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GEOLOGICAL SURVEY

HYDROLOGIC CONDITIONS IN CONNORS BOG AREA, ANCHORAGE, ALASKA

By Roy L. Glass

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CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION TABLE

For readers who may prefer to use International System of Units (SI) rather than inch-pound units, the conversion factors for the terms used in this report are listed below:

Multiply	By	To obtain
inch (in.)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
acre	0.4047	hectare
degree Fahrenheit (°F)	(°F-32)/1.8	degree Celsius (°C)

Other abbreviations in this report are:

mg/L, milligrams per liter
µg/L, micrograms per liter
µS/cm, microsiemens per centimeter at 25 degrees Celsius

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ABSTRACT

Connors Bog is a wetland in Anchorage, Alaska, which provides habitat for many wildlife species and is a popular area for driving off-road vehicles. A landfill and residential and commercial developments are present in areas which were once wetland.

The main source of water is precipitation, which averages about 15 inches per year. Estimates of evapotranspiration, which is the main component of water outflow, range from 10 to 20 inches per year. Minor amounts of ground water and surface runoff flow into the area from the northeast and southwest and flow out of the area to the northwest and south.

Within the wetland, water in peat and sand is unconfined and becomes more mineralized with depth. A leachate beneath and near an abandoned landfill is characterized by concentrations of dissolved solids, dissolved chloride, and total organics that are higher than those of the area's natural water. The maximum lateral extent of detectable contamination in 1984 was less than 500 feet from the landfill's edge.

Water in glacial deposits that underlie a poorly permeable layer of silt and clay is confined. A well completed in this confined aquifer yielded water that had a low concentration of dissolved solids, 150 milligrams per liter. The potentiometric surface of this aquifer was about 20 feet lower than the water table during 1984.

Connors Lake occupies a depression that extends below adjacent ground-water levels. The 40-acre lake has a maximum depth of about 9 feet and a low rate of biological production. The quality of water in the lake has not been adversely impacted by nearby residential development or landfill operations. Lake levels appear to be influenced by precipitation and adjacent ground-water levels.

INTRODUCTION

The demand for land for residential, commercial, and recreational uses in Anchorage, Alaska has increased as a result of rapid population growth. As a consequence, increasingly greater portions of Anchorage's wetlands -- the only remaining large "undeveloped" areas -- are being drained and filled. Connors Bog (fig. 1), a 700-acre, low-shrub wetland, provides habitat for wildlife and is a popular recreational area, but it also offers potential development sites.

As part of an agreement with the Municipality of Anchorage, the U.S. Geological Survey conducted a hydrologic study in the Connors Bog area during 1984. This report describes the results of a study to determine the direction of ground-water flow and the chemical quality of water in the northern part of Connors Bog. The study area is approximately 450 acres of lowlands bounded by International Airport Road, Minnesota Drive, Raspberry Road, and Jewel Lake Road. It contains an abandoned landfill and about 270 acres of Connors Bog, including Connors Lake. The information in this report will be used in decisions concerning proposed residential, commercial, or recreational development, and other changes in the natural landscape.

Most of Connors Bog is no longer in its natural condition. A buried waste-water pipeline, Minnesota Drive, and Raspberry Road have been built through the wetland. The area north of Connors Lake is designated for off-road vehicle use; however, most of the study area is used by off-road vehicles. A landfill which was operated from 1958 to 1977 covers approximately 100 acres in the northeastern part of the original wetland, including two former shallow lakes. Disposal operations began in the northwestern corner of the landfill site and progressed to the south and east. The surface of the landfill is being reclaimed for softball and soccer fields and as a site for commercial buildings. Two areas along the western edge of this landfill are now used as disposal sites for snow collected from streets. Residential and commercial developments are also present along the margin of the wetland.

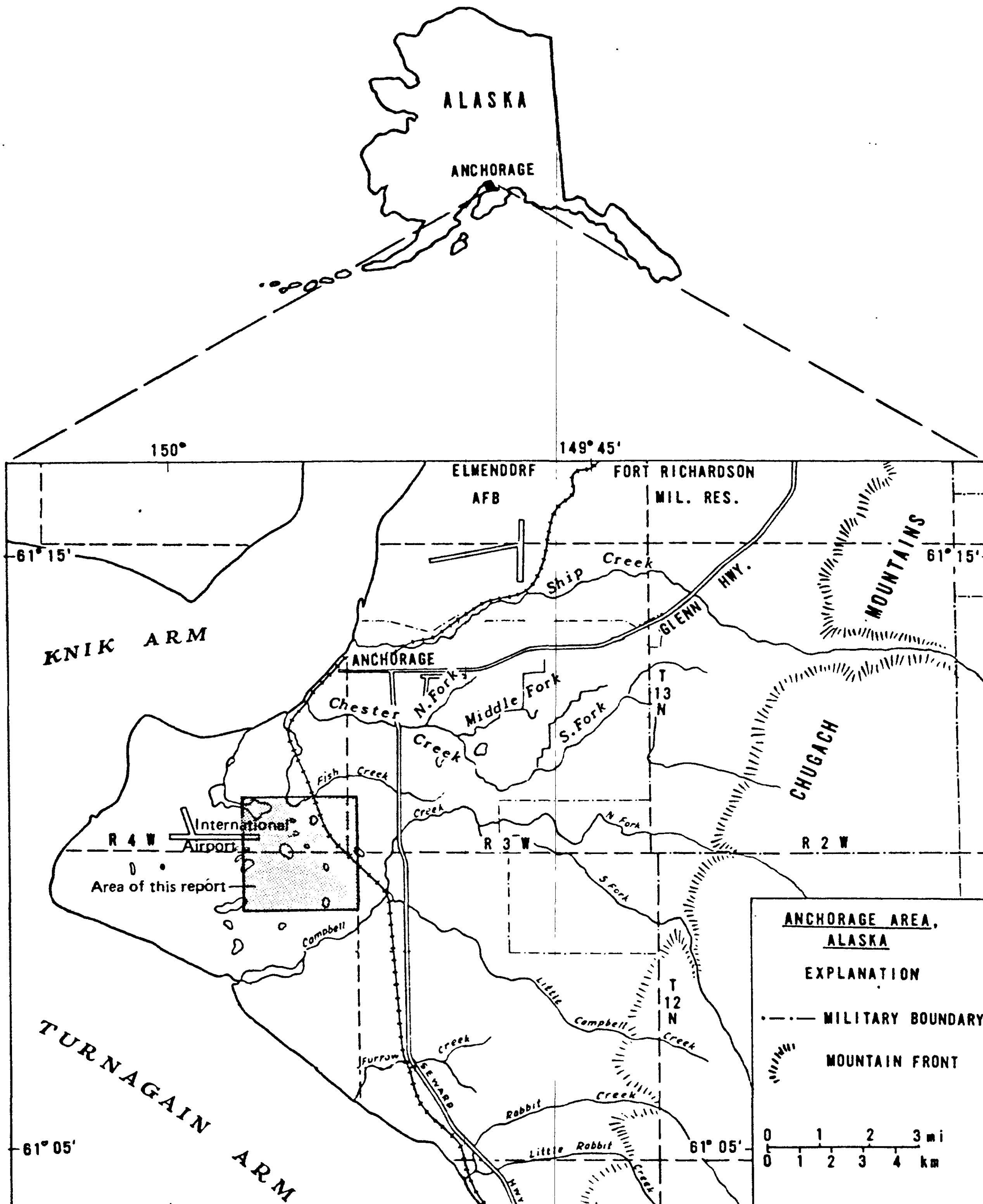
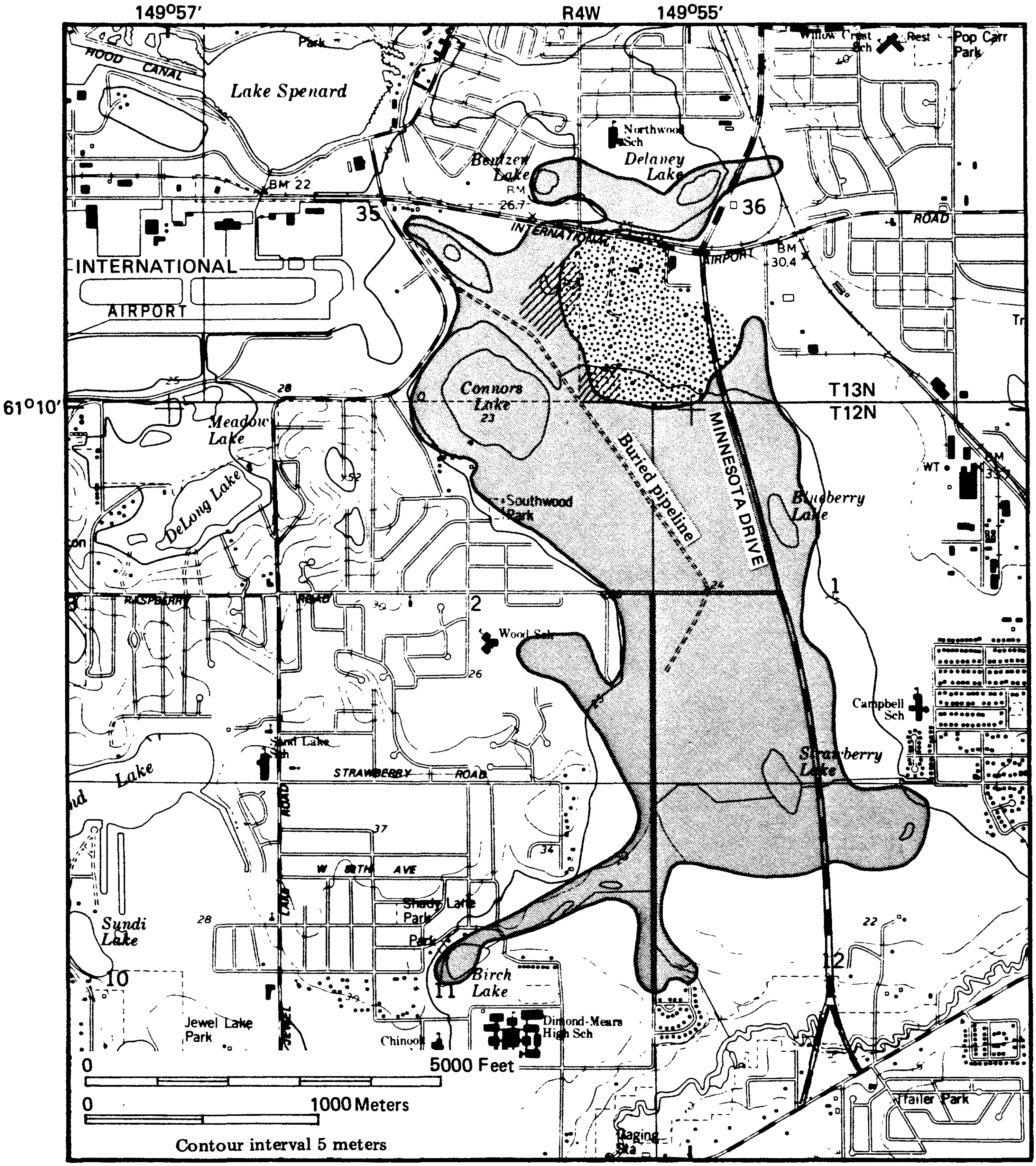


Figure 1.--Location of Connors Bog.



Base from U.S. Geological Survey, Anchorage (A-8) NW Quadrangle, 1:25,000, 1979

EXPLANATION

Connors Bog

Landfill

Snow-disposal site

Figure 1.--Continued.

The land surface south and southeast of Connors Lake is much wetter than other parts of the study area and is less disturbed. String bogs, parallel ridges up to 3 ft high consisting of bog and moss vegetation separating shallow ponds, are scattered throughout this area.

Previous investigations relating to Connors Bog and nearby areas include a management plan for Anchorage's wetlands (Municipality of Anchorage, 1982), a hydrologic overview of Anchorage's wetlands (Fugro Northwest, 1980), a study of the geology and hydrology of this lowland lake area in Anchorage (Zenone, 1976), and studies of water quality and geohydrology at the landfill (Zenone and Donaldson, 1974; Zenone and others, 1975). Hogan and Tande (1982) described the wetland's vegetation types and patterns of vegetation in relation to drainage. An evaluation of the environmental impact on ground water from any hazardous wastes from the landfill concluded that "there is no indication of a threat to the public's health from the ground water in the unconfined aquifer beneath the International Airport Road Sanitary Landfill." (Ecology and Environment, Inc., 1981, p. 57).

Personnel from U.S. Geological Survey have collected water-level and water-quality data from wells in the Connors Bog area intermittently since 1973. Observation wells 1 through 10 are cased with 4-inch diameter steel casing, well 11 is cased with 6-inch steel casing, and wells 12 through 36 are cased with 2-inch PVC casing. Well 11 is completed in a confined aquifer; all others are completed in an unconfined aquifer. (See well locations on figures 3 and 4 later in report).

GEOLOGIC SETTING

Connors Bog lies within an extensive muskeg and lake complex in the western part of the Anchorage glacial plain. The geohydrology of this lowland-lake area is discussed by Zenone (1976).

Lithologic logs from the 36 observation wells (table 1) drilled for this or previous U.S. Geological Survey studies, and numerous test holes drilled for design and construction of a buried pipeline (Shannon and Wilson, Inc., 1969), roads, and proposed commercial developments provide the basis for the following discussion of the near-surface stratigraphy.

Peat, composed chiefly of coarse to decomposed sphagnum moss and sedge fibers, is present at the surface in all "undisturbed" areas. The peat is typically 4 to 12 ft thick south of Connors Lake and the landfill, but is 5 ft thick or less north of the lake.

Underlying the peat is a layer that is primarily sand but also contains gravel and silt. The thickness of the sand unit ranges from 11 ft near Minnesota Drive (at well 29) to 57 ft beneath the landfill (at well 11). Near the southwestern part of the landfill (at wells 33, 35, and 36) it is 20 to 26 ft thick.

Beneath the peat and sand is a poorly permeable layer of silty clay and clayey silt, which is known locally as the Bootlegger Cove Formation of Pleistocene age. The formation is less than 15 ft thick at Lake Spenard (0.3 mi northwest of study area), 75 to 164 ft thick at Raspberry Road, 150 to 195 ft thick beneath hills 0.3 mi southwest of Connors Lake, and is more than 50 ft thick beneath the study area (Ulery and Updike, 1983, pl. 3). At well 11 in the landfill, the Bootlegger Cove Formation is made up of 16 ft of clay and 42 ft of clay with sand and gravel.

Glacial deposits underlie the Bootlegger Cove Formation. These generally poorly sorted mixtures of clay, silt, sand, and gravel are several hundreds of feet thick. About half of the water used for public supply in Anchorage is pumped from wells that tap these deposits throughout the Anchorage area.

HYDROLOGY

The inflow of water to an area is balanced by water outflow and changes in water storage. In Connors Bog, the major component of water inflow is precipitation, which averages about 15 in/yr at adjacent International Airport. Ground-water inflow, surface runoff, and water from snow-disposal operations add relatively minor amounts of water. The main component of water outflow is evapotranspiration; estimates of evapotranspiration for this area range from 10 to 20 in. (Zenone, 1976). In comparison, ground-water flow and surface runoff are considered to be minor components of outflow. No streams flow into or out of the study area, but water flowing through culverts under Minnesota Drive may add minor amounts of surface water; no measurable flows were observed at those culverts in 1984.

GROUND WATER

Ground water is present in all geologic units and is the result of the infiltration and downward movement of water from the surface. Water in peat and sand is unconfined whereas water in glacial deposits is confined by the Bootlegger Cove Formation.

In 1984, the water table (the top surface of the unconfined ground-water body) was typically between 1 and 6 ft below land surface south of Connors Lake and south of the landfill, and from 2 to 16 ft below land surface north of the lake (table 2). Beneath the landfill, the water table was as much as 25 ft below the top of fill materials; most of the landfill's refuse is above the water table.

Water levels in wells completed in the unconfined aquifer generally were highest in late spring, due to recharge from snowmelt, and lowest in late winter when recharge was negligible. Hydrographs of water levels in wells 5 and 7 are shown in figure 2. Water levels in the confined aquifer (measured in well 11) were highest in winter and lowest in summer, when ground-water pumpage in the Anchorage area is greatest, which may indicate that the influence of pumping extends into the study area.

A water-table map (fig. 3) drawn from water levels measured on August 1, 1984 indicates a northeast-southwest trending ground-water divide in the southeastern part of the study area. Water flows into the study area from the northeast and southwest and flows out of the area towards the northwest and south. Water that has moved through or beneath the landfill eventually flows northwestward towards Knik Arm, not southward towards Campbell Creek. Ground-water levels adjacent to Connors Lake are virtually the same as the water level in the lake. In summer 1984, the water level in well 30, in the northwestern part of study area, was about 12 ft lower than Connors Lake and about 5 ft lower than Lake Spenard, 0.3 mi northwest of well 30.

The slope of the water table and the hydraulic conductivity of aquifer materials affect the rate of ground-water movement. The slope of the water table ranges from about 4 ft/mi between well 23 and Connors Lake to about 42 ft/mi between wells 13 and 30. The hydraulic conductivities of woody peat and deep, undecomposed sphagnum moss peat commonly range from about 1.6 to 3 ft/d (Boelter, 1965, p. 230). Representative values of hydraulic conductivity for fine and coarse sand are 8.2 and 148 ft/d, respectively (Todd, 1980, p. 71). Assuming a porosity of 0.85 for peat and 0.4 for sand, and hydraulic gradients between 4 and 42 ft/mi, the rate of ground-water movement (average linear velocity) would range from 0.5 to 10 ft/yr through peat and from 5.7 to 1,070 ft/yr through sand. Differences in water quality near the landfill suggest that ground-water movement is less than 72 ft/yr; water samples collected from wells more than 500 ft from the landfill have no detectable levels of pollution.

Water levels in some wells completed at depths near the water table were at times 1 ft or more higher than those in adjacent wells completed 10 to 15 ft below the water table. Such water-level relations indicate a downward component of ground-water flow in addition to horizontal flow. Changes in water quality with depths confirm this downward-flow component.

In 1984, the potentiometric surface of the confined aquifer (as indicated by water levels in well 11 and in a 243-ft deep observation well 0.8 mi southeast of study area) was about 20 ft lower than the water table in the study area. Such water-level relations suggest that water from the unconfined aquifer recharges the confined aquifer by vertical leakage. However, even though the hydraulic gradient through the Bootlegger Cove Formation is downward, only a small amount of water flows through the poorly permeable silt and clay beneath the study area. Assuming a 20 ft difference in head over a 50 ft layer of silt and clay that has a hydraulic conductivity of 0.0002 ft/d [a value reported by Nelson (1982) for a silt and clay layer at Merrill Field, 4.2 mi northeast of study area], less than 0.4 in. of water per year (per unit area) would infiltrate through the layer to recharge the confined aquifer.

GROUND-WATER QUALITY

The composition and concentration of substances dissolved in water depend on the chemical composition of the source water, the chemical composition and physical structure of the rocks through which the water moves, water-movement rates, and biological and chemical reaction rates. The suitability of water for an intended use depends both on the substances dissolved in the water and on certain properties and characteristics, such as hardness and pH, that these substances impart to the water. Tables 3 and 4 show selected results of analyses of water collected from wells and Connors Lake since 1973 by U.S. Geological Survey personnel. During sampling, water was

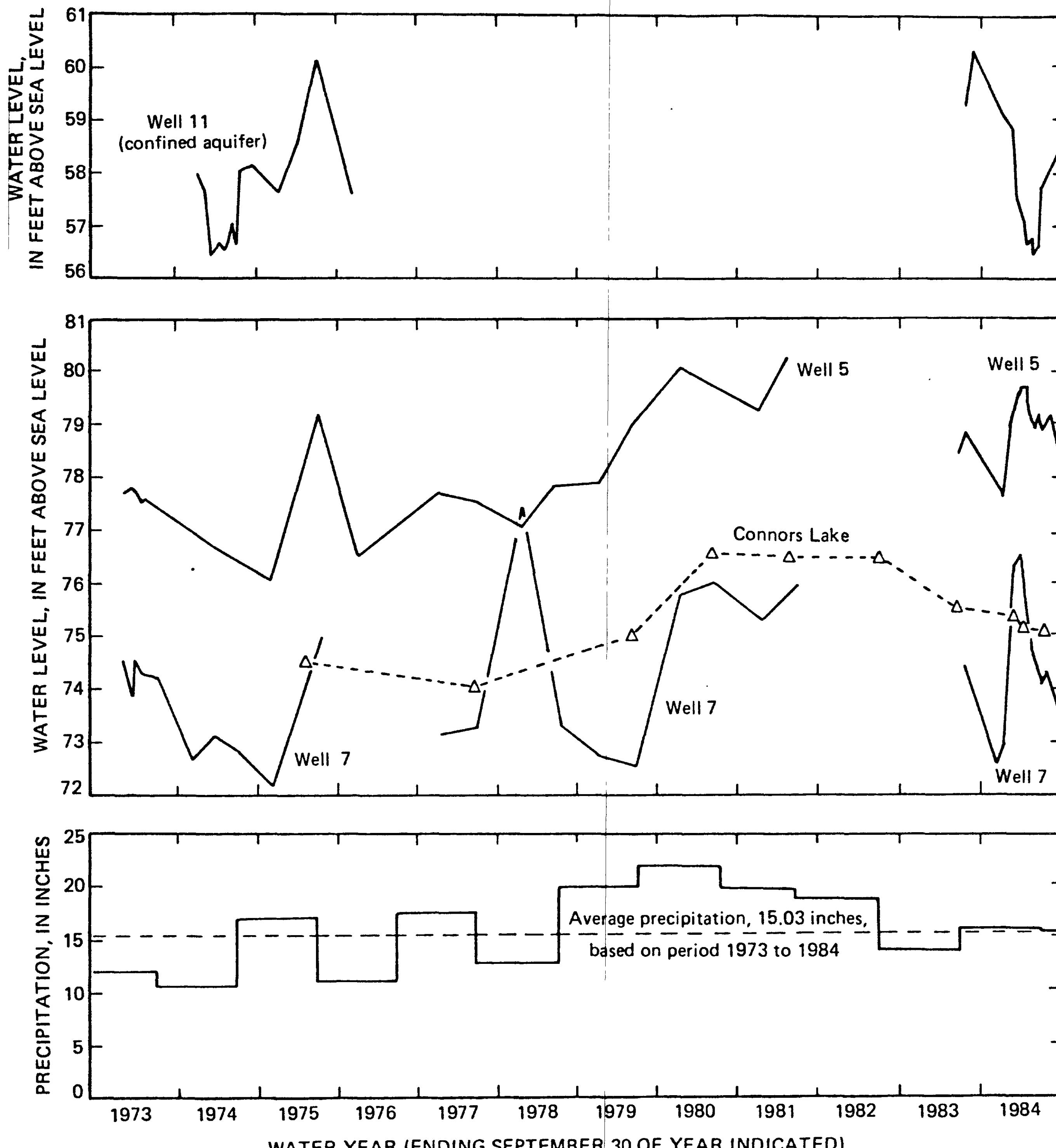
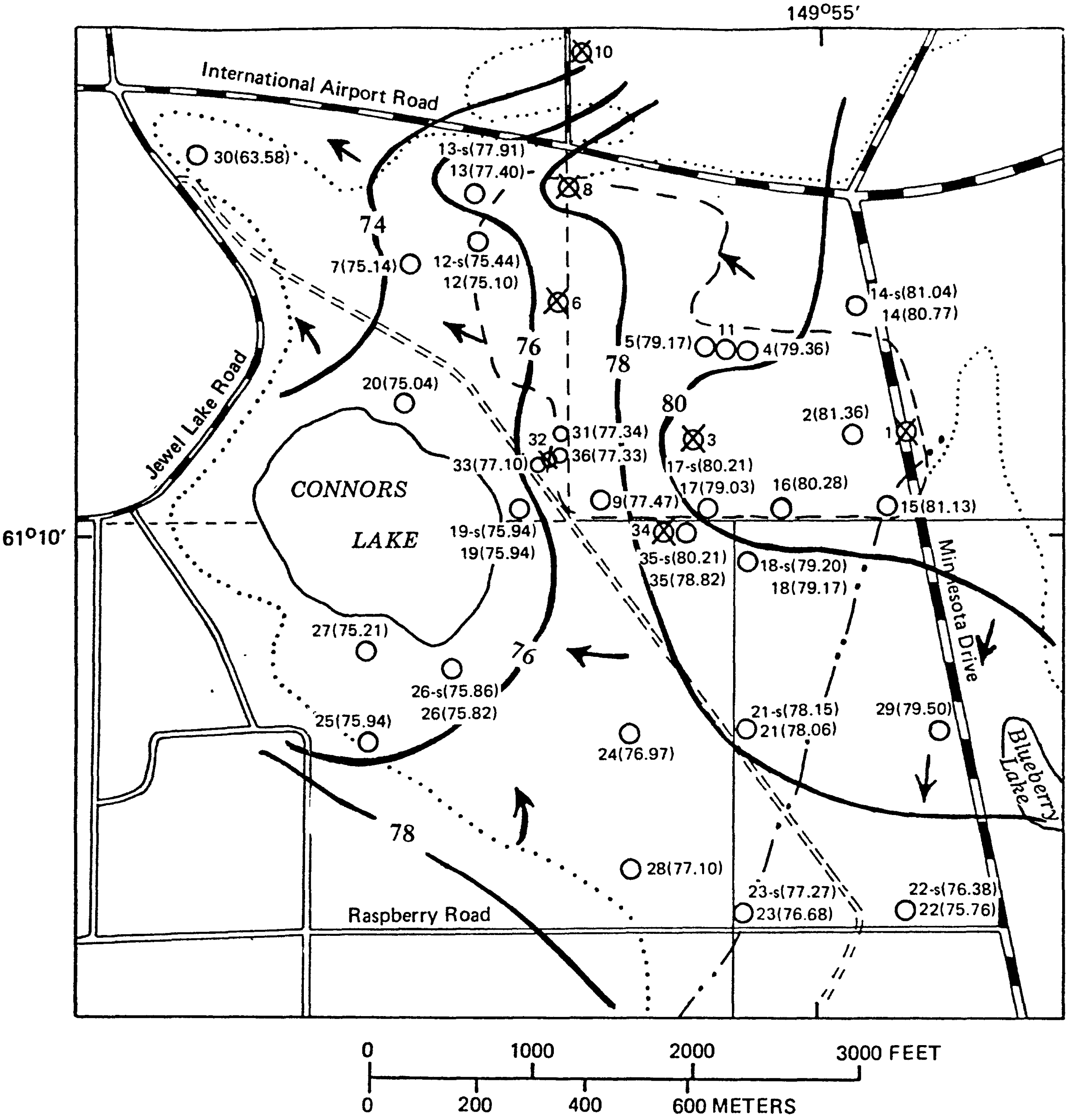


Figure 2.--Annual precipitation at Anchorage International Airport and water levels of three observation wells and Connors Lake.



EXPLANATION

—76— Potentiometric contour--shows altitude at which water level would have stood in tightly cased wells. Contours are approximately located. Contour interval 2 feet. Datum is sea level.

← Generalized direction of ground-water movement.

— · · — Ground-water divide--approximately located.

— — — Approximate extent of International Airport Road Sanitary Landfill.

· · · · · · · · · Boundary of Connors Bog.

○ 18-s(79.20) 18(79.17) Observation well and number. Number in parentheses is altitude of water surface in feet above sea level. Where two numbers, top is from shallow well and bottom is from deeper well at same location.

8⊗ Destroyed observation well and number.

Figure 3.--Observation wells, water table and inferred directions of ground-water movement, August 1, 1984.

pumped from each well until at least three casing volumes of water were extracted and the temperature and specific conductance of the water stabilized.

Water-quality Types

Water-quality types are based on the relative percentage of cations and anions in the water. Analyses showed a variety of water-quality types. In unconfined ground water in the wetland and beneath the landfill, calcium and bicarbonate (as indicated by "alkalinity" in table 4) were generally the predominant dissolved cation and anion. However, the predominant ions in water from well 7 were calcium, sulfate, and bicarbonate. In confined ground water collected from well 11 the main dissolved ions were magnesium, calcium, and bicarbonate.

Water-quality variation near and beneath the landfill is perhaps partially due to differences in age and composition of refuse materials, distance from refuse materials, and local geologic and flow conditions.

Specific Conductance

The specific conductance of water is an easily measured property which is directly proportional to the water's dissolved-solids content; thus specific conductance is an indicator of overall chemical quality. The concentration (in milligrams per liter) of dissolved solids in ground water in the Connors Bog area and in water from Connors Lake is approximately 0.65 times the numerical value of specific conductance.

Specific conductance of ground water samples has ranged from 60 µS/cm to 7,000 µS/cm, which represents a range of dissolved solids from about 39 to about 4,550 mg/L. Water samples collected from the unconfined aquifer beneath and adjacent to the landfill in spring 1984 had specific conductance values between 430 and 4,000 µS/cm (fig. 4). At distances greater than 500 ft from the landfill, however, specific conductance values were between 60 and 510 µS/cm. Samples collected in other seasons had comparable values.

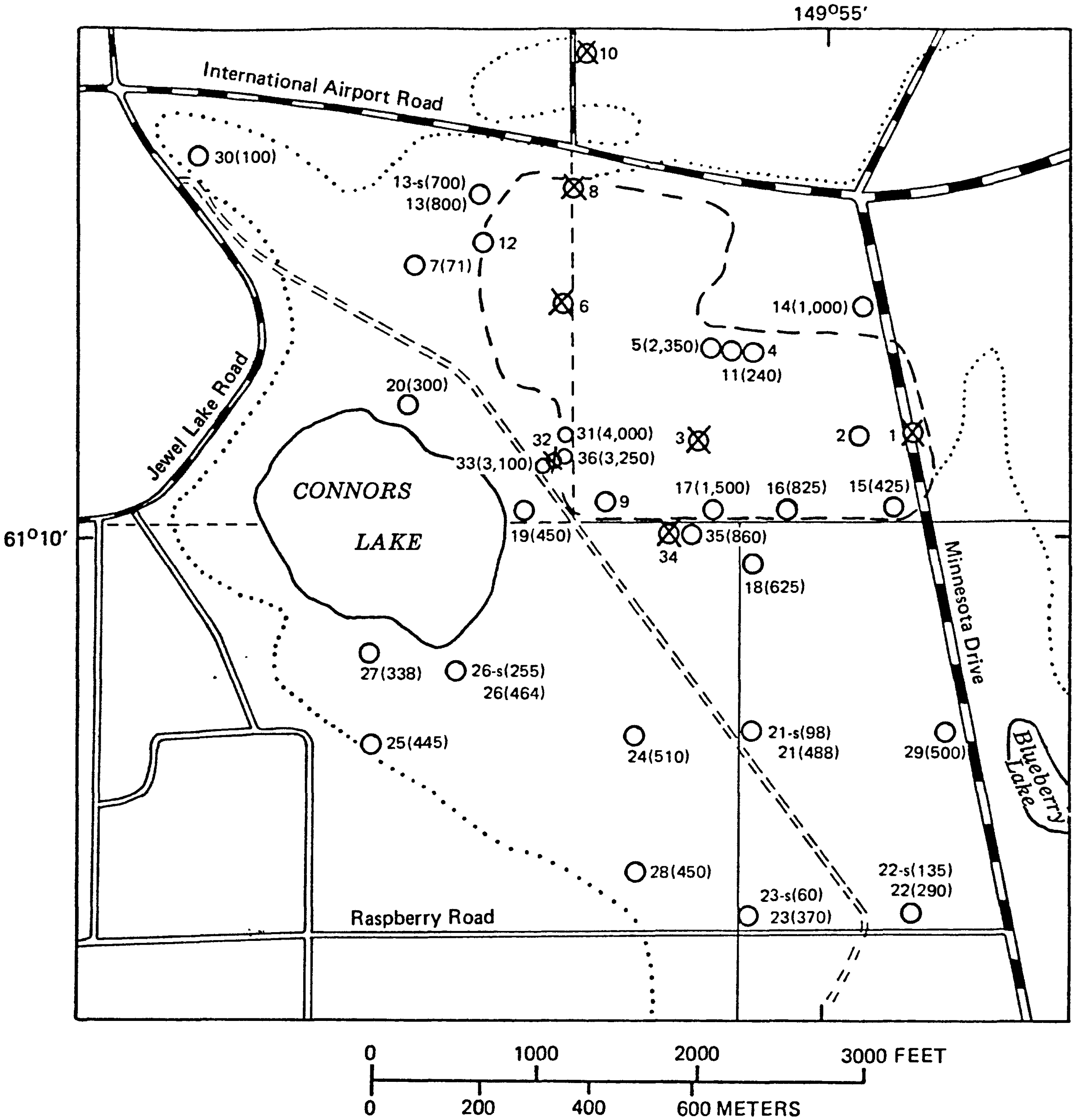
Water from shallow wells had lower values of specific conductance than did adjacent, deeper wells that were completed in the same unconfined aquifer. For example, water from a shallow well at site 21 (depth 7.7 ft) had a specific conductance of 98 µS/cm in May 1984, whereas water from an adjacent well (depth 18 ft) had a specific conductance of 488 µS/cm. This water-quality change corroborates the existence of a downward component of ground-water flow indicated by head differences between the unconfined and confined aquifers.

Wells 7 and 30, completed in the shallow, unconfined aquifer, are hydraulically downgradient from the landfill and a snow-disposal site. Water samples from these wells have low specific conductance values, indicating that leachate from landfill and snow-disposal operations has not yet reached these sites, that the leachate is diluted or attenuated before reaching these wells, or that the wells are missing the leachate plume, if one exists. The plume might not be detected if it did not flow past the wells or if it flowed only through the lower part of the aquifer. However, these are unlikely because some of the constituents that make up the plume tend to spread out in the direction of flow due to mixing and molecular diffusion. A sample from well 14 (also completed in the unconfined aquifer), near Minnesota Drive and the northeastern edge of the landfill, had a specific conductance of 1,000 µS/cm in May 1984. This high value suggests that leachate from the landfill and (or) de-icing salts in surface runoff from Minnesota Drive are present in this area.

A water sample from well 11, completed in the deep, confined aquifer had a specific conductance of 240 µS/cm, indicating that leachate from the landfill and water from the wetland's unconfined aquifer are not major sources of water to the confined aquifer.

Chloride

Chloride is readily leached into water as water migrates through landfill refuse. It may also be present in high concentrations in runoff from roads that have been salted (such as the roads bordering the study area) or in snow that has been removed from these roads. Chloride is relatively nonreactive and during migration in the ground-water system it is not readily attenuated by adsorption, ion exchange, precipitation, co-precipitation, or biochemical degradation. Thus, chloride is a good indicator of contamination.



EXPLANATION

••••••••	Boundary of Connors Bog.
— — —	Approximate extent of International Airport Road Sanitary Landfill.
O 21-s(98) 21(488)	Observation well and number. Number in parentheses is specific conductance of water in microsiemens per centimeter at 25 degrees Celsius. Where two numbers, top is from shallow well and bottom is from deeper well at same location.
8⊗	Destroyed observation well and number.

Figure 4.--Specific conductance of ground water in the Connors Bog area, April 30 to May 16, 1984.

Water near and beneath the landfill contains chloride concentrations much greater than the natural ground water in Connors Bog. Ground water distant from the landfill has less than 10 mg/L dissolved chloride, whereas highly contaminated water has concentrations greater than 100 mg/L. In 1984, the highest chloride concentrations, 290 and 360 mg/L, were found in water from wells 31 and 33, respectively, near the southwest corner of the landfill (table 4). Wells 18 and 35 near the southern edge of the landfill yielded water that contained 41 and 49 mg/L chloride, respectively, (table 4), indicating that leachate has also moved in that direction. Water from well 11 in the confined aquifer had the lowest chloride concentration (1.7 mg/L) sampled. In comparison, the recommended maximum concentration of dissolved chloride in drinking water is 250 mg/L (U.S. Environmental Protection Agency, 1977).

Iron and Manganese

In some locations the natural concentrations of iron and manganese and a yellow-brown color make unconfined ground water unsuitable for most uses without treatment. In 1984, concentrations of iron and manganese beneath the landfill were as high as 120,000 µg/L and 4,700 µg/L, respectively, but extremely high concentrations (as great as 15,000 µg/L iron and 1,100 µg/L manganese) were also present in ground water distant from the landfill. Water containing less than 300 µg/L iron and less than 50 µg/L manganese is preferred for domestic uses and many industrial processes.

Organic Substances

Dissolved organic substances of natural origin occur normally in all ground water. Most dissolved organic matter in subsurface flow is fluvic and humic acid, and concentrations of dissolved organic carbon in the range 0.1 to 10 mg/L (100 to 10,000 µg/L) are common in ground water (Freeze and Cherry, 1979, p. 86). Many organic substances, including biodegradable materials and many pollutants, tend to break down by oxidation and by bacterial action in the unsaturated zone. Certain earth materials, especially clay and peat, also may absorb certain complex organic pollutants and trace metals, so that the concentrations of these constituents decrease as they move through the ground-water system.

Gas chromatography can be used to indicate the presence of many organic compounds, including many that are toxic or cause cancer. However, gas chromotography has some limitations: it may underestimate the concentration of an organic constituent; it may fail to detect low molecular weight compounds and halogenated compounds; and it may detect, identify, and quantify fewer than half of the organic constituents in a sample.

Gas chromatographic scans using a flame ionization detector (GC/FID) were used to estimate total concentrations of organic substances in water from eight wells (table 4). In 1984, the highest concentration of organics, 790 µg/L, was from water from well 5, which is completed beneath landfill refuse; the lowest concentration, 34 µg/L, was from water from well 35, which is about 100 ft south of the landfill. Two wells distant from the landfill yielded water that had concentrations of 66 and 96 µg/L. Well 11, completed in the confined aquifer, yielded water that had 39 µg/L of total organics.

Water samples from four wells in or near the landfill were analyzed to determine if any of 27 purgeable organic pollutants were present. In water from wells 7, 31, and 35, the concentration of each organic compound was less than the limit of analytical detection, 3 µg/L. The sample from well 5 yielded water that contained benzene, ethyl benzene, methylene chloride, toluene, and dichloroethylene (table 5). These substances are believed to cause cancer or are toxic to humans. The U.S. Environmental Protection Agency's (1980) concentration limits for three of these substances in ambient water are: benzene, 0.66 µg/L (for a cancer risk level over lifetime of one in one million); ethyl benzene, 1,400 µg/L; and toluene, 14,300 µg/L. Organic substances other than the above four may also be present in low concentrations in the leachate and may be derived from refuse materials. Zenone and others (1975, p. 184) report that the sources of refuse materials added to the landfill during 1973-74 were 50.4 percent residential, 28.2 percent commercial, 8.3 percent demolition materials, and 0.8 percent industrial.

CONNORS LAKE

Connors Lake occupies a depression that extends below adjacent ground-water levels. In 1984, the lake had a surface area of about 40 acres and a maximum depth of about 9 ft. It has no observable surface inlet or outlet. Water in the lake is brown and the bottom sediments are organic rich.

Water levels in Connors Lake have been measured intermittently by U.S. Geological Survey personnel since 1975 and have ranged from 74.0 to 76.5 ft above sea level (fig. 2). Prior to 1975, however, lake levels may at times have been as much as a foot higher than those measured, based on aerial photographs and the lake's shoreline. Lake levels appear to lag about one year behind annual precipitation (measured from October through September so that autumn and winter snows are grouped together) (fig. 2). Precipitation was above average during water years 1979 through 1982 whereas measured lake levels were highest from 1980 through 1982. Lake levels declined in 1983, when precipitation was below average, and continued to decline in 1984, even though precipitation was slightly above average.

In April 1984, ground-water levels within a few hundred feet of Connors Lake were slightly (as much as 1 ft) higher than the lake surface, indicating ground-water flow toward the lake. During summer and autumn, ground-water levels to the east and south of the lake were as much as 1 ft higher than the lake surface, and to the north were about 0.5 ft lower, indicating possible lake recharge from the east and south and lake discharge to the north.

On June 28, 1984, the water column in the lake was unstratified: the temperature of water near (at a depth of 0.5 ft) the surface was 16.6 °C, water near the middle of the water column was 16.5 °C, and water near the bottom (and at a depth of 7.6 ft) was 15.8 °C. Specific conductance was 127 µS/cm throughout the water column. Concentration of dissolved oxygen was 8.7 mg/L near the surface, 8.9 mg/L at a depth of 7.6 ft, and 8.0 mg/L at the bottom (8.2 ft). Results of a chemical analysis of a water sample collected 4.6 ft below the lake's surface in June 1984 are similar to the analysis of a sample collected in 1973 (table 4). Water in the lake had a low dissolved-solids concentration, 72 mg/L, and the predominant ions were calcium and bicarbonate.

The concentration of phytoplanktonic algae in a lake is an indicator of its biological productivity. Lakes that contain less than 7 µg/L chlorophyll a (a photosynthetic pigment found in all algae) are considered oligotrophic (nutrient poor), whereas lakes that contain more than 12 µg/L chlorophyll a are considered eutrophic (nutrient rich) (Taylor and others, 1980). Eutrophic conditions are generally undesirable because they result in deterioration of cold-water fisheries and aesthetics of lakes. In June 1984, the concentration of phytoplankton chlorophyll a was 0.9 µg/L, indicating that the lake has a low rate of productivity.

Rates of lake productivity are regulated to a large extent by inorganic nutrients, especially phosphorus and nitrogen. Concentrations of phosphorus and nitrogen in Connors Lake (table 4) are considered low to intermediate.

SUMMARY AND CONCLUSIONS

Water-level and water-quality data collected in 1984 and intermittently since 1973 were analyzed to determine the direction of ground-water flow and the chemical quality of water in the northern part of Connors Bog, a wetland in Anchorage, Alaska.

Water is present in peat and sand and is unconfined; water in glacial deposits that underlie a poorly permeable layer of silt and clay is confined. The main source of unconfined water is precipitation, which averages about 15 in/yr. The main component of water outflow is evapotranspiration, estimates of which range from 10 to 20 in/yr. Ground-water flow and surface runoff are minor components of inflow and outflow.

Unconfined ground water flows into Connors Bog from the northeast and southwest and flows out of the area to the northwest and south. Water-level relations indicate that during most of 1984, ground water flowed into Connors Lake from the south and east and out of the lake as ground water to the north. Water from the unconfined aquifer recharges the confined aquifer, but the volume of recharge from this area is minimal because the aquifers are separated by a poorly permeable layer of silt and clay.

In some locations, natural concentrations of iron and manganese and a yellow-brown color make unconfined ground water unsuitable for most uses without treatment.

A leachate was detected beneath and near an abandoned landfill. The leachate had higher concentrations of dissolved solids, dissolved chloride, and total organics than those of the area's natural water. Four organic pollutants were present in leachate beneath the landfill, but concentrations of 27 organic pollutants were below detection limits in water from wells downgradient from the landfill. The leachate has migrated less than 500 ft, or has attenuated in concentration laterally within a short distance from the landfill. This leachate does not pose an immediate hazard to the confined aquifers that Anchorage uses for municipal water supply, to Connors Lake, or to Connors Bog because (1) beneath the landfill a poorly permeable layer of silt and clay more than 50 ft thick separates the leachate from the confined aquifer; (2) ground-water movement is slow, allowing many of the contaminants to be attenuated by physical, chemical, and biochemical processes before they travel very far; and (3) the concentrations of the leachate's substances that do not attenuate, such as chloride, do not greatly exceed quality criteria for drinking water.

The water table in 1984 indicates that water that has flowed through or beneath the landfill may initially flow towards the southwest, west, or northwest, but eventually it flows northwestward towards Knik Arm.

Connors Lake is a shallow lake that has no suface inlet or outlet. The lake level seems to respond, with about a year lag, to variations in annual precipitation. Water levels in nearby wells indicate that ground water moves toward Connors Lake from the east and south. The quality of water in the lake in 1984 indicates that the lake has not been adversely impacted by nearby residential development, snow-disposal operations, or landfill operations.

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Table 1.--Lithologic logs and descriptions of observation wells in the Connors Bog area

[S, shallow well adjacent to deep well at same location; ft, feet]

Well number	Total depth of well below land surface, in feet	Depth of perforations below land surface, in feet	Lithology, depth below land surface
1	18	13-18	0-4.5 ft, peat; 4.5-13 ft, sand; 13-18 ft, sand and gravel.
2	18	13-18	0-3.5 ft, peat; 3.5-12 ft, sand; 12-18 ft, sand and gravel.
3	18	13-18	0-1 ft, fill; 1-9 ft, refuse; 9-13 ft, peat; 13-14 ft, peat and sand; 14-18ft, sand.
4	29	24-27	0-17 ft, garbage; 17-23 ft, garbage, mud, and sand; 23-29 ft, sand.
5	46	38-46	0-17 ft, garbage; 17-24 ft, garbage, mud, and sand; 28-46 ft, gravel and sand.
6	18	15-16	0-1 ft, peat; 1-4 ft, silt; 4-10 ft, sand; 10-13 ft, silty clay; 13-18 ft, sand, trace silt and gravel.
7	23	15-23	0-1 ft, peat; 1-3.5 ft, silt; 3.5-10 ft, sand; 10-23 ft, gravel and sand.
8	28	20-28	0-3 ft, fill; 3-12 ft, sand; 12-14.5 ft, sand and gravel; 14.5-23 ft, silt; 23-28 ft, silt and gravel.
9	17.5	13-17	0-4.5 ft, peat; 4.5-6.5 ft, sand; 6.5-17.5 sand and gravel.
10	33	28-33	0-4.5 ft, peat; 4.5-11 ft, sand and trace gravel; 11-29 ft, silt and trace gravel; 29-33 ft, silt and sand.
11	.145	145	0-27 ft, garbage; 27-30 ft, peat; 30-40 ft, sand and gravel; 40-87 ft, sand; 87-103 ft, clay; 103-123 ft, clay, sand, and gravel; 123-145 ft, clay and gravel; 145 ft, sand and gravel.
12-S	12.7	10.5-12.5	0-3 ft, peat; 3-25 ft, sand.
12	24	19-24	
13-S	8.5	6.5-8.5	0-4 ft, peat; 4-18 ft, sand; 18-20 ft, sand and trace gravel.
13	19.2	17-19	
14-S	7.5	5.5-7.5	0-7 ft, peat; 7-20 ft, sand.
14	19.5	17.5-19.5	
15	16.9	14.9-16.9	0-5 ft, peat; 5-13 ft, sand; 13-14 ft, sand, trace silt; 14-18 ft, sand.
16	11.7	9.7-11.7	0-6 ft, peat; 6-18 ft, sand.
17-S	5.1	3.1-5.1	0-7 ft, peat; 7-20 ft, sand.
17	19.1	17-19	
18-S	5	3-5	0-6 ft, peat; 6-20 ft, sand.
18	18	16-18	
19-S	7.5	5.5-7.5	0-4 ft, peat; 4-25 ft, sand.
19	22	20-22	
20	12	10-12	0-5 ft, peat; 5-18 ft, sand.
21-S	7.7	5.5-7.7	0-7 ft, peat; 7-18 ft, sand.
21	18	16-18	
22-S	8.4	6.4-8.4	0-7 ft, peat; 7-20 ft, sand.
22	19	17-19	
23-S	8.2	6-8	0-8 ft, peat; 8-18 ft, sand.
23	15.5	13.5-15.5	
24	18	16-18	0-4 ft, peat; 4-18 ft, sand.
25	17	12-17	0-4.5 ft, peat; 4.5-18 ft, sand.
26-S	9.2	7-9	0-5 ft, peat; 5-18 ft, sand.
26	18	16-18	
27	18.5	16.5-18.5	0-4.5 ft, peat; 4.5-18 ft, sand.
28	18	16-18	0-6 ft, peat; 6-20 ft, sand.
29	19	17-19	0-7 ft, peat; 7-18 ft, sand; 18-20 ft, clayey silt.
30	17	15-17	0-2 ft, fill; 2-20 ft, sand.
31	11.2	9-11	0-5 ft, peat; 5-15 ft, sand.
32	18	16-18	0-2 ft, peat; 2-22 ft, sand; 22-40 ft, silt and sand; 40-45 ft, silt.
33-S	3.9	1.9-3.9	0-4 ft, soil; 4-24 ft, sand; 24-25 ft, silt.
33	24	19-24	
34	--	--	0-6 ft, peat; 6-30 ft, sand.
35-S	5.4	3.4-5.4	0-7 ft, peat; 7-33 ft, sand; 33-35 ft, clayey silt.
35	33.2	28-33	
36-S	4.2	2-4	0-2 ft, soil; 2-22 ft, sand; 22-25 ft, clay and silt.
36	21.5	15-21	

Table 2.--Measurements of ground-water levels

[Water in feet below land surface datum. Datum is altitude of land surface at the time each well was drilled]

OBSERVATION WELL 1
ALTITUDE OF LAND SURFACE DATUM 85.0 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAY 07, 1973	2.64	OCT 03, 1973	2.65	OCT 15, 1975	1.14	SEP 26, 1978	2.98
JUN 14	2.75	MAR 22, 1974	5.12	APR 15, 1976	4.18	APR 17, 1979	2.14
28	2.87	JUN 12	3.87	APR 14, 1977	2.91	SEP 25	1.65
AUG 02	3.27	OCT 08	3.67	SEP 29	2.53	APR 24, 1980	0.93
29	2.64	MAR 25, 1975	5.17	APR 11, 1978	4.08		

OBSERVATION WELL 2
ALTITUDE OF LAND SURFACE DATUM 84.38 FEET
(ALTITUDE OF LAND SURFACE DURING 1984 WAS 96 FEET)

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAY 07, 1973	3.94	JUN 12, 1974	4.55	APR 03, 1984	3.68	AUG 01, 1984	3.02
JUN 14	3.82	MAR 25, 1975	5.49	MAY 01	2.90	15	3.37
28	3.90	OCT 15	1.86	31	1.99	31	2.60
AUG 02	4.23	APR 16, 1976	5.64	JUN 14	2.13	SEP 26	2.65
29	3.73			29	2.50	OCT 16	2.26
MAR 22, 1974	5.90	NOV 02, 1983	2.67	JUL 11	2.66		

OBSERVATION WELL 3
ALTITUDE OF LAND SURFACE DATUM 85.0 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAY 07, 1973	3.43	AUG 29, 1973	3.87	OCT 08, 1974	2.84		
JUN 14	3.69	OCT 03	3.97	MAR 25, 1975	2.98		
28	3.80	MAR 21, 1974	4.69	OCT 16	6.55		
AUG 02	3.90	JUN 12	2.76	APR 15, 1976	7.92		

OBSERVATION WELL 4
ALTITUDE OF LAND SURFACE DATUM 96.56 FEET
(ALTITUDE OF LAND SURFACE DURING 1984 WAS 104 FEET)

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAY 07, 1973	18.35	OCT 03, 1973	18.33	OCT 21, 1983	17.42	AUG 01, 1984	17.20
09	18.25	MAR 21, 1974	19.82	APR 03, 1984	18.70	15	17.42
JUN 14	18.19	JUN 12	21.27	MAY 01	18.32	31	17.18
28	18.25	MAR 26, 1975	20.11	31	16.78	SEP 26	17.44
AUG 02	18.46			JUN 14	16.66		
14	18.44	AUG 15, 1983	17.50	29	16.62		
29	18.30	SEP 22	17.85	JUL 11	16.96		

OBSERVATION WELL 5
ALTITUDE OF LAND SURFACE DATUM 96.64 FEET
(ALTITUDE OF LAND SURFACE DURING 1984 WAS 103 FEET)

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAY 07, 1973	18.95	APR 16, 1976	20.12	APR 06, 1981	17.43	JUN 14, 1984	16.94
09	18.86	APR 14, 1977	18.91			29	16.89
JUN 14	18.76	SEP 29	19.08	SEP 16	16.17	JUL 11	17.20
28	18.85	APR 13, 1978	19.57	SEP 22, 1983	18.14	AUG 01	17.47
AUG 02	19.03	SEP 26	18.79	OCT 21	17.77	15	17.69
14	19.01	APR 17, 1979	18.75	APR 03, 1984	18.98	31	17.46
15	19.03	19	18.73	MAY 01	17.66	SEP 26	17.72
MAR 26, 1975	20.54	SEP 25	17.64	07	17.50	OCT 16	17.45
OCT 15	17.42	APR 24, 1980	16.60	31	17.07	DEC 31	18.50

OBSERVATION WELL 6
ALTITUDE OF LAND SURFACE DATUM 82.7 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAY 07, 1973	5.9	AUG 02, 1973	6.50	MAR 22, 1974	8.08		
JUN 14	6.19	29	6.35	JUN 13	7.96		
28	6.25	OCT 31	6.64	OCT 08	8.10		

Table 2.--Continued

OBSERVATION WELL 7
ALTITUDE OF LAND SURFACE DATUM 83.38 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAY 07, 1973	8.80	MAR 27, 1975	11.19	SEP 25, 1980	7.39	JUN 29, 1984	7.09
JUN 14	9.49	OCT 16	8.42	APR 06, 1981	8.12	JUL 11	7.60
28	8.78	APR 14, 1977	10.19	OCT 21, 1983	8.90	AUG 01	8.24
AUG 02	9.05	SEP 29	10.09	MAR 14, 1984	10.75	15	8.63
29	9.08	APR 11, 1978	5.95	APR 03	10.34	31	8.80
OCT 03	9.09	SEP 26	9.99	30	8.74	SEP 26	9.17
MAR 22, 1974	10.68	APR 17, 1979	10.66	MAY 05	8.16	OCT 16	9.05
JUN 12	10.20	SEP 25	10.86	31	6.93	DEC 31	9.93
OCT 08	10.54	APR 24, 1980	7.61	JUN 14	6.79		

OBSERVATION WELL 8
ALTITUDE OF LAND SURFACE DATUM 85.5 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAY 07, 1973	9.58	AUG 02, 1973	10.04	MAR 21, 1974	11.47	MAR 27, 1975	11.87
JUN 14	9.24	27	10.03	JUN 13	11.12	OCT 15	8.99
28	9.72	OCT 03	10.12	OCT 08	11.35		

OBSERVATION WELL 9
ALTITUDE OF LAND SURFACE DATUM 82.60 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAY 07, 1973	5.00	JUN 12, 1974	5.95	APR 11, 1978	4.96	SEP 16, 1981	2.73
JUN 14	4.79	OCT 08	5.65	SEP 26	5.49	OCT 11, 1983	4.97
28	4.82	MAR 27, 1975	6.92	APR 17, 1979	4.22	21	4.82
AUG 02	4.99	OCT 16	3.61	SEP 25	4.29	AUG 01, 1984	5.13
29	4.39	APR 15, 1976	7.11	APR 24, 1980	2.97	15	5.43
OCT 03	4.56	APR 14, 1977	5.57	SEP 25	2.70	31	4.84
MAR 27, 1974	6.75	SEP 29	5.05	APR 06, 1981	4.08	SEP 26	5.09

OBSERVATION WELL 10
ALTITUDE OF LAND SURFACE DATUM 78.67 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAY 07, 1973	10.63	AUG 02, 1973	10.92	MAR 22, 1974	12.38	APR 03, 1984	11.98
JUN 14	10.69	29	10.78			MAY 03	11.00
28	10.74	OCT 03	10.90	OCT 31, 1983	11.31		

OBSERVATION WELL 11
ALTITUDE OF LAND SURFACE DATUM 96. FEET
(ALTITUDE OF LAND SURFACE DURING 1984 WAS 104 FEET)

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
APR 25, 1974	38.01	DEC 20, 1974	37.86	APR 03, 1984	36.97	AUG 15, 1984	39.56
MAY 28	38.36	APR 23, 1975	38.38	MAY 03	37.17	31	39.38
JUN 26	39.54	JUL 24	37.41	08	37.70	SEP 26	38.29
JUL 26	39.33	OCT 15	35.89	31	38.43	OCT 16	38.10
AUG 22	39.49	APR 19, 1976	38.38	JUN 14	38.72	DEC 31	37.50
SEP 23	38.91			29	38.96		
OCT 09	39.31	SEP 22, 1983	36.70	JUL 11	39.33		
24	37.95	OCT 21	35.73	AUG 01	39.28		

OBSERVATION WELL 12-S
ALTITUDE OF LAND SURFACE DATUM 81.49 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
JUN 29, 1984	4.72	JUL 18, 1984	5.46	AUG 15, 1984	6.45	SEP 26, 1984	6.87
JUL 11	5.23	AUG 01	6.05	31	6.49		

OBSERVATION WELL 12
ALTITUDE OF LAND SURFACE DATUM 81.49 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
JUN 29, 1984	2.25	JUL 18, 1984	5.46	AUG 15, 1984	6.79	SEP 26, 1984	7.29
JUL 11	5.70	AUG 01	6.39	31	6.83		

OBSERVATION WELL 13-S
ALTITUDE OF LAND SURFACE DATUM 81.8 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAR 07, 1984	6.24	MAY 31, 1984	1.72	JUL 11, 1984	2.87	AUG 15, 1984	4.35
APR 03	5.61	JUN 14	1.90	18	3.22	31	4.01
30	3.54	29	2.26	AUG 01	3.89	SEP 26	4.72

OBSERVATION WELL 13
ALTITUDE OF LAND SURFACE DATUM 81.8 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAR 07, 1984	7.09	MAY 31, 1984	2.84	JUL 11, 1984	3.09	AUG 15, 1984	4.89
APR 03	6.48	JUN 14	2.74	18	3.27	31	4.90
30	4.61	29	2.76	AUG 01	4.40	SEP 26	5.49

OBSERVATION WELL 14-S
ALTITUDE OF LAND SURFACE DATUM 85.3 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
APR 03, 1984	3.14	JUN 14, 1984	3.53	AUG 01, 1984	4.26	SEP 26, 1984	3.60
MAY 01	3.24	29	3.60	15	4.57		
31	3.34	JUL 11	3.85	31	3.76		

OBSERVATION WELL 14
ALTITUDE OF LAND SURFACE DATUM 85.3 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAR 07, 1984	6.30	MAY 31, 1984	3.80	JUL 11, 1984	4.20	AUG 31, 1984	4.21
APR 03	4.88	JUN 14	3.89	AUG 01	4.53	SEP 26	4.37
MAY 01	3.93	29	3.94	15	4.77		

OBSERVATION WELL 15
ALTITUDE OF LAND SURFACE DATUM 84.37 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAR 13, 1984	4.93	JUN 14, 1984	2.22	AUG 01, 1984	3.24	AUG 31, 1984	2.70
MAY 01	1.87	JUL 11	2.71	15	3.64	SEP 26	2.70
31	2.01						

OBSERVATION WELL 16
ALTITUDE OF LAND SURFACE DATUM 83.88 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAR 08, 1984	5.49	MAY 31, 1984	2.40	JUL 19, 1984	3.25	AUG 31, 1984	3.23
APR 03	4.20	JUN 14	2.55	AUG 01	3.60	SEP 26	3.29
MAY 01	2.34	JUL 11	3.08	15	4.01		

OBSERVATION WELL 17-S
ALTITUDE OF LAND SURFACE DATUM 83.04 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
APR 03, 1984	1.40	JUN 14, 1984	1.63	AUG 01, 1984	2.83	SEP 26, 1984	2.33
MAY 01	1.25	JUL 11	2.14	15	3.32		
31	1.52	19	2.47	31	2.43		

OBSERVATION WELL 17
ALTITUDE OF LAND SURFACE DATUM 83.04 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAR 08, 1984	6.00	MAY 31, 1984	2.83	JUL 19, 1984	3.66	AUG 31, 1984	3.75
APR 03	5.04	JUN 14	2.96	AUG 01	4.01	SEP 26	3.94
MAY 01	2.92	JUL 11	3.49	15	4.40		

OBSERVATION WELL 18-S
ALTITUDE OF LAND SURFACE DATUM 82.42 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
APR 03, 1984	2.72	MAY 31, 1984	0.95	JUL 19, 1984	2.67	AUG 31, 1984	2.54
MAY 01	0.89	JUN 14	1.54	AUG 01	3.22	SEP 26	2.28
09	1.10	JUL 11	2.24	15	3.70		

OBSERVATION WELL 18
ALTITUDE OF LAND SURFACE DATUM 82.42 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAR 13, 1984	5.18	MAY 09, 1984	1.90	JUL 11, 1984	2.63	AUG 15, 1984	3.71
APR 03	4.10	31	1.94	19	2.86	31	2.97
MAY 01	1.94	JUN 14	2.12	AUG 01	3.25	SEP 26	3.09

OBSERVATION WELL 19-S
ALTITUDE OF LAND SURFACE DATUM 80.13 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
APR 03, 1984	4.95	JUN 14, 1984	3.58	AUG 01, 1984	4.19	AUG 31, 1984	4.07
30	3.28	JUL 11	3.92	15	4.44	SEP 26	4.24
MAY 31	3.23						

OBSERVATION WELL 19
ALTITUDE OF LAND SURFACE DATUM 80.13 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAR 07, 1984	5.50	MAY 31, 1984	3.46	AUG 01, 1984	4.19	SEP 26, 1984	4.23
APR 03	5.02	JUN 14	3.62	15	4.43		
30	3.30	JUL 11	3.94	31	4.05		

OBSERVATION WELL 20
ALTITUDE OF LAND SURFACE DATUM 77.52 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAR 07, 1984	3.76	MAY 31, 1984	1.82	JUL 11, 1984	2.25	AUG 31, 1984	2.68
APR 03	3.66	JUN 14	1.93	AUG 01	2.48	SEP 26	2.95
30	2.56	29	2.03	15	2.70		

OBSERVATION WELL 21-S
ALTITUDE OF LAND SURFACE DATUM 81.71 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAR 14, 1984	5.21	MAY 31, 1984	1.98	AUG 01, 1984	3.56	SEP 26, 1984	3.52
APR 03	4.09	JUN 14	2.28	15	4.04		
MAY 02	1.77	JUL 11	2.86	31	3.30		

OBSERVATION WELL 21
ALTITUDE OF LAND SURFACE DATUM 81.71 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAR 14, 1984	5.34	MAY 31, 1984	2.09	AUG 01, 1984	3.65	SEP 26, 1984	3.58
APR 03	4.36	JUN 14	2.39	15	4.09		
MAY 02	2.02	JUL 11	2.95	31	3.42		

OBSERVATION WELL 22-S
ALTITUDE OF LAND SURFACE DATUM 80.90 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
APR 03, 1984	4.34	MAY 31, 1984	2.40	AUG 01, 1984	4.52	AUG 31, 1984	4.90
MAY 02	1.97	JUN 14	2.85	09	4.95	SEP 26	5.30
09	1.93	JUL 11	3.30	15	5.21		

OBSERVATION WELL 22
ALTITUDE OF LAND SURFACE DATUM 80.90 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAR 14, 1984	5.73	MAY 09, 1984	2.54	JUL 11, 1984	3.92	AUG 15, 1984	5.82
APR 03	4.85	31	3.02	AUG 01	5.14	31	5.53
MAY 02	2.60	JUN 14	3.47	09	5.58	SEP 26	5.94

OBSERVATION WELL 23-S
ALTITUDE OF LAND SURFACE DATUM 81.00 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
APR 03, 1984	4.16	JUN 14, 1984	2.65	AUG 01, 1984	3.73	AUG 31, 1984	3.79
MAY 02	1.97	JUL 11	3.16	15	4.20	SEP 26	4.01
31	2.37						

OBSERVATION WELL 23
ALTITUDE OF LAND SURFACE DATUM 81.00 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAR 08, 1984	5.43	MAY 31, 1984	2.82	AUG 01, 1984	4.32	SEP 26, 1984	4.70
APR 03	4.94	JUN 14	3.12	15	4.78		
MAY 02	3.08	JUL 11	3.66	31	4.40		

OBSERVATION WELL 24
ALTITUDE OF LAND SURFACE DATUM 81.42 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAR 13, 1984	5.97	MAY 31, 1984	3.15	AUG 01, 1984	4.45	AUG 31, 1984	4.30
APR 03	5.60	JUN 14	3.53	15	4.78	SEP 26	4.55
MAY 02	3.13						

OBSERVATION WELL 25
ALTITUDE OF LAND SURFACE DATUM 81.22 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAR 04, 1984	6.54	MAY 31, 1984	4.19	JUL 11, 1984	4.92	AUG 15, 1984	5.49
APR 03	5.38	JUN 18	4.60	AUG 01	5.28	31	4.93
MAY 03	3.78	28	4.66	09	5.39	SEP 26	5.06

OBSERVATION WELL 26-S
ALTITUDE OF LAND SURFACE DATUM 80.46 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAR 08, 1984	5.87	MAY 31, 1984	3.72	AUG 01, 1984	4.60	AUG 31, 1984	4.38
APR 03	4.98	JUN 14	4.00	09	4.73	SEP 26	4.50
MAY 03	3.45	JUL 11	4.28	15	4.83		

OBSERVATION WELL 26
ALTITUDE OF LAND SURFACE DATUM 80.46 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAR 08, 1984	5.87	MAY 31, 1984	3.73	AUG 01, 1984	4.64	AUG 31, 1984	4.40
APR 03	4.99	JUN 14	4.01	09	4.76	SEP 26	4.54
MAY 03	3.47	JUL 11	4.33	15	4.86		

OBSERVATION WELL 27
ALTITUDE OF LAND SURFACE DATUM 80.14 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAR 08, 1984	6.08	MAY 31, 1984	4.16	AUG 01, 1984	4.93	AUG 31, 1984	4.70
APR 03	5.20	JUN 14	4.42	09	5.02	SEP 26	4.80
MAY 03	3.95	JUL 11	4.69	15	5.08		

OBSERVATION WELL 28
ALTITUDE OF LAND SURFACE DATUM 81.85 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAR 13, 1984	6.24	MAY 31, 1984	3.59	AUG 01, 1984	4.75	SEP 26, 1984	4.96
APR 03	5.89	JUN 14	3.85	15	5.10		
MAY 02	3.65	JUL 11	4.27	31	4.73		

OBSERVATION WELL 29
ALTITUDE OF LAND SURFACE DATUM 82.90 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAR 14, 1984	4.40	MAY 31, 1984	1.83	AUG 01, 1984	3.40	SEP 26, 1984	3.15
APR 03	3.07	JUN 14	2.10	15	3.97		
MAY 02	1.63	JUL 11	2.61	31	3.07		

OBSERVATION WELL 30
ALTITUDE OF LAND SURFACE DATUM 79.22 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAR 07, 1984	16.69	APR 30, 1984	15.91	JUN 29, 1984	15.70	AUG 15, 1984	15.68
14	16.68	MAY 31	15.83	JUL 11	15.73	31	15.68
APR 03	15.95	JUN 14	15.78	AUG 01	15.64	SEP 26	15.67

OBSERVATION WELL 31
ALTITUDE OF LAND SURFACE DATUM 82.3 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAR 07, 1984	6.33	MAY 08, 1984	4.27	JUL 11, 1984	4.22	AUG 15, 1984	5.23
APR 03	5.88	31	3.26	19	4.58	31	4.68
MAY 02	4.38	JUN 14	3.79	AUG 01	4.96	SEP 26	4.38

OBSERVATION WELL 33-S
ALTITUDE OF LAND SURFACE DATUM 80.60 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAY 31, 1984	2.14	JUL 11, 1984	3.02	AUG 31, 1984	3.31	SEP 26, 1984	3.53
JUN 14	2.51						

OBSERVATION WELL 33
ALTITUDE OF LAND SURFACE DATUM 80.60 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAY 31, 1984	2.12	JUL 11, 1984	2.95	AUG 15, 1984	3.84	SEP 26, 1984	3.38
JUN 14	2.49	AUG 01	3.50	31	3.25		

OBSERVATION WELL 35-S
ALTITUDE OF LAND SURFACE DATUM 82.31 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAY 31, 1984	1.05	JUL 11, 1984	1.30	AUG 01, 1984	2.10	AUG 31, 1984	1.59
JUN 14	1.15	19	1.66	15	2.61	SEP 26	1.48

OBSERVATION WELL 35
ALTITUDE OF LAND SURFACE DATUM 82.31 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAY 31, 1984	2.29	JUL 11, 1984	2.98	AUG 01, 1984	3.49	AUG 31, 1984	3.26
JUN 14	2.45	19	3.13	15	3.89	SEP 26	3.45

OBSERVATION WELL 36-S
ALTITUDE OF LAND SURFACE DATUM 81.31 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAY 31, 1984	2.46	JUL 11, 1984	3.43	AUG 15, 1984	DRY	SEP 26, 1984	DRY
JUN 14	3.20	AUG 01	DRY	31	3.80		

OBSERVATION WELL 36
ALTITUDE OF LAND SURFACE DATUM 81.31 FEET

DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL	DATE	WATER LEVEL
MAY 31, 1984	2.46	JUL 11, 1984	3.41	AUG 01, 1984	3.98	AUG 31, 1984	3.71
JUN 14	2.91	19	3.66	15	4.30	SEP 26	3.72

Table 3.–Field measurements of water-quality properties

Well number (fig. 4)	Date	Specific conductance (µS/cm)	pH (units)	Temperature (degrees Celsius)
1	73-05-08	290	7.3	1.0
	73-08-02	260	6.6	1.5
	74-03-22	260	7.0	1.0
	74-06-12	265	7.3	1.0
	74-10-08	307	6.9	1.0
	75-03-25	375	7.2	1.0
	75-10-15	375	7.4	2.0
	76-04-15	260	6.6	1.0
	77-04-14	415	7.0	1.5
	77-09-29	475	7.2	1.0
	78-04-11	360	6.5	1.0
	78-09-26	345	6.2	2.0
	79-04-17	445	7.0	1.5
	79-09-25	470	6.3	3.0
	80-04-24	505	7.0	2.5
2	73-05-09	514	7.2	3.0
	73-08-02	1,100	5.9	1.5
	74-03-22	650	6.4	2.0
	74-06-12	800	6.0	3.5
	75-03-25	730	6.7	2.5
	75-10-15	560	7.0	3.5
	76-04-16	950	6.5	2.5
3	73-05-09	5,350	6.7	--
	73-08-02	7,000	6.2	--
	74-03-21	6,000	6.2	4.0
	74-06-12	4,600	6.7	3.5
	74-10-08	5,850	6.2	7.0
	75-03-25	4,100	6.1	4.0
	75-10-16	4,800	6.7	4.5
	76-04-15	5,000	6.7	2.0
4	73-05-09	2,440	6.4	3.0
	73-08-02	2,300	5.9	1.5
	74-06-12	2,600	6.5	2.0
	75-03-26	2,500	6.3	2.0
5	73-05-09	2,460	5.7	3.5
	73-08-02	2,200	5.2	3.0
	74-06-12	2,000	6.3	3.5
	75-03-26	2,500	6.7	2.5
	75-10-15	2,100	6.5	3.0
	76-04-16	2,600	6.3	3.0
	77-04-14	2,500	6.2	2.5
	77-09-29	3,000	6.2	2.0
	78-04-13	2,950	6.3	2.0
	78-09-26	3,000	6.1	3.0
	79-09-25	2,850	6.1	3.0
	80-04-24	3,020	6.6	3.0
	81-04-06	3,100	6.7	3.5
	81-09-16	2,900	6.1	4.0
	84-05-07	2,350	6.8	3.5
6	73-05-08	1,750	6.9	8.5
	73-08-02	2,000	6.5	--
	74-03-22	1,150	7.0	2.0
	74-06-13	1,500	7.2	1.5
	74-10-08	1,640	6.6	3.0
7	73-05-08	80	7.1	2.5
	73-08-02	80	7.2	2.5
	74-03-22	80	7.0	2.0
	74-06-12	75	6.4	2.0
	74-10-08	79	6.0	3.0
	75-03-27	90	6.5	2.5
	75-10-16	80	6.5	3.5
	77-04-14	75	6.1	2.5
	77-09-29	80	6.6	3.0
	78-04-11	78	5.4	2.0
	78-09-26	73	5.2	3.0
	79-04-17	72	5.6	2.5
	79-09-25	70	5.2	3.5
7	80-04-24	78	6.0	3.0
	80-09-25	72	5.8	3.5
	81-04-06	68	6.0	3.0
	81-09-16	60	6.3	4.0
	84-05-07	71	6.5	3.0
8	73-05-08	400	6.3	5.0
	73-08-02	460	6.2	3.0
	74-03-21	600	6.7	3.0
	74-06-13	600	6.8	4.0
	74-10-08	515	6.6	4.5
	75-03-27	545	6.2	4.0
	75-10-15	388	6.7	4.5
9	73-05-08	240	7.1	2.0
	73-08-02	355	6.9	--
	74-03-27	340	7.0	1.0
	74-06-12	290	7.2	1.5
	74-10-08	354	7.0	1.5
	75-03-27	400	7.1	1.0
	75-10-16	350	7.3	3.0
	76-04-15	375	6.8	1.5
	77-04-14	460	7.1	2.0
	77-09-29	750	7.2	2.5
	78-04-11	455	6.4	2.0
	78-09-26	550	6.6	3.5
	79-04-17	475	7.0	3.0
	79-09-25	430	6.5	4.5
	80-04-24	415	7.2	3.5
	80-09-25	600	7.1	4.0
	81-04-06	530	7.4	4.0
	81-09-16	205	7.6	4.0
10	73-05-25	220	7.7	4.0
11	74-04-22	240	--	3.0
	74-06-13	220	8.7	2.5
	74-10-09	229	8.4	2.0
	75-03-26	200	9.4	2.0
	75-10-16	195	9.3	3.0
	84-05-08	240	8.8	3.0
12	84-07-18	700	--	3.0
13-S	84-04-30	700	--	2.0
	84-07-18	605	--	5.5
13	84-03-07	595	--	2.0
	84-04-30	800	--	2.5
	84-07-18	755	--	3.5
14	84-03-07	745	--	3.0
	84-05-01	1,000	--	3.0
15	84-03-13	390	--	2.0
	84-05-01	425	--	3.0
16	84-03-13	845	--	2.0
	84-05-01	825	--	3.0
	84-07-19	850	--	4.0
17	84-03-08	1,500	--	2.5
	84-05-01	1,500	--	3.0
	84-07-19	1,550	--	3.5
18	84-03-13	675	--	2.0
	84-05-01	738	--	3.0
	84-05-09	625	7.2	3.5
	84-07-19	660	--	4.0
19	84-03-07	375	--	2.0
	84-04-30	450	--	2.0
20	84-03-07	266	--	2.0
	84-04-30	300	--	4.0

Table 3.--Continued

Well number (fig. 4)	Date	Specific conductance (µS/cm)	pH (units)	Temperature (degrees Celsius)
21-S	84-05-02	98	--	3.0
21	84-03-14	480	--	3.5
	84-05-02	488	--	3.5
22-S	84-05-02	135	--	3.5
22	84-03-14	275	--	3.5
	84-05-02	290	--	4.0
	84-05-09	290	6.4	5.0
	84-08-09	262	--	4.0
23-S	84-05-02	60	--	5.0
23	84-03-08	362	--	3.5
	84-05-02	370	--	4.0
24	84-03-13	495	--	2.0
	84-05-02	510	--	4.0
25	84-03-08	405	--	2.5
	84-05-03	445	--	3.0
	84-06-28	425	7.0	4.0
	84-08-09	440	--	4.0
26-S	84-05-03	255	--	2.0
26	84-03-08	470	--	2.0
	84-05-03	462	--	2.5
	84-08-09	450	--	3.0
27	84-03-08	330	--	2.5
	84-05-03	338	--	3.0
	84-08-09	325	--	4.0
28	84-03-13	448	--	2.0
	84-05-02	450	--	3.0
29	84-03-14	455	--	2.5
	84-05-02	500	--	3.0
30	84-04-30	100	--	4.0
31	84-03-07	3,100	--	2.0
	84-05-02	4,000	--	3.0
	84-05-08	3,340	6.7	4.0
	84-07-19	3,250	--	5.0
33	84-05-14	2,250	--	3.0
	84-05-15	2,120	--	3.0
	84-05-16	3,100	6.8	2.5
35	84-05-15	838	--	3.5
	84-05-16	860	7.8	3.0
	84-07-19	862	--	3.5
36	84-05-15	3,250	--	4.0
	84-07-19	3,600	--	4.0

Table 4.--Selected chemical analyses of water from the Connors Bog area

Site No. (see fig. 4)	Date of sample	Sample depth (feet)	Depth below land surface (water level) (feet)	Specific conductance (µS/cm)	pH (standard units)	Temperature (°C)	Hardness (mg/L as $CaCO_3$)	Hardness noncarbonate (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)
Well												
a5	1973-84	--	--	(2000-3000 2725 N=14)	(5.2-6.7 6.3 N=14)	(2-4 3.0 N=14)	(810-1400 1100 N=11)	(0-122 0 N=11)	(160-440 360 N=11)	(43-100 60 N=11)	(73-150 120 N=13)	(4.5-27 16.5 N=8)
5	84-05-07	38-46	17.50	2350	6.8	3.5	1000	0	320	54	93	23
a7	1973-84	--	--	(60-90 78 N=17)	(5.2-7.2 6.1 N=17)	(2-4 3.0 N=17)	(24-32 27 N=12)	(7-18 13.5 N=12)	(7.5-10 8.1 N=12)	(1.2-1.9 1.5 N=12)	(1.5-2.4 2.1 N=15)	(0.4-0.6 .5 N=10)
7	84-05-07	15-23	8.16	71	6.5	3.0	31	18	10	1.5	2.1	0.60
11	84-05-08	145	43.90	240	8.8	3.0	120	0	20	17	8.8	2.7
18	84-05-09	16-18	1.90	625	7.2	3.5	310	222	99	16	15	1.3
22	84-05-09	17-19	2.54	290	6.4	5.0	110	0	28	10	4.1	.50
25	84-06-28	12-17	4.66	425	7.0	4.0	220	6	60	18	4.0	1.2
31	84-05-08	9-11	4.27	3,340	6.7	4.0	1,400	0	380	98	150	4.5
33	84-05-16	19-24	2.58	3,100	6.8	2.5	--	--	--	--	--	--
35	84-05-16	28-33	2.28	860	7.8	3.0	--	--	--	--	--	--
Connors Lake												
	73-05-24	--	--	116	7.5	13.0	53	--	15	3.8	2.6	.9
	84-06-28	4.6	--	127	7.0	16.5	64	2	19	4.0	2.7	1.3

Site number	Date of sample	Alkalinity lab (mg/L as $CaCO_3$)	Sulfete dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Solids, sum of constituents, dissolved (mg/L)	Nitrogen, NO_2+NO_3 total (mg/L as N)	Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	Nitrogen, ammonia + organic total (mg/L as N)	Phosphorus, total (mg/L as P)
Well											
a5	1973-84	(1,180-1,300 1,250 N=3)	(1.9-14 5.9 N=11)	(91-180 150 N=15)	(0.1-0.2 .1 N=6)	(10-34 13 N=6)	(1,400-2,100 1,650 N=6)	-- -- --	(<.1-.8 0.1 N=9)	-- -- --	-- -- --
5	84-05-07	1180	1.9	110	.10	13	1400	0.200	<.100	32	0.300
a7	1973-84	(12-13 12 N=3)	(11-18 15 N=14)	(1.4-5.8 2.5 N=18)	(<.1-.1 .1 N=7)	(14-15 14 N=7)	(50-57 53 N=7)	-- -- --	(<.1-.4 .23 N=12)	-- -- --	-- -- --
7	84-05-07	13	14	3.4	.10	15	55	.200	.140	<.20	.030
11	84-05-08	136	4.9	1.7	.20	13	150	<.100	<.100	1.5	.880
18	84-05-09	301	4.4	41	<.10	42	280	<.100	<.100	1.5	.070
22	84-05-09	119	14	3.5	<.10	41	200	<.100	<.100	1.6	.030
25	84-06-28	218	11	8.2	<.10	29	280	<.100	<.100	.40	.100
31	84-05-08	1,540	2.7	290	<.10	22	2,300	<.100	<.100	.60	.300
33	84-05-16	--	--	360	--	--	--	--	--	--	--
35	84-05-16	--	--	49	--	--	--	--	--	--	--
Connors Lake											
	73-05-24	52	2.0	2.7	--	.4	59	--	.01	--	.04
	84-06-28	66	3.3	2.9	<.10	.8	72	<.100	<.100	.50	.010

a Minimum - maximum, and median values shown for multiple (N) analyses over period 1973-84

Table 4.--Continued

Site number	Date of sample	Phosphate, ortho, dissolved (mg/L as PO_4)	Iron, dissolved (µg/L as Fe)	Manganese, dissolved (µg/L as Mn)	Organic compounds, methlyene chloride-extractable, total recoverable (µg/L)
Well					
a5	1973-84	-- --	(66,000- 340,000 180,000 N=12)	(4,700- 14,000 10,000 N=12)	-- --
5	84-05-07	0.06	120,000	4,700	790
a7	1973-84	-- --	(220-5,000 750 N=14)	(10-280 60 N=14)	-- --
7	84-05-07	.03	220	16	41
11	84-05-08	.15	190	76	39
18	84-05-09	.03	20	1,200	90
22	84-05-09	.03	27	800	96
25	84-06-28	.03	15,000	1,100	66
31	84-05-08	.03	85,000	5,200	140
33	84-05-16	--	--	--	--
35	84-05-16	--	--	--	34
Connors Lake					
	73-05-24	--	220	30	--
	84-06-28	.02	140	27	--

a Minimum - maximum, and median values shown for multiple (N) analyses over period 1973-84

Table 5.--Results of analysis for purgeable organic compounds in water from well 5

Compound	Concentration, total recoverable (micrograms per liter)
Benzene	16
Bromoform	<3
Carbon tetrachloride	<3
Chlorobenzene	<3
Chloroethane	<3
2-Chloroethyl vinyl ether	<3
Chloroform	<3
Dibromochloromethane	<3
Dichlorobromomethane	<3
Dichlorodifloromethane	<3
1,1-Dichloroethane	<3
1,2-Dichloroethane	<3
1,1-Dichloroethylene	<3
1,2-trans-Dichloroethylene	320
1,2-Dichloropropane	<3
1,3-Dichloropropane	<3
Ethylbenzene	13
Methyl bromide	<3
Methylene chloride	4
1,1,2,2-Tetrachloroethane	<3
Tetrachloroethylene	<3
Toluene	260
1,1,1-Trichloroethane	<3
1,1,2-Trichloroethane	<3
Trichloroethylene	<3
Trichloroflouromethane	<3
Vinyl chloride	<3