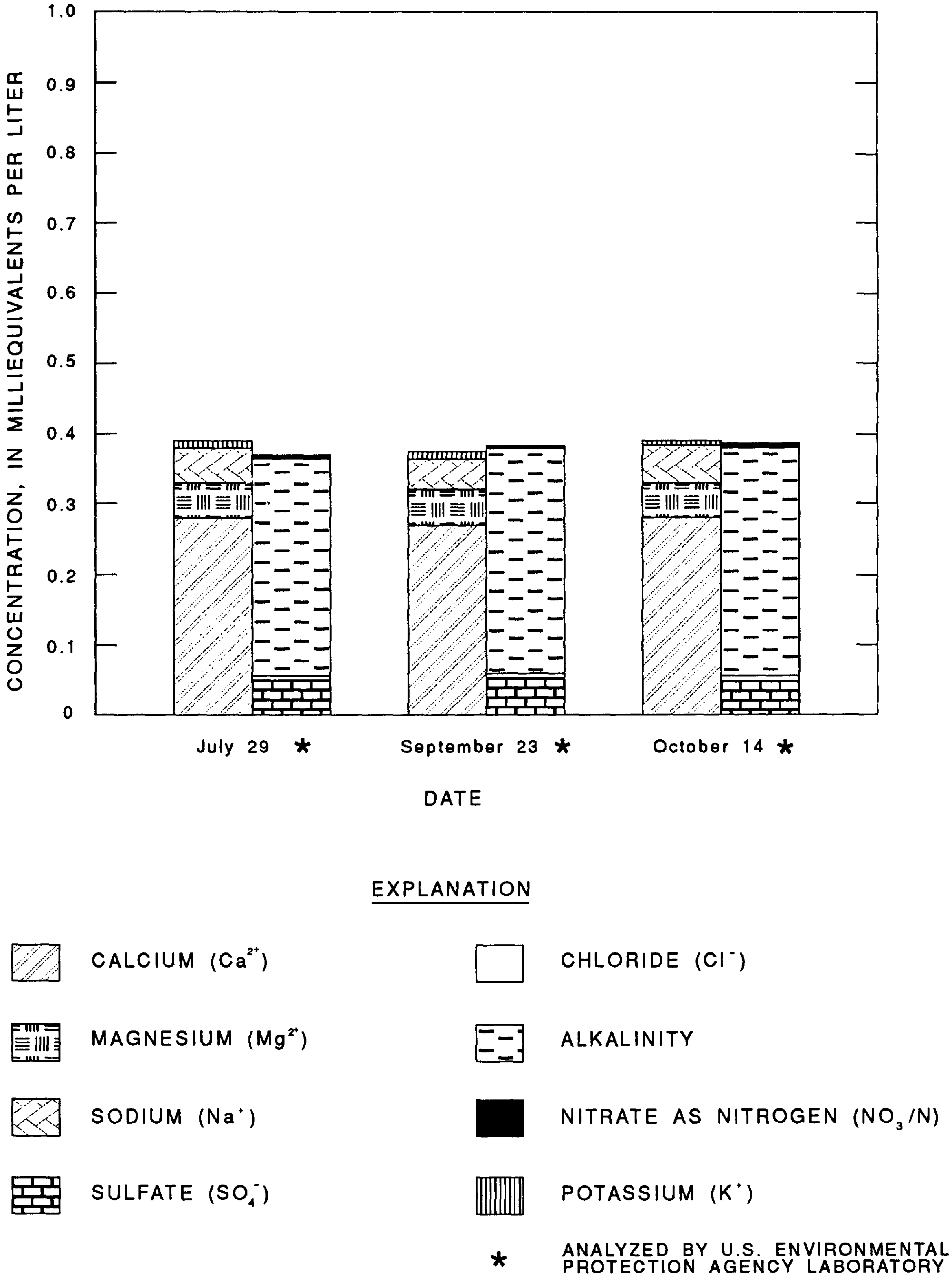


Figure 29.--Chemical composition of lake 9 outflow water, 1987.

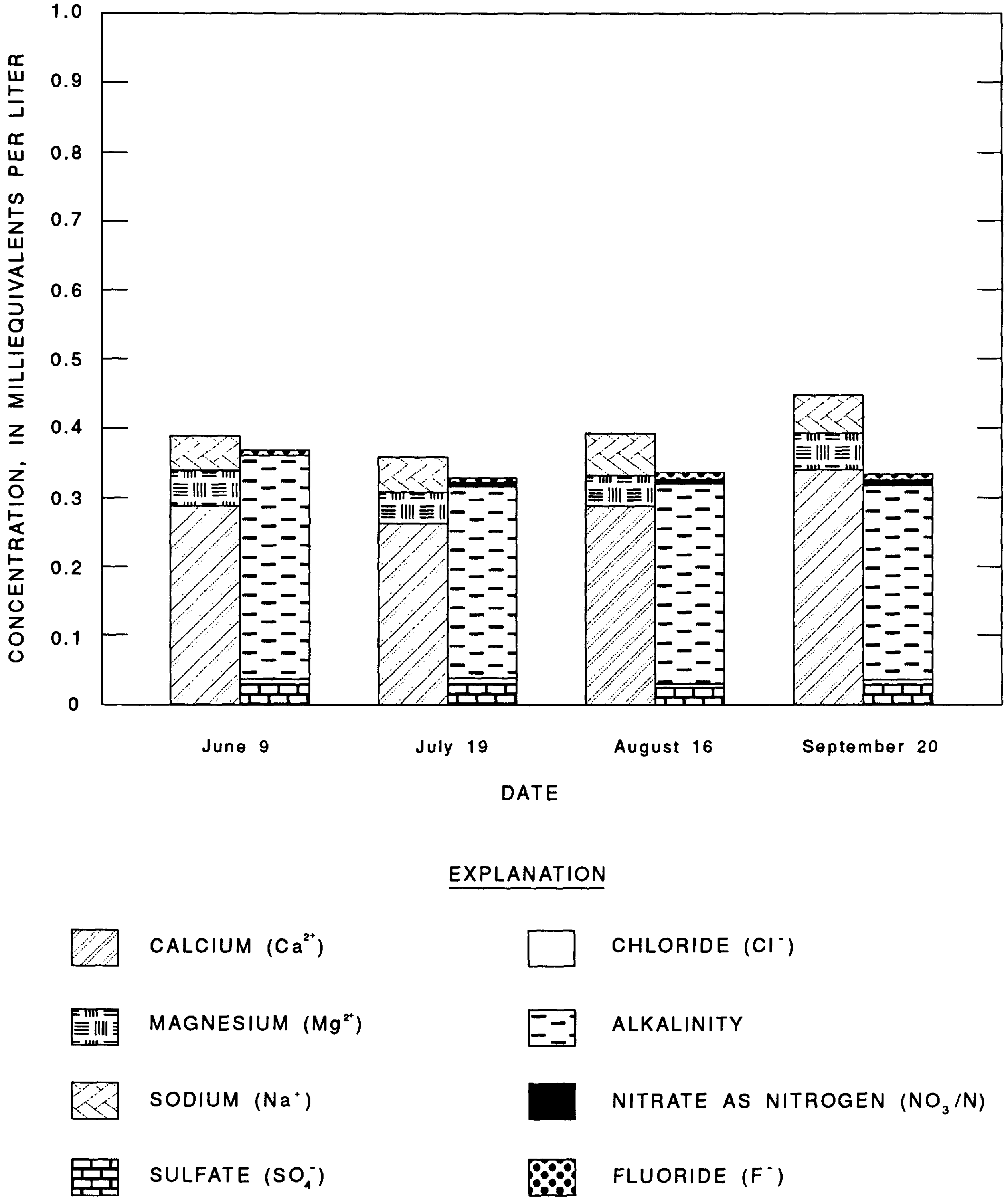


Figure 30.--Chemical composition of lake 9 outflow water, 1988.

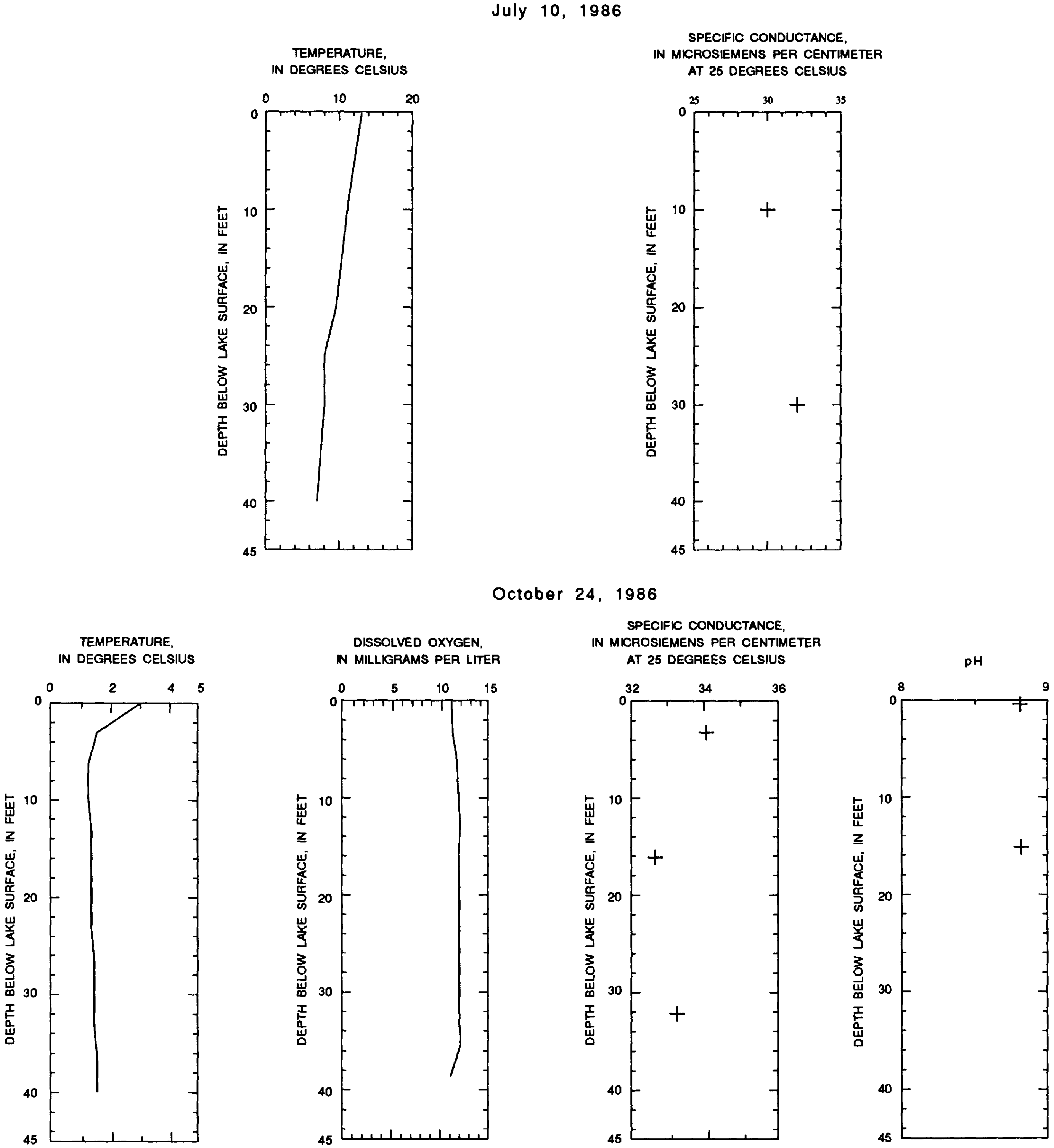
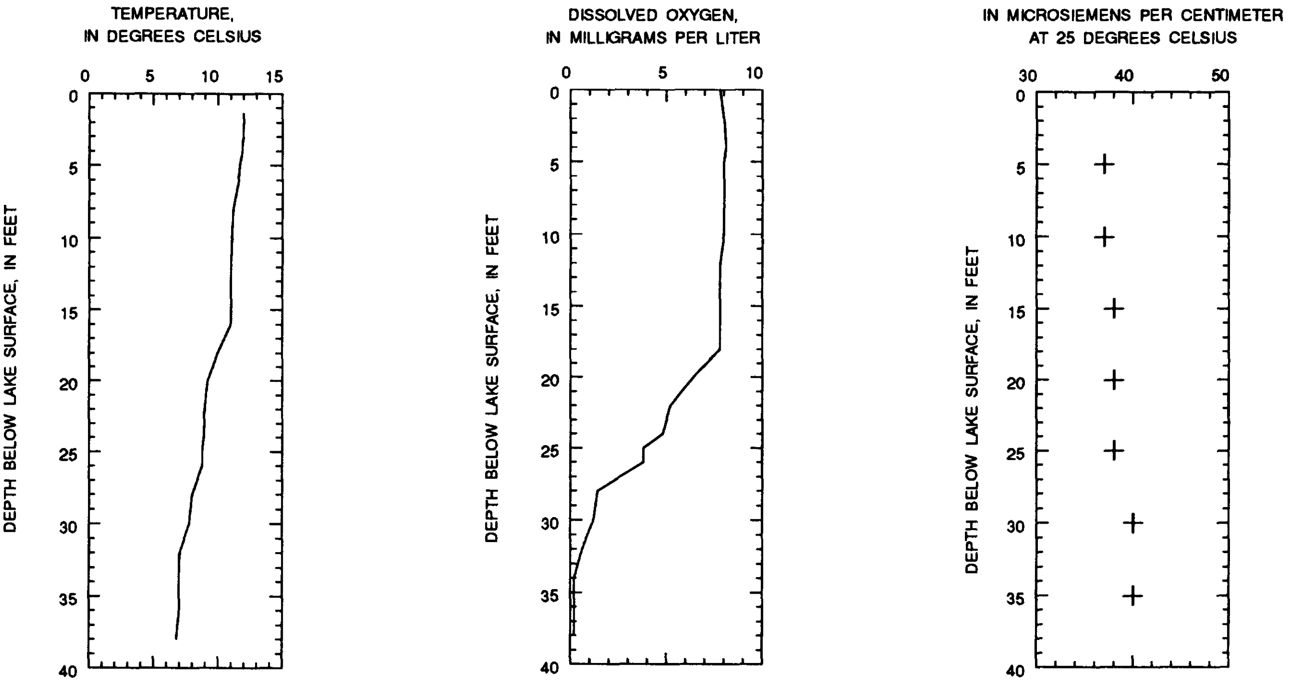


Figure 31.--Depth profile of temperature, dissolved oxygen, specific conductance, and pH of water from lake 9.

July 29, 1987



October 14, 1987

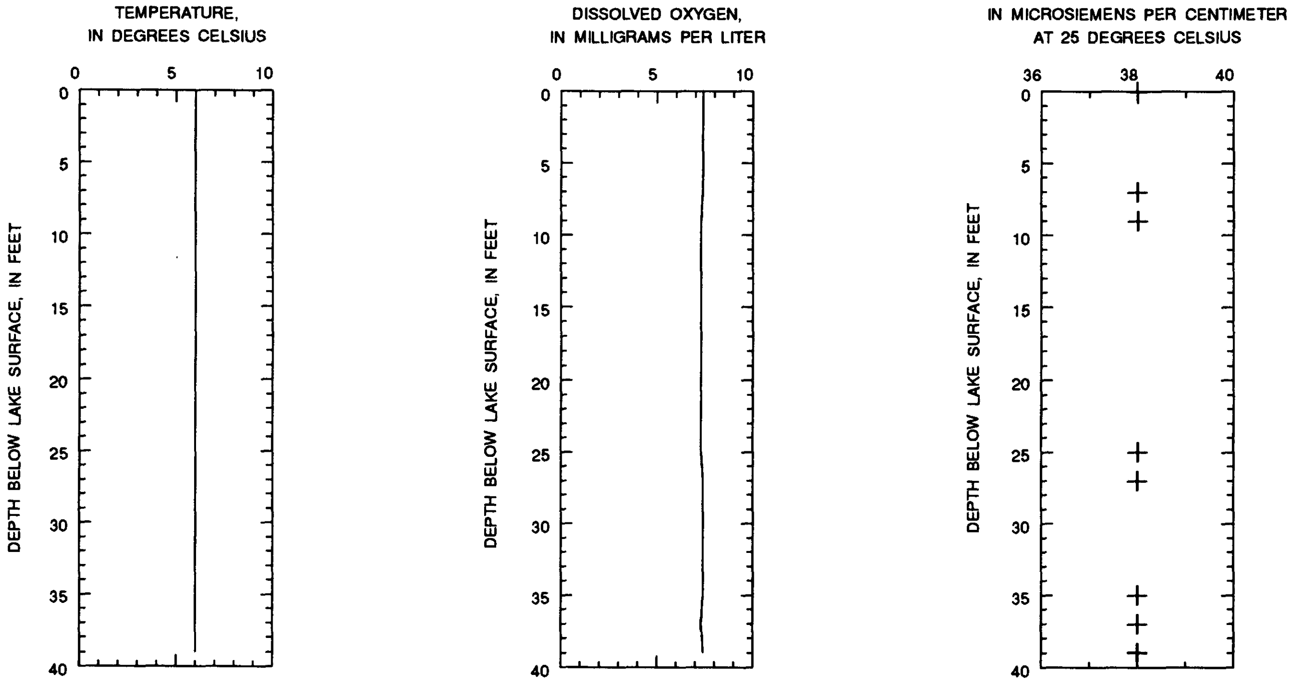
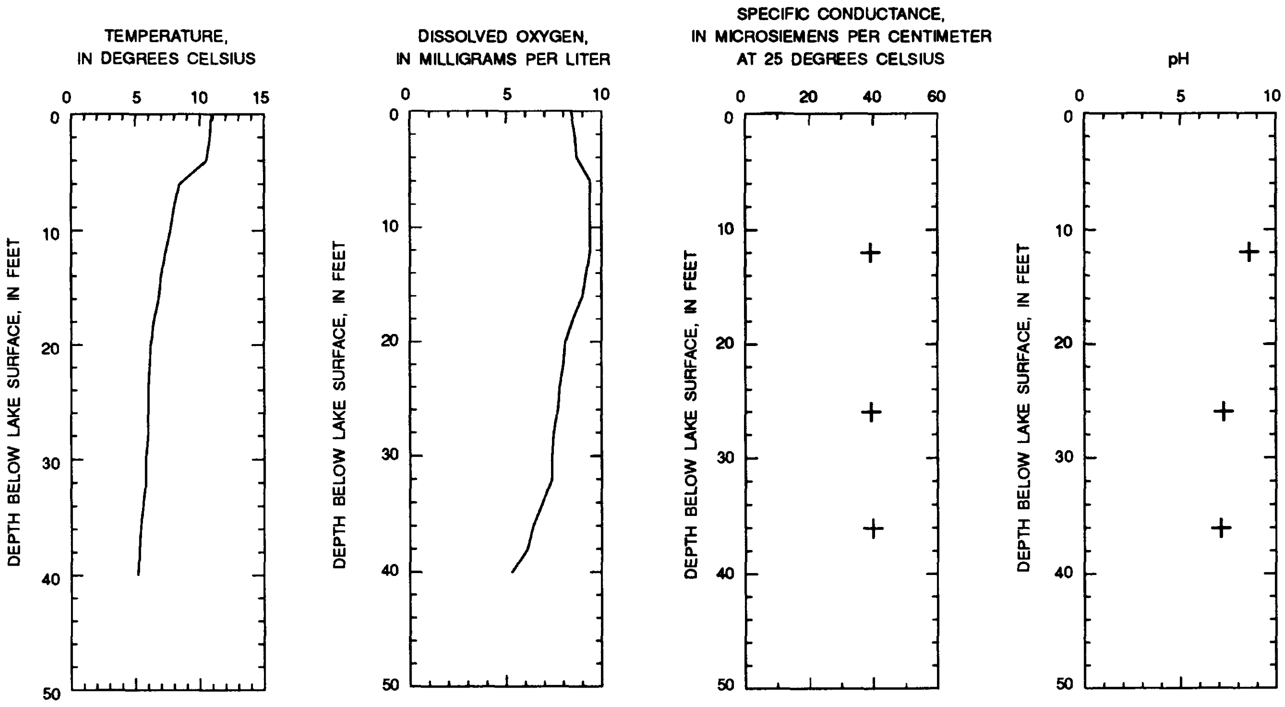


Figure 31.--Depth profile of temperature, dissolved oxygen, specific conductance, and pH of water from lake 9--Continued.

June 9, 1988



July 19, 1988

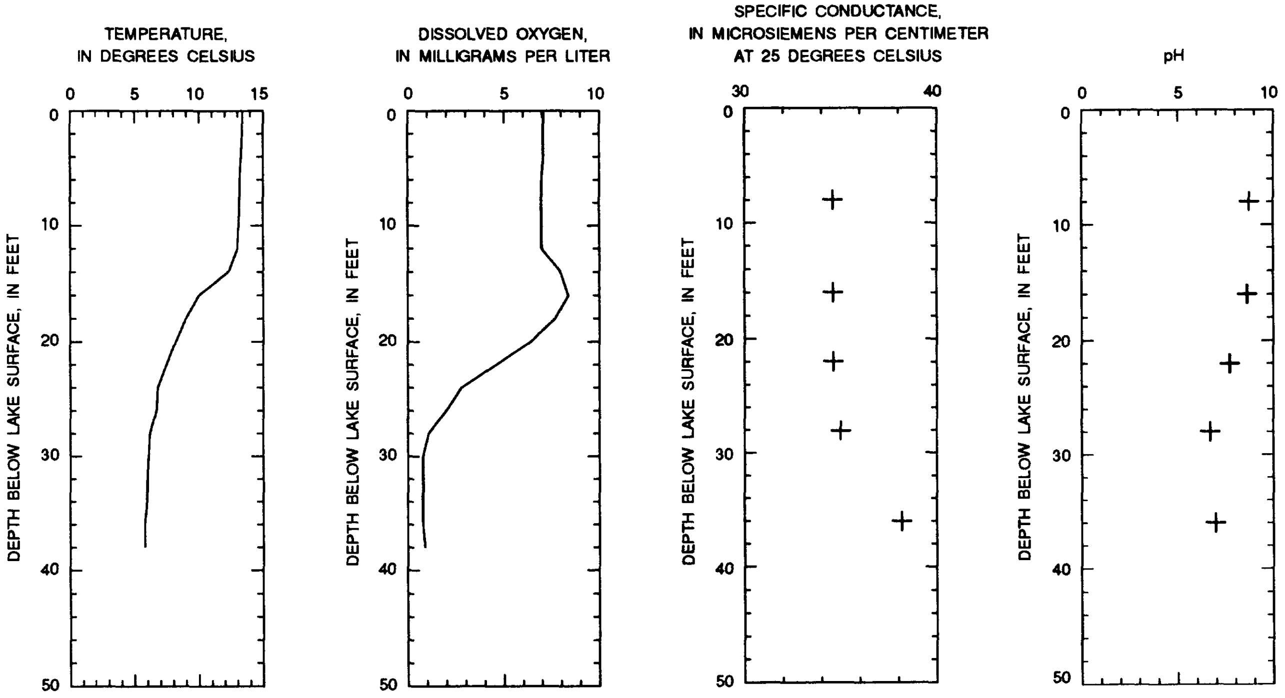
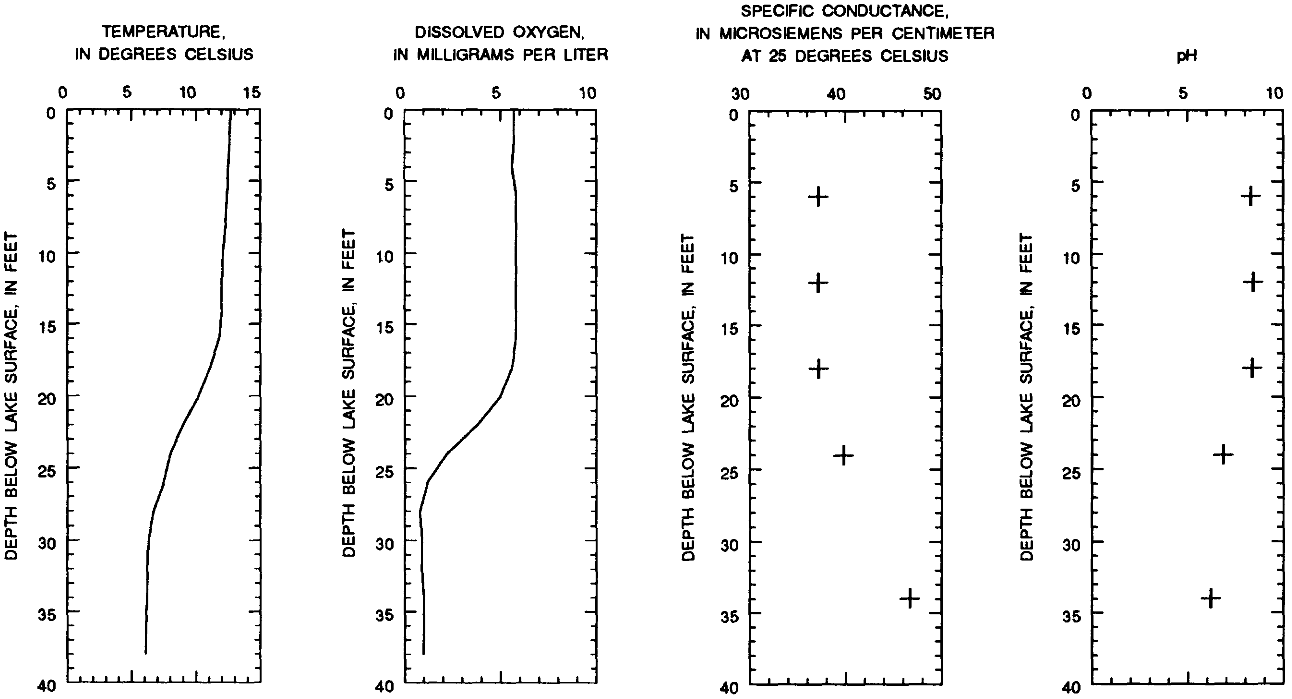


Figure 31.--Depth profile of temperature, dissolved oxygen, specific conductance, and pH of water from lake 9--Continued.

August 16, 1988



September 20, 1988

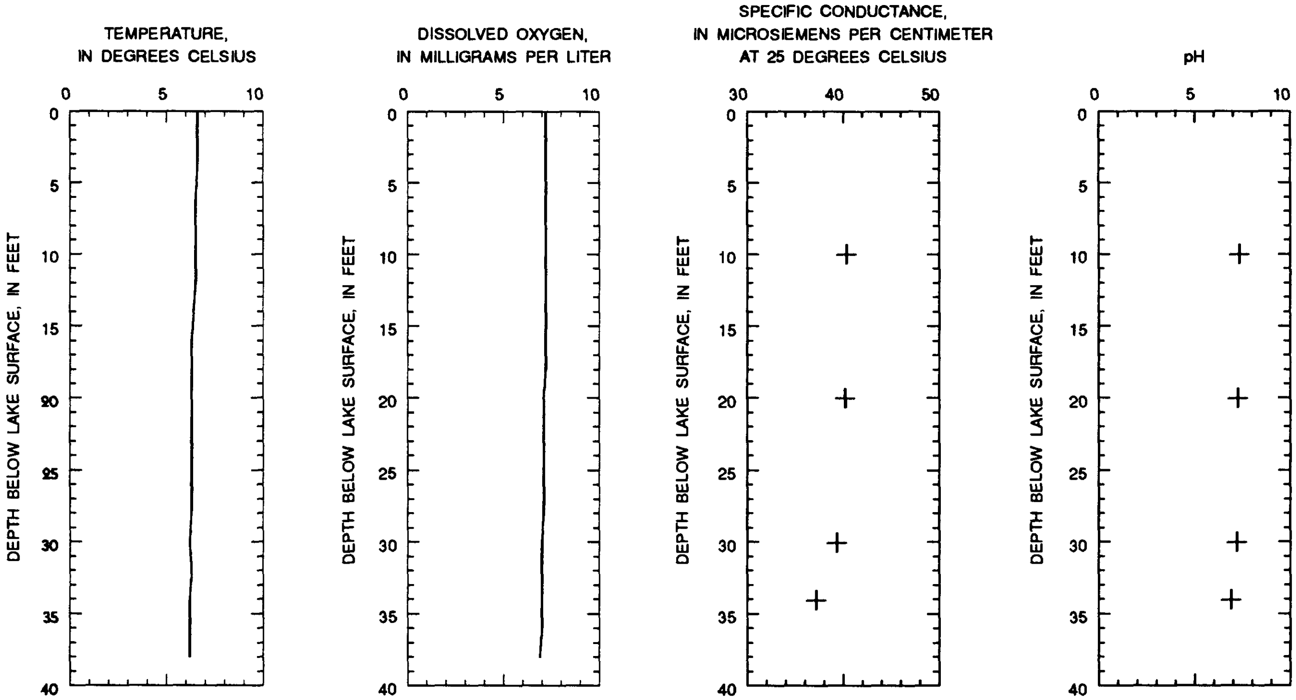


Figure 31.--Depth profile of temperature, dissolved oxygen, specific conductance, and pH of water from lake 9--Concluded.

Lake 8

Lake 8 is at an altitude of 11,775 feet. Lake 8 is the sixth largest of the nine Latir Lakes, having a total surface area of 3.07 acres. By volume it is the fifth largest, containing 675,900 cubic feet (15.5 acre-feet) of water. Maximum depth is 10.1 feet and average depth is 5.0 feet (fig. 32; table 6). An area of seeps flows into lake 8 on the south side. This water is probably seepage from lake 9. Surface-water outflow from lake 8 to Latir Creek was observed only in the spring when the lake level was high. The area between lake 8 and Latir Creek, however, was damp all summer long although no surface-water flow was observed.

Lake 8 was not selected for intensive lake sampling because lake 9 contributed substantially more discharge to the lake system. Two lake-outflow samples collected on July 24, 1985, were analyzed for major constituents; the results of the analyses are listed in table 8. Specific conductance and pH of the lake outflow were measured monthly during the field season from 1986 through 1988 (table 7).

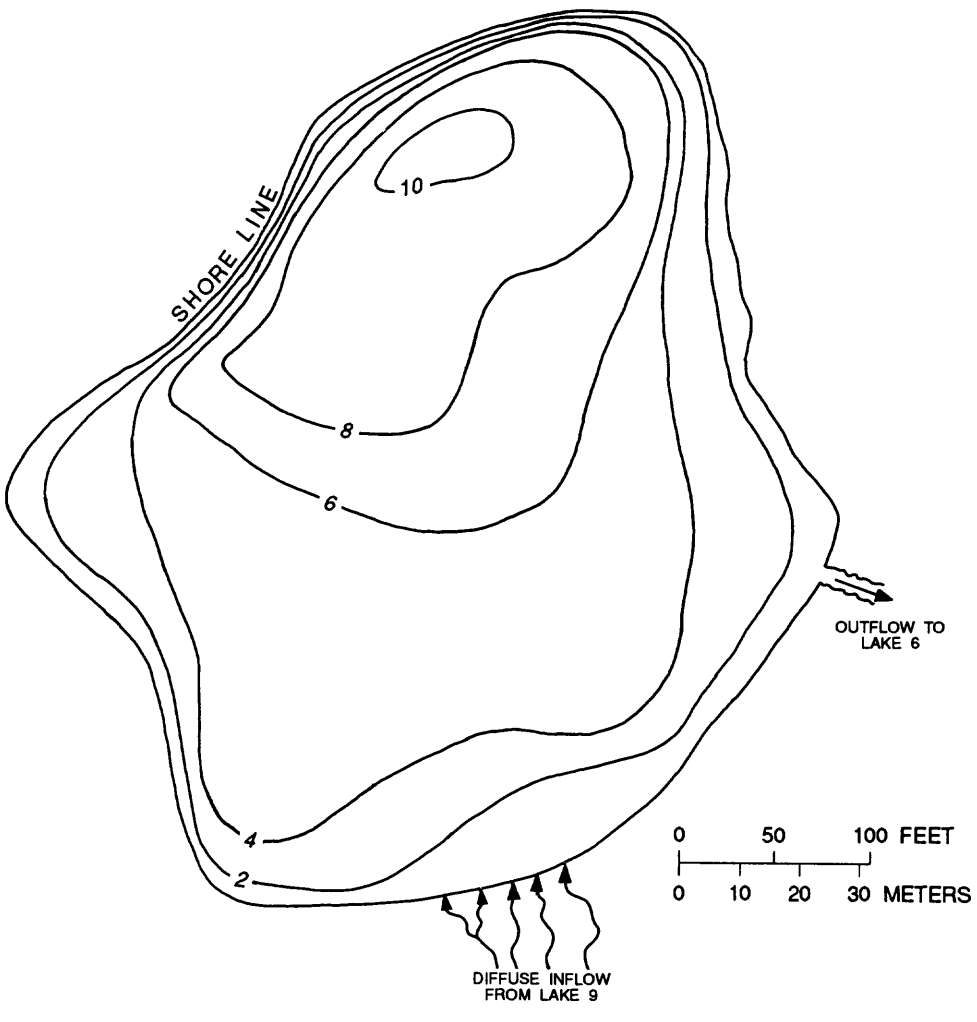
Lake 7

Located slightly north of the east-to-west trend of the other Latir Lakes, lake 7 is at an altitude of 11,630 feet. It has the seventh largest surface area of the lakes (2.0 acres) and contains 429,700 cubic feet (9.9 acre-feet) of water. Maximum depth located was 8 feet and average depth is 4.95 feet (fig. 33; table 6).

During the first visit to the lake in July 1986, no outflow from the lake was observed. Because there is no continuous outflow from the lake and the lake is not located along Latir Creek, no samples were collected and specific conductance and pH were not measured for the study.

Lake 6

At an altitude of 11,670 feet, lake 6 has the second smallest surface area of the Latir Lakes (1.63 acres). It is also the second smallest in volume, containing 188,800 cubic feet (4.3 acre-feet) of water. Maximum depth of this lake is only 5.2 feet and average depth is 2.6 feet (fig. 34; table 6). The only surface-water inflow to lake 6 is along the northwest side from lake 9 and lake 8. Specific conductance and pH of the lake outflow were measured monthly from 1986 through 1988 (table 7).



EXPLANATION

—2— LINE OF EQUAL LAKE DEPTH, IN FEET, 1986--Interval is 2 feet

Figure 32.--Bathymetric map of lake 8.

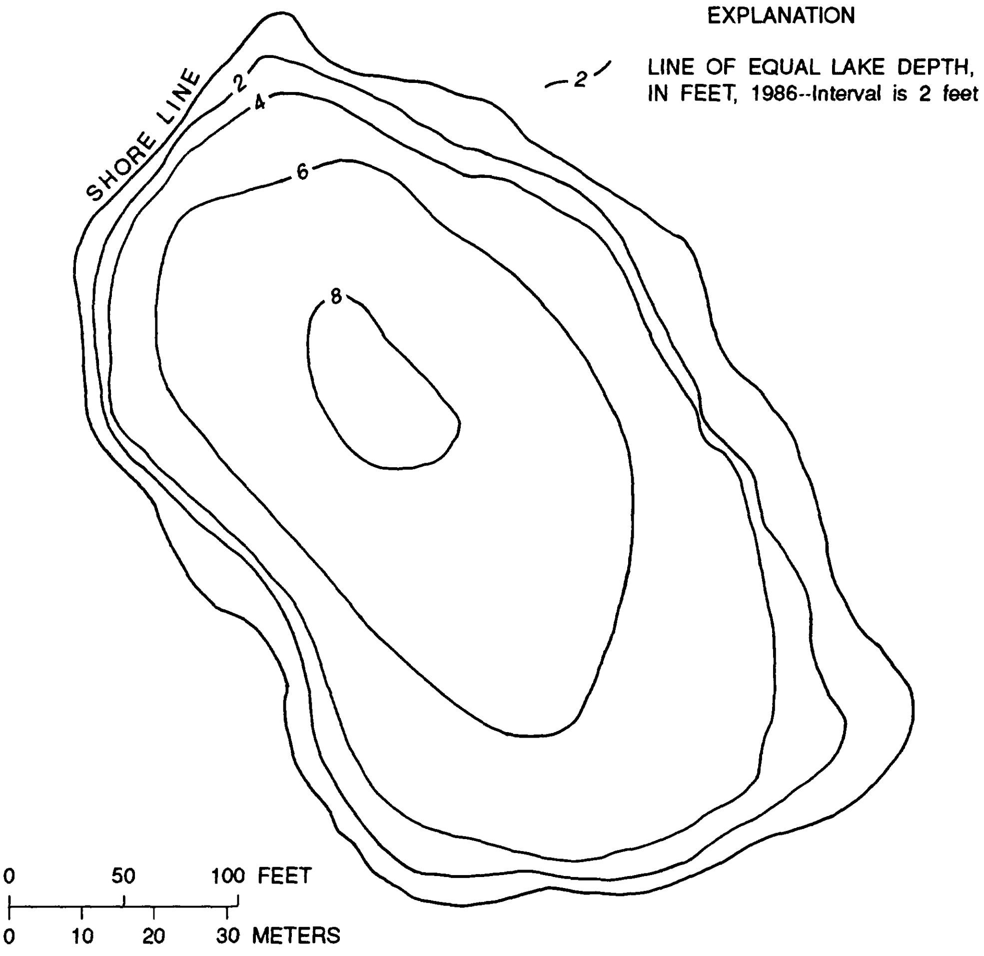


Figure 33.--Bathymetric map of lake 7.

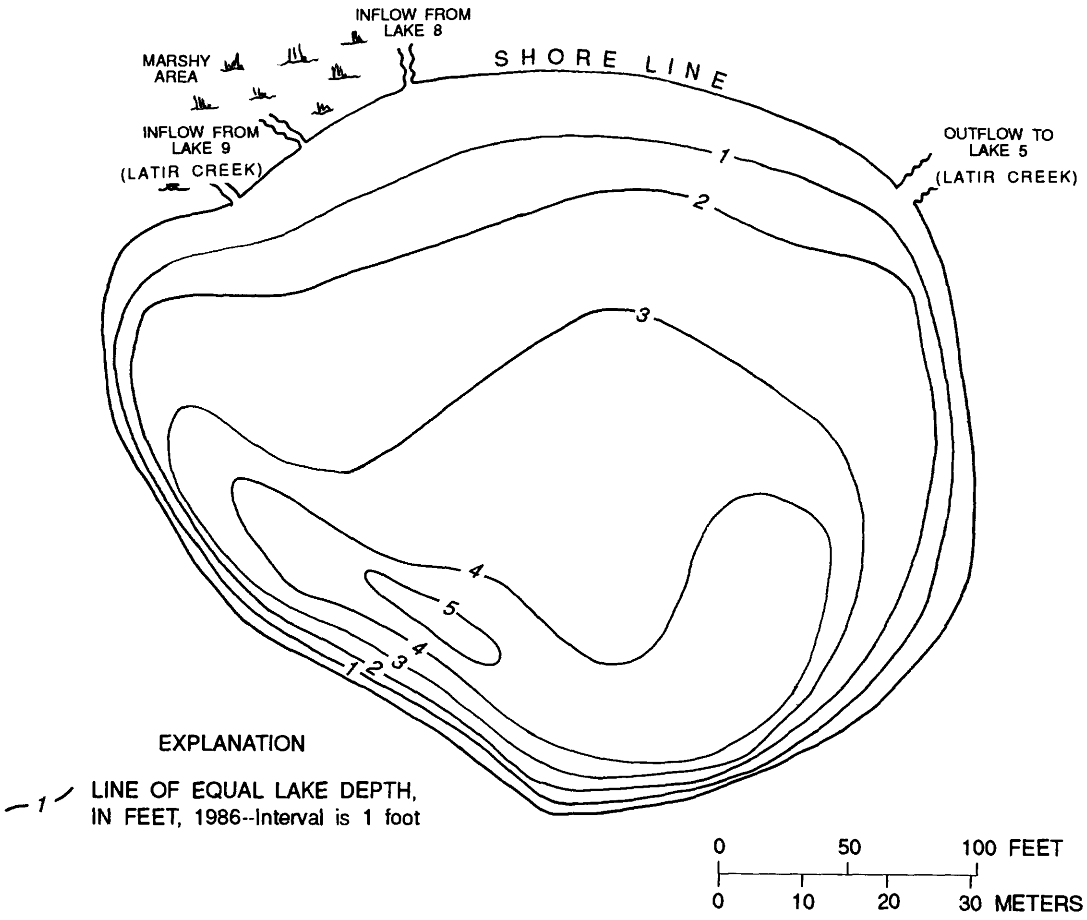


Figure 34.--Bathymetric map of lake 6.

Lake 5

Just upstream from lake 4, lake 5 is at an altitude of 11,570 feet. It is the fourth largest of the Latir Lakes in area (4.11 acres), and the third largest in volume (2,132,000 cubic feet or 49.0 acre-feet). Maximum depth is about 19 feet; average depth is 11.9 feet (fig. 35; table 6). The only surface-water inflow to lake 5 (Latir Creek) is along the west side of the lake.

Specific conductance of outflow water from lake 5 generally is larger than that of outflow water from lake 9 (table 7). The pH of lake 5 outflow water was larger than 9.0 in October 1986 and July 1987, but was 6.88 in September 1988 (table 8). This relatively small pH may have been in response to the large amount of precipitation that fell in early September 1988. Calcium is the dominant cation and the ions that produce alkalinity are the dominant anions in water from lake 5 (figs. 36 and 37). Concentrations of magnesium, sodium, sulfate, and chloride are relatively constant throughout the year and from year to year. There is a substantial increase in calcium and alkalinity in the outflow water from lake 5 from July to October 1987 and from June to August 1988 (figs. 36 and 37). Concentrations of most dissolved constituents decreased from August to September in 1988. This decrease could have been due to dilution resulting from increased discharge from lake 9 and precipitation on the lake surface because of the large amount of precipitation that fell during this time.

Trends in the depth-profile data for lake 5 are similar from year to year and to those for lake 9; however, a pH and dissolved-oxygen "bulge" can be seen in data for June, July, and August 1988 in lake 5 (fig. 38). Dissolved-oxygen concentrations below the thermocline in lake 5 were larger than those below the thermocline in lake 9 in July and August of 1988 (figs. 31 and 38). Lake 5 also had a larger increase in specific conductance with depth (prior to the time the lake "turned over" in June, July, and August 1988) compared with lake 9 (figs. 31 and 38).

Lake 4

At 11,550 feet in altitude, lake 4 is just downstream from lake 5 and substantially upstream from lake 3. Lake 4 is the third largest of the Latir Lakes in area (4.61 acres) and fourth largest in volume (1,490,000 cubic feet or 34.2 acre-feet). Maximum depth is only 10.9 feet and average depth is 7.4 feet (fig. 39; table 6). Latir Creek (inflow from lake 5) is the only surface-water inflow to lake 4. Specific conductance and pH of the lake outflow were measured monthly from 1986 through 1988 (table 7).

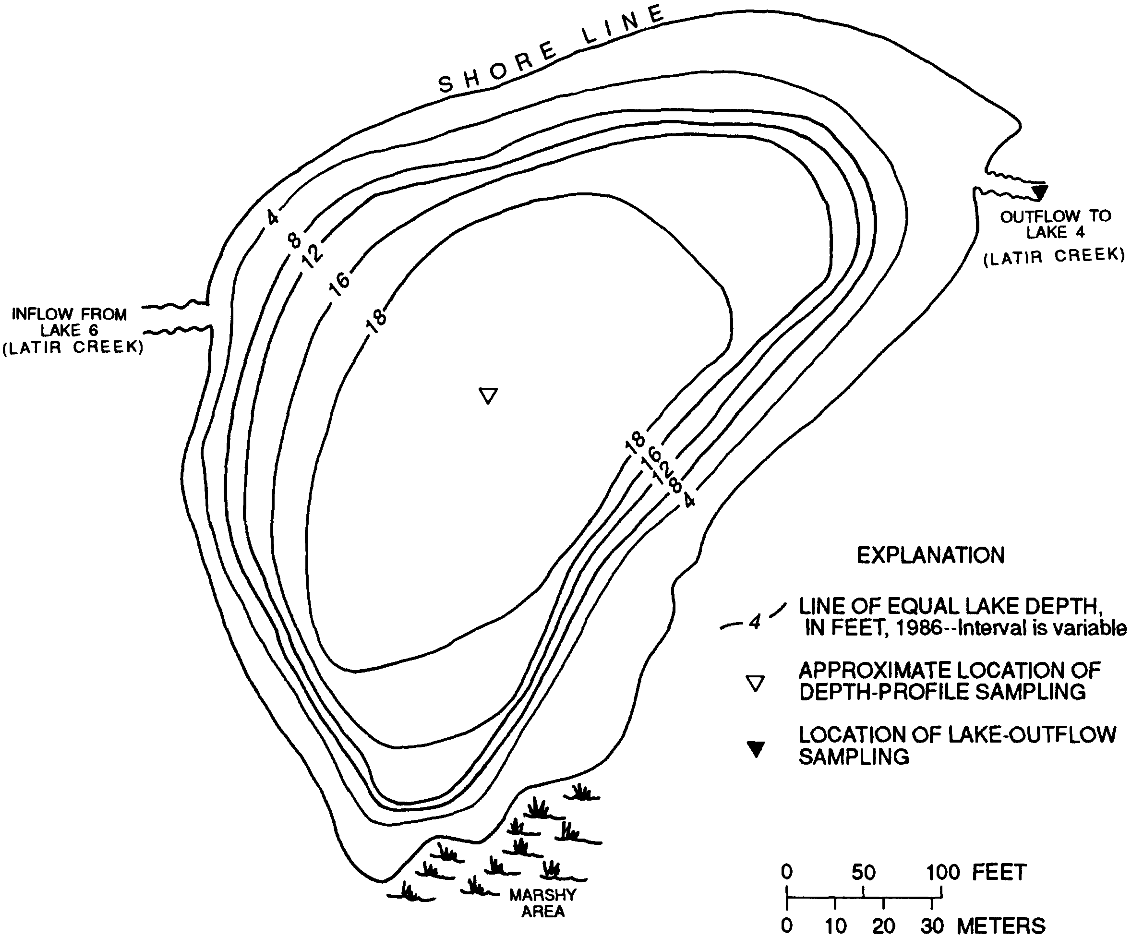


Figure 35.--Bathymetric map of lake 5.

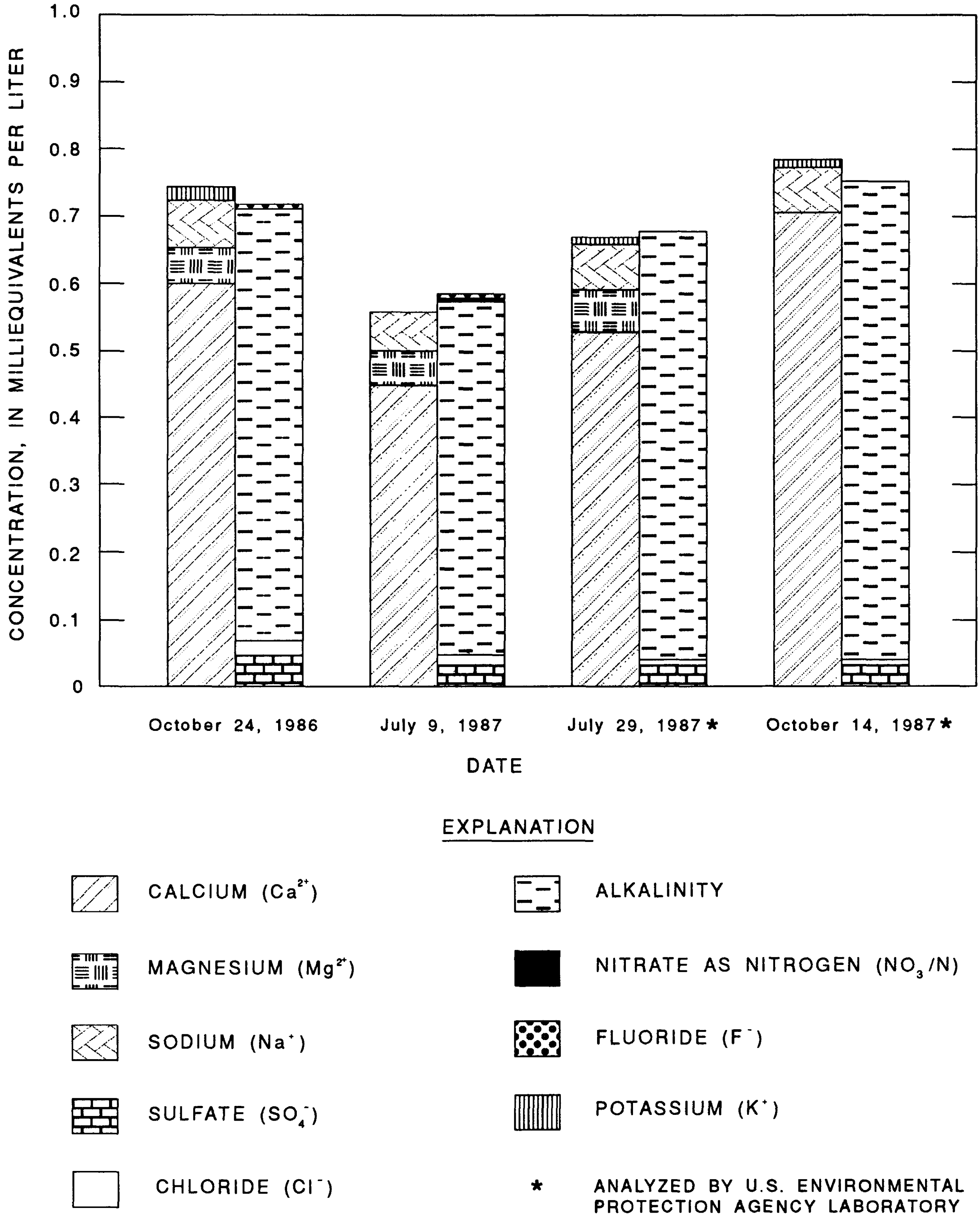


Figure 36.--Chemical composition of lake 5 outflow water, 1986-87.

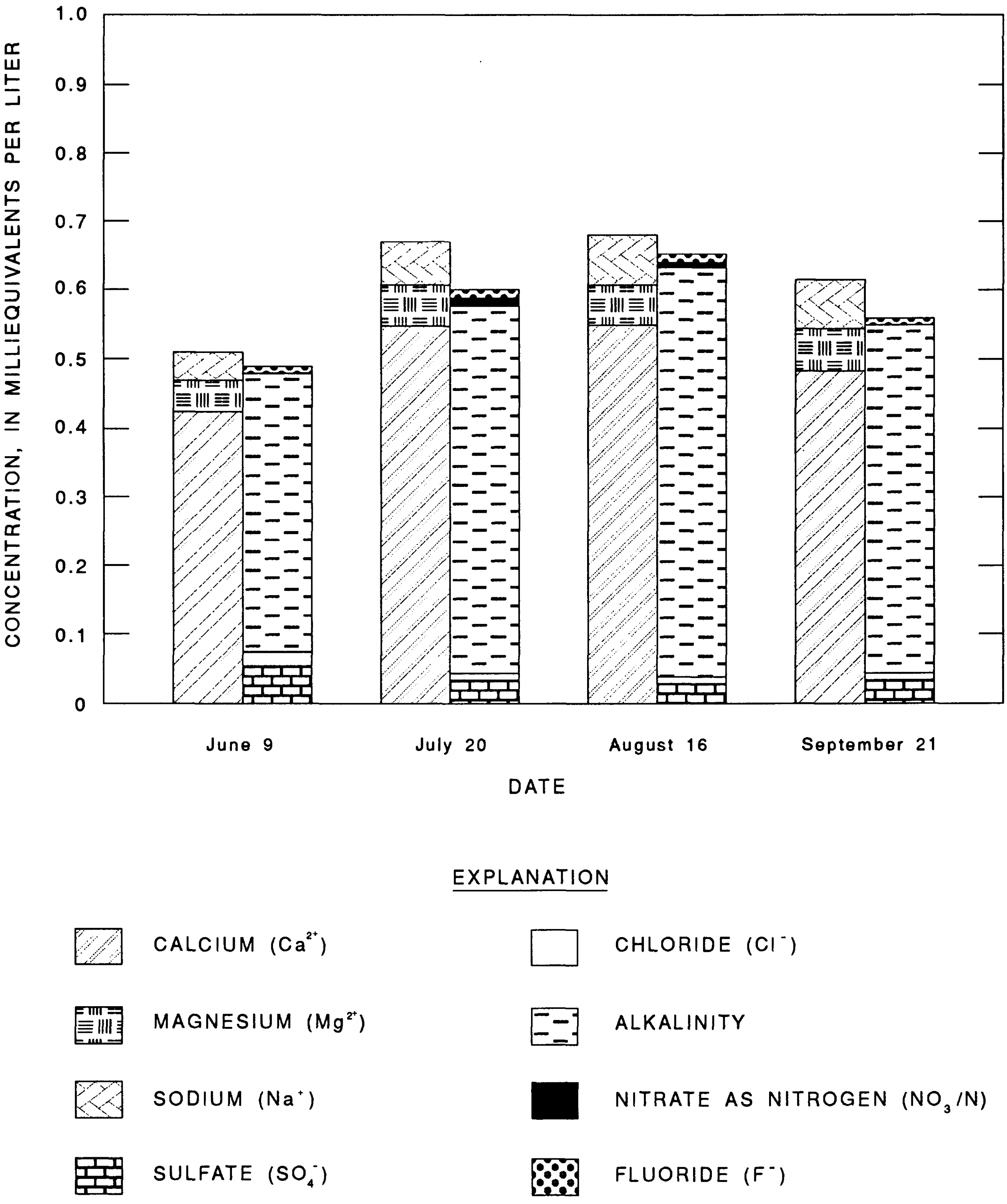
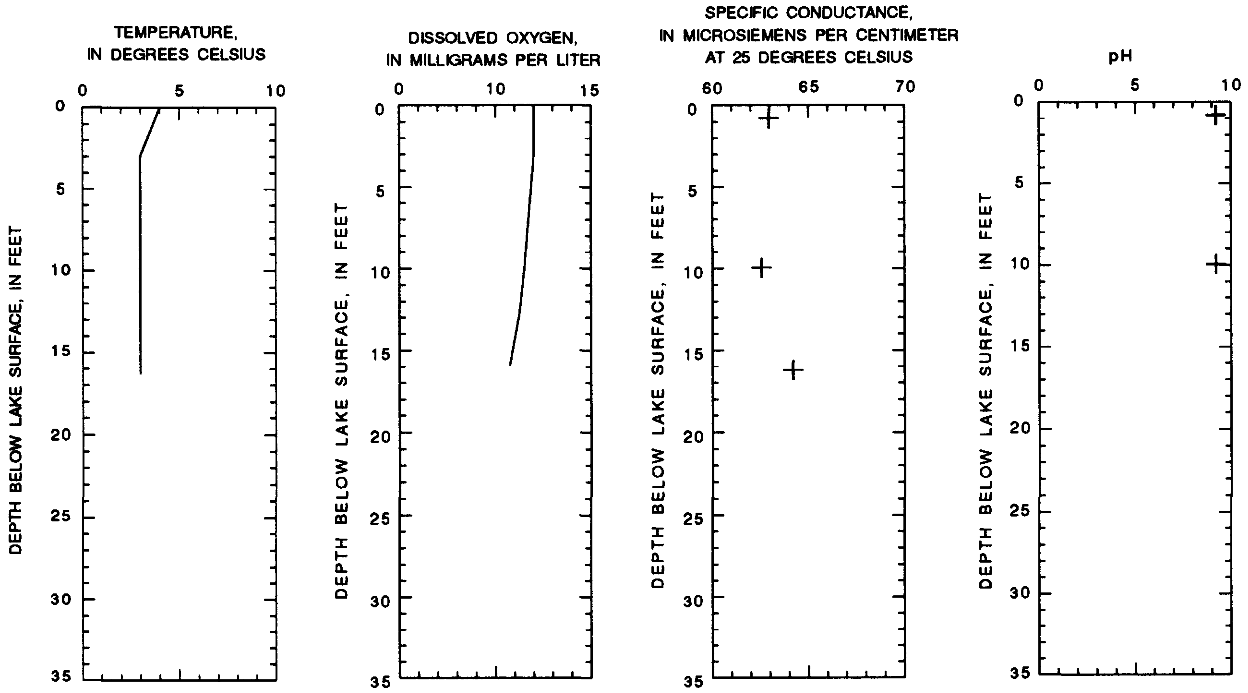


Figure 37.--Chemical composition of lake 5 outflow water, 1988.

October 24, 1986



July 29, 1987

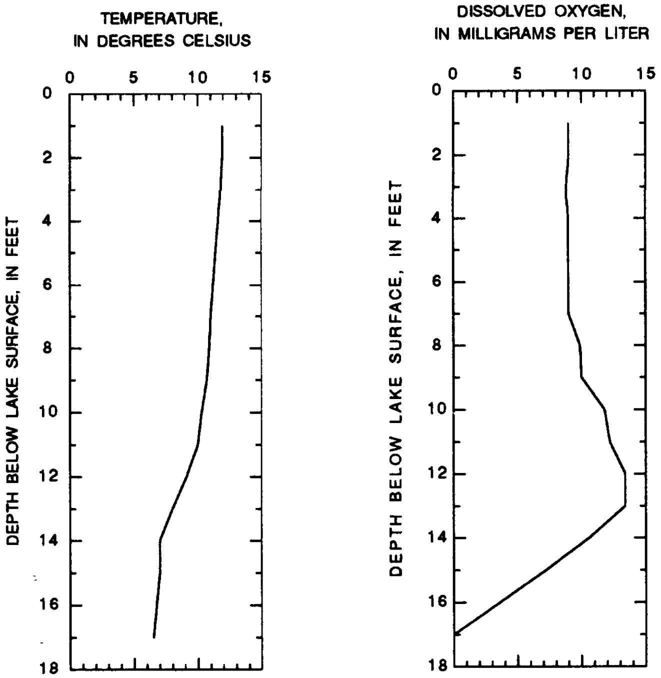
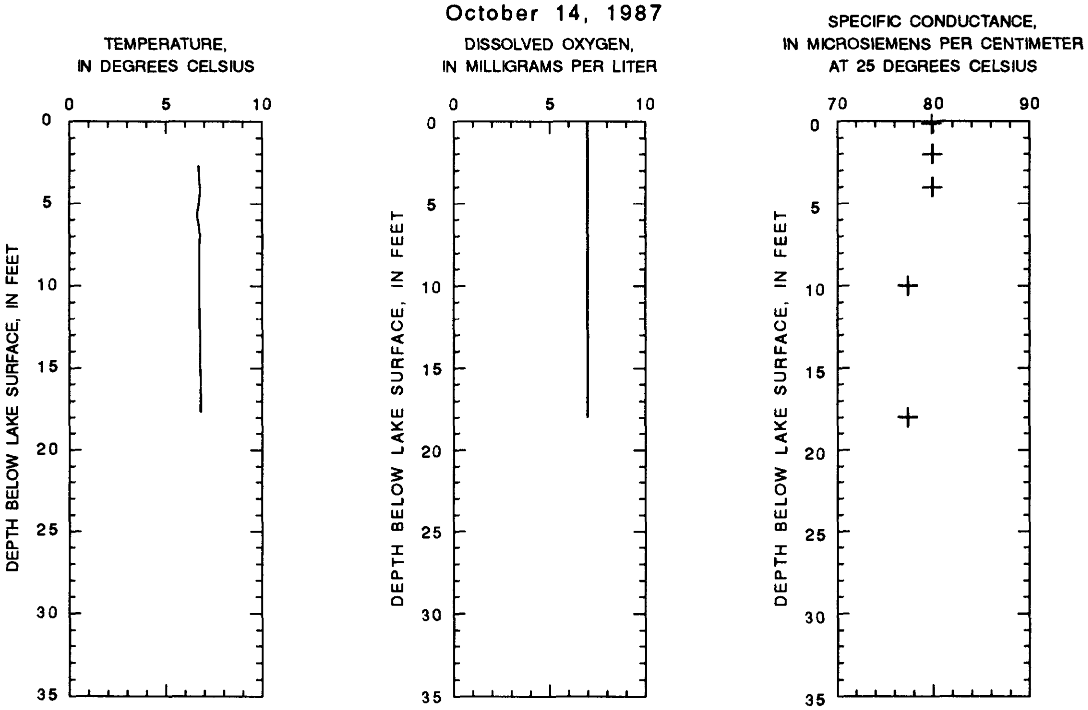


Figure 38.--Depth profile of temperature, dissolved oxygen, specific conductance, and pH of water from lake 5.

October 14, 1987



June 9, 1988

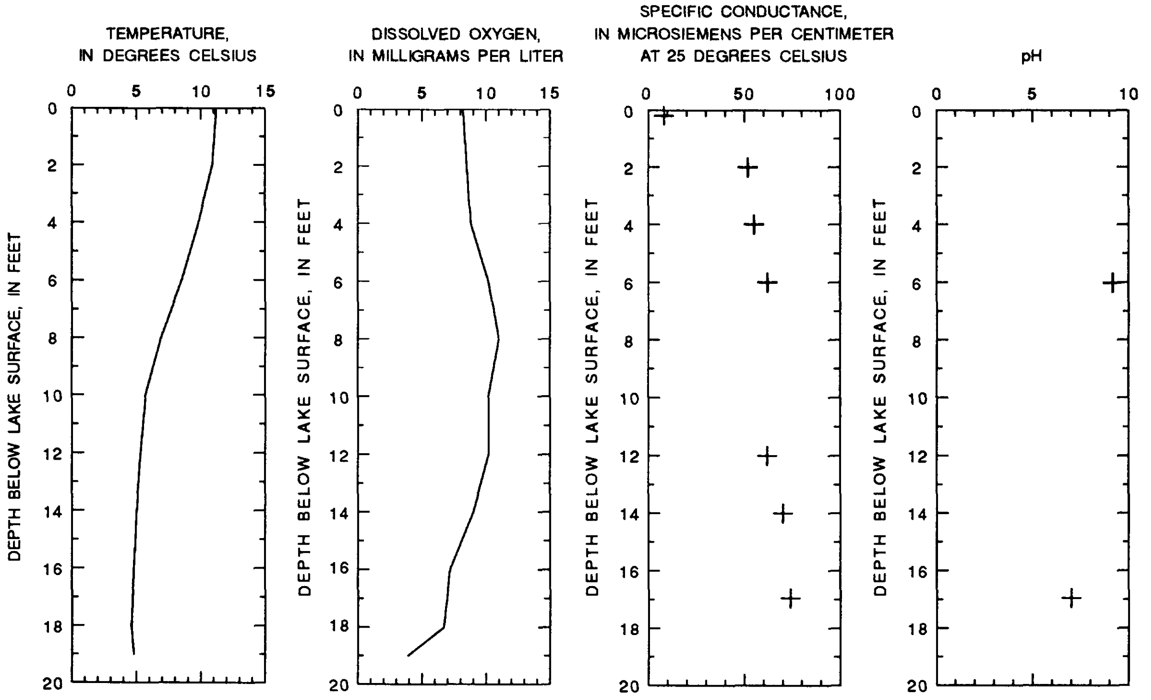
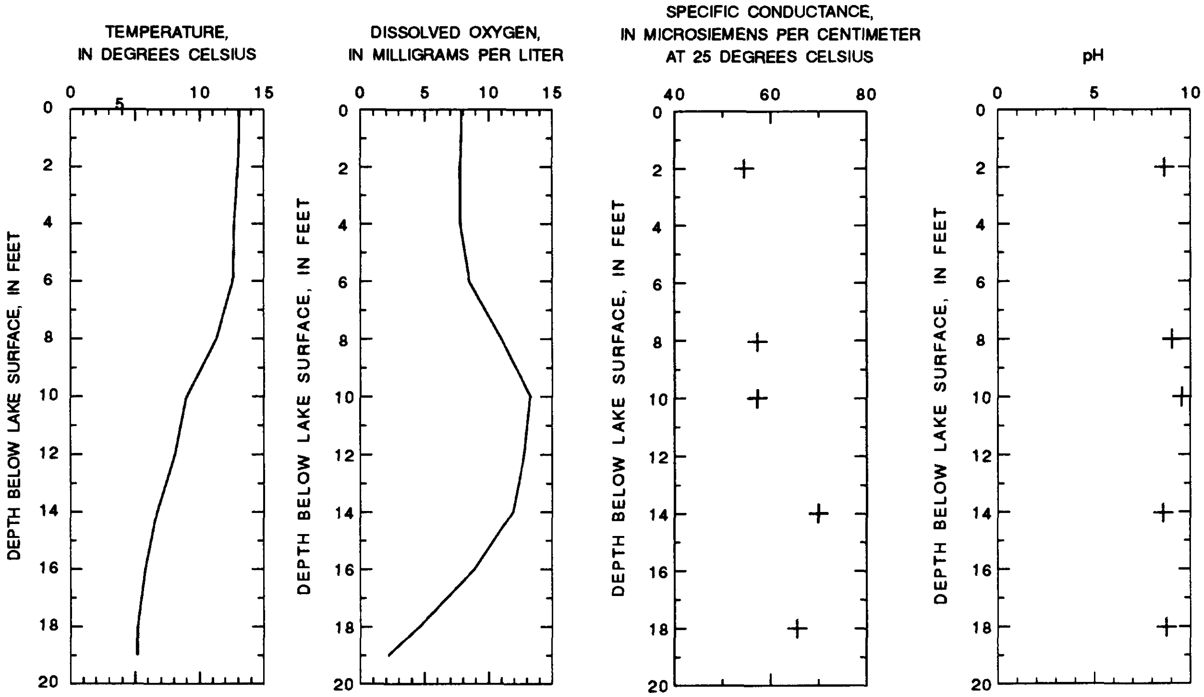


Figure 38.--Depth profile of temperature, dissolved oxygen, specific conductance, and pH of water from lake 5--Continued.

July 19, 1988



August 16, 1988

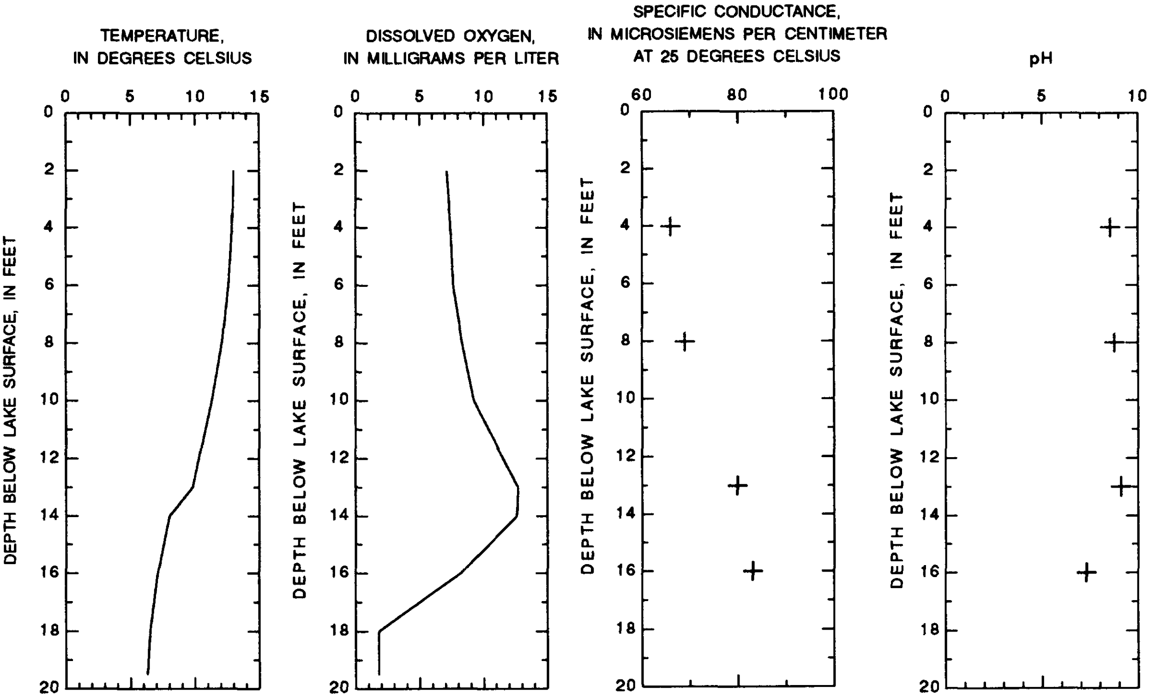


Figure 38.--Depth profile of temperature, dissolved oxygen, specific conductance, and pH of water from lake 5--Continued.

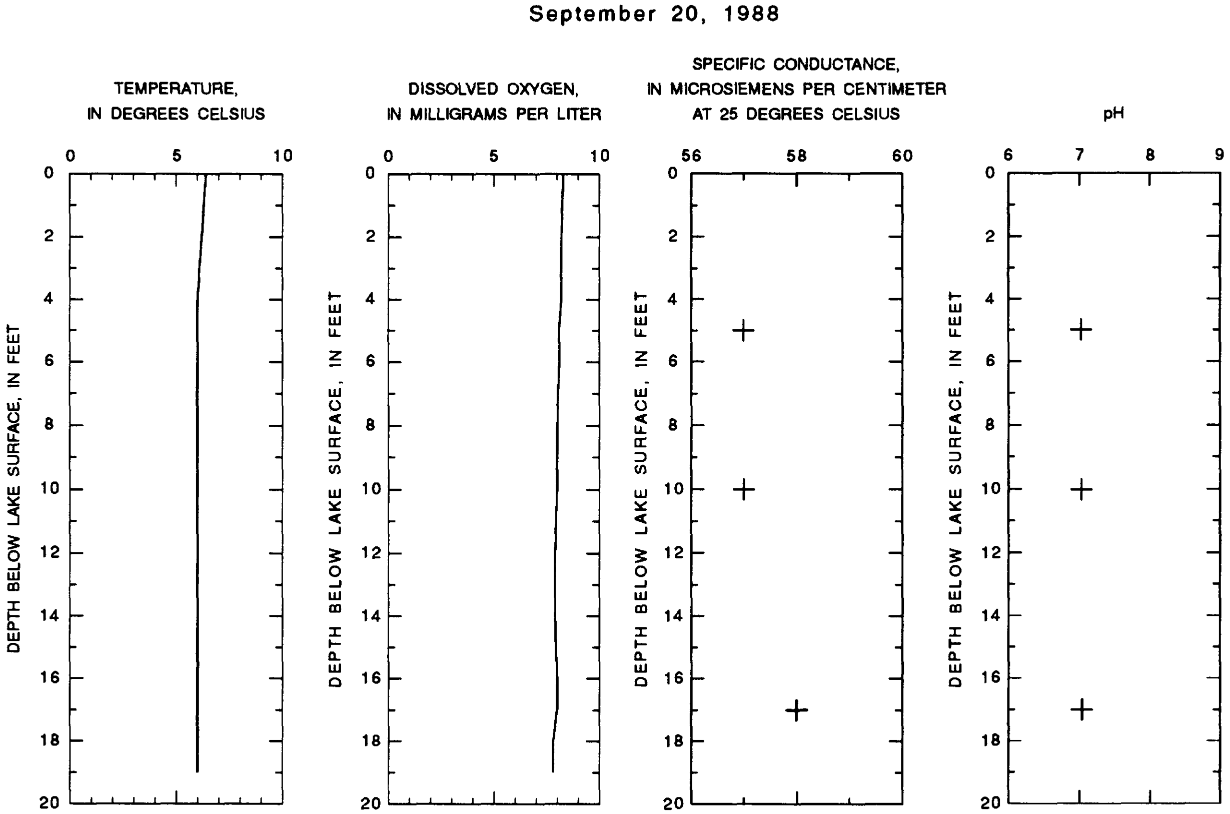


Figure 38.--Depth profile of temperature, dissolved oxygen, specific conductance, and pH of water from lake 5--Concluded.

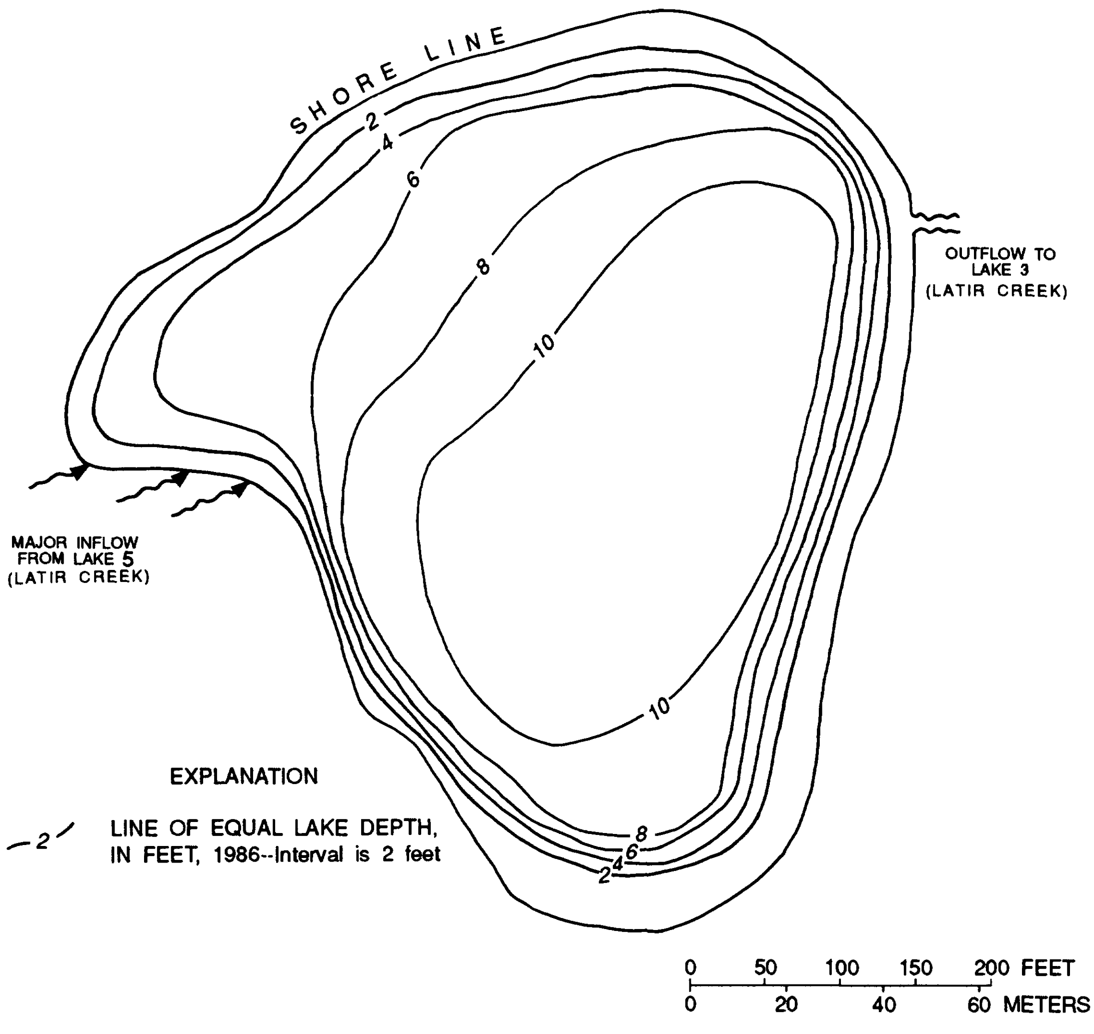


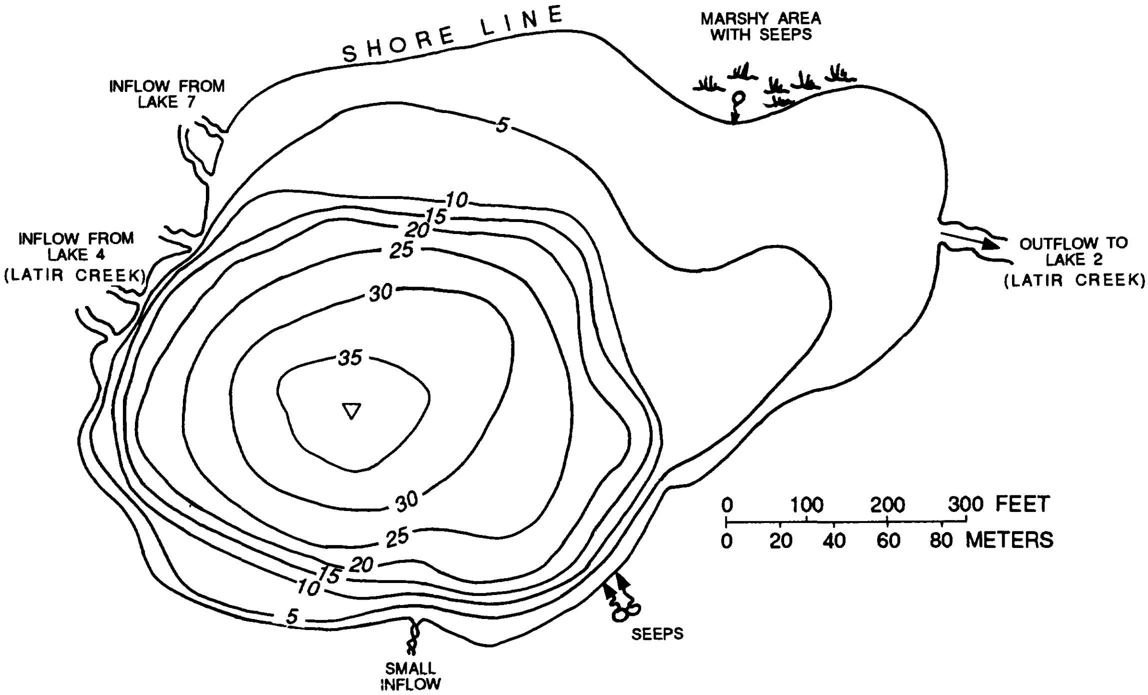
Figure 39.--Bathymetric map of lake 4.

Lake 3

At an altitude of 11,131 feet, lake 3 is just upstream from lake 2. Lake 3 is the largest of the three lowest lakes. Having a surface area of 13.09 acres, it is the largest of the Latir Lakes in surface area and the second largest in volume, containing more than 8 million cubic feet (188 acre-feet) of water. Maximum depth is 36.7 feet and average depth is 14.4 feet (fig. 40; table 6). Latir Creek is the largest surface-water inflow to lake 3, although several small seeps are along the margins of the lake. In the spring a small amount of water flows from lake 7 into lake 3. During the summer there is no obvious surface-water inflow to lake 3 from lake 7.

Only three chemical analyses were performed on water from lake 3--two samples collected from the surface and one collected 10 feet below the lake surface--but some observations can be made from these data (table 8). The location of the sample collection is uncertain. Specific conductance and concentrations of dissolved constituents in water from lake 3 generally are larger than those in water from the outflow of lake 5 (table 8). Alkalinity and concentrations of calcium, sulfate, and chloride were similar in two samples collected at the lake surface on July 23, 1985, and October 25, 1986 (fig. 41). Calcium is the dominant cation and the ions that produce alkalinity are the dominant anions.

Depth-profile data for lake 3 are similar to data for lakes 9 and 5; however, the pronounced pH and dissolved-oxygen "bulges" shown in depth-profile data for lake 5 are not as pronounced in data for lake 3 (fig. 42). Specific conductance increased substantially with depth in lake 3 prior to the time that the lake "turned over." Dissolved-oxygen concentration in water below the thermocline generally was less than 1.5 milligrams per liter during the summer months.



EXPLANATION

5 LINE OF EQUAL LAKE DEPTH, IN FEET, 1986--Interval is 5 feet

▽ APPROXIMATE LOCATION OF DEPTH-PROFILE SAMPLING

Figure 40.--Bathymetric map of lake 3.

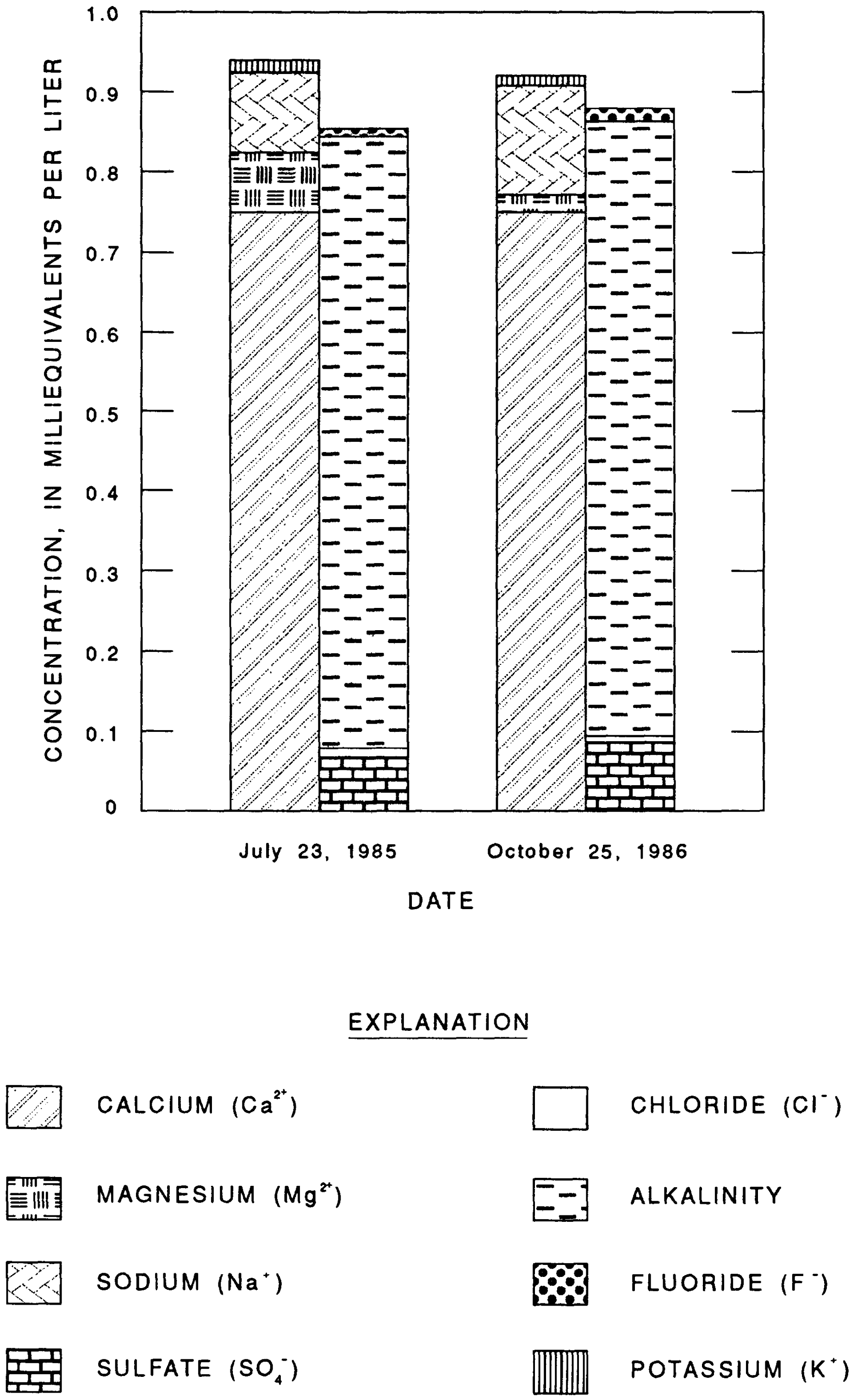
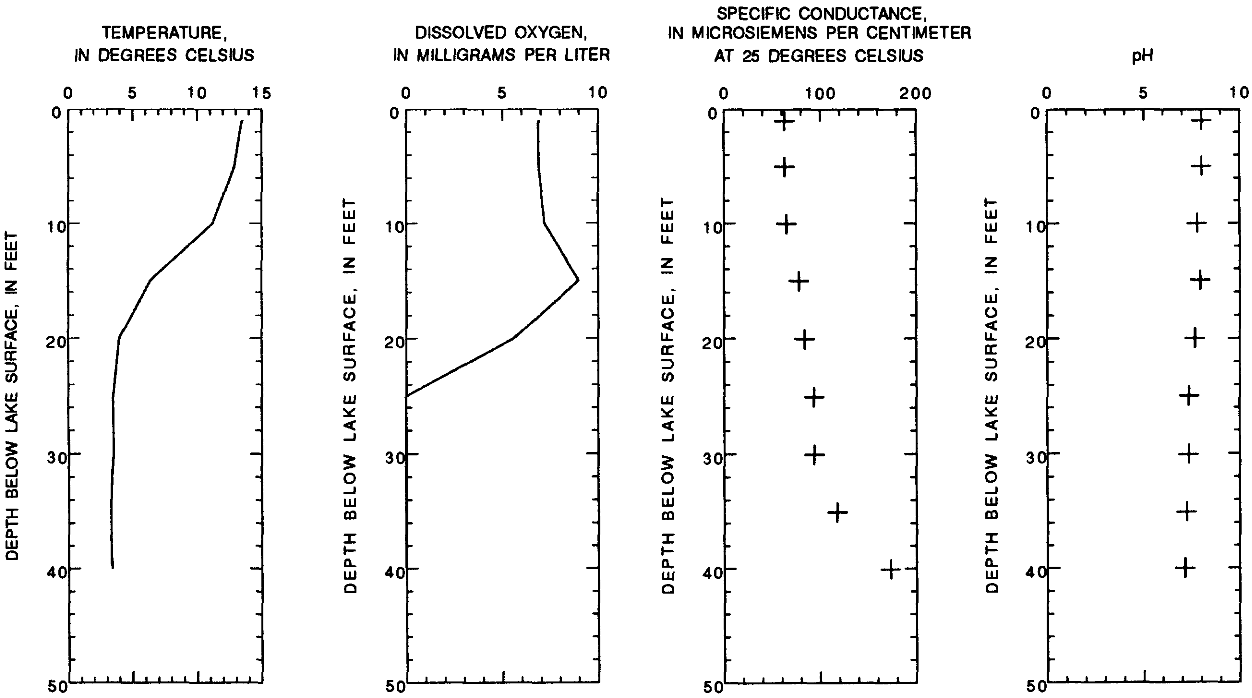


Figure 41.--Chemical composition of water from lake 3, 1985-86.

July 23, 1985



October 25, 1986

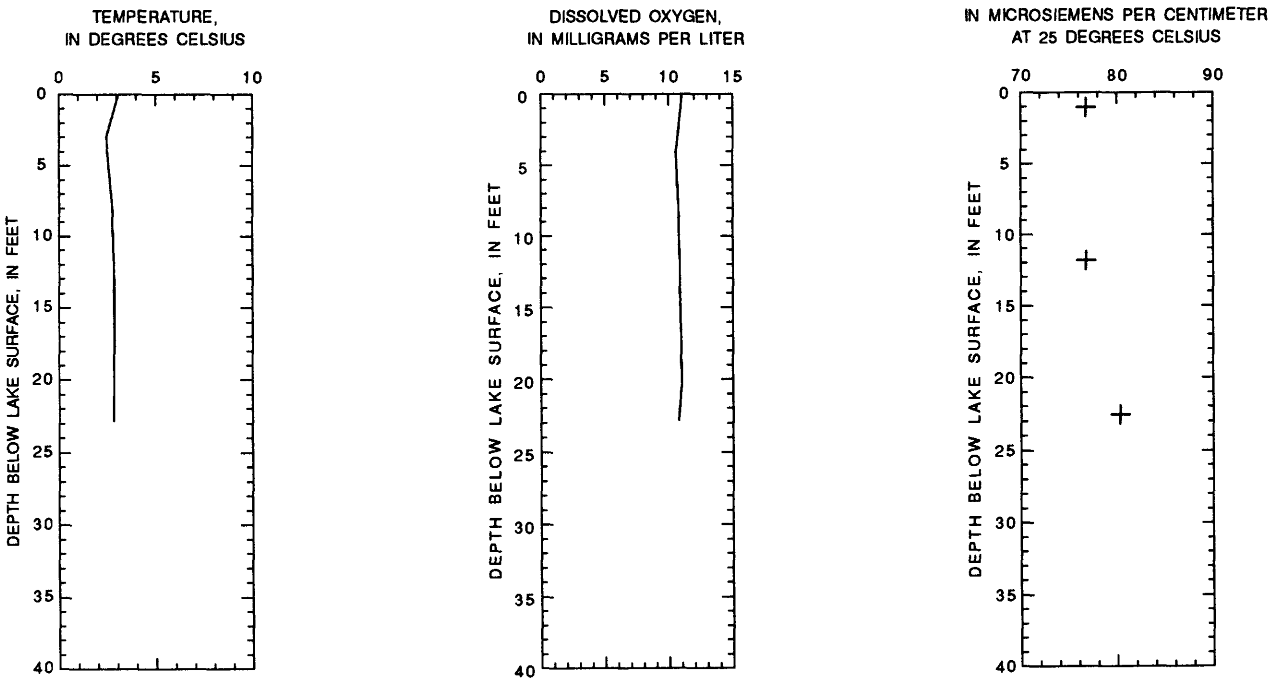
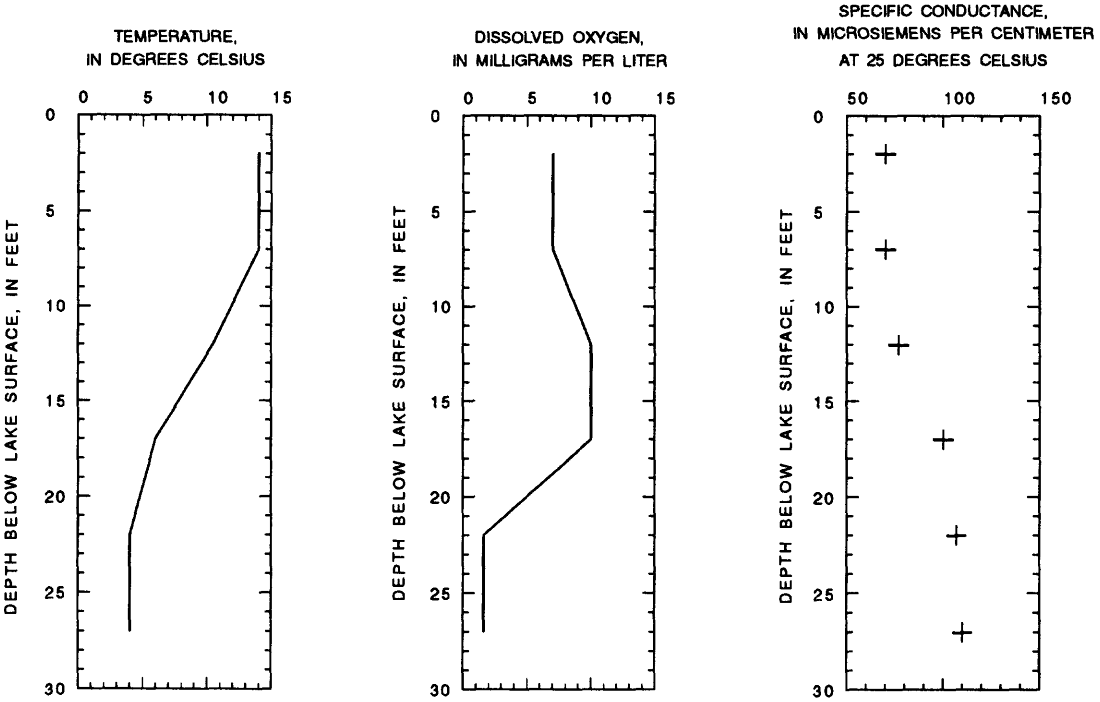


Figure 42.--Depth profile of temperature, dissolved oxygen, specific conductance, and pH of water from lake 3.

July 9, 1987



July 28, 1987

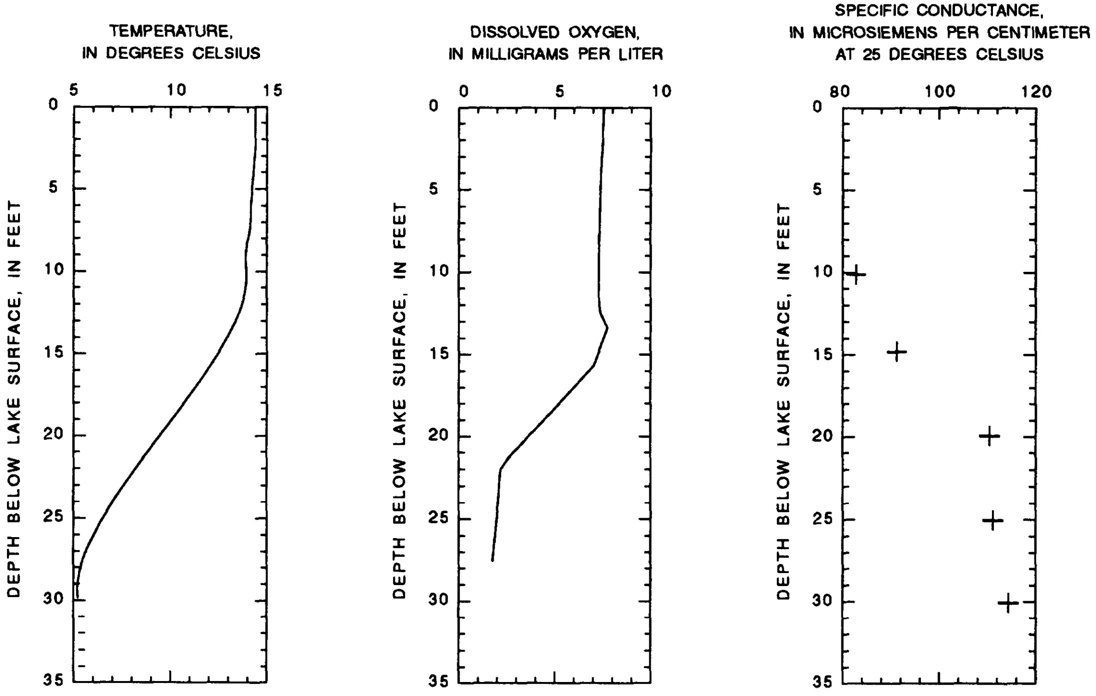
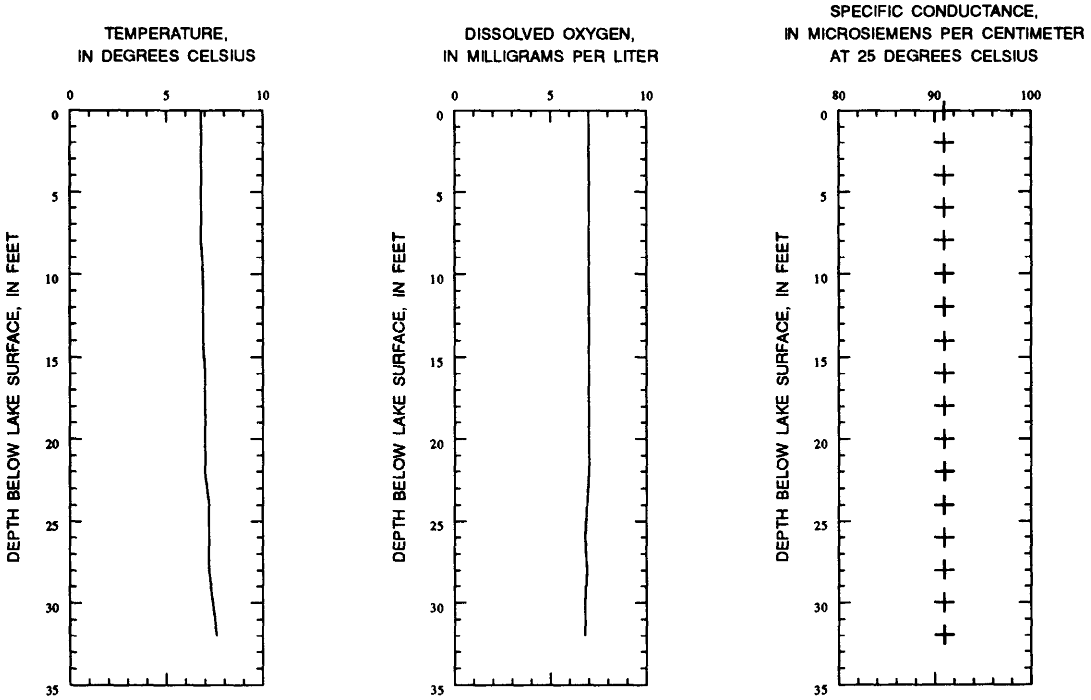


Figure 42.--Depth profile of temperature, dissolved oxygen, specific conductance, and pH of water from lake 3--Continued.

October 14, 1987



July 21, 1988

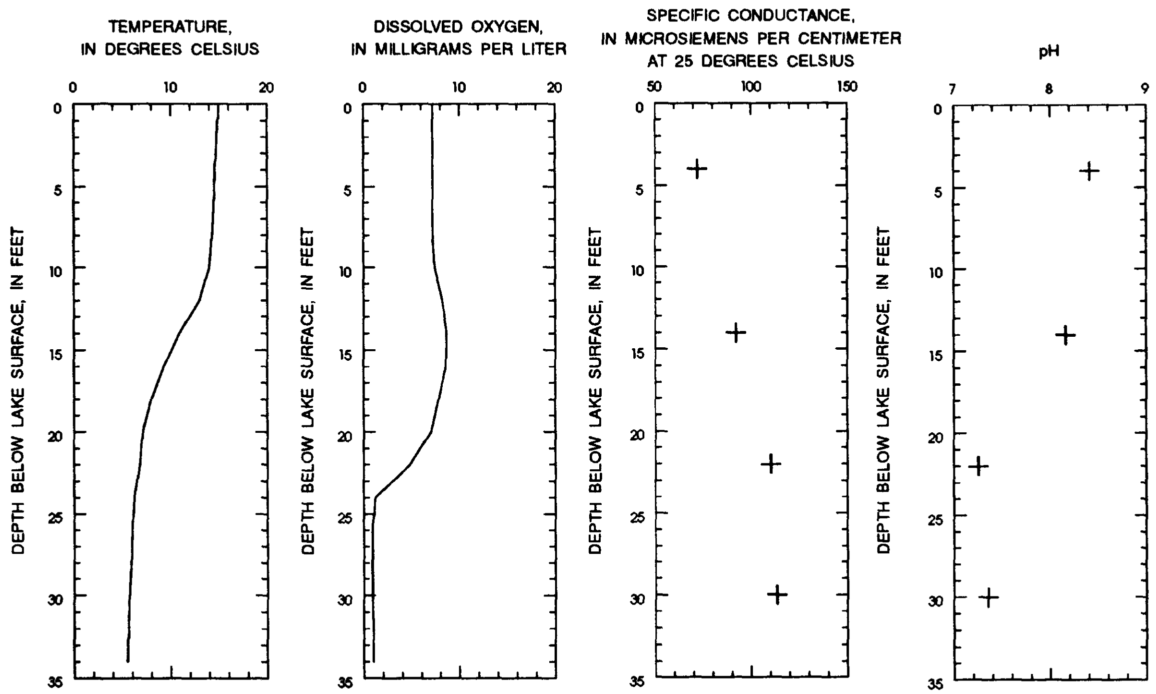
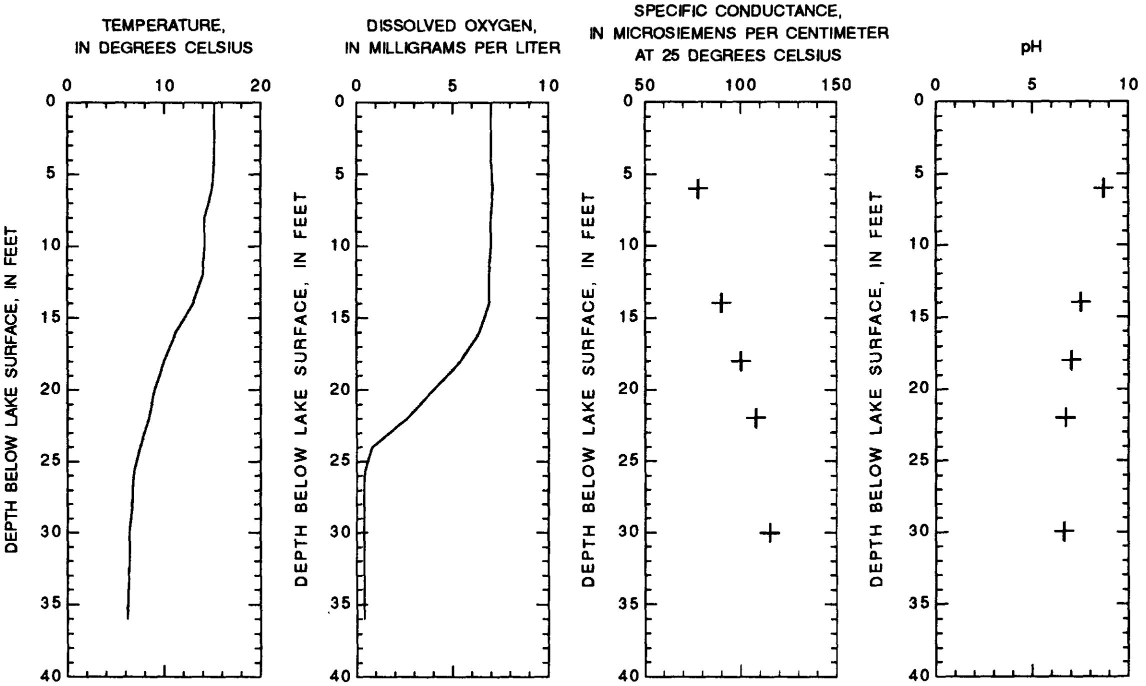


Figure 42.--Depth profile of temperature, dissolved oxygen, specific conductance, and pH of water from lake 3--Continued.

August 17, 1988



September 21, 1988

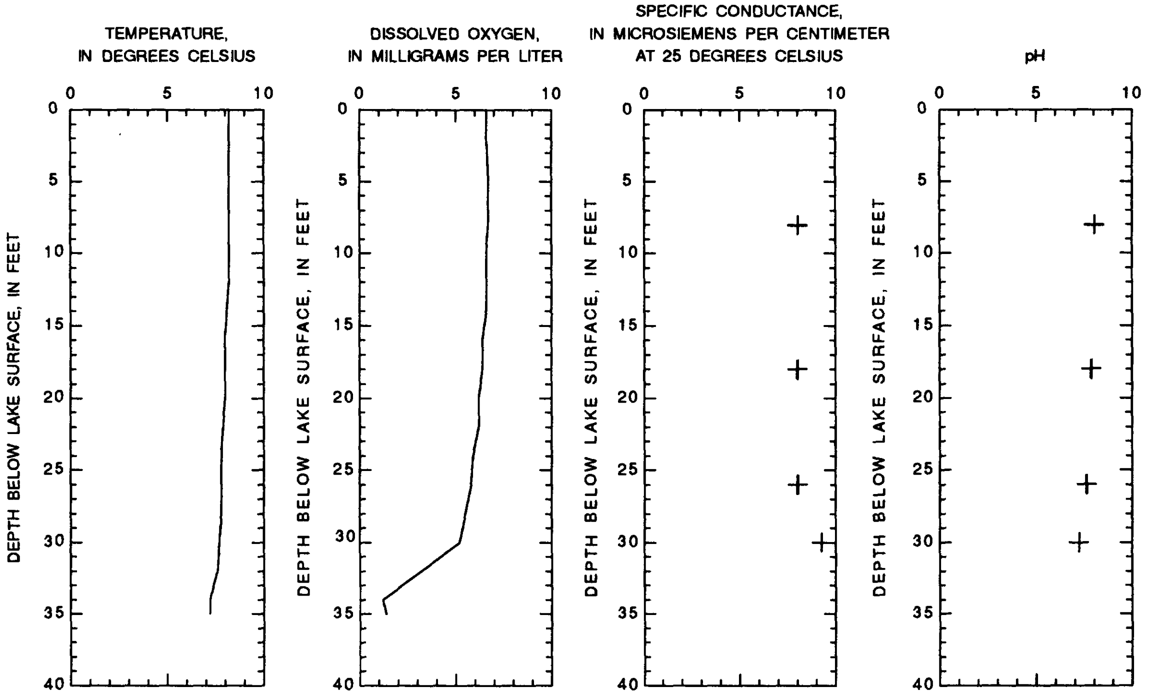


Figure 42.--Depth profile of temperature, dissolved oxygen, specific conductance, and pH of water from lake 3--Concluded.

Lake 2

At an altitude of 11,122 feet, lake 2 is just above lake 1. Lake 2 is the smallest of all the Latir Lakes, having a surface area of only 0.74 acre. It is also the shallowest lake with a maximum depth of less than 3 feet. An attempt was made to take fathometer measurements for lake depth in lake 2. However, because the lake is so shallow and the bottom is muddy, the definition of the bottom on the fathometer charts was not clear enough to construct a bathymetric map. The perimeter of the lake was surveyed, however, and the lake volume was calculated to be about 49,000 cubic feet (1.1 acre-feet) using an average depth of 1.5 feet (fig. 43; table 6). This average depth was estimated on the basis of random depth sounding measurements. Latir Creek is the only surface-water inflow to lake 2.

The chemical data set for water from the outflow of lake 2 is the most complete; thus, many observations can be made concerning the effects of snowmelt and precipitation on lake chemistry. Specific conductance of water from lake 2 is similar to that of water from lake 3 (table 7). Calcium is the dominant cation and the ions that produce alkalinity are the dominant anions. Concentrations of most dissolved constituents were largest in the early spring (April) prior to snowmelt and in the late summer and early fall (September and October) at the end of the 1987 field season (figs. 44-46). In 1988 the concentrations of dissolved constituents generally had less variation (figs. 44-46).

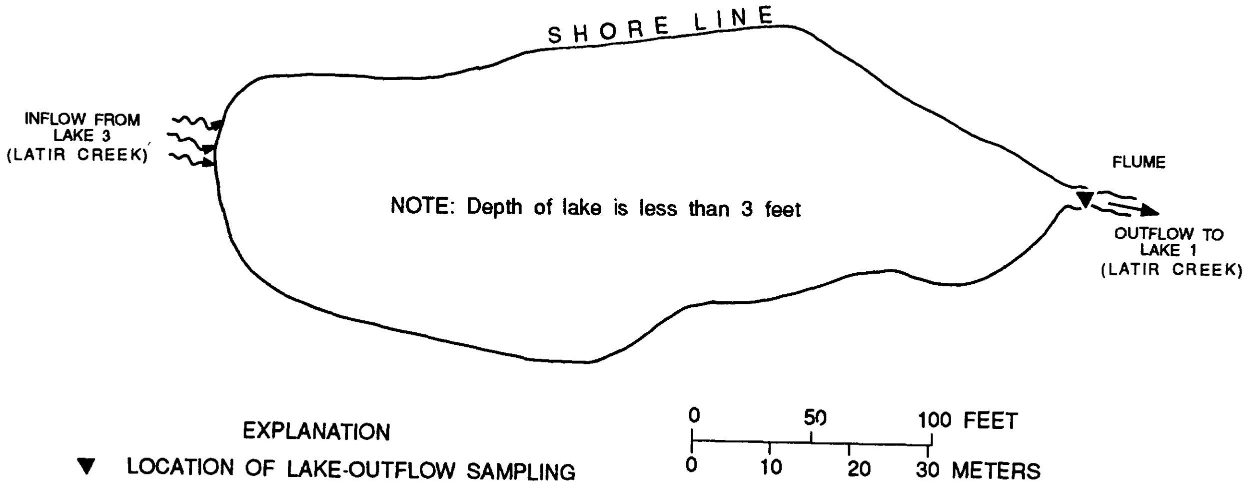


Figure 43.--Lake 2.

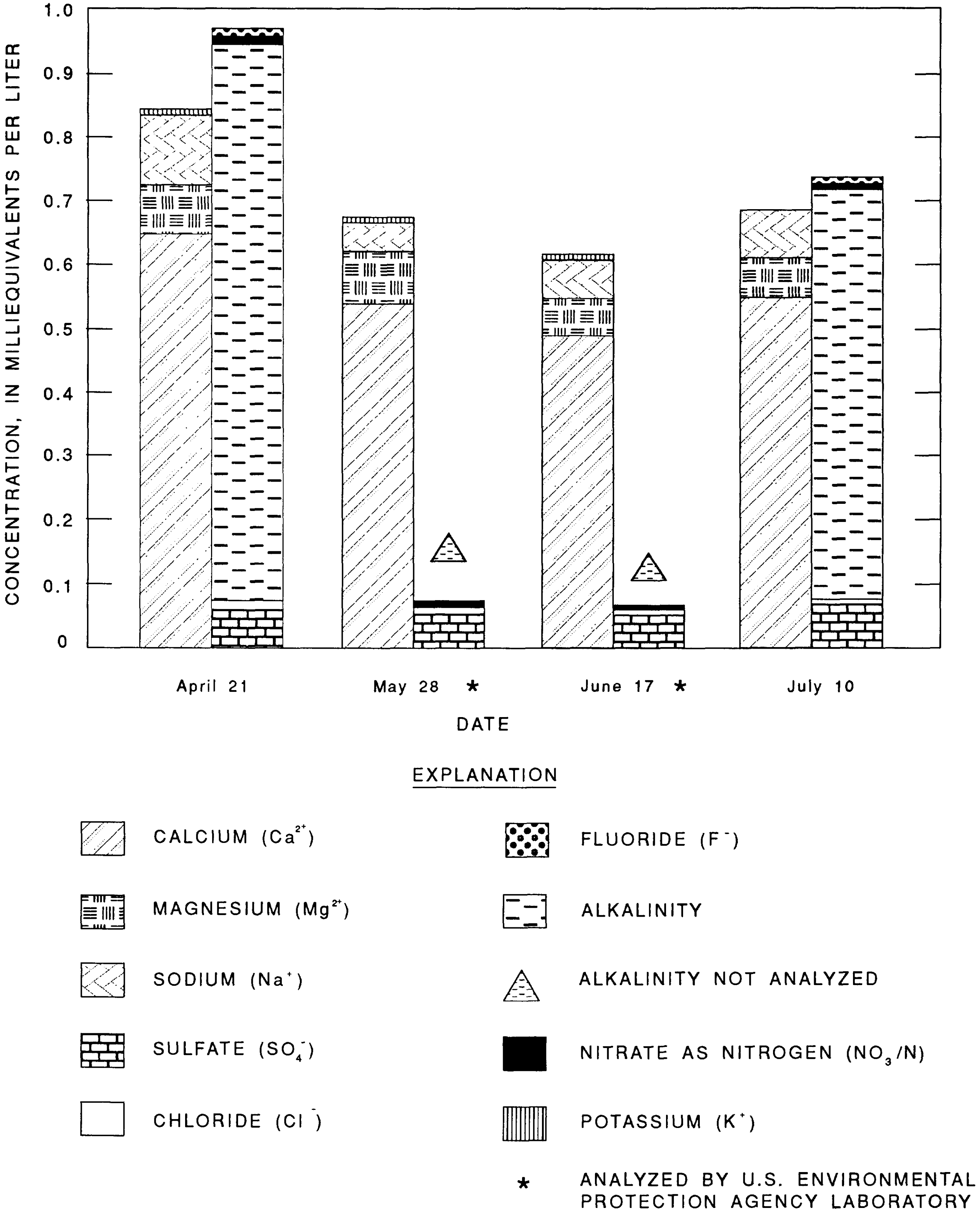


Figure 44.--Chemical composition of lake 2 outflow water, April-July 1987.

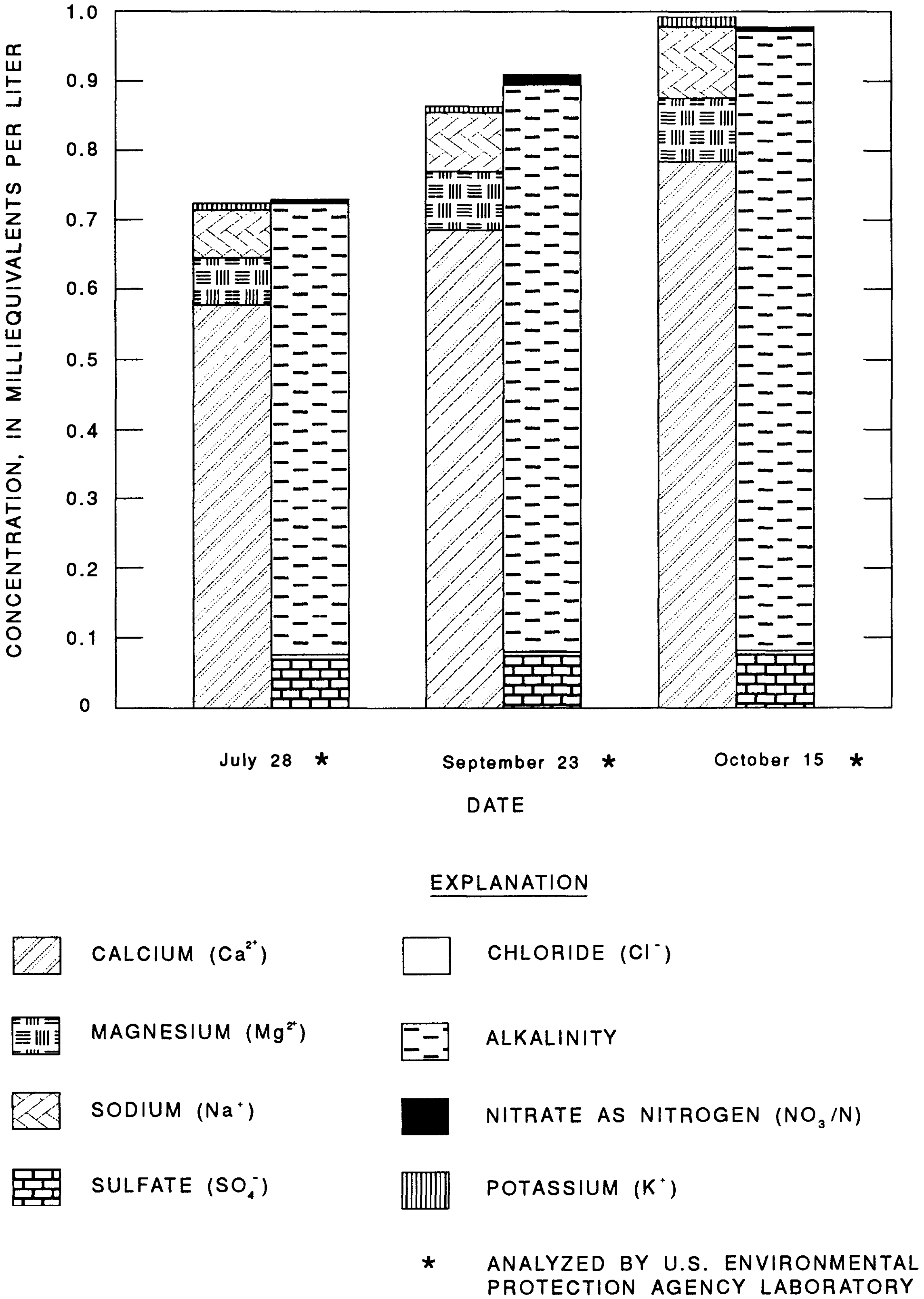


Figure 45.--Chemical composition of lake 2 outflow water, July-October 1987.

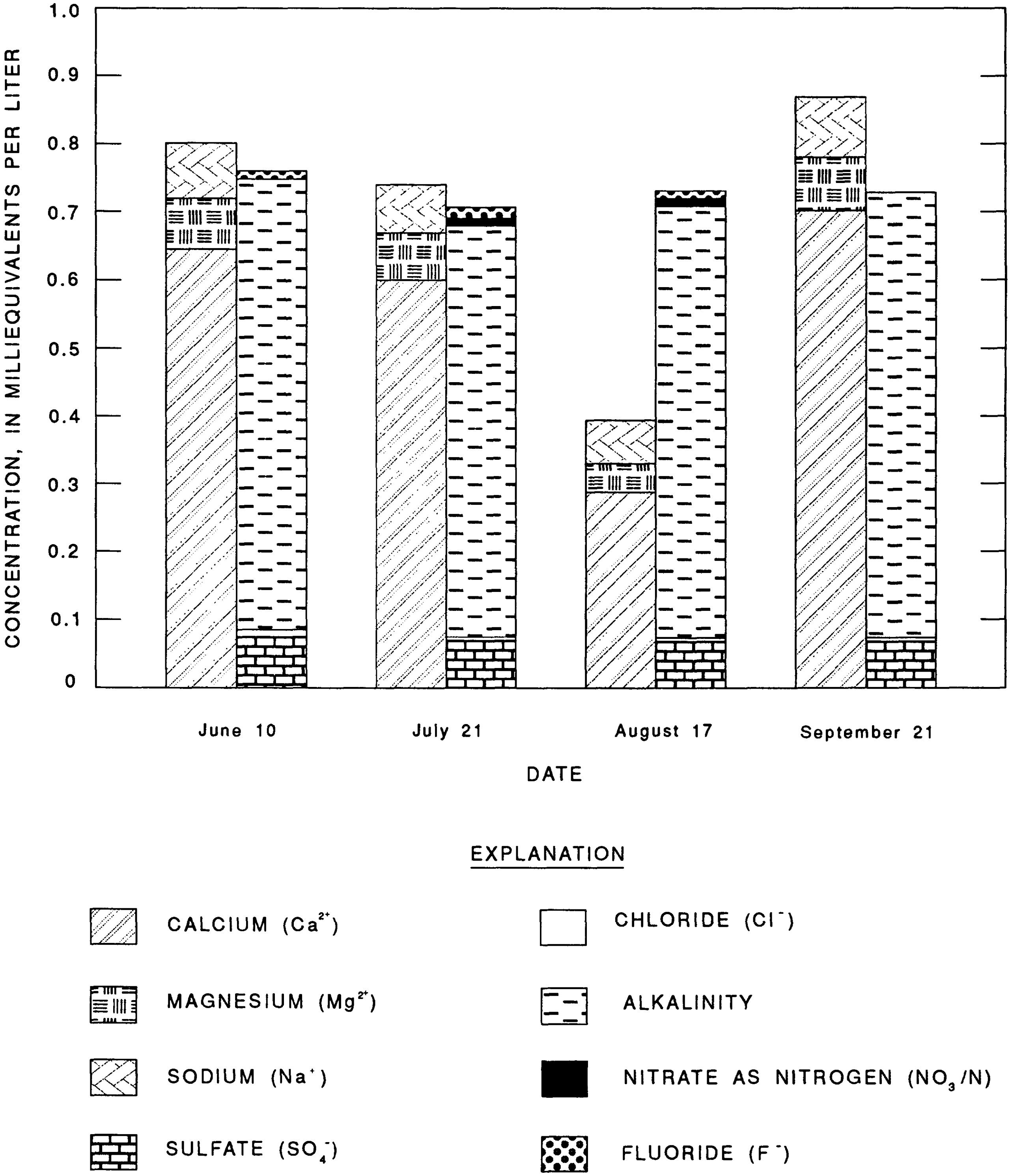
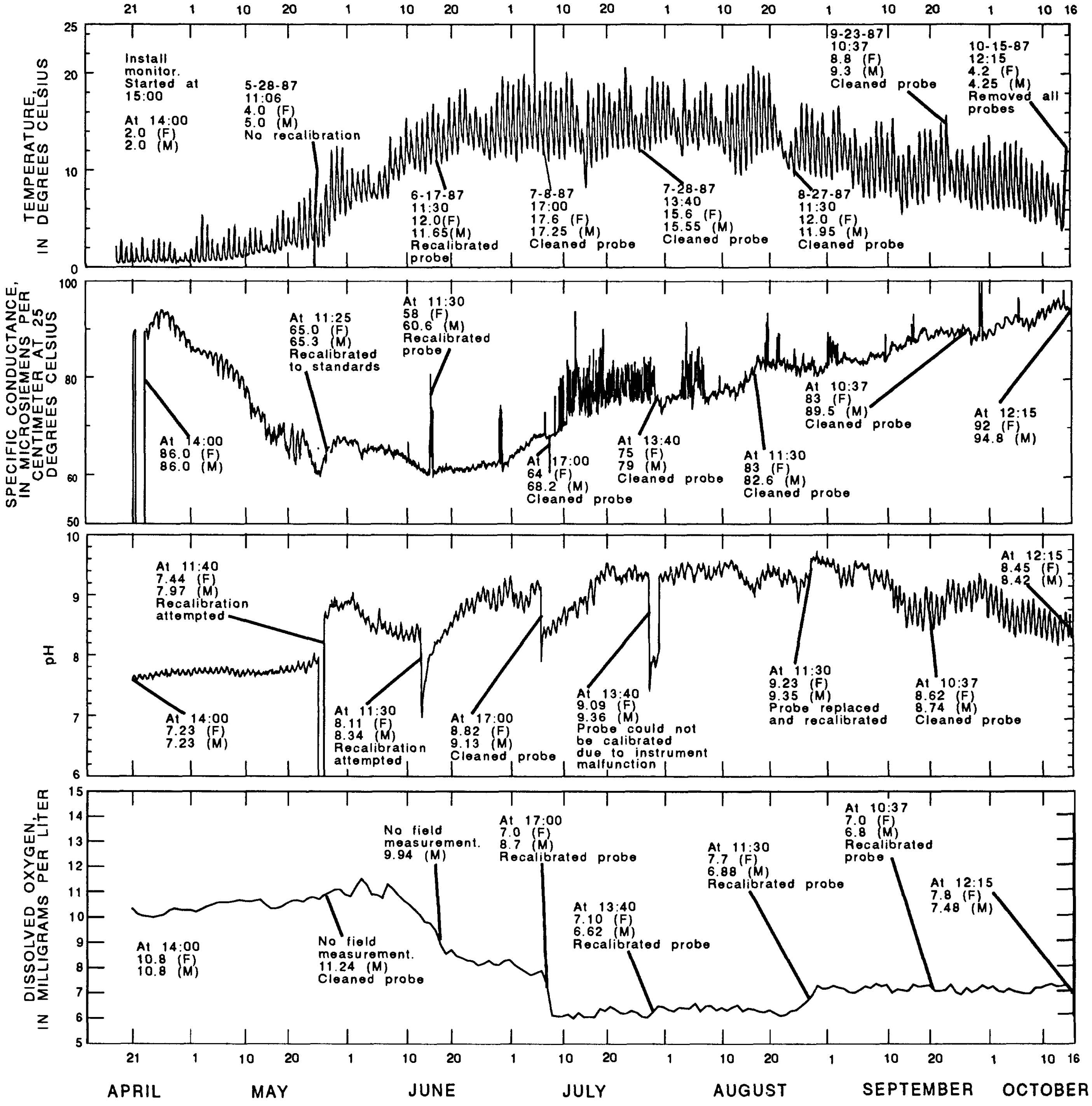


Figure 46.--Chemical composition of lake 2 outflow water, 1988.

The continuous monitoring of temperature, specific conductance, pH, and dissolved oxygen of lake 2 outflow water during 1987 and 1988 indicates daily and seasonal variation (figs. 47 and 48). The large and abrupt changes in specific conductance, pH, and dissolved oxygen are due to recalibration of the probes or, in the case of specific conductance, possible fouling of the probe. The data in figures 47 and 48 were not shifted to compensate for drift in the calibration of individual probes, because a suitable method to make the shifts could not be determined. As a result, the raw data as collected are presented along with notes from field visits when calibration of the probes was checked and if necessary the probes were recalibrated. The reader is cautioned that the true value for a given parameter may not be correct in figures 47, 48, and 49, but the relative variation with time for a particular parameter can be determined from figures 47 and 48. In 1987, the temperature of outflow water started to increase about May 15; specific conductance decreased steadily from April 27 to May 27, probably in response to snowmelt (fig. 47). Specific conductance increased from about July 1 until the monitor was removed from the lake in October (fig. 47). The pH of outflow water from lake 2 did not decrease as the result of snowmelt runoff as was seen with the specific conductance. The pH of outflow water increased approximately 2 units from late April until late August.

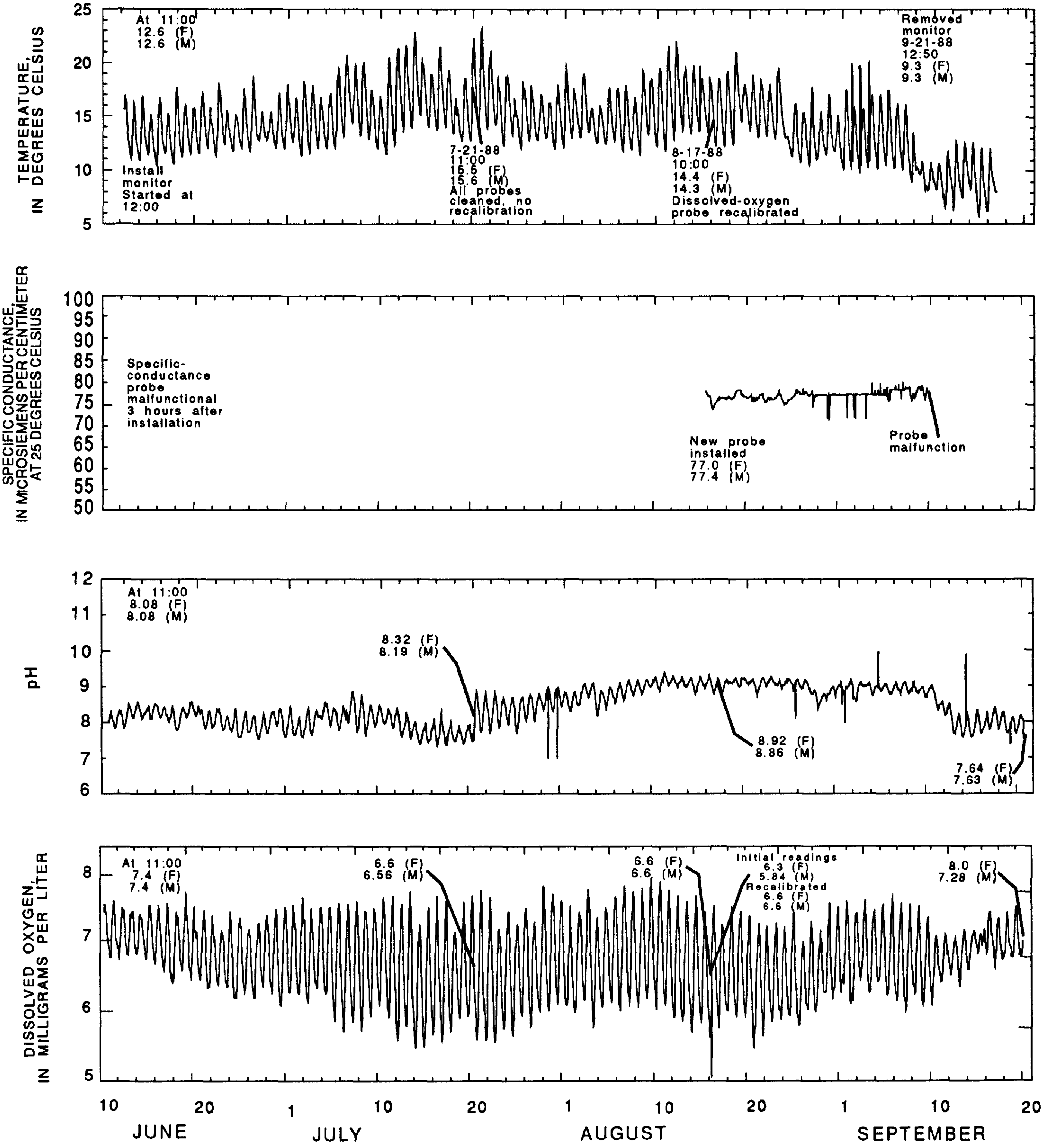
In 1988 the monitor was installed after snowmelt. The specific-conductance probe on the monitor was not working correctly during most of the field season; thus, no yearly trends in specific conductance can be seen. Daily fluctuations of all properties measured by the monitor are shown in the data (fig. 48). Temperature generally reaches a daily minimum in the early morning (6 a.m. to 8 a.m.), increases throughout the day until middle to late afternoon, then starts to decrease. Daily temperature fluctuations range from a few degrees to more than 10 degrees. Specific conductance and dissolved oxygen also vary during the day and follow the same general trend as temperature; pH, however, which also fluctuates during the day, lags several hours behind the other properties (figs. 47 and 48). Daily fluctuations in pH and dissolved oxygen probably are in part a response to biological activity in the lake.

Large volumes of precipitation appear to affect the chemistry of outflow water from lake 2 (fig. 49). A large amount of precipitation fell September 11-13, 1988 (1.13 inches on the 11th, 0.92 inch on the 12th, and 1.10 inches on the 13th at the atmospheric-deposition station). Streamflow discharge from lake 2 increased abruptly from 1.5 cubic feet per second to more than 8 cubic feet per second as a result of this large amount of precipitation. Examination of the continuous data shows that temperature, specific conductance, and pH decreased during this time (fig. 49). Temperature decreased approximately 5 degrees Celsius and pH decreased approximately 1 unit. Specific conductance of lake 2 outflow water decreased 3 to 4 microsiemens and then increased to prestorm levels twice from September 11 to September 13 (fig. 49). There also was a decrease in the daily variation of temperature, pH, and dissolved oxygen during this time, probably due to increased cloud cover. The decrease in temperature and pH observed were probably due to the large amount of precipitation during this time. Comparison of precipitation, streamflow, and monitor data indicates several incidences in which pH is affected by precipitation, although none are as obvious as that described above.



(F) indicates field measurement; (M) indicates monitor measurement.

Figure 47.--Temperature, specific conductance, pH, and dissolved oxygen in lake 2 outflow water, 1987.



(F) indicates field measurement; (M) indicates monitor measurement.

Figure 48.--Temperature, specific conductance, pH, and dissolved oxygen in lake 2 outflow water, 1988.

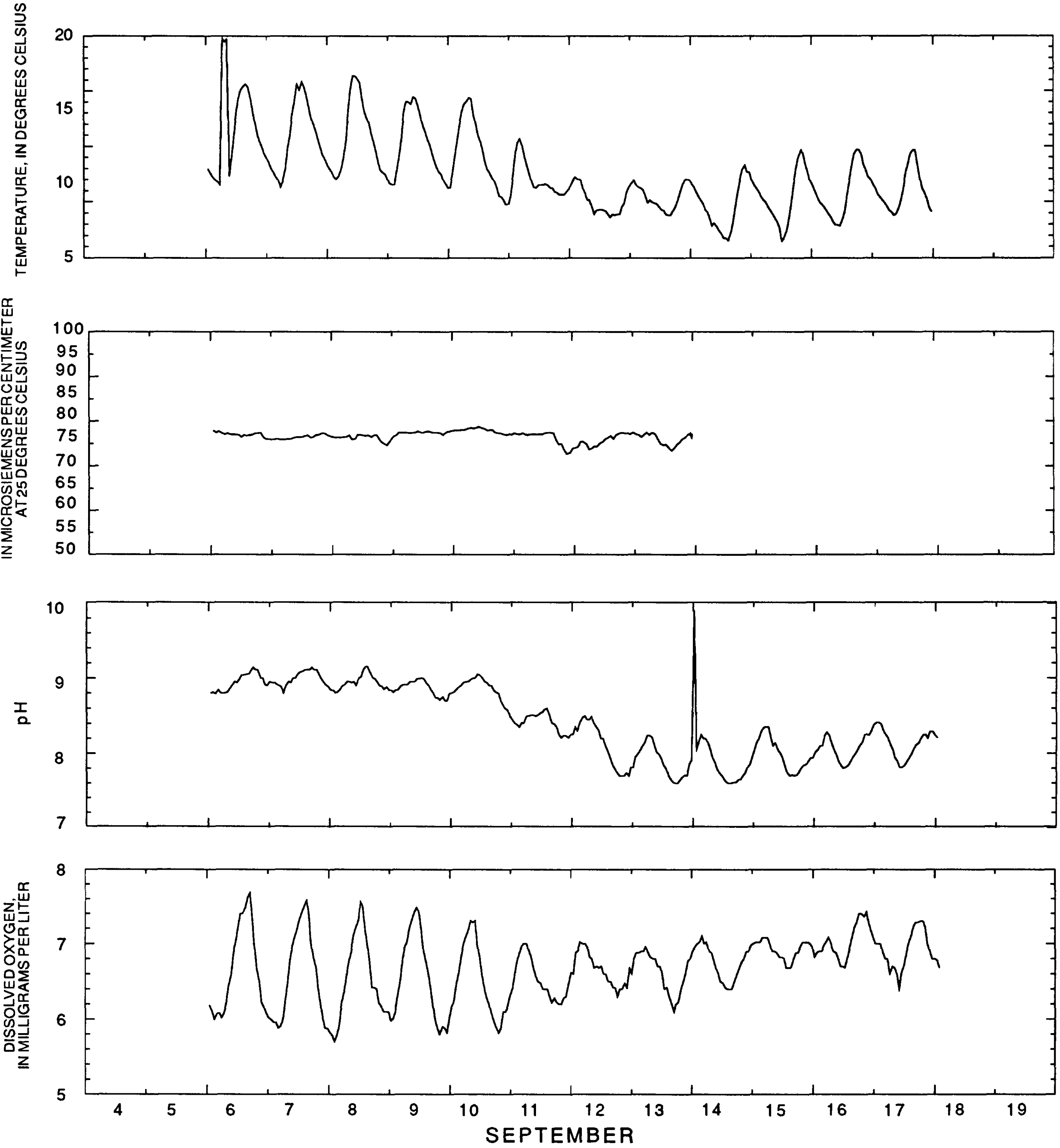


Figure 49.--Temperature, specific conductance, pH, and dissolved oxygen in lake 2 outflow water, September 6 to September 18, 1988.

Lake 1

The fifth largest of the nine Latir Lakes in area and volume, lake 1 is also the lowest in altitude at 11,061 feet. The lake is very shallow throughout, rarely exceeding 4 feet in depth and having an average depth of 2.7 feet (fig. 50; table 6). Latir Creek is the only surface-water inflow to lake 1. Specific conductance and pH of lake outflow were measured monthly from 1986 through 1988 (table 7).

Latir Lakes System

Variation of Surface-Water Flow

Discharge measurements taken in the summer of 1986 at the outflow of all of the Latir Lakes, except lakes 7 and 8, are useful in understanding the interaction of the ground-water/surface-water system. Latir Creek begins at lake 9 and flows through lakes 6, 5, 4, 3, 2, and 1. There are no other major surface-water inflows to the Latir Lakes. During snowmelt and intense summer thunderstorms, some overland flow into the lakes from adjacent areas was observed; because the soils along the margins of the lakes are relatively porous, however, much of the snowmelt and precipitation infiltrates into the soils. The increase in surface-water discharge from lake 9 downstream to lake 1 indicates that the water infiltrating into the soils (ground water) discharges into the lakes (fig. 51). Discharge from most of the lakes was larger in June than later in the summer, which probably indicates that the lakes were still responding to large inflows of snowmelt waters. By July, the discharge from lakes 5 and 4 had decreased substantially relative to the June discharges; however, the discharge from lakes 9, 6, 3, 2, and 1 had not. Discharge from the lakes in August was substantially less than discharge earlier in the summer, which probably indicates that ground-water inflows to the lakes resulting from snowmelt no longer affected the surface-water system (fig. 51). Discharges from lakes 9, 6, 5, and 4 were similar (0.4 to 1.0 cubic foot per second) in August (fig. 51). The small increase in discharge downstream from lake 9 indicates that ground-water inflow to lakes 6, 5, and 4 was not large during August; the largest ground-water inflow was between lake 6 and lake 5 outflow. The increase in discharge from lake 3 compared with that from lake 4 indicates more ground-water inflow between lake 4 outflow and lake 3 outflow than between lake 9 and lakes 6, 5, and 4. The decrease in discharge between lake 3 and lakes 2 and 1 indicates that water from Latir Creek downstream from lake 3 or water from lakes 2 and 1 seeps into the ground.

Discharge from lake 2 has a similar pattern to discharge from lake 9, although discharge from lake 2 is approximately six times larger than that from lake 9 (figs. 52-54). Draining of snowmelt from lake 2 can be seen in the discharge records for 1987 (fig. 53). Large increases in discharge from lakes 9 and 2 after snowmelt probably are in response to precipitation. For example, a large increase in discharge from lakes 9 and 2 can be seen on September 11-13, 1988 (fig. 54). Approximately 3.1 inches of precipitation was measured at the atmospheric-deposition station for a 3-day period starting on September 11. The increase in discharge from the lakes probably is in response to this large volume of precipitation. Comparison of the recession of discharge from lake 2 in response to this precipitation with the recession of discharge from lake 2 in response to snowmelt in the spring of 1987 shows that discharge decreases much more quickly in response to precipitation than to snowmelt.

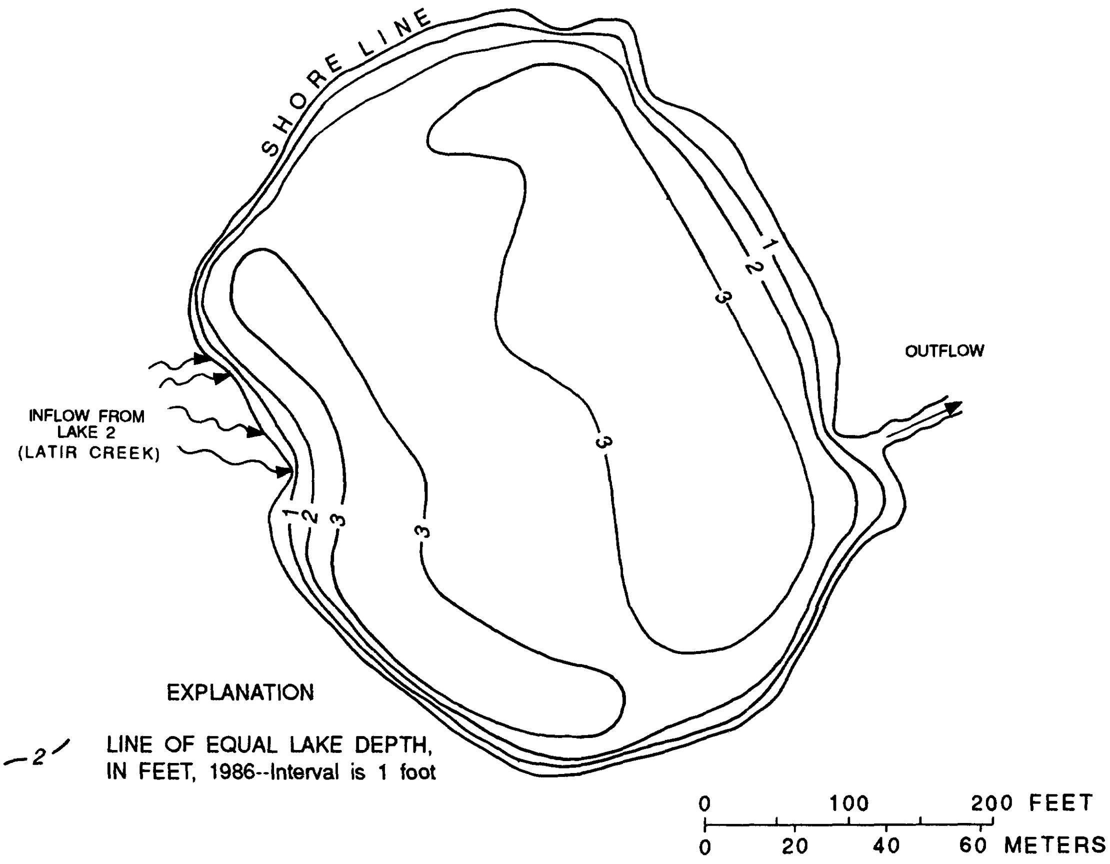


Figure 50.--Bathymetric map of lake 1.

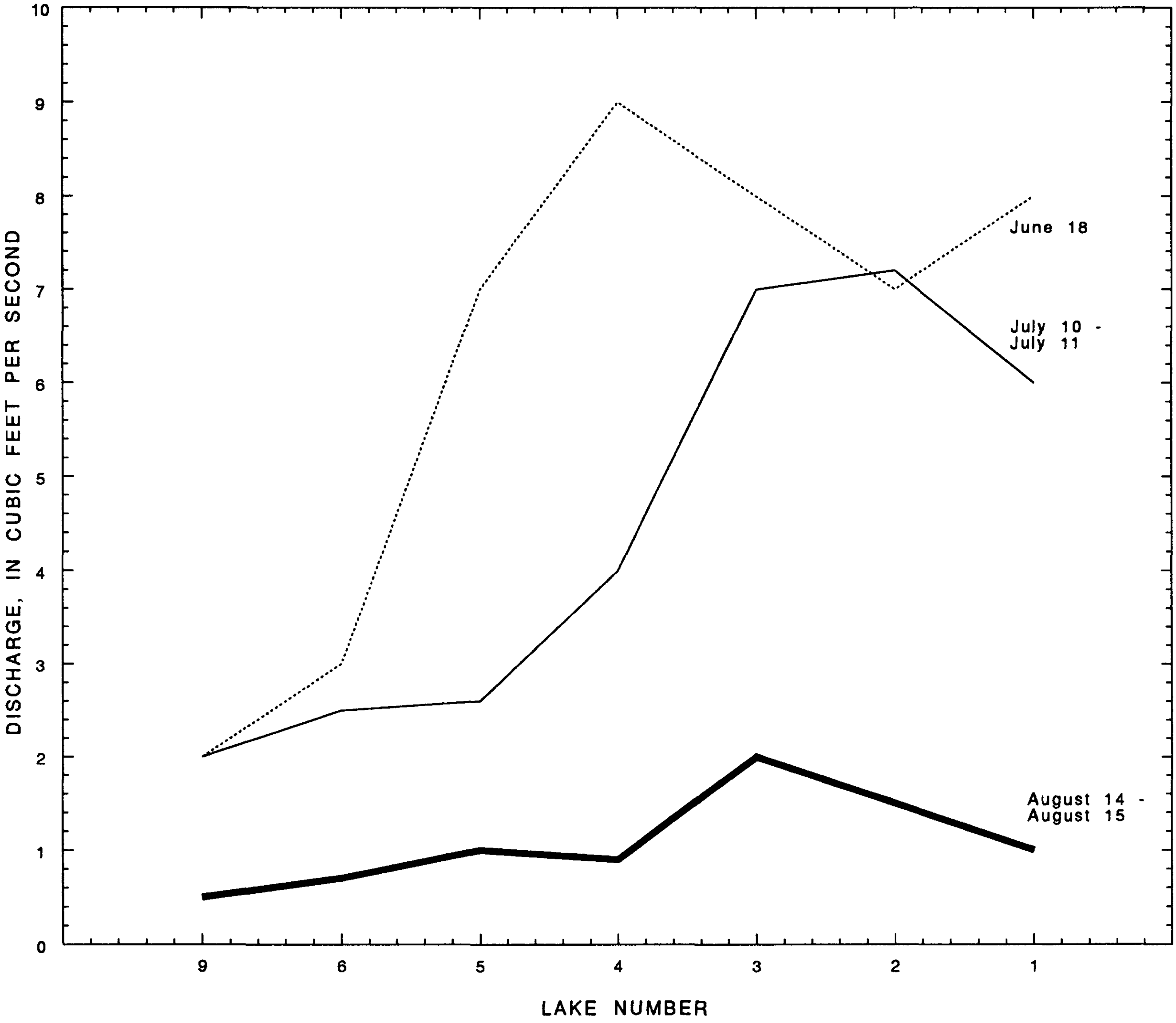


Figure 51.--Variation in discharge from the Latir Lakes, 1986.

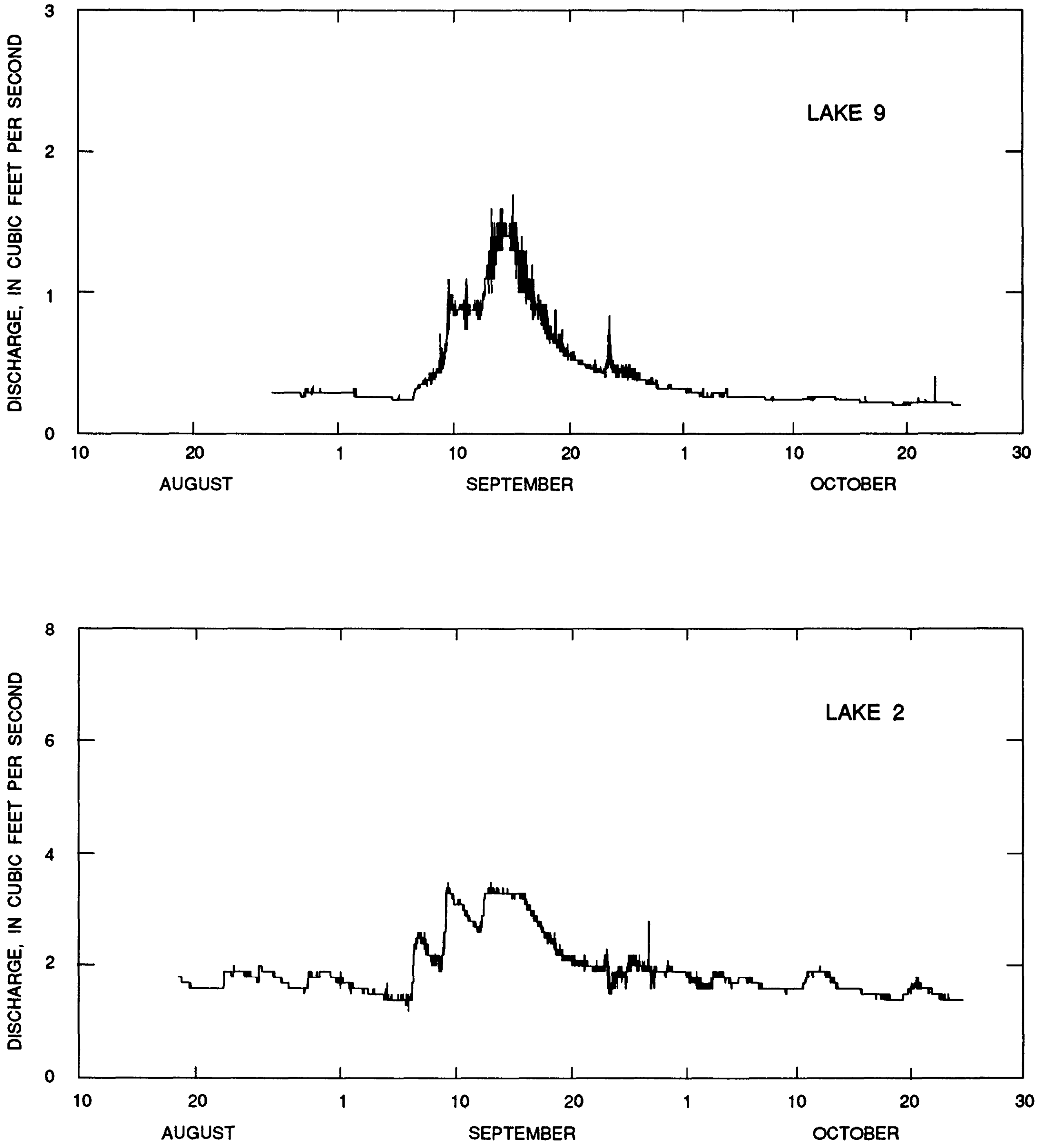


Figure 52.--Discharge from lake 9 and lake 2, 1986.

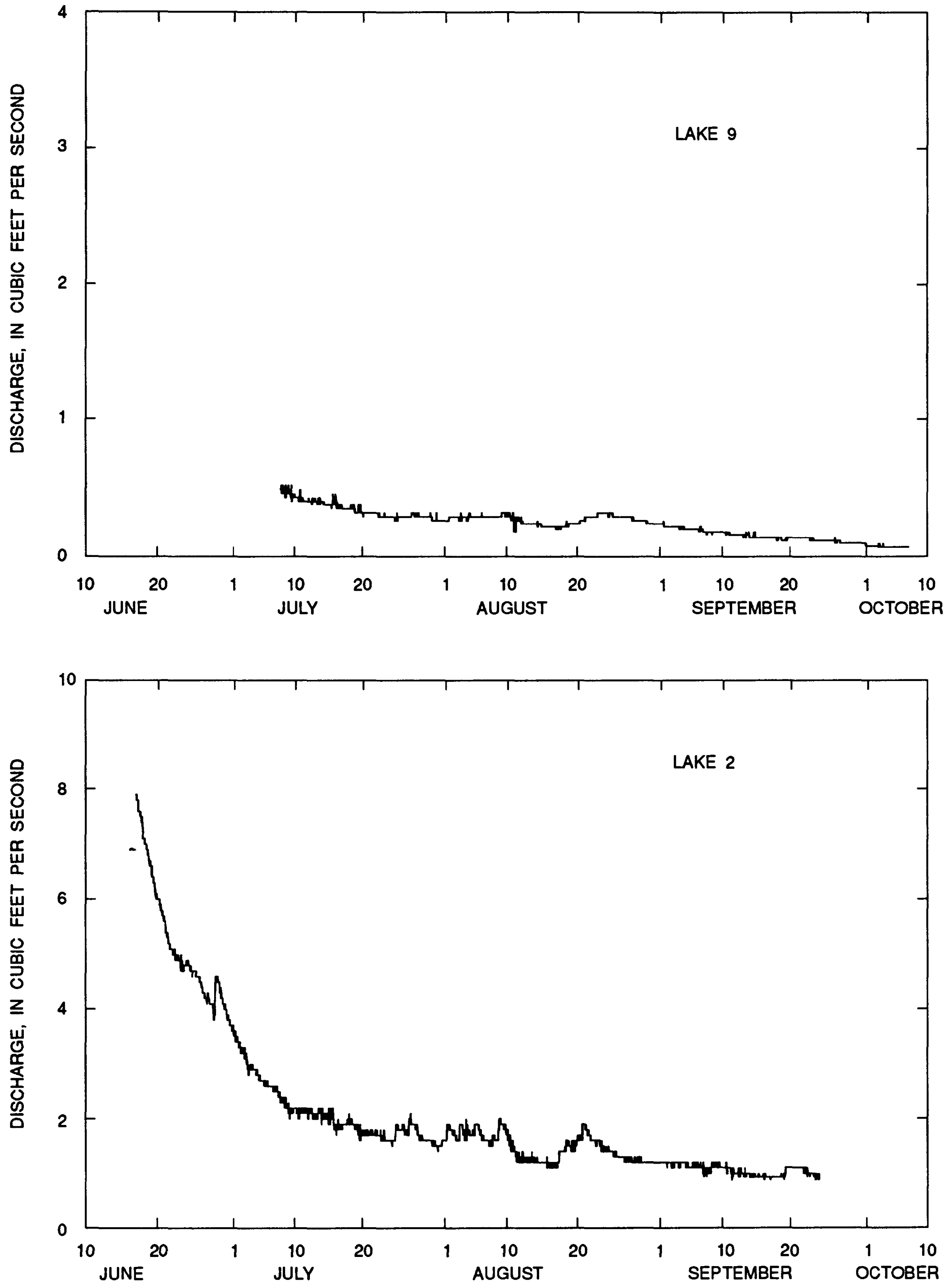


Figure 53.--Discharge from lake 9 and lake 2, 1987.

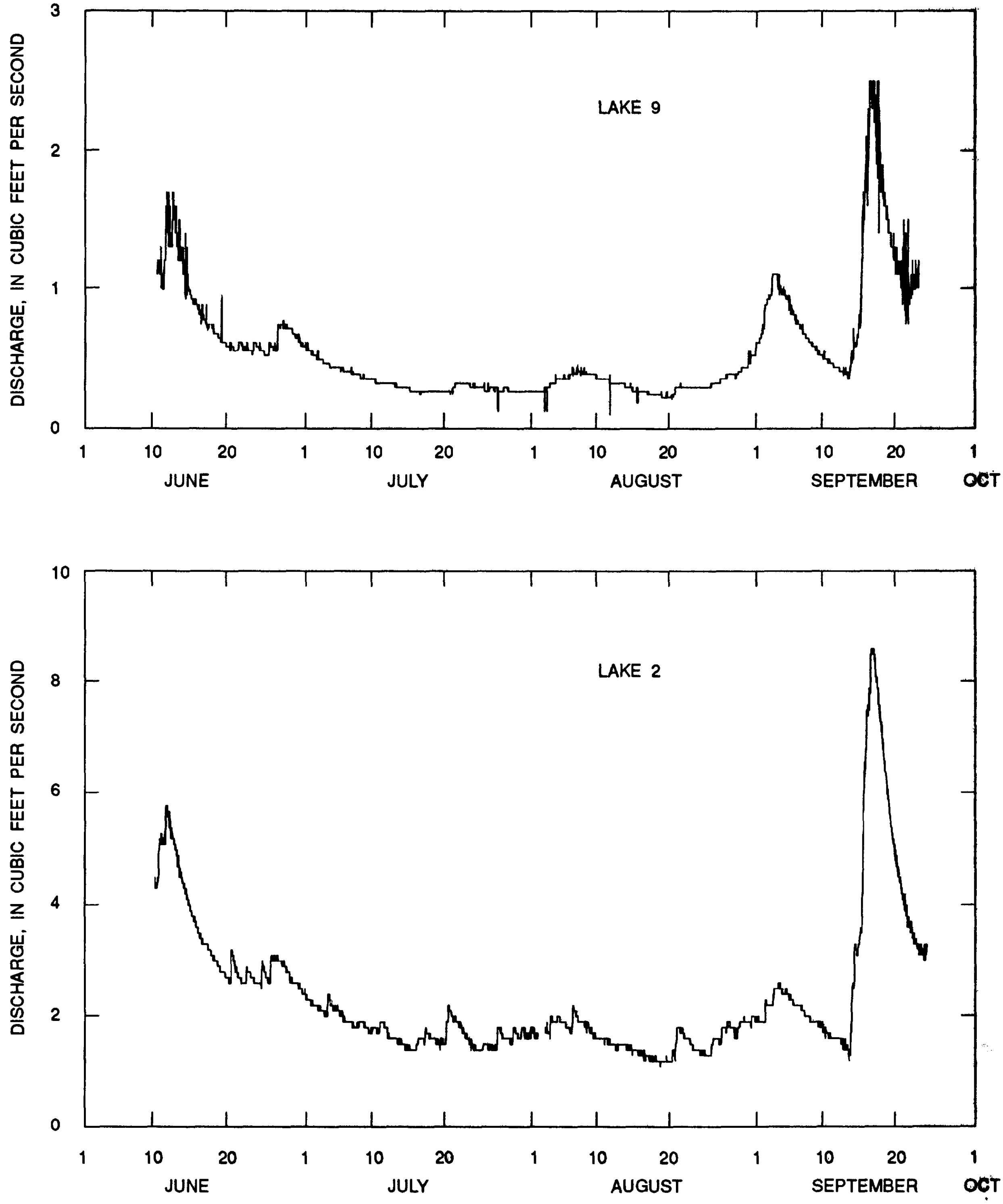


Figure 54.--Discharge from lake 9 and lake 2, 1988.

Variation of Water Chemistry

Specific conductance varied between lakes and with time. Specific conductance of outflow water from lake 9 generally is the smallest, increasing downstream from lake 9 (table 7 and fig. 55). Specific conductance of outflow water from the Latir Lakes generally increases during the summer (June, July, and August) and the largest increases generally are in lakes 1-6. In 1986, specific conductance of outflow water from lakes 9, 4, 3, 2, and 1 decreased from September to October, and in 1988 specific conductance of outflow water from lakes 8, 6, 5, and 4 decreased from August to September (fig. 55). These decreases probably are the result of dilution of lake water by precipitation; large amounts of precipitation fell during these times. Why the lakes do not respond the same is unknown, but is probably due in part to the residence time of water in each lake, the volume of water in each lake, and the composition or type of inflow to each lake (ground-water inflow versus surface-water inflow).

The pH of outflow water from the Latir Lakes also varies from lake to lake and from year to year (fig. 56). In 1986 the differences of pH in the Latir Lakes were less than 1 unit in mid-June, but were greater than 2.5 units by late October. The pH increased from mid-June to October in all the lakes; however, the largest increases occurred from July to August in 1986 (fig. 56). The pH of lake 2 outflow water generally increased from April through August in 1987 (fig. 56). There was no significant variation in pH of outflow water from the Latir Lakes in 1987 from July to October. In 1988, the pH of outflow water from all but lakes 9, 5, and 4 increased from June through August, then decreased (fig. 56). The pH of outflow water from lake 9 decreased from June through September 1988. The pH of water from all the Latir Lakes generally was less in 1988 than in 1987 (fig. 56). In general, pH of outflow water from lake 6 was the smallest and pH of outflow water from lakes 3 and 1 was the largest (fig. 56).

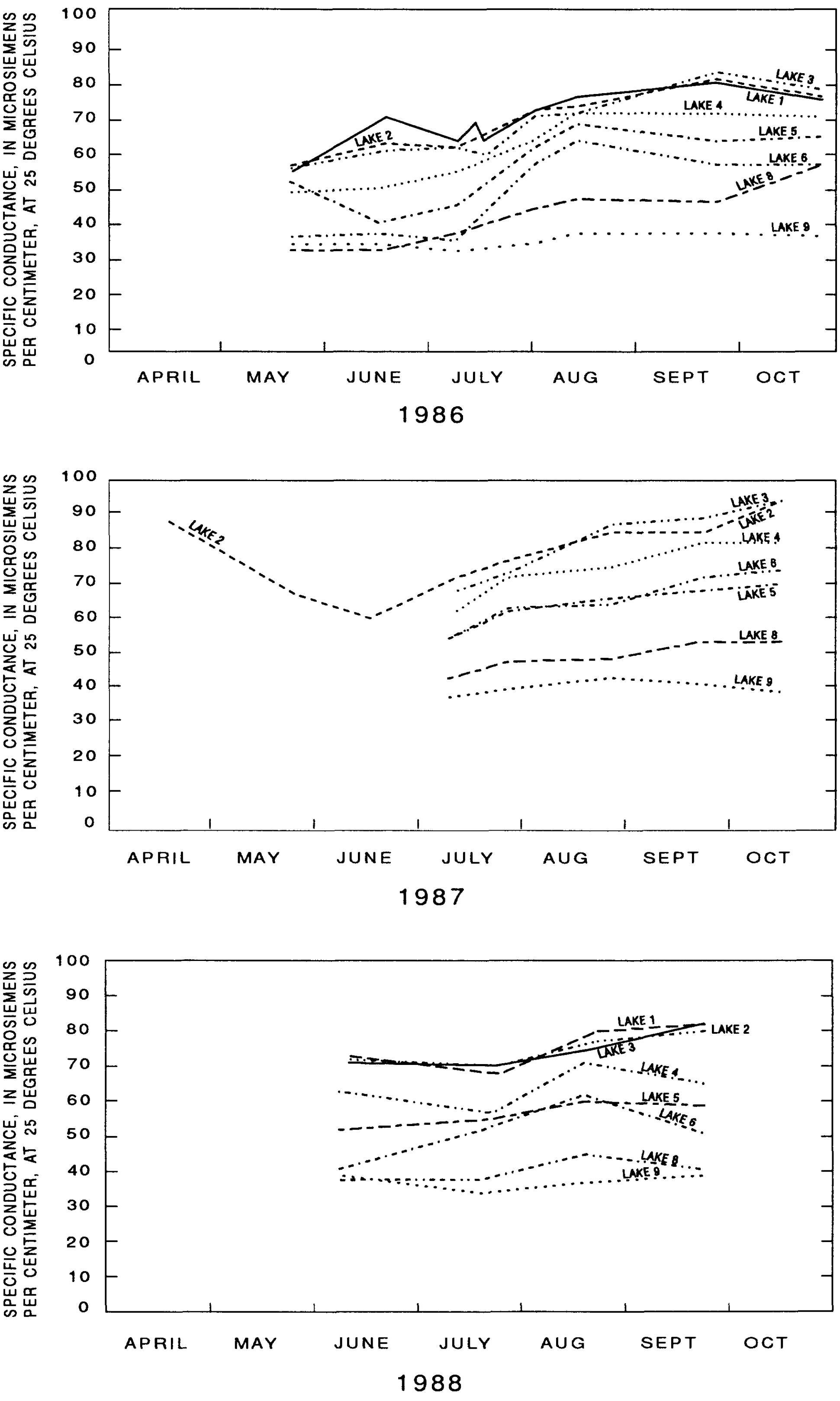


Figure 55.--Variation of specific conductance in outflow water from the Latir Lakes, 1986-1988.

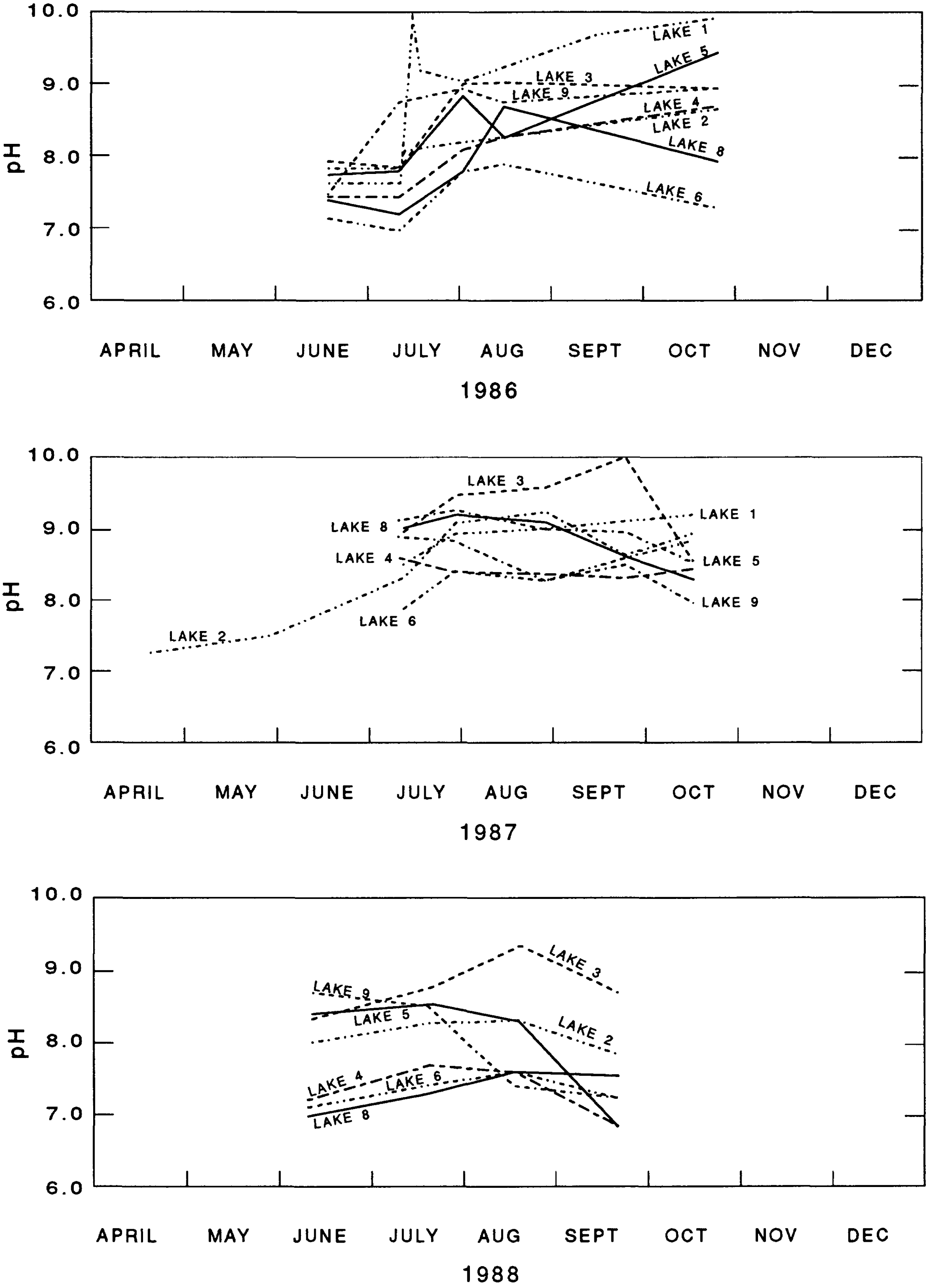


Figure 56.--Variation of pH in outflow water from the Latie Lakes, 1986-1988.

Variation of Nutrient Concentrations

Prior to study of the Latir Lakes, the lakes were assumed to be oligotrophic (unproductive) because in areas where there has been little modification of the watersheds by human activities, alpine lakes generally are oligotrophic. Oligotrophic lakes have small levels and supplies of nutrients, thus low densities and yields of biota such as phytoplankton, zooplankton, and weeds (Goldman and Horne, 1983, p. 352). Dissolved-oxygen concentrations in oligotrophic lakes generally do not vary with depth in the lake and are near saturation. Eutrophic (productive) lakes have large levels and supplies of nutrients, thus high densities of biota, and dissolved-oxygen concentrations vary considerably with depth (Goldman and Horne, 1983, p. 352). Depletion of dissolved oxygen observed in the deeper parts of lakes 9, 5, and 3 was not initially expected in the Latir Lakes. In the late summer, rooted plants in lake 3 were observed to cover much of the bottom where water depth was less than 10 feet. Algae blooms in the lakes observed during the summer indicate that these lakes are quite productive. The Latir Lakes can be classified as eutrophic on the basis of the above observations.

Depletion of dissolved oxygen in water from the deeper parts of lakes 9, 5, and 3 during the summer months probably is due to biological oxidation of organic matter and respiration of organisms. Oxidation of organic matter occurs in the water and at the sediment/water interface at the bottom of the lake. The source of the organic matter is in the upper zones of the lake where biological activity is most intense. Wetzel (1983, p. 161) noted that, in general, oxygen in water above the thermocline diffuses slowly to the lower depths of lakes where dissolved-oxygen concentrations are small. Many organisms cannot live in water containing small dissolved-oxygen concentrations; thus, large volumes of water in lake 9 and lake 3 probably are not suitable for habitation by many organisms during the summer months when dissolved-oxygen concentrations are depleted in the lower parts of the lakes.

The productivity of a lake can be controlled by the supply of nutrients (nitrogen and phosphorus) to the lake. Dissolved-nitrate concentrations in precipitation and snowmelt generally are much larger than those in lake outflow water (tables 3, 5, and 8). The dissolved-nitrate concentrations in lake 2 outflow water generally were larger than those in outflow water from the other Latir Lakes at similar times during the year (table 8). Concentrations of dissolved ammonia plus organic nitrogen in three samples (October 24, 1986, lake 9; October 24, 1986, lake 5; April 21, 1987, lake 2) generally were substantially larger than concentrations of dissolved ammonia or dissolved nitrate.

The nutrient data collected for lake 2 outflow water are the most complete and probably indicate trends similar to those that would be observed in the other Latir Lakes. During 1987, dissolved-nitrate concentrations in lake 2 outflow water were largest in April, decreased until late July, and then generally increased through September (table 8). No samples were collected from October 1987 until June 1988. In June 1988, the dissolved-nitrate concentration was less than 0.01 milligram per liter as nitrogen. Wetzel (1983, p. 243-245) stated that in eutrophic lakes (rich in nutrients, with rich organic production) dissolved-nitrate concentrations generally reach a maximum concentration in late winter to early summer and a minimum in the fall. Dissolved-nitrate concentrations decrease during the summer as the result of increased rates of nitrate assimilation by plankton and nitrate reduction by bacteria (Wetzel, 1983, p. 243). Dissolved-nitrate concentrations can decrease extremely rapidly in productive lakes due to the above processes (Wetzel, 1983, p. 243). During the winter months, decreases in biological activity are due to colder water temperatures and a reduction in the amount of light penetrating the lake water as the result of ice and snow cover on the lake surface. This decrease in biological activity results in increases in dissolved-nitrate concentrations. The decrease in dissolved-nitrate concentrations in lake 2 outflow water during the spring and early summer of 1987 probably is the result of increased assimilation of nitrate by phytoplankton and the increase in nitrate reduction by bacteria. No water-chemistry data were collected from the Latir Lakes from November to June with the exception of two samples from lake 2; however, the April to October variation in nitrate concentrations seen in lake 2 outflow water probably is representative of the variations in dissolved-nitrate concentrations in the other Latir Lakes. There has been little modification of the Latir Lakes watersheds by human activity and therefore the principal input of nitrogen to the Latir Lakes occurs during precipitation and snowmelt. The nitrogen probably is assimilated by plankton during the summer and therefore large nitrogen concentrations are not observed in the lakes during the summer. Increases in nitrate concentrations in precipitation and dry fall could result in increases in the productivity of lakes (Wetzel, 1983, p. 223-224).

The productivity of the Latir Lakes appears to be controlled by the amount of dissolved nitrogen in the lake waters. Nutrients are usually taken up by a particular species in proportions approximately equal to the proportions in the body tissues. Plants and algae require a nitrogen-phosphorus ratio of 7:1 by weight (Goldman and Horne, 1983, p. 132). Dissolved-nitrogen to dissolved-phosphorus ratios in the Latir Lakes outflow were generally less than 7:1, indicating that the productivity of these lakes generally is limited by nitrogen. Samples collected from lake 2 outflow in April and May 1987 had some of the largest dissolved-nitrogen concentrations and at this time of the year the lakes seem to be phosphorus limited.

Evolution of Water Chemistry

The evolution of water chemistry in the Latir Lakes system can be examined by comparing water chemistry from different lakes. Water from lake 9, which is the headwaters for the surface-water system, moves downstream through lake 5 and then to lake 2. The discharge data show an increase in discharge from lake 9 to lake 2, indicating ground-water and surface-water discharge into the lakes downstream from lake 9 in addition to the flow of Latir Creek. Changes in water chemistry from lake 9 to lake 5 and from lake 5 to lake 2 can be used to identify (1) processes that occur during the evolution of water chemistry as the water moves downstream in Latir Creek and through the lakes; or (2) differences in the chemistry of ground water and surface water that discharge into the different lakes.

Silica concentrations in outflow water from the Latir Lakes range from 3.93 to 6.80 milligrams per liter (table 8). These silica concentrations are relatively large considering the dilute nature of the water in the Latir Lakes and indicate weathering of silicate minerals during the evolution of lake waters.

The chemical composition of water in the Latir Lakes is the result of precipitation that falls in the watershed, infiltrates the soil, and reacts with minerals in the soil. The soil water then moves downward and laterally through the rock and soil, discharging into the lake through the lake bed. The water continuously reacts with the rock and soil. The reactions that occur while the water moves through the soil and into the lakes affect the chemistry of water in the lakes.

Biological activity in the lakes and streams also affects the chemical composition of water, especially nitrogen and phosphorus concentrations as discussed previously.

Outflow water samples from lakes 9, 5, and 2 collected in June 1988 were used as representative samples in the analysis of the evolution of water chemistry in the Latir Lakes system (table 9). Precipitation is an important source of solutes found in water in the Latir Lakes; therefore, the amount of solutes in lake water due to precipitation needs to be accounted for prior to estimating the amount of solutes in lake water due to weathering reactions. The average concentration of dissolved solutes in snowmelt was used in this analysis instead of wet precipitation because snowmelt represents bulk precipitation (wet fall plus dry fall). Evapotranspiration of precipitation would result in the concentration of solutes in precipitation; therefore, the solute concentration due to evapotranspiration was calculated assuming that chloride is conservative and no sources of chloride are in the soil zone. For example, the chloride concentration in snowmelt was 0.1 milligram per liter and in lake 9 water was 0.2 milligram per liter, indicating that evapotranspiration resulted in a twofold increase in the concentration of chloride. Therefore, all solutes in precipitation at lake 9 were assumed to increase twofold as a result of evapotranspiration concentration. This evapotranspiration-concentration factor was calculated to be 2 in lake 9, 2.5 in lake 5, and 2.3 in lake 2, indicating that the solute concentration due to evapotranspiration is relatively constant from lake 2 upstream. The average concentration of solutes in snowmelt was then multiplied by these factors and subtracted from the concentration of solutes in each particular lake (table 9). This difference or residual represents the amount of a particular solute in lake water that results from weathering reactions in the soil or biologically mediated reactions in the soil or lake. This difference will hereafter be referred to as "lake X residual."

No major surface water inflows to lake 9, indicating that ground water, overland flow of precipitation, and precipitation on the lake surface are the major inputs of water to the lake. Subtraction of the average snowmelt water chemistry multiplied by the evapotranspiration-concentration factor from lake 9 outflow water chemistry indicates that dissolved calcium, magnesium, sodium, bicarbonate, and silica increase and sulfate decreases slightly in lake 9 outflow water compared to snowmelt (table 9). The increases in calcium, magnesium, sodium, bicarbonate, and silica could result from weathering of minerals in the soil zone. Possible weathering reactions that might result in the increases in these constituents would be the weathering of silicate minerals to clay minerals (Garrels and MacKenzie, 1971, p. 154-163). The silicate minerals andesine, oligoclase, and quartz are common in rocks in the Latir Lakes watershed (McKinlay, 1956). Weathering of andesine and weathering of oligoclase probably are two important reactions that influence water chemistry in the Latir Lakes watershed. More sodium than calcium would be expected to be released as dissolved species during the weathering of these minerals; however, calcium increases are about the same as sodium increases in the calculated lake 9 residual. Possible reasons for more sodium not being released include (1) silicate minerals containing calcium are more reactive than the sodium-rich silicate minerals; or (2) the weathering products of andesine and oligoclase contain the sodium, and little sodium is released to the aqueous phase during the weathering reactions.

The lake 5 and lake 2 residuals show calcium, bicarbonate, and silica to increase substantially and magnesium and sodium to increase slightly as the result of weathering reactions. The relatively large increases in calcium, bicarbonate, and silica indicate that weathering reactions releasing these ions are more common in the soil downstream from lake 9 than in the lake 9 watershed.

The chemistry of water in Latir Creek changes downstream from lake 9 to lake 2 (table 9). Streamflow increases fourfold between lake 9 and lake 2 in early June 1988, indicating substantial ground-water inflow (fig. 54). Calcium, sulfate, and bicarbonate concentrations increase the most in lake 2 outflow compared with lake 9 outflow (table 9). The increase in calcium and bicarbonate could be due to the weathering of silica minerals or the dissolution of calcite. Dissolved-silica concentrations do not increase significantly from lake 9 to lake 5 or lake 2, indicating that if the dissolution of silicates occurs, the silica is precipitated as quartz or amorphous silica. The reason for the increase in sulfate in lake 2 is not known.

Carbon-13 samples were collected from Latir Lakes 9, 8, and 3 in 1985. The carbon-13 composition of lake 9 water was -8.80 per mil, in lake 8 water was -3.20 per mil, and in lake 3 water was -3.40 per mil (table 8). Carbon-13 data were examined to determine whether they support the interpretation of silicate weathering as a major mechanism in the geochemistry of Latir Lakes. If silicate weathering reactions are controlling water chemistry in the lakes and the carbon-13 composition of soil gas is between -15 and -25 per mil, the carbon-13 composition of lake waters should be between -15 and -25 per mil. If calcite dissolution is the major reaction controlling the water chemistry in the lakes and the carbon-13 composition of the calcite is 0 per mil, the carbon-13 composition of lake water should be between -7.5 and -12.5 per mil. Because the carbon-13 composition of lake water is heavier than would result from silicate weathering and calcite dissolution, other processes are affecting lake-water chemistry. Biologically mediated reactions or isotopic exchange and fractionation are processes that could be occurring, in addition to the above reactions that could affect the carbon-13 composition of the lake waters.

On the basis of the measured chemical and isotopic composition of lake water, the evolution of water in the Latir Lakes is influenced by reactions other than, or in addition to, the silicate weathering or calcite dissolution. Additional data are needed to discern which weathering and biologically mediated reactions are controlling the evolution of water chemistry in the Latir Lakes.

SUMMARY

This report describes the chemistry of atmospheric deposition and water of the Latir Lakes in Taos County, New Mexico. The data presented were collected from 1985 through 1988. The pH of wet precipitation generally ranged from 4.6 to 5.5 and the specific conductance of wet precipitation ranged from 1 to 18 microsiemens.

Snowpack-chemistry data indicate a change in specific conductance, pH, and alkalinity of the snowpack from month to month. The dominant cation in the snowpack is calcium and the dominant anions are nitrate and sulfate. The samples having the smallest values of specific conductance generally did not have measurable alkalinity. When the snowpack starts to melt in spring, specific conductance of the entire snowpack decreases, consistent with the hypothesis that the initial fluid draining from the snowpack transports a large amount of dissolved material out of the snowpack. This hypothesis is consistent with snowmelt-chemistry data. The chemistry of the first snowmelt sample had a specific conductance of 34.2 microsiemens, a pH of 7.17, and an alkalinity of 11.57 milligrams per liter as calcium carbonate. The relatively large pH and alkalinity in this sample could indicate that initial snowmelt dissolved a large amount of carbonate dust, which neutralized acids in the snowpack.

Discharge of lake 2 outflow is approximately six times as large as discharge of lake 9 outflow. Discharge from all the lakes is largest during the spring in response to snowmelt. Discharge from the lakes also increases in response to large volumes of precipitation.

Water chemistries in the Latir Lakes are similar in composition although specific conductance increases downstream from lake 9 to lake 1. Calcium is the dominant cation and the ions that produce alkalinity are the dominant anions. Concentrations of sodium, magnesium, chloride, and sulfate do not vary significantly from year to year or during the year in a particular lake. Alkalinity and calcium concentration, however, vary from year to year and during the year. The pH in outflow water from the Latir Lakes varies from lake to lake and from year to year. In 1986, the differences in pH in the Latir Lakes ranged from less than 1 in mid-June to greater than 2.5 by late October. The pH generally was larger than 7.0 in all of the lakes and was as large as 9.9 in several of the lakes during the period of study. The pH of outflow water generally increases from early spring to late summer in the Latir Lakes. Snowmelt does not appear to cause decreases of pH in the lakes, although a large amount of precipitation in September 1988 did result in a decrease in pH of 1 unit in the outflow of lake 2. Daily variations of dissolved oxygen and pH were observed in the outflow from lake 2 and probably are due to the intense biological activity in the lake.

Depth profiles of selected lakes show that dissolved-oxygen concentration approaches zero below the thermocline. This suggests that biological oxidation of organic matter is occurring in the lower zones in these lakes. Because few organisms can live in water containing small dissolved-oxygen concentrations, large volumes of water in lakes 9 and 3 probably are not suitable for habitation during the summer months.

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Table 1.--Precipitation at the atmospheric-deposition station in the Latir Lakes study area

[Station began operation December 5, 1986. * indicates values were calculated from weight of precipitation collected in deposition collector, and are totals for the days enclosed in brackets. Because site visits generally were during midday, values for the beginning day and ending day within a bracket represent precipitation for a partial day. All values are in inches of water. --, no data]

						1986						
Date	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
01	--	--	--	--	--	--	--	--	--	--	--	--
02	--	--	--	--	--	--	--	--	--	--	--	--
03	--	--	--	--	--	--	--	--	--	--	--	--
04	--	--	--	--	--	--	--	--	--	--	--	--
05	--	--	--	--	--	--	--	--	--	--	--	0.00
06	--	--	--	--	--	--	--	--	--	--	--	.25
07	--	--	--	--	--	--	--	--	--	--	--	.00
08	--	--	--	--	--	--	--	--	--	--	--	.06
09	--	--	--	--	--	--	--	--	--	--	--	.40
10	--	--	--	--	--	--	--	--	--	--	--	.00
11	--	--	--	--	--	--	--	--	--	--	--	.00
12	--	--	--	--	--	--	--	--	--	--	--	.00
13	--	--	--	--	--	--	--	--	--	--	--	.00
14	--	--	--	--	--	--	--	--	--	--	--	.00
15	--	--	--	--	--	--	--	--	--	--	--	.00
16	--	--	--	--	--	--	--	--	--	--	--	.00
17	--	--	--	--	--	--	--	--	--	--	--	.08
18	--	--	--	--	--	--	--	--	--	--	--	.06
19	--	--	--	--	--	--	--	--	--	--	--	.00
20	--	--	--	--	--	--	--	--	--	--	--	.00
21	--	--	--	--	--	--	--	--	--	--	--	.00
22	--	--	--	--	--	--	--	--	--	--	--	.00
23	--	--	--	--	--	--	--	--	--	--	--	.00
24	--	--	--	--	--	--	--	--	--	--	--	.00
25	--	--	--	--	--	--	--	--	--	--	--	.00
26	--	--	--	--	--	--	--	--	--	--	--	.00
27	--	--	--	--	--	--	--	--	--	--	--	.00
28	--	--	--	--	--	--	--	--	--	--	--	.00
29	--		--	--	--	--	--	--	--	--	--	.00
30	--		--	--	--	--	--	--	--	--	--	.00
31	--		--		--		--	--		--		.00
Total	--	--	--	--	--	--	--	--	--	--	--	0.85

Table 1.--Precipitation at the atmospheric-deposition station in the Latir Lakes study area--Continued

						1987						
Date	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
02	.0	.0	.00	.06	.25	.0	.0	.0	.0	.0		
03	.0	.0	.0	.0	.65	.0	.0	.31	.0	.0	0.47*	
04	.0	.0	.00	.15	.20	.11	.0	.22	.04	.0		
05	.3	.07	.00	.40	.0	.27	.0	.0	.0	.0		0.0*
06	.0	.0	.00	.03	.03	.03	.0	.02	.0			
07	.7	.0	.0	.0	.0	.59	.0	.04	.0			
08	.05	.0	.17	.0	.0	.05	.0	.03	.07		.83*	
09	.04	.0	.04	.0	.0	.10	.0	.0	.0	.0*		
10	.0	.0	.01	.0	.17	.0	.0	.0	.07			
11	.0	.0	.22	.0	.07	.0	.0	.12	.0			
12	.0	.26	.0	.90	.17	.0	.0	.43	.43			.10*
13	.0	.05	.0	.05	.03	.0	.0	.0	.13			
14	.08	.79	.0	.0	.0	.0	.0	.0	.0			
15	.33	.04	.32	.0	.04	.0	.02	.0	.0	.33*		
16	.16	.12	.21	.0	.03	.0	.0	.0				
17	.14	.08	.22	.0	.05	.0	.08		.06*			
18	.0	.35	.0	.0	.0	.0	.0				.4*	
19	.16	.11	.10	.0	.05	.0	.0					
20	.0	.10	.10	.0	.18	.0	.0					
21	.0	.0	.40	.0		.0	.0		.0			
22	.0	.0	.22	.0		.0	.02	1.45*	.0			.49*
23	.0	.07	.02	.0		.03	.23		.0	.18*		
24	.0	.08	.0	.0		.0	.0		.02			
25	.0	.18	.33	.0	.76*	.0	.0		.06			
26	.0	1.16	.0	.0		.0	.0		.02			
27	.0	.13	.11	.08		.0	.15		.04			
28	.03	.0	.17	.0		.10	.03	.0	.01		.23*	
29	.0		.23	.0	.0	.40	.25	.0	.0			
30	.0		.0	.10	.0	.0	.0	.0	.0			
31	.12		--		.0		.0	.07				
Total	2.11	3.59	2.87	1.77	2.68	1.68	0.78	2.69	0.95	0.51	1.93	0.59
Annual total												22.15

Table 1.--Precipitation at the atmospheric-deposition station in the Latir Lakes study area--Concluded

Date	Jan	Feb	Mar	Apr	May	1988 June	July	Aug	Sept	Oct	Nov	Dec
01		0.25	0.0	0.40	0.0	0.0	0.0	0.0	0.0	0.0	--	--
02		.49	.0	.0	.30	.0	.01	.0	.02	.0	--	--
03		.0	.04	.0	.0	.0	.0	.0	.0	.0	--	--
04		.0	.03	.0		.0	.03	.15	.0	.13	--	--
05		.0	.0	.05		.14	.0	.05	.0	.07	--	--
06		.0	.0	.0		.0	.0	.0	.0	.91	--	--
07		.0	.07	.0	.15*	.0	.25	.0	.0	.27	--	--
08	0.49*	.0	.0	.0		.0	.0	.07	.0	.03	--	--
09		.0	.0	.0		.75	.08	.0	.03	.0	--	--
10		.09	.0	.0	.0	.05	.16	.0	.0	.0	--	--
11		.0	.08	.0	.0	.17	.0	.0	1.13	--	--	--
12		.0	.10	.0	.0	.0	.0	.10	.92	--	--	--
13		.0	.08	.0	.0	.0	.0	.0	1.10	--	--	--
14		.0	.0	.10	.0	.0	.05	.0	.08	--	--	--
15		.0	.0	.0	.0	.0	.10	.0	.0	--	--	--
16		.0	.35	.45	.0	.0	.38	.15	.0	--	--	--
17	.31*	.15	.05	.37	.36	.0	.0	.0	.0	--	-	--
18		.0	.0	.0	.54	.0	.15	.55	.0	--	--	--
19		.0	.0	.0	.60	.0	.43	.0	.0	--	--	--
20		.0	.0	.0	.67	.0	.23	.0	.0	--	--	--
21		.0	.0	.04	.03	.0	.0	.0	.18	--	--	--
22		.0	.0	.27	.0	.0	.0	.0	.09	--	--	--
23	.01*	.0	.0	.0	.0	.0	.0	.14	.01	--	--	--
24		.0	.0	.03	.07	.23	.0	.43	.0	--	--	--
25		.0	.0	.0	.0	.15	.0	.05	.0	--	--	--
26		.0	.0	.0	.0	.23	.0	.0	.02	--	--	--
27		.0	.0	.0	.02	.0	.0	.45	.03	--	--	--
28	.0	.0	.0	.0	.0	.27	.0	.40	.01	--	--	--
29	.0		.30	.0	.0	.20	.0	.0	.0	--	--	--
30	.0		.52	.0	.0	.01	.0	.15	.0	--	--	--
31	.02		--		.01		.0	.30		--		--
Total	0.83	0.98	1.62	1.71	2.75	2.20	1.87	2.99	3.62	1.41		
Annual total												19.98

Table 2.--Precipitation at the Rio Costilla precipitation station

[Period of record 1914-21. Latitude, 36 °59', longitude, 105 °32'. Altitude is 7,700 feet. Data from Gabin and Lesperance, 1977, p. 384. Values are in inches]

Precipitation	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Years of record	5	5	5	4	5	6	7	6	6	6	5	5	3
Mean	0.80	0.42	0.66	1.45	1.71	0.93	2.60	1.60	1.00	1.22	0.25	0.30	12.34

Table 3.--Selected properties of and chemical constituents in precipitation in the Latir Lakes study area

[Date represents period of collection of composite sample; µS/cm, microsiemens per centimeter at 25 degrees Celsius; alkalinity, unfiltered sample, Gran (1952) titration; mg/L, milligrams per liter; µg/L, micrograms per liter; EPA, U.S. Environmental Protection Agency; USGS, U.S. Geological Survey; --, no data; <, less than]

Starting date and time	Ending date and time	Agency analyzing sample	Specific conductance (µS/cm)	Specific conductance, lab (µS/cm)	pH (standard units)	Alkalinity (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)
Dec 5, 1986 1600	Dec 12 1100	USGS	7.1	--	4.88	0.16	--	--	--	--
Dec 12 1100	Dec 20 1040	USGS	2.32	--	5.34	.28	--	--	--	--
Dec 20 1040	Dec 30 1100	USGS	--	--	--	--	--	--	--	--
Dec 30 1115	Jan 6, 1987 1000	USGS	1.5	--	6.02	--	--	--	--	--
Jan 6, 1987 1000	Jan 13 1440	USGS	5.3	--	5.07	.12	--	--	--	--
Jan 13 1445	Jan 20 1010	USGS	6.5	--	4.99	.00	--	--	--	--
Jan 20 1010	Jan 28 0900	USGS	--	--	--	--	--	--	--	--
Jan 28 1010	Feb 3 1313	USGS	9.4	--	4.95	.00	--	--	--	--
Feb 3 1315	Feb 10 1000	USGS	10.0	--	5.22	.00	--	--	--	--
Feb 10 1000	Feb 17 1230	USGS	4.6	--	5.13	.00	--	--	--	--
Feb 17 1230	Feb 25 0920	USGS	4.6	--	5.08	.11	--	--	--	--
Feb 25 0920	Mar 3 1415	USGS	2.0	--	5.51	.16	--	--	--	--
Mar 3 1415	Mar 10 1510	USGS	12.2	--	4.64	.00	--	--	--	--
Mar 10 1510	Mar 17 0900	USGS	4.8	--	6.19	1.08	--	--	--	--

Table 3.--Selected properties of and chemical constituents in precipitation in the Latir Lakes study area--Continued

Starting date and time	Ending date and time	Agency analyzing sample	Specific conductance (µS/cm)	Specific conductance, lab (µS/cm)	pH (standard units)	Alkalinity (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)
Mar 17, 1987 0916	Mar 24 0930	USGS	7.9	--	5.20	0.00	--	--	--	--
Mar 24 0930	Mar 31 0900	USGS	7.0	--	4.86	.00	--	--	--	--
Mar 31 0900	Apr 7 1430	EPA	3.1	--	5.41	.00	0.341	0.0105	0.0385	0.0211
Apr 7 1430	Apr 14 1000	EPA	4.1	--	5.25	.00	.355	.0187	.0520	.0155
Apr 22 0900	May 5 1000	EPA	4.71	--	5.18	.00	1.01	.0397	.0509	.0296
May 5 1000	May 14 1100	EPA	11.0	--	4.74	--	.519	.0386	.0994	.0548
May 14 1100	May 20 1030	EPA	11.9	--	4.74	--	.341	.0210	.158	.0436
May 20 1030	May 29 1000	EPA	9.2	--	5.00	.00	.582	.0479	.147	.0576
June 4 0900	June 12 1100	EPA	6.0	--	5.04	.00	.232	.0140	.0464	.0464
June 4 0900 (duplicate)	June 12 1100	EPA	6.0	--	5.04	.00	.948	.0222	.0599	--
June 26 1015	July 10 1640	EPA	8.2	--	5.22	.80	.467	.0421	.0814	.0548
July 17 0830	July 24 0820	EPA	11.8	--	4.70	.00	.347	.0233	.0802	.0352
July 24 0820	Aug 2 0900	EPA	7.3	--	5.03	.00	.284	.0280	.0644	.0324
Aug 2 1100	Aug 7 0730	EPA	9.5	--	4.49	.00	.163	.0116	.0317	.0296
Aug 7 0730	Aug 16 1200	EPA	7.0	--	4.98	.00	.152	.0810	.0351	.0239

Table 3.--Selected properties of and chemical constituents in precipitation in the Latir Lakes study area--Continued

Starting date and time	Ending date and time	Agency analyzing sample	Specific conductance (µS/cm)	Specific conductance, lab (µS/cm)	pH (standard units)	Alkalinity (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)
Aug 16, 1987 1200	Aug 28 1600	EPA	7.3	--	4.94	0.00	0.261	0.0810	0.0430	0.0155
Aug 16, 1987 1200 (duplicate)	Aug 28 1600	EPA	7.3	--	4.94	.00	.215	.0093	.0396	--
Aug 28 1600	Sept 4 1530	EPA	8.8	--	5.50	.00	--	--	--	--
Sept 4 1530	Sept 15 1215	EPA	8.1	--	5.34	.00	.593	.0292	.134	.0548
Oct 13 1545	Oct 20 1200	USGS	6.4	6.9	5.05	.00	.870	.040	.068	--
Oct 20 1200	Oct 28 1200	USGS	8.9	8.9	4.97	.00	.130	.060	.010	--
Oct 28 1200	Nov 5 1400	USGS	3.71	4.1	5.47	.00	.130	<.010	.004	--
Oct 28 1200	Nov 13 1200	USGS	7.2	6.6	4.99	.00	1.100	.030	.050	--
Nov 13 1200	Nov 25 1400	USGS	5.0	5.0	5.30	.00	.080	<.010	.110	--
Nov 25 1400	Dec 2 1245	USGS	5.5	5.5	5.41	.00	.460	.080	.200	--
Dec 16 1515	Jan 13, 1988 1400	USGS	3.51	--	5.29	.69	.050	.020	.200	--
Dec 16 1515 (duplicate)	Jan 13, 1988 1400	USGS	3.5	3.5	5.29	.69	.040	.010	<.200	--
Jan 13, 1988 1400	Jan 21 1430	USGS	5.95	5.2	5.07	.00	.350	.040	.060	--
Jan 28 1045	Feb 5 1341	USGS	4.47	4.6	5.09	.00	.050	.100	.060	--
Mar 9 0930	Mar 13 1400	USGS	6.0	--	5.03	.00	.200	<.010	<.200	--

Table 3.--Selected properties of and chemical constituents in precipitation in the Latir Lakes study area--Continued

Starting date and time	Ending date and time	Agency analyzing sample	Specific conductance (µS/cm)	Specific conductance, lab (µS/cm)	pH (standard units)	Alkalinity (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)
Mar 13, 1988 1400	Mar 24 1030	USGS	6.5	--	5.87	0.33	1.100	0.060	0.300	--
Mar 24 1030	Mar 31 1000	USGS	12.0	--	6.63	2.03	1.500	.060	.500	--
Mar 31 1000	Apr 8 1200	USGS	5.0	7.0	6.30	.36	.700	.070	.310	--
Apr 8 1200	Apr 18 1640	USGS	4.01	4.0	6.06	.59	1.000	.050	.250	--
Apr 25 1100	May 2 1200	USGS	3.0	3.0	6.22	.40	.730	<.010	.260	--
May 17 1200	May 24 1120	USGS	6.3	6.0	5.12	.00	.630	.010	.100	--
May 24 1120	June 1 1600	USGS	18.1	15	4.75	.00	--	--	--	--
June 1 1600	June 27 1030	USGS	11.0	11	4.90	.00	.300	.030	.120	--
June 27 1030	July 7 1126	USGS	9.1	--	4.87	.00	1.300	.140	<.200	--
July 7 1126	July 12 0850	USGS	8.2	--	4.92	.00	.580	.080	.060	--
July 12 0850	July 20 1035	USGS	8.8	--	4.93	.00	.330	.040	.060	--
July 20 1035	July 27 1220	USGS	8.9	8.0	5.16	.00	.700	.010	.070	--
July 27 1220	Aug 9 0724	USGS	9.2	6.0	4.88	.00	.490	<.010	.060	--
Aug 9 0724	Aug 18 0730	USGS	8.6	--	4.85	.00	.410	.020	.070	--
Aug 18 0730	Aug 24 0930	USGS	4.44	--	5.51	.00	3.400	.060	.040	--
Aug 24 0930	Sept 4 1230	USGS	6.9	--	5.13	.00	.520	<.010	.040	--

Table 3.--Selected properties of and chemical constituents in precipitation in the Latir Lakes study area--Continued

Date	Sulfate, dis- solved (mg/L as SO_4)	Chlo- ride, dis- solved (mg/L as Cl)	Fluo- ride, dis- solved (mg/L as F)	Bromide, dis- solved (mg/L as Br)	Silica, dis- solved (mg/L as SiO_2)	Nitro- gen, nitrate, dis- solved (mg/L as N)	Nitro- gen, ammonia, dis- solved (mg/L as N)	Phos- phorus, dis- solved (mg/L as P)	Iron, dis- solved (µg/L as Fe)	Manga- nese, dis- solved (µg/L as Mn)
Mar 31-Apr 7, 1987	0.330	0.006	0.0027	--	0.096	0.05	0.0413	0.0057	5.6	--
Apr 7-14	.330	.047	.0100	--	.099	.125	.0333	.0046	8.1	2.2
Apr 22-May 5	.412	.044	.0024	--	.032	.1009	.0634	.0039	4.9	.5
May 5-14	1.32	.071	.0038	--	.050	.28	.1221	.0079	3.8	6.4
May 14-20	1.21	.082	.0030	--	.041	.218	--	--	8.6	1.0
May 20-29	1.33	.215	.0078	--	.064	.202	.0856	.0055	7.6	5.0
June 4-12	.521	.058	.0022	--	.057	.139	.0674	.0043	5.1	.0
June 4-12 (duplicate)	.513	.061	.054	--	.054	.14	--	.0043	4.9	.8
June 26-July 10	.726	.147	.0023	--	.070	.264	--	--	7.6	3.4
July 17-24	.960	.107	.0023	--	.122	.207	--	--	8.1	1.9
July 24-Aug 2	.804	.070	.0040	--	.046	.187	--	--	3.6	1.1
Aug 2-7	.595	.050	.0026	--	.050	.226	--	--	4.6	.3
Aug 7-16	1.43	.036	.0029	--	.041	.178	.0523	.0041	5.1	.3
Aug 16-28	.64	.050	.0020	--	.029	.174	.0654	.0031	3.1	.0
Aug 16-28 (duplicate)	.592	.048	.0018	--	.035	.173	--	.0036	3.9	.3
Aug 28-Sept 4	1.29	.089	.0033	--	.222	.300	--	--	--	--
Sept 4-15	.976	.153	.0022	--	.122	.195	.1843	.0060	12.3	2.4
Oct 13-20	1.00	.04	<.01	<0.01	.03	.06	--	<.01	6.0	2.0
Oct 20-28	1.00	.07	.01	<.01	.03	.12	--	<.01	13.0	4.0
Oct 28-Nov 5	.37	<.01	.02	<.01	.02	.05	--	<.01	<3.0	4.0
Oct 28-Nov 13	.53	.04	.01	<.01	.02	.13	--	<.01	<3.0	4.0
Nov 13-25	.38	.05	.04	<.01	.02	.12	--	<.01	<3.0	4.0
Nov 25-Dec 2	.40	.08	.09	<.01	.04	.25	--	<.01	<3.0	4.0

Table 3.--Selected properties of and chemical constituents in precipitation in the Latir Lakes study area--Concluded

Date	Sulfate, dis-solved (mg/L as SO_4)	Chlo-ride, dis-solved (mg/L as Cl)	Fluo-ride, dis-solved (mg/L as F)	Bromide, dis-solved (mg/L as Br)	Silica, dis-solved (mg/L as SiO_2)	Nitro-gen, nitrate, dis-solved (mg/L as N)	Nitro-gen, ammonia, dis-solved (mg/L as N)	Phos-phorus, dis-solved (mg/L as P)	Iron, dis-solved (µg/L as Fe)	Manga-nese, dis-solved (µg/L as Mn)
Dec 16, 1987-Jan 13, 1988	--	--	--	--	0.03	--	--	--	<3.0	4.0
Dec 16, 1987-Jan 13, 1988 (duplicate)	0.25	0.04	<0.01	<0.01	.02	0.38	--	<0.01	<3.0	1.0
Jan 13-21	.38	.05	.02	<.01	.02	.16	--	<.01	<3.0	4.0
Jan 28-Feb 5	.40	.06	.05	<.01	.04	.08	--	<.01	<3.0	4.0
Mar 9-13	.35	.06	.01	<.01	<.01	.19	--	<.01	<3.0	<1.0
Mar 13-24	.59	.16	.02	<.01	.02	.33	--	<.01	<3.0	5.0
Mar 24-31	1.20	.28	.03	<.01	.10	.43	--	<.01	4.0	12.
Mar 31-Apr 8	.87	.21	.03	<.01	.36	.11	--	<.01	59.0	15.
Apr 8-18	.44	.06	<.01	<.01	.03	.12	--	<.01	6.0	5.0
Apr 25-May 2	.34	.08	.01	<.01	.05	.06	--	<.01	4.0	5.0
May 17-24	.75	.05	.02	<.01	.09	.14	--	<.01	13.0	2.0
May 24-June 1	2.30	.26	.04	<.01	--	.49	--	.01	--	--
June 1-27	1.30	.10	.02	<.01	.04	.26	--	<.01	<3.0	<1.0
June 27-July 7	.71	.10	.03	<.01	.08	.22	--	<.01	<3.0	6.0
July 7-12	.68	.10	.02	<.01	.06	<.01	--	<.01	<3.0	4.0
July 12-20	.74	.11	<.01	<.01	.02	.24	--	<.01	<3.0	3.0
July 20-27	.85	.12	.06	<.01	.05	.23	--	<.01	<3.0	7.0
July 27-Aug 9	.65	.08	.02	<.01	.01	.23	--	<.01	<3.0	2.0
Aug 9-18	.67	.14	.06	<.01	.05	.22	--	<.01	<3.0	2.0
Aug 18-24	.34	.05	<.01	<.01	<.01	.13	--	<.01	9.0	6.0
Aug 24-Sept 4	.36	.05	.01	<.01	<.01	.13	--	<.01	4.0	1.0

Table 4.--Selected properties of and chemical constituents in snowpack in the Latir Lakes study area

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; alkalinity, unfiltered sample, Gran (1952) titration; mg/L, milligrams per liter; µg/L, micrograms per liter; --, no data; <, less than]

Sample interval (inches above ground surface)	Date	Time	Specific conductance (µS/cm)	Specific conductance, lab (µS/cm)	pH (standard units)	Alkalinity (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)
10 to 14	04-01-87	1200	12.0	12.38	5.89	0.580	1.20	0.11	0.42	0.30
26 to 30	04-01-87	1200	9.00	8.81	5.32	--	.50	.06	.29	.07
38 to 44	04-01-87	1200	4.50	3.71	5.28	--	.17	.02	.05	.02
5 to 7	01-21-88	1530	--	4.00	5.03	.000	.35	<.01	<.20	--
9 to 13	01-21-88	1530	--	3.00	5.29	.000	.18	<.01	<.20	--
17 to 19	01-21-88	1530	--	3.00	5.88	.540	.98	<.01	<.20	--
0 to 9.5	02-24-88	1400	5.00	6.00	5.19	.150	.36	<.01	<.20	--
9.5 to 18	02-24-88	1400	4.18	4.00	5.14	.000	.12	.02	<.20	--
18 to 26	02-24-88	1400	4.49	4.00	5.26	.000	.18	<.01	<.20	--
10 to 14	03-17-88	1530	--	3.00	5.52	.235	.15	.01	<.20	--
20 to 24	03-17-88	1530	--	4.00	5.05	.000	.29	<.01	<.20	--
24 to 28	03-17-88	1530	--	6.00	5.89	.320	.56	.01	<.20	--
2 to 4	04-06-88	1400	6.00	--	5.70	.243	.27	.04	<.20	--
16 to 18	04-06-88	1400	2.92	--	5.80	.250	.23	<.01	<.20	--
18 to 21	04-06-88	1400	9.80	--	6.71	1.910	1.30	.06	.30	--

Table 4.--Selected properties of and chemical constituents in snowpack in the Latir Lakes study area--Concluded

Sample interval (inches above ground surface)	Date	Sulfate, dis-solved (mg/L as SO_4)	Chlo-ride, dis-solved (mg/L as Cl)	Fluo-ride, dis-solved (mg/L as F)	Bromide, dis-solved (mg/L as Br)	Silica, dis-solved (mg/L as SiO_2)	Nitro-gen, nitrate, dis-solved (mg/L as N)	Nitro-gen, ammonia, dis-solved (mg/L as N)	Phos-phorus, dis-solved (mg/L as P)	Iron, dis-solved (µg/L as Fe)	Manga-nese, dis-solved (µg/L as Mn)
10 to 14	04-01-87	1.70	0.37	0.06	<0.01	--	0.42	0.150	<0.01	--	--
26 to 30	04-01-87	.38	.16	.03	.02	--	.09	.120	<.01	--	--
38 to 44	04-01-87	2.70	.11	.03	<.01	--	.13	.026	<.01	--	--
5 to 7	01-21-88	.37	.04	.02	<.01	0.05	.10	--	<.01	<3.0	5.00
9 to 13	01-21-88	.24	.06	.02	<.01	.05	.08	--	<.01	<3.0	4.00
17 to 19	01-21-88	.19	.05	.01	<.01	.03	<.01	--	<.01	5.0	5.00
0 to 9.5	02-24-88	.36	.08	.04	<.01	.02	.18	--	<.01	3.0	1.00
9.5 to 18	02-24-88	.24	.05	.07	<.01	.01	.08	--	<.01	<3.0	5.00
18 to 26	02-24-88	.37	.09	.01	<.01	.03	.09	--	<.01	4.0	4.00
10 to 14	03-17-88	.16	.04	.01	<.01	.03	.06	--	<.01	3.0	1.00
20 to 24	03-17-88	.47	.03	.02	<.01	.03	.08	--	<.01	4.0	3.00
24 to 28	03-17-88	.61	.01	.02	<.01	.07	.21	--	<.01	<3.0	3.00
2 to 4	04-06-88	.48	.08	.02	<.01	.01	.19	--	<.01	4.0	4.00
16 to 18	04-06-88	.21	.04	.01	<.01	<.01	.09	--	<.01	<3.0	<1.00
18 to 21	04-06-88	.70	.16	.03	<.01	.71	.26	--	<.01	6.0	12.0

Table 5.--Selected properties of and chemical constituents in snowmelt in the Latir Lakes study area

[Date represents period of collection of composite sample; µS/cm, microsiemens per centimeter at 25 degrees Celsius; alkalinity, unfiltered sample, Gran (1952) titration; mg/L, milligrams per liter; µg/L, micrograms per liter; USGS, U.S. Geological Survey; --, no data; <, less than]

Starting date and time	Ending date and time	Agency analyzing sample	Specific conductance (µS/cm)	Specific conductance, lab (µS/cm)	pH (standard units)	Alkalinity (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)
Apr 6, 1988 1000	Apr 6, 1988 1500	USGS	34.2	36.0	7.17	11.57	7.30	0.230	0.50	2.10	0.26
Apr 6 1500	Apr 11 1630	USGS	9.3	10.0	6.63	2.90	1.50	.050	<.20	.57	.11
Apr 11 1630	Apr 12 1615	USGS	5.0	6.0	6.43	1.64	1.10	.020	<.20	.26	.08
Apr 12 1615	Apr 13 1517	USGS	3.8	4.0	6.43	1.48	1.90	<.010	.05	.08	.03
Apr 13 1517	Apr 14 1615	USGS	4.7	6.0	6.43	1.55	.90	.050	.05	.15	.04
Apr 14 1615	Apr 15 1110	USGS	13.5	16.0	6.50	3.50	2.30	.120	.18	.94	.09
Apr 15 1110	Apr 18 1630	USGS	10.0	11.0	6.79	3.36	2.70	.080	.08	.41	.05
Apr 18 1630	May 6 --	USGS	11.0	13.0	6.52	2.90	1.60	.070	.30	1.00	.15

Table 5.--Selected properties of and chemical constituents in snowmelt in the Latir Lakes study area--Continued

Date	Fluoride, dissolved (mg/L as F)	Bromide, dissolved (mg/L as Br)	Silica, dissolved (mg/L as SiO_2)	Nitrogen, nitrate, dissolved (mg/L as N)	Phosphorus ortho, dissolved (mg/L as P)	Barium, dissolved (µg/L as Ba)	Beryllium, dissolved (µg/L as Be)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)	Cobalt, dissolved (µg/L as Co)	Copper, dissolved (µg/L as Cu)
Apr 6-6, 1988	0.05	<0.01	0.45	0.45	0.02	4.0	<0.50	<1.0	<5.0	<3.0	<10.0
Apr 6-11	.01	<.01	.11	.17	<.01	<2.0	<.50	<1.0	<5.0	<3.0	<10.0
Apr 11-12	<.01	<.01	.04	.08	<.01	<2.0	<.50	<1.0	<5.0	<3.0	<10.0
Apr 12-13	<.01	<.01	.11	.06	<.01	--	--	--	--	--	--
Apr 13-14	<.01	<.01	.38	.08	<.01	--	--	--	--	--	--
Apr 14-15	.02	<.01	.21	.32	<.01	3.0	<.50	<1.0	<5.0	<3.0	<10.0
Apr 15-18	.03	<.01	.14	.13	<.01	3.0	<.50	<1.0	<5.0	<3.0	<10.0
Apr 18-May 6	.02	<.01	.10	.06	<.01	2.0	<.50	<1.0	<5.0	<3.0	<10.0

Table 5.--Selected properties of and chemical constituents in snowmelt in the Latir Lakes study area--Concluded

Date	Iron, dis- solved (µg/L as Fe)	Lead, dis- solved (µg/L as Pb)	Lithium, dis- solved (µg/L as Li)	Manga- nese, dis- solved (µg/L as Mn)	Molyb- denum, dis- solved (µg/L as Mo)	Nickel, dis- solved (µg/L as Ni)	Silver, dis- solved (µg/L as Ag)	Stron- tium, dis- solved (µg/L as Sr)	Vana- dium, dis- solved (µg/L as V)	Zinc, dis- solved (µg/L as Zn)
Apr 6-6, 1988	11.0	<10.0	<4.0	8.0	<10.0	<10.0	1.0	9.0	<6.00	68.0
Apr 6-11	<3.0	<10.0	<4.0	6.0	<10.0	<10.0	2.0	5.0	<6.00	8.0
Apr 11-12	4.0	<10.0	<4.0	5.0	<10.0	<10.0	2.0	2.0	<6.00	13.0
Apr 12-13	5.0	--	--	1.0	--	--	--	--	--	--
Apr 13-14	8.0	--	--	5.0	--	--	--	--	--	--
Apr 14-15	6.0	<10.0	<4.0	10.	<10.0	<10.0	2.0	5.0	<6.00	9.0
Apr 15-18	5.0	<10.0	<4.0	7.0	<10.0	<10.0	1.0	4.0	<6.00	16.0
Apr 18-May 6	<3.0	<10.0	<4.0	5.0	<10.0	<10.0	<1.0	4.0	<6.00	7.0

Table 6.--Physical characteristics of the Latir Lakes

[<, less than; *, average depth estimated from random depth soundings]

Lake number	Perimeter (feet)	Lake area (square feet)	Lake area (acres)	Watershed area (square miles)	Watershed area (acres)	Watershed/ lake area (acres)	Altitude (feet)	Latitude (at outflow)	Longitude (at outflow)	Volume (cubic feet)	Volume (acre-feet)	Average depth (feet)	Maximum depth (feet)
1	1,600	171,700	3.94	1.17	746	189	11,061	364814	1052648	462,700	10.6	2.7	4.2
2	820	32,400	0.74	1.07	685	925	11,122	364809	1052658	49,000	1.1	1.5*	<3
3	3,058	570,300	13.09	1.04	665	50.8	11,131	364811	1052706	8,174,000	188	14.4	36.7
4	1,780	201,100	4.61	0.60	384	83.3	11,550	364812	1052732	1,490,000	34.2	7.4	10.9
5	1,713	179,200	4.11	0.52	334	81.3	11,570	364809	1052741	2,132,000	49.0	11.9	19
6	975	70,800	1.63	0.41	264	162	11,670	364806	1052753	188,800	4.3	2.6	5.2
7	1,180	87,300	2.00	0.04	25	12.5	11,630	364819	1052743	429,700	9.9	4.95	8
8	1,410	134,000	3.07	0.30	192	62.5	11,775	364812	1052759	675,900	15.5	5.0	10.1
9	2,830	471,900	10.83	0.26	164	15.2	11,893	364806	1052808	11,226,000	258	23.8	42
Total basin		1,918,700	44.02	5.41	3,459								

Table 7.--Temperature, specific conductance, and pH of the Latir Lakes, 1986-88

[--, no data]

Date	Time	Water temperature (degrees Celsius)	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)	pH
Lake 9				
5-22-86		--	32.0	--
6-18-86	1330	--	31.9	7.43
7-10-86	1440	13	29.8	8.70
8-01-86		16	32.1	8.84
8-14-86	1707	13.5	35	8.71
9-24-86	0903	5.0	34.4	--
10-25-86		2.8	34	8.88
7-09-87	1205	13.6	34.3	8.91
7-29-87	1300	15.3	37	8.86
8-27-87	1604	14.2	40	8.26
9-23-87	1515	12.5	38.1	8.52
10-14-87	1115	4.5	36.0	7.95
6-09-88	1545	11.1	39.1	8.66
7-19-88	1300	13.8	34.5	8.54
8-16-88	1215	14.5	37.2	7.38
9-20-88	1330	6.8	38.3	7.21
Lake 8				
5-22-86		--	30.0	--
6-18-86	1420	11.5	30.0	7.39
7-10-86	1445	13.5	35.0	7.20
8-01-86		17.1	41.8	7.78
8-14-86	1625	16.0	45	8.69
9-24-86		--	43.8	--
10-25-86		6.2	55	7.92
7-09-87	1335	16.1	40	9.00
7-29-87	1634	17.7	45	9.22
8-27-87	1615	14.0	46.2	9.09
9-23-87	1645	10.9	51	8.66
10-14-87	1415	6.0	51	8.33
6-09-88	1644	14.7	37.8	6.94
7-19-88		15.0	37.3	8.24
8-16-88	1540	15.8	45.0	7.58
9-20-88		8.7	40.5	7.56

Table 7.--Temperature, specific conductance, and pH of the Latir Lakes, 1986-88--Continued

Date	Time	Water temperature (degrees Celsius)	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)	pH
		Lake 6		
5-22-86		--	34	--
6-18-86	1340	8.5	35	7.08
7-10-86	1500	13.0	33	6.96
8-01-86		14.2	55	7.83
8-14-86	1540	14.5	62	7.90
9-24-86		--	55	--
10-25-86		4.6	55	7.30
7-09-87	1420	12.6	52	7.82
7-29-87	1650	15.3	61	8.46
8-27-87	1630	12.8	62	8.24
9-23-87	1645	14.0	70	8.64
10-14-87	1441	8.1	72	8.87
6-09-88	1715	12.2	40.1	7.10
7-19-88		13.3	52	7.37
8-16-88	1600	14.9	62	7.59
9-21-88	1045	6.3	51	7.23
		Lake 5		
5-22-86		--	50	--
6-18-86	1250	10.5	38	7.71
7-10-86	1515	12.9	42.9	7.80
8-01-86		13.0	60	8.85
8-14-86	1430	14.5	67	8.30
9-24-86		--	62	--
10-25-86		4.6	63	9.43
7-09-87		12.0	52	9.13
7-29-87	1713	15.2	70	9.26
8-27-87	1651	15.2	73	9.00

Table 7.--Temperature, specific conductance, and pH of the Latir Lakes, 1986-88--Continued

Date	Time	Water temperature (degrees Celsius)	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)	pH
Lake 5				
9-23-87	1700	12.6	76	8.96
10-14-87	1647	8.1	78	8.55
6-09-88	1031	11.1	52	8.38
7-20-88	1545	16.0	55.5	8.50
8-16-88	1647	15.9	60	8.29
9-21-88	1115	6.9	59	6.88
Lake 4				
5-22-86		--	47	--
6-18-86	1200	10.8	48	7.46
7-10-86	1530	14.2	53	7.48
8-01-86		13.5	62	8.11
8-14-86	1330	15.0	70	8.30
9-24-86		--	70	--
10-25-86		5.1	69	8.66
7-09-87	1446	15.6	60	8.58
7-29-87	1830	15.7	70	8.41
8-27-87	1705	15.4	73	8.38
9-23-87	1730	13.4	80	8.31
10-14-87	1751	6.5	80	8.44
6-09-88	1745	13.2	63	7.24
7-20-88	1600	16.5	57.3	7.68
8-16-88	1705	16.9	71	7.56
9-21-88	1136	7.3	65	6.85

Table 7.--Temperature, specific conductance, and pH of the Latir Lakes, 1986-88--Continued

Date	Time	Water temper- ature (degrees Celsius)	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)	pH
		Lake 3		
5-22-86		--	54	--
6-18-86	1040	11.0	59	7.94
7-10-86		15.0	60	7.68
7-18-86	0900	12.0	57	7.92
8-01-86		13.5	69	8.99
8-15-86	1100	14.0	70	8.95
9-24-86		--	82	--
10-25-86		2.8	77	8.87
7-10-87	1003	13.1	66	8.97
7-30-87	0900	13.7	72	9.51
8-27-87	1724	14.9	85	9.61
9-23-87	1815	12.0	87	9.50
10-15-87	1402	6.0	91	8.57
6-10-88	1250	13.7	71	8.33
7-21-88	1310	17.7	70	8.74
8-18-88	0730	14.6	75	9.37
9-21-88	1615	8.2	82	8.73
		Lake 2		
5-22-86		--	55	--
6-18-86	1010	11.5	61	7.85
7-10-86		15.0	60	7.68
7-11-86		--	--	--
7-15-86		--	--	--
7-17-86	1910	13.5	64	8.08
8-01-86		12.0	71	8.19
8-15-86	1015	13.0	72	8.30
9-24-86		--	80	--
10-25-86		1.7	75	8.68

Table 7.--Temperature, specific conductance, and pH of the Latir Lakes, 1986-88--Concluded

Date	Time	Water temper-ature (degrees Celsius)	Specific conductance (microsiemens per centimeter at 25 degrees Celsius)	pH
		Lake 2		
4-21-87		2.0	86	7.23
5-28-87	1125	4.0	65.0	7.44
6-17-87	1130	12.0	58.0	8.11
7-10-87	0830	11.8	69.4	8.36
7-28-87	1340	15.6	75.0	9.09
8-27-87	1130	12.0	83.0	9.23
9-23-87	1037	8.8	83.0	8.62
10-15-87	1215	4.2	92	8.45
6-10-88	0850	11.4	72	7.99
7-21-88	1052	15.5	70	8.27
8-17-88	1010	14.4	77	8.29
9-21-88	1250	9.3	80	7.64
		Lake 1		
5-22-86		--	53	--
6-18-86	0900	9.5	69	7.66
7-10-86		15.5	62	7.68
7-15-86		17.0	67	9.94
7-17-86	1840	14.5	62	9.23
8-01-86		11.8	72	8.98
8-15-86	0830	12.5	75	9.75
9-24-86	1100	--	79	--
10-25-86		2.9	74	9.94
7-10-87	0940	13.0	69.0	8.49
7-30-87	0830	13.4	73.0	8.93
10-15-87	1336	4.1	88.0	9.18
6-10-88	1145	14.0	73.0	8.20
7-21-88	1251	16.5	68.0	9.18
8-18-88	0830	14.9	80.0	8.37
9-21-88	1625	9.2	82.0	9.06

Table 8.--Selected properties of and chemical constituents in water from the Latir Lakes

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; deg C, degrees Celsius; alkalinity, unfiltered sample, Gran (1952) titration; mg/L, milligrams per liter; µg/L, micrograms per liter; USGS, U.S. Geological Survey; EPA, U.S. Environmental Protection Agency; --, no data; <, less than; E, estimated]

Sample location	Date	Time	Agency analyzing sample	Specific conductance (µS/cm)	Specific conductance, lab (µS/cm)	pH (standard units)	Temperature (deg C)	Oxygen, dissolved (mg/L)	Alkalinity (mg/L as $CaCO_3$)
Lake 9	07-25-85	1100	USGS	--	34.0	--	--	--	--
Lake 9	10-24-86	1500	USGS	32.6	38.0	8.87	1.3	11.6	16.60
Lake 9 outflow	07-09-87	1230	USGS	34.3	41.0	8.91	13.6	--	16.00
Lake 9 outflow	07-09-87	1231	USGS	34.3	--	--	13.6	--	16.00
Lake 9 outflow	07-29-87	1400	EPA	37.0	--	8.86	15.5	7.8	16.65
Lake 9, 35-foot depth	07-29-87	1500	EPA	38.9	--	6.70	7.0	.2	16.80
Lake 9 outflow	09-23-87	--	EPA	38.1	--	8.52	12.5	7.2	17.30
Lake 9 outflow	10-14-87	--	EPA	36.0	--	7.95	4.5	7.4	17.00
Lake 9 outflow	06-09-88	1545	USGS	39.1	40.0	8.66	11.1	8.4	16.30
Lake 9 outflow	07-19-88	1300	USGS	34.5	--	8.54	13.8	--	14.70
Lake 9 outflow	08-16-88	1215	USGS	37.2	--	7.38	14.5	--	15.10
Lake 9 outflow	09-20-88	1330	USGS	38.3	43.0	7.21	6.8	--	14.50
Lake 8 outflow	07-24-85	1100	USGS	--	40.0	--	--	--	--
Lake 8 outflow	07-24-85	1200	USGS	--	39.0	--	--	--	--
Lake 5 outflow	10-24-86	1000	USGS	65.0	71.0	9.45	2.8	11.6	32.40
Lake 5 outflow	07-09-87	1030	USGS	52.0	62.0	9.13	12.0	--	26.10
Lake 5 outflow	07-09-87	1031	USGS	52.0	--	9.13	E12.0	--	26.10
Lake 5 outflow	07-29-87	1715	EPA	70.0	--	9.26	15.2	--	30.75
Lake 5 outflow	10-14-87	1647	EPA	78.0	--	8.55	8.1	6.8	35.50
Lake 5 outflow	06-09-88	1100	USGS	52.0	53.0	8.38	11.1	--	22.20

Table 8.--Selected properties of and chemical constituents in water from the Latir Lakes--Continued

Sample location	Date	Time	Agency analyzing sample	Specific conductance (µS/cm)	Specific conductance, lab (µS/cm)	pH (standard units)	Temperature (deg C)	Oxygen, dissolved (mg/L)	Alkalinity, (mg/L as $CaCO_3$)
Lake 5 outflow	07-20-88	1545	USGS	55.5	--	8.44	16.0	--	27.20
Lake 5 outflow	08-16-88	1630	USGS	60.0	--	7.95	15.9	--	30.05
Lake 5 outflow	09-21-88	1115	USGS	59.0	61.0	6.88	6.9	--	22.55
Lake 3	07-23-85	1600	USGS	--	92.0	--	--	--	--
Lake 3	10-25-86	1200	USGS	77.0	88.0	8.87	3.0	11.1	38.70
Lake 3, 10-foot depth	07-23-85	1500	USGS	--	68.0	--	--	--	--
Lake 2 outflow	04-21-87	1500	USGS	86.0	96.6	7.23	2.0	10.8	--
Lake 2 outflow	05-28-87	1140	EPA	65.0	--	7.44	4.0	--	--
Lake 2 outflow	06-17-87	1130	EPA	58.0	--	8.11	12.0	--	--
Lake 2 outflow	07-10-87	0837	USGS	70.0	74.0	8.28	11.8	E5.76	32.25
Lake 2 outflow	07-10-87	0838	USGS	70.0	--	8.28	11.8	5.76	32.25
Lake 2 outflow	07-28-87	1400	EPA	75.0	--	9.15	15.6	7.1	32.25
Lake 2 outflow	09-23-87	1215	EPA	83.0	--	8.62	8.8	7.0	40.55
Lake 2 outflow	10-15-87	1133	EPA	92.0	--	8.45	4.2	--	43.6
Lake 2 outflow	06-10-88	0850	USGS	72.0	79.0	8.07	11.4	7.4	34.20
Lake 2 outflow	07-21-88	1100	USGS	70.0	--	8.27	15.5	6.6	31.10
Lake 2 outflow	08-17-88	1030	USGS	77.0	--	8.85	14.4	6.3	34.20
Lake 2 outflow	09-21-88	1530	USGS	80.0	85.0	7.64	9.3	8.0	33.05

Table 8.--Selected properties of and chemical constituents in water from the Latir Lakes--Continued

Sample location	Date	Alkalinity, lab (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Bromide, dissolved (mg/L as Br)
Lake 9	07-25-85	13.0	4.3	0.400	1.20	0.300	1.20	0.250	<0.060	0.03
Lake 9	10-24-86	18.0	5.5	.500	1.20	.400	2.30	1.000	<.100	--
Lake 9 outflow	07-09-87	--	5.0	.490	1.20	--	1.10	.260	.070	<.01
Lake 9 outflow	07-09-87	--	5.3	.570	1.70	--	--	--	--	--
Lake 9 outflow	07-29-87	--	5.88	.510	1.11	.265	1.29	.183	.035	--
Lake 9, 35-foot depth	07-29-87	--	5.61	.534	1.12	.310	1.40	.231	.031	--
Lake 9 outflow	09-23-87	--	5.41	.528	1.18	.274	1.31	.185	.041	--
Lake 9 outflow	10-14-87	--	5.57	.539	1.17	.265	1.28	.210	.041	--
Lake 9 outflow	06-09-88	--	5.8	.530	1.30	--	1.20	.200	.050	<.01
Lake 9 outflow	07-19-88	--	5.3	.560	1.10	--	1.20	.190	.070	<.01
Lake 9 outflow	08-16-88	--	5.8	.560	1.30	--	1.10	.190	.100	<.01
Lake 9 outflow	09-20-88	--	6.9	.600	1.30	--	1.20	.200	.080	<.01
Lake 8 outflow	07-24-85	16.0	5.9	.400	1.10	.300	2.30	<.200	<.100	.02
Lake 8 outflow	07-24-85	15.0	6.0	.500	1.10	2.400	2.70	<.200	<.100	.06
Lake 5 outflow	10-24-86	33.0	12.0	.700	1.70	.500	2.60	.600	.100	--
Lake 5 outflow	07-09-87	--	9.0	.560	1.40	--	1.70	.250	.150	<.01
Lake 5 outflow	07-09-87	--	9.1	.610	1.60	--	--	--	--	--
Lake 5 outflow	07-29-87	--	10.6	.692	1.47	.271	1.92	.182	.129	--
Lake 5 outflow	10-14-87	--	12.9	.779	1.65	.305	2.00	.234	.155	--
Lake 5 outflow	06-09-88	--	8.5	.570	1.00	--	1.60	.250	.110	<.01

Table 8.--Selected properties of and chemical constituents in water from the Latir Lakes--Continued

Sample location	Date	Alkalinity, lab (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Bromide, dissolved (mg/L as Br)
Lake 5 outflow	07-20-88	--	11.0	0.710	1.40	--	1.80	0.190	0.160	<0.01
Lake 5 outflow	08-16-88	--	11.0	.760	1.70	--	1.70	.220	.200	<.01
Lake 5 outflow	09-21-88	--	9.8	.650	1.50	--	1.80	.250	.150	<.01
Lake 3	07-23-85	38.0	15.0	.900	2.20	0.400	3.70	.310	.200	.05
Lake 3	10-25-86	41.0	15.0	.900	2.00	.400	4.50	<.200	.200	--
Lake 3, 10-foot depth	07-23-85	27.0	11.0	.700	1.70	.300	4.50	.200	.200	.04
Lake 2 outflow	04-21-87	--	13.0	.940	2.40	.420	3.60	.360	.220	<.01
Lake 2 outflow	05-28-87	--	10.8	.756	1.54	.321	2.71	.274	.121	--
Lake 2 outflow	06-17-87	--	9.79	.698	1.38	.310	2.61	.233	.096	--
Lake 2 outflow	07-10-87	--	11.0	.760	1.70	--	3.30	.250	.180	<.01
Lake 2 outflow	07-10-87	--	11.0	.730	1.90	--	--	--	--	--
Lake 2 outflow	07-28-87	--	11.5	.815	1.58	.159	3.46	.105	.152	--
Lake 2 outflow	09-23-87	--	13.9	.976	1.99	.263	3.97	.144	.192	--
Lake 2 outflow	10-15-87	--	15.8	1.03	2.08	.293	3.95	.161	.197	--
Lake 2 outflow	06-10-88	--	13.0	.840	1.90	--	2.90	.230	.210	<.01
Lake 2 outflow	07-21-88	--	12.0	.890	1.60	--	2.90	.160	.200	<.01
Lake 2 outflow	08-17-88	--	5.8	.560	1.30	--	3.00	.130	.250	<.01
Lake 2 outflow	09-21-88	--	14.0	1.000	1.90	--	3.00	.210	.230	<.01

Table 8.--Selected properties of and chemical constituents in water from the Latir Lakes--Continued

Sample location	Date	Silica, dis-solved (mg/L as SiO_2)	Nitro-gen, nitrate, dis-solved (mg/L as N)	Nitro-gen, $NO_2 + NO_3$, total (mg/L as N)	Nitro-gen, $NO_2 + NO_3$, dis-solved (mg/L as N)	Nitro-gen, ammonia, dis-solved (mg/L as N)	Nitro-gen, ammonia, total (mg/L as N)	Nitro-gen, ammonia + organic, dissolved (mg/L as N)	Nitro-gen, ammonia + organic, total (mg/L as N)	Phos-phorus, dis-solved (mg/L as P)
Lake 9	07-25-85	5.00	--	<0.10	<0.10	--	0.04	--	0.60	--
Lake 9	10-24-86	4.90	--	<.10	<.10	<0.010	.07	0.40	.90	<0.01
Lake 9 outflow	07-09-87	5.00	<0.010	--	--	--	--	--	--	--
Lake 9 outflow	07-09-87	5.30	--	--	--	--	--	--	--	--
Lake 9 outflow	07-29-87	5.00	.001	--	--	.0094	--	--	--	.0098
Lake 9, 35-foot depth	07-29-87	6.25	--	--	--	--	--	--	--	--
Lake 9 outflow	09-23-87	5.23	.0005	--	--	--	--	--	--	--
Lake 9 outflow	10-14-87	4.88	.0131	--	--	--	--	--	--	--
Lake 9 outflow	06-09-88	5.90	<.010	--	--	--	--	--	--	--
Lake 9 outflow	07-19-88	5.70	.020	--	--	--	--	--	--	--
Lake 9 outflow	08-16-88	5.70	.020	--	--	--	--	--	--	--
Lake 9 outflow	09-20-88	6.30	.060	--	--	--	--	--	--	--
Lake 8 outflow	07-24-85	4.90	--	<.10	<.10	--	.10	--	1.90	--
Lake 8 outflow	07-24-85	4.90	--	<.10	<.10	--	.02	--	.60	--
Lake 5 outflow	10-24-86	6.00	--	<.10	<.10	<.010	.07	.70	.70	.01
Lake 5 outflow	07-09-87	5.80	<.010	--	--	--	--	--	--	--
Lake 5 outflow	07-09-87	6.00	--	--	--	--	--	--	--	--
Lake 5 outflow	07-29-87	6.33	.0005	--	--	.0072	--	--	--	--
Lake 5 outflow	10-14-87	5.89	.0029	--	--	.0223	--	--	--	.0119
Lake 5 outflow	06-09-88	6.30	<.010	--	--	--	--	--	--	.0136

Table 8.--Selected properties of and chemical constituents in water from the Latir Lakes--Continued

Sample location	Date	Silica, dis-solved (mg/L as SiO_2)	Nitro-gen, nitrate, dis-solved (mg/L as N)	Nitro-gen, $NO_2 + NO_3$, total (mg/L as N)	Nitro-gen, $NO_2 + NO_3$, dis-solved (mg/L as N)	Nitro-gen, ammonia, dis-solved (mg/L as N)	Nitro-gen, ammonia, total (mg/L as N)	Nitro-gen, ammonia + organic, dissolved (mg/L as N)	Nitro-gen, ammonia + organic, total (mg/L as N)	Phos-phorus, dis-solved (mg/L as P)
Lake 5 outflow	07-20-88	6.00	0.010	--	--	--	--	--	--	--
Lake 5 outflow	08-16-88	6.50	.010	--	--	--	--	--	--	--
Lake 5 outflow	09-21-88	6.80	.010	--	--	--	--	--	--	--
Lake 3	07-23-85	6.40	--	<0.10	<0.10	0.110	0.08	--	0.50	--
Lake 3	10-25-86	6.30	--	<.10	<.10	<.010	.07	0.40	.70	0.01
Lake 3, 10-foot depth	07-23-85	5.60	--	<.10	<.10	--	.04	--	.50	--
Lake 2 outflow	04-21-87	--	.220	.20	.12	.010	.01	.30	1.00	.01
Lake 2 outflow	05-28-87	5.71	.11	--	--	.0040	--	--	--	.0098
Lake 2 outflow	06-17-87	6.02	.028	--	--	.0342	--	--	--	.0112
Lake 2 outflow	07-10-87	5.80	<.010	--	--	--	--	--	--	--
Lake 2 outflow	07-10-87	6.00	--	--	--	--	--	--	--	--
Lake 2 outflow	07-28-87	5.15	.0063	--	--	.0094	--	--	--	.0119
Lake 2 outflow	09-23-87	3.93	.183	--	--	--	--	--	--	--
Lake 2 outflow	10-15-87	4.13	.032	--	--	.0137	--	--	--	.0131
Lake 2 outflow	06-10-88	6.30	<.010	--	--	--	--	--	--	--
Lake 2 outflow	07-21-88	4.60	.030	--	--	--	--	--	--	--
Lake 2 outflow	08-17-88	5.70	.030	--	--	--	--	--	--	--
Lake 2 outflow	09-21-88	6.30	<.010	--	--	--	--	--	--	--

Table 8.--Selected properties of and chemical constituents in water from the Latir Lakes--Continued

Sample location	Date	Phosphorus, total (mg/L as P)	Phosphorus, total (mg/L as PO_4)	Phosphorus, ortho, dissolved (mg/L as P)	Aluminum, dissolved (µg/L as Al)	Barium, dissolved (µg/L as Ba)	Beryllium, dissolved (µg/L as Be)	Boron, dissolved (µg/L as B)	Cadmium, dissolved (µg/L as Cd)
Lake 9	07-25-85	0.03	0.09	<0.01	30	--	--	<10.0	--
Lake 9	10-24-86	.03	--	--	<10	--	--	--	--
Lake 9 outflow	07-09-87	--	--	<.01	--	--	--	--	--
Lake 9 outflow	07-09-87	--	--	--	--	26.0	<0.5	--	<1.0
Lake 9 outflow	07-29-87	--	--	--	--	--	--	--	--
Lake 9, 35-foot depth	07-29-87	--	--	--	--	--	--	--	--
Lake 9 outflow	09-23-87	--	--	--	--	--	--	--	--
Lake 9 outflow	10-14-87	--	--	--	--	--	--	--	--
Lake 9 outflow	06-09-88	--	--	<.01	--	10.0	<.5	--	<1.0
Lake 9 outflow	07-19-88	--	--	<.01	--	--	--	--	--
Lake 9 outflow	08-16-88	--	--	<.01	--	--	--	--	--
Lake 9 outflow	09-20-88	--	--	<.01	--	--	--	--	--
Lake 8 outflow	07-24-85	.04	.12	.01	10	--	--	<10.0	--
Lake 8 outflow	07-24-85	.03	.09	<.01	<10	--	--	<10.0	--
Lake 5 outflow	10-24-86	.03	--	--	<10	--	--	--	--
Lake 5 outflow	07-09-87	--	--	<.01	--	--	--	--	--
Lake 5 outflow	07-09-87	--	--	--	--	28.0	<.5	--	2.0
Lake 5 outflow	07-29-87	--	--	--	--	--	--	--	--
Lake 5 outflow	10-14-87	--	--	--	--	--	--	--	--
Lake 5 outflow	06-09-88	--	--	<.01	--	--	--	--	--

Table 8.--Selected properties of and chemical constituents in water from the Latir Lakes--Continued

Sample location	Date	Phos-phorus, total (mg/L as P)	Phos-phorus, total (mg/L as PO_4)	Phos-phorus, ortho, dis-solved (mg/L as P)	Alum-inum, dis-solved (µg/L as Al)	Barium, dis-solved (µg/L as Ba)	Beryl-lium, dis-solved (µg/L as Be)	Boron, dis-solved (µg/L as B)	Cadmium, dis-solved (µg/L as Cd)
Lake 5 outflow	07-20-88	--	--	<0.01	--	--	--	--	--
Lake 5 outflow	08-16-88	--	--	<.01	--	--	--	--	--
Lake 5 outflow	09-21-88	--	--	<.01	--	--	--	--	--
Lake 3	07-23-85	<0.01	--	.01	--	--	--	<10.0	--
Lake 3	10-25-86	.02	--	--	<10	--	--	--	--
Lake 3, 10-foot depth	07-23-85	.02	0.06	.01	30	--	--	<10.0	--
Lake 2 outflow	04-21-87	.02	--	<.01	--	--	--	--	--
Lake 2 outflow	05-28-87	--	--	--	--	--	--	--	--
Lake 2 outflow	06-17-87	--	--	--	--	--	--	--	--
Lake 2 outflow	07-10-87	--	--	<.01	--	--	--	--	--
Lake 2 outflow	07-10-87	--	--	--	--	4.0	<0.5	--	2.0
Lake 2 outflow	07-28-87	--	--	--	--	--	--	--	--
Lake 2 outflow	09-23-87	--	--	--	--	--	--	--	--
Lake 2 outflow	10-15-87	--	--	--	--	--	--	--	--
Lake 2 outflow	06-10-88	--	--	<.01	--	4.0	<.5	--	<1.0
Lake 2 outflow	07-21-88	--	--	<.01	--	--	--	--	--
Lake 2 outflow	08-17-88	--	--	<.01	--	--	--	--	--
Lake 2 outflow	09-21-88	--	--	<.01	--	--	--	--	--

Table 8.--Selected properties of and chemical constituents in water from the Latir Lakes--Continued

Sample location	Date	Chromium, dissolved (µg/L as Cr)	Cobalt, dissolved (µg/L as Co)	Copper, dissolved (µg/L as Cu)	Lead, dissolved (µg/L as Pb)	Lithium, dissolved (µg/L as Li)	Manganese, dissolved (µg/L as Mn)	Molybdenum, dissolved (µg/L as Mo)	Nickel, dissolved (µg/L as Ni)
Lake 9	07-25-85	--	--	--	--	--	--	--	--
Lake 9	10-24-86	--	--	<10.0	<10.0	--	<1.0	--	--
Lake 9 outflow	07-09-87	--	--	--	--	--	2.0	--	--
Lake 9 outflow	07-09-87	<5.0	<4.0	<10.0	<10.0	<4.0	2.0	<10.0	<10.0
Lake 9 outflow	07-29-87	--	--	--	--	--	--	--	--
Lake 9, 35-foot depth	07-29-87	--	--	--	--	--	--	--	--
Lake 9 outflow	09-23-87	--	--	--	--	--	--	--	--
Lake 9 outflow	10-14-87	--	--	--	--	--	--	--	--
Lake 9 outflow	06-09-88	<5.0	<3.0	<10.0	<10.0	<4.0	2.0	<10.0	<10.0
Lake 9 outflow	07-19-88	--	--	--	--	--	1.0	--	--
Lake 9 outflow	08-16-88	--	--	--	--	--	1.0	--	--
Lake 9 outflow	09-20-88	--	--	--	--	--	11.0	--	--
Lake 8 outflow	07-24-85	--	--	--	--	--	--	--	--
Lake 8 outflow	07-24-85	--	--	--	--	--	--	--	--
Lake 5 outflow	10-24-86	--	--	<10.0	<10.0	--	<1.0	--	--
Lake 5 outflow	07-09-87	--	--	--	--	--	2.0	--	--
Lake 5 outflow	07-09-87	<5.0	<3.0	<10.0	<10.0	<4.0	<1.0	<10.0	<10.0
Lake 5 outflow	07-29-87	--	--	--	--	--	--	--	--
Lake 5 outflow	10-14-87	--	--	--	--	--	--	--	--
Lake 5 outflow	06-09-88	--	--	--	--	--	<1.0	--	--

Table 8.--Selected properties of and chemical constituents in water from the Latir Lakes--Continued

Sample location	Date	Chromium, dissolved (µg/L as Cr)	Cobalt, dissolved (µg/L as Co)	Copper, dissolved (µg/L as Cu)	Lead, dissolved (µg/L as Pb)	Lithium, dissolved (µg/L as Li)	Manganese, dissolved (µg/L as Mn)	Molybdenum, dissolved (µg/L as Mo)	Nickel, dissolved (µg/L as Ni)
Lake 5 outflow	07-20-88	--	--	--	--	--	1.0	--	--
Lake 5 outflow	08-16-88	--	--	--	--	--	2.0	--	--
Lake 5 outflow	09-21-88	--	--	--	--	--	<1.0	--	--
Lake 3	07-23-85	--	--	--	--	--	--	--	--
Lake 3	10-25-86	--	--	<10.0	<10.0	--	<1.0	--	--
Lake 3, 10-foot depth	07-23-85	--	--	--	--	--	--	--	--
Lake 2 outflow	04-21-87	--	--	--	--	--	--	--	--
Lake 2 outflow	05-28-87	--	--	--	--	--	--	--	--
Lake 2 outflow	06-17-87	--	--	--	--	--	--	--	--
Lake 2 outflow	07-10-87	--	--	--	--	--	5.0	--	--
Lake 2 outflow	07-10-87	<5.0	<3.0	<10.0	<10.0	<4.0	4.0	<10.0	<10.0
Lake 2 outflow	09-23-87	--	--	--	--	--	--	--	--
Lake 2 outflow	10-15-87	--	--	--	--	--	--	--	--
Lake 2 outflow	06-10-88	<5.0	<3.0	<10.0	<10.0	<4.0	3.0	<10.0	<10.0
Lake 2 outflow	07-21-88	--	--	--	--	--	7.0	--	--
Lake 2 outflow	08-17-88	--	--	--	--	--	1.0	--	--
Lake 2 outflow	09-21-88	--	--	--	--	--	2.0	--	--

Table 8.--Selected properties of and chemical constituents in water from the Latir Lakes--Continued

Sample location	Date	Silver, dis-solved (µg/L as Ag)	Stron-tium, dis-solved (µg/L as Sr)	Vana-dium, dis-solved (µg/L as V)	Zinc, dis-solved (µg/L as Zn)	Carbon, organic, total (mg/L as C)	Carbon, organic, dis-solved (mg/L as C)	Carbon, inor-ganic, dis-solved (mg/L as C)	C-13/C-12 stable isotope ratio (per mil)
Lake 9	07-25-85	--	--	--	--	3.70	2.50	2.40	-8.80
Lake 9	10-24-86	--	--	--	<3.0	5.90	--	--	--
Lake 9 outflow	07-09-87	--	--	--	--	--	--	--	--
Lake 9 outflow	07-09-87	6.0	33.0	<6.0	<3.0	--	--	--	--
Lake 9 outflow	07-29-87	--	--	--	--	--	1.07	--	--
Lake 9, 35-foot depth	07-29-87	--	--	--	--	--	--	--	--
Lake 9 outflow	09-23-87	--	--	--	--	--	--	--	--
Lake 9 outflow	10-14-87	--	--	--	--	--	--	--	--
Lake 9 outflow	06-09-88	2.0	34.0	<6.0	<3.0	--	--	--	--
Lake 9 outflow	07-19-88	--	--	--	--	--	--	--	--
Lake 9 outflow	08-16-88	--	--	--	--	--	--	--	--
Lake 9 outflow	09-20-88	--	--	--	--	--	--	--	--
Lake 8 outflow	07-24-85	--	--	--	--	2.60	3.20	3.80	-3.20
Lake 8 outflow	07-24-85	--	--	--	--	3.60	3.30	3.40	--
Lake 5 outflow	10-24-86	--	--	--	<3.0	3.70	--	--	--
Lake 5 outflow	07-09-87	--	--	--	--	--	--	--	--
Lake 5 outflow	07-09-87	12.0	44.0	<6.0	3.0	--	--	--	--
Lake 5 outflow	07-29-87	--	--	--	--	--	1.02	--	--
Lake 5 outflow	10-14-87	--	--	--	--	--	1.19	--	--
Lake 5 outflow	06-09-88	--	--	--	--	--	--	--	--

Table 8.--Selected properties of and chemical constituents in water from the Latir Lakes--Concluded

Sample location	Date	Silver, dis- solved (µg/L as Ag)	Stron- tium, dis- solved (µg/L as Sr)	Vana- dium, dis- solved (µg/L as V)	Zinc, dis- solved (µg/L as Zn)	Carbon, organic, total (mg/L as C)	Carbon, organic, dis- solved (mg/L as C)	Carbon, inor- ganic, dis- solved (mg/L as C)	C-13/ C-12 stable isotope ratio (per mil)
Lake 5 outflow	07-20-88	--	--	--	--	--	--	--	--
Lake 5 outflow	08-16-88	--	--	--	--	--	--	--	--
Lake 5 outflow	09-21-88	--	--	--	--	--	--	--	--
Lake 3	07-23-85	--	--	--	--	3.20	3.60	8.40	-3.40
Lake 3	10-25-86	--	--	--	<3.0	2.90	--	--	--
Lake 3, 10-foot depth	07-23-85	--	--	--	--	--	3.70	6.0	--
Lake 2 outflow	04-21-87	--	--	--	--	1.80	--	--	--
Lake 2 outflow	05-28-87	--	--	--	--	--	2.01	--	--
Lake 2 outflow	06-17-87	--	--	--	--	--	3.42	--	--
Lake 2 outflow	07-10-87	--	--	--	--	--	--	--	--
Lake 2 outflow	07-10-87	7.0	68.0	<6.0	<3.0	--	--	--	--
Lake 2 outflow	07-28-87	--	--	--	--	--	1.92	--	--
Lake 2 outflow	09-23-87	--	--	--	--	--	--	--	--
Lake 2 outflow	10-15-87	--	--	--	--	--	--	--	--
Lake 2 outflow	06-10-88	<1.0	79.0	<6.0	3.0	--	--	--	--
Lake 2 outflow	07-21-88	--	--	--	--	--	--	--	--
Lake 2 outflow	08-17-88	--	--	--	--	--	--	--	--
Lake 2 outflow	09-21-88	--	--	--	--	--	--	--	--

Table 9.--Differences in outflow water chemistry in Latir Lakes 9, 5, and 2

[Values in milligrams per liter. Samples collected in June 1988]

	Calcium	Magnesium	Sodium	Sulfate	Chloride	Bicarbonate	Silica (SiO_2)
Lake 9 outflow	5.8	0.53	1.3	1.2	0.2	19.9	5.9
2 x snowmelt	4.82	0.178	0.34	1.378	0.2	8.80	0.386
Residual	0.98	0.352	0.96	-0.178	0	11.1	5.514

	Calcium	Magnesium	Sodium	Sulfate	Chloride	Bicarbonate	Silica (SiO_2)
Lake 5 outflow	8.5	0.57	1.0	1.6	0.25	27.1	6.3
2.5 x snowmelt	6.03	0.223	0.43	1.723	0.25	11.0	0.483
Residual	2.47	0.347	0.57	-0.123	0.0	16.1	5.817

	Calcium	Magnesium	Sodium	Sulfate	Chloride	Bicarbonate	Silica (SiO_2)
Lake 2 outflow	13.0	0.84	1.9	2.9	0.23	41.7	6.3
2.3 x snowmelt	5.54	0.205	0.39	1.585	0.23	10.1	0.444
Residual	7.46	0.635	1.51	1.315	0.0	31.6	5.856

	Calcium	Magnesium	Sodium	Sulfate	Chloride	Bicarbonate	Silica (SiO_2)
Lake 2 outflow	13.0	0.84	1.9	2.9	0.23	41.7	6.3
Lake 9 outflow	5.8	0.53	1.3	1.2	0.2	19.9	5.9
Difference	7.2	0.31	0.6	1.7	0.03	21.8	0.4

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