UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SPOKANE VALLEY-RATHDRUM PRAIRIE AQUIFER, WASHINGTON AND IDAHO

By B. W. Drost and H. R. Seitz

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For further information on this investigation
and on other water-resources studies in Washington
carried out by the U.S. Geological Survey, contact
the U.S. Geological Survey, Water Resources Division,
1201 Pacific Avenue, Suite 600, Tacoma, Washington 98402

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METRIC CONVERSIONS

Multiply	By	To obtain
Inches (in.)	25.4	millimeters (mm)
	2.54	centimeters (cm)
	.0254	meters (m)
Feet (ft)	.3048	meters (m)
Miles (mi)	1.609	kilometers (km)
Feet per mile (ft/mi)	.1894	meters per kilometer (m/km)
Square feet (ft^2)	.0929	square meters (m^2)
Square miles (mi^2)	2.590	square kilometers (km^2)
Gallons	3.785	liters (L)
Cubic feet per second (ft^3/s)	28.12	liters per second (L/s)
	.02832	cubic meters per second (m^3/s)
Degrees Fahrenheit (°F)	Subtract 32, multiply remainder by 0.5556	degrees Celsius (°C)

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WASHINGTON AND IDAHO

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ABSTRACT

The Spokane Valley-Rathdrum Prairie aquifer is composed of unconsolidated Quaternary glaciofluvial deposits underlying an area of about 350 square miles. Transmissivities in the aquifer range from about 0.13 million to 11 million feet squared per day and ground-water velocities exceed 60 feet per day in some areas. The water-table gradient ranges from about 2 feet per mile to more than 60 feet per mile, and during a year the water table fluctuates on the order of 5 to 10 feet. For most of the aquifer the water table is between 40 and 400 feet below land surface. The aquifer is recharged and discharged at an average rate of about 1,320 cubic feet per second.

Water is presently (1976) pumped from the aquifer at an average rate of about 239 cubic feet per second for domestic, industrial, and agricultural uses. Most of this is discharged to the Spokane River, lost to evapotranspiration, or applied to the land surface with little or no change in quality. However, about 34 cubic feet per second becomes waste water generated by domestic and industrial activities and is returned to the aquifer by percolation from cesspools and drain fields.

The quality of water in the aquifer is generally good. Less than one-half of 1 percent of the 3,300 analyses available exceeded the maximum contaminant levels specified in the National Interim Primary (or Proposed Secondary) Drinking Water Regulations (U.S. Environmental Protection Agency, 1975) for constituents which may be hazardous to health. Of the 6,300 analyses for constituents considered detrimental to the esthetic quality of water, about 1.4 percent have yielded values which exceeded the recommended levels.

Alternative water sources for the area supplied by the aquifer are the Spokane and Little Spokane Rivers, lakes adjacent to the aquifer, and other aquifers. All of these potential sources are less desirable than the Spokane Valley-Rathdrum Prairie aquifer because of insufficient supplies, poor water quality, and (or) remoteness from the areas of need.

INTRODUCTION

Purpose

The U.S. Environmental Protection Agency (EPA) has been petitioned for "sole source" designation of the Spokane Valley-Rathdrum Prairie aquifer of Washington and Idaho (pl. 1, in pocket) in accordance with the 1974 Federal "Safe Drinking Water Act" (Public Law 93-523). If the aquifer is determined to be the only economical source of safe drinking water capable of supplying the Spokane Valley-Rathdrum Prairie area, then a "sole source" designation can be assigned by EPA. This would give EPA the responsibility of protecting the quality of water in the aquifer from any detrimental effects caused by any Federal financially assisted projects in the area.

The purpose of this report is to describe the hydrologic characteristics, patterns of water use and disposal, quality of water in the aquifer, and alternative water sources for the area served by the aquifer. The report is based on available basic data and previous studies in the area and is intended for use as a decisionmaking aid in the disposition of the "sole source" petition.

Previous Investigations

The earliest studies of the Spokane Valley-Rathdrum Prairie aquifer were by Fosdick (1931) and Newcomb (1933), both of whom outlined some basic geologic, physiographic, and hydrologic features of the aquifer and its recharge area. Newcomb concluded that a buried ridge of basalt near Spokane causes the ground-water flow to divide, one part moving northward into the Hillyard Trough, another part moving westward into the basalt, and a third part moving through the Miocene Latah Formation into underlying basalt. Both authors suggested that the water flowing through the Hillyard Trough (the area between Fivemile and Orchard Prairies, Wash.; pl. 2), emerges as springs along the south side of the Little Spokane River valley. Newcomb indicated that the Spokane River is a losing stream between Post Falls, Idaho, and Trent, Wash., and a gaining stream from Trent to Spokane. The two authors disagreed on the major source of recharge to the aquifer; Newcomb claimed Pend Oreille Lake as the source, while Fosdick suggested that precipitation directly over the aquifer and in adjacent highlands is the source.

Piper and Huff (1943), Huff (1943), and Piper and La Rocque (1944), studied the aquifer in more detail. Piper and Huff measured water levels in a series of wells and made estimates of the hydraulic gradient in different parts of the aquifer. They concluded that Hayden, Coeur d'Alene, and Pend Oreille Lakes, and the Spokane River are the major sources of recharge, with Pend Oreille Lake making the greatest contribution. They also estimated that the discharge from the aquifer to springs and rivers was 900 ft^3/s.

Huff estimated the total discharge from the aquifer to be about 1,100 ft^3/s, which included his estimated total pumpage of 100 ft^3/s in 1942.

In a report on long-term water-level fluctuations in wells, Piper and La Rocque (1944) made some generalizations about the aquifer. They estimated total flow through the aquifer to be about 1,000 ft^3/s. They also discussed Pend Oreille Lake as a possible recharge source, but not as a major source.

Interest in the aquifer grew in the early 1950's. Nace and Fader (1950) tabulated all data then available in U.S. Geological Survey files on wells tapping the aquifer. In unpublished reports of the U.S. Bureau of Reclamation, Lenz (1950), Meneely (1951), and Anderson (1951), studied various aspects of different parts of the aquifer with the general intention of determining the sources and volumes of water that could be used for irrigation in the Rathdrum Prairie area. Lenz estimated water requirements, seepage losses, and storm flows that would be associated with a large irrigation project. Meneely studied the contribution of precipitation to the aquifer. Anderson calculated discharge from the aquifer to the Spokane and Little Spokane Rivers to be about 470 and 250 ft^3/s, respectively.

Broom (1951) and McDonald and Broom (1951), analyzed gaging-station records for the Spokane and Little Spokane Rivers for the 1950 water year (Oct. 1, 1949-Sept. 30, 1950). In addition to calculating the net annual gains and losses of the rivers, they observed large variations in the directions as well as amounts of flow between the Spokane River and the aquifer along various stretches of the river.

Fader (1951) compiled water-level data from wells in the Rathdrum Prairie of Idaho and in Pend Oreille, Hayden, and Coeur d'Alene Lakes, and Weigle and Mundorff (1952) compiled well records and data on water levels and water quality for wells in the Washington part of the aquifer.

The first significant information on the thickness of the aquifer was an interpretation by Newcomb (1953) of seismic profiles near the Washington-Idaho State line and across Hillyard Trough. His interpretations indicated a thickness of about 240 to 375 feet near the State line and about 150 feet in the Hillyard Trough.

Sources of recharge to the aquifer were studied in detail by Thomas (1963) and Walker (1964). Thomas estimated a total of 1,200 ft^3/s inflow to the aquifer in 1959, exclusive of recharge from Pend Oreille Lake. He estimated total discharge to be 1,450 ft^3/s, which led to an indirect estimate of 250 ft^3/s of recharge from Pend Oreille Lake. Walker suggested the existence of an additional source of recharge from the Hoodoo Valley.

Frink (1964) evaluated the conclusions of Anderson (1951) on recharge and agreed that Pend Oreille Lake was only a minor source of recharge, about 50 ft^3/s. Frink also suggested that at least 600 ft^3/s of recharge occurred east of Post Falls, Idaho, and another 150 ft^3/s occurred between Post Falls and the State line.

Rorabaugh and Simons (1966) evaluated methods of relating ground water and surface water. They found that the ground-water flow to the rivers varied according to the water-table altitude and predicted a decline of about 12 ft/yr in the aquifer if all recharge ceased.

The literature to date (1977) continues to show a conflict over the importance of Pend Oreille Lake as a recharge source. Pluhowski and Thomas (1968) developed a ground-water budget for the aquifer and assigned a recharge rate of 50 ft^3/s from Pend Oreille Lake in order to balance the budget. However, they concluded that the contribution from the lake might be as great as 200 ft^3/s. They also estimated that the ground-water flow at the State line was about 1,000 ft^3/s.

Cline (1969) studied the western end of the aquifer and the Little Spokane River basin to the north. He estimated that the 1964 water use from the aquifer near Spokane was about 8 billion gallons per year (34 ft^3/s), and concluded that this rate of use had very little effect on the hydrologic system.

Hammond (1974) determined that the ground-water flow southward from Pend Oreille Lake and Spirit and Hoodoo Valleys was confined between Twin Lakes and Round Mountain. Earlier authors assumed that the aquifer extended eastward around Round Mountain. Hammond based his conclusion on his apparent identification of bedrock as occurring at relatively high elevations and underlying the unconsolidated materials east of Round Mountain. This theory was supported by the high water-level altitudes in wells tapping these unconsolidated materials, which indicated that the materials were a source of recharge to the aquifer but were not part of the aquifer.

In 1976, a massive report on the water resources of the metropolitan Spokane region was completed by the U.S. Army Corps of Engineers (1976). The report is contained in 13 volumes totaling nearly 4,000 pages, and includes data on the water resources and pertinent human activities related to the Washington part of the aquifer. The investigation concentrated on waste-water management considerations to be faced between 1980 and 2000.

There are two ongoing studies of the aquifer. The U.S. Geological Survey, in cooperation with the Washington State Department of Ecology (DOE), is making a computer model of ground-water flow in the Washington part of the aquifer. The U.S. Geological Survey and Spokane County, with cooperation from DOE and EPA, have recently established a ground-water-quality network and plan to use the data to construct a water-quality computer model for the part of the aquifer in Washington.

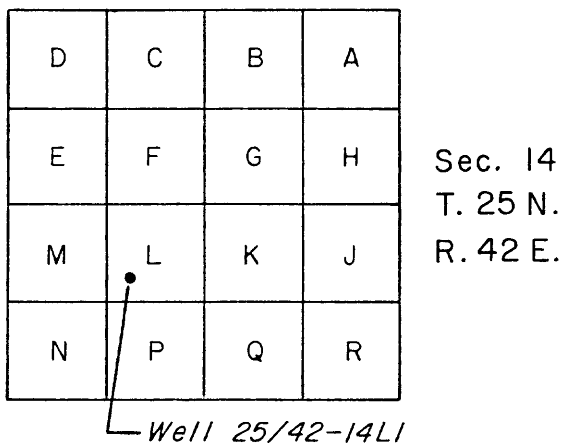
In cooperation with the Idaho Department of Health and Welfare, the Idaho Department of Water Resources, the Panhandle Health District, and EPA, the U.S. Geological Survey plans to extend the water-quality and ground-water flow models to include the Idaho part of the aquifer.

Acknowledgments

This study was conducted in cooperation with EPA. Harold Scott of EPA supplied data on some cases of historical pollution and reviewed the designation of standards shown on plate 10. Dennie Byram of the Spokane County Health District was the primary source of information on historical pollution problems. Additional information on this subject was supplied by L. Peterson of DOE and L. Esvelt of the Spokane County Engineers' office. Most of the ground-water-quality data was obtained from the State of Washington Department of Social and Health Services and the Idaho Department of Health and Welfare.

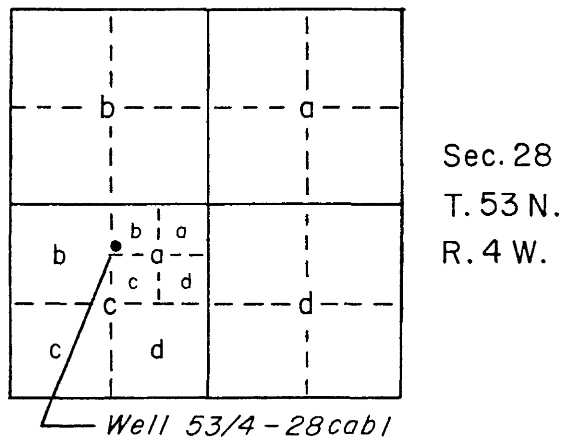
Well- and Spring-Location Numbering System

The well- and spring-location numbers used by the U.S. Geological Survey in Washington give the location of wells and springs according to the official rectangular public-land survey in Washington. For example, in well number 25/42-14L1, the part preceding the hyphen indicates successively the township and range (T.25 N., R.42 E.) north and east of the Willamette base line and meridian, respectively. The first number following the hyphen indicates the section (sec.14), and the letter (L) indicates the 40-acre subdivision of the section as shown in the sketch below. The last number is the sequence number of the well in the particular 40-acre tract. Thus, well 25/42-14L1 is the first well listed in the NE¼ of the SW¼ of sec.14, T.25 N., R.42 E. An s following the sequence number indicates that the site is a spring.



The location of well 25/42-14L1 is shown on plate 2.

The well-numbering system used by the U.S. Geological Survey in Idaho indicates the location of wells within the official rectangular public-land survey in Idaho. The first two segments of the number designate the township and range, north and west of the Boise baseline and meridian, respectively. The third segment gives the section number, followed by three letters and a number, which indicate the quarter section, the 40-acre tract, the 10-acre tract, and the sequence number of the well within the tract, respectively. Quarter sections are lettered a,b,c, and d in counterclockwise order from the northeast quarter of each section, as shown below. Within the quarter sections, the 40-acre and 10-acre tracts are lettered in the same manner. Well 53/4-28cabl is in the NW¼ of the NE¼ of the SW¼ of sec.28, T.53 N., R.4 W., and was the first well inventoried in that tract.



The water-level hydrographs (figs. 7-11) were printed by computer, thus all letters necessarily appear in upper case form.

The location of well 53/4-28cabl is shown on plate 2.

DATA-BASE DESCRIPTION AND DISCUSSION

Aquifer

Geology

The Spokane Valley-Rathdrum Prairie aquifer is composed predominantly of Quaternary glaciofluvial deposits which extend from Pend Oreille Lake, Idaho, to Long Lake, Wash., and cover an area of about 350 square miles (pl. 1). The deposits consist mostly of sand and gravel, fine to coarse, and are poorly to moderately sorted, having scattered cobbles and boulders. Some beds are composed almost exclussively of cobbles and boulders as well as a few scattered clay lenses. The sand and gravel is relatively free of fine sand and silt, except in the uppermost 3 to 5 feet, where fine-grained materials fill most voids in the sand and gravel. In the Hillyard Trough, the sediments become progressively finer grained toward the north, where the aquifer is composed predominantly of stratified sand but includes some gravel and silt and a few boulders.

In most areas, the aquifer probably overlies the semiconsolidated, fine-grained Latah Formation of Miocene age. In some areas the aquifer has abrupt lateral contacts with sloping bedrock surfaces, but in other areas, it grades laterally into less permeable, unconsolidated materials which are not readily distinguishable from the aquifer materials. In such places, the selected aquifer boundaries (pl. 2) are somewhat arbitrary. The aquifer boundaries were extended up the small tributary valleys below Newman and Liberty Lakes, Wash., to include all the unconsolidated materials. Rather arbitrary boundaries were drawn across Saltese Flats and Peone Prairie, Wash., because of insufficient subsurface data. Placement of the boundary between Pend Oreille and Hayden Lakes, Idaho, excludes a large area of unconsolidated materials which are not considered part of the aquifer. These materials are believed to be relatively thin and to directly overlie bedrock, and they have high water-table altitudes (generally above 2,200 ft) which do not fit the overall flow pattern in the aquifer. Boundaries were not drawn across the Spirit and Hoodoo Valleys in Idaho because of insufficient subsurface data.

The thickness of the aquifer is not well established. The best data exist where two seismic surveys have supplemented available drilling data. The seismic data (Newcomb, 1953) indicate a total thickness of about 400 feet of unconsolidated materials near the Idaho-Washington State line. Because the water table is at a depth of about 120 feet, the saturated thickness of the aquifer is approximately 280 feet.

In the Hillyard Trough, a test hole showed about 780 feet of unconsolidated material (Rieber and Turner, 1963). Newcomb's seismic interpretation for the same area designated about 160 feet of these materials as the saturated part of the aquifer, about 150 feet as unsaturated materials above the aquifer, and the rest as Latah Formation underlying the aquifer.

The only other wells that penetrate the entire thickness of the aquifer do so near its margins, in the thinner parts of the aquifer. Wells drilled away from the margins generally penetrate only 50 feet or less below the water table because sufficient supplies of water are generally found within this part of the aquifer.

Hydraulic Characteristics

The transmissivity of the aquifer (the rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient) is generally high. Values calculated by the U.S. Geological Survey's computer model range from 0.13 million to 11 million ft^2/day (pl. 3). The values shown in plate 3 are averages for designated parts of the aquifer and are based on calculated flow rates and observed water-table gradients. Transmissivities calculated from pumping tests at individual wells range from less than 0.13 million ft^2/d in the western end of the aquifer to more than 13 million ft^2/d near the Washington-Idaho State line.

The specific yield of the aquifer--the ratio of (1) the volume of water which the aquifer, after being saturated, will yield by gravity to (2) the volume of the aquifer--cannot be accurately calculated with the available data. Most unconfined aquifers have values of specific yield ranging from 0.1 to 0.3, and the Spokane Valley-Rathdrum Prairie aquifer, at least in its upper 50 feet of saturated section, is probably nearer to the 0.3 value.

Calculated values of ground-water velocities are high. Assuming a saturated thickness of 280 feet, a transmissivity of 3.4×10^6 ft^2/day, a water-table gradient of 7 ft/mile, and a porosity of 0.25 for the aquifer at the State line, the calculated velocity is about 64 ft/day. In an earlier study (U.S. Army Corps of Engineers, 1976) a different set of estimated aquifer characteristics led to a calculated velocity of 90.5 ft/day. For the Hillyard Trough, assuming a saturated thickness of 160 feet, a transmissivity of 0.4×10^6 ft^2/day, a water-table gradient of 30 ft/mile and a porosity of 0.30, the calculated average velocity is 47 ft/day. In the Corps of Engineers study, the velocity was calculated to be 41.1 ft/day.

Rates of ground-water flow of about 960 and 350 ft^3/s were calculated at the State line and in the Hillyard Trough, respectively, assuming the above transmissivity and gradient values and aquifer widths of 3.5 and 2.5 miles, respectively. The rates calculated in the U.S. Army Corps of Engineers (1976) study were 1,000 and 200 ft^3/s, respectively. The estimated rates of 960 and 350 ft^3/s closely agree with the ground-water budget obtained from estimated rates of recharge and discharge. (See section on recharge to and discharge from the aquifer.) From the ground-water budget (pl. 4) a flow of 930 to 1,010 ft^3/s is indicated near the State line. Also, the budget shows a gain of 310 ft^3/s in the Little Spokane River, which is derived almost entirely from the discharge of water from the aquifer at the northern end of the Hillyard Trough.

Water Levels

The water table in the aquifer slopes from Hoodoo Valley and Lake Pend Oreille, Idaho, to Nine Mile Falls, Wash. It is at a maximum altitude of about 2,180 feet in northern Idaho and declines to about 1,540 feet near Nine Mile Falls. The water table in the northermost part of the aquifer slopes about 20 ft/mile, while the major part, from north of Round Mountain, Idaho, to the southern end of the Hillyard Trough in Washington slopes relatively gently, from 2 to 10 ft/mile. The steepest slopes are in parts of the Hillyard Trough where the water table slopes more than 60 ft/mile. The mean annual altitude of the water table is shown on plate 2.

The water-table contours on plate 2 are by no means the only possible, reasonable interpretation of the available data and reflect at best an estimated average annual condition. Water-level data are maintained primarily by the U.S. Geological Survey, which has computer files of more than 16,000 water levels from about 430 wells tapping the aquifer in Washington and from about 200 wells tapping the aquifer in Idaho. These water-level data are of various qualities, including those reported by owners and well drillers, those measured by U.S. Geological Survey personnel, and those recorded by monitoring devices installed in selected wells. The data represent a long period of time, from the earliest measurements in about 1920 to the present. As shown in the hydrographs of 11 wells (figs. 1-11), water-level fluctuations are usually less than 15 feet during a year in most areas. Generally, the greatest annual fluctuations occur in those wells nearest to the Spokane River, in response to changing stages of the river.

The water table is deepest in northern Idaho, about 300 to 400 feet below the land surface, and becomes gradually shallower downgradient, reaching depths of about 120 feet at the Washington-Idaho State line and about 40 feet near Spokane, Wash. Continuing downgradient, the depth to the water table increases to about 150 feet in the Hillyard Trough.

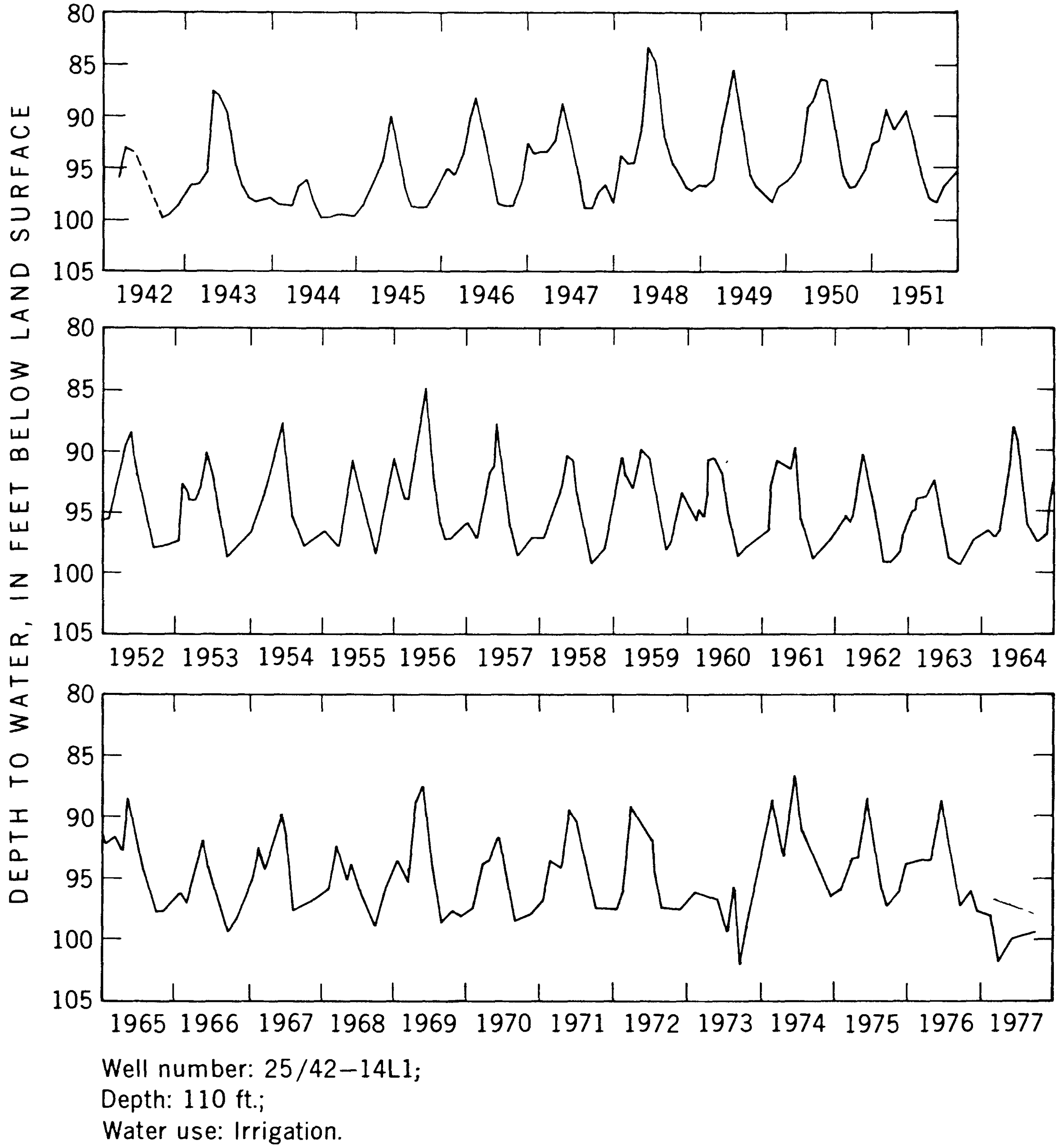


FIGURE 1.--Water-level fluctuations in well 25/42-14L1, 1942-77.

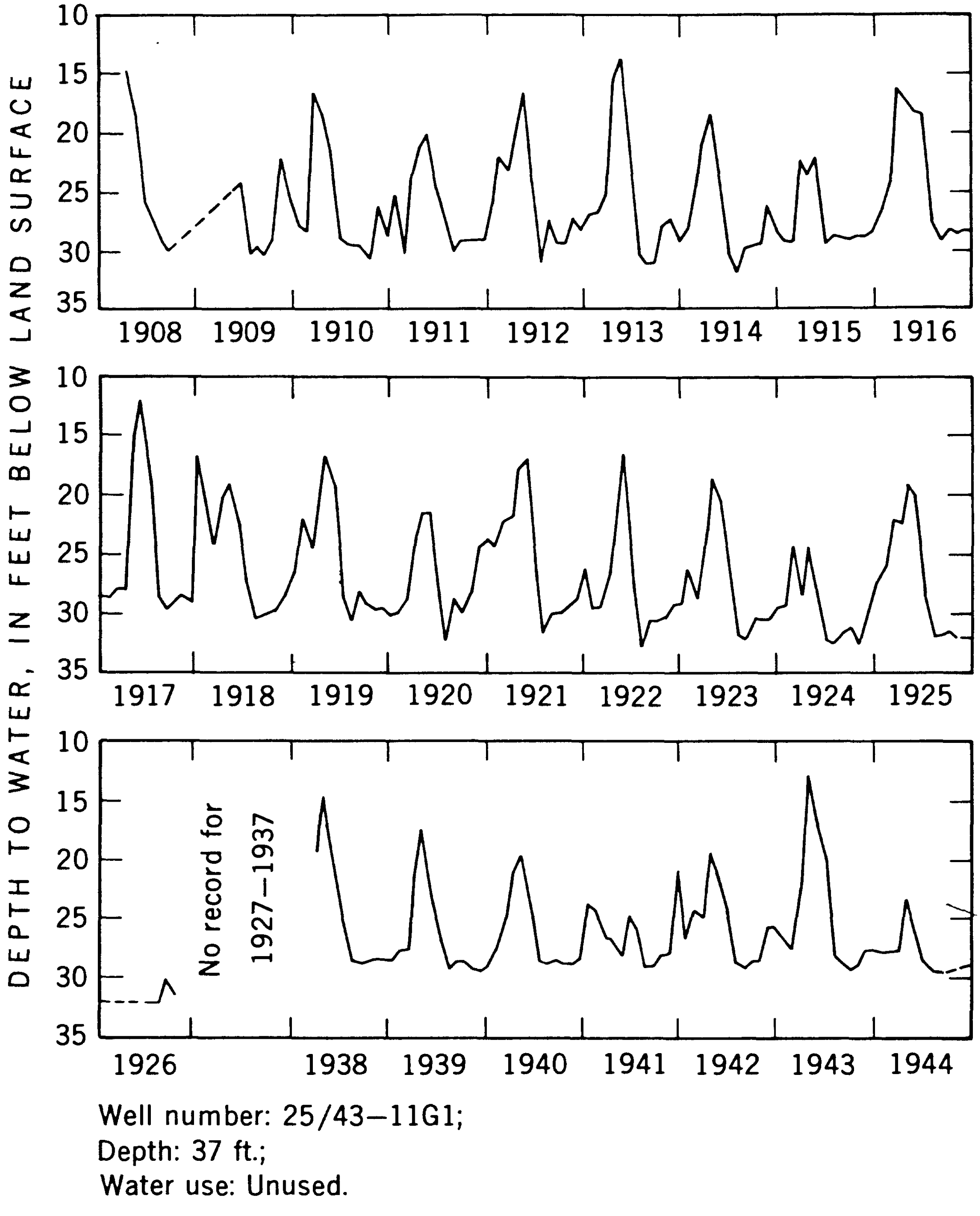


FIGURE 2.--Water-level fluctuations in well 25/43-11G1, 1908-26, 1938-45, 1951, 1960-72, and 1974.

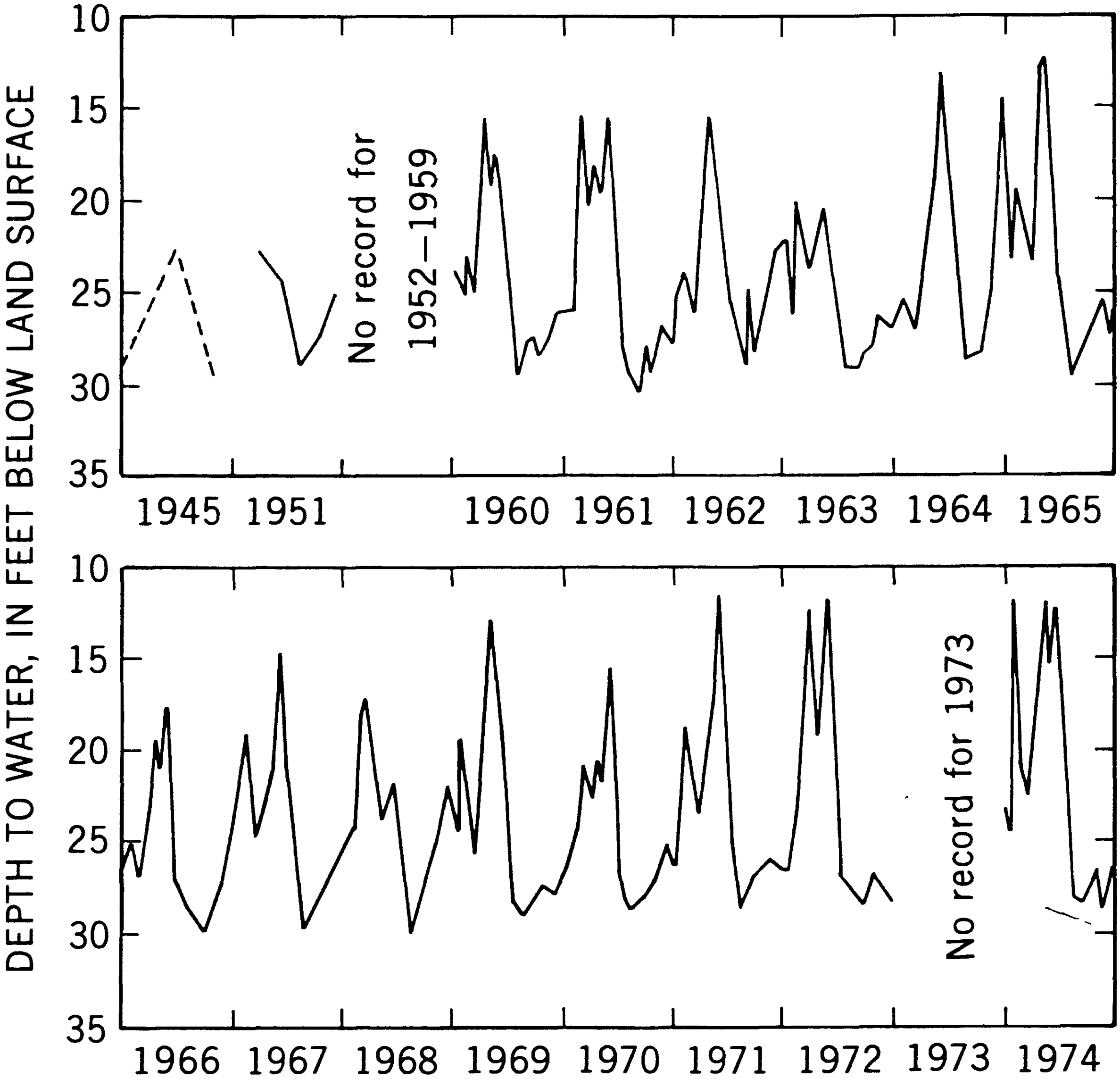


FIGURE 2.--Continued

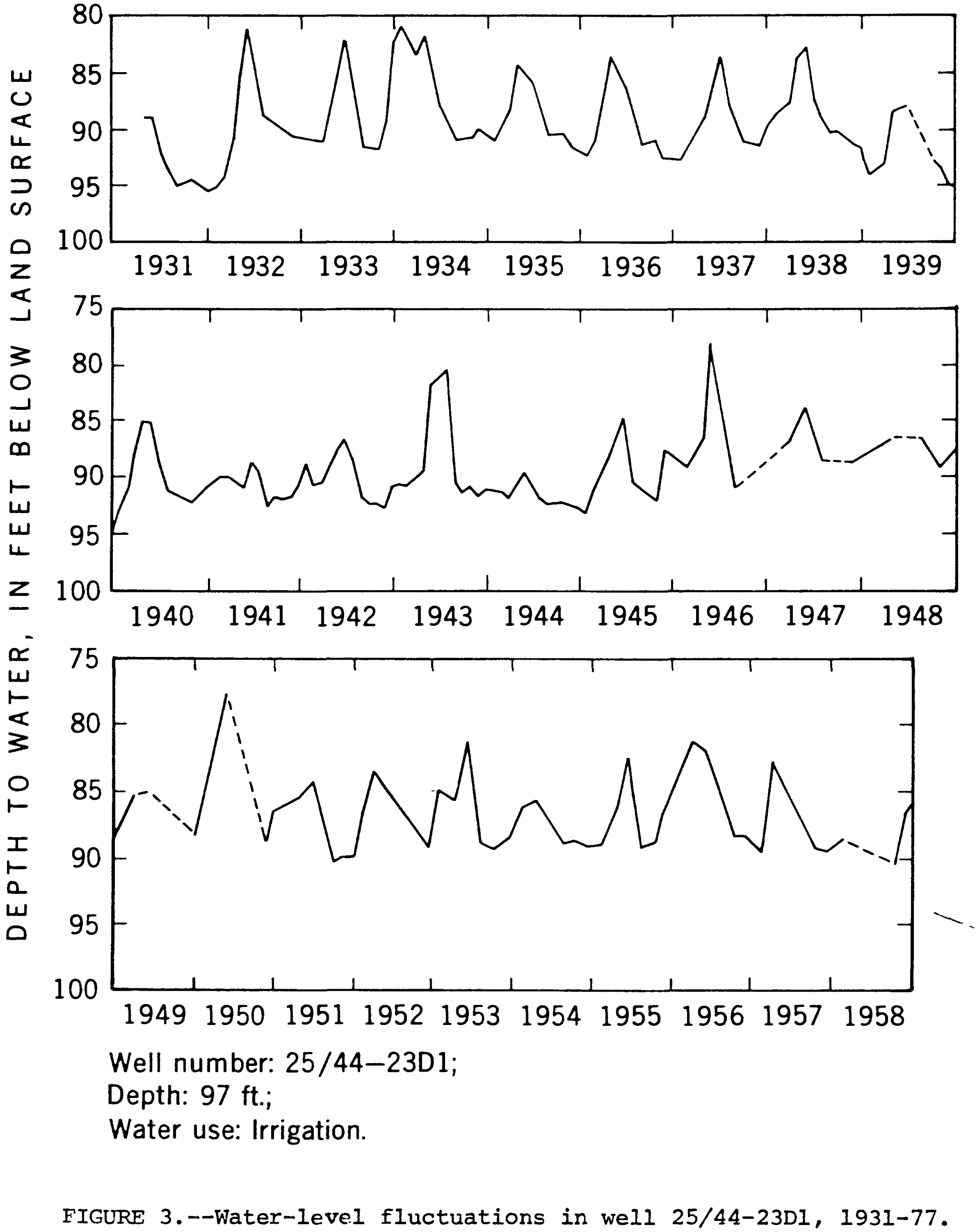


FIGURE 3.--Water-level fluctuations in well 25/44-23D1, 1931-77.

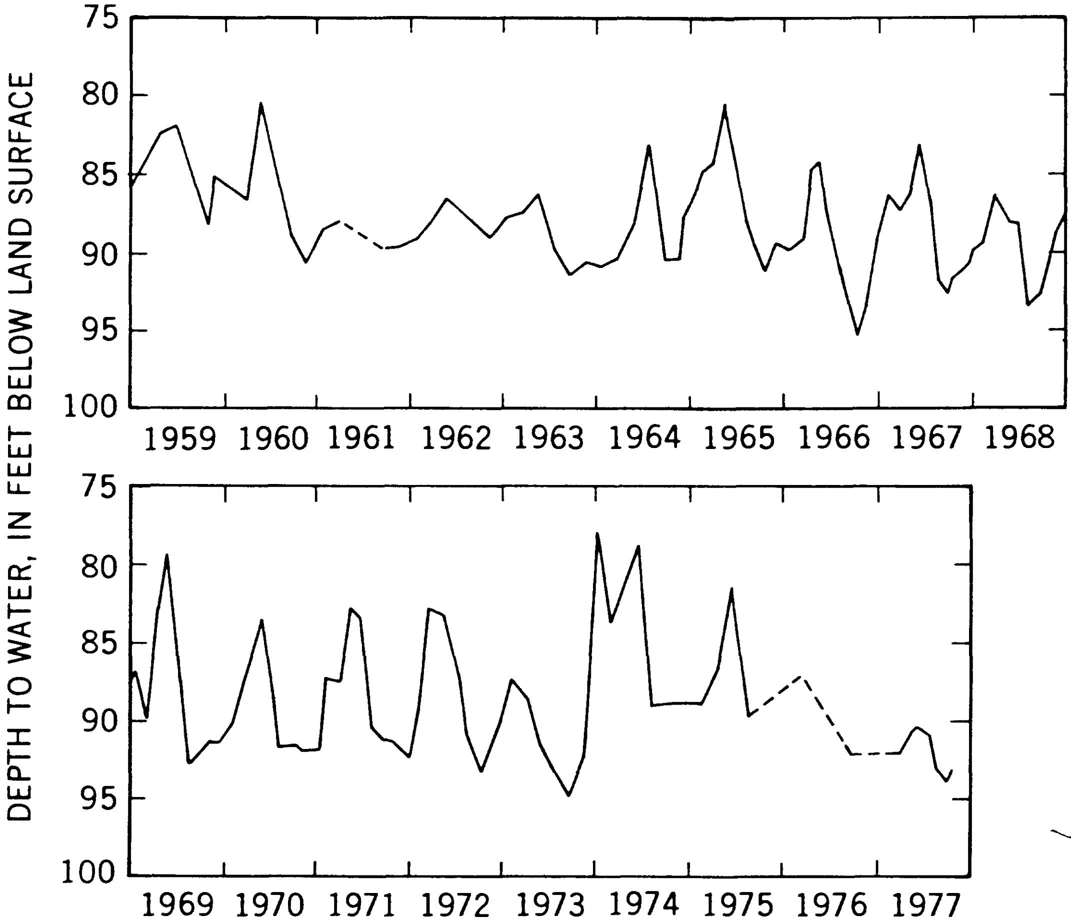


FIGURE 3.--Continued

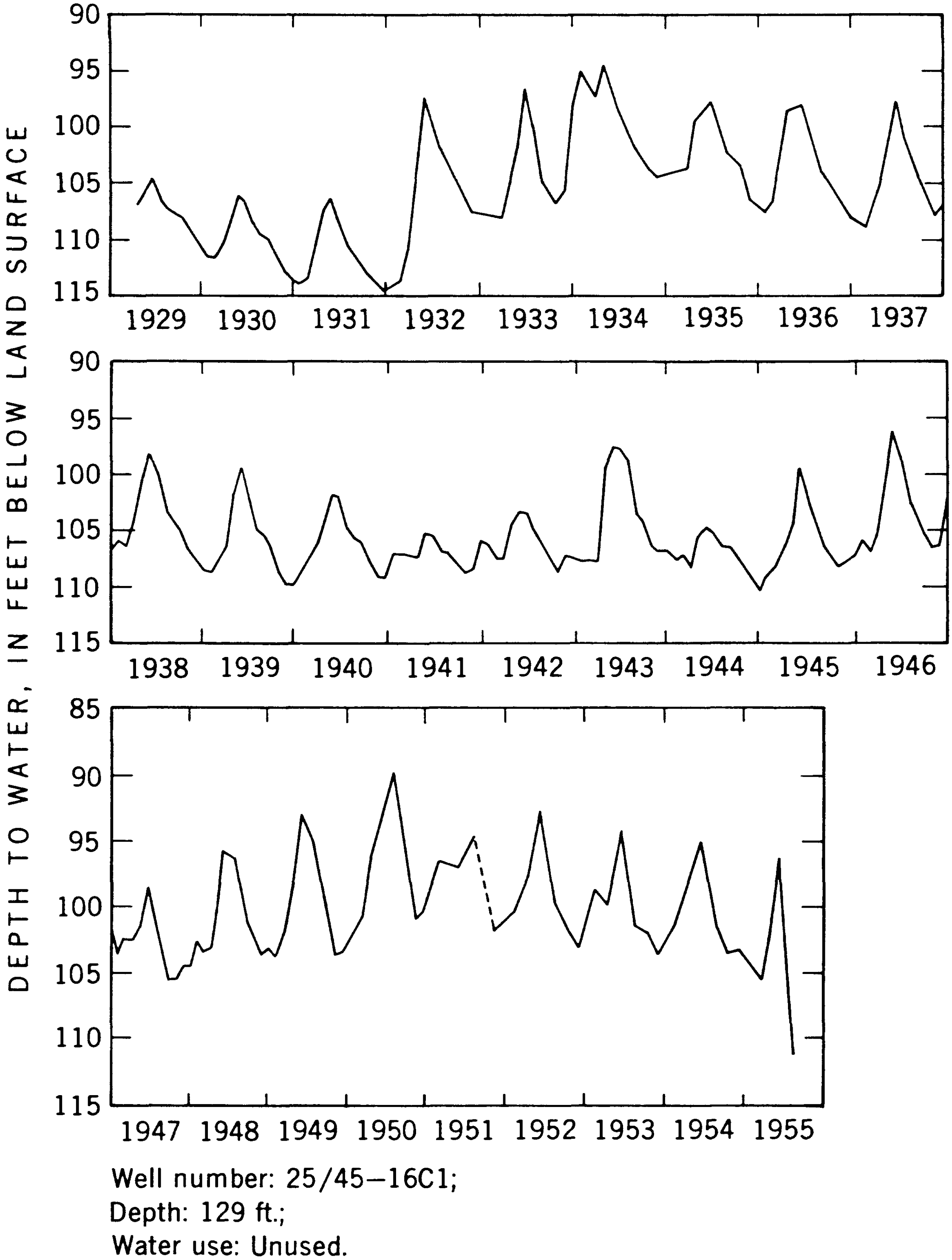


FIGURE 4.--Water-level fluctuations in well 25/45-16C1, 1929-55 and 1957-77

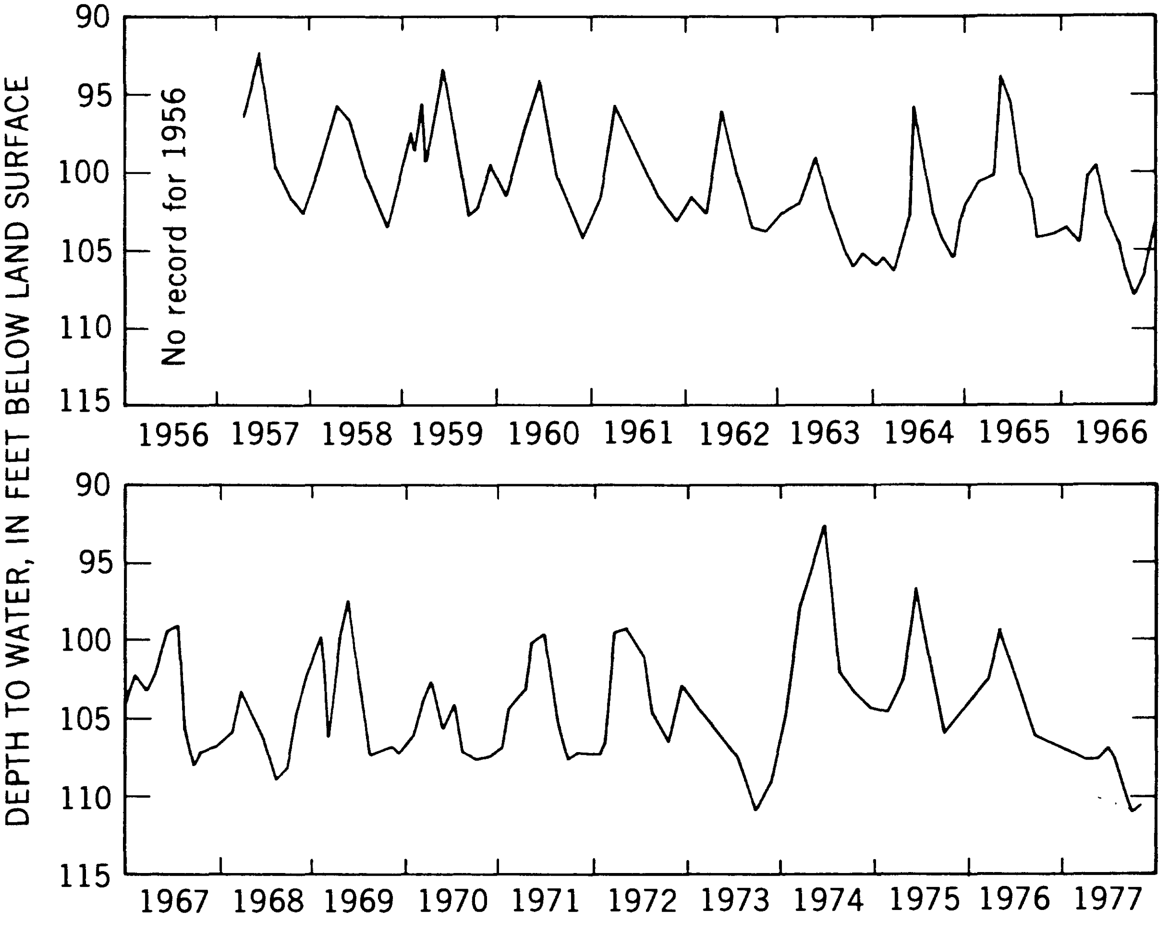


FIGURE 4.--Continued

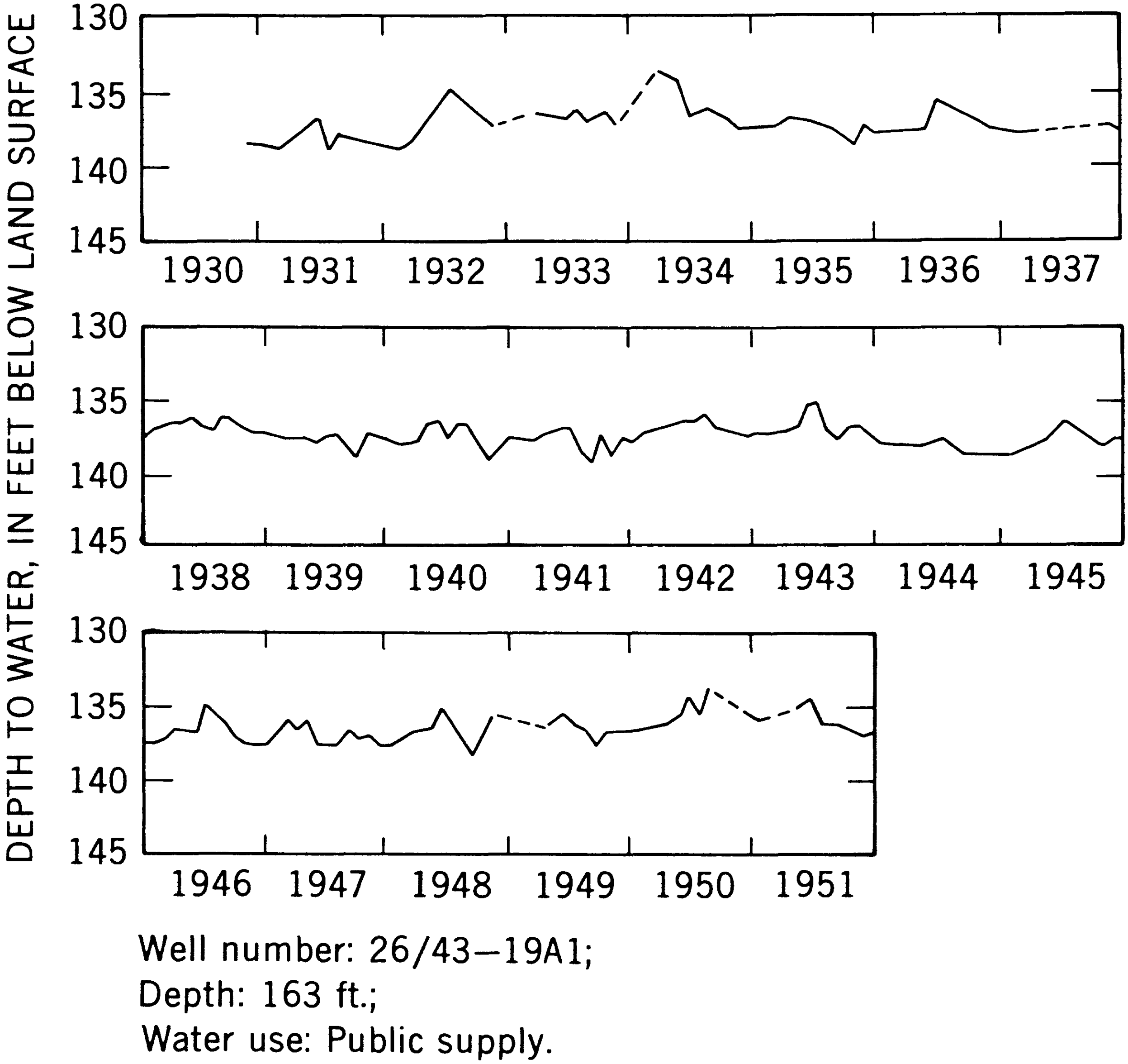


FIGURE 5.--Water-level fluctuations in well 26/43-19A1, 1930-68 and 1970-77.

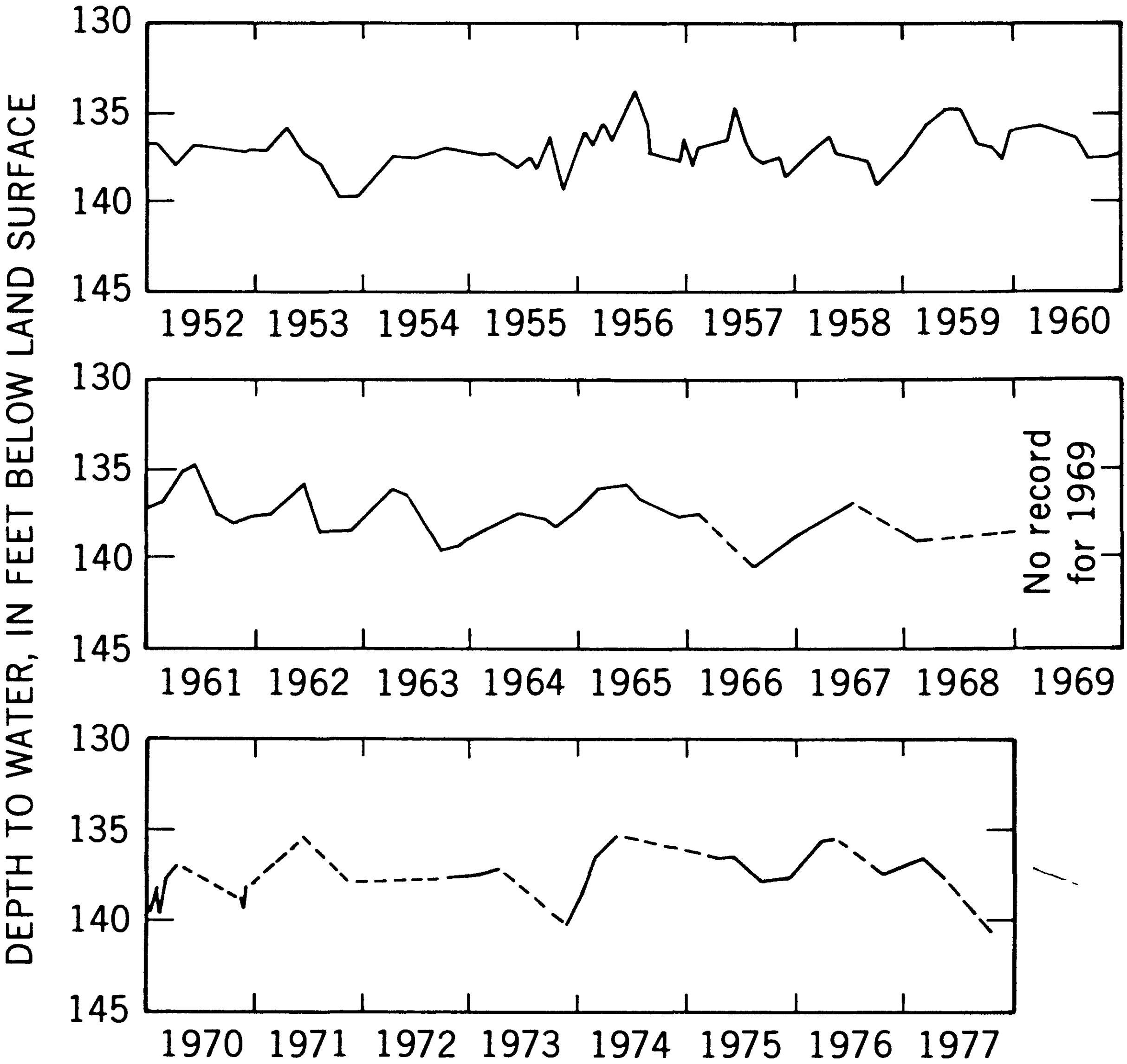


FIGURE 5.--Continued

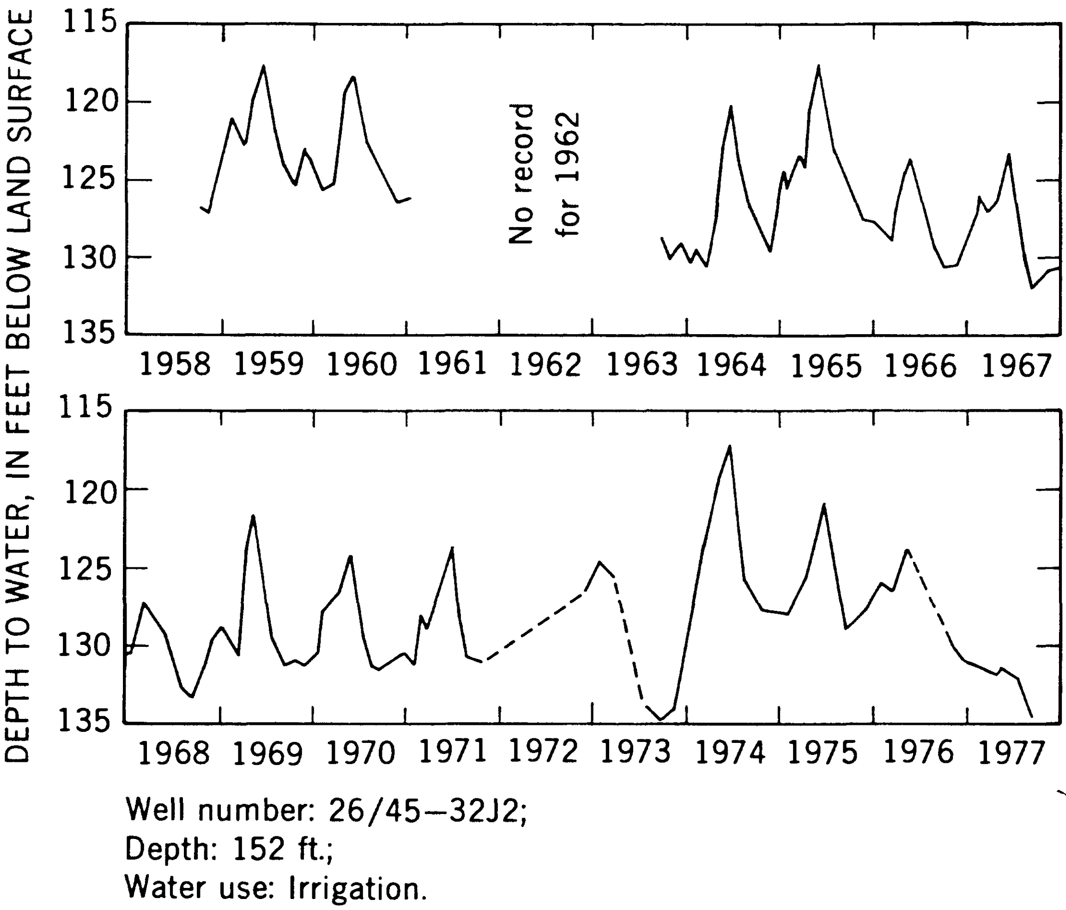


FIGURE 6.--Water-level fluctuations in well 26/45-32J2, 1958-61 and 1963-77.

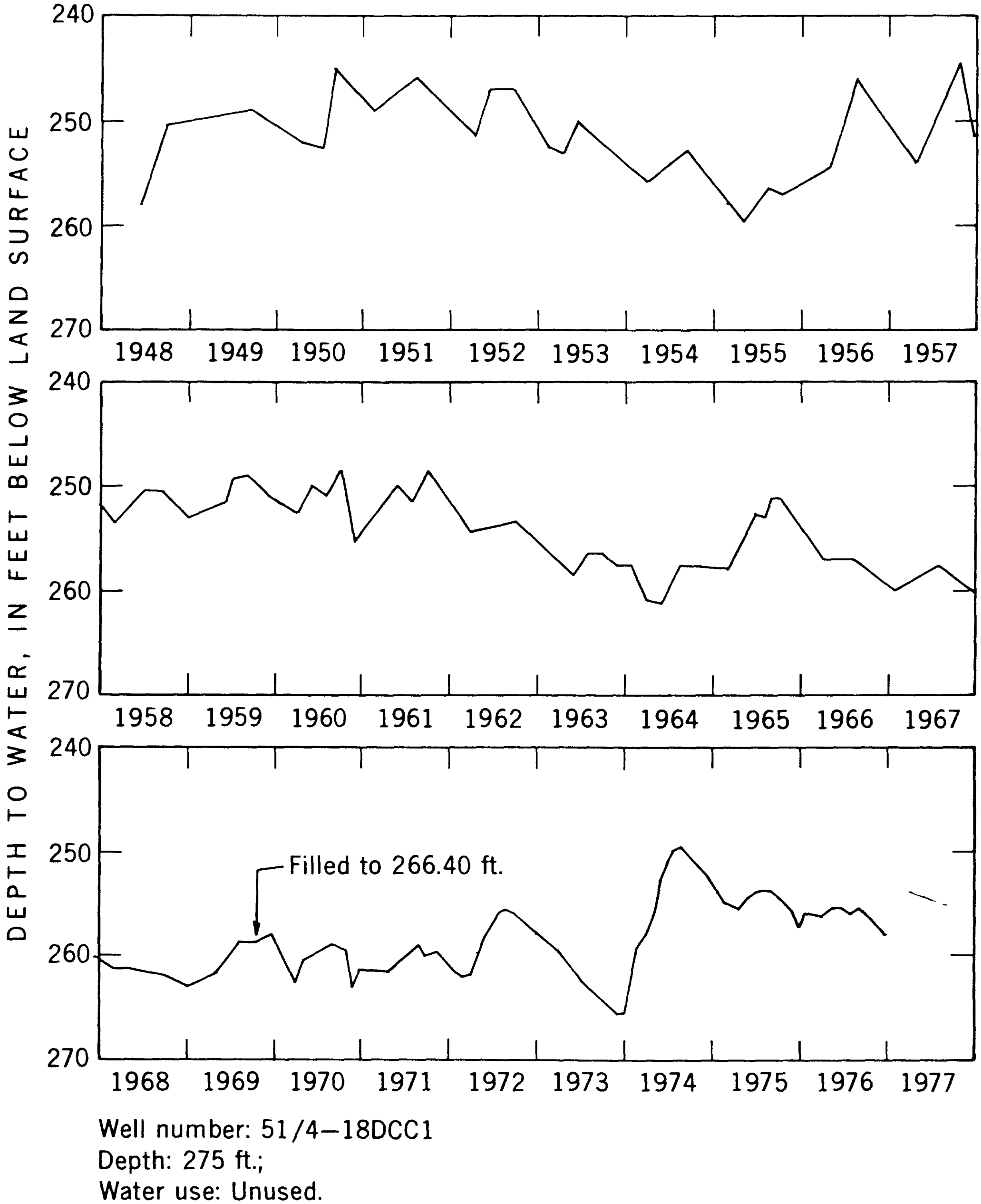


FIGURE 7.--Water-level fluctuations in well 51/4-18DCC1, 1948-76.

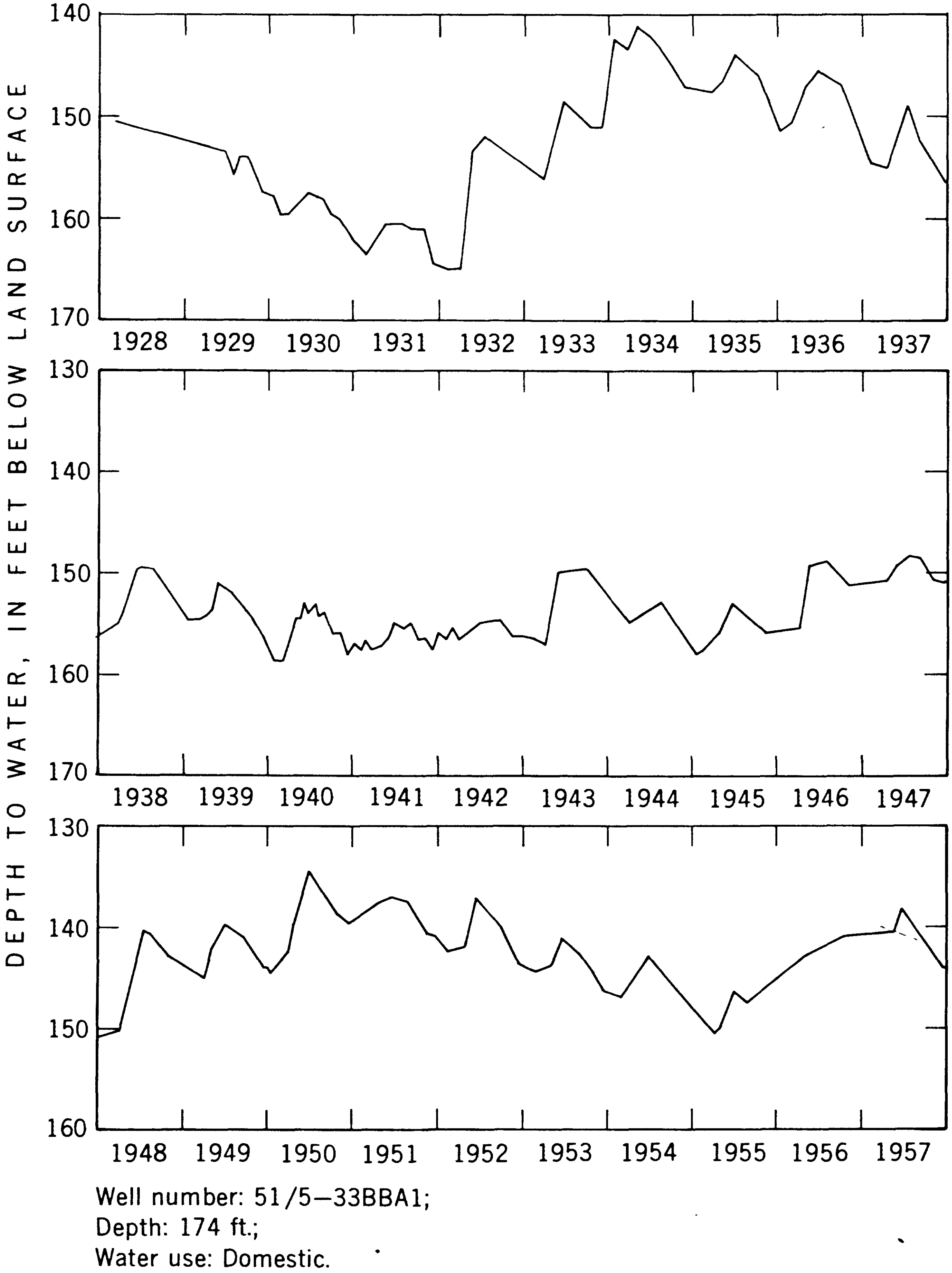


FIGURE 8.--Water-level fluctuations in well 51/5-33BBA1, 1928-76.

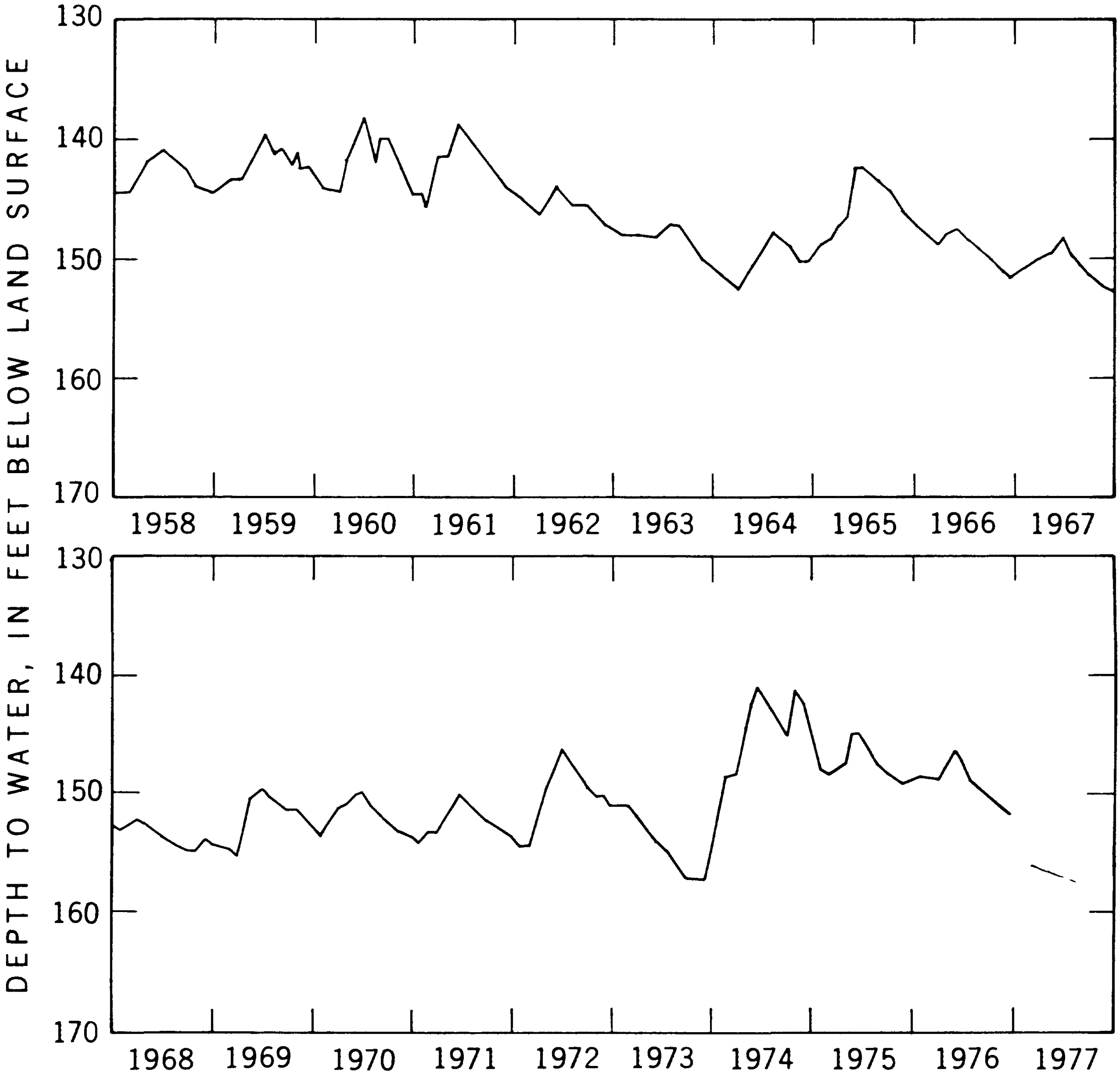


FIGURE 8.--Continued

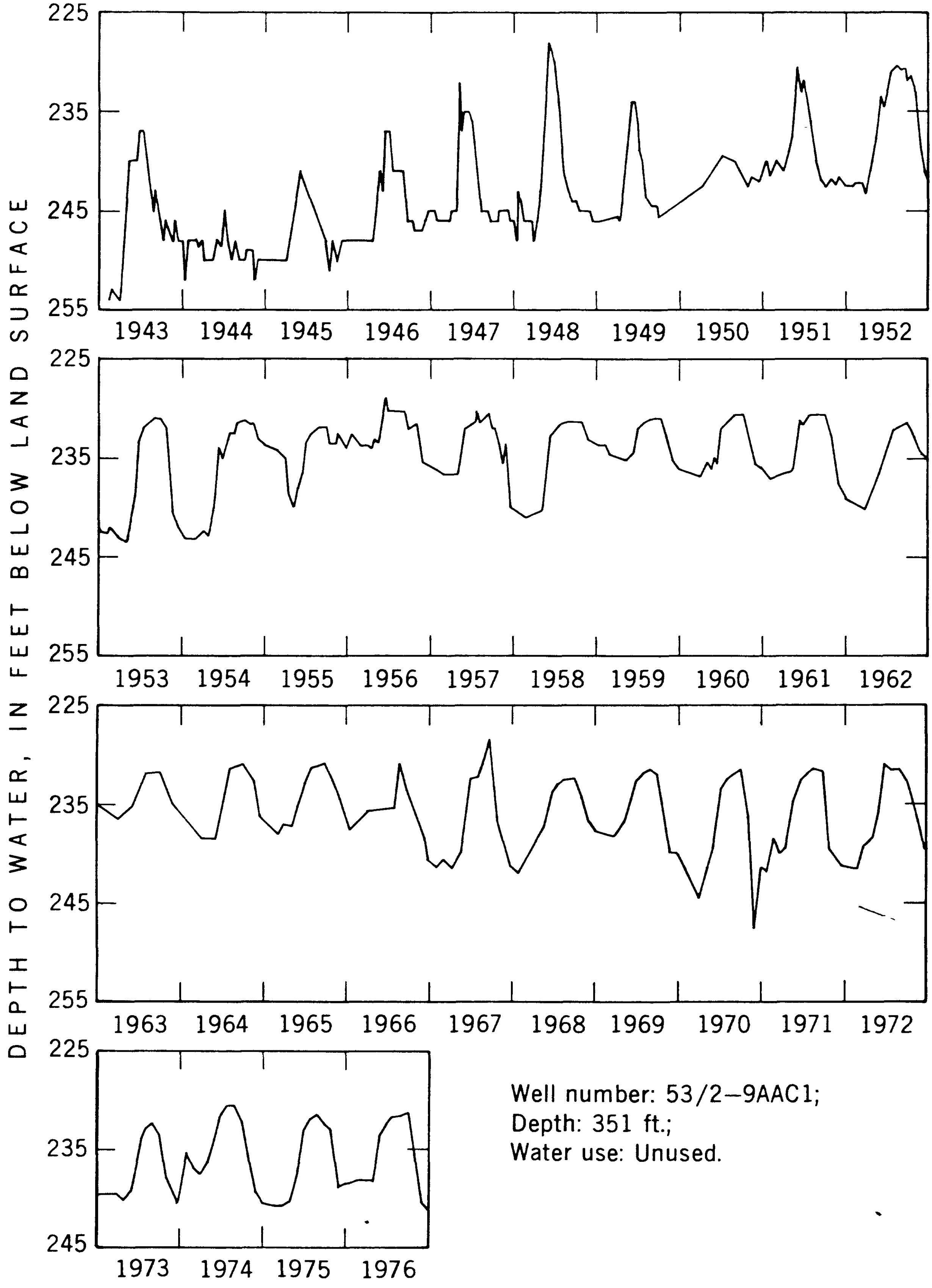
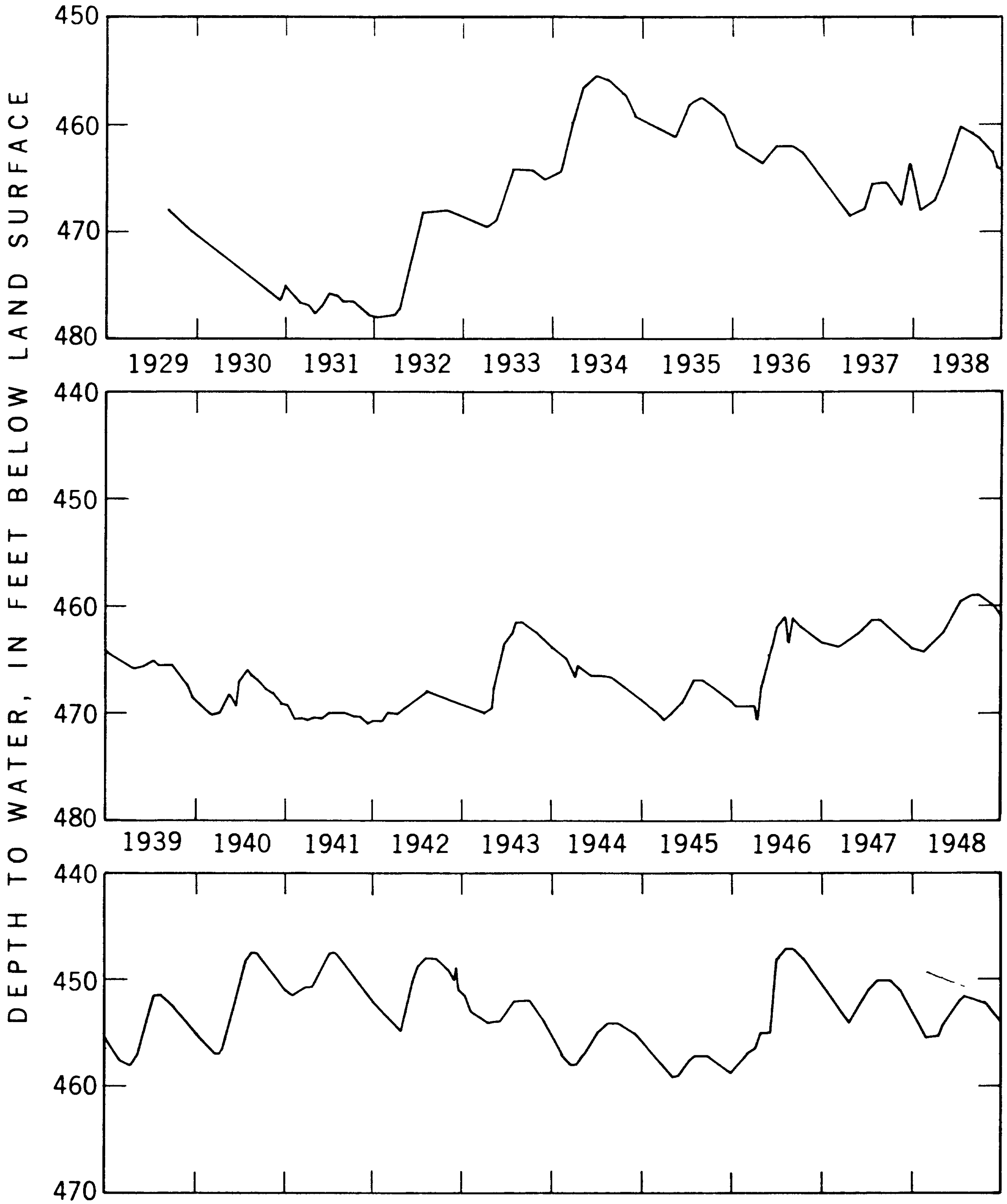


FIGURE 9.--Water-level fluctuations in well 53/2-9AAC1, 1943-76.



Well number: 53/4—24BBA1;
Depth: 485 ft.;
Water use: Domestic and Stock.

FIGURE 10.--Water-level fluctuations in well 53/4-24BBA1, 1929-76.

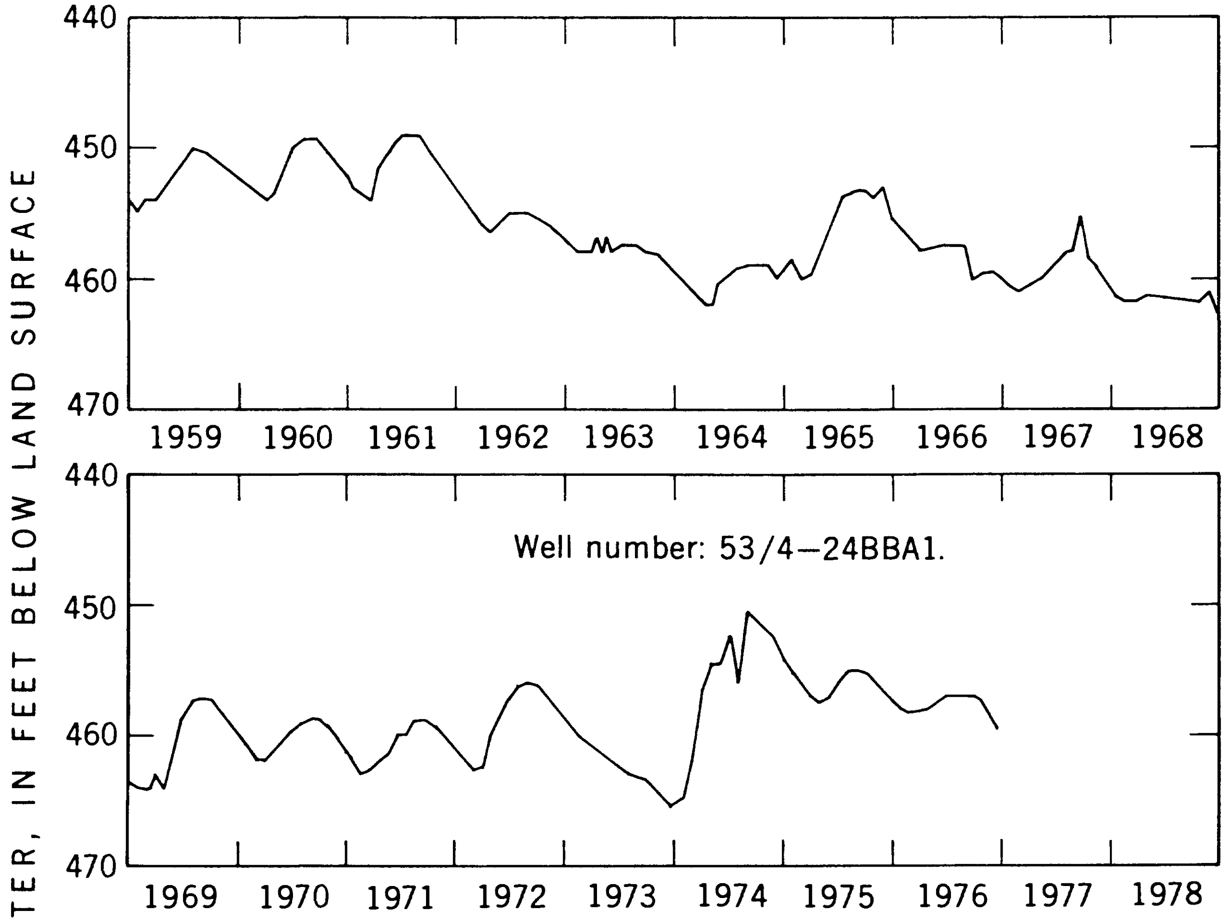


FIGURE 10.--Continued

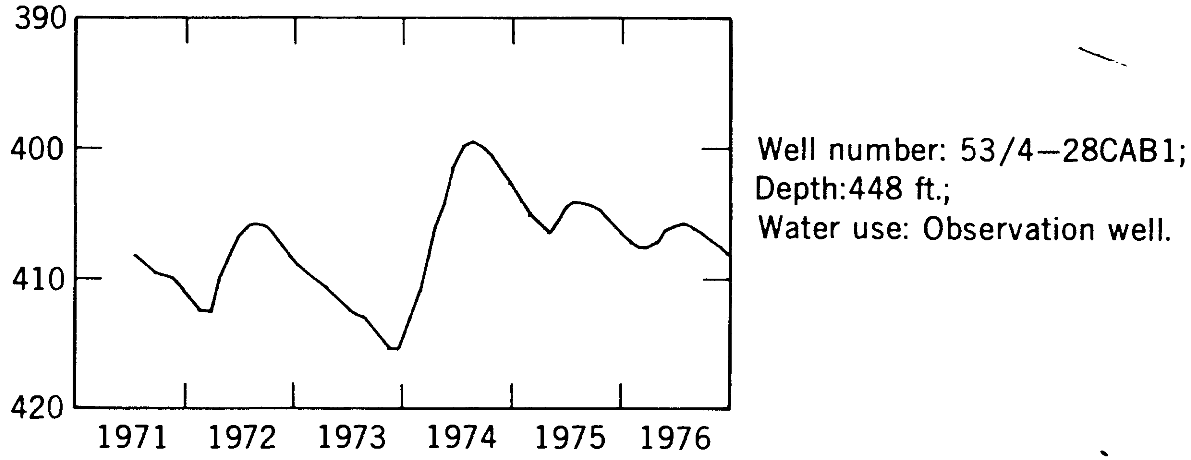


FIGURE 11.--Water-level fluctuations in well 53/4-28CAB1, 1971-76.

Ground Water-Surface Water Relationships

The major part of the ground water flowing through the aquifer eventually discharges to the Spokane and Little Spokane Rivers. Although this has been known for many years, the amounts and areas of interchange have not been entirely identified because of the complexity of the system. From 1948 to 1950, the U.S. Geological Survey, in cooperation with the U.S. Bureau of Reclamation, added six gaging stations to the five stations then in operation on the Spokane and Little Spokane Rivers. Broom (1951) and McDonald and Broom (1951) analyzed the gaging-station records for the 1950 water year (Oct. 1, 1949-Sept. 30, 1950) and estimated the amounts and locations of water transferred from the aquifer to the river and vice versa. Their analyses showed there were large variations during the 1950 water year, not only in magnitude of flow, but also in direction of flow. For example, between Post Falls, Idaho, and Greenacres, Wash., the Spokane River varied from gaining as much as 529 ft^3/s to losing as much as 757 ft^3/s, with an average annual loss to the aquifer of about 78 ft^3/s.

These kinds of variations take place in most years and result from fluctuations of the levels of both the river stage and the water table. In locations where the water table stands above the level of the river, water discharges from the aquifer to the river. Where the water table is below the level of the river, the aquifer is recharged by the river. The levels of both the Spokane River and the water table generally fluctuate about 10 feet per year; however, because these fluctuations do not coincide, there are changes in the respective water levels with resulting changes in the amounts, directions, and locations of interchanges of water. The conditions are such that instantaneous flow rates, as well as directions of flow of water between the aquifer and the river may change drastically on a short-term basis, although the long-term average exchange for any reach of the river is probably fairly constant.

J. V. Tracy of the U.S. Geological Survey, as part of an ongoing project to construct a computer model of the ground-water flow system of the Spokane Valley part of the aquifer, has used the data compiled by Broom and McDonald and the long-term gaging station records at Post Falls, Idaho, and Long Lake, Wash., to estimate the average annual gains and losses between the aquifer and the Spokane and Little Spokane Rivers. The results of this analysis are shown on plate 4. The only losing reach of the Spokane River is between Post Falls, Idaho, and Greenacres, Wash., and it averages about 80 ft^3/s. The remainder of the Spokane River from Greenacres to Nine Mile Falls gains an annual average of 780 ft^3/s from the aquifer. The Little Spokane River gains about 310 ft^3/s from the aquifer below Dartford and has the most consistent interchange with the aquifer.

The total of the estimated average annual exchanges of water between the aquifer and the rivers shows an estimated net discharge to the rivers from the aquifer of 1,010 ft^3/s.

Recharge to and Discharge from the Aquifer

Plate 4 shows locations and rates of recharge to and discharge from the aquifer and contains a ground-water budget. The part of the Spokane River basin which contributes water for recharge to the aquifer has a total area of about 5,900 square miles upstream of site 78 (pl. 10). This includes the Little Spokane River, Hangman Creek, and Coeur d'Alene River basins. The aquifer also receives some recharge (about 50 ft^3/s) from Pend Oreille Lake, by seepage through the lakebed into the aquifer. The surface-water drainage basin above the outlet of Pend Oreille Lake totals about 22,900 square miles and extends to Butte, Mont.(pl. 1).

The aquifer is recharged by percolation of surface-water runoff and underflow from adjoining highlands, by percolation of precipitation, by seepage from the Spokane River, and by percolation of irrigation water diverted from surface-water sources.

Estimates of recharge from adjoining highland areas upstream of Spokane are from Thomas (1963), Frink (1964), Pluhowski and Thomas (1968), and Hammond (1974). Amounts of recharge from adjoining highland downstream of Spokane and from areas adjoining the Hillyard Trough and the Little Spokane River were estimated by the U.S. Geological Survey (H. H. Tanaka, written commun., 1975). Coeur d'Alene, Pend Oreille, Spirit, Twin, Hayden, Hauser, Newman, and Liberty Lakes, are all adjacent to the aquifer. Part of the water that flows into these lakes, is evapotranspired, diverted, increases storage or becomes surface outflow, and part percolates into the ground and recharges the aquifer. In the adjacent hills, precipitation produces small streams which lose most of their water to infiltration as they flow only short distances across the land surface above the aquifer. Average inflow from adjoining areas totals about 1,010 ft^3/s, with about 800 ft^3/s in Idaho and 210 ft^3/s in Washington.

Direct recharge from precipitation was calculated by Pluhowski and Thomas (1968) for Idaho (130 ft^3/s) and by the U.S. Geological Survey (J. V. Tracy, written commun., 1977) for Washington (50 ft^3/s). These amounts represent that part of the precipitation which is not lost as surface runoff or as evapotranspiration and is therefore available for recharge to the aquifer.

As stated previously, the aquifer receives an average of about 80 ft^3/s from the Spokane River between Post Falls, Idaho and Greenacres, Wash. The 250 ft^3/s of recharge shown on plate 4 near Coeur d'Alene includes recharge from both Coeur d'Alene Lake and the Spokane River between the lake and Post Falls. The entire amount is treated here as recharge from an adjoining area.

Additional recharge comes from the Spokane River near Post Falls, where about 100 ft^3/s is diverted from the river and used for irrigation. Pluhowski and Thomas (1968) estimated that approximately one-half of this water (50 ft^3/s) recharges the aquifer.

The above estimates gives a total average rate of recharge of about 1,320 ft^3/s. Because no long-term change in storage has been observed within the past 50 years, discharge from the aquifer probably equals recharge and a state of near equilibrium exists in the aquifer.

The aquifer loses water to the Spokane and Little Spokane Rivers at an average rate of about 1,090 ft^3/s, and an additional ground-water outflow of about 55 ft^3/s occurs at the downstream end of the aquifer near Nine Mile Falls, Wash., as estimated by the U.S. Geological Survey (J. V. Tracy, written commun., 1977).

Water use accounts for most of the remainder of ground-water discharge. Approximately 62 ft^3/s of water in Washington and 2 ft^3/s of water in Idaho are pumped from the aquifer and are eventually discharged through sewer systems to the Spokane River (and in one place to Deadman Creek). In addition, large quantities of water are pumped from the aquifer and applied as irrigation water at the land surface or are discharged to cesspools or drain fields, after domestic or industrial use, where only a part of the water returns, by infiltration, to the aquifer.

Irrigation use of ground water averages about 31 ft^3/s in Washington and 61 ft^3/s in Idaho. Assuming a consumptive-use factor of 0.67, a total of 21 ft^3/s in Washington and 41 ft^3/s in Idaho are lost from the aquifer. Water pumped from the aquifer and discharged to cesspools or drain fields, or used for domestic irrigation, averages about 74 ft^3/s in Washington and 9 ft^3/s in Idaho. Using a consumptive use factor of 0.59, as calculated by Todd (U.S. Army Corps of Engineers, 1976), total loss from the aquifer is about 44 ft^3/s in Washington and 5 ft^3/s in Idaho. These various pumping losses total 127 ft^3/s in Washington and 48 ft^3/s in Idaho, for a total pumping loss of 175 ft^3/s.

Some water probably flows from the aquifer into the underlying materials or vice versa. The magnitude of this flow cannot be even roughly approximated because of the lack of data on the aquifer geometry, hydraulic characteristics, and head difference between the aquifer and these underlying materials. If the underlying materials are predominantly of the fine-grained Latah Formation or are relatively impermeable bedrock, as presently believed, then the amount of flow from the aquifer is probably an insignificant item in the ground-water budget.

A potential additional loss from the aquifer is ground-water evapotranspiration. However, the depth to the water table in most parts of the aquifer is in excess of 40 feet, precluding any significant loss by this means.

Summing all of the losses gives a total average discharge of about 1,320 ft^3/s from the aquifer. This is equal to the estimated average recharge indicating that the system is in balance or nearly so.

Soils

The major types of soil overlying the aquifer are shown on plate 5. The four soil units in the Washington part are simplified from 29 units mapped by Donaldson and Giese (1968). The map for the Idaho part (Idaho Water Resources Board, 1969) was designed to classify soil types as to their general suitability for irrigation. The emphasis on irrigability required a map consisting of only three general soil types and resulted in some unmapped areas (urban areas, air terminals, etc.) and straight-line and right-angle contacts between units. The explanation on plate 5 attempts to correlate the soil units in Washington with those in Idaho. The units do not exactly match, as evidenced by the apparent, but unnatural, soil change along the State line.

The infiltration rates of soils as estimated by Donaldson and Giese (1968) range from 2.5 to 10.0 inches per hour for most of the area overlying the aquifer in Washington. Although no infiltration rates were calculated for the Idaho soils, the values are probably roughly equivalent to those for corresponding units in Washington. Permeabilities are probably greater below the upper 3 to 6 feet, where general observations indicate an increase proportion of void space and a decrease in fine-grained materials.

Population

The distribution of population overlying the aquifer is shown on plate 6. The available population data in Washington is from enumeration districts with boundaries that roughly coincide with the aquifer boundaries. This is not the case in Idaho, where some large enumeration districts only partly overlie the aquifer. This necessitates the inclusion on plate 6 of substantial areas which do not overlie the aquifer.

The population densities are greatest over the Washington part of the aquifer, generally from 100 to 5,000 people/mi^2. In Idaho, popuation densities are mostly less than 100 people/mi^2, and only four small areas (totaling about 13 mi^2) have densities in excess of 399 people/mi^2.

Land Use

The use of the land surface overlying the aquifer is shown on plate 7. The Washington data are from a series of unpublished maps at a scale of 1 to 4,800 which were prepared during a previous study (U.S. Army Corps of Engineers, 1976). In plate 7, the data were modified to show the predominant type of land use per quartersection. The Idaho data are from the files of the Kootenai County Planning Commission.

From Pend Oreille Lake, Idaho, to Greenacres, Wash., the land surface is used primarily for agriculture. The land use west of Greenacres is mostly residential and industrial.

Water Use

Estimated volumes of water pumped from the aquifer in 1976 by public water-supply systems for domestic, irrigation, and industrial purposes, are shown on plate 8. The estimates in Washington are modified from a combination of data from a previous study (U.S. Army Corps of Engineers, 1976) and from data collected during a 1975 statewide water-use study (Dion and Lum, 1977). In Idaho, the estimated volumes were obtained in personal interviews with managers of water-supply systems.

The accuracy of these estimated volumes varies considerably. Some data were directly available from metered-flow records, while others had to be calculated on the basis of reported number of consumers and estimated average per capita annual use for each system.

Public water-supply systems pumped a total of about 30 billion gallons (128 ft^3/s) of water from the aquifer in 1976 for domestic use. Plate 8 shows that the major part of the water (about 27.5 billion gallons) was pumped in Washington. All publicly supplied water used for domestic purposes by the population overlying the aquifer was obtained from the aquifer, except for a very small portion (less than 1 percent of the total domestic use) which was obtained from Hayden Lake, Idaho. Wells are presently being constructed which will replace this surface-water supply with additional withdrawals from the aquifer. The major public water-supply systems are listed in table 1.

An additional 22 billion gallons (92 ft^3/s) of water was pumped from the aquifer in 1976 for irrigation and almost 5 billion gallons (19 ft^3/s) for industrial uses. Diverted from the Spokane River in 1976 were about 24 billion gallons (100 ft^3/s) for irrigation (near Post Falls, Idaho) and 10 billion gallons (42 ft^3/s) for industrial use (Kaiser- Trentwood cooling processes). Virtually all the water diverted by Kaiser-Trentwood is returned directly to the river.

TABLE 1.--Summary of public water-supply systems obtaining water from the aquifer

Name of water system[1]	Location of wells	Approximate population served in 1976	Approximate water use in 1976 (millions of gallons)	Number of samples tested[2]	Water quality: Chemical standards[3]: Standards exceeded	Water quality: Chemical standards[3]: Number of times exceeded	Present water treatment
City of Spokane	25/42-3 25/43-4,8,11 26/43-31	180,000	19,800	35	Iron	1	Chlorination
Modern Electric Water Company	25/44-8,15,16, 17,21,22, 27	25,000	1,760	51	Iron Manganese Dissolved solids	6 1 1	None
City of Coeur d' Alene	51/4-1,3,12	21,000	1,400	--	--	--	Chlorination
Whitworth Water District #2	26/43-7,19,20, 30	14,000	979	13	Iron	1	None
Fairchild Air Force Base	25/42-11	14,000	727	61	Iron	1	Chlorination
Vera Irrigation District #15	25/44-13,15,22, 23,26	12,000	590	37	Iron Nitrate	2 2	None
Washington Water Power #2	25/44-20,27,28, 29	7,400	590	20	Iron Copper Lead	3 1 1	Chlorination
Washington Water Power #1	25/43-13,23 25/44-7,18	4,800	343	50	Iron Phenols	5 1	Chlorination
Model Irrigation District #18	25/44-21, 28	4,600	82	5	Iron	1	None
City of Post Falls	50/5-1	4,500	431	--	--	--	None
Washington Water Power #3A	26/43-19,20,30	4,500	273	9	Iron	1	Chlorination
Orchard Avenue Irrigation District #6	25/43-12 25/44-7	4,500	102	24	Manganese Phenols	2 1	None
Carnhope Irrigation District #7	25/43-23	4,200	206	1	None	0	None
Trentwood Irrigation District #3	25/44-2,3 26/44-35	3,600	427	8	Iron	1	None
North Spokane Irrigation District #8	26/43-27,28	2,800	174	5	None	0	None
East Spokane Water District #1	25/43-24	2,800	161	22	Iron	5	None
Consolidated Irrigation District #19 (Greenacres)	25/45-17	2,700	134	2	None	0	None
Washington Water Power #3B	26/43-8,10	2,400	202	6	Iron Manganese	1 1	None
Ross Point Association	51/5-35,36	2,200	150	--	--	--	None
Hutchinson Irrigation District #16	25/44-18	2,000	181	3	None	0	None
Consolidated Irrigation District #19 (Corbin)	25/45-18	2,000	100	19	Iron	1	None
Pasadena Park Irrigation District #17	25/44-5,6	2,000	32	2	None	0	None
Irvin Water District #6	25/44-4,9	1,800	406	5	None	0	None
Town of Millwood	25/44-5,7,8	1,800	36	4	None	0	None
Consolidated Irrigation District #19 (East Farms)	26/46-31	1,500	72	18	Iron Manganese	2 1	None
Consolidated Irrigation District #19 (Otis Orchards)	25/45-2	1,300	65	2	None	0	None
City of Rathdrum	52/4-31	1,000	161	--	Nitrate	2	None
Pine Villa Estates	50/4-6	1,000	60	--	--	--	None
Dishman Water Company	25/44-19	1,000	24	2	None	0	None
Consolidated Irrigation District #19 (West Farms)	25/45-7	870	43	2	Iron	1	None
City of Spirit Lake	53/4-6	700	50	--	--	--	None
East Greenacres	51/5-28	600	38	--	--	--	None
Hauser Lake	51/5-19	600	40	--	--	--	None
Consolidated Irrigation District #19 (Carder)	25/44-11	510	25	2	None	0	None
City of Athol	53/3-9	330	50	--	--	--	None
Hoffman Water	50/4-1	300	20	--	--	--	None
Hayden Pines	51/4-23	250	15	--	--	--	None
Liberty Lakes Utilities Co.	25/45-14,15	240	13	17	Iron	2	None
Pine View Estates	51/4-12	200	13	--	--	--	None
Norms Trailer Court	51/4-23	150	10	--	--	--	None

TABLE 1.--Summary of public water-supply systems obtaining water from the aquifer--continued

Name of water system[1]	Location of wells	Approximate population served in 1976	Approximate water use in 1976 (millions of gallons)	Water quality: Number of samples tested[2]	Water quality: Chemical standards[3]: Standards exceeded	Water quality: Chemical standards[3]: Number of times exceeded	Present water treatment
Moab Irrigation District #20	26/45-25	140	7	4	Iron	1	None
Panhandle Mobile Estates	52/4-22	125	8	--	--	--	None
Mountain View	51/4-14	125	8	--	--	--	None
Sun Air Mobile	51/4-11	100	7	--	--	--	None
Country Living	52/4-27	100	7	--	--	--	None
Heutter	50/4-4	100	7	--	--	--	None
Rivilla Water Corporation	26/43-6	97	6	4	None	0	None
Howard Water	52/4-5	50	2	--	--	--	None
Bunco Road Water	53/2-17	40	2	--	--	--	None
Pleasant Prairie Water Company	26/44-32	34	5	2	Nitrate	1	None
Pinecroft Mobile Home Park	25/44-9	--	--	--	--	--	Chlorination
Hidden Village Estates	52/4-22	--	--	--	--	--	None
Upper Twin Lakes	53/5-36	--	--	--	--	--	None
Emerald Estates	51/4-12	Subdivision not yet completed					None
Caravelle Corporation	51/4-21	Subdivision not yet completed					None

[1] A few additional small systems probably exist that are not included in the basic data.

[2] Data not available for Idaho.

[3] Chemical standards are explained on plate 10.

Waste-Water Disposal

In 1976 water was pumped from the aquifer at a rate of about 147 ft^3/s for domestic and industrial uses. After being used, about 64 ft^3/s (44 percent) of this water was treated in municipal or industrial sewage treatment plants and then discharged to surface-water bodies. Of the remaining 83 ft^3/s, about 49 ft^3/s (33 percent of the pumpage) was lost to evapotranspiration. (See section on recharge to and discharge from the aquifer.) This leaves about 34 ft^3/s (23 percent of the pumpage) which returns to the aquifer through an assortment of waste-water disposal facilities.

Interim sewage-treatment facilities processed about 5 of the 34 ft^3/s of waste water. These interim facilities are generally small systems which collect, treat, and dispose of waste water generated at apartment complexes, shopping areas, mobile home parks, housing developments, educational institutions, recreational areas, military installations, motels, and hotels. These systems are not considered to be permanent and may be replaced in the future by extensions of existing sewer systems or by more elaborate small systems. The treatment processes utilized at these interim facilities are activated sludge, both extended aeration and conventional, and stabilization lagoons, some of which are provided with supplemental mechanical aeration (U.S. Army Corps of Engineers, 1976). The effluent from these systems is ultimately discharged to drain fields, lagoons, or seepage ditches.

Individual household systems disposed of the remaining 29 ft^3/s of waste water. The three basic methods of individual treatment and disposal employed in the area overlying the aquifer include cesspools, septic tanks with drain fields, and aerobic treatment units with drain fields. The vast majority of individual systems consist of septic tanks with drain fields (U.S. Army Corps of Engineers, 1976).

Plate 9 shows the distribution of the various types of waste-water treatment above the aquifer and the locations of effluent discharges to surface-water bodies. Also shown are the locations of landfills and other solid-waste disposal sites, which, though not within the scope of this study, could possibly have some effect on the quality of water in the aquifer.

Streamflows

Table 2 is a summary of streamflow data from 49 sites in the recharge area of the aquifer. Sixteen of the sites are in the Pend Oreille Lake drainage basin, the remainder are in the Spokane River-Coeur d'Alene Lake drainage basin. Twenty-one of the sites are currently (1977) active stations maintained by the U.S. Geological Survey. The earliest records go back to 1891 when discharge measurements were first recorded on the Spokane River at Spokane, Wash. The station locations are shown on plates 1 and 10.

Where sufficient records are available, mean annual, maximum, and minimum discharges were calculated and are listed in table 2. These calculated discharges reflect only that period of time during which data were collected at any particular station. Therefore, direct comparison of discharges at different sites having different periods of record can be misleading and should be avoided.

TABLE 2.--Summary of streamflow data

Site number[1]	Station name	USGS station number	Drainage area[2] (mi^2)	Period of record[3]: Daily or monthly figures (calendar years)	Period of record[3]: Low-flow measurements (water years)	Discharge[4] (ft^3/s): Mean annual	Discharge[4] (ft^3/s): Maximum recorded	Discharge[4] (ft^3/s): Minimum recorded
1	Clark Fork near Galen, Mont.	12323800	940	--	1971.	--	--	--
2	Flint Creek near Philipsburg, Mont.	12328500	--	--	1971.	--	--	--
3	Flint Creek near Drummond, Mont.	12331500	490	1948-49.	--	161	1,800	10
4	Clark Fork at Drummond, Mont.	12331600	2,378	--	1971.	--	--	--
5	Blackfoot River near Lincoln, Mont.	12334600	15.1	1968-70.	--	16.4	294	0.70
6	Clark Fork above Missoula, Mont.	12340500	5,999	1929-	--	3,002	32,300	115
7	Bitterroot River near Missoula, Mont.	12352980	2,850	--	1971.	--	--	--
8	Clark Fork near Alberton, Mont.	12353300	9,272	1959-63.	--	5,668	34,900	1,000
9	Flathead River at Flathead, British Columbia	12355000	427	1929-	--	3,024	69,100	198
10	Flathead River near Big Fork, Mont.	12369000	6,300	--	1971.	--	--	--
12	Flathead River at Perma, Mont.	12388700	8,795	--	1971.	--	--	--
13	Clark Fork near Plains, Mont.	12389000	19,958	1910-	--	20,050	134,000	3,200
14	Thompson River near Thompson Falls, Mont.	12389500	642	1965-	--	499	6,080	68
15	Clark Fork at Thompson Falls, Mont.	12391000	21,113	--	1971.	--	--	--
16	Clark Fork at Clark Fork, Idaho	12392050	a22,100	--	1970-71.	--	--	--
17	Pack River near Colburn, Idaho	12392300	124	1958-	--	341	6,880	15
20	Coeur d'Alene River at Enaville, Idaho	12413000	895	1939-	--	1,980	61,000	104
21	South Fork Coeur d'Alene River near Mullan, Idaho	12413080	--	--	1974.	--	--	--
22	South Fork Coeur d'Alene River at Kellogg, Idaho	12413250	194	1974-	--	406	11,100	30
23	South Fork Coeur d'Alene River near Smelterville, Idaho	12413300	202	1966-74.	--	457	11,500	50
24	Coeur d'Alene River at Rose Lake, Idaho	12413810	1,318	--	1971-	--	--	--
25	St. Maries River near Santa, Idaho	12414900	275	1965-	--	383	10,700	23
26	St. Joe River at Calder, Idaho	12414500	1,030	1920-	--	2,384	53,000	91
27	St. Joe River at St. Maries, Idaho	12415075	--	--	1974-	--	--	--
31	Coeur d'Alene Lake at Coeur d'Alene, Idaho	--	b3,700	--	--	--	--	--
33	Hayden Creek below North Fork near Hayden Lake, Idaho	12416000	22.0	1948-53, 58, 59, 61-	--	31.0	790	1.9
39	Spokane River near Post Falls, Idaho	12419000	a3,840	1912-	--	6,345	50,100	65
42	Spokane River above Liberty Bridge near Otis Orchards, Wash.	12419500	a3,880	1929-	--	6,225	50,100	59
43	Newman Lake near Newman Lake, Wash.	12419800	b 28.6	1958-*	--	--	--	--
44	Liberty Lake at Liberty Lake, Wash.	12420000	b 13.3	1950-*	--	--	--	--
46	Spokane River at Greenacres, Wash.	12420500	a4,150	1948-52.	--	7,059	>40,000	52
48	Spokane River at Trent, Wash.	12421000	a4,200	1911-13.	--	6,070	22,400	1,310
48	Spokane River below Trent Bridge, near Spokane, Wash.	12421500	a4,200	1948-54.	--	7,332	40,100	615
53	Spokane River below Green Street at Spokane, Wash.	12422000	a4,220	1948-52.	--	7,410	34,400	702
59	Spokane River at Spokane, Wash.	12422500	a4,290	1891-	--	6,924	49,000	95
61	Hangman (Latah) Creek at Spokane, Wash.	12424000	689	1948-	--	259	20,600	1.4
63	Spokane River at Riverside State Park at Spokane, Wash.	12424200	a5,010	1972-	--	--	45,200	450
64	Spokane River above Seven-Mile Bridge near Spokane, Wash.	12424500	a5,020	1948-52.	--	7,860	33,400	302
65	Deep Creek near Spokane, Wash.	12425500	77.3	1949-50.	--	--	--	--
67	Spokane River below Nine-Mile Dam near Spokane, Wash.	12426000	a5,200	1948-50.	--	9,164	--	296
71	Little Spokane River above Wandermere Lake Creek near Dartford, Wash.	12430700	650	--	1953-	--	--	--

TABLE 2.--Summary of streamflow data--Continued

Site number[1]	Station name	USGS station number	Drainage area[2] (mi²)	Period of record[3]: Daily or monthly figures (calendar years)	Period of record[3]: Low-flow measurements (water years)	Discharge[4] (ft³/s): Mean annual	Discharge[4] (ft³/s): Maximum recorded	Discharge[4] (ft³/s): Minimum recorded
72	Wandermere Lake Creek near Dartford, Wash.	12430800	4.32	--	1953-	--	--	--
73	Little Spokane River at Dartford, Wash.	12431000	665	1929-32; 1946-	--	322	3,170	63
75	Little Spokane River below Country Club near Dartford, Wash.	12431200	691	--	1953-	--	--	--
76	Little Spokane River near Dartford, Wash.	12431500	698	1903-5*; 1948-52.	1953; 1956-57; 1961-	627	2,220	377
77	Little Spokane River at Norman's Ranch near Spokane, Wash.	12431900	700	1911-12*.	--	--	--	--
77	Little Spokane River near Spokane, Wash.	12432000	701	1913.	1920-24; 1930-32; 1947-48; 1953-	--	2,140	426
Not shown	Long Lake at Long Lake, Wash.	12432500	a6,020	1913-	--	--	--	--
Not shown	Spokane River at Long Lake, Wash.	12433000	a6,020	1939-	--	8,145	49,700	114

[1] Site number and locations are shown on plates 1 and 10.

[2] a = approximately   b = drainage area above lake outlet

[3] - A date followed by a dash shows that the station was continued in operation beyond September 30, 1975

. A date followed by a period indicates discontinuance.

; A date followed by a semicolon indicates a break in the collection of records.

* Gage heights, elevations, or gage heights and discharge measurements only.

Water year begins on October 1 and ends on September 30 and is designated by the calendar year in which it ends.

[4] The mean annual, maximum, and minimum discharges for any particular station reflect only that period of time during which data were collected at that station. Direct comparison of discharges at different sites with different periods of record is not possible.

Water Quality

Ground Water

Physical and inorganic chemical characteristics

In preparing this report, a primary goal was tabulation of all available data on the chemical quality of water in the aquifer. The final accumulation of data from the files of Federal, State, and local agencies, from previous studies of the aquifer, and from private laboratories, includes approximately 20,000 analyses of physical and chemical characteristics in about 1,200 samples from about 400 groundwater sites (wells and springs). The vast majority of data were obtained from State and Federal agencies, about 67 and 27 percent, respectively, and about two-thirds of the samples were collected from sites in Washington. A tabulation of the Washington analyses is on file in the District office, U.S. Geological Survey, Tacoma, Wash. Idaho data are on file in the Coeur d'Alene office of the Idaho Department of Health and Welfare. Some of the data are contained in Storet (a computer data-storage system maintained by EPA).

A summary of the chemical quality of water from the aquifer is included in plate 10. With the exception of phenols, only those chemical characteristics that are included in the National Interim Primary (or Proposed Secondary) Drinking Water Regulations (U.S. Environmental Protection Agency, 1975) are included in plate 10. These characteristics may affect the health of consumers or the esthetic quality of the water. Plate 10 also contains an explanation of the MCL's (maximum contaminant level) and proposed secondary levels included in the regulations.

About 3,300 analyses were made for 11 physical and inorganic chemical characteristics listed in plate 10 which reportedly may affect the health of consumers. Of these characteristics five exceeded their respective MCL's in 16 analyses (in about one-half of one percent of the analyses). The MCL's for the other characteristics (barium, cadmium, chromium, mercury, selenium, and silver) were never exceeded. Fluoride, nitrate, turbidity, arsenic, and lead MCL's were exceeded in 1.2 percent or less of the samples tested for each characteristic.

The recommended levels of 8 of the 10 characteristics included in the proposed secondary levels, which deal with those characteristics that may affect the esthetic quality of water, have been exceeded in a small number of samples from the aquifer. The recommended levels of sulfate and foaming agents (detergents) were never exceeded. The recommended levels of manganese, chloride, total dissolved solids, pH, color, copper, and zinc were exceeded in less than 2 percent of the samples. Iron exceeded the recommended level in almost 8 percent of the samples tested. Proposed secondary levels were exceeded a total of 87 times (1.4 percent), from a total of more than 6,300 tests. Table 3 lists the ground-water sites where constituents in water samples exceeded the MCL's and proposed secondary levels. The general locations of these sites are shown on plate 10.

Nitrate analyses of water from two wells east of Round Mountain, Idaho, are of interest even though the wells do not tap the Spokane Valley-Rathdrum Prairie aquifer. These wells are in unconsolidated materials which underlie part of the aquifer's recharge area. Water from well 52/3-7dca1 had a nitrate (as N) concentration of 12 mg/L (milligrams per liter) in August 1975 and a sample from well 52/3-35aac1, had 20 mg/L of nitrate (as N) in November 1975.

Because of the huge number of physical and inorganic chemical analyses and because the data were obtained from a wide variety of sources representing different sampling techniques, analytical methods, and data-reporting practices, the potential exists for inclusion of some incompatible, if not inaccurate, data in the tabulations shown in plate 10 and given in table 3. For example, determinations of one of the high concentrations of fluoride (table 3) and the maximum concentrations of lead and copper (pl. 10) are suspect. Water from well 25/44-26L1 was tested for fluoride 19 times between 1964 and 1974. Of these tests, 17 showed values of fluoride of 0.2 mg/L or less, one showed 0.6 mg/L, and one showed 2.7 mg/L, exceeding the MCL. Because there was no obvious source of fluoride near this well, the extreme value might represent an analytical error or contamination of the sample. The water sample which contained concentrations of copper exceeding its recommended level and of lead exceeding its MCL was collected on September 14, 1972, as part of an EPA study of the quality of water in the aquifer. Samples collected at that time yielded very high concentrations of mercury, which were later believed to have resulted from an apparent contamination of the preserving agent used in the field. Although a resampling of the same wells for mercury in January 1973 essentially confirmed the contamination theory, and showed mercury concentrations only about 0.01 times as large as in September 1972; the accuracy of the large copper and lead concentrations in September 1972 remains undetermined. At present there are no obvious indications that any of the other analyses involving violations of the MCL's or recommended levels may be in error.

Data for 10 ground-water sites with the most complete, long-term water-quality records available are listed in table 4. These data show that, although the concentration of any one constituent may change significantly from one sampling date to the next at any particular site, no long-term trends of changing water quality are readily observable. Detailed statistical analyses of these data can be misleading because changes in sampling techniques and analytical methods over the years have continually improved the accuracy of results.

TABLE 3.--Records of locations where constituents in ground-water samples have exceeded chemical standards

Constituent	Site number	Date sampled	Value	Site number	Date sampled	Value	Site number	Date sampled	Value
Iron	25/42-11M1	11-22-65	0.58 mg/L	25/44-15E2	5-12-70	1.1 mg/L	26/45-24F1	4-29-64	1.1 mg/L
	25/43-23A1	5-07-70	.43		12-14-71	.32	-24F2	10-27-61	1.2
		12-13-71	.32	-17M1	7-02-75	.40		4-29-64	.61
		1-18-72	.44	-27E1	7-17-72	.48	-25C1	5-07-75	.35
		7-24-72	.74	-27L1	5-11-70	1.4	-34L1	4-27-71	1.0
		9-14-72	.70	-28L1	5-10-71	.34	-36N1	6-28-73	2.4
	-24G1	5-13-70	.62	-29A1	2-14-72	.42		9-26-73	.55
		12-31-71	.34		3-31-72	.36		12-18-73	1.5
		6-12-72	.36	25/45-7A3	4-27-71	.90	26/46-31M1	5-14-70	.42
	-24L1	2-14-72	.38	-15D1	12-13-71	.34		12-14-71	.40
		3-31-72	.46	-15R1	2-14-72	.34	50/4-3AAD1	6-23-76	78
	25/44-3B1	10-09-75	.38		8-14-72	.32	50/5-4BBA1	3-16-76	6.8
	-8N1	5-12-70	.48	-18R1	7-24-72	.68		4-29-76	.79
	-9J2	4-16-71	.38	26/42-12L1	5-12-64	.32		6-14-76	16
	-11R	4-16-71	2.0		5-15-75	.32	51/5-29CAA1	5- -76	.60
	-12A1	5-01-75	.31	26/43-6Q1S	10-18-72	.44		6- -76	.50
	-12D	5-01-75	.32	-6Q3S	10-18-72	.34	-31DDC1	6-23-76	3.6
	-13M1	5-15-70	.44	-19A1	7-09-75	.34	-33BCD1	5-25-76	1.3
	-15E1	2-16-72	.32	-30F1	9-30-70	.80	53/2-3BAC1	10- -76	.70
				-31A1	5-28-75	.31			
Manganese	25/42-13B1	3-20-74	0.14 mg/L	25/44-7C1	5-14-70	0.052 mg/L	26/43-8B4	5-12-64	0.46 mg/L
	25/43-12H1	6-19-72	.30	-15E1	7-02-75	.060	26/46-31M1	5-14-70	.060
	25/44-1J1	11-05-75	1.6	-26L1	5-22-72	.060	50/4-3AAD1	6-23-76	1.4
	-6A1	10-10-72	.052	26/42-12L1	5-15-75	.060	54/2-34	5-08-74	.21
Chloride	26/43-34P1	5-24-55	370 mg/L						
		5-25-55	470						
		6-13-55	700						
		6-24-55	>1,000						
Fluoride	25/44-26L1	12-13-71	2.7 mg/L	52/4-2CDC	3-07-74	3.2 mg/L			
Nitrate (as N)	25/44-26L1	11-04-70	16 mg/L	52/4-31CAB1	7- -75	26 mg/L	54/2-34CAC1	10- -75	14 mg/L
		2-14-72	11	52/5-25DCD1	7- -75	28		3- -76	12
	26/44-32Q1	9-27-71	11	54/2-34CAC1	8- -75	23		8- -76	11
	51/4-35BBA1	10- -76	11					10- -76	20
Total dissolved solids	25/44-2Q1	6-10-74	537 mg/L	25/44-17A1	6-06-74	539 mg/L	53/4-27DAC1	8- -75	508 mg/L
pH	25/43-24G1	5-13-70	8.8 units	25/45-14N1	10-22-59	9.4 units	26/43-20J2	12-26-62	9.0 units
Color[1]	25/44-4J1	5-04-71	21 PCU	25/44-8D1	4-19-71	17 PCU	26/44-32R1	5-05-71	20 PCU
	5R1	5-14-71	20	-18J1	5-10-71	16			
Turbidity[2]	26/43-6Q1S	1-17-73	10 JTU						
Arsenic	26/43-7B1S	9-26-73	0.064 mg/L						
Copper	25/44-29A1	9-14-72	5.2 mg/L						
Lead	25/44-29A1	9-14-72	0.42 mg/L						
Zinc	52/4-17ABC1	8- -75	7.5 mg/L						
Toxaphene	26/42-12A1S	9-26-73	0.060 mg/L						
Phenols	25/43-14K1	6-27-73	0.002 mg/L	25/44-19D1	9-26-73	0.002 mg/L	26/42-27N1	6-29-73	0.012 mg/L
	25/44-1J1	11-17-75	15	25/45-4C3	6-06-74	.002	26/43-5L1S	6-29-73	.002
	-2Q1	6-27-73	.007	-15D1	9-25-73	.004	-7B1S	6-29-73	.004
		6-10-74	.002	26/42-11J1S	6-27-73	.005	-16F	6-10-74	.002
	-7C1	9-25-73	.002	-12A1S	6-29-73	.003	26/45-35F1	6-28-73	.004
	-18D2	6-27-73	.002		9-26-73	.004	-36Q1	9-26-73	.002

[1] PCU = platinum-cobalt units
[2] JTU = Jackson turbidity units

TABLE 4.--Chemical quality of ground water from selected sites

Site number	Data source[a]	Date sampled	Dissolved silica (SiO_2) (mg/L)	Dissolved iron (Fe) (µg/L)	Dissolved manganese (Mn) (µg/L)	Dissolved calcium (Ca) (mg/L)	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved potassium (K) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Alkalinity as $CaCO_3$ (mg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Dissolved fluoride (F) (mg/L)	Total nitrate (N) (mg/L)	Total nitrite (N) (mg/L)
25/42-11M1	USGS	1- 2-48	13	10	--	27	7.9	--	--	114	93	10	2.2	0.1	0.35	--
	USGS	8-11-48	14	--	--	--	--	--	--	112	92	14	3.0	--	--	--
	USGS	7-19-49	13	60	--	27	7.5	--	--	110	90	10	2.3	.1	.25	--
	USGS	12- 6-50	14	10	--	25	7.8	2.5	1.6	103	84	11	2.3	.1	.32	--
	USGS	12- -51	12	<5	--	24	7.3	2.1	3.0	101	83	10	2.5	.2	.23	--
	USGS	1-14-53	12	100	--	25	7.4	1.9	1.2	104	85	10	1.4	.1	.23	--
	USGS	12-15-53	13	20	--	24	7.4	2.4	1.0	100	82	9.5	2.7	.2	.46	--
	USGS	10- 6-54	11	30	--	25	7.5	2.3	1.2	106	87	11	2.2	.0	.53	--
	USGS	10-29-55	11	<5	--	27	7.1	2.9	1.7	112	92	10	2.1	.0	.48	--
	USGS	10-30-56	14	50	--	26	8.4	2.4	1.4	103	84	10	4.5	.2	.41	--
	USGS	11- 6-57	--	10	--	28	7.5	2.4	1.3	110	90	9.6	2.0	.0	.51	--
	USGS	7-22-58	13	--	--	28	7.8	2.3	1.3	108	89	11	[b]3.8	.3	.64	--
	USGS	9-22-59	16	150	--	34	11	5.6	2.5	148	121	14	3.0	.0	.83	--
	USGS	11- 8-60	21	40	--	36	11	5.4	2.4	154	126	13	[b]3.0	.2	1.1	--
	USGS	10-10-61	14	70	<50	28	6.8	4.0	1.7	115	94	11	1.2	.1	.39	--
	USGS	10- 8-62	12	<5	<50	26	7.6	3.1	1.4	108	89	10	2.0	.0	.51	--
	USGS	4-29-64	9.5	10	<50	26	7.2	2.7	1.1	104	85	12	2.0	.1	.41	--
	USGS	3-12-65	17	130	<50	34	10	5.2	2.2	145	119	13	3.5	.1	.92	--
	USGS	11-22-65	18	580	<50	35	10	5.5	2.5	146	120	14	2.5	.1	.94	--
	USGS	12- 5-66	12	70	10	26	7.0	2.9	1.4	105	86	13	1.0	.1	.41	--
	USGS	12-12-67	16	10	<5	31	9.9	4.1	1.9	137	112	13	2.0	.2	.74	--
	USGS	11-14-68	12	30	<5	28	7.4	3.1	1.2	108	89	15	2.4	.1	.67	--
	USGS	10-28-69	12	30	<5	29	7.8	3.0	1.5	115	94	13	2.3	.1	.53	--

Date sampled	Total ammonia (N) (mg/L)	Total Kjeldahl nitrogen (N) (mg/L)	Total phosphorus (F) (mg/L)	Dissolved orthophosphorus (P) (mg/L)	Dissolved solids (residue at 180°C) (tons/acre-ft)	Dissolved solids (residue at 180°C) (mg/L)	Hardness (Ca,Mg) (mg/L)	Noncarbonate hardness (mg/L)	Percent sodium	Sodium adsorption ratio	Specific conductance (micromhos)	pH (units)	Water temperature (°C)
1- 2-48	--	--	--	--	0.16	116	100	--	--	--	206	7.7	--
8-11-48	--	--	--	--	--	--	--	--	--	--	206	--	12.0
7-19-49	--	--	--	--	.16	119	98	--	--	--	203	7.9	10.0
12- 6-50	--	--	--	--	.15	111	94	--	5	0.1	184	7.9	12.0
12- -51	--	--	--	--	.15	108	90	--	5	.1	184	7.8	13.0
1-14-53	--	--	--	--	.16	116	93	--	4	.1	186	8.0	12.0
12-15-53	--	--	--	--	.15	109	90	--	5	.1	185	7.9	11.5
10- 6-54	--	--	--	--	.16	116	93	--	5	.1	193	7.9	12.0
10-29-55	--	--	--	--	.15	111	97	--	6	.1	205	8.2	11.5
10-30-56	--	--	--	--	.15	112	99	--	5	.1	202	7.5	13.5
11- 6-57	--	--	--	--	.16	116	101	--	5	.1	202	7.9	10.0
7-22-58	--	--	--	--	.16	118	102	--	5	.1	197	7.5	20.0
9-22-59	--	--	--	--	.22	159	131	--	8	.2	270	8.2	14.5
11- 8-60	--	--	--	--	.23	168	134	--	8	.2	275	8.2	11.0
10-10-61	--	--	--	--	.17	124	98	4	8	.2	203	8.1	13.5
10- 8-62	--	--	--	--	.16	118	96	8	6	.1	199	8.0	16.0
4-29-64	--	--	--	--	.15	112	94	10	6	.1	195	8.0	9.5
3-12-65	--	--	--	--	.21	157	127	8	8	.2	264	7.8	15.5
11-22-65	--	--	--	--	.22	159	130	10	8	.2	263	7.7	12.0
12- 5-66	--	--	--	--	.16	115	94	8	6	.1	198	7.7	12.0
12-12-67	--	--	--	--	.19	140	118	6	7	.2	251	7.8	8.0
11-14-68	--	--	--	--	.18	134	101	12	6	.1	214	8.0	12.0
10-28-69	--	--	--	--	.18	136	105	11	6	.1	220	8.1	13.5

Date sampled	Color (platinum-cobalt units)	Turbidity (JTU)	Carbon dioxide (CO_2) (mg/L)	Phenols (µg/L)	Foaming agents (detergents) (µg/L)	Dissolved arsenic (As) (µg/L)	Dissolved cadmium (Cd) (µg/L)	Dissolved chromium (Cr) (µg/L)	Dissolved copper (Cu) (µg/L)	Dissolved lead (Pb) (µg/L)	Total mercury (Hg) (µg/L)	Dissolved zinc (Zn) (µg/L)
1- 2-48	0	--	--	--	--	--	--	--	--	--	--	--
8-11-48	--	--	--	--	--	--	--	--	--	--	--	--
7-19-49	--	--	--	--	--	--	--	--	--	--	--	--
12- 6-50	2	--	--	--	--	--	--	--	--	--	--	--
12- -51	5	--	--	--	--	--	--	--	--	--	--	--
1-14-53	5	--	--	--	--	--	--	--	--	--	--	--
12-15-53	3	--	--	--	--	--	--	--	--	--	--	--
10- 6-54	3	--	--	--	--	--	--	--	--	--	--	--
10-29-55	0	--	--	--	--	--	--	--	--	--	--	--
10-30-56	5	--	--	--	--	--	--	--	--	--	--	--
11- 6-57	5	--	--	--	--	--	--	--	--	--	--	--
7-22-58	0	--	--	--	--	--	--	--	--	--	--	--
9-22-59	5	--	--	--	--	--	--	--	--	--	--	--
11- 8-60	5	--	--	--	--	--	--	--	--	--	--	--
10-10-61	0	--	1.5	--	--	--	--	--	--	--	--	--
10- 8-62	0	--	1.7	--	--	--	--	--	--	--	--	--
4-29-64	0	--	1.7	--	--	--	--	--	--	--	--	--
3-12-65	0	--	3.6	--	--	--	--	--	--	--	--	--
11-22-65	5	--	4.7	--	--	--	--	--	--	--	--	--
12- 5-66	0	--	3.4	--	--	--	--	--	--	--	--	--
12-12-67	0	--	3.4	--	--	--	--	--	--	--	--	--
11-14-68	5	--	1.7	--	--	--	--	--	--	--	--	--
10-28-69	0	--	--	--	--	--	--	--	--	--	--	--

TABLE 4.--Chemical quality of ground water from selected sites--Continued

Site number	Data source[a]	Date sampled	Dissolved silica (SiO_2) (mg/L)	Dissolved iron (Fe) (µg/L)	Dissolved manganese (Mn) (µg/L)	Dissolved calcium (Ca) (mg/L)	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved potassium (K) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Alkalinity as $CaCO_3$ (mg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Dissolved fluoride (F) (mg/L)	Total nitrate (N) (mg/L)	Total nitrite (N) (mg/L)
25/43-12H1	GSBR	5(or)6-51	--	--	--	--	--	--	--	232	190	--	2.9	--	--	--
	DSHS	4- 1-71	2.5	0	0	31	19	4.4	1.7	168	138	19	2.2	0.1	1.8	0.051
	DSHS	9-17-71	6.2	200	9	38	26	9.0	2.1	237	194	17	3.5	.1	1.6	.033
	DSHS	10-14-71	.0	60	9	39	12	4.2	2.1	110	90	29	3.0	.1	1.2	.075
	DSHS	11-15-71	4.0	20	9	32	57	4.8	2.2	364	298	15	9.0	.3	1.5	.040
	DSHS	12-13-71	2.5	40	0	27	11	4.4	2.2	154	126	13	2.2	.2	1.4	.04
	DSHS	1-18-72	5.0	180	0	33	20	4.2	2.0	163	134	24	2.0	.1	1.4	.035
	DSHS	2-14-72	4.5	80	3	39	19	6.0	2.4	165	135	21	4.5	.1	.92	.012
	DSHS	3-31-72	5.0	160	6	34	15	4.6	3.5	156	128	28	3.0	.1	1.1	.009
	DSHS	4-19-72	7.0	180	6	40	21	4.4	2.3	207	170	27	5.5	.1	.87	.022
	DSHS	5-22-72	12	120	0	34	17	5.0	2.3	176	144	33	2.2	.1	1.6	.027
	DSHS	6-19-72	69	90	300	34	21	5.5	2.2	165	135	24	11	.1	1.4	.024
	DSHS	7-17-72	1.2	300	6	40	25	5.0	2.5	163	134	17	10	.1	1.3	.038
	DSHS	8-14-72	4.2	20	18	36	16	5.5	2.2	149	122	16	3.8	.2	.68	.021
	DSHS	9-14-72	5.8	80	6	97	20	5.3	2.2	163	134	33	4.2	.1	.78	.004
	EPA	9-14-72	--	[c]<100	2	73	16	3.9	1.8	138	--	15	2	.0	1.1	--
	EPA	1-15-73	--	10	2	--	--	--	--	--	--	--	--	--	--	--
	DSHS	7-28-75	12	200	50	40	15	1.8	--	177	145	18	4.5	.5	.6	.02

Site number	Data source[a]	Date sampled	Total ammonia (N) (mg/L)	Total Kjeldahl nitrogen (N) (mg/L)	Total phosphorus (P) (mg/L)	Dissolved orthophosphorus (P) (mg/L)	Dissolved solids (residue at 180°C) (tons/acre-ft)	Dissolved solids (residue at 180°C) (mg/L)	Hardness (Ca,Mg) (mg/L)	Noncarbonate hardness (mg/L)	Percent sodium	Sodium adsorption ratio	Specific conductance (micromhos)	pH (units)	Water temperature (°C)
25/43-12H1	GSBR	5(or)6-51	--	--	--	--	--	--	156	--	--	--	253	--	--
	DSHS	4- 1-71	--	--	0.080	--	0.22	164	154	16	6	0.2	296	7.6	5.6
	DSHS	9-17-71	--	--	.060	--	.30	221	204	10	9	.3	360	7.6	--
	DSHS	10-14-71	--	--	.020	--	.20	145	148	58	6	.2	300	7.7	--
	DSHS	11-15-71	--	--	.026	--	.42	306	316	18	3	.1	300	7.1	--
	DSHS	12-13-71	--	--	.050	--	.19	140	112	--	8	.2	264	7.6	--
	DSHS	1-18-72	--	--	.030	--	.23	172	164	30	5	.1	292	7.5	--
	DSHS	2-14-72	--	--	.000	--	.24	179	179	41	7	.2	312	8.1	--
	DSHS	3-31-72	--	--	.030	--	.23	172	148	20	6	.2	300	7.7	--
	DSHS	4-19-72	--	--	.040	--	.29	211	188	18	5	.1	326	8.0	--
	DSHS	5-22-72	--	--	.025	--	.26	194	154	10	6	.2	310	8.3	10
	DSHS	6-19-72	--	--	.030	--	.41	304	194	59	6	.2	308	8.4	--
	DSHS	7-17-72	--	--	.040	--	.25	183	204	70	5	.2	330	7.7	--
	DSHS	8-14-72	--	--	.040	--	.21	158	156	34	7	.2	300	7.8	--
	DSHS	9-14-72	--	--	<.010	--	.34	248	324	190	3	.1	320	7.9	--
	EPA	9-14-72	--	--	.020	--	.24	174	156	--	--	--	310	7.4	--
	EPA	1-15-73	--	--	--	--	--	--	--	--	--	--	--	--	--
	DSHS	7-28-75	--	--	.080	--	.24	180	160	--	--	.1	320	8.3	--

Site number	Data source[a]	Date sampled	Color (platinum-cobalt units)	Turbidity (JTU)	Carbon dioxide (CO_2) (mg/L)	Phenols (µg/L)	Foaming agents (detergents) (µg/L)	Dissolved arsenic (As) (µg/L)	Dissolved cadmium (Cd) (µg/L)	Dissolved chromium (Cr) (µg/L)	Dissolved copper (Cu) (µg/L)	Dissolved lead (Pb) (µg/L)	Total mercury (Hg) (µg/L)	Dissolved zinc (Zn) (µg/L)
25/43-12H1	GSBR	5(or)6-51	--	--	--	--	--	--	--	--	--	--	--	--
	DSHS	4- 1-71	5	0	11	--	--	--	--	--	--	--	--	--
	DSHS	9-17-71	4	0	13	--	--	--	--	--	--	--	--	--
	DSHS	10-14-71	2	0	5.0	--	--	--	--	--	--	--	--	--
	DSHS	11-15-71	3	1	65	--	--	--	--	--	--	--	--	--
	DSHS	12-13-71	5	0	9.0	--	--	--	--	--	--	--	--	--
	DSHS	1-18-72	0	1	12	--	--	--	--	--	--	--	--	--
	DSHS	2-14-72	4	1	3.1	--	--	--	--	--	--	--	--	--
	DSHS	3-31-72	5	1	8.0	--	--	--	--	--	--	--	--	--
	DSHS	4-19-72	6	1	4.3	--	--	--	--	--	--	--	--	--
	DSHS	5-22-72	5	1	2.0	--	--	--	--	--	--	--	--	--
	DSHS	6-19-72	0	0	1.1	--	--	--	--	--	--	--	--	--
	DSHS	7-17-72	5	0	8.0	--	--	--	--	--	--	--	--	--
	DSHS	8-14-72	5	1	5.1	--	--	--	--	--	--	--	--	--
	DSHS	9-14-72	4	0	4.5	--	--	--	--	--	--	--	--	--
	EPA	9-14-72	--	--	--	--	--	[c]2	[c]2	[c]6	[c]152	[c]20	--	[c]120
	EPA	1-15-73	--	--	--	--	--	--	--	--	--	[c]30	[c]0.2	[c]56
	DSHS	7-28-75	5	0	--	--	--	--	--	--	--	--	--	--

TABLE 4.--Chemical quality of ground water from selected sites--Continued

Site number	Data source[a]	Date sampled	Dissolved silica (SiO_2) (mg/L)	Dissolved iron (Fe) (µg/L)	Dissolved manganese (Mn) (µg/L)	Dissolved calcium (Ca) (mg/L)	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved potassium (K) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Alkalinity as $CaCO_3$ (mg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Dissolved fluoride (F) (mg/L)	Total nitrate (N) (mg/L)	Total nitrite (N) (mg/L)
25/43-23A1	DSHS	5- 7-70	19	430	23	29	12	5.2	3.4	148	121	11	5.0	0.1	2.3	0.003
	DSHS	7-21-71	5.0	140	15	38	15	6.0	2.3	161	132	13	4.8	.1	3.2	.000
	DSHS	9-16-71	6.2	160	15	40	11	6.6	2.3	173	142	14	5.5	.1	3.2	.020
	DSHS	10-13-71	2.5	60	2	40	15	6.5	2.5	156	128	27	4.0	.1	2.7	.009
	DSHS	11-15-71	2.5	140	6	39	30	6.6	2.1	246	202	15	4.5	.0	3.2	.060
	DSHS	12-13-71	.0	320	9	34	16	6.4	2.4	173	142	19	7.2	.2	3.2	.024
	DSHS	1-18-72	2.5	440	12	42	23	7.0	2.4	163	134	84	4.5	.2	2.8	.032
	DSHS	2-14-72	8.0	160	6	50	12	6.4	2.6	77	6[illegible]	48	6.5	.2	9.2	.012
	DSHS	3-31-72	3.0	160	0	40	18	5.1	2.5	163	134	23	5.0	.1	1.7	.011
	DSHS	4-18-72	7.5	0	0	36	26	6.1	2.7	209	171	22	5.2	.1	1.6	.022
	DSHS	5-11-72	16	40	6	35	19	5.8	2.3	159	130	14	6.5	.1	2.9	.048
	DSHS	6-16-72	5.7	220	3	36	17	5.4	2.2	168	138	21	6.5	.1	2.0	.017
	DSHS	7-24-72	2.7	740	6	36	18	7.0	2.4	142	116	23	11	.6	1.4	.084
	DSHS	8-23-72	11	120	12	63	7.3	6.6	2.4	163	134	24	4.5	.3	1.9	.029
	DSHS	9-14-72	10	700	15	36	15	6.6	2.2	181	146	25	4.0	.2	1.4	.048
	EPA	9-14-72	--	[c]<100	3	--	13	5.4	2.1	--	--	12	4	.0	2.7	--
	EPA	1-15-73	--	30	2	--	--	--	--	--	--	--	--	--	--	--
	DSHS	3-12-75	16	240	<5	46	28	4.0	--	165	135	19	1.0	.1	6.0	.01

Site number	Data source	Date sampled	Total ammonia (N) (mg/L)	Total Kjeldahl nitrogen (N) (mg/L)	Total phosphorus (P) (mg/L)	Dissolved ortho-phosphorus (P) (mg/L)	Dissolved solids (residue at 180 C) (tons/acre-ft)	Dissolved solids (residue at 180 C) (mg/L)	Hardness (Ca,Mg) (mg/L)	Noncarbonate hardness (mg/L)	Percent sodium	Sodium adsorption ratio	Specific conductance (micromhos)	pH (units)	Water temperature (C)
25/43-23A1	DSHS	5- 7-70	--	--	0.000	--	0.23	167	120	--	8	0.2	284	8.3	7.3
	DSHS	7-21-71	--	--	.000	--	.23	167	156	24	8	.2	234	7.5	--
	DSHS	9-16-71	--	--	.050	--	.24	174	144	2	9	.2	370	7.9	--
	DSHS	10-13-71	--	--	.030	--	.26	193	160	32	8	.2	280	7.7	--
	DSHS	11-15-71	--	--	.070	--	.31	225	220	18	6	.2	310	7.6	--
	DSHS	12-13-71	--	--	.025	--	.24	175	154	12	8	.2	300	6.9	--
	DSHS	1-18-72	--	--	.040	--	.34	249	200	66	7	.2	320	7.8	--
	DSHS	2-14-72	--	--	.000	--	.23	169	128	65	7	.2	330	8.0	--
	DSHS	3-31-72	--	--	.020	--	.24	179	176	42	5	.2	300	8.0	--
	DSHS	4-18-72	--	--	.040	--	.29	210	208	37	6	.2	314	8.1	--
	DSHS	5-11-72	--	--	.030	--	.25	181	166	36	7	.2	310	7.9	12.2
	DSHS	6-16-72	--	--	.000	--	.24	179	160	22	7	.2	300	8.3	--
	DSHS	7-24-72	--	--	.016	--	.24	173	164	48	8	.2	300	7.6	--
	DSHS	8-23-72	--	--	.020	--	.27	202	188	54	7	.2	298	8.0	--
	DSHS	9-14-72	--	--	.060	--	.26	191	152	4	9	.2	280	8.0	--
	EPA	9-14-72	--	--	.010	--	.30	218	158	--	--	--	310	7.5	--
	EPA	1-15-73	--	--	--	--	--	--	--	--	--	--	--	--	--
	DSHS	3-12-75	--	--	.12	--	.27	202	200	--	--	.1	351	7.2	--

Site number	Data source	Date sampled	Color (platinum-cobalt units)	Turbidity (JTU)	Carbon dioxide (CO_2) (mg/L)	Phenols (µg/L)	Foaming agents (detergents) (µg/L)	Dissolved arsenic (As) (µg/L)	Dissolved cadmium (Cd) (µg/L)	Dissolved chromium (Cr) (µg/L)	Dissolved copper (Cu) (µg/L)	Dissolved lead (Pb) (µg/L)	Total mercury (Hg) (µg/L)	Dissolved zinc (Zn) (µg/L)
25/43-23A1	DSHS	5- 7-70	0	0	1.6	--	--	--	--	--	--	--	--	--
	DSHS	7-21-71	2	0	12	--	--	--	--	--	--	--	--	--
	DSHS	9-16-71	4	0	4.8	--	--	--	--	--	--	--	--	--
	DSHS	10-13-71	2	1	7.0	--	--	--	--	--	--	--	--	--
	DSHS	11-15-71	3	1	12	--	--	--	--	--	--	--	--	--
	DSHS	12-13-71	5	1	40	--	--	--	--	--	--	--	--	--
	DSHS	1-18-72	5	1	5.0	--	--	--	--	--	--	--	--	--
	DSHS	2-14-72	4	1	1.6	--	--	--	--	--	--	--	--	--
	DSHS	3-31-72	4	1	3.6	--	--	--	--	--	--	--	--	--
	DSHS	4-18-72	8	1	4.0	--	--	--	--	--	--	--	--	--
	DSHS	5-11-72	4	1	4.2	--	--	--	--	--	--	--	--	--
	DSHS	6-16-72	5	1	1.9	--	--	--	--	--	--	--	--	--
	DSHS	7-24-72	6	0	8.0	--	--	--	--	--	--	--	--	--
	DSHS	8-23-72	2	1	3.5	--	--	--	--	--	--	--	--	--
	DSHS	9-14-72	6	1	3.8	--	--	--	--	--	--	--	--	--
	EPA	9-14-72	--	--	--	--	--	[c]4	[c]1	[c]4	[c]620	[c]40	--	[c]210
	EPA	1-15-73	--	--	--	--	--	--	--	--	--	[c]15	[c]<0.2	[c]160
	DSHS	3-12-75	4	0	--	--	--	--	--	--	--	--	--	--

TABLE 4.--Chemical quality of ground water from selected sites--Continued

Site number	Data source[a]	Date sampled	Dissolved silica (SiO_2) (mg/L)	Dissolved iron (Fe) (µg/L)	Dissolved manganese (Mn) (µg/L)	Dissolved calcium (Ca) (mg/L)	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved potassium (K) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Alkalinity as $CaCO_3$ (mg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Dissolved fluoride (F) (mg/L)	Total nitrate (N) (mg/L)	Total nitrite (N) (mg/L)
25/44-15E2	DSHS	5-12-70	14	1,100	29	24	12	2.2	3.1	133	109	12	0.0	0.1	0.99	0.001
	DSHS	[illegible]-14-71	4.5	120	0	40	8.8	4.8	2.0	159	130	13	14	.1	2.5	.013
	DSHS	10-14-71	6.3	10	6	29	17	3.0	1.8	183	150	17	4.2	.1	1.2	.000
	DSHS	11-16-71	3.0	0	6	30	18	3.8	1.8	137	112	18	4.0	.1	1.6	.040
	DSHS	12-14-71	1.0	320	9	31	11	3.5	2.0	142	116	17	7.5	.1	1.1	.027
	DSHS	1-17-72	2.5	180	18	36	20	2.6	1.8	210	172	24	3.5	.4	1.5	.11
	DSHS	3-28-72	12	240	0	30	20	2.8	1.8	146	120	28	.0	.1	.61	.002
	DSHS	4-19-72	2.0	200	19	45	14	4.2	1.8	184	151	22	4.0	.1	.16	.016
	DSHS	5-11-72	10	140	6	27	21	2.8	1.8	146	120	17	4.0	.0	1.2	.034
	DSHS	6-19-72	2.9	280	3	32	19	3.2	1.7	176	144	25	4.5	.1	1.3	.10
	DSHS	7-17-72	.0	20	6	32	8.8	2.8	2.1	132	108	15	7.5	.1	.9	.060
	DSHS	8-23-72	5.6	200	3	38	15	3.5	2.0	154	126	21	2.5	.4	.71	.011
	DSHS	9-14-72	4.2	80	0	25	19	3.0	1.8	142	116	24	3.5	.1	.62	.005
	EPA	9-14-72	--	[c]<100	2	--	13	3.0	2.0	--	--	15	6	.0	.74	--
	DSHS	3-11-75	6.3	140	<5	33	17	2.6	--	132	108	16	3.5	<.1	3.8	.02

Date sampled	Total ammonia (N) (mg/L)	Total Kjeldahl nitrogen (N) (mg/L)	Total phosphorus (P) (mg/L)	Dissolved orthophosphorus (P) (mg/L)	Dissolved solids (residue at 180 C) (tons/acre-ft)	Dissolved solids (residue at 180 C) (mg/L)	Hardness (Ca,Mg) (mg/L)	Noncarbonate hardness (mg/L)	Percent sodium	Sodium adsorption ratio	Specific conductance (micromhos)	pH (units)	Water temperature (°C)
5-12-70	--	--	0.040	--	0.19	138	108	--	4	0.1	249	8.3	10
[illegible]-14-71	--	--	.080	--	.23	168	136	6	7	.1	360	7.6	--
10-14-71	--	--	.000	--	.23	169	142	--	4	.1	240	7.5	--
11-16-71	--	--	.15	--	.20	148	148	36	5	.1	268	7.8	--
12-14-71	--	--	.020	--	.20	144	124	8	6	.1	256	7.7	--
1-17-72	--	--	.040	--	.14	106	172	56	3	.1	240	7.0	--
3-28-72	--	--	.020	--	.23	167	156	36	4	.1	260	7.8	--
4-19-72	--	--	.000	--	.25	184	168	17	5	.1	240	7.8	--
5-11-72	--	--	.020	--	.21	158	156	36	4	.1	280	7.9	10
6-19-72	--	--	.030	--	.24	177	160	16	4	.1	300	7.4	--
7-17-72	--	--	.080	--	.18	135	116	8	5	.1	288	7.5	--
8-23-72	--	--	.010	--	.22	165	156	30	5	.1	232	7.9	--
9-14-72	--	--	<.010	--	.21	151	140	24	4	.1	260	7.6	--
9-14-72	--	--	<.010	--	.20	146	135	--	--	--	260	7.5	--
3-11-75	--	--	.000	--	.21	151	152	--	--	.1	270	7.4	--

Date sampled	Color (platinum-cobalt units)	Turbidity (JTU)	Carbon dioxide (CO_2) (mg/L)	Phenols (µg/L)	Foaming agents (detergents) (µg/L)	Dissolved arsenic (As) (µg/L)	Dissolved cadmium (Cd) (µg/L)	Dissolved chromium (Cr) (µg/L)	Dissolved copper (Cu) (µg/L)	Dissolved lead (Pb) (ug/L)	Total mercury (Hg) (µg/L)	Dissolved zinc (Zn) (µg/L)
5-12-70	0	0	1.4	--	--	--	--	--	--	--	--	--
[illegible]-14-71	1	1	10	--	--	--	--	--	--	--	--	--
10-14-71	0	0	12	--	--	--	--	--	--	--	--	--
11-16-71	1	0	4.6	--	--	--	--	--	--	--	--	--
12-14-71	0	0	7.5	--	--	--	--	--	--	--	--	--
1-17-72	5	2	30	--	--	--	--	--	--	--	--	--
3-28-72	4	1	4.5	--	--	--	--	--	--	--	--	--
4-19-72	0	0	7.0	--	--	--	--	--	--	--	--	--
5-11-72	5	0	4.2	--	--	--	--	--	--	--	--	--
6-19-72	4	1	16	--	--	--	--	--	--	--	--	--
7-17-72	4	0	10	--	--	--	--	--	--	--	--	--
8-23-72	2	1	4.1	--	--	--	--	--	--	--	--	--
9-14-72	5	1	7.5	--	--	--	--	--	--	--	--	--
9-14-72	--	--	--	--	--	[c]4	[c]1	[c]3	[c]98	[c]10	--	[c]40
3-11-75	4	0	--	--	--	--	--	--	--	--	--	--

TABLE 4.--Chemical quality of ground water from selected sites--Continued

Site number	Data source[a]	Data sampled	Dissolved silica (SiO_2) (mg/L)	Dissolved iron (Fe) (μg/L)	Dissolved manganese (Mn) (μg/L)	Dissolved calcium (Ca) (mg/L)	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved potassium (K) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Alkalinity as $CaCO_3$ (mg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Dissolved fluoride (F) (mg/L)	Total nitrate (N) (mg/L)	Total nitrite (N) (mg/L)
25/44-26L1	GSBR	5(or)6-51	--	--	--	--	--	--	--	229	188	--	3.4	--	--	--
	WSDH	3- 2-64	20	40	2	44	15	12	2.9	195	160	12	3.0	0.2	5.1	0.005
	WSDH	10- 7-64	18	40	5	--	--	--	--	198	162	12	2.2	.2	2.2	.003
	DSHS	11- 4-70	7.5	0	6	46	14	6.2	2.6	200	164	18	3.0	.1	3.7	.000
	DSHS	8- 9-71	5.0	200	0	32	18	6.0	2.6	190	156	19	7.5	.1	2.8	.033
	DSHS	9-14-71	2.5	40	3	48	30	6.8	2.7	278	228	20	10	.1	2.7	.015
	DSHS	10-13-71	.0	20	29	49	12	6.6	2.8	178	146	30	6.0	.1	2.6	.007
	DSHS	11-16-71	2.5	220	6	46	2.9	6.6	2.6	205	168	18	3.0	.1	2.9	.042
	DSHS	12-13-71	6.0	300	9	38	16	7.0	2.6	156	128	17	.52	.7	2.8	.049
	DSHS	1-17-72	2.5	60	15	70	6.3	6.3	2.5	198	162	14	5.0	.1	2.4	.032
	DSHS	2-14-72	7.5	160	6	50	34	6.8	2.8	238	195	22	2.5	.2	11	.011
	DSHS	3-31-72	1.0	100	3	43	16	6.4	2.8	176	--	23	2	.1	1.4	.011
	DSHS	4-18-72	4.8	10	0	44	24	5.6	2.7	205	168	23	2.5	.1	1.4	.025
	DSHS	5-22-72	11	20	60	22	20	3.1	1.8	110	90	17	3.0	.1	1.7	.024
	DSHS	6-19-72	5.5	200	9	45	19	6.0	2.5	220	180	25	4.0	.1	2.0	.012
	DSHS	7-17-72	1.7	140	9	50	11	6.6	2.8	196	161	14	10	.1	1.9	.046
	DSHS	8-23-72	11	60	3	34	36	7.0	2.9	185	152	28	3.0	.6	1.7	.019
	DSHS	9-14-72	5.5	60	6	33	24	6.9	2.6	149	122	28	4.0	.2	2.1	.004
	EPA	9-14-72	--	[c]<100	2	--	13	4.7	2.5	--	--	13	2	.0	2.3	--
	DSHS	9-30-74	19	0	<10	51	13	4.0	--	163	134	32	6.4	.1	2.0	.02

Site number	Data source[a]	Data sampled	Total ammonia (N) (mg/L)	Total Kjeldahl nitrogen (N) (mg/L)	Total phosphorus (P) (mg/L)	Dissolved orthophosphorus (P) (mg/L)	Dissolved solids (residue at 180°C) (tons/acre-ft)	Dissolved solids (residue at 180°C) (mg/L)	Hardness (Ca,Mg) (mg/L)	Noncarbonate hardness (mg/L)	Percent sodium	Sodium adsorption ratio	Specific conductance (micromhos)	pH (units)	Water temperature (°C)
25/44-26L1	GSBR	5(or)6-51	--	--	--	--	--	--	159	--	--	--	261	--	--
	WSDH	3- 2-64	--	--	0.62	--	0.26	188	166	6	13	0.4	320	7.6	10
	WSDH	10- 7-64	--	--	.17	--	--	--	192	30	--	--	326	8.3	11
	DSHS	11- 4-70	--	--	.00	--	.29	212	174	10	7	.2	340	7.6	10
	DSHS	8- 9-71	--	--	.17	--	.26	188	156	--	8	.2	340	7.6	--
	DSHS	9-14-71	--	--	.04	--	.35	260	244	16	6	.2	370	7.3	--
	DSHS	10-13-71	--	--	.09	--	.27	196	172	26	8	.2	340	7.8	--
	DSHS	11-16-71	--	--	1.0	--	.25	186	178	10	10	.3	346	7.7	--
	DSHS	12-13-71	--	--	.16	--	.23	171	164	36	8	.2	326	7.1	--
	DSHS	1-17-72	--	--	.26	--	.28	207	200	38	7	.2	370	8.3	--
	DSHS	2-14-72	--	--	.00	--	.35	254	264	69	5	.2	340	8.2	--
	DSHS	3-31-72	--	--	--	--	.25	181	172	--	--	--	310	7.9	--
	DSHS	4-18-72	--	--	.10	--	.28	208	208	40	5	.2	324	7.9	--
	DSHS	5-22-72	--	--	.00	--	.18	134	136	46	5	.1	200	8.0	11
	DSHS	6-19-72	--	--	.00	--	.30	217	192	12	6	.2	326	8.0	--
	DSHS	7-17-72	--	--	.17	--	.27	195	180	20	8	.2	380	7.9	--
	DSHS	8-23-72	--	--	.010	--	.29	215	232	80	6	.2	332	7.9	--
	DSHS	9-14-72	--	--	<.02	--	.24	180	182	60	8	.2	326	6.8	--
	EPA	9-14-72	--	--	.010	--	.30	223	183	--	--	--	350	7.1	--
	DSHS	9-30-74	--	--	.06	--	.28	208	180	46	--	.1	438	7.7	--

Site number	Data source[a]	Data sampled	Color (platinum-cobalt units)	Turbidity (JTU)	Carbon dioxide (CO_2) (mg/L)	Phenols (μg/L)	Foaming agents (detergents) (μg/L)	Dissolved arsenic (As) (μg/L)	Dissolved cadmium (Cd) (μg/L)	Dissolved chromium (Cr) (μg/L)	Dissolved copper (Cu) (μg/L)	Dissolved lead (Pb) (μg/L)	Total mercury (Hg) (μg/L)	Dissolved zinc (Zn) (μg/L)
25/44-26L1	GSBR	5(or)6-51	--	--	--	--	--	--	--	--	--	--	--	--
	WSDH	3- 2-64	3	0	9.5	--	--	--	--	--	--	--	--	--
	WSDH	10- 7-64	12	4	--	--	--	--	--	--	--	--	--	--
	DSHS	11- 4-70	4	1	11	--	--	--	--	--	--	--	--	--
	DSHS	8- 9-71	10	0	11	--	--	--	--	--	--	--	--	--
	DSHS	9-14-71	2	0	33	--	--	--	--	--	--	--	--	--
	DSHS	10-13-71	2	0	6.1	--	--	--	--	--	--	--	--	--
	DSHS	11-16-71	2	1	9.0	--	--	--	--	--	--	--	--	--
	DSHS	12-13-71	4	0	28	--	--	--	--	--	--	--	--	--
	DSHS	1-17-72	6	1	2.5	--	--	--	--	--	--	--	--	--
	DSHS	2-14-72	5	0	3.1	--	--	--	--	--	--	--	--	--
	DSHS	3-31-72	4	--	4.7	--	--	--	--	--	--	--	--	--
	DSHS	4-18-72	4	0	7.0	--	--	--	--	--	--	--	--	--
	DSHS	5-22-72	5	0	2.4	--	--	--	--	--	--	--	--	--
	DSHS	6-19-72	5	0	4.1	--	--	--	--	--	--	--	--	--
	DSHS	7-17-72	7	0	4.5	--	--	--	--	--	--	--	--	--
	DSHS	8-23-72	1	1	4.7	--	--	--	--	--	--	--	--	--
	DSHS	9-14-72	6	0	49	--	--	--	--	--	--	--	--	--
	EPA	9-14-72	--	--	--	--	--	[c]4	[c]2	[c]2	[c]67	[c]15	--	[c]25
	DSHS	9-30-74	8	0	--	--	--	--	--	--	--	--	--	--

TABLE 4.--Chemical quality of ground water from selected sites--Continued

Site number	Data source[a]	Date sampled	Dissolved silica (SiO_2) (mg/L)	Dissolved iron (Fe) (µg/L)	Dissolved manganese (Mn) (µg/L)	Dissolved calcium (Ca) (mg/L)	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved potassium (K) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Alkalinity as $CaCO_3$ (mg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Dissolved fluoride (F) (mg/L)	Total nitrate (N) (mg/L)	Total nitrite (N) (mg/L)
25/45-15D1	DSHS	7-21-71	6.0	120	4	34	17	5.0	1.8	166	136	16	0.0	0.1	0.45	0.013
	DSHS	8-18-71	3.0	0	15	27	16	4.7	2.0	120	98	16	7.0	.1	1.4	.060
	DSHS	8-26-71	7.5	0	15	34	12	6.5	1.9	110	90	12	3.5	.2	2.7	.015
	DSHS	9-16-71	5.0	100	9	35	28	5.4	2.0	234	192	8.6	5.0	.1	2.3	.050
	DSHS	10-13-71	2.5	140	0	30	8.8	5.9	2.0	117	96	21	3.5	.1	2.0	.018
	DSHS	11-16-71	.0	50	3	33	13	6.4	1.8	134	110	14	5.0	.2	2.6	.046
	DSHS	12-13-71	5.0	340	0	25	15	5.4	2.0	127	104	7.4	2.2	.2	2.4	.026
	DSHS	1-18-72	5.0	20	0	15	4.9	4.8	1.6	93	76	14	3.5	.1	2.5	.10
	DSHS	2-14-72	5.0	80	9	38	13	6.0	2.2	129	106	28	4.5	.2	3.5	.011
	DSHS	3-28-72	16	60	6	30	11	4.8	1.7	146	120	18	1.5	.2	1.2	.001
	DSHS	4-18-72	4.5	80	0	56	46	4.0	1.8	227	186	2.3	2.0	.1	.76	.16
	DSHS	5-10-72	15	300	9	19	16	4.6	1.5	96	79	9.5	6.8	.1	1.4	.012
	DSHS	6-19-72	.8	40	6	30	12	5.9	1.8	127	104	16	6.0	.1	2.5	.000
	DSHS	7-24-72	.8	20	3	26	17	6.8	2.1	124	102	17	8.5	.2	1.3	.022
	DSHS	8-14-72	5.5	300	3	35	14	6.5	1.9	146	120	10	2.8	.1	1.2	.020
	DSHS	9-14-72	2.4	80	6	28	17	5.9	1.8	132	108	17	4.5	.1	2.0	.006
	EPA	9-14-72	--	[c]<100	2	--	8.0	4.6	1.7	--	--	8	2	.0	2.2	<.02
	EPA	1-15-73	--	15	2	--	--	--	--	--	--	--	--	--	--	--
	USGS	6-28-73	--	10	10	32	8.9	4.4	1.8	141	116	12	2.3	.1	2.8	.000
	USGS	9-25-73	--	10	0	35	8.7	3.9	1.9	135	111	11	2.3	.1	1.5	.002
	USGS	12-18-73	--	0	0	35	8.8	4.4	2.0	131	107	11	2.5	.2	2.0	.002
	USGS	3-20-74	--	20	7	33	8.2	4.5	1.8	124	102	8.0	2.6	.1	1.3	.002
	DSHS	7- 3-75	14	190	40	38	7.8	3.4	--	109	89	9.5	2.5	.4	2.0	.01

Date sampled	Total ammonia (N) (mg/L)	Total Kjeldahl nitrogen (N) (mg/L)	Total phosphorus (P) (mg/L)	Dissolved orthophosphorus (P) (mg/L)	Dissolved solids (residue at 180°C) (tons/acre-ft)	Dissolved solids (residue at 180°C) (mg/L)	Hardness (Ca,Mg) (mg/L)	Noncarbonate hardness (mg/L)	Percent sodium	Sodium adsorption ratio	Specific conductance (micromhos)	pH (units)	Water temperature (°C)
7-21-71	--	--	0.070	--	0.22	163	156	40	6	0.2	236	7.3	11.7
8-18-71	--	--	.14	--	.18	136	132	34	7	.2	270	8.1	--
8-26-71	--	--	.020	--	.18	134	132	42	9	.2	260	7.8	--
9-16-71	--	--	.010	--	.27	196	204	12	5	.2	260	7.4	--
10-13-71	--	--	.070	--	.18	134	112	16	10	.2	228	7.7	--
11-16-71	--	--	.060	--	.22	159	136	26	9	.2	250	7.7	--
12-13-71	--	--	.050	--	.17	127	124	20	8	.2	216	7.2	--
1-18-72	--	--	.055	--	.13	97	94	18	15	.3	248	7.9	--
2-14-72	--	--	.020	--	.22	164	148	42	8	.2	248	8.2	--
3-28-72	--	--	.060	--	.21	156	118	--	--	.2	220	7.3	--
4-18-72	--	--	.060	--	.24	176	196	10	3	.1	184	7.3	--
5-10-72	--	--	.030	--	.17	124	120	41	8	.2	192	7.8	11.7
6-19-72	--	--	.050	--	.19	138	124	20	9	.2	242	8.1	--
7-24-72	--	--	.15	--	.19	141	136	34	10	.3	248	7.6	--
8-14-72	--	--	.050	--	.20	149	144	24	9	.2	246	8.1	--
9-14-72	--	--	<.010	--	.20	144	140	32	8	.2	256	7.5	--
9-14-72	--	--	.020	--	.25	181	125	--	--	--	260	--	--
1-15-73	--	--	--	--	--	--	--	--	--	--	--	--	--
6-28-73	0.03	0.06	.021	0.21	.21	158	120	1	7	.2	266	7.6	12.0
9-25-73	.01	.05	.023	.022	.21	157	120	12	6	.2	259	8.1	12.0
12-18-73	.01	.04	.073	.073	.21	154	120	16	7	.2	263	8.1	12.0
3-20-74	.03	.56	.023	.021	.19	143	120	14	8	.2	242	7.8	11.8
7- 3-75	--	--	.02	--	.18	132	128	--	--	.1	243	8.0	--

Date sampled	Color (platinum-cobalt units)	Turbidity (JTU)	Carbon dioxide (CO_2) (mg/L)	Phenols (µg/L)	Foaming agents (detergents) (µg/L)	Dissolved arsenic (As) (µg/L)	Dissolved cadmium (Cd) (µg/L)	Dissolved chromium (Cr) (µg/L)	Dissolved copper (Cu) (µg/L)	Dissolved lead (Pb) (µg/L)	Total mercury (Hg) (µg/L)	Dissolved zinc (Zn) (µg/L)
7-21-71	8	4	17	--	--	--	--	--	--	--	--	--
8-18-71	4	1	3.0	--	--	--	--	--	--	--	--	--
8-26-71	13	0	4.2	--	--	--	--	--	--	--	--	--
9-16-71	4	1	19	--	--	--	--	--	--	--	--	--
10-13-71	3	0	5.2	--	--	--	--	--	--	--	--	--
11-16-71	2	0	6.5	--	--	--	--	--	--	--	--	--
12-13-71	5	1	20	--	--	--	--	--	--	--	--	--
1-18-72	5	1	2.7	--	--	--	--	--	--	--	--	--
2-14-72	7	1	1.9	--	--	--	--	--	--	--	--	--
3-28-72	4	1	16	--	--	--	--	--	--	--	--	--
4-18-72	5	0	25	--	--	--	--	--	--	--	--	--
5-10-72	5	0	3.3	--	--	--	--	--	--	--	--	--
6-19-72	5	1	2.5	--	--	--	--	--	--	--	--	--
7-24-72	5	0	8.0	--	--	--	--	--	--	--	--	--
8-14-72	7	0	2.9	--	--	--	--	--	--	--	--	--
9-14-72	6	0	10	--	--	--	--	--	--	--	--	--
9-14-72	--	--	--	--	--	[c]4	[c]4	[c]4	[c]147	[c]20	--	[c]110
1-15-73	--	--	--	--	--	--	--	--	--	[c]20	[c]<0.2	[c]27
6-28-73	--	--	--	0	0.00	5	1	0	3	1	[c].1	10
9-25-73	--	--	--	4	.04	6	0	0	6	2	[c].0	50
12-18-73	--	--	1.7	0	.02	5	0	0	3	0	[c].0	0
3-20-74	--	--	3.1	0	--	2	0	0	5	1	[c].1	20
7- 3-75	3	0	--	--	--	--	--	--	--	--	--	--

TABLE 4.--Chemical quality of ground water from selected sites--Continued

Site number	Data source[a]	Date sampled	Dissolved silica (SiO_2) (mg/L)	Dissolved iron (Fe) (ug/L)	Dissolved manganese (Mn) (ug/L)	Dissolved calcium (Ca) (mg/L)	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved potassium (K) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Alkalinity as $CaCO_3$ (mg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Dissolved fluoride (F) (mg/L)	Total nitrate (N) (mg/L)	Total nitrite (N) (mg/L)
25/45-18R1	DSHS	5-14-70	19	0	6	16	4.6	2.4	2.2	76	--	7	0	0.1	0.76	0.000
	DSHS	9-14-71	2.5	0	18	27	16	2.4	1.2	139	114	10	1.0	.1	2.0	.025
	DSHS	10-13-71	.0	20	15	25	6.3	2.4	1.3	90	74	23	1.5	.1	1.1	.015
	DSHS	11-16-71	5.0	140	9	28	14	2.6	1.4	110	90	10	3.0	.0	1.4	.057
	DSHS	12-14-71	5.0	0	0	21	12	3.2	1.5	88	72	11	6.0	.1	1.6	043
	DSHS	1-17-72	2.5	120	0	31	12	2.2	1.4	102	84	21	7 0	.1	1 4	.20
	DSHS	2-16-72	2.8	140	3	30	2.4	3.8	1.8	90	74	16	1.5	.1	1.1	015
	DSHS	3-28-72	11	140	6	20	8.5	2.1	1.2	98	80	19	.0	.1	.62	001
	DSHS	4-19-72	4.5	140	3	22	16	2.4	1.2	129	106	20	3 0	.1	.22	018
	DSHS	5-10-72	11	20	3	17	11	2.4	1.3	81	66	12	1.0	1	1.3	.034
	DSHS	6-19-72	24	140	0	17	14	2.8	1.2	79	65	17	6.5	.1	.75	.021
	DSHS	7-24-72	2.7	680	6	24	27	3.0	1.6	83	68	15	10	.1	.05	.028
	DSHS	8-14-72	2.2	40	15	24	9 7	2.9	1.4	93	76	11	2.0	.1	.33	.02
	DSHS	9-14-72	4.5	120	6	37	1.9	2.8	1.4	107	88	23	2.5	.1	.90	.004
	EPA	9-14-72	--	[c]<100	<1	--	--	--	--	--	--	--	--	0	.96	--
	PLSF	6- 6-74	--	<10	<10	12	7.7	2.5	1.7	92	75	7.3	<.5	1	1.2	<.002
	DSHS	3-21-75	11	80	<5	30	2.4	2.9	--	95	78	8.8	1.5	.1	1.5	1.0

Site number	Data source[a]	Date sampled	Total ammonia (N) (mg/L)	Total Kjeldahl nitrogen (N (mg/L)	Total phosphorus (P) (mg/L)	Dissolved orthophosphorus (P) (mg/L)	Dissolved solids (residue at 180 C) (tons/acre-ft)	Dissolved solids (residue at 180 C) (mg/L)	Hardness (Ca,Mg) (mg/L)	Noncarbonate hardness (mg/L)	Percent sodium	Sodium adsorption ratio	Specific conductance (micromhos)	pH (units)	Water temperature (°C)
25/45-18R1	DSHS	5-14-70	--	--	0.010	--	0.13	92	60	--	--	--	150	7.8	8.9
	DSHS	9-14-71	--	--	.050	--	.18	131	88	--	4	0.1	210	7.2	--
	DSHS	10-13-71	--	--	.030	--	.14	105	88	14	5	.1	172	7.5	--
	DSHS	11-16-71	--	--	.000	--	.16	120	128	--	4	.1	180	7.6	--
	DSHS	12-14-71	--	--	.040	--	.14	104	100	28	6	.1	170	7.6	--
	DSHS	1-17-72	--	--	.060	--	.16	118	82	--	4	.1	180	7.7	--
	DSHS	2-16-72	--	--	.000	--	.14	104	84	10	9	.2	172	8.2	--
	DSHS	3-28-72	--	--	.050	--	.15	111	84	4	5	.1	150	7.7	--
	DSHS	4-19-72	--	--	.000	--	.18	136	132	26	4	.1	150	7.7	--
	DSHS	5-10-72	--	--	.030	--	.13	98	90	24	6	.1	164	7.8	11.7
	DSHS	6-19-72	--	--	.020	--	.17	122	98	33	6	.1	159	7.7	--
	DSHS	7-24-72	--	--	.028	--	.17	126	112	44	4	.1	168	7.4	--
	DSHS	8-14-72	--	--	<.010	--	.14	100	100	24	6	.1	176	7.6	--
	DSHS	9-14-72	--	--	<.010	--	.17	127	100	12	6	.1	168	7.4	--
	EPA	9-14-72	--	--	--	--	--	--	88	--	--	--	180	7.2	--
	PLSF	6- 6-74	<0.06	<0.28	.026	0.22	.16	121	88	13	6	.1	170	7.8	11.0
	DSHS	3-21-75	--	--	.030	--	.14	105	84	--	--	.1	170	8.2	--

Site number	Data source[a]	Date sampled	Color (platinum-cobalt units)	Turbidity (JTU)	Carbon dioxide (CO_2) (mg/L)	Phenols (µg/L)	Foaming agents (detergents) (µg/L)	Dissolved arsenic (As) (µg/L)	Dissolved cadmium (Cd) (µg/L)	Dissolved chromium (Cr) (µg/L)	Dissolved copper (Cu) (µg/L)	Dissolved lead (Pb) (µg/L)	Total mercury (Hg) (µg/L)	Dissolved zinc (Zn) (µg/L)
25/45-18R1	DSHS	5-14-70	3	--	2.5	--	--	--	--	--	--	--	--	--
	DSHS	9-14-71	6	0	23	--	--	--	--	--	--	--	--	--
	DSHS	10-13-71	2	0	6.2	--	--	--	--	--	--	--	--	--
	DSHS	11-16-71	4	0	7.0	--	--	--	--	--	--	--	--	--
	DSHS	12-14-71	2	0	6.5	--	--	--	--	--	--	--	--	--
	DSHS	1-17-72	4	1	5.0	--	--	--	--	--	--	--	--	--
	DSHS	2-16-72	4	0	1.2	--	--	--	--	--	--	--	--	--
	DSHS	3-28-72	4	1	4.2	--	--	--	--	--	--	--	--	--
	DSHS	4-19-72	1	1	5.7	--	--	--	--	--	--	--	--	--
	DSHS	5-10-72	5	0	2.5	--	--	--	--	--	--	--	--	--
	DSHS	6-19-72	1	0	3.1	--	--	--	--	--	--	--	--	--
	DSHS	7-24-72	4	5	7.5	--	--	--	--	--	--	--	--	--
	DSHS	8-14-72	5	0	5.1	--	--	--	--	--	--	--	--	--
	DSHS	9-14-72	6	0	10	--	--	--	--	--	--	--	--	--
	EPA	9-14-72	--	--	--	--	--	[c]<2	[c]1	[c]4	[c]63	[c]10	--	[c]30
	PLSF	6- 6-74	--	--	3.0	<1	<0.05	<6	<5	<5	330	30	<0.2	540
	DSHS	3-21-75	6	0	--	--	--	--	--	--	--	--	--	--

TABLE 4.--Chemical quality of ground water from selected sites--Continued

Site number	Data source[a]	Date sampled	Dissolved silica (SiO_2) (mg/L)	Dissolved iron (Fe) (µg/L)	Dissolved manganese (Mn) (µg/L)	Dissolved calcium (Ca) (mg/L)	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved potassium (K) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Alkalinity as $CaCO_3$ (mg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Dissolved fluoride (F) (mg/L)	Total nitrate (N) (mg/L)	Total nitrite (N) (mg/L)
26/42-11J1s	WSGD	10-22-46	--	[c]100	[c]<50	33	15	--	--	139	114	4.1	0.0	--	2.0	--
	EPA	9-13-72	--	--	--	--	--	--	--	--	--	--	--	--	.51	--
	DSHS	10-18-72	5.2	60	3	26	24	5.4	2.3	176	144	29	6.0	0.0	2.3	0.057
	DSHS	1-17-73	35	0	0	20	27	4	2.0	148	121	159	7.1	.0	.8	.000
	DSHS	4-20-73	10	100	3	31	20	5.0	2.4	186	154	27	7.5	.1	1.2	.011
	USGS	6-27-73	--	10	0	39	20	4.7	2.4	192	157	20	5.8	.0	2.5	.002
	USGS	9-26-73	--	50	0	39	19	5.1	2.4	191	157	19	5.9	.0	2.5	.002
	USGS	12-17-73	--	0	40	39	19	5.3	2.6	184	151	18	5.6	.2	2.3	004
	USGS	3-19-74	--	20	36	37	20	4.8	2.5	182	149	20	5.8	.1	2.0	001
26/43-7K1	DSHS	8- 4-71	2.5	120	6	28	17	3.9	2.0	122	100	31	3.0	.2	1.8	.032
	DSHS	8-18-72	6.2	80	3	33	26	6.3	2.4	210	172	33	6.8	.1	2.0	.060
	DSHS	1-17-73	35	0	0	21	24	3	1.0	152	125	128	7.0	.0	.56	.000
	DSHS	4-23-73	.6	140	0	27	16	3.8	1.8	164	134	29	4.0	.1	1.0	.10
	DSHS	5-15-75	20	190	<5	28	26	2.6	--	145	119	16	4.5	.2	.8	00
	DSHS	8-11-75	14	<5	<5	40	23	2.4	--	173	142	5.8	7.5	.1	2.7	02

Site number	Total ammonia (N) (mg/L)	Total Kjeldahl nitrogen (N) (mg/L)	Total phosphorus (P) (mg/L)	Dissolved orthophosphorus (P) (mg/L)	Dissolved solids (residue at 180° C) (tons/acre-ft)	Dissolved solids (residue at 180° C) (mg/L)	Hardness (Ca,Mg) (mg/L)	Noncarbonate hardness (mg/L)	Percent sodium	Sodium adsorption ratio	Specific conductance (micromhos)	pH (units)	Water temperature (°C)
26/42-11J1s (continued)	--	--	--	--	0.23	166	148	--	--	--	--	7.7	--
	--	--	<0.010	--	.24	179	--	--	--	--	350	7.5	10.0
	--	--	.030	--	.25	187	164	20	7	0.2	292	8.1	--
	--	--	<.010	--	.45	331	159	38	5	.1	265	7.8	--
	--	--	.000	--	.19	142	158	4	6	.2	290	8.2	--
	0.02	0.05	.009	0.005	.27	200	180	22	5	.2	367	7.6	10.8
	.02	.21	.048	.043	.25	186	180	19	6	.2	360	8.0	11.0
	.01	.04	.012	.010	.27	198	180	25	6	.2	354	8.0	11.0
	.01	.26	.013	.007	.27	195	170	25	6	.2	358	7.7	10.3
26/43-7K1 (continued)	--	--	.016	--	.20	150	140	--	6	.1	280	7.6	--
	--	--	.060	--	.30	220	192	20	7	.2	350	7.3	--
	--	--	.000	--	.41	298	152	27	4	.1	233	7.9	--
	--	--	.000	--	.22	164	134	--	6	.1	220	7.2	--
	--	--	.010	--	.23	169	176	--	--	.1	288	7.1	--
	--	--	<.010	--	.25	181	196	--	--	.1	380	7.7	--

Site number	Color (platinum-cobalt units)	Turbidity (JTU)	Carbon dioxide (CO_2) (mg/L)	Phenols (µg/L)	Foaming agents (detergents) (µg/L)	Dissolved arsenic (As) (µg/L)	Dissolved cadmium (Cd) (µg/L)	Dissolved chromium (Cr) (µg/L)	Dissolved copper (Cu) (µg/L)	Dissolved lead (Pb) (µg/L)	Total mercury (Hg) (µg/L)	Dissolved zinc (Zn) (µg/L)
26/42-11J1s (continued)	--	--	--	--	--	--	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	[c]20	--
	5	0	3.4	--	--	--	--	--	--	--	--	--
	1	0	--	--	--	--	--	--	--	--	--	--
	5	1	2.4	--	--	--	--	--	--	--	--	--
	--	--	--	5	0.00	1	1	0	0	0	[c]0.1	10
	--	--	--	1	.00	9	0	0	0	3	[c].0	10
	--	--	2.9	0	.02	4	0	0	1	0	[c].0	0
	--	--	5.8	0	.08	3	0	0	3	2	[c].0	20
26/43-7K1 (continued)	8	1	7.0	--	--	--	--	--	--	--	--	--
	4	0	24	--	--	--	--	--	--	--	--	--
	2	0	--	--	--	--	--	--	--	--	--	--
	4	1	21	--	--	--	--	--	--	--	--	--
	3	0	--	--	--	--	--	--	--	--	--	--
	4	0	--	--	--	--	--	--	--	--	--	--

TABLE 4.--Chemical quality of ground water from selected sites--Continued

Site number	Data source[a]	Date sampled	Dissolved silica (SiO_2) (mg/L)	Dissolved iron (Fe) (µg/L)	Dissolved manganese (Mn) (µg/L)	Dissolved calcium (Ca) (mg/L)	Dissolved magnesium (Mg) (mg/L)	Dissolved sodium (Na) (mg/L)	Dissolved potassium (K) (mg/L)	Bicarbonate (HCO_3) (mg/L)	Alkalinity as $CaCO_3$ (mg/L)	Dissolved sulfate (SO_4) (mg/L)	Dissolved chloride (Cl) (mg/L)	Dissolved fluoride (F) (mg/L)	Total nitrate (N) (mg/L)	Total nitrite (N) (mg/L)
26/46-31M1	DSHS	10- 7-64	--	220	13	--	--	--	--	146	120	10	0.2	0.2	0.10	0.003
	DSHS	5-14-70	8.8	420	60	21	11	2.8	3.4	126	103	14	2.5	.0	.37	.000
	DSHS	10-13-71	8.0	20	9	25	15	2.8	1.9	139	114	12	3.0	.1	1.2	.002
	DSHS	11-16-71	5.0	0	3	35	17	3.0	1.9	171	140	12	2.5	.0	1.2	.038
	DSHS	12-14-71	2.5	400	3	29	12	3.4	2.2	134	110	12	4.5	.1	1.3	.055
	DSHS	1-17-72	.0	0	6	34	27	3.4	2.0	239	196	27	3.0	.2	1.1	.038
	DSHS	2-16-72	4.5	80	6	28	18	3.8	2.3	144	118	17	5.5	.1	1.4	.013
	DSHS	3-28-72	13	180	0	25	17	2.6	1.9	155	127	26	.0	.1	.68	.001
	DSHS	4-19-72	4.5	120	3	32	19	4.8	1.8	177	145	24	3.0	.1	.21	.009
	DSHS	5-10-72	13	220	0	22	19	2.8	1.9	126	103	14	1.5	.1	1.1	019
	DSHS	6-19-72	4.5	60	3	24	18	2.5	1.8	134	110	20	2.5	.1	.88	.02
	DSHS	7-24-72	3.0	240	6	20	21	2.6	1.8	149	122	26	2.5	.2	.06	.10
	DSHS	8-14-72	5.2	40	9	25	14	3.2	2.0	156	128	13	2.0	.1	.12	.03
	DSHS	9-14-72	6.5	60	9	120	17	3.8	1.9	415	340	20	1.2	.1	.56	.007
	EPA	9-14-72	--	[c]<100	0	--	12	2.8	1.7	--	--	10	1	.0	.68	--
	EPA	1-15-73	--	15	2	--	--	--	--	--	--	--	--	--	--	--

Total ammonia (N) (mg/L)	Total Kjeldahl nitrogen (N) (mg/L)	Total phosphorus (P) (mg/L)	Dissolved orthophosphorus (P) (mg/L)	Dissolved solids (residue at 180°C) (tons/acre-ft)	Dissolved solids (residue at 180°C) (mg/L)	Hardness (Ca,Mg) (mg/L)	Noncarbonate hardness (mg/L)	Percent sodium	Sodium adsorption ratio	Specific conductance (micromhos)	pH (units)	Water temperature (°C)
--	--	0.080	--	--	--	166	--	--	--	253	7.9	13
--	--	.010	--	0.14	102	100	--	6	0.1	232	8.4	8 4
--	--	.000	--	.19	137	122	8	5	.1	232	7.6	--
--	--	.000	--	.22	162	140	22	4	.1	260	7.8	--
--	--	.070	--	.18	133	120	--	6	.1	247	7.6	--
--	--	.070	--	.29	215	196	78	4	.1	246	7.5	--
--	--	.000	--	.21	151	144	26	5	.1	254	8.3	--
--	--	.060	--	.21	155	132	18	4	.1	240	7.8	--
--	--	.11	--	.24	177	160	15	6	.2	220	7.8	--
--	--	.020	--	.19	138	134	31	4	.1	240	8.1	10.6
--	--	.000	--	.19	140	132	22	4	.1	224	7.6	--
--	--	.060	--	.20	150	136	--	4	.1	244	7.4	--
--	--	<.010	--	.19	141	120	--	5	.1	234	7.2	--
--	--	<.010	--	.56	410	372	32	2	.1	220	7.7	--
--	--	<.010	--	.21	158	121	--	--	--	240	7.2	--
--	--	--	--	--	--	--	--	--	--	--	--	--

Color (platinum-cobalt units)	Turbidity (JTU)	Carbon dioxide (CO_2) (mg/L)	Phenols (µg/L)	Foaming agents (detergents) (µg/L)	Dissolved arsenic (As) (µg/L)	Dissolved cadmium (Cd) (µg/L)	Dissolved chromium (Cr) (µg/L)	Dissolved copper (Cu) (µg/L)	Dissolved lead (Pb) (µg/L)	Total mercury (Hg) (µg/L)	Dissolved zinc (Zn) (µg/L)
12	5	--	--	--	--	--	--	--	--	--	--
4	0	1.0	--	--	--	--	--	--	--	--	--
0	0	8.5	--	--	--	--	--	--	--	--	--
2	0	6.5	--	--	--	--	--	--	--	--	--
5	0	8.0	--	--	--	--	--	--	--	--	--
6	1	9.5	--	--	--	--	--	--	--	--	--
4	1	1.3	--	--	--	--	--	--	--	--	--
4	1	5.1	--	--	--	--	--	--	--	--	--
1	1	7.0	--	--	--	--	--	--	--	--	--
5	1	2.3	--	--	--	--	--	--	--	--	--
5	1	8.0	--	--	--	--	--	--	--	--	--
6	1	14	--	--	--	--	--	--	--	--	--
5	0	23	--	--	--	--	--	--	--	--	--
6	0	17	--	--	--	--	--	--	--	--	--
--	--	--	--	--	[c]4	[c]6	[c]4	[c]320	[c]20	--	[c]20
--	--	--	--	--	--	--	--	--	[c]30	[c]<0.2	[c]150

[a]Data sources: USGS, U.S. Geological Survey; GSBR, U.S. Geological Survey in cooperation with U.S. Bureau of Reclamation; EPA, U.S. Environmental Protection Agency; DSHS, State of Washington Department of Social and Health Services; WSDH, State of Washington Department of Health; WSGH, State of Washington Department of Game; PLSF, Pacific Environments Laboratory of San Francisco.

[b]Sample collected after chlorination.

[c]Total concentration.

Pesticides, phenols, and radionuclides

On September 25 and 26, 1973, water samples were collected from 17 sites and analyzed by EPA personnel for the concentrations of 13 pesticides. In addition to endrin, lindane, and toxaphene, which are included in the summary on plate 10, tests were made for aldrin, aroclor 1260, BHC, chlordane, DDD, DDE, DDT, dieldrin, heptachlor, and heptachlor-epoxide. At the time these samples were taken, the minimum detection levels for endrin and toxaphene were 0.002 and 0.060 mg/L, respectively, at the laboratory involved. The new drinking-water regulations (pl. 10) list the maximum contaminant levels for these two substances as 0.0002 and 0.005 mg/L, respectively, well below the analytical capabilities of the laboratory conducting the tests. The only sample (table 3) which showed the presence of either substance in 1973 (26/42-12A1s, 0.060 mg/L toxaphene) exceeded the MCL. All 17 samples tested for lindane had concentrations of <0.001 mg/L, below the MCL of 0.004 mg/L.

Recommended limits for 6 of the 10 pesticides which were tested for but not included in the new drinking-water regulations, are listed below (National Academy of Sciences - National Academy of Engineering, 1973):

Substance	Mg/L	Substance	Mg/L
Aldrin	0.001	Dieldrin	0.001
Chlordane	.003	Heptachlor	.0001
DDT	.05	Heptachlor-epoxide	.0001

The observed concentrations of aldrin, DDT, and dieldrin were all below the recommended limits. Of these, only DDT was positively identified--0.005 and 0.007 mg/L in samples from wells 25/44-18D2 and 2Q1, respectively. The analyses for heptachlor and heptachlor-epoxide indicated concentrations of <0.001 mg/L, the minimum analytical capability of the laboratory in 1973. Water from well 25/42-13B1 yielded a chlordane concentration of 0.005 mg/L, above the recommended limit of 0.003 mg/L. The other samples tested for chlordane were all below the minimum analytical capability of 0.005 mg/L.

Although phenols are not included in the new drinking water regulations, the data were included in plate 10 because of the frequent use of phenols by industries situated above the aquifer, and because of the instance of phenol contamination in the Spokane Industrial Park. (See section on historical contamination problems.) Only 77 samples from 24 sites have been analyzed for phenols. However, 18 of these samples (23 percent of the total) from 16 sites, exceeded the recommended maximum limit of 0.001 mg/L (Public Health Service, 1962).

No analyses were available of radionuclides in ground-water samples.

Coliform bacteria

Individual results of a large number of bacteriological tests of ground-water samples from the aquifer are contained in the files of State and local agencies, but no tabulation or summary of these data is presently available. No attempt was made during the course of this study to tabulate these data because the vast majority of analyses reflect the sanitary conditions of the wells and distribution systems involved and probably are not indicative of the bacteriological quality of the aquifer.

Two studies of drain-field performance above the aquifer have been made (Phillips and others, 1962; Crosby and others, 1968, Crosby, Johnstone, and Fenton, 1970 and 1971; and Crosby and others 1971). Phillips and others (1962) discovered that coliform bacteria survived 1 to 2 months in the soil, were concentrated near the land surface, and penetrated to a maximum depth of 47 feet. Their conclusion was that the "subsoil in the Spokane Valley region acts as a very efficient barrier to the transmission of bacteria and other particulate matter from septic-tank disposal fields." Crosby and others (1968) concurred, saying, "Passage of waters through 20 feet of soil normally removes coliform bacteria....virtual certainty of (coliform bacteria) removal can be inferred if wastes filter through 50 feet of soil."

Because the depth of the water table is greater than 100 feet in most of the aquifer, and in excess of 40 feet almost everywhere else, penetration of coliform bacteria to the water table is unlikely. However, in a few special cases there is a potential for penetration. Penetration to the water table is possible where the water table is near the land surface, as in the area immediately upgradient of springs which feed the Little Spokane River at the north end of the Hillyard Trough and in areas immediately downgradient of excavations, which intersect, or nearly intersect, the water table. Also, because coliform bacteria have been known to travel as much as 180 feet horizontally upon reaching the water table (Randall, 1970), penetration may be possible in narrow strips of the aquifer along those reaches of the Spokane River where the aquifer is in contact with the river and where water flows from the river to the aquifer.

Coliform bacteria have been identified in water samples from the aquifer at a number of sites. At least four cases of serious coliform-bacteria problems have reportedly occurred (D. Byram, Spokane County Health District, oral commun., 1977). Before the Washington Water Power Company took charge of and consolidated a number of small public water-supply systems north of Spokane, a few old wells were being chlorinated owing to previous contamination problems. (However, none of the original records remain to document the individual wells involved or the extent of the problem.) The Model Irrigation District 18 reportedly abandoned a well in past years owing to coliform-bacteria contamination.

The Spokane Country Club formerly obtained a drinking-water supply from a number of shallow wells in the area of spring flow near 26/42-12H. Byram reported that very high coliform counts were observed in water from these wells and caused the country club to discontinue use of these wells for drinking water and to join Whitworth Water District 2. The well supplying the Pinecroft Mobile Home Park (near 25/44-9J), reportedly had a continuing problem of high coliform- bacteria counts until a chlorination system was installed. It is not known if the observed coliform bacteria were present because of contamination of the aquifer or because of poor well construction (for example, drainage down the outside of the casing in a well).

Historical contamination problems

Personnel of Federal, State, and local agencies have observed at least six cases of water-quality degradation in the aquifer which presumably resulted from human activities. Also there is evidence in the available data of at least two additional instances of ground-water pollution which apparently went unnoticed by consumers.

The earliest observed case of ground-water pollution on record is discussed by Esvelt and Saxton (1964). Beginning in late November 1954, solid and liquid wastes from an aluminum-recovery operation at the old Hillyard plant were dumped into a gravel pit approximately 170 feet above the water table. The data in table 5 show that the chloride concentration in well 26/43-34P1, located about 1,000 feet northward and downgradient from the gravel pit, rapidly increased after initiation of the dumping operation. Even though the dumping was stopped in February 1955, and much of the waste material was removed from the pit, the chloride concentration continued to increase, exceeding 1,000 mg/L by June 24, 1955. By March 1956, the chloride concentration had decreased to 250 mg/L. A sample collected on May 5, 1975, yielded a chloride concentration of 36 mg/L.

In 1964, a nearly identical pollution problem occurred at the Kaiser-Trentwood aluminum plant, also reported by Esvelt and Saxton (1964). The same type of water as that involved in the Hillyard incident had been dumped in a gravel pit about 20 feet above the water table. For about 20 years these wastes had no readily observable effect on neighboring wells. In 1964, a new gravel pit was opened next to the old pit and the gravel-washing waste water was discharged over the accumulated wastes. The resulting leaching action was apparently responsible for a salty taste experienced by consumers of water from well 25/44-2Q1, located about 1,000 feet from the old pit. Water samples collected from the well showed a maximum chloride concentration of 177 mg/L in June 1964. Discharge of the gravel-washing waste water into the old pit was subsequently halted and the chloride concentration in well 25/44-2Q1 reportedly decreased to 0.18 mg/L within 6 months.

TABLE 5.--Water-quality data relative to historical ground-water pollution

[Constituents, in milligrams per liter]

Well Number	Data Source[1]	Date sample collected	Dissolved calcium (Ca)	Dissolved sodium (Na)	Dissolved potassium (K)	Dissolved chloride (Cl)	Total nitrate (as N)	Total nitrite (as N)	Total ammonia (as N)	Total Dissolved solids (residue at 180°C)
25/42-13B1	USGS	5-06-42	34	6.4	1.8	5.2	1.6	--	--	166
	USGS	1-13-48	33	--	--	7.1	--	--	--	100
	USGS	6-20-73	39	6.6	2.3	8.6	1.7	0.002	0.01	179
	USGS	9-26-73	40	7.0	2.5	12	1.4	.001	.01	188
	USGS	12-17-73	43	11	2.8	24	1.3	.002	.01	210
	USGS	3-20-74	47	9.5	2.8	24	1.6	.003	.02	231
	PLSF	6-04-74	42	15	2.9	22	1.1	<.002	<.06	233
25/44-2Q1	ESVT	6- -64	--	--	--	177	--	--	--	--
	DSHS	4-14-71	42	14	8.1	23	4.7	.015	--	225
	USGS	6-27-73	39	5.8	7.5	4.4	2.0	.000	.01	175
	USGS	9-25-73	40	4.5	6.9	3.0	1.4	.002	.01	174
	USGS	12-18-73	43	5.4	7.1	7.3	3.1	.003	.02	197
	USGS	3-20-74	49	34	12	60	5.4	.013	.69	329
	PLSF	6-10-74	56	67	21	130	< .01	.039	1.1	537
25/44-11J2	DSHS	2-07-71	39	5.0	3.1	8.5	.82	.052	--	190
	DSHS	4-27-71	34	33	18	50	1.8	.002	--	257
	DSHS	5-18-71	58	59	23	152	4.0	.059	--	403
	DSHS	6-07-71	--	--	--	14	1.8	.007	--	--
	DSHS	8-03-71	39	3.0	5.5	7.5	1.8	.043	--	227
	DSHS	2-07-72	--	--	--	8.5	--	--	--	--
	DSHS	9-08-72	28	3.5	4.6	1.5	.64	.005	--	173
26/43-34P1	GSBR	5 or 6-51	--	--	--	2.5	--	--	--	--
	ESVT	12-01-54	--	--	--	2.1	--	--	--	--
	ESVT	1-10-55	--	--	--	12	--	--	--	--
	ESVT	1-19-55	--	--	--	36	--	--	--	--
	ESVT	1-26-55	--	--	--	54	--	--	--	--
	ESVT	2-15-55	--	--	--	76	--	--	--	--
	ESVT	3-14-55	--	--	--	100	--	--	--	--
	ESVT	4-11-55	--	--	--	210	--	--	--	--
	ESVT	5-24-55	--	--	--	370	--	--	--	--
	ESVT	5-25-55	--	--	--	470	--	--	--	--
	ESVT	6-13-55	--	--	--	700	--	--	--	--
	ESVT	6-24-55	--	--	--	>1,000	--	--	--	--
	ESVT	3- -56	--	--	--	250	--	--	--	--
	DSHS	5-05-75	--	--	--	36	--	--	--	--

[1] USGS = U.S. Geological Survey
PLSF = Pacific Environment Laboratory of San Francisco
ESVT = Esvelt and Saxton, (1964)
DSHS = State of Washington Department of Social & Health Services
GSBR = U.S. Geological Survey in cooperation with U.S. Bureau of Reclamation

The same well showed increased concentrations of sodium, potassium, chloride, nitrite, ammonia, and dissolved solids in water samples taken in March and June of 1974. These increases are as yet unexplained.

A leak in an aluminum-recovery vat at the Hillyard plant in the Spokane Industrial Park was apparently the cause of high chloride concentrations in water samples from well 25/44-11J2 in 1971 (D. Byram, Spokane County Health District, oral commun., 1977). The highest chloride concentration in any water sample from the well analyzed by the Washington State Department of Social and Health Service (DSHS) laboratory was 152 mg/L (table 5), but earlier samples tested at the Spokane sewage treatment plant reportedly had chloride concentrations in excess of 300 mg/L. DSHS ordered the aluminum-recovery operation to shut down to repair the leak. Chloride concentrations returned to normal in a few months.

Five water samples collected from well 25/42-13B1 between June 28, 1973 and June 4, 1974 (table 5) show a pattern of steadily increasing concentrations of dissolved solids (from 179 to 233 mg/L). No potential source of contamination has been identified.

In the summer of 1975, a gasolinelike odor and a frothy effervescence appeared in water from a Coeur d'Alene public-supply well (50/4-1cdc1) (N.Malueg, written commun., 1975). Samples collected on July 30, 1975, contained benzene, toluene, P + M-xylene, O-xylene, methylethylbenzene, trimethylbenzene and other organic substances. These are the partly water-soluble compounds found in gasoline. The source of the contamination was never definitely established, but possible sources included gasoline-station drains, which lead to a freeway storm sewer about 1,000 feet south of the well, and a reported accidental dumping of about 500 gallons of gasoline into a dry well in the vicinity of the public-supply well. The well was resampled on November 19, 1975, and most of the same organic substances were still present, but in considerably lesser concentrations.

In late 1975, a severe taste and odor appeared in water from well 25/44-1J1 at the Spokane Industrial Park (D. Byram, oral commun., 1977). The well was sampled on November 17, 1975, and analyzed for organic compounds. The sample yielded a trace of chloroform and an extremely high concentration (15 mg/L) of relatively pure phenol (C_6H_6O). This well water was determined to be phenol free (0.000 mg/L) in four analyses made during June 1973-March 1974. The source of the contamination was never clearly identified but was possibly associated with the materials used in a glue-manufacturing plant near the well.

The Milwaukee Road railroad company reported that 26,500 gallons of diesel fuel was missing in November 1976. During a subsequent investigation by DOE (L. Peterson, oral commun., 1977), a leak was discovered in a buried diesel-fuel pipeline. Three wells were then drilled: at the site, 100 feet downgradient, and 200 feet downgradient. These wells were all pumped and analyses of water samples showed the presence of diesel fuel in water from all three locations. Milwaukee Road was then instructed to move the pipeline above ground or to surround the buried pipeline with impermeable materials.

The above cases of ground-water pollution are all of those with some degree of documentation and which appear in the files of Federal, State, and local agencies or which are readily observable in the basic data accumulated for this report. The number of unreported cases and (or) cases involving polluting materials which are not easily identifiable by changes in taste, odor, or appearance of the water, is unknown.

TABLE 6.--Summary of surface-water quality data

Map location number[1]	Site name[2] and USGS number	Period of record	Data source[3]	Number of times sampled	Number of times exceeding: Dissolved iron (Fe)	Dissolved manganese (Mn)	Dissolved chloride (Cl)	Dissolved fluoride (Fl)	Total nitrate (N)
1	Clark Fork near Galen, Montana 12323800	10/71-12/73	USGS.	25	3/3	0/1	0/13	0/13	0/11
2	Flint Creek near Philipsburg, Montana 12328500	4/72-9/72	USGS.	6	0/6	--	0/6	0/6	0/6
3	Flint Creek near Drummond, Montana 12331500	4/72-9/72	USGS.	6	0/6	--	0/6	0/6	0/6
4	Clark Fork at Drummond, Montana 12331600	10/71-12/73	USGS.	25	0/9	--	0/5	0/14	0/9
5	Blackfoot River near Lincoln, Montana 12334600	10/70-9/73	USGS.	82	0/63	2/63	0/61	0/60	0/63
6	Clark Fork above Missoula, Montana 12340500	10/69-6/71	USGS.	21	2/5	4/5	0/13	0/9	0/21
7	Bitterroot River near Missoula, Montana 12352980	7/70-9/73	USGS.	38	0/13	--	0/18	0/17	0/21
8	Clark Fork near Alberton, Montana 12353300	10/70-6/71	USGS.	21	1/15	2/14	0/13	0/8	0/21
9	Flathead River at Flathead, British Columbia 12355000	10/74-9/75	USGS.	10	0/3	0/3	0/10	0/10	0/10
10	Flathead River near Big Fork, Montana 12369000	10/69-6/71	USGS.	21	0/13	1/15	0/14	0/10	0/21
11	Flathead Lake at Polson, Montana 12371550	10/69-6/71	USGS.	21	0/13	0/15	0/14	0/9	0/21
12	Flathead River at Perma, Montana 12388700	7/71-9/73	USGS.	26	0/10	--	0/14	0/26	0/9
13	Clark Fork near Plains, Montana 12389000	10/69-6/70	USGS.	9	0/9	--	0/9	0/4	0/9
14	Thompson River near Thompson Falls, Montana - 12389500	9/75	USGS.	1	0/1	0/1	0/1	0/1	0/1
15	Clark Fork at Thompson Falls, Montana 12391000	10/69-9/73	USGS.	46	0/33	0/7	0/26	0/33	0/31
16	Clark Fork at Clark Fork, Idaho - 12392050	10/69-6/72	USGS.	33	0/27	0/18	0/26	0/14	0/31
17	Pack River near Colburn, Idaho 12392300	5/74-9/76	USGS.	22	--	--	0/4	0/4	0/4
18	Pend Oreille Lake near Hope, Idaho	6/73-9/76	USGS.	34	1/34	0/32	0/34	0/26	0/33
19	Pend Oreille Lake near Bayview, Idaho	6/73-9/76	USGS.	34	1/34	0/34	0/34	0/26	0/34
20	Coeur d'Alene River at Enaville, Idaho 12413000	8/71-9/76	USGS.	39	0/15	--	0/20	0/15	0/28
21	South Fork Coeur d'Alene River near Mullan, Idaho - 12413080	7/71-9/74	USGS.	19	4/18	0/4	0/4	--	0/16
22	South Fork Coeur d'Alene River at Kellogg, Idaho - 12413250	7/73-9/76	USGS.	24	0/1	1/1	0/4	0/4	0/5
23	South Fork Coeur d'Alene River at Smelterville, Idaho - 12413300	4/69-9/73	USGS.	14	8/8	8/8	0/7	2/6	0/10

chemical standards[4]/ Number of times tested											
Total dis- solved solids (residue at 180°C)	pH	Color	Tur- bid- ity	Dis- solved arsenic (As)	Dis- solved cad- mium (Cd)	Dis- solved chro- mium (Cr)	Dis- solved copper (Cu)	Dis- solved lead (Pb)	Dis- solved mercury (Hg)	Dis- solved zinc (Zn)	Total times chemi- cal stand- ards exceeded
25/25	2/25	0/9	5/9	0/3	1/3	0/3	0/3	0/3	0/9	0/9	36
0/6	0/6	--	--	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0
0/6	0/6	--	--	0/3	0/3	0/3	0/3	0/3	0/3	0/3	0
19/25	0/25	--	--	0/3	0/3	0/3	0/3	0/3	0/9	0/9	19
0/82	0/35	--	--	0/10	0/10	0/9	0/6	0/6	0/6	0/6	2
0/21	0/21	--	7/11	0/14	0/14	0/14	0/17	1/17	0/11	0/17	14
0/38	0/33	--	--	0/4	0/4	0/4	0/4	0/4	0/3	0/3	0
0/21	0/21	--	7/12	0/9	0/9	0/9	0/21	0/19	0/10	0/21	10
0/10	0/9	--	3/10	0/3	0/3	0/3	0/3	0/3	0/3	0/3	3
0/21	0/21	--	0/3	0/15	0/15	0/15	0/15	0/15	0/3	0/15	1
0/21	0/21	--	--	0/15	0/15	0/15	0/15	0/15	0/2	0/15	0
0/26	0/26	0/3	1/3	0/4	0/4	0/4	0/4	0/4	0/3	0/4	1
0/9	0/9	--	4/9	0/9	0/9	0/9	0/9	0/9	--	0/9	4
0/1	0/1	--	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0
0/46	0/46	0/16	4/11	0/18	0/18	0/18	0/25	0/23	0/21	0/33	4
0/33	1/33	1/25	3/26	0/15	0/16	0/15	0/22	0/22	0/18	0/18	5
0/22	1/4	--	1/1	--	--	--	--	--	--	--	2
0/34	1/34	--	0/24	0/8	--	--	--	2/34	--	0/34	4
0/34	1/34	--	0/24	0/8	--	--	--	0/34	--	0/32	2
0/38	2/30	--	0/26	0/15	2/15	1/15	0/15	2/15	0/15	0/15	7
0/15	2/15	--	4/14	0/18	0/19	0/18	0/18	3/19	2/15	0/18	15
0/24	1/6	--	2/2	0/1	1/1	0/1	0/1	1/1	--	0/1	6
1/14	6/11	0/2	1/1	0/10	9/9	0/8	0/9	4/9	3/5	7/10	49

TABLE 6.--Summary of surface-water quality data--Continued

Map location number[1]	Site name[2] and USGS number	Period of record	Data source[3]	Number of times sampled	Number of times exceeding: Dissolved iron (Fe)	Dissolved manganese (Mn)	Dissolved chloride (Cl)	Dissolved fluoride (Fl)	Total nitrate (N)
24	Coeur d'Alene River at Rose Lake, Idaho 12413810	8/71-9/75	USGS.	60	39/47	4/4	0/19	0/11	0/54
25	St. Maries River near Santa, Idaho 12414900	10/72-9/75	USGS.	22	--	--	0/4	0/4	0/4
27	St. Joe River at St. Maries, Idaho 12415075	12/73-6/75	USGS.	41	19/35	--	0/7	--	0/41
28	Coeur d'Alene Lake across from Half Round Bay, Idaho	7/73-5/75	Storet.	36	0/8	0/2	--	--	0/9
29	Coeur d'Alene Lake off Echo Bay to North, Idaho	7/73-5/75	Storet.	36	1/9	0/2	--	--	0/9
30	Coeur d'Alene Lake near outlet, Idaho	7/73-5/75	Storet.	36	1/6	0/2	--	0/3	0/6
31	Coeur d'Alene Lake at Coeur d'Alene, Idaho	8/71--/76	Funk 1973, & IDHW.	127	1/11	0/11	0/2	0/1	0/120
32	Spokane River at Spokane Yacht Club, Idaho	10/71-12/71	Funk 1973.	7	0/6	0/7	--	--	0/6
33	Hayden Creek near Hayden Lake, Idaho 12416000	11/66-9/76	USGS.	72	1/30	1/18	0/10	0/69	0/68
34	Lewellen Creek at Bunco Road, Idaho	1/76	IDHW.	1	0/1	--	0/1	--	0/1
35	Chilco Lake outlet, Idaho	1/76	IDHW.	1	0/1	--	0/1	--	0/1
36	Spokane River at Ross Point, Idaho	10/71-9/72	Funk 1973.	17	0/10	0/10	--	--	0/15
37	Rathdrum Creek, south of Rathdrum, Idaho	1/76	IDHW.	1	0/1	--	0/1	--	0/1
38	Spokane River above Post Falls, Idaho	10/71-9/72	Funk 1973.	17	0/11	0/11	--	--	0/16
39	Spokane River near Post Falls, Idaho 12419000	12/73-9/76	USGS and Storet.	336	8/71	0/2	0/12	0/11	0/56
40	Spokane River at Corbin Park, Idaho	10/71-12/71	Funk 1973.	7	0/7	0/7	--	--	0/7
41	Hauser Creek above Hauser Lake, Idaho	1/76	IDHW.	1	0/1	--	0/1	--	0/1
42	Spokane River above Liberty Bridge, Washington - 12419500 and 12419495	7/59-3/77	USGS. Storet and Funk 1973.	183	0/27	0/26	0/127	0/149	0/176
43	Newman Lake, Washington 12419800	3/71-9/71	USGS.	7	--	--	0/2	0/1	0/7
44	Liberty Lake, Washington 12420000	3/71-6/75	USGS and Funk 1975b.	164	0/17	--	0/112	0/1	0/7
45	Spokane River at Harvard Road, Washington	10/71-2/74	Funk 1973, 1975a and Storet.	40	1/28	0/11	--	--	0/37
46	Spokane River at Barker Road, Washington	9/72	Storet.	2	--	--	--	--	--
47	Spokane River at Sullivan Road Bridge, Washington	9/72	Storet.	3	--	--	--	--	0/3
48	Spokane River at Trent Bridge, Washington 12421200	9/66-9/73	USGS and Storet.	26	0/18	1/18	--	0/22	0/22

chemical standards[4]/Number of times tested											
Total dis- solved solids (residue at 180°C)	pH	Color	Tur- bid- ity	Dis- solved arsenic (As)	Dis- solved cad- mium (Cd)	Dis- solved chro- mium (Cr)	Dis- solved copper	Dis- solved lead (Pb)	Dis- solved mercury (Hg)	Dis- solved zinc (Zn)	Total times chemi- cal stand- ards exceeded
0/60	17/60	2/11	14/53	1/47	35/47	0/47	0/48	13/47	5/46	1/49	131
0/22	0/4	--	--	--	--	--	--	--	--	--	0
0/40	3/41	--	13/41	0/10	0/12	0/10	0/9	1/9	0/31	0/10	36
--	0/35	--	--	0/19	1/21	--	0/10	0/24	2/21	0/23	3
--	0/36	--	--	0/13	0/15	--	0/8	0/25	1/24	0/24	2
--	0/36	--	--	0/22	1/24	--	0/8	2/25	0/23	0/24	4
0/12	1/70	--	0/2	--	0/1	--	0/13	0/1	0/1	0/13	2
0/7	0/7	--	--	--	--	--	0/7	--	--	0/7	0
0/68	0/72	0/10	0/6	0/16	0/9	0/15	0/15	0/16	0/11	0/11	2
0/1	--	--	--	--	0/1	--	--	0/1	--	0/1	0
0/1	--	--	--	--	0/1	--	--	0/1	--	0/1	0
0/12	0/17	--	--	--	--	--	0/11	--	--	0/12	0
0/1	--	--	--	--	0/1	--	--	0/1	--	0/1	0
0/12	0/17	--	--	--	--	--	0/11	--	--	0/12	0
0/191	10/218	2/182	141/266	0/72	3/73	1/77	0/111	4/106	0/73	0/103	169
0/7	0/7	--	--	--	--	--	0/7	--	--	0/7	0
0/1	--	--	--	--	0/1	--	--	0/1	--	0/1	0
0/134	3/176	14/146	5/73	0/13	0/20	0/36	0/43	0/38	0/4	0/43	22
0/1	1/7	2/4	--	--	--	--	--	--	--	--	3
0/1	21/123	0/3	--	--	--	--	--	--	--	--	21
0/12	1/25	--	--	--	0/17	--	0/28	0/16	--	0/29	2
--	0/2	--	--	--	--	--	--	--	--	--	0
--	1/3	--	--	--	--	--	--	--	--	--	1
--	0/22	3/22	0/22	0/11	0/21	0/18	0/17	1/20	0/2	0/13	5

TABLE 6.--Summary of surface-water quality data--Continued

Map location number[1]	Site name[2] and USGS number	Period of record	Data source[3]	Number of times sampled	Number of times exceeding: Dissolved iron (Fe)	Dissolved manganese (Mn)	Dissolved chloride (Cl)	Dissolved fluoride (Fl)	Total nitrate (N)
49	Spokane River at Plantes Ferry, Washington	8/73-2/74	Funk 1975a.	5	0/5	--	--	--	0/4
50	Spokane River at Argonne Road Bridge, Washington	9/66-9/72	Storet	4	--	--	--	--	0/3
51	Spokane River at Upriver Dam, Washington	8/72-2/74	Funk 1975a and Storet.	33	0/16	--	--	--	0/30
52	Spokane River below Spokane City Dam, Washington	9/72	Storet.	2	--	--	--	--	0/2
53	Spokane River below Green Street, Washington - 12422000	10/52	USGS	1	--	--	0/1	--	0/1
54	Spokane River at Upriver Drive, Washington	1/72-2/74	Funk 1973, 1975a.	30	0/19	0/4	--	--	0/25
55	Spokane River at Mission Avenue, Washington - 12422010	11/70-9/73	USGS and Storet.	42	0/18	0/17	--	0/22	0/41
56	Spokane River at Gonzaga, Washington	11/72-2/74	Funk 1975a.	20	0/15	--	--	--	0/17
57	Spokane River at Washington Street Bridge, Washington	9/72	Storet.	3	--	--	--	--	0/2
58	Spokane River at Monroe Street Bridge, Washington	9/72	Storet.	3	--	--	--	--	0/3
59	Spokane River at Spokane, Washington - 12422500	2/10-1/11	USGS.	35	0/33	--	0/33	--	0/28
59	-----do-----------------	6/47-10/52	USGS.	3	--	--	0/3	--	0/3
59	----do------------------	11/71-9/73	USGS and Storet.	29	0/19	0/17	--	0/22	0/22
60	Hangman Creek near Spokane, Washington 12423980	2/67 plus 6/68	USGS.	2	--	--	0/2	0/2	1/1
61	Hangman Creek at mouth, Washington - 12424000	10/52	USGS.	1	--	--	0/1	--	0/1
61	Hangman Creek at mouth, Washington - 12424003	11/71-9/73	USGS and Storet.	31	1/15	0/14	--	0/21	0/21
62	Spokane River at Fort Wright Bridge, Washington 12424100	11/70-9/73	USGS and Storet.	68	1/19	1/18	--	0/21	0/44
63	Spokane River at Riverside State Park, Washington 12424200	9/72-2/77	USGS and Storet.	75	18/37	1/17	0/4	0/22	0/64
64	Spokane River at 7-Mile Bridge, Washington 12424500	12/65-9/72	USGS and Storet.	55	--	--	0/49	0/49	0/51
66	Spokane River above 9-Mile Dam, Washington	9/72	Storet.	7	--	--	--	--	0/6
67	Spokane River below 9-Mile Dam, Washington 12426000	3/68-9/73	USGS and Storet.	77	2/28	7/20	--	0/22	0/69
68	Little Spokane River, Station #7, Washington	2/68-9/68	Burkhalter 1970.	6	--	--	0/6	--	0/6
69	Deadman Creek, Station #6, Washington	2/68-9/68	Burkhalter 1970.	6	--	--	0/6	--	0/6

chemical standards[4]/ Number of times tested											
Total dis-solved solids (residue at 180 C)	pH	Color	Tur-bid-ity	Dis-solved arsenic (As)	Dis-solved cad-mium (Cd)	Dis-solved chro-mium (Cr)	Dis-solved copper (Cu)	Dis-solved lead (Pb)	Dis-solved mercury (Hg)	Dis-solved zinc (Zn)	Total times chemi-cal stand-ards exceeded
0/1	--	--	--	--	0/5	--	0/5	0/5	--	0/5	0
--	0/4	--	--	--	--	--	--	--	--	--	0
--	1/16	--	--	--	0/16	--	0/16	0/14	--	0/16	1
--	0/2	--	--	--	--	--	--	--	--	--	0
0/1	0/1	--	--	--	--	--	--	--	--	--	0
0/5	0/14	--	--	--	0/15	--	0/19	0/15	--	0/20	0
--	1/42	17/42	1/42	0/15	0/20	0/18	0/19	0/19	0/3	0/15	19
--	0/4	--	--	--	0/15	--	0/15	0/15	--	0/15	0
--	0/3	--	--	--	--	--	--	--	--	--	0
--	0/3	--	--	--	--	--	--	--	--	--	0
0/34	--	--	10/34	--	--	--	--	--	--	--	10
0/3	0/1	--	--	--	--	--	--	--	--	--	0
--	0/22	3/22	1/22	0/14	0/20	0/17	0/18	0/18	0/3	0/13	4
0/2	0/2	2/2	--	--	--	--	--	--	--	--	3
0/1	0/1	--	--	--	--	--	--	--	--	--	0
--	6/30	25/28	19/30	0/12	0/15	0/14	0/14	0/13	0/2	0/10	51
--	0/42	10/42	11/42	0/11	0/20	0/17	0/18	1/20	0/2	0/14	24
0/23	4/65	16/26	21/64	0/37	1/37	2/37	0/37	3/37	2/37	0/37	68
0/49	0/51	2/49	--	0/2	0/1	0/8	0/10	0/1	0/1	0/10	2
--	0/7	--	--	--	--	--	--	--	--	--	0
--	2/77	27/64	16/65	0/1	1/25	0/65	0/65	3/68	11/27	0/63	69
--	0/5	--	0/4	--	--	--	--	--	--	--	0
--	2/5	--	1/4	--	--	--	--	--	--	--	3

TABLE 6.--Summary of surface-water quality data--Continued

Map location number[1]	Site name[2] and USGS number	Period of record	Data source[3]	Number of times sampled	Number of times exceeding: Dissolved iron (Fe)	Dissolved manganese (Mn)	Dissolved chloride (Cl)	Dissolved fluoride (Fl)	Total nitrate (N)
70	Little Spokane River Station #5, Washington	2/68-9/68	Burkhalter 1970.	6	--	--	0/6	--	0/6
71	Little Spokane River above Wandermere Creek, Washington 12430700	10/72-9/73	USGS.	22	0/19	0/18	--	0/22	0/22
73	Little Spokane River at Dartford, Washington 12431000	10/52 plus 7/60-9/70	USGS.	89	1/26	--	0/86	0/85	0/86
74	Little Spokane River Station #4; Washington	2/68-9/68	Burkhalter 1970.	6	--	--	0/6	--	0/6
75	Little Spokane River Station #3, Washington	2/68-9/68	Burkhalter 1970.	6	--	--	0/6	--	0/6
76	Little Spokane River Station #2, Washington	2/68-9/68	Burkhalter 1970.	6	--	--	0/6	--	0/6
77	Little Spokane River near mouth, Washington 12431900	11/70-3/77	USGS and Storet.	53	0/19	0/18	--	0/22	0/42
78	Little Spokane River Station #1, Washington	2/68-9/68	Burkhalter 1970.	6	--	--	0/6	--	0/6
		Totals-------		2552	114/972	33/495	0/876	2/903	1/1718

[1]Site locations are shown on plates 1 and 10.

[2]All U.S. Geological Survey sites include site name and 8-digit site number. Other sites retain names and numbers as assigned in original sources.

[3]Data source: USGS = U.S. Geological Survey.
Storet = Data storage system of the Environmental Protection Agency.
Funk 1973 = Funk and others, 1973.
Funk 1975a = Funk and others 1975a.
Funk 1975b = Funk and others 1975b.
IDHW = Idaho Department of Health and Welfare.
Burkhalter 1970 = Burkhalter, Cunningham and Tracy, 1970.

[4]Chemical standards are explained on plate 10.

chemical standards[4]/ Number of times tested											
Total dissolved solids (residue at 180°C)	pH	Color	Turbidity	Dissolved arsenic (As)	Dissolved cadmium (Cd)	Dissolved chromium (Cr)	Dissolved copper (Cu)	Dissolved lead (Pb)	Dissolved mercury (Hg)	Dissolved zinc (Zn)	Total times chemical standards exceeded
--	0/5	--	1/4	--	--	--	--	--	--	--	1
--	1/22	15/22	6/22	0/13	0/19	0/17	0/16	0/18	0/3	0/14	22
0/86	0/86	5/47	--	0/5	--	0/11	0/13	--	--	0/13	6
--	0/5	--	1/4	--	--	--	--	--	--	--	1
--	0/5	--	0/4	--	--	--	--	--	--	--	0
--	0/5	--	1/4	--	--	--	--	--	--	--	1
--	0/51	24/49	20/51	0/16	0/20	0/19	0/16	0/20	0/3	0/13	44
--	0/5	--	0/4	--	--	--	--	--	--	--	2
45/1360	92/2031	170/826	326/1050	1/554	55/666	4/595	0/824	41/856	26/457	8/922	918/15105

Surface Water

Physical and inorganic chemical constituents

Many different surface-water bodies are direct or indirect sources of recharge to the aquifer, and some of these bodies must be considered as potential alternative water sources. Therefore, the available data on surface-water quality were summarized for this study (table 6). The table lists 15,105 analyses of the chemical constituents in 2,552 water samples from 76 surface-water sites. Most of the tabulated data is for samples that were collected and analyzed by U.S. Geological Survey personnel. The data from individual analyses appear in annual U.S. Geological Survey water-data reports for each of the States involved. The remaining data were obtained from the sources shown in table 6. The locations of surface-water-quality sites are shown on plates 1 and 10.

The 16 constituents in table 6 are included in the National Interim Primary (or Proposed Secondary) Drinking Water Regulations (U.S. Environmental Protection Agency, 1975) presented on plate 10.

Eight of the constituents listed in table 6 may affect the health of consumers. The MCL's for these constituents (pl. 10) have been exceeded a total of 456 times, about 7 percent of the 6,799 tests conducted. The MCL's for fluoride, nitrate, and arsenic were exceeded in less than 1 percent of the samples analyzed for those constituents. Cadmium, lead, and mercury MCL's were exceeded in 4 to 9 percent of the samples tested, and turbidities exceeded the MCL in about 31 percent of the 1,050 samples tested.

An additional constituent, not included in table 6, but which may affect the health of consumers is selenium. About 140 selenium analyses of water from nine sites are listed in Storet. In 1971-73, sites 42,48,55,59,62, and 63 were each sampled 17 or 18 times. The maximum value of selenium in any of these samples was 0.006 mg/L, below the MCL of 0.01 mg/L. The mean value of selenium for each of these 6 sites, as noted in the available data, is from 0.0021 to 0.0022 mg/L.

Copper and chloride, 2 of the 8 constituents listed in table 6 that may affect the esthetic quality of water, have never been observed to exceed their proposed secondary levels. The proposed secondary levels were exceeded in 4 to 9 percent of the samples tested for manganese, dissolved solids, pH, and zinc; in 11 percent of the samples tested for iron; and in 21 percent of the samples tested for color. These 8 constituents were tested a total of 8,306 times. In 462 instances, about 6 percent of the tests, the recommended levels were exceeded.

Because most of the surface-water samples were collected and analyzed by a single agency, and because most of the samples were collected in the last 5-6 years, the accuracy and compatibility of results is probably more consistent than that for the available ground-water data. However, the quality of surface-water generally fluctuates over a relatively wide range (in comparison with ground water) in response to changes in flow, seasons, and the quality of inflowing waters; this makes identification of long-term trends very difficult.

Pesticides, phenols, and radionuclides

A small amount of data on the amounts of pesticides, phenols, and radionuclides in surface water is available. Water samples from four sites have been tested a total of 70 times for five different pesticides. Sixty-four of these samples were collected at two sites--sites 33 (Hayden Creek) and 67 (Spokane River). The rather remote location of site 33 should ensure the availability of water samples which represent natural conditions, whereas site 67 is at the downstream end of an area which includes agricultural, industrial, and urban developments. The MCL's for pesticides not included in plate 10 are as follows: 0.1 mg/L methoxychlor, 0.1 mg/L 2,4D, and 0.01 mg/L 2,4,5TP silvex.

During the period 1967-1975, water from site 33 was analyzed 9 times for endrin, 2,4-D, and 2,4,5-TP silvex, and 10 times for lindane. All of these analyses showed no trace of these substances, nor did a single sample that was analyzed for toxaphene in 1975.

Water from site 67 was tested 18 times between 1969 and 1973 for endrin, and 4 times between 1971 and 1973 for lindane and toxaphene. The maximum concentrations observed were 0.000003 mg/L endrin, 0.000001 mg/L lindane, and 0.00008 mg/L toxaphene, all below their respective MCL's.

Water from site 39 was analyzed for endrin four times between 1964 and 1967, and all values were 0.000000 mg/L. A single sample from site 39 in 1971 contained 0.000003 mg/L endrin. A single analysis for endrin at site 24 in 1971 yielded a value of 0.000003 mg/L.

In September 1972, water samples from five surface-water sites on the Spokane River (sites 42, 50, 51, 62, and 63) and from five of six locations where sewage effluents are discharged into the river between sites 42 and 63, were analyzed for concentrations of phenols. The samples from the five river sites had phenol concentrations ranging from 0.0011 to 0.011 mg/L, and the samples from the five sewage effluent sites had concentrations ranging from <0.010 to 0.084 mg/L (pl. 10).

Apparently only two sites were tested for radionuclides. Gross alpha radioactivity was tested 10 times at site 33 (1967-74) and 62 times at site 39 (1962-68). Maximum values observed were 0.54 and 1.0 pCi/L (picocuries per liter) at sites 33 and 39, respectively. The 10 samples from site 33 were also tested for dissolved radium-226, and yielded a maximum value of <0.1 pCi/L. The MCL's for gross alpha radioactivity and for radium-226 are 15 and 5 pCi/L, respectively.

Coliform bacteria

A summary of coliform-bacteria counts in water samples from selected surface-water sites listed in Storet is included below. The summary lists data for one site on the Coeur d'Alene River and five sites on the Spokane River.

Site number	Period of record	Number of samples	Total coliform bacteria (col/100 mL)	
			Mean	Maximum
24	1968-76	54	390	4,500
42	1970-77	51	653	4,000
55	1970-73	42	732	8,000
59	1972-73	22	1,097	4,000
62	1970-73	42	2,049	14,000
67	1968-73	72	2,158	21,500

Mean fecal-coliform-bacteria counts for each of these sites ranged from 3 to 8 percent of the mean total-coliform-bacteria counts. A pattern of increased mean total-coliform-bacteria counts in the downstream direction is apparent in the above data. However, this pattern holds true only relative to long-term means.

In September 1972, a large number of water samples was collected from the Spokane River and from seven sewage-treatment plants that discharge effluent into the river. The five industrial sewage treatment plants yielded effluent having mean total-coliform-bacteria counts of <10 to 550 colonies/100 mL, less than the long-term means for the river near each plant. The Spokane and Coeur d'Alene sewage-treatment plants yielded effluents having counts of 19,157 and 25,849 colonies/100 mL, respectively, far above the long-term means for the river near each of these plants.

ALTERNATIVE WATER SOURCES

Three types of alternative water sources for the Spokane Valley-Rathdrum Prairie area should be considered: the Spokane and Little Spokane Rivers, the lakes along the foothill margins of the aquifer, and other aquifers adjacent to the Spokane Valley-Rathdrum Prairie aquifer. All sources must be evaluated relative to the quantity of water available (the rate of water use from the aquifer in 1976 being about 240 ft^3/s), the quality of the water (the aquifer generally yielding water of good quality), and the proximity of the source to the areas of need (sufficient supplies for almost any purpose now being obtainable from the aquifer at almost any location).

The mean flow of the Little Spokane River is about 627 ft^3/s near Dartford, Wash. (site 76). Nineteen years of low-flow measurements at site 76 show a minimum flow of 377 ft^3/s, about 1.6 times the rate of water use from the aquifer in 1976. Although there appears to be sufficient flow in the river, some of this water is undoubtedly claimed by existing water rights which would have to be considered prior to any development. The Little Spokane River is about 7 miles from the center of Spokane, about 15 miles from the areas of intensive use of water east of Spokane, and more than 20 miles from the nearest water users in Idaho. The river also is about 300-500 feet lower than the elevation at Spokane. However, the quality of the river water is quite good. In 53 samples collected between November 1970 and March 1977 at station 77 (near the river's mouth), only color and turbidity MCL's were exceeded (in about 50 and 40 percent of the samples, respectively). During the same period, 51 water samples tested for total-coliform-bacteria counts showed a range of 20 to 12,000 colonies/100 milliliters and a mean value of more than 1,100 colonies/100 milliliters.

The mean flow of the Spokane River is in excess of 6,000 ft^3/s between Post Falls, Idaho and Long Lake, Wash. However, this flow has varied considerably in the past, including minimum recorded flows of 59 ft^3/s at Post Falls and 95 ft^3/s at Spokane. Also, the water in the river is generally of poorer quality than water in the aquifer; in particular, the river tends to have higher values for color and turbidity, and greater concentrations of heavy metals, phenols, and coliform bacteria. The mean total-coliform-bacteria counts observed in samples from the river (see discussion on surface-water quality, p.64) ranged from 653 col/100 mL near Otis Orchards (site 42) to 2,158 col/100 mL below Nine Mile Dam (site 67). Although the river is within 1 to 3 miles of much of the area supplied by the aquifer, parts of the Hillyard Trough area are 5 miles or more from the river, and most of the area in Idaho supplied by the aquifer is from 5 to 20 miles from the river.

Coeur d'Alene and Pend Oreille Lakes are the only lakes adjacent to the aquifer which have large annual inflows and which contain volumes of water that are large relative to the volume of water presently (1976) pumped annually from the aquifer (7.5×10^9 ft^3/yr or about 240 ft^3/s). These lakes contain average volumes of roughly 9×10^9 ft^3 and 4×10^{10} ft^3 of water, respectively, and receive average inflows in excess of 5,000 and 20,000 ft^3/s, respectively. However, the water in the lakes is generally of poorer quality than that in the aquifer, particularly in respect to heavy-metals concentrations. The MCL for lead has been exceeded in samples from both lakes, and the MCL's for cadmium and mercury have been exceeded in samples from Coeur d'Alene Lake. Furthermore, nearly 70 percent of the water pumped from the aquifer in 1976 was used in Washington, the major portion being used within a few miles of Spokane; Coeur d'Alene and Pend Oreille Lakes are 25 to 40 miles away from this area of greatest water demand.

Three types of geologic materials occurring adjacent to the aquifer were considered for their water-yielding characteristics. These include pre-Tertiary igneous and metamorphic rocks, Tertiary basalts, and Quaternary glacial drift. In an earlier report (U.S. Army Corps of Engineers, 1976), the water-yielding capabilities of these materials are summarized. The igneous and metamorphic rocks are capable of supplying only a very sparse population, the basalts yield large quantities of water at some locations but are unable to sustain these rates owing to their low rate of recharge, and the glacial drift yields large quantities of water only in the largest valleys where it has an upper limit of about 15 ft^3/s. The largest valley and the one exception is the Little Spokane River basin where Cline (1969) estimated the average rate of recharge to the ground-water system to be approximately 220 ft^3/s from precipitation and 180 ft^3/s from underflow from the glacio-fluvial deposits in the Hillyard Trough. The water from these materials is generally of about the same quality as water from the Spokane Valley-Rathdrum Prairie aquifer. With the exception of the glacial drift, obtaining large quantities of water from these materials probably would require much deeper wells than those tapping the Spokane Valley-Rathdrum Prairie aquifer.

SUMMARY

The Spokane Valley-Rathdrum Prairie aquifer in 1976 supplied almost all the water used in public-supply systems on the land surface overlying the aquifer. The aquifer is recharged and discharged at an average rate of about 1,320 ft^3/s, including an average pumping rate of about 240 ft^3/s to meet all water needs in 1976. Treated industrial and domestic waste water is discharged to the Spokane River (and Hangman Creek) and the land surface overlying the aquifer at rates of 65 ft^3/s and 5 ft^3/s, respectively. About 30 ft^3/s of waste water returns to the aquifer by infiltration from cesspools and drainfields. The remainder of the water pumped from the aquifer is either lost to evapotranspiration or undergoes minor water-quality changes before being applied to the land surface, after which the water percolates back to the aquifer.

The available water-quality data indicate that the aquifer generally yields water of good quality. Less than one-half of 1 percent of the analyses for inorganic chemical and physical constituents that may be hazardous to the health of consumers showed values exceeding the established maximum contaminant levels (pl. 10) for those constituents. About 1.4 percent of the analyses for constituents considered detrimental to the esthetic quality of water showed values exceeding the established secondary levels (pl. 10). The data also show that there has apparently been no significant change in the quality of water in the aquifer with time. However, at least six cases of relatively short-term ground-water contamination from industrial materials occurred during the period 1954-76. Among the contaminants involved in these six cases were unnaturally high concentrations of chloride, dissolved solids, sodium, potassium, nitrite, ammonia, gasoline, diesel fuel, and phenols.

Potential alternative sources of water to supply the area now supplied by the aquifer are the Spokane and Little Spokane Rivers, the lakes bordering the aquifer, and other aquifers. These are all less desirable sources than the Spokane Valley-Rathdrum Prairie aquifer because of insufficient supplies, poor water quality, and (or) remoteness from the areas of water need.

BIBLIOGRAPHY

Anderson, A. L., 1927, Some Miocene and Pleistocene drainage changes in northern Idaho: Idaho Bur. Mines and Geology Pamph. 18, 28 p.

-----1940, Geology and metaliferous deposits of Kootenai County, Idaho: Idaho Bur. Mines and Geology Pamph. 53, 67 p.

Baker, V. R., 1971, Paleohydrology of catastrophic Pleistocene flooding in eastern Washington: Geol. Soc. America Abs. with Programs, v. 3, p. 497.

-----1973, Paleohydrology and sedimentology of Lake Missoula flooding in eastern Washington: Geol. Soc. America Spec. Paper 144, 79 p.

----1974, Erosional forms and processes for the catastrophic Pleistocene Missoula floods in eastern Washington, in Fluvial geomorphology, Marie Morisawa, ed., pub. in geomorphology: New York State Univ. (Binghamton), p. 123-148.

Bannon, G., 1974, Productivity of the Spokane River: Washington State Univ. (Pullman), M.S. thesis, 69 p.

Bishop, R. A., and Lee, R. A., 1972, Spokane River cooperative water quality study: Washington Dept. Ecology Tech. Rept. 72001, 72 p.

Bodhaine, G. L., and Robinson, W. H., 1952, Floods in western Washington, frequency and magnitude in relation to drainage basin characteristics: U.S. Geol. Survey Circ. 191, 124 p.

Bodhaine, G. L., and Thomas, D. M., 1964, Magnitude and frequency of floods in the United States, part 12, Pacific slope basins in Washington and upper Columbia River basin: U.S. Geol. Survey Water-Supply Paper 1687, 337 p.

Bortleson, G. C., Dion, N. P., McConnell, J. B., and Nelson, L. M., 1976, Reconnaissance data on lakes in Washington, v. 7, Pend Oreille, Spokane, and Stevens Counties: Washington Dept. Ecology Water-Supply Bull. 43, 267 p.

Bortleson, G. C., Higgins, G. T., and Hill, G. W., 1974, Data on selected lakes in Washington, part 2: Washington Dept. Ecology Water-Supply Bull. 42, 145 p.

Bretz, J H., 1924, The age of the Spokane glaciation: Am. Jour. Sci., 5th series, v. 8, p. 336-342.

----1927, Channeled scabland and the Spokane flood: Washington Acàd. Sci. Jour., v. 17, p. 200-211.

-----1969, The Lake Missoula floods and the channeled scabland: Jour. Geology, v. 77, p. 505-543.

Briscoe, R. H., 1972, A cost-benefit analysis of water-resources and wastewater disposal methods in the Spokane Valley: Washington State Univ. M.S. thesis, 112 p.

Broom, H. C., 1951, Gaging station records in Spokane River basin, Washington from Post Falls, Idaho to Long Lake, Washington including Little Spokane River, water years 1948 to 1950: U.S. Geol. Survey open-file report, Tacoma, 29 p.

Burkhalter, R. A., Cunningham, R. K., and Tracy, H. B., 1970, A report on the water quality of the Little Spokane River: Washington Pollution Control Comm. Tech. Rept. 70-1, 27 p.

Chung, S. K., 1975, Little Spokane River basin (Revised review draft): Washington Dept. Ecology, Water Resources Management Program, Basin Program Ser.1, 68 p.

Cline, D. R., 1969, Ground-water resources and related geology, north-central Spokane and southeastern Steven Counties, Washington: Washington Dept. Water Resources Water Supply Bull. 27, 195 p.

Columbia Basin Inter-Agency Committee, 1964, River-mile index, Spokane River Basin, Washington-Idaho: Hydrology Subcommittee, 24 p.

Crosby, J. W. III, Johnstone, D. L., Drake, C. H., and Fenton, R. L., 1968, Migration of pollutants in a glacial outwash environment: Water Resources Research, v. 4, no. 5, p. 1095-1114.

Crosby, J. W. III, Johnstone, D. L., and Fenton, R. L., 1970, Migration of pollutants in a glacial outwash environment, part II: Water Resources Research, v. 7, no. 1, p. 204-208.

----1971, Migration of pollutants in a glacial outwash environment, part III: Water Resources Research, v. 7, no. 3, p. 713-720.

Crosby, J. W. III, Johnstone, D. L., Fenton, R. L., Drake, C. H., Purves, W. J., Kiesler, J. P., Ko, C., and Weakly, E. C., 1971, Final report: Investigation of techniques to provide advance warning of ground water pollution hazards with special reference to aquifers in glacial outwash: Washington State Univ. (Pullman), OWRR Project No. B005, 148 p.

Cunningham, R. K., and Rothwell, G., 1971, Water quality report, Spokane and Little Spokane Rivers, December 1970-March 1971: Washington Dept. Ecology, 28 p.

Davenport, R. W., 1921, Coeur d'Alene Lake, Idaho and the overflow lands: U.S. Geol. Survey Water-Supply Paper 500-A, p. 1-32.

Dion, N. P., and Lum, W. E. II, 1977, Municipal, industrial, and irrigation water use in Washington, 1975: U.S. Geol. Survey Open-File Rept. 77-308, 34 p.

Donaldson, N. C., and Giese, L. D., 1968, Soil survey of Spokane County, Washington: U.S. Soil Conserv. Service, 143 p.

Dunigan, P. F. X., 1972, Chemical investigations of Coeur d'Alene Lake sediments: Washington State Univ. (Pullman), Coll. of Eng. M.S. thesis, 46 p.

Esvelt and Saxton Consulting Engineers, 1964, Public health relationship of the Minnihaha sewer district to the Greater Spokane Community: Spokane, Washington, 33 p.

Fader, S. W., 1951, Water levels in wells and lakes in Rathdrum Prairie and contiguous areas, Bonner and Kootenai Counties, northern Idaho: U.S. Geol. Survey Basic Data Report, 90 p.

Flaherty, D. C., 1973, Good water? A study of the Coeur d'Alene Spokane River region: Washington Water Research Center (Pullman), Special Publication, 24 p.

Flint, R. F., 1936, Stratified drift and deglaciation of eastern Washington: Geol. Soc. Am. Bull., v. 47, no. 12, p. 1849-1884.

Fosdick, E. R., 1931, A study of ground water in the Spokane and Rathdrum Valleys: Washington Water Power Co., 22 p.

Funk, W. H., and others, 1973, Biological impact of combined metallic and organic pollution in the Coeur d'AleneSpokane River drainage system: Washington State Univ./Idaho Univ., Joint Completion Report to OWRR (B-044 WASH and B-015 IDA), 187 p.

----1975a, An integrated study on the impact of metallic trace element pollution in the Coeur d'AleneSpokane Rivers - Lake drainage system: Washington State Univ./Idaho Univ. Project Completion Report to OWRT (Title II Project C-4145), 332 p.

-----1975b, Determination, extent, and nature of nonpoint source enrichment of Liberty Lake and possible treatment: Washington State Water Research Center, Rept. 23, 163 p.

Futrell, Redford, and Saxton, Consulting Engineers, 1974, Comprehensive waste water and treatment plan for the Liberty Lake Sewer District: Spokane, Wash., 94 p.

Gasparino, A. F., 1974, The effect of nutrient enrichment on the phytoplankton dynamics of Long Lake, Washington, U.S.A.: Eastern Washington State College (Cheney), M.S. thesis, 30 p.

Graham, W. G., 1975, The effect of eutrophication on the zooplankton community of Long Lake, Washington, U.S.A.: Eastern Washington State Coll. (Cheney), M.S. thesis, 35 p.

Griggs, A. B., 1965, Reconnaissance geologic map of the west half of the Spokane (AMS) quadrangle: Lincoln, Spokane, Stevens, and Whitman Counties, Washington and Bonner, Kootenai, Benewah, and Latah Counties, Idaho: U.S. Geol. Survey Misc. Geol. Inv. Map I-464.

-----1973, Geologic map of the Spokane quadrangle, Washington, Idaho, and Montana: U.S. Geol. Survey, Map I-768.

Grover, N. C., and Parker, G. L., 1940, Summary of records of surface waters of Washington, 1919 to 1935: U.S. Geol. Survey Water Supply Paper 870, 456 p.

Hammond, R. E., 1974, Ground water occurrence and movement in the Athol area and the northern Rathdrum Prairie, northern Idaho: U.S. Geol. Survey Water Inf. Bull. 35, 19 p.

Harston, C. B., 1971, Baseline data on Liberty Lake: Washington State Cooperative Ext. Serv., 2 p.

Idaho Water Resources Board, 1968, Potentially irrigable lands in Idaho: Soil Report No. 18, Kootenai County: 2 p.

Johnstone, D. L., 1970, Bacterial ecology of the Spokane River: Washington State Univ. (Pullman), M.S. thesis, 51 p.

Marshall, R. B., 1915, Profile surveys in Spokane River basin, Washington and John Day River basin, Oregon: U.S. Geol. Survey Water-Supply Paper 377, 7 p.

Maytin, I. L., and Gilkeson, R., 1962, State of Washington Engineering soils manual, Soils of Spokane County: Washington State Univ. (Pullman), 198 p.

McDonald, C. C., and Broom, H. C., 1951, Analysis of increments of discharge in Spokane River, Post Falls, Idaho to Long Lake, Washington: U.S. Geol. Survey open-file report, 19 p.

Mink, L. L., Williams, R. E., and Wallace, A. T., 1971, Effects of industrial and domestic effluents on the water quality of the Coeur d'Alene River basin: Idaho Bur. Mines and Geology Pamph. 149, 30 p.

Minter, R. F., 1971, Plankton population structure in the lower Còeur d'Alene River, Delta, and Lake: Idaho Univ. (Moscow), M.S. thesis, 70 p.

Nace, R. L., and Fader, S. W., 1950, Record of wells on Rathdrum Prairie, Bonner and Kootenai Counties, northern Idaho: U.S. Geol. Survey, Basic Data Report, 50 p.

National Academy of Sciences - National Academy of Engineering, 1973, Water quality criteria 1972: U.S. Environmental Protection Agency, Ecological Research Ser., EPA R3-73-033, 594 p.

Newcomb, R. C., 1933, Underground water of the upper Spokane River valley: Washington State Coll. (Pullman), undergraduate competition paper, submitted to Columbia Section, Am. Inst. of Mining and Metallurgical Engineers, 16 p.

-----1953, Seismic cross sections across the Spokane River valley and the Hillyard Trough, Idaho and Washington: U.S. Geol. Survey open-file rept., 16 p.

Orsborn, J. F., 1973, Water balance of Liberty Lake Washington: report to Futrell, Redford, and Saxton, consulting engineers, 37 p.

Pardee, J. T., and Bryan, K., 1926, Geology of the Latah Formation in relation to the lavas of the Columbia Plateau near Spokane, Washington: U.S. Geol. Survey Prof. Paper 140-A, p. 1-16.

Parker, J. I., 1972, Algae production and nutrient enrichment in Lake Coeur'd'Alene, Idaho: Idaho Univ. (Moscow) M.S. thesis, 39 p.

Phillips, R. A., Cavin, R. E., Dunston, A. H., and Crosby, J. W. III, 1962, Spokane Valley ground water pollution study: Washington State Univ. Research Report 6219-123.

Piper, A. M., and Huff, L. C., 1943, Some ground-water features of Rathdrum Prairie, Spokane Valley area, Washington-Idaho, with respect to seepage loss from Pend Oreille Lake: U.S. Geol. Survey open-file report, 13 p.

Piper, A. M., and LaRocque, G. A., 1944, Water-table fluctuations in the Spokane Valley and contiguous area, Washington-Idaho: U.S. Geol. Survey Water-Supply Paper 889-B, p. 83-139.

Pluhowski, E. J., and Thomas, C. A., 1968, A water-balance equation for the Rathdrum Prairie ground-water reservoir near Spokane, Washington: U.S. Geol. Survey Prof. Paper 600-D, p. D75-D78.

Purves, W. J., 1969, Stratigraphic control of the ground water through the Spokane Valley: Washington State Univ. (Pullman), M.S. thesis, 213 p.

Randall, A. D., 1970, Movement of bacteria from a river to a municipal well--a case history: Am. Water Works Assoc. Jour., v. 62, no. 11, p. 717-720.

Rantz, S. E., and Riggs, H. C., 1949, Floods of May-June 1948 in Columbia River basin: U.S. Geol. Survey Water-Supply Paper 1080, 476 p.

Richmond, G. M., Fryxell, R., Neff, G. E., and Weis, P. L., 1965, The Cordilleran ice sheet of the northern Rocky Mountains, and related Quaternary history of the Columbia Plateau: in the Quaternary of the United States: Princeton Univ. Press, Princeton, New Jersey, p. 231-241.

Rorabaugh, M. I., and Simons, W. D., 1966, Exploration methods of regulating ground water to surface water - Columbia River basin, second phase: U.S. Geol. Survey open-file report, 62 p.

Sagsted, S. R., and Ralston, D. R., 1976, Analysis of a ground water flow system in northern Idaho related to heavy metal concentrations: Paper presented at 14th Annual Engineering Geology and soils Symposium, Boise, Idaho, 14 p.

Simons, W. D., and others, 1953, Subsurface facilities of water management and patterns of supply-type area studies, ch. 10, Spokane-Coeur d'Alene River basin, Washington-Idaho, in The physical and economic foundation of natural resources; House of Representatives, Internal and Insular Affairs Comm., U.S. Cong., p. 162-185.

Sisco, H. G., 1974, Ground water levels and well records for current observation wells in Idaho, 1922-73, Part A: U.S. Geol. Survey, Basic-Data Release, 309 p.

-----1976, Ground-water levels and well records for discontinued observation wells in Idaho, 1915-72, Part A: U.S. Geol. Survey, Basic-Data Release No. 3, 261 p.

Soltero, R. A., Gasperino, A. F., and Graham, W. G., 1973, An investigation of the cause and effect of eutrophication in Long Lake, Washington: Eastern Washington State Coll., Project Completion Report (OWRR, A-058-WASH), 86 p.

-----1974, Further investigations as to the cause and effect of eutrophication in Long Lake, Washington: Eastern Washington State Coll. (Cheney), Project Completion Report (DOE 74-025A), 85 p.

Soltero, R. A., Gasperino, A. F., Williams, P.H., and Thomas, S. R., 1975, Response of the Spokane River periphyton community to primary sewage effluent and continued investigation of Long Lake: Eastern Washington State Coll. (Cheney), Project Completion Report (DOE 74-144), 117 p.

U.S. Army Corps of Engineers, 1951, Seismic survey of the Spokane River Valley: U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Miss., 9 p.

U.S. Army Corps of Engineers, 1976, Metropolitan Spokane Region Water Resources Study: Summary report, technical report, and appendixes A to J: U.S. Army Corps of Engineers, Seattle

- Summary rept., 119 p.
- Technical rept., 316 p.
- Appendix A, surface water, 360 p.
- appendix B, geology and ground water, 227 p.
- appendix C, water use, 234 p.
- appendix D, wastewater generation and treatment, 466 p.
- appendix E, environment and recreation, 145 p.
- appendix F, demographic and economic characteristics, 320 p.
- appendix G, planning criteria, 384 p.
- appendix H, vols. 1 and 2, plan formulation and evaluation, 715 p.
- appendix I, institutional analysis, 248 p.
- appendix J, water quality simulation model, 247 p.

U.S. Bureau of Reclamation, 1966, Rathdrum Prairie Project, Prairie division, east Greenacres unit, Idaho: U.S. Bur. Reclamation Feasibility rept., 54 p.

U.S. Environmental Protection Agency, 1975, National interim primary drinking water regulations: Federal Register, v. 40, no. 248, p. 59566-59588.

-----1977, National secondary drinking water regulations: Proposed regulations: Federal Register, v. 42, no. 62, p. 17143-17146.

U.S. Public Health Service, 1952, Report on water pollution control, Spokane River basin: U.S. Public Health Service Pub. 223, 123 p.

-----1962, Drinking water standards 1962: U.S. Public Health Service Pub. 956, 61 p.

Van Denburgh, A. S., and Santos, J. F., 1965, Ground water in Washington, its chemical and physical quality: Washington Div. Water Resources Water Supply Bull. 24, 93 p.

Van Duyne, C., and Mortlock, H. C., 1921, Soil survey of Spokane County, Washington: U.S. Dept. Agriculture, Washington D.C., 108 p.

Van Winkle, W., 1914, Quality of the surface waters of Washington: U.S. Geol. Survey Water-Supply Paper 339, 105 p.

Walker, E. H., 1964, Ground water in the Sand Point region, Bonner County, Idaho: U.S. Geol. Survey Water-Supply Paper 1779-I, 29 p.

Weigle, J. M., and M. J. Mundorff, 1952, Records of wells, water levels, and quality of ground water in the Spokane Valley, Spokane County, Washington: U.S. Geol. Survey open-file report, 102 p.

Weis, P. L., 1968, Geologic map of the Greenacres quadrangle, Washington and Idaho: U.S. Geol. Survey Geol. Quad. Map GQ-734

Weis, P. L., and Richmond, G. M., 1965, Maximum extent of late Pleistocene Cordilleran glaciation in northeastern Washington and northern Idaho: U.S. Geol. Survey Prof. Paper 525-C, p.C128-C132.

Williams, P. H., 1975, Response of the Spokane River diatom community to primary sewage effluent: Eastern Washington State Coll. (Cheney) M.S. thesis, 38 p.

Winner, J. E., 1972, Macrobenthic communities in the Coeur d'Alene Lake system: Idaho Univ. (Moscow), M.S. thesis, 41 p.

Wissmar, R. C., 1972, Some effects of mine drainage on primary production in Coeur d'Alene River and Lake Idaho: Idaho Univ. (Moscow), Ph.D. dissert., 61 p.

MISCELLANEOUS UNPUBLISHED REFERENCES

Anderson, K. E., 1951, Geology and ground-water resources of the Rathdrum Prairie project and contiguous area, Idaho-Washington: U.S. Bur. Reclamation unpub. rept., 39 p.

Condit, R. J., 1972, Diatom population in Coeur d'Alene Lake bottom sediments: Washington State Univ. (Pullman), Coll. of Eng., unpublished manuscript, 22 p.

Ellis, M. M., 1932, Pollution of the Coeur d'Alene River and adjacent waters by mine wastes: U.S. Bur. Fisheries, Washington, D.C., unpublished report to the commissioner, 61 p.

Frink, J. W., 1962, Spokane Valley Project, geology and ground-water factors controlling design and construction of water wells: U.S. Bur. Reclamation, Boise, Idaho, unpublished report, 38 p.

----1964, Geology and ground water resources in Rathdrum Prairie, Idaho, as they relate to design and construction of East Greenacres unit--Rathdrum Praire Project: U.S. Bur. Reclamation, Boise, Idaho, 23 p.

----1968, An appraisal of potential ground water supply for Avondale and Hayden Lake irrigation districts, Rathdrum Prairie Project, Idaho: U.S. Bur. Reclamation, Boise, Idaho, unpublished report, 8 p.

Hangman Creek Task Force Committee, 1974, Environmental conservation in the Hangman Creek watershed: unpublished report.

Huff, L. C., 1943, Geology and ground-water resources of the Spokane Valley and vicinity, Washington, Idaho: U.S. Geol. Survey, unpublished report., 153 p.

Johnson, W. E., 1970, Spokane ground water; derivation of source and minimum annual yield of record, based on streamflow records: Wash ngton State Univ. (Pullman) unpublished report, 13 p.

Lenz, A. T., 1950, Irrigation water requirements, seepage losses, and return flow, Rathdrum Prairie project, Idaho: U.S. Bur. Reclamation, Boise, Idaho, unpublished memorandum, December 1950.

Meneely, E. N., 1951, Contribution of precipitation to ground water, Rathdrum Prairie-Spokane Valley area: U.S. Bur. Reclamation, mimeographed report.

Orsborn, J. F., and Sood, M. N., 1974, Preliminary report; technical supplement to the hydrographic atlas; Spokane River basin study area: Washington Water Research Center (Pullman) unpublished report.

Rieber, F., Jr., and Turner, D. S., 1963, Drilling and completion report of the Hillyard Trough well no. 1, Spokane County, Washington: Ball Assoc. Ltd., unpublished report to Washington Water Power Co.

Thomas, C. A., 1963, Investigation of the inflow to the Rathdrum Prairie-Spokane Valley aquifer: U.S. Geol. Survey unpub. report., 46 p.

U.S. Bureau of Reclamation, 1954, Spokane valley project, Washington: unpublished reconnaissance report, 71 p.

-----1956, Spokane valley project, Washington: unpublished report, 62 p.

U.S. Environmental Protection Agency, 1974, Ground-water monitoring FY 1974, Spokane Valley, Washington: EPA, Seattle, Washington, unpublished rept.