HYDROLOGY OF VALLEY FILL AND POTENTIAL FOR ADDITIONAL GROUND-WATER WITHDRAWALS ALONG THE NORTH FLANK OF THE LITTLE ROCKY MOUNTAINS, FORT BELKNAP INDIAN RESERVATION, NORTH-CENTRAL MONTANA

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CONVERSION FACTORS, VERTICAL DATUM, AND OTHER ABBREVIATED UNITS

Multiply	By	To obtain
	Length or Height	
foot (ft)	0.3048	meter
inch (in.)	25.4	millimeter

Multiply	By	To obtain
mile (mi)	1.609	kilometer
	Area	
acre	4,047	square meter
square foot (ft^2)	0.0929	square meter
square mile (mi^2)	2.59	square kilometer
	Volume	
acre-foot (acre-ft)	1,233	cubic meter
	Flow or Consumptive Use	
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year
cubic foot per second (ft^3/s)	0.028317	cubic meter per second
cubic foot per second per mile [(ft^3/s)/mi]	0.0176	cubic meter per second per kilometer
gallon per minute (gal/min)	0.06309	liter per second
inch per year (in/yr)	25.4	millimeter per year
	Gradient	
foot per foot (ft/ft)	1.0	meter per meter
foot per mile (ft/mi)	0.1894	meter per kilometer
	Hydraulic Conductivity	
foot per day [(ft^3/d)/ft^2 or ft/d]	0.3048	meter per day
	Transmissivity	
foot squared per day [((ft^3/d)/ft^2)ft or ft^2/d]	0.0929	meter squared per day
	Change in Hydraulic Head	
foot per day (ft/d)	0.3048	meter per day

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

$$°C = 5/9\ (°F - 32)$$
$$°F = 9/5\ (°C) + 32$$

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

Other units that are abbreviated in this report:

h	hours
µg/L	micrograms per liter
µS/cm	microsiemens per centimeter at 25 °C
mg/L	milligrams per liter
min	minutes

HYDROLOGY OF VALLEY FILL AND POTENTIAL FOR ADDITIONAL GROUND-WATER WITHDRAWALS ALONG THE NORTH FLANK OF THE LITTLE ROCKY MOUNTAINS, FORT BELKNAP INDIAN RESERVATION, NORTH-CENTRAL MONTANA

By

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ABSTRACT

The stratigraphy of the southern part of the Fort Belknap Indian Reservation is composed of igneous, metamorphic, and sedimentary rocks, and unconsolidated deposits. Extensive terraces surrounding the base of the Little Rocky Mountains have been cut by streams draining the highlands. The continental ice sheet advanced across the plains, but not the mountains, of the study area at least twice during the Pleistocene Epoch.

Quaternary valley fill consists of cobbles, gravel, sand, silt, and clay that have been deposited as glacial deposits, colluvium, and alluvium. Glacial deposits occur as till and glaciolacustrine clay, are relatively impermeable, and typically form a confining unit overlying the valley-fill aquifer. Colluvium is relatively impermeable and does not yield water. Alluvium occurs in sequences as much as 90 feet thick near the mountain front and contains layers of sand and gravel that form the primary aquifer in the valley-fill sequence.

Of the five principal stream valleys in the study area, only Little Peoples and Lodge Pole Creeks have deposits of sand and gravel that are continuous along most of the length of the valleys. Valley fill beneath these two valleys is bounded by shale, except where the valleys cross the Eagle Sandstone and localized sandstone sequences of the Judith River Formation, both of Late Cretaceous age. Hydraulic connection between the sandstone and the valley fill is implied but not quantified by this report. The principal aquifer consists of multiple layers of sand and gravel in the lower part of the valley-fill sequence. These deposits average about 20 feet in aggregate thickness in the center of the valleys. The aquifers are unconfined in the southern, upgradient, unglaciated parts of the valleys and confined in the northern, downgradient parts, where they are blanketed by glacial sediments. Ground-water levels in the unglaciated parts of the valleys respond quickly to increased streamflow. Ground-water levels in the glaciated parts of the valleys display little response to changes in streamflow. Aquifer tests indicate a maximum estimated hydraulic-conductivity value of 760 feet per day near the mountains, decreasing to a minimum 180 feet per day downgradient in the system. The valley-fill aquifers are recharged by infiltration of streamflow, runoff, and precipitation, and by leakage from bedrock. The aquifers are discharged by leakage to streams, evapotranspiration, and outflow through valley fill at the downstream end of the study area.

In the valleys, water in wells near the mountain front is a calcium bicarbonate type, with dissolved-solids concentrations as small as 232 milligrams per liter, whereas water in wells farther downgradient is a sodium sulfate or magnesium sulfate type with dissolved-solids concentrations as large as 11,500 milligrams per liter. The increase in dissolved-solids concentration downflow in the aquifer probably results from a combination of leakage of water from bedrock, dissolution of minerals within the aquifer, and evapotranspiration.

The potential is good for additional withdrawals of water from the valley-fill aquifer of Little Peoples Creek. However, the development of additional large-capacity wells capable of sustaining 150-250 gallons per minute for irrigation could lower water levels or hydraulic heads in the aquifer, increase leakage of water from bedrock, and increase infiltration

of water from Little Peoples Creek. The result of additional pumping would possibly be an increase in dissolved-solids concentration downflow in the aquifer and a decrease in streamflow of Little Peoples Creek.

The potential is limited for additional withdrawals of water from the valley-fill aquifer along Lodge Pole Creek, because insufficient long-term recharge to the aquifer would severely limit the use of large-capacity wells. However, the potential is good for additional withdrawals in the southern, unconfined part of the aquifer for domestic and stock-watering use. Water quality in the northern, confined part of the aquifer might be undesirable for domestic use.

Investigation of the Jim Brown, Big Warm, and Beaver Creek valleys indicated that none had sufficient aquifer thickness or recharge area to support the development of large-capacity irrigation wells. However, areas of Beaver Creek near the mountain front have the potential to support additional wells for domestic, stock-watering, and small-scale irrigation use.

INTRODUCTION

In the southern part of the Fort Belknap Indian Reservation (fig. 1), surface-water supply is inadequate to meet the demands for irrigation of potentially irrigable lands. However, ground-water supplies of sufficient quantity and quality for irrigation might be obtained from the shallow valley-fill aquifers along the north flank of the Little Rocky Mountains near the southern boundary of the reservation (Feltis, 1983). To explore that potential for additional water supply, the U.S. Geological Survey (USGS), in cooperation with the U.S. Bureau of Indian Affairs and the Fort Belknap Community Council, conducted a study from August 1987 through July 1989 to evaluate the shallow ground-water conditions in the area. The objectives of the study were to describe the hydrology of the valley fill along the north flank of the Little Rocky Mountains and to assess the potential for additional water withdrawals from the valley fill.

Purpose and Scope

This report describes the results of that study. Specifically, the report describes the hydrology of valley fill in terms of: (1) the geometry of valley-fill aquifers; (2) the flow system within the aquifers including water-level fluctuations, distribution of hydraulic characteristics, and sources of recharge and discharge; and (3) the distribution of water quality in the flow systems. The report also describes the potential for the aquifers to yield water of sufficient quantity and quality for additional irrigation, stock, and domestic use.

Study Methods

The results of previous geologic (Knechtel, 1944, 1959; Alden, 1952; Alverson, 1965) and hydrologic (Feltis, 1983) studies were compiled to identify conditions in the study area. On the basis of this information, 110 test holes were drilled using mud-rotary methods to determine the distribution and thickness of the valley fill. Four to seven test holes were drilled across the valleys at each of several locations. Observation wells were completed at 66 of the test holes to allow water-level monitoring, aquifer testing, and water-quality sampling; the remaining 44 test holes were back-filled and abandoned. The wells were developed with compressed air and logged with downhole natural-gamma geophysical equipment to define changes in stratigraphy. The altitude of each well was determined by leveling. Fifty-eight of the observation wells were constructed with screened 2-in.-diameter polyvinyl chloride (PVC) casing, 7 with screened 4-in.-diameter PVC casing, and 1 with 12-in.-diameter stainless-steel screen and steel casing. Each 4-in. well was drilled near the 2-in. well in each test section that showed the greatest potential for aquifer yield, thus permitting aquifer testing with multiple observation wells at each site. One 4-in. well was used as an observation well for

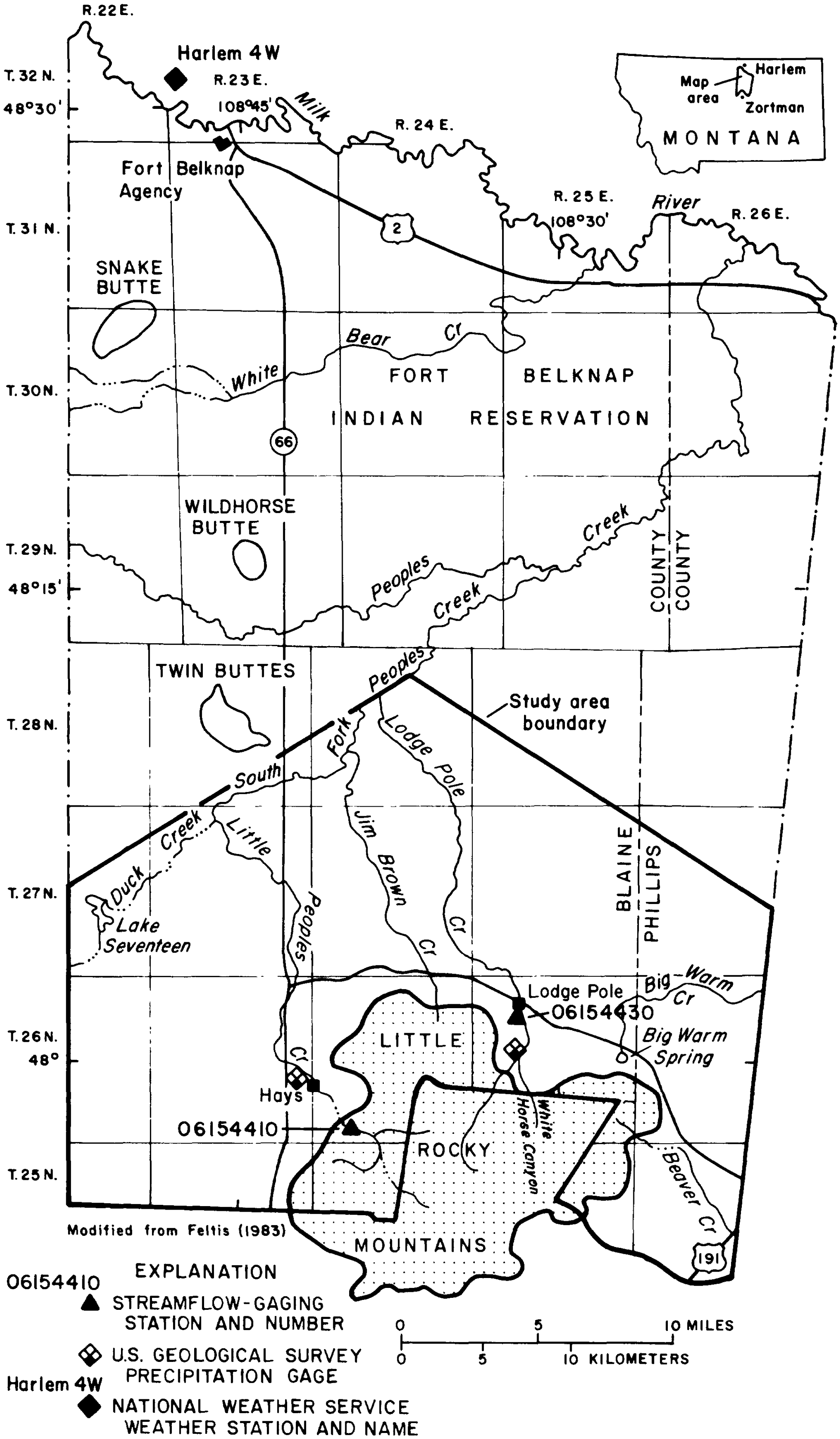


Figure 1.--Location of study area.

a 1,450-minute continuous-discharge aquifer test that was conducted on the 12-in.-diameter well located in Little Peoples Creek valley.

Water levels were measured approximately monthly at 32 wells. In five of the wells, water levels were monitored by continuous recorders.

To estimate a water budget and to determine the relations of recharge and discharge in the aquifer systems, several analyses were performed. The available record for streamflow-gaging stations on Little Peoples and Lodge Pole Creeks was extended using statistical techniques to estimate long-term streamflow in the area. Also, discharge was measured during low-flow conditions on both streams. Satellite photography was used to estimate the areal extent of phreatophytes along the valleys.

Water-quality samples were collected from 67 wells (8 research wells, 48 observation wells, and 11 private wells) and 8 streamflow-measurements sites to supplement data from 15 private wells that had been sampled in 1973. Selected sites were sampled more than once to determine any changes in water quality with time or as a result of sustained pumping. Water samples were analyzed for selected physical properties, dissolved major ions, and dissolved trace elements.

Site-Identification Systems

A site number is used as the primary identification for wells, test holes, streamflow-measurement sites, and streamflow-gaging stations referred to in this report. For wells, test holes, and streamflow-measurement sites, the site number consists of as many as five characters. The first two characters denote the site type: (B-) U.S. Bureau of Indian Affairs research well, (O-) USGS observation well, (P-) private well, (T-) USGS test hole, or (S-), USGS project streamflow-measurement site established for this study. The next one to three characters denote a sequence number assigned to each site within a site type on the basis of its location relative to the southwest corner of the study area. For formal USGS streamflow-gaging stations, the site number consists of eight digits. The complete number, such as 06154410, includes the first two digits, which identify the major drainage basin (herein the Missouri River basin), and the remaining six digits, which identify the station relative to position within the major drainage basin. The six-digit numbers are assigned in downstream order.

A location number is used to identify the location of wells, test holes, streamflow-measurement sites, gaging stations, and other geographic features. The location number is based on the rectangular system for the subdivision of public lands (fig. 2). The number consists of as many as 14 characters and is assigned according to the location of the site within a given township, range, and section. The first three characters specify the township and its position north (N) of the Montana Base Line. The next three characters specify the range and its position east (E) of the Montana Principal Meridian. The next two characters indicate the section. The next one to four characters indicate the position of the site within the section. The first letter denotes the quarter section (160-acre tract); the second, the quarter-quarter section (40-acre tract); the third, the quarter-quarter-quarter section (10-acre tract); and the fourth, the quarter-quarter-quarter-quarter section (2.5-acre tract). The subdivisions of the section are numbered A, B, C, and D in a counterclockwise direction beginning in the northeast quadrant. The last two characters form a sequence number based on the order of inventory in that tract. For example, location number 26N23E12ABAC01 (site O-17) represents the first well inventoried in the SW1/4 NE1/4 NW1/4 NE1/4 sec. 12, T. 26 N., R. 23 E.

Description of Study Area

The study area is located in the southern part of the Fort Belknap Indian Reservation north, east, and west of the Little Rocky Mountains in north-central Montana (fig. 1). The area encompasses about 376 mi^2.

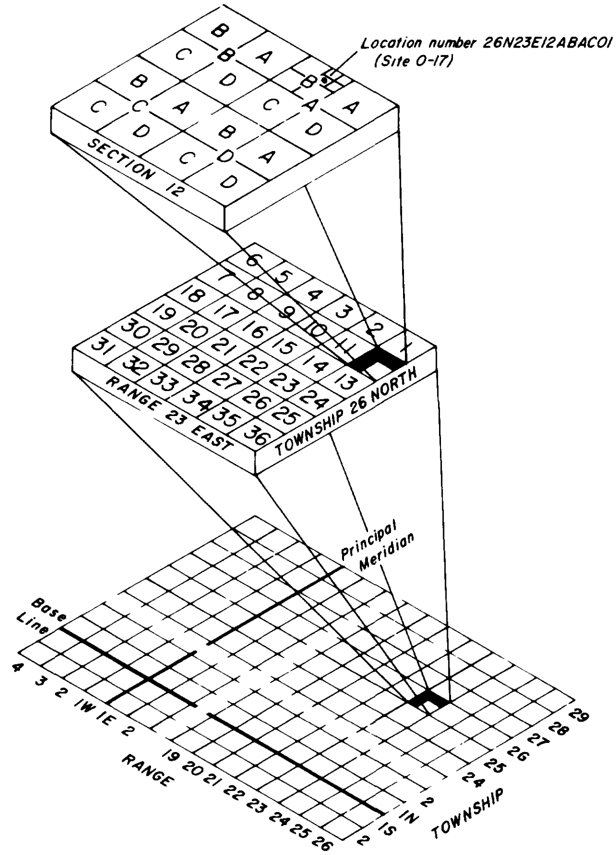


Figure 2.--Location numbering system.

Physiography and Drainage

Three physiographic units are present in the study area: (1) plains in the northern and central parts, (2) foothills surrounding the Little Rocky Mountains in the southern part, and (3) the Little Rocky Mountains uplift (Alverson, 1965, p. 7). The altitude of the study area ranges from about 2,650 ft where Lodge Pole Creek joins South Fork Peoples Creek to about 5,250 ft in the Little Rocky Mountains. The altitude of the foothills ranges from about 3,400 to 3,700 ft.

Plains extend from the low bluffs overlooking the flood plain of the Milk River south to the foothills of the Little Rocky Mountains, a distance of 20-30 mi. Most of the plains is underlain by glacial deposits, except where present-day streams have eroded into the underlying bedrock. The streams draining the plains meander and have incised their channels several feet beneath the flood plain. Several streams flow in relatively broad, even-banked channels through which glacial melt water drained during the most recent glaciation. Knob-and-kettle topography, which is common in areas affected by continental glaciation, is present on the plains. A terminal moraine from the most recent glaciation is preserved in places along the north flank of the mountains (Alverson, 1965, p. 8-9).

The foothills are defined by flat terraces that are underlain by gravel and that slope gently away from the mountain front. The terraces are best preserved near Hays and Lodge Pole at distinct altitudes: 3,700, 3,650, and 3,400 ft (Alverson, 1965, p. 9). Where the terraces have been dissected by post-glacial erosion, the underlying bedrock is exposed.

The Little Rocky Mountains uplift is composed of a central core of igneous and metamorphic rocks surrounded by sedimentary rocks domed by the intrusion. The intrusive rocks have been eroded into steep-sided ridges and peaks.

Five principal creeks drain the northern flank of the Little Rocky Mountains: Little Peoples, Lodge Pole, Jim Brown, Big Warm, and Beaver Creeks (fig. 1). Little Peoples Creek--the largest of the five--originates on the western slopes of the mountains by the joining of three tributaries. The three tributaries join in the mountains upstream from streamflow-gaging station 06154410, which is located 0.3 mi upstream from the mountain front (location numbers of gaging stations are given in table 12 in the Supplemental Data section at back of report). The creek flows northwestward through a Mississippian-limestone canyon at location 26N24E32BDC, across the mountain front, onto a broad alluvial valley near Hays, and then northward to its junction with South Fork Peoples Creek--13 valley mi downstream. Little Peoples Creek is perennial except for about a 1-mi intermittent section just south of Hays. The slope of Little Peoples Creek is greater than 6 percent in the headwaters area, and gradually decreases to about 0.2 percent near its mouth (fig. 3). The drainage area of the basin upstream from the gaging

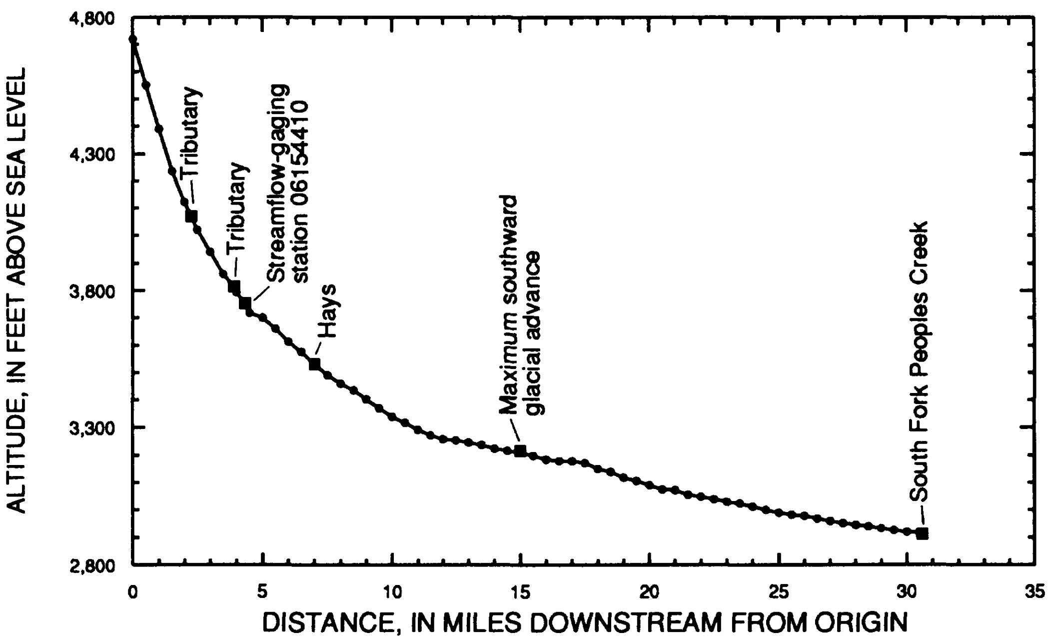


Figure 3.--Profile of channel of Little Peoples Creek.

station is 13.0 mi^2, whereas the area of the basin downstream from the gaging station to the confluence with South Fork Peoples Creek is 37.2 mi^2. The average recorded flow at gaging station 06154410 is 3,420 acre-ft/yr (or about 4.72 ft^3/s), on the basis of 16 years of record (water years[1] 1972-87).

Lodge Pole Creek originates on the north slopes of the mountains, flows northward past gaging station 06154430 just south of Lodge Pole, and eventually joins South Fork Peoples Creek about 16 mi north of the mountain front. Lodge Pole Creek is perennial except for the intermittent reach from the mountain front to just south of gaging station 06154430. The slope of the creek is greater than 3 percent in the headwaters area and decreases to less than 0.5 percent 4 mi northwest of Lodge Pole (fig. 4). The area of the drainage basin upstream from

[1] A water year is the 12-month period October 1 through September 30. It is designated by the calendar year in which it ends.

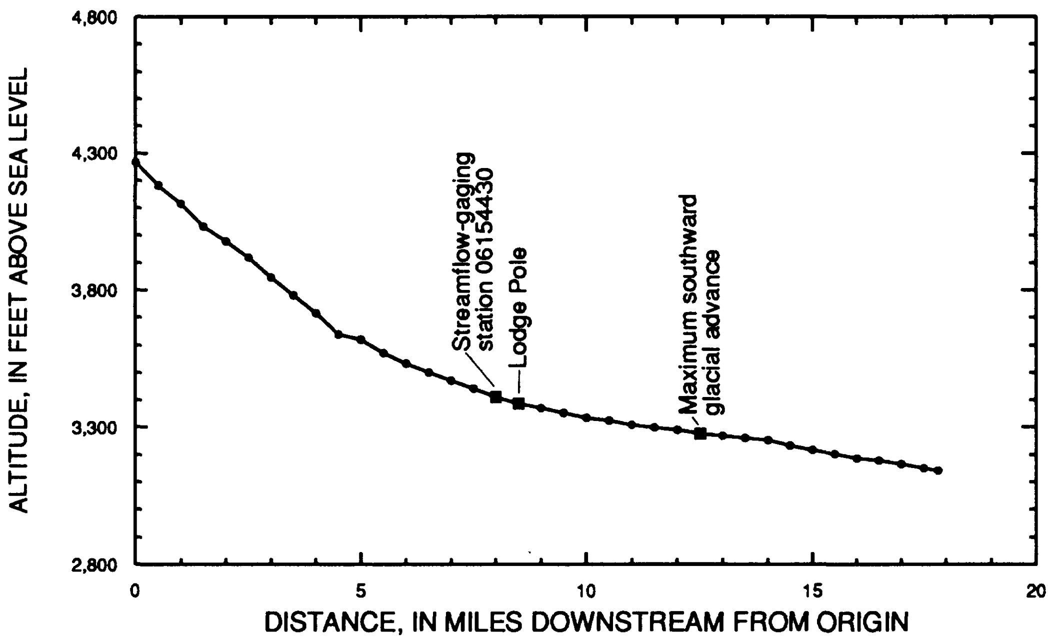


Figure 4.--Profile of channel of Lodge Pole Creek.

the gaging station is 19.5 mi^2, whereas the area of the basin downstream from the gaging station to the line of maximum southward glacial advance (pl. 1) is 11.7 mi^2. The recorded flow at gaging station 06154430 for water year 1988 was 585 acre-ft (or about 0.81 ft^3/s).

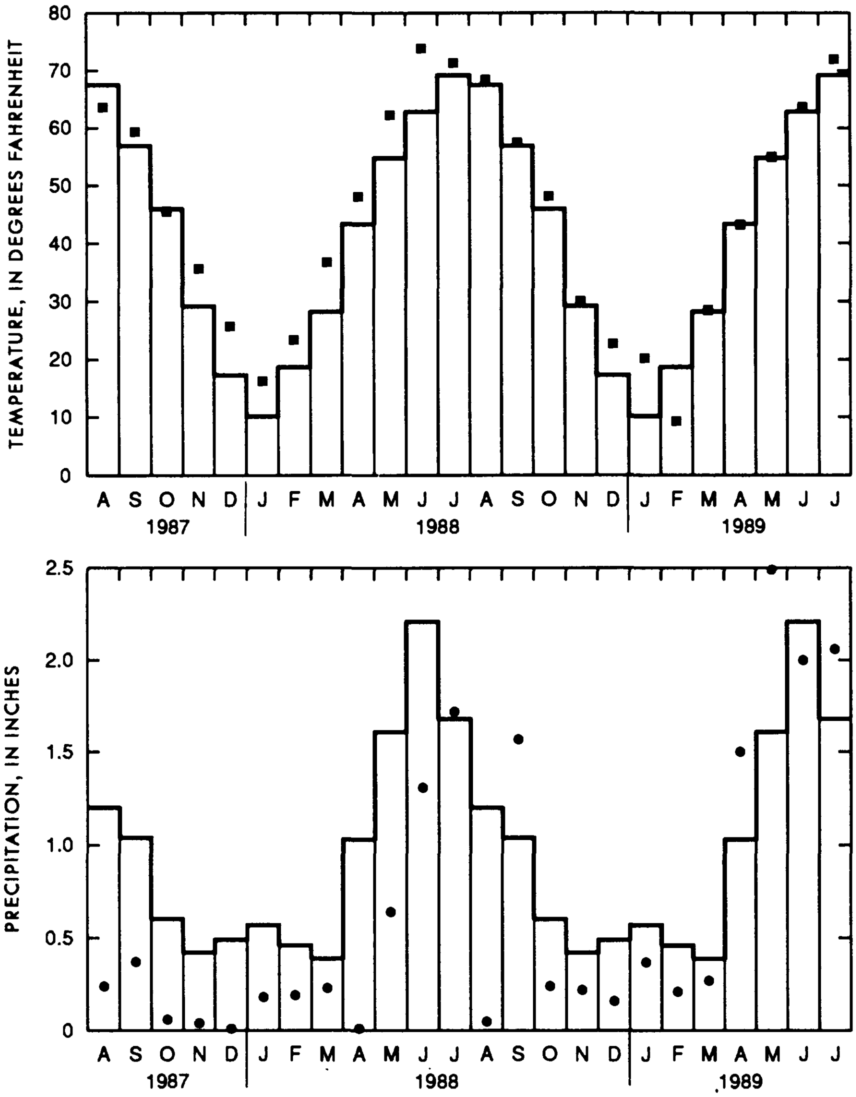
Jim Brown Creek drains about 3 mi^2 of the mountains before flowing through its alluvial valley to join South Fork Peoples Creek--11 mi to the north (fig. 1). The Jim Brown Creek valley is narrow, has been glaciated almost to the mountain front, and has a small drainage area.

Big Warm Creek extends from Big Warm Spring at location 26N25E24BDBC to the eastern boundary of the reservation about 7 mi to the northeast. Within the study area, this valley lacks alluvial deposits along much of its length.

Beaver Creek drains about 7.5 mi^2 of the mountains and extends about 5 mi from the mountain front to the eastern boundary of the reservation. The valley is narrow except for the lower 1 mi, where other small streams coalesce to form an alluvial plain about 1 mi wide. Beaver Creek is perennial in the mountains but loses its flow to infiltration after entering the alluvial valley.

Climate

The weather station Harlem 4W, located near the northern end of the reservation and about 30 mi from the study area (fig. 1), has continuously recorded temperature for 52 years and precipitation for 59 years. On the basis of the 1951-80 period of record at that station, the mean annual temperature is 42.0 °F and the mean annual precipitation is 11.70 in. The mean monthly temperature is largest in July (69.2 °F) and smallest in January (10.2 °F). The mean monthly precipitation is largest in June (2.21 in.) and smallest in March (0.39 in.). The relation between long-term mean monthly temperature and precipitation and the monthly mean temperature and total monthly precipitation during the study are shown in figure 5. The period of study was warmer and drier than the recorded 30-year normals for the area near Harlem.



EXPLANATION

☐ MEAN MONTHLY FOR PERIOD OF RECORD (1951-80)

■ MONTHLY MEAN TEMPERATURE DURING STUDY

● MONTHLY PRECIPITATION DURING STUDY

Figure 5.--Monthly temperature and precipitation at Harlem for the period of record (1951-80) and for the study period (August 1987-July 1989). Data from National Oceanic and Atmospheric Administration (1982).

Continuous-record precipitation gages were installed downstream from the headwaters of Little Peoples Creek near Hays at location 26N23E24DDAC, and along Lodge Pole Creek near Lodge Pole at location 26N25E17CDCC (fig. 1). The period of record for these two precipitation gages is August 1987 through July 1989, excluding the winters (November through March). Records of daily precipitation at the gages are shown in figure 6.

Precipitation patterns for the study area have been determined on the basis of the 1941-70 period of record (U.S. Soil Conservation Service, 1977). Average

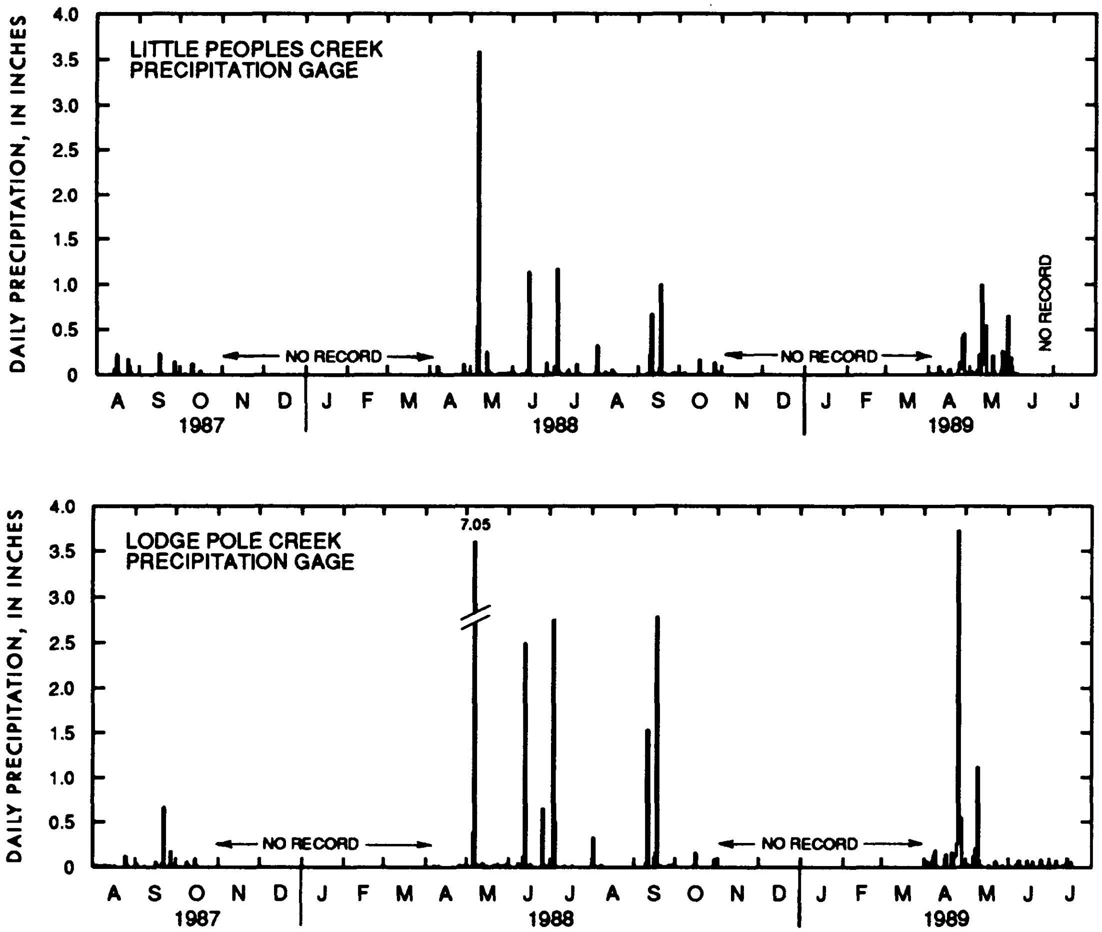


Figure 6.--Daily precipitation at continuous-record gages along Little Peoples and Lodge Pole Creeks.

annual precipitation ranges from about 12 in. at the northern end of the reservation to about 20 in. in the higher altitudes of the Little Rocky Mountains (fig. 7). Average annual precipitation in the foothills is about 16 in.

Acknowledgments

The authors wish to thank the Fort Belknap Community Council for their help in obtaining access to tribal land (used in common) and allotted land (owned by individuals) for test-drilling and water-level-monitoring activities. In addition, access to the Forest Fire Yard of the Tribal Forestry Department in Hays greatly aided the logistics of the project. We also wish to thank individual landowners for their cooperation and valuable contribution of historical information regarding the occurrence and use of water resources in the study area.

GENERAL GEOLOGY

The geology of the study area was most recently interpreted by Alverson (1965). The discussion of geologic history in this report is based principally on that work. The character and extent of valley fill were determined by test drilling as part of this study.

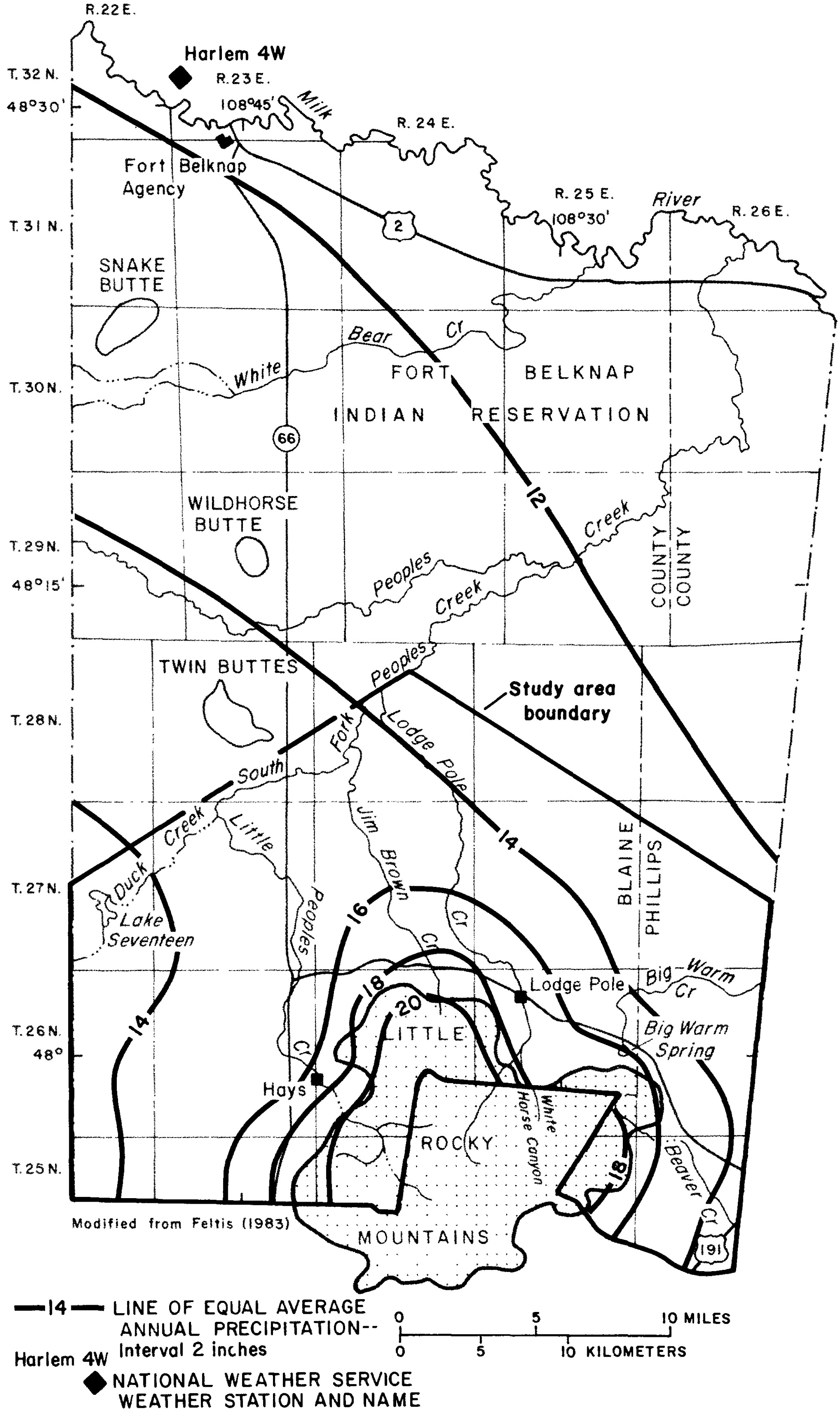


Figure 7.--Average annual precipitation in the Fort Belknap Indian Reservation, 1941-70. Data from U.S. Soil Conservation Service (1977).

Geologic History

The geologic history of the study area is characterized by alternating periods of marine and fluvial deposition, erosion, and structural uplift. During the Paleozoic Era, deposition on a Precambrian erosional surface resulted in about 3,000 ft of limestone, dolomite, sandstone, and shale. Rocks of Pennsylvanian, Permian, and Triassic age are absent in the area (table 1). During the Jurassic Period, deposition in a shallow, near-shore marine environment resulted in about 500 ft of limestone, calcareous shale, and sandstone.

Deposition during the Cretaceous Period resulted in about 3,500 ft of sandstone, siltstone, and shale. The sequence of formations from the Kootenai Formation upward through the Bearpaw Shale represents alternating terrestrial deposition of sand and silt derived from the west (Kootenai, Eagle, and Judith River Formations) with near-shore marine deposition of clay (Colorado Group and Claggett and Bearpaw Shales).

Early in the Tertiary Period, the dominant structural feature of the study area was created by the intrusion of a syenite-porphyry laccolith under and into the overlying sedimentary strata, thereby forming the Little Rocky Mountains. The resulting domed sedimentary strata dip nearly vertically at the land surface along the mountain front and generally dip away from the center of the intrusion. In the central plains, these sedimentary rocks have dips of 80-100 ft/mi (about 1 degree).

Erosion removed a large part of the domed sedimentary rocks, exposing the igneous and metamorphic core of the Little Rocky Mountains by the end of the Tertiary Period. Detritus from the erosion was transported across extensive terraces surrounding the base of the mountains. Several times during late Tertiary time, and possibly early Pleistocene time, the area was uplifted slightly, and streams eroded the terraces. Between these times of uplift, terrace building resumed at lower levels, and streams deposited sand and gravel in valleys descending from the Little Rocky Mountains.

The continental ice sheet advanced across the plains of the study area at least twice during the Pleistocene Epoch. Although the mountains were not overridden by ice, terraces a few miles north of the mountain front were removed by glacial scour. As the ice receded, detritus was deposited on the hummocky plains as glacial drift. Streams issuing from the mountains have eroded steep-sided channels into the glacial debris.

Character and Extent of Valley Fill

Valley fill is considered to be the total assemblage of unconsolidated material that overlies bedrock in the topographically definable stream valleys draining the Little Rocky Mountains. The valley fill in the study area consists of cobbles, gravel, sand, silt, and clay and has a wide range in permeability. Specific assemblages of these types of material indicate distinctly different environments of deposition. These distinctions allow grouping the valley fill into three general types: glacial deposits, colluvium, and alluvium.

Glacial deposits underlie the entire project area north of the line of maximum southward glacial advance (pl. 1). These deposits consist of relatively impermeable till and glaciolacustrine clay at the surface and grade to increased quantities of sand and gravel with depth. Localized layers of proglacial silt and clay also occur just south of the line of glacial advance. In the partly buried preglacial drainage valleys, the glacial material commonly has a basal layer of sand and gravel.

Colluvium is present in valleys adjacent to terraces predominantly near the mountains. These deposits characteristically are drilled slowly, produce chatter of the drill string, provide a competent borehole, and do not yield water. Colluvium is distinguished in drill cuttings by an abundance of poorly sorted angular rock fragments bound tightly in a reddish-brown sandy-clay matrix, and by the presence of stringers of white clay. The largest rock fragments found in test

Table 1.--*Generalized geologic units and water-yielding properties*

[Table modified from Feltis (1983). ft, feet; gal/min, gallons per minute. Symbols identify mapped units on plate 1]

Erathem	System	Series	Formation or group		Approximate thickness (ft)	General character	Water-yielding properties
Cenozoic	Quaternary	Holocene	Valley fill (Qvf)	Alluvium	0-90	Unconsolidated cobbles, gravel, sand, silt, and clay along coulees and stream channels.	A source of water in valleys of perennial streams. Yields 3 to about 500 gal/min to wells. Water quality suitable for most uses near the Little Rocky Mountains but deteriorates downstream.
			Valley fill (Qvf)	Colluvium	0-65	Angular gravel in reddish-brown sandy-clay matrix; includes stringers of white clay. Occurs in valleys adjacent to terraces.	Not an aquifer.
		Pleistocene	Glacial deposits		0-130	Gravel, sand, silt, and clay intermixed. Occurs primarily as till; however, outwash deposits form localized sand and gravel lenses and beds.	A limited source of water except in outwash deposits. Yields 2 to 10 gal/min to wells. Water quality might be unsuitable for some uses.
	Quaternary–Tertiary	Pleistocene–Pliocene through Paleocene(?)	Terrace deposits (QTt)		0-60	Unconsolidated to consolidated gravel; contains sand and silt. Occurs as long, narrow remnants or wide tracts of several square miles around the flank of the Little Rocky Mountains.	Might contain small quantities of water suitable for most uses.
	Tertiary	Pliocene through Paleocene(?)	Intrusive igneous rocks (Tsp)			Syenite porphyry and related rocks forming laccoliths, stocks, dikes, and sills.	Yields 2 to 25 gal/min of water suitable for most uses from fracture springs at Snake Butte, Wildhorse Butte, and Twin Buttes. Some water might be available from fault zones and fractures in the Little Rocky Mountains.
			Unconformity				
Mesozoic	Cretaceous	Upper Cretaceous	Montana Group	Bearpaw Shale (Kb)	500	Dark-gray marine shale; weathers light gray. Contains a few beds of bentonite and sandstone and many thin beds and lenses of cherty material and calcareous nodules.	Not an aquifer.
			Montana Group	Judith River Formation (Kjr)	360	Interbedded light-gray to buff, soft, fine-grained sandstone, shale, and clay. A few thin coal beds in upper part.	Yields 2 to 150 gal/min of water to many wells. Water under artesian pressure in some places. Water quality might be unsuitable for some uses.
			Montana Group	Claggett Shale (Kcl)	530	Dark-gray shale and siltstone; weathers to brownish-gray. Contains a few beds of bentonite and beds containing large boulderlike septarian nodules.	Not an aquifer.

Table 1.--*Generalized geologic units and water-yielding properties*--Continued

Erathem	System	Series	Formation or group	Approximate thickness (ft)	General character	Water-yielding properties
Mesozoic	Cretaceous	Upper Cretaceous	Montana Group: Eagle Sandstone (Ke)	260	Upper member: Chiefly gray shale with many thin beds of siltstone, sandy shale, and friable sandstone that weather reddish tan. Virgelle Sandstone Member: Yellow to buff, massive sandstone, gray siltstone, and gray shale.	Sandstone of lower member yields 2 to 10 gal/min of water to wells. Water under artesian pressure in some places. Water quality might be unsuitable for some uses.
Mesozoic	Cretaceous	Upper Cretaceous	Colorado Group (Kc)	1,740	Dark-gray to bluish-gray shale containing lenticular beds of limestone and calcareous sandstone.	Shale is nearly impermeable. The sandstone beds would probably yield water too mineralized for culinary use.
Mesozoic	Cretaceous	Lower Cretaceous	KJke: Kootenai Formation	180	Variegated argillaceous member: Clay, mottled maroon and gray, with a few thin beds and lenses of variable light-gray sandstone. Lower unit, or Third Cat Creek sandstone of drillers' usage: Largely sandstone, locally friable, light-gray, with a hard, coarse-grained, arkosic sandstone layer at the base and a layer of dense, light-gray limestone at the top.	Sandstone yields 10 gal/min of water to wells. Generally under artesian pressure but deeply buried in most of reservation. Water quality suitable for most uses.
			Unconformity			
Mesozoic	Jurassic	Upper Jurassic	KJke; Ellis Group: Swift Formation	210	Light- and dark-gray, gypsiferous shale containing numerous large, brown, calcareous concretions; layers of glauconitic sandstone, sandy mudstone, dark shale, and impure limestone in upper part.	Sandstone and limestone beds yield 2 to 5 gal/min to wells on the flank of the Little Rocky Mountains. Water quality suitable for most uses.
Mesozoic	Jurassic	Middle Jurassic	KJke; Ellis Group: Rierdon Formation	200	Gray, limy shale and light- to dark-gray marly limestone.	Beds might yield water suitable for culinary use from fractures near the Little Rocky Mountains.
Mesozoic	Jurassic	Middle Jurassic	KJke; Ellis Group: Piper Formation	100	Alternating beds of shale, limestone, and calcareous sandstone. A brown, dense limestone, 60-ft thick, occurs at base.	Limestone and sandstone beds might yield water from fractures. Water quality is unknown.
			Unconformity			
Paleozoic	Mississippian	Upper Mississippian Lower Mississippian	PzpЄu; Madison Group: Mission Canyon Limestone	220	Mostly massive beds of gray limestone. Some beds are composed almost entirely of bioclastic detritus. Upper part contains solution cavities that range from small vugs to caverns.	Yields water to Big Warm Spring. Might yield large quantities of water to wells from solution channels, faults, and fractures. Discharge at Big Warm Spring ranges from 2,700 to 4,050 gal/min. Water quality probably suitable for irrigation.

Table 1.--*Generalized geologic units and water-yielding properties*--Continued

Erathem	System	Series		Formation or group	Approximate thickness (ft)	General character	Water-yielding properties
Paleozoic	Mississippian	Lower Mississippian	PzpЄu	Madison Group: Lodgepole Limestone Unconformity	540	Mostly thin-bedded, light- to dark-gray limestone; contains many small lenses of chert and thin partings of shale.	Would probably yield water to wells from faults and fractures. Water quality probably suitable for irrigation.
	Devonian, Ordovician and Cambrian			Devonian, Ordovician, and Cambrian rocks undivided Unconformity	2,410	Mostly limestone and dolomite but contains shale, siltstone, claystone, sandstone, and conglomerate. Includes Jefferson Limestone, Bighorn Limestone, and Flathead Sandstone.	Would probably yield water to wells from faults and fractures. Water quality near the Little Rocky Mountains might be suitable for irrigation.
Precambrian				Pre-Belt Supergroup metamorphic and intrusive igneous rocks		Metasedimentary rocks, mainly biotite, schist and gneiss; metavolcanic rocks, mainly hornblende gneiss and amphibolite; younger pre-Belt Supergroup (?) ferromagnesium rocks form a few dikes and sills.	Would probably yield water to wells from faults and fractures in the Little Rocky Mountains. Water quality is unknown.

holes were about 2.5 in. diameter and very angular at sites near the mountain front, grading to about 0.5 in. diameter and subangular at distant locations. The stringers of white clay are possibly the result of alteration of feldspar or reworked bentonite from the source area of the colluvial material.

Drilling and lithologic characteristics were almost identical between colluvium and terrace deposits near the mountains. Considering similarities in test holes and the topographic relation of these deposits, the colluvium most probably results from the mass movement of terrace material and underlying shale from the highlands onto the adjacent valley floor. On the basis of several occurrences of colluvium overlying loose sand and gravel in the valley-fill sequence, the colluvium was assigned a Quaternary age.

Alluvium is present in sequences as much as 90 ft thick (Feltis, 1983) near the mountain front and as thin, lenticular deposits in recent stream channels throughout the study area. Near the mountain source, alluvium consists of cobbles, gravel, sand, silt, and clay deposited in valleys eroded into the Jurassic and Cretaceous bedrock. Alluvium both underlies and overlies the colluvium. With increasing distance from the sediment source, the alluvium becomes finer grained and consists predominantly of reworked glacial sediments. Sand and gravel underlying glacial sediments may represent buried preglacial alluvium.

HYDROLOGY OF VALLEY FILL

Various types of data pertaining to the valley fill were collected. Water-yielding properties of geologic units are identified in table 1. Records and selected lithologic logs of wells and test holes are given in tables 13-15; all lithologic logs are compiled in a companion report by Briar and Christensen (1993).

Records of water levels in monitoring wells are given in table 16. The results of chemical analysis of water samples collected during this and previous studies are given in tables 17 and 18. Drinking-water regulations for public supply are given in table 19. Tables 13-19 are in the Supplemental Data section at back of the report. The location of generalized geologic sections, wells, and test holes is shown on plates 1 and 2.

Little Peoples Creek Valley

Little Peoples Creek valley is underlain mostly by shale of Cretaceous and Jurassic age. The valley crosses the permeable Eagle Sandstone at location 26N23E14D and numerous localized sandstone sequences of the Judith River Formation. Hydraulic connection between the sandstone and the valley fill is implied but not quantified by this report.

Valley fill along Little Peoples Creek, south of the line of glacial advance (fig. 8), is topographically distinct, ranges in width from 0.25 to 1 mi, and is as much as 78 ft thick (well O-2). Topography of the preglacial valley in the northern part of the study area is masked by varying thicknesses of till, which makes estimating the lateral extent of valley fill difficult. The maximum thickness of alluvium and glacial deposits penetrated during drilling along Little Peoples Creek is 145 ft at well O-34 (table 15).

Aquifer Geometry

The principal aquifer in Little Peoples Creek valley is layered sand and gravel that are common in the lower part of the valley-fill sequence. Considering the ease of drilling, tendency of the drill hole to cave, loss of drilling fluids, degree of rounding of gravel, and lack of clay matrix, the sand and gravel of this aquifer are believed to have resulted primarily from fluvial cut-and-fill depositional processes. The geometry of these deposits can best be envisioned as a vertical sequence of sinuous braided channels, lenticular in cross section, which aggraded valleys formerly eroded into Cretaceous and Jurassic bedrock.

Lateral continuity of individual sand and gravel deposits that have been formed in a channel cut-and-fill depositional environment is difficult to determine. For example, drilling at well O-6 (fig. 8) indicated a single 40-ft thickness of gravel overlying 15 ft of colluvium (table 15). However, drilling at wells O-8 and O-9 (190 ft to the southeast and directly upgradient along the axis of the valley) indicated three distinct gravel layers 3, 18, and 6 ft thick that are separated by layers of hard clay with no underlying colluvium. Even with the uncertainty in determining lateral continuity, the geometry of the valley-fill aquifer in Little Peoples Creek valley can be generalized. First, in the unglaciated part of the drainage, drilling data indicate that the aggregate thickness of sand and gravel is about 20 ft in the center of the valley and remains relatively constant along its length. In the glaciated part, aquifer thickness is less constant, and sand and gravel layers could be discontinuous locally owing to glacial scouring. Second, because the sand and gravel layers commonly occur in the lower part of the valley-fill sequence, their lateral extent in the unglaciated part of the drainage is only about one-half the width of the valley. In the glaciated part, thick deposits of till mask the preglacial valley.

Water-Level Fluctuations

Water levels were measured approximately monthly in 16 observation wells along Little Peoples Creek (table 16); of these, continuous recorders were operated on wells O-9, O-22, and O-33. Hydrographs of water levels (fig. 9) display two trends according to well location along the drainage. The trends likely are the result of the degree of hydraulic confinement and source of recharge to the aquifer in the two areas.

In the unglaciated part of the drainage (represented by well O-9), ground-water levels respond quickly to increased flow in Little Peoples Creek. Well O-9 is

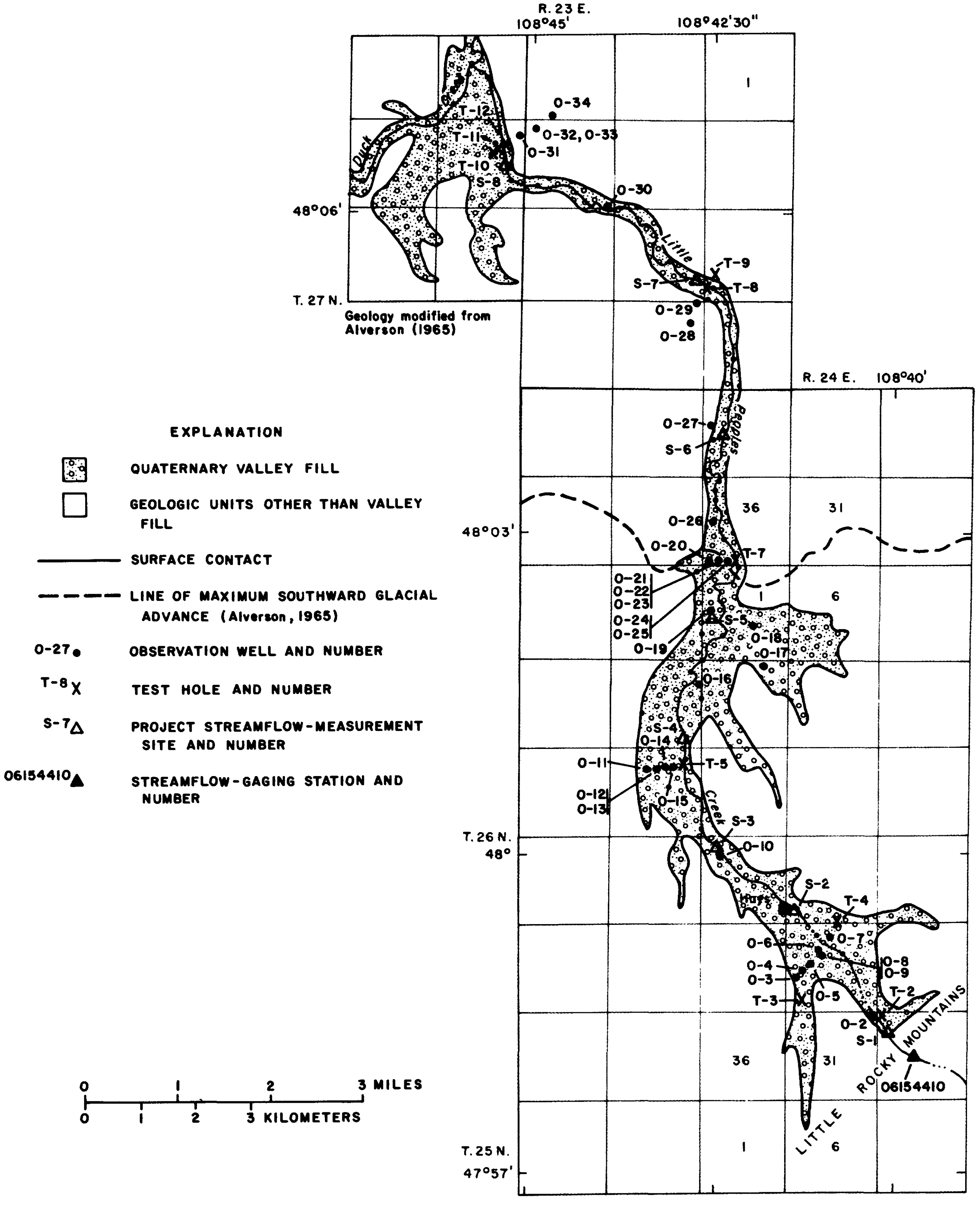


Figure 8.--Surface extent of valley fill and location of observation wells, test holes, streamflow-measurement sites, and streamflow-gaging stations along Little Peoples Creek.

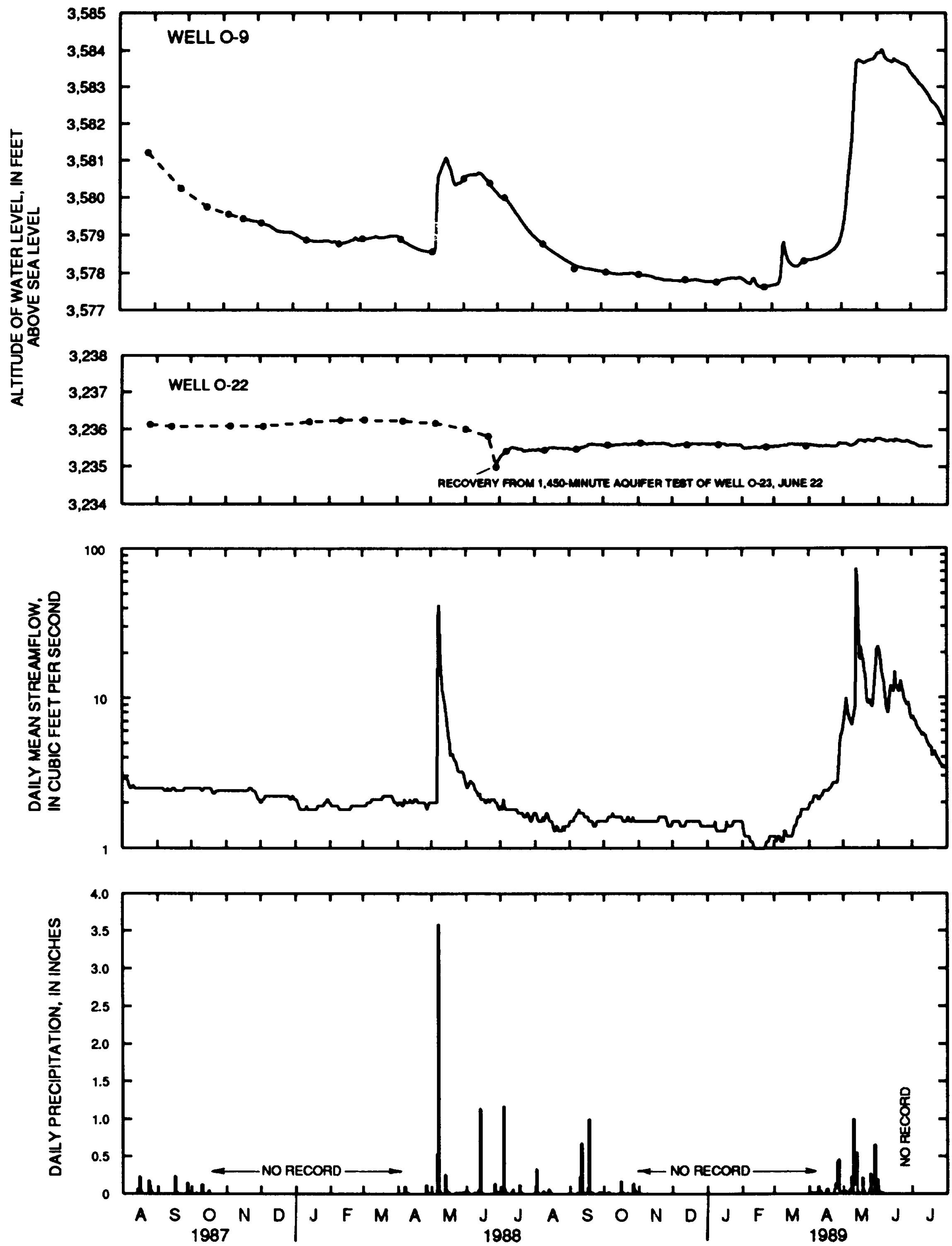


Figure 9.--Relation of water levels in selected wells to streamflow at gaging station 06154410 and precipitation at a continuous-record gage along Little Peoples Creek. Continuous water-level recorders were maintained on wells O-9 and O-22.

completed in gravels that are hydraulically connected to Little Peoples Creek. Evidence for hydraulic connection is the infiltration and disappearance of flow of Little Peoples Creek (about 2 ft^3/s) into the alluvium 0.5 mi upstream (southeast) from well O-9 and the reemergence of approximately the same discharge about 0.5 mi downstream from well O-9.

In contrast, hydrographs of water levels in the glaciated part of the drainage (represented by well O-22) display little response to changes in streamflow. Well O-22, which is near the line of glacial advance, is completed in sand and gravel that are hydraulically confined by proglacial clay. Therefore, the ground water is isolated from surface flow in Little Peoples Creek and overland runoff. This confined aquifer receives water primarily by lateral flow from the upgradient unconfined aquifer. Presumably, the greater saturated thickness of the southern unconfined aquifer can transmit more water than the lesser saturated thickness of the northern confined aquifer can accept. Therefore, during periods of increased recharge to the unconfined aquifer, some water moving through the valley fill flows upward to the land surface near the boundary between the unconfined (unglaciated) and confined (glaciated) aquifers and discharges to Little Peoples Creek.

Hydraulic Characteristics

Constant-discharge aquifer tests were conducted on four wells completed in the valley-fill aquifer of Little Peoples Creek. Water levels in observation wells were monitored during the tests and the time-versus-drawdown data were analyzed using standard curve-matching and straight-line-solution techniques (Lohman, 1972). The resulting transmissivity, hydraulic-conductivity, and storage-coefficient data are summarized in table 2.

Two significant trends are apparent from the data. First, transmissivity and hydraulic-conductivity estimates decrease with distance from the mountain front. This relation is consistent with drilling data, which indicate a general decrease in particle size of aquifer material with distance downgradient. Second, the storage-coefficient estimates for wells O-9 and O-13 are inconsistent with the previously discussed degree of hydraulic confinement of the unglaciated and glaciated parts of the valley-fill aquifer.

The storage-coefficient estimates at wells O-9 and O-13 are anomalously small given the unconfined nature of the aquifer, as demonstrated by the hydraulic connection with Little Peoples Creek near the wells. The drawdown data for observation well O-8, which is 11 ft north of well O-9, indicate an almost immediate response of 1.11 ft at 0.83 min, then a slowed response of 1.40 ft after 240 min. Similarly, the drawdown data for well O-12, which is 16 ft north of well O-13, indicate a response of 1.18 ft at 0.17 min, then a slowed response of 2.44 ft at 240 min. This response in wells O-8 and O-12 would be consistent with a condition in which both wells were completed in an aquifer having a localized, discontinuous confining unit. If a localized, discontinuous confining unit is creating the observed aquifer-test response in wells O-8 and O-12, the transmissivity values reported in table 2 would be anomalously large.

Recharge and Discharge

For purposes of describing recharge and discharge, the Little Peoples Creek drainage basin was divided into two sub-basins according to degree of hydraulic confinement of the valley-fill aquifer. The south basin consists of the drainage area downgradient from the Mississippian-limestone canyon southeast of Hays to the unconfined aquifer-confined aquifer boundary. Thus, the south basin extends from the Mississippian-limestone canyon southeast of Hays to surface-water measurement site S-5, about 0.5 mi south of the line of glacial advance. The adjacent north basin consists of the drainage area downgradient from the unconfined aquifer-confined aquifer boundary. Therefore, the north basin extends from the north boundary of the south basin to approximately the north boundary of the study area.

Table 2.--*Results of aquifer tests in the valley-fill aquifer of Little Peoples Creek*

[Valley mile is approximate distance downstream from beginning of valley fill. Abbreviations: ft, feet; ft/d, feet per day; ft^2/d, feet squared per day; gal/min, gallons per minute; min, minutes]

Pumped well number	Valley mile	Discharge (gal/min)	Date of test	Length of test (min)	Calculated values: Transmissivity (ft^2/d)	Calculated values: Average aquifer thickness (ft)	Calculated values: Hydraulic conductivity (ft/d)	Calculated values: Storage coefficient	Observation well number	Total drawdown (ft)
O-9	1.4	60	06-24-88	240	10,000	21	480	0.00001	O-5	0
									O-6	0.09
									O-7	0
									O-8	1.40
O-13	4.0	70	06-28-88	240	6,000	20	300	.000005	O-11	0
									O-12	2.44
									O-14	0
O-23	6.3	270	06-22-88	1,450	3,800	15	250	.0002	O-20	5.90
									O-21	13.10
									O-22	13.30
									O-24	8.34
									O-25	0
O-33	12.3	66	09-11-87	240	3,700	20	180	.00007	O-31	1.11
									O-32	3.68
									O-34	0

South basin

Recharge to and discharge from the valley-fill aquifer in the south basin of Little Peoples Creek can be summarized with a mass-balance equation as follows:

$$SWi + BRGWi + R + P = SWo + VFGWo + ET \qquad (1)$$

where

SWi = Inflow to the basin from Little Peoples Creek; an unquantified major part of this water infiltrates to the aquifer south of Hays;
$BRGWi$ = Leakage from bedrock;
R = Infiltration of ephemeral runoff from the drainage area;
P = Infiltration of precipitation that falls directly on the valley fill;
SWo = Outflow from the basin by Little Peoples Creek; an unquantified major part of this water leaks upward from the aquifer;
$VFGWo$ = Outflow through valley fill at the downgradient boundary of the basin; and
ET = Evapotranspiration by phreatophytes along Little Peoples Creek.

The first four variables of equation 1 represent recharge to the aquifer; the remaining variables represent discharge from the aquifer.

Infiltration of water from Little Peoples Creek is a principal source of recharge to the aquifer upgradient from Hays. Except during relatively short periods of large discharge, the stream infiltrates and disappears into the alluvium 1 mi southeast of Hays, subsequently reemerging behind the post office near the southeastern part of town. The percentage of streamflow that infiltrates to the aquifer is a function of the permeability and the area of the streambed, which remain relatively constant, and the rate of streamflow and the available storage of the aquifer, which are extremely variable. For example, the daily mean flow of 42 ft^3/s on May 5, 1988 (fig. 9), did not result in surface flow along the normally dry section of the streambed south of Hays. However, the relatively sustained flow of about 10 ft^3/s in May and June 1989 was sufficient to essentially fill the aquifer and result in surface flow along the entire length of Little Peoples Creek. Because the percentage of streamflow that infiltrates the aquifer could not be precisely quantified, total surface-water inflow to (*SWi*) and outflow from (*SWo*) the south basin were used in equation 1.

To better estimate the long-term potential for surface-water recharge to the aquifer, the 16-year streamflow record for gaging station 06154410 on Little Peoples Creek was extended to a 1937-86 base period using a method of statistical correlation (Alley and Burns, 1983) and records at nearby gaged sites. Estimated mean monthly flow at the gaging station for the 50-year base period is given in line 1 of table 3. On the basis of these estimates, the long-term mean annual flow of Little Peoples Creek at the gaging station is 2,960 acre-ft/yr.

Table 3.--*Estimated mean monthly and mean annual streamflow of Little Peoples Creek, water years 1937-86*

Variable	Description	Mean monthly streamflow, in cubic feet per second												Mean annual streamflow, in acre-feet per year
		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	
SWi	Inflow[1] to south basin	2.4	2.2	2.3	2.0	1.8	2.5	4.8	12.0	8.8	4.5	3.0	2.6	2,960
--	Additions within south basin	2.8	2.5	2.6	2.3	2.1	2.9	5.5	13.8	10.1	5.2	3.4	3.0	3,400
SWo	Outflow from south basin	5.2	4.7	4.9	4.3	3.9	5.4	10.3	25.8	18.9	9.7	6.4	5.6	6,360

[1]Determined at streamflow-gaging station 06154410.

Water entering the aquifer through leakage from bedrock (*BRGWi*) was not measured directly, but its existence is implied by: (1) a hydraulic gradient from bedrock into the valley fill determined by measurement of water levels in bedrock wells P-2, P-3, P-7, P-9, P-15, P-50, P-64, P-76, and P-91; (2) an increase in stream discharge with increasing distance from the mountain source; and (3) an increase in dissolved-solids concentration in the aquifer and the stream with distance from the mountain front, which might indicate mixing with water from a deeper, more mineralized flow system. However, the increase in dissolved-solids concentration also might be due to reaction of aquifer water with aquifer material or to the concentrating effect of evapotranspiration on dissolved constituents.

A low-flow investigation of Little Peoples Creek on October 19, 1987, was hindered by a lack of good gaging sites but was sufficiently accurate to indicate an increase in streamflow along the length of the south basin. Climatic conditions for the low-flow investigation were good and the approximate increase of more than 2 ft^3/s in streamflow (table 4) is interpreted to result entirely from upward leakage of water from the valley-fill aquifer.

Outflow from the valley-fill aquifer to the stream is derived from two sources--a decrease in aquifer storage in response to the seasonal decrease in hydraulic head, and leakage from bedrock. The daily mean change in aquifer storage between September 24 and November 5, 1987 (period of 42 days), was calculated from: change in hydraulic head (mean of 0.0127 ft/d) in wells O-2, O-9, O-10, O-13, and O-16 (table 16); areal extent of the unconfined part of the valley-fill aquifer of 47,500,000 ft^2; and estimated specific yield of 0.15. Estimated daily mean change in aquifer storage accounts for about 1.0 ft^3/s or one-half the 2 ft^3/s increase in streamflow; therefore, leakage from bedrock is estimated to be a relatively constant 1 ft^3/s or about 724 acre-ft/yr.

Table 4.--*Results of low-flow measurements of Little Peoples Creek, October 19, 1987*

[Valley mile is approximate distance downstream from beginning of valley fill. Abbreviations: ft^3/s, cubic feet per second; $(ft^3/s)/mi$, cubic feet per second per mile. Symbol: --, not applicable]

Site number (fig. 8)	Valley mile	Discharge (ft^3/s)	Change in discharge per mile [$(ft^3/s)/mi$]	Estimated measurement error (percent)
06154410	-0.3	2.37	--	5-8
		South basin		
S-1	.1	1.74	-1.05	8
S-2	1.8	1.73	- .01	5-8
S-3	2.8	3.25	+1.52	5
S-4	4.0	3.31	+ .05	8
S-5	5.8	4.51	+ .67	5
		North basin		
S-6	7.7	5.04	+ .27	8
S-7	9.5	4.30	- .41	5-8
S-8	12.3	4.64	+ .12	More than 8

Infiltration of ephemeral runoff from the surrounding drainage area (*R*) also recharges the aquifer. Recharge from runoff can occur as a result of rainfall or snowmelt. For example, the increase in water level in well O-9 during March 1989 (fig. 9) does not correlate with any significant change in streamflow in Little Peoples Creek. This increase most probably was produced by melting of low-altitude snowpack and subsequent recharge to the aquifer. The drainage area of the south basin, excluding the surface extent of valley fill, is 11.8 mi^2 and the long-term mean annual precipitation is 16 in. (fig. 7). However, the percentage of precipitation that runs off is unknown. Assuming a runoff rate of 15 percent, runoff recharge to the valley-fill aquifer in the south basin is about 1,510 acre-ft/yr.

Part of the precipitation that falls directly on valley fill infiltrates the aquifer (*P*). The surface extent of valley fill is about 4.7 mi^2, and the long-term mean annual precipitation is about 16 in. (fig. 7). The U.S. Soil Conservation Service (no date) estimates that near the study area the effective annual precipitation for alfalfa is about 53 percent, which indicates the percentage of total precipitation that is available to the root zone of plants during the growing season. Thus, 47 percent of average total precipitation is not available to plants. Assuming that this quantity is equally divided between evaporation and percolation below the root zone to the ground-water system, about 3.8 in/yr of water, on average, directly recharges the aquifer. By this method, average total precipitation recharge in the south basin is about 953 acre-ft/yr.

Outflow from the basin by Little Peoples Creek (*SWo*) was estimated by multiplying the long-term mean annual streamflow at gaging station 06154410 (2,960 acre-ft/yr) by a drainage-area-ratio adjustment factor to account for the downstream ungaged south basin (Omang and others, 1986, p. 23). The drainage-area-ratio adjustment factor (*DAR*) can be expressed as:

$$DAR = (DAm \ / \ DAg)^{X} \qquad (2)$$

where

DAm = Drainage area of south basin downstream from the gaging station,
DAg = Drainage area of Little Peoples Creek upstream from the gaging station, and
X = Exponent to account for the fact that runoff per square mile of drainage area is less for larger drainage areas that have proportionately less mountain runoff than for smaller drainage areas that have proportionately more mountain runoff.

The drainage area of the south basin downstream from the gaging station (*DAm*) is 16.5 mi^2 and the drainage area upstream (*DAg*) is 13.0 mi^2. To estimate *X*, long-term mean annual streamflows (base period water years 1937-86) previously determined for four gaging stations in and near the study area (Parrett and Johnson, 1989, p. 22) were plotted against drainage area on a log-log scale (fig. 10). The manual line of best fit through the four points has a slope of 0.58, which is considered to be a reasonable estimate for *X* in equation 2. Applying a DAR of 1.148 to mean annual flow at the gaging station gives an estimated mean annual flow contributed by the ungaged south basin of 3,400 acre-ft/yr. Therefore, the total surface-water outflow from the south basin is about 6,360 acre-ft/yr (table 3).

Outflow through valley fill at the downgradient boundary of the south basin (*VFGWo*) was determined by Darcy's equation. On the basis of estimated cross-sectional area (16,000 ft^2), hydraulic gradient between wells O-19 and O-23 (0.0075 ft/ft), and hydraulic conductivity of the aquifer near the boundary determined by aquifer testing (250 ft/d), the flow is estimated to be about 251 acre-ft/yr.

Determining the quantity of water discharged from the aquifer by evapotranspiration (*ET*) necessitated knowing the areal extent of phreatophytes. The Denver Geographical Information System Office of the U.S. Bureau of Indian Affairs estimated the areal extent of phreatophytes along Little Peoples Creek by digital analysis of satellite images. The area of phreatophytes for the south basin was

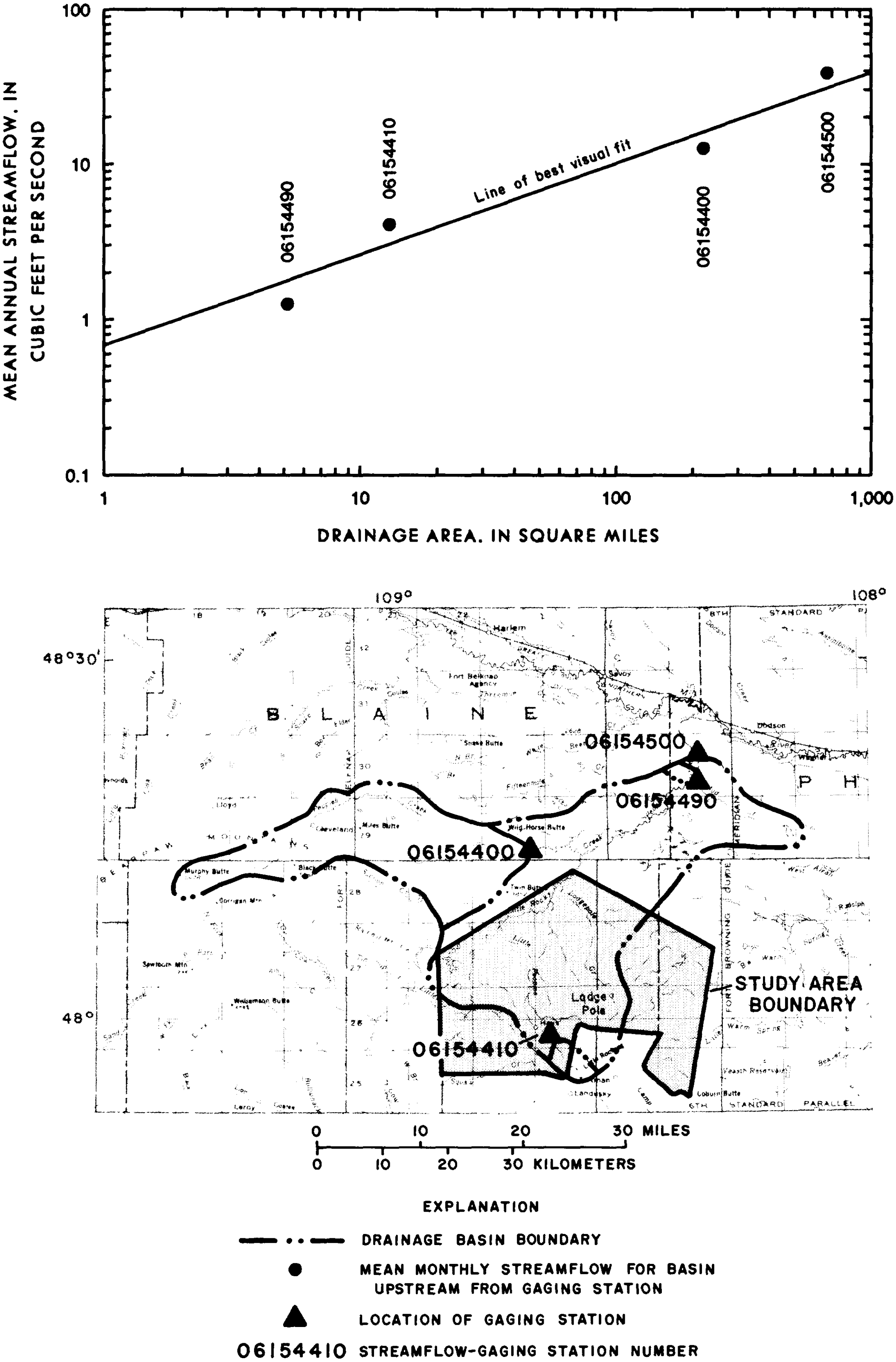


Figure 10.--Relation of drainage area to mean monthly streamflow for gaged basins near Little Peoples Creek, water years 1937-86.

129 acres. Consumptive use of the phreatophytes was assumed to be equivalent to the consumptive use of alfalfa (26.11 in/yr or 2.18 acre-ft/yr per acre), as calculated by the U.S. Department of Agriculture (1974). The estimated depletion due to evapotranspiration by phreatophytes along Little Peoples Creek is about 281 acre-ft/yr; the depletion by month is given in table 5.

Table 5.--*Monthly evapotranspiration depletion along the south basin of Little Peoples Creek*

Depletion, in acre-feet							
Apr.	May	June	July	Aug.	Sept.	Oct.	Total (rounded)
0.7	39.7	61.3	80.8	66.1	31.5	0.8	281

Recharge to and discharge from the valley-fill aquifer in the south basin of Little Peoples Creek are summarized in table 6. Given that the south basin is hydraulically connected to the surface hydrologic processes of streamflow, precipitation, ephemeral runoff, and evapotranspiration, and given that streamflow entering the basin is approximately known, values in table 6 are probably reasonable estimates for recharge to and discharge from the south basin. The difference between total recharge and total discharge in table 6 is a result of estimation error, not a change in aquifer storage.

North basin

Recharge to and discharge from the confined aquifer in the north basin of Little Peoples Creek can be summarized as follows:

$$VFGWi + BRGWi = VFGWo \qquad (3)$$

where

$VFGWi$ = Inflow from the valley fill of south basin,
$BRGWi$ = Leakage from bedrock, and
$VFGWo$ = Outflow through valley fill at the downgradient boundary of the basin.

The principal source of recharge to the aquifer in the north basin ($VFGWi$) is outflow from the valley-fill aquifer of the adjacent south basin ($VFGWo$). This recharge is estimated to be about 251 acre-ft/yr.

Leakage of water from bedrock ($BRGWi$) was not measured directly, but is implied by the existence of a hydraulic gradient from bedrock into the valley fill measured in bedrock wells and an increase in dissolved-solids concentrations downgradient in the basin. Because of the hydraulic confinement of the aquifer in the north basin, leakage from bedrock to Little Peoples Creek could not be detected by the low-flow investigation conducted in October 1987 as it was in the south basin. Therefore, $BRGWi$ was not estimated.

Outflow through valley fill at the downgradient boundary of the basin is the principal source of discharge. On the basis of estimated cross-sectional area (36,000 ft^2), hydraulic gradient (0.005 ft/ft), and hydraulic conductivity of the aquifer near this boundary (180 ft/d), ground-water discharge is estimated to be

Table 6.--*Summary of estimated recharge to and discharge from the south and north basins of Little Peoples Creek*

Variable	Description	Acre-feet per year
	South basin	
Recharge		
SWi	Inflow to the basin from Little Peoples Creek; based on extended streamflow record at gaging station 06154410	2,960
BRGWi	Leakage from bedrock; inferred from low-flow investigation	724
R	Infiltration of ephemeral runoff from the drainage area	1,510
P	Infiltration of precipitation that falls directly on the valley fill	953
Total in (rounded)		6,150
Discharge		
SWo	Outflow from the basin by Little Peoples Creek; based on estimated streamflow at boundary from basin-comparison analysis	6,360
VFGWo	Outflow through valley fill at the downgradient boundary of the basin; based on Darcy's equation	251
ET	Evapotranspiration; based on satellite analysis of phreatophytes along Little Peoples Creek	281
Total out (rounded)		6,890
	North basin	
Recharge		
VFGWi	Inflow from the valley fill of south basin	251
BRGWi	Leakage from bedrock; not estimated	?
Total in		251+
Discharge		
VFGWo	Outflow through valley fill at the north boundary of study area; based on Darcy's equation (imprecise estimate)	271
Total out		271

about 271 acre-ft/yr. Because these parameters are imprecisely known, the value given is at best an approximation of the flow. Recharge and discharge from the aquifer in the north basin of Little Peoples Creek are summarized in table 6. The difference between total recharge and total discharge in table 6 is a result of unknown values or estimation error, not a change in aquifer storage.

Water Quality

Water samples for chemical analysis were collected from 24 wells and 4 streamflow sites in 1987 and from 20 wells in 1988 in the Little Peoples Creek valley (tables 17 and 18). Samples were collected according to guidelines described by Knapton (1985).

Water-quality diagrams for major ions and dissolved-solids data for selected wells are shown in figure 11. Water in wells completed in the valley-fill aquifer near the mountain front is a calcium bicarbonate type with a dissolved-solids concentration as small as 282 mg/L, whereas water in wells completed in the central part of the aquifer farther downgradient is a sodium sulfate type with a dissolved-solids concentration as large as 1,380 mg/L (examples of anomalously large concentrations at wells O-17, O-18, and O-25 are described later). The trend of increasing dissolved-solids concentration with distance from the mountain front probably results from one or more of the following processes: (1) leakage from bedrock, (2) dissolution of minerals within the aquifer, and (3) evapotranspiration.

Water in bedrock generally has larger concentrations of sodium, magnesium, and sulfate than water in the overlying valley-fill aquifer (Feltis, 1983, p. 8). The quantity and quality of surface water recharging the valley-fill aquifer at the upgradient end are relatively constant. The quantity of inflow of water from bedrock is directly proportional to the contact area between the aquifer and the underlying lenses of permeable sandstone. Therefore, the percentage of total ground-water flow that is derived from bedrock increases with distance along the flow path.

Because the valley-fill aquifer is composed primarily of material locally eroded from bedrock, dissolution of minerals that occur in the bedrock flow system also can occur in the valley-fill aquifer. The resulting water quality is also similar.

Evapotranspiration removes unmineralized water from the aquifer, thereby concentrating the mineral content of the remaining water. Evapotranspiration accounts for part of the discharge from the aquifer in the south basin. Discharge by evapotranspiration from thin, shallow gravel layers is probably responsible for the anomalously large dissolved-solids concentrations observed in water samples from wells O-17 (11,500 mg/L, the largest concentration determined in this study), O-18 (5,510 mg/L), and O-25 (2,380 mg/L) (table 19). The effects of evapotranspiration are cumulative.

The large difference in water quality at some well sites along the western edge of the valley (fig. 11) is significant. Wells O-20, O-22, and O-24 have a range of dissolved-solids concentration from 464 mg/L at the easternmost well (O-24) to 1,100 mg/L at the westernmost well (O-20). The situation is nearly identical at wells O-11, O-13, and O-14, which are about 2.3 mi to the south. Water samples from these wells indicate that the increase in dissolved-solids concentrations is the result of increased concentrations of sodium, magnesium, and sulfate--a chemistry that is characteristic of water from sandstone of the underlying Judith River Formation (Feltis, 1983, p. 8). This anomalous water quality is probably representative of areas where a significant percentage of flow to the well is derived from bedrock.

The suitability of water for irrigation is judged principally by the total concentration of soluble salts and the relative proportion of sodium to other cations. Large concentrations of soluble salts (salinity hazard) can interfere with plant growth by inhibiting the uptake of water and nutrients. Large concentrations of sodium relative to other cations, as measured by the sodium-

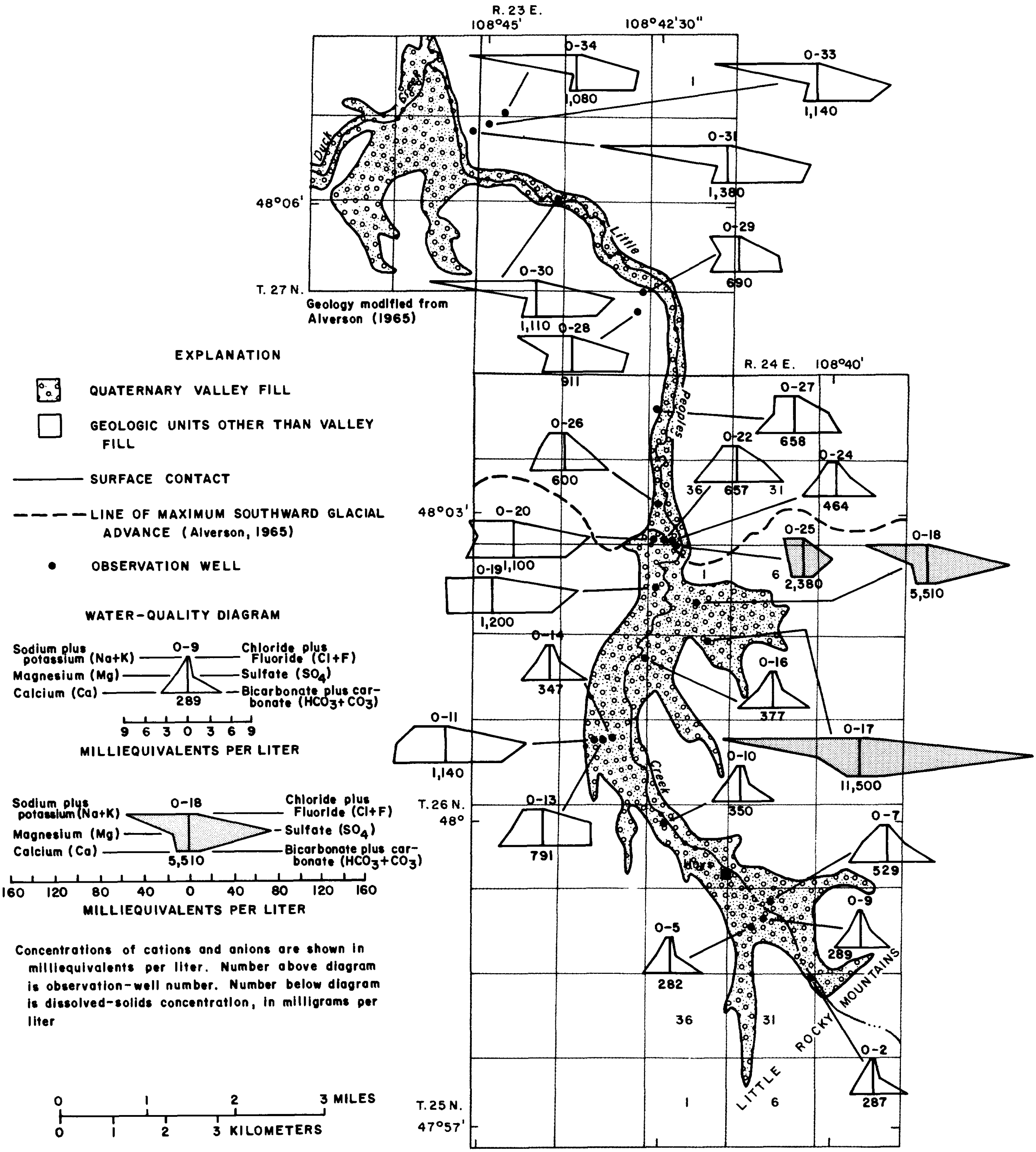


Figure 11.--Water-quality diagrams for water samples from selected observation wells along Little Peoples Creek.

adsorption ratio (U.S. Salinity Laboratory Staff, 1954, p. 72), can cause accumulations of sodium in the soil and a breakdown of granular soil structure. The sodium-adsorption ratio (SAR) is defined as:

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}} \quad (4)$$

where ion concentrations are expressed in milliequivalents per liter. The effect of the SAR (sodium hazard) is more pronounced in the presence of large concentrations of total soluble salts. A diagram for classifying water with respect to salinity and sodium hazards is presented in figure 12.

Water-quality samples from Little Peoples Creek valley (table 17) indicate that water from most wells completed in the valley-fill aquifer north of well O-13 has a high salinity hazard. High salinity water cannot be used without adverse effects on soils that have restricted drainage; use of this water may require special salinity control and selection of salt-tolerant crops even on soils having adequate drainage (U.S. Salinity Laboratory Staff, 1954, p. 81). Water from wells completed in the valley-fill aquifer north of well O-29 has a high sodium hazard. High sodium water may produce harmful accummulations of sodium in the soil and will require special soil management--good drainage, extensive leaching, and additions of organic matter (U.S. Salinity Laboratory Staff, 1954, p. 81). Water in wells O-17 and O-18 has very high salinity and sodium hazards. Wells O-17 and O-18 are completed in shallow gravel lenses of a tributary basin where evapotranspiration greatly increases the concentration of soluble salts in the water.

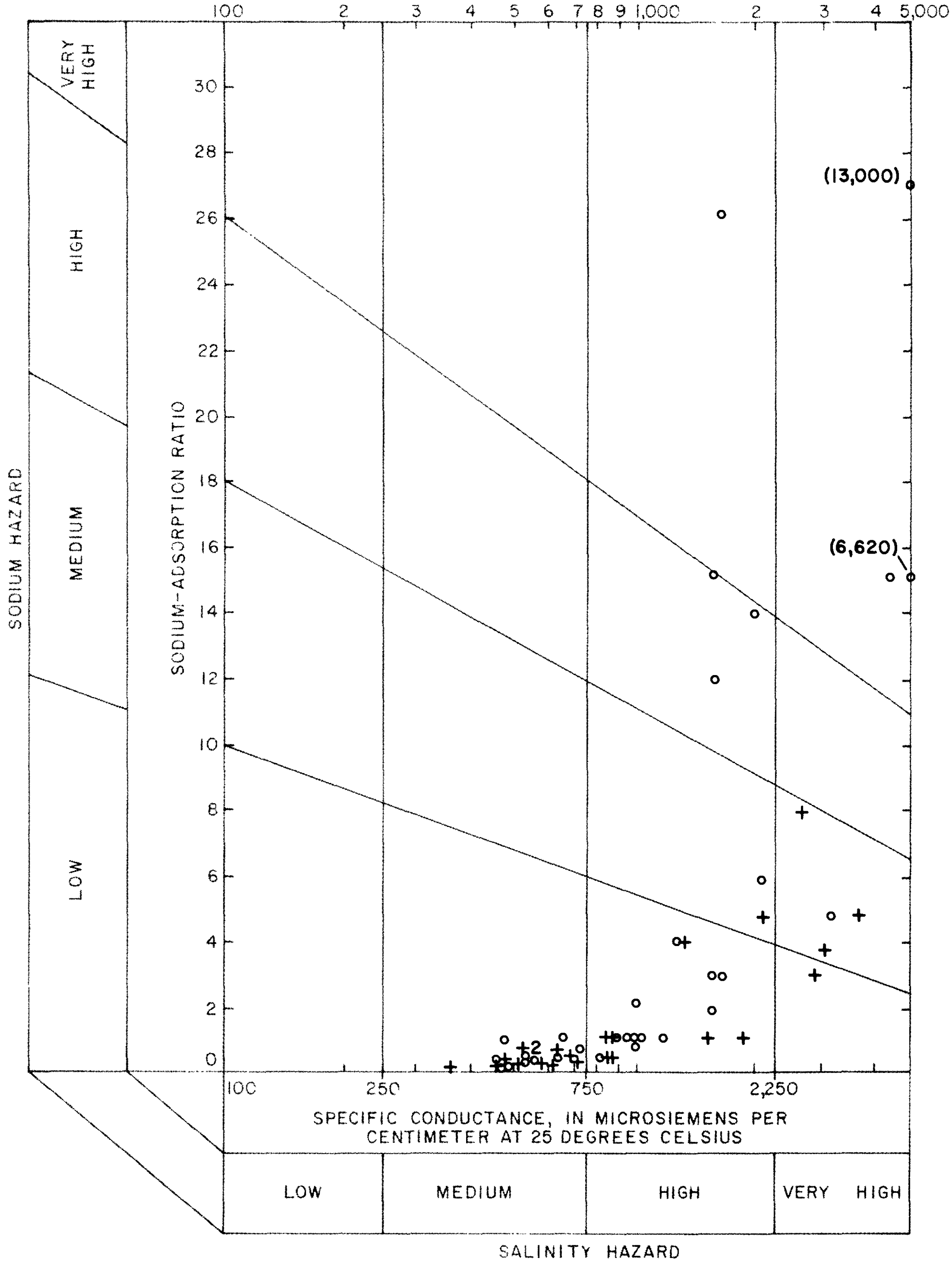
The suitability of water for public drinking-water supply is established by the U.S. Environmental Protection Agency Primary and Secondary Drinking-Water Regulations (table 19). National Primary Drinking-Water Regulations are established for contaminants, which, if present in drinking water, may cause adverse human health effects. Either a Maximum Contaminant Level (MCL) or a treatment technique is specified by these regulations for regulated contaminants. MCL's are health-based and enforceable (U.S. Environmental Protection Agency, 1991a). National Secondary Drinking-Water Regulations are established for contaminants that can adversely affect the odor or appearance of water and result in discontinuation of use of the water. These regulations specify Secondary Maximum Contaminant Levels (SMCL's), which are esthetically based and nonenforceable (U.S. Environmental Protection Agency, 1991b).

Analyses of water samples from 25 observation wells and 10 private wells that are completed in valley fill along Little Peoples Creek are given in tables 17 and 18. Of these 35 wells, 3 have water with a cadmium concentration larger than the MCL of 5 µg/L and 3 have water with the concentrations equal to the MCL. Twenty-six wells have water with a dissolved-solids concentration larger than the SMCL of 500 mg/L; 20 have water with a sulfate concentration larger than the SMCL of 250 mg/L; 6 have water with an iron concentration as large or larger than the SMCL of 300 µg/L; and 14 have water with a manganese concentration larger than the SMCL at 50 µg/L.

Lodge Pole Creek Valley

Lodge Pole Creek valley extends from the Mississippian-limestone canyon where Lodge Pole Creek exits the Little Rocky Mountains at location 26N25E20BCB northward about 16 mi to its confluence with South Fork Peoples Creek. The Lodge Pole Creek valley is underlain mostly by shale of Cretaceous and Jurassic age. The valley crosses permeable Eagle Sandstone at location 26N25E08B and numerous localized sandstone sequences of the Judith River Formation in the north part of the study area.

Valley fill along Lodge Pole Creek is topographically well defined south of the line of glacial advance (fig. 13), ranges in width from 0.01 to 1.0 mi, and is as



EXPLANATION

o DATA FOR WELL ALONG LITTLE PEOPLES CREEK

\+ DATA FOR WELL ALONG LODGE POLE CREEK

2 NUMBER, WHERE PRESENT, INDICATES MORE THAN ONE DATA VALUE AT SAME LOCATION

Figure 12.--Diagram for determining salinity and sodium hazards of water used for irrigation (modified from U.S. Salinity Laboratory Staff, 1954, p. 80).

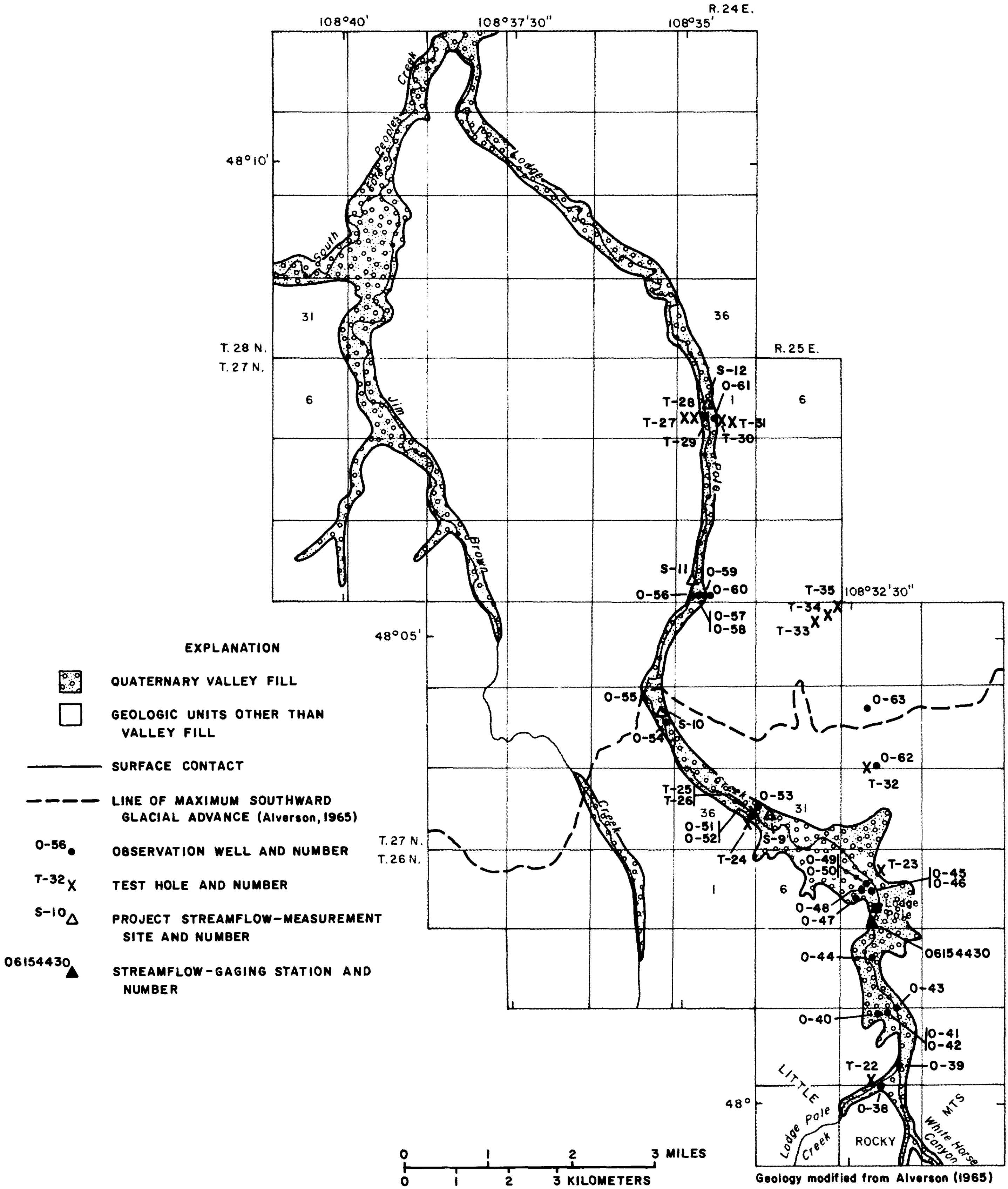


Figure 13.--Surface extent of valley fill and location of observation wells, test holes, streamflow-measurement sites, and streamflow-gaging stations along Lodge Pole Creek.

much as 89 ft thick (well O-53). Topography of the preglacial valley in the northern part of the study area is masked by varying thicknesses of till and glaciofluvial sediments, which makes estimating the lateral extent of valley fill difficult.

Aquifer Geometry

The principal aquifer in the Lodge Pole Creek valley is layered sand and gravel that occur at several levels in the valley-fill sequence. As along Little Peoples Creek valley, these sand and gravel deposits probably result from fluvial cut-and-fill depositional processes. The resulting deposit is a vertical sequence of sinuous braided channels, lenticular in cross section, which aggraded valleys eroded into Cretaceous and Jurassic bedrock.

Sand and gravel layers beneath Lodge Pole Creek valley are more randomly distributed and discontinuous than those in Little Peoples Creek valley. For example, well O-41 (fig. 13) penetrated two layers of loose gravel: one 13 ft thick (at depths of 8-21 ft) and one 6 ft thick (at 49-55 ft). In contrast, well O-42, only 10 ft to the east, penetrated four layers of gravel: two 1 ft thick (at depths of 10-11 ft and 22-23 ft), one 2 ft thick (at 25-27 ft), and one 19 ft thick (35-54 ft) (table 15).

The degree of hydraulic connection between sand and gravel layers can be inferred at several locations in the valley. Both observation-well pairs O-49/O-50 and O-51/O-52 (table 13) indicate that a lower sand and gravel layer has a higher hydraulic head than an upper layer, which implies limited hydraulic connection of the layers near the sites. Limited hydraulic connection also is indicated by the hydrographs of wells O-51, O-52, and O-53 (table 16), which show dissimilar water-level fluctuations even though all three wells are located within 1,200 ft of one another in a direction transverse to the axis of the valley.

In the glaciated part of Lodge Pole Creek valley, lithologic logs of well O-61 and test holes T-27 through T-31 indicate thick sequences of drift directly overlying shale. Presumably, the scarcity of sand and gravel beneath the present-day stream channel in this area is the result of glacial scour. Likewise, the aquifer at the line of glacial advance probably is discontinuous.

To investigate the possibility that preglacial Lodge Pole Creek flowed almost due north through the broad valley from location 27N25E32 to 27N25E18 rather than through its present-day channel, observation wells O-62 and O-63 and test holes T-33 through T-35 were drilled (fig. 13). Although well O-62 penetrated some sand and gravel, shale was drilled at an altitude of 3,279 ft, which is 54-60 ft higher than the altitude of the shale that was drilled at wells O-51 and O-53 along the present-day channel northwest of Lodge Pole. Likewise, well O-63 penetrated shale at 3,218 ft, which is 81 ft higher than the altitude of the shale that was drilled at well O-54. Whether the northern valley at one time contained the ancestral Lodge Pole Creek or was instead carved by glacial ice could not be determined from the data.

Water-Level Fluctuations

Water levels were measured approximately monthly in 14 observation wells along Lodge Pole Creek; of these, continuous recorders were operated on wells O-42 and O-58. Hydrographs of wells along Lodge Pole Creek valley (table 16) display trends similar to those observed in Little Peoples Creek valley. Hydrographs of wells in the unglaciated part of the drainage display a water-level fluctuation of as much as 33 ft (well O-42) during the period of record and indicate a sudden response to precipitation and snowmelt recharge. In contrast, hydrographs for the part of the drainage northwest of Lodge Pole and southeast of the line of glacial advance, which was blanketed by proglacial silt and clay, display an annual water-level fluctuation under non-pumping conditions of less than 3 ft and show no significant correlation with precipitation and snowmelt recharge.

Hydrographs of wells O-45 and O-42 are shown in figure 14; also shown for comparison are streamflow of Lodge Pole Creek and precipitation at the gage south

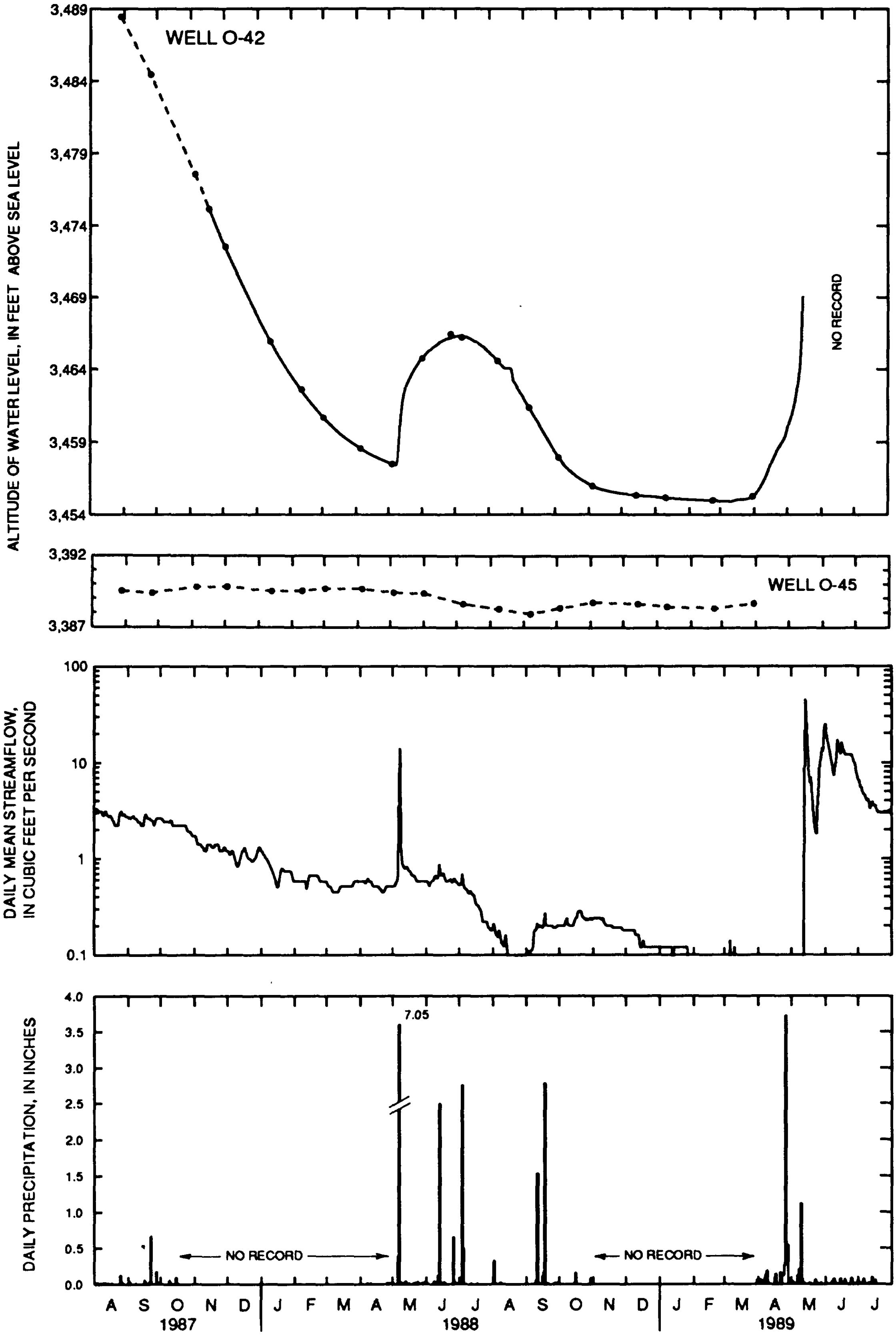


Figure 14.--Relation of water levels in selected wells to streamflow at gaging station 06154430 and precipitation at a continuous-record gage along Lodge Pole Creek. A continuous water-level recorder was maintained on well O-42.

of Lodge Pole. Although the water level in well O-45 shows no apparent response to periods of large streamflow, the water level in well O-42 displays a strong correlation to this stress. The observed responses are similar to those observed in Little Peoples Creek valley.

Well O-45 is completed in sand and gravel that are hydraulically confined by proglacial silt and clay. Recharge to this confined part of the aquifer is primarily by flow from the upgradient unconfined aquifer. The hydraulic head in the confined aquifer is controlled by an impoundment of Lodge Pole Creek about 0.25 mi south of well O-45. The interaction between the unconfined and confined aquifers in the Lodge Pole Creek valley is conceptually identical to the interaction in Little Peoples Creek valley.

In contrast to well O-45, coarse gravels penetrated by well O-42 are not overlain by proglacial silt and clay but are hydraulically connected to the intermittent flow of Lodge Pole Creek and ephemeral runoff. Field evidence corroborates the connection. The flow of Lodge Pole Creek infiltrates and disappears into the alluvium at the point of exit from the Mississippian-limestone canyon at the head of the drainage and reemergence 2.5 mi downstream, just upstream from the gaging station.

Persistent drought conditions during the 2 years of this study are probably responsible for the general decline in water levels in wells O-39 through O-44. However, human activities were responsible for the large decline in water level at well O-54 during June and July 1988. The decline resulted from use of the flowing-artesian well O-55 for stockwater. The discharge of well O-55 caused water levels to decline in all wells in the drainage as far upgradient as well O-45, 3.6 mi to the southeast, but did not cause any water-level change at well O-58, 1.4 mi downgradient to the north. The unquantified discharge at well O-55 did not allow mass balance analyses of the effects of discharge on the aquifer. The lack of response at well O-58 indicates that the aquifer is essentially discontinuous between well O-55 and well O-58 to the north. This area of probable aquifer discontinuity, which coincides with the line of glacial advance, defines the northernmost extent of the continuous valley-fill aquifer in the Lodge Pole Creek valley.

Hydraulic Characteristics

Constant-discharge aquifer tests were conducted on three wells completed in the valley-fill aquifer of Lodge Pole Creek. Water levels in observation wells were monitored during the tests and the time-versus-drawdown data were analyzed. The resulting transmissivity, hydraulic-conductivity, and storage-coefficient data are summarized in table 7.

As in the Little Peoples Creek valley, transmissivity and hydraulic-conductivity values appear to decrease with distance from the mountain front. Aquifer-test data for observation well O-58 were unsolvable, owing to the violation of basic assumptions regarding radial flow to the discharging well on which the analytical solutions are based. The estimated storage coefficient at well O-46 (0.00001) is consistent with the degree of hydraulic confinement at the site, but the value at well O-42 (0.0008) is anomalously small given the degree of hydraulic connection with streamflow near the site.

Recharge and Discharge

For purposes of describing recharge and discharge, the Lodge Pole Creek drainage basin was divided into two sub-basins according to degree of hydraulic confinement of the valley-fill aquifer. The south basin consists of the total drainage area upgradient from gaging station 06154430 near Lodge Pole and represents the area potentially supplying recharge to the unconfined aquifer. The relation between water-levels in well O-42 and streamflow at the gaging station (fig. 14) corroborate the hydraulic connection between the surface and ground-water systems in the south basin. The adjacent north basin consists of the drainage area downgradient from the gaging station to the line of glacial advance.

Table 7.--*Results of aquifer tests in the valley-fill aquifer of Lodge Pole Creek*

[Valley mile is approximate distance downstream from beginning of valley fill. Abbreviations: ft, feet; ft/d, feet per day; ft^2/d, feet squared per day; gal/min, gallons per minute; min, minutes. Symbols: ---, no solution possible because basic flow assumptions were not met]

					Calculated values					
Pumped well number	Valley mile	Discharge (gal/min)	Date of test	Length of test (min)	Transmissivity (ft^2/d)	Average aquifer thickness (ft)	Hydraulic conductivity (ft/d)	Storage coefficient	Observation well number	Total drawdown (ft)
O-42	1.6	60	06-27-88	240	8,400	11	760	0.0008	O-40	0
									O-41	0.99
									O-43	0
O-46	3.1	68	10-18-87	240	880	5	180	.00001	O-45	15.03
									O-47	0
									O-48	3.71
									O-49	5.21
									O-50	0
O-58	8.1	55	10-16-87	240	---	6	---	---	O-56	15.19
									O-57	17.53
									O-59	17.49
									O-60	0

South basin

Recharge to and discharge from the valley-fill aquifer in the south basin of Lodge Pole Creek can be summarized with a mass balance equation as follows:

$$BRGWi + R + P = SWo + VFGWo + ET \tag{5}$$

where

$BRGWi$ = Leakage from bedrock;
R = Infiltration of ephemeral runoff from the drainage area; includes ephemeral flow in upper Lodge Pole Creek and White Horse Canyon;
P = Infiltration of precipitation that falls directly on the valley fill;
SWo = Outflow from the basin by Lodge Pole Creek; an unquantified major part of this water is leakage from the aquifer;
$VFGWo$ = Outflow through valley fill at the downgradient boundary of the basin; and
ET = Evapotranspiration by phreatophytes along Lodge Pole Creek.

The first three variables of equation 5 represent recharge to the aquifer; the remaining variables represent discharge from the aquifer.

Leakage of water from bedrock (*BRGWi*) was not measured directly, but its existence is implied by: (1) a hydraulic gradient from bedrock into the valley fill determined by measurement of water levels in bedrock wells P-111, P-112, P-124, P-137, and P-147, and (2) an increase in dissolved-solids concentration in the aquifer with distance from the mountain front, which might indicate inflow of more mineralized water from bedrock. The increase in dissolved-solids concentration might also be due to a chemical interaction of aquifer water with aquifer material or to the concentrating effect of evapotranspiration on dissolved constituents. Because surface-water inflow to the south basin was not continuous, as it was in the south basin of Little Peoples Creek, leakage from bedrock into the aquifer was not identifiable from a low-flow investigation conducted on Lodge Pole Creek in October 1987.

A principal source of recharge to the aquifer in the south basin is ephemeral runoff from the surrounding drainage area (*R*). This component of recharge includes infiltration of intermittent streamflow in both upper Lodge Pole Creek and White Horse Canyon. Streamflow disappears into the coarse valley fill a short distance from the mountain front during all but infrequent periods of large runoff. The total drainage area of the south basin excluding the surface extent of the valley fill is about 18.5 mi^2 and the long-term mean annual precipitation is 19 in. (fig. 7). However, the percentage of precipitation that runs off is unknown. Assuming a runoff rate of 15 percent, runoff recharge to the aquifer is about 2,810 acre-ft/yr.

Infiltration of precipitation that falls directly on the valley fill (*P*) also recharges the aquifer. The surface extent of the valley fill in the south basin is about 1 mi^2. The long-term mean annual precipitation is about 19 in. (fig. 6). Using the same methodology and assumptions presented for Little Peoples Creek, precipitation recharge to the aquifer in the south basin is about 240 acre-ft/yr.

Outflow from the basin by leakage to Lodge Pole Creek (*SWo*) is represented by the appearance of streamflow about 0.25 mi upstream from gaging station 06154430 near Lodge Pole in the south basin. During all but infrequent periods of large runoff, the channel of Lodge Pole Creek is dry from the mountain front to just south of the gaging station. Therefore, streamflow recorded at the gaging station comprises a significant part of the discharge from the aquifer in the south basin. To estimate the long-term streamflow at the gaging station, the streamflow record was extended to the base period (water years 1937-86) by statistical correlation with extended flow records previously developed for gaging station 06154410 on Little Peoples Creek (Parrett and Johnson, 1989, p. 22). The resulting log-linear regression equation is:

$$Qlgp = 0.10(Qltp)^{1.853} \qquad (6)$$

where

$Qlgp$ = Mean monthly streamflow for Lodge Pole Creek, in cubic feet per second; and
$Qltp$ = Mean monthly streamflow for Little Peoples Creek, in cubic feet per second.

The coefficient of determination for equation 6 is 0.72. Estimated mean monthly streamflow for Lodge Pole Creek at the gaging station during the 50-year base period is presented in table 8. The estimated long-term mean annual flow of Lodge Pole Creek at the gaging station is 1,400 acre-ft/yr.

Outflow through the valley fill at the downgradient boundary of the south basin (*VFGWo*) was estimated by Darcy's equation using a transmissivity of 880 ft^2/d determined by the aquifer test at well O-46, a combined aquifer width for the two lowest sand and gravel layers of 1,770 ft, and a hydraulic gradient of 0.011 ft/ft determined between well O-45 and O-49, 230 ft downgradient. Outflow through valley fill is estimated to be about 144 acre-ft/yr.

Evapotranspiration (*ET*) also discharges the aquifer. Satellite imagery was used to estimate the areal extent of phreatophytes along Lodge Pole Creek. The south basin contains 201 acres of phreatophytes. Consumptive use of the phreatophytes was assumed to equal the consumptive use of alfalfa (26.11 in/yr or 2.18 acre-ft/yr per acre), as calculated by the U.S. Department of Agriculture (1974). The estimated depletion due to evapotranspiration is 438 acre-ft/yr (table 9).

Table 8.--*Estimated mean monthly and mean annual streamflow of Lodge Pole Creek, water years 1937-86*

Vari-able	De-scrip-tion	Mean monthly streamflow, in cubic feet per second												Mean annual stream-flow, in acre-feet per year
		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	
SWo	Outflow[1] from south basin	0.5	0.4	0.5	0.4	0.3	0.6	1.8	10.0	5.6	1.6	0.8	0.6	1,400

[1] Determined at streamflow-gaging station 06154430.

Table 9.--*Monthly evapotranspiration depletion along the south basin of Lodge Pole Creek*

Depletion, in acre-feet							
Apr.	May	June	July	Aug.	Sept.	Oct.	Total (rounded)
1.0	61.9	95.5	126	103	49.0	1.2	438

Recharge to and discharge from the aquifer in the south basin of Lodge Pole Creek are summarized in table 10. The most imprecisely known value is for recharge by ephemeral runoff from the drainage area including ungaged flow in upper Lodge Pole Creek and White Horse Canyon. Most of the remaining values in table 10 are probably reasonable estimates of recharge to and discharge from the aquifer in the south basin. The difference between total recharge and total discharge in table 10 is a result of unknown values or estimation error, not a change in aquifer storage.

Table 10.--*Summary of estimated recharge to and discharge from the south and north basins of Lodge Pole Creek*

Variable	Description	Acre-feet per year
	South basin	
Recharge		
BRGWi	Leakage from bedrock; not estimated	?
R	Infiltration of ephemeral runoff from the drainage area; includes ephemeral flow in upper Lodge Pole Creek and White Horse Canyon	2,810
P	Infiltration of precipitation that falls directly on the valley fill	240
Total in		3,050
Discharge		
SWo	Outflow from the basin by Lodge Pole Creek; based on extended streamflow record at gaging station 06154430	1,400
VFGWo	Outflow through valley fill at the downgradient boundary of the basin; based on Darcy's equation	144
ET	Evapotranspiration; based on satellite analysis of phreatophytes along Lodge Pole Creek	438
Total out (rounded)		1,980
	North basin	
Recharge		
VFGWi	Inflow from the valley fill of south basin	144
BRGWi	Leakage from bedrock; not estimated	?
Total in		144
Discharge		
VFGWo	Outflow through the valley fill at the north boundary of basin is possible, but not estimated	?
Total out		?

North basin

Recharge to and discharge from the valley-fill aquifer in the north basin of Lodge Pole Creek can be summarized as follows:

$$VFGWi + BRGWi = VFGWo \qquad (7)$$

where

VFGWi = Inflow from the valley fill of south basin,
BRGWi = Leakage from bedrock, and
VFGWo = Outflow through valley fill at the downgradient boundary of the basin.

The principal source of recharge to the aquifer in the north basin (*VFGWi*) is outflow from the valley-fill aquifer of the adjacent south basin (*VFGWo*). This recharge is estimated to be about 144 acre-ft/yr.

Leakage of water from bedrock (*BRGWi*) was not measured directly but is implied by the existence of an upward hydraulic gradient in the aquifer (wells O-49, O-50, O-51, and O-52) and an increase in dissolved-solids concentration downgradient in the basin. However, these factors did not allow quantification of the recharge.

Potential discharge of water from the aquifer through leakage to Lodge Pole Creek might explain the occurrence of seeps, which remained active when sections of the creek became dry during the summer of 1988. Unfortunately, the low-flow investigation conducted on the creek did not detect the leakage under the more normal streamflow conditions in October 1987 (table 11).

Table 11.--*Results of low-flow measurements of Lodge Pole Creek, October 18, 1987*

[Valley mile is approximate distance downstream from the beginning of valley fill. Abbreviations: ft^3/s, cubic feet per second; $(ft^3/s)/mi$, cubic feet per second per mile. Symbol: --, not applicable]

Site number (fig. 12)	Valley mile	Discharge (ft^3/s)	Change in discharge per mile ($(ft^3/s)/mi$)	Estimated measurement error (percent)
		North basin		
06154430	2.7	2.22	--	8 or more
S-9	4.8	1.41	-0.39	8 or more
S-10	6.4	1.89	+ .30	5
S-11	8.1	1.85	- .02	8
S-12	10.2	1.82	- .01	8

Outflow through valley fill at the downgradient boundary of the north basin (*VFGWo*) is more difficult to identify than in the south basin. The lack of response of water levels in observation wells located north of the line of glacial advance when well O-55 was flowing in the summer of 1988 indicates that the aquifer is essentially discontinuous. However, a minor quantity of ground water, which could flow through this area if the aquifer does not totally pinch out, might be responsible for part of the discharge from the confined aquifer.

Recharge to and discharge from the aquifer in the north basin of Lodge Pole Creek are summarized in table 10. Most of the components of recharge and discharge in the north basin are imprecisely known.

Water Quality

Water samples for chemical analysis were collected from 20 wells and 4 streamflow sites in 1987 and from 5 wells in 1988 in the Lodge Pole Creek valley (tables 17 and 18). Samples were collected according to guidelines described by Knapton (1985).

Water-quality diagrams for major ions and dissolved-solids data for selected wells are shown in figure 15. Water in wells completed in the valley-fill aquifer near the mountain front is a calcium bicarbonate type with dissolved-solids concentrations as small as 232 mg/L, whereas water in wells farther downgradient is a sodium sulfate or magnesium sulfate type with dissolved-solids concentrations as large as 2,500 mg/L. The trend of increasing dissolved-solids concentrations with distance from the mountain front probably results from a combination of the following processes: (1) leakage from bedrock, (2) dissolution of minerals within the aquifer, (3) limited flow through the confined part of the aquifer, and (4) evapotranspiration.

Water in bedrock well P-136 has larger concentrations of calcium, magnesium, potassium, and sulfate than water in the valley-fill aquifer (table 17). Also, water in bedrock well P-129 has a larger specific conductance than water in the valley-fill aquifer (table 13). The quantity of inflow of water from bedrock to the aquifer is directly proportional to the surface area of the aquifer in contact with the underlying lenses of permeable sandstone. Therefore, the percentage of total ground-water flow that is derived from bedrock increases with distance along the flow path and can result in increased dissolved-solids concentrations downgradient.

Because the valley-fill aquifer is composed primarily of material locally eroded from bedrock, dissolution of minerals that occur in the bedrock flow system also can occur in the valley-fill aquifer. The resulting water quality is also similar.

Water-level data imply that the confined aquifer of Lodge Pole Creek is essentially discontinuous at the line of glacial advance, and, therefore, probably does not discharge to the thin sand and gravel deposits to the north. This aquifer geometry limits flow through the confined aquifer, thereby decreasing the dilution of mineralized aquifer water by recharge.

Evapotranspiration accounts for part of the discharge from localized areas of the unconfined aquifer. Evapotranspiration also increases the dissolved-solids concentration of the impounded surface water, which functions as a constant-head source for the confined aquifer.

Water-quality samples from Lodge Pole Creek valley (table 17) indicate that water from most wells completed in the valley-fill aquifer north of well O-50 has a high or very high salinity hazard (fig. 12). High salinity water cannot be used without adverse effects on soils that have restricted drainage; use of this water may require special salinity control and selection of salt-tolerant crops even on soils having adequate drainage (U.S. Salinity Laboratory Staff, 1954, p. 81). None of the water-quality samples indicate a sodium hazard that would adversely affect soil structure.

Analyses of water samples from 19 observation wells and 3 private wells that are completed in valley fill along Lodge Pole Creek are given in tables 17 and 18. Of these 22 wells, 10 have water with a dissolved-solids concentration larger than the SMCL of 500 mg/L; 8 have water with a sulfate concentration larger than the SMCL of 250 mg/L; 8 have water with an iron concentration larger than the SMCL of

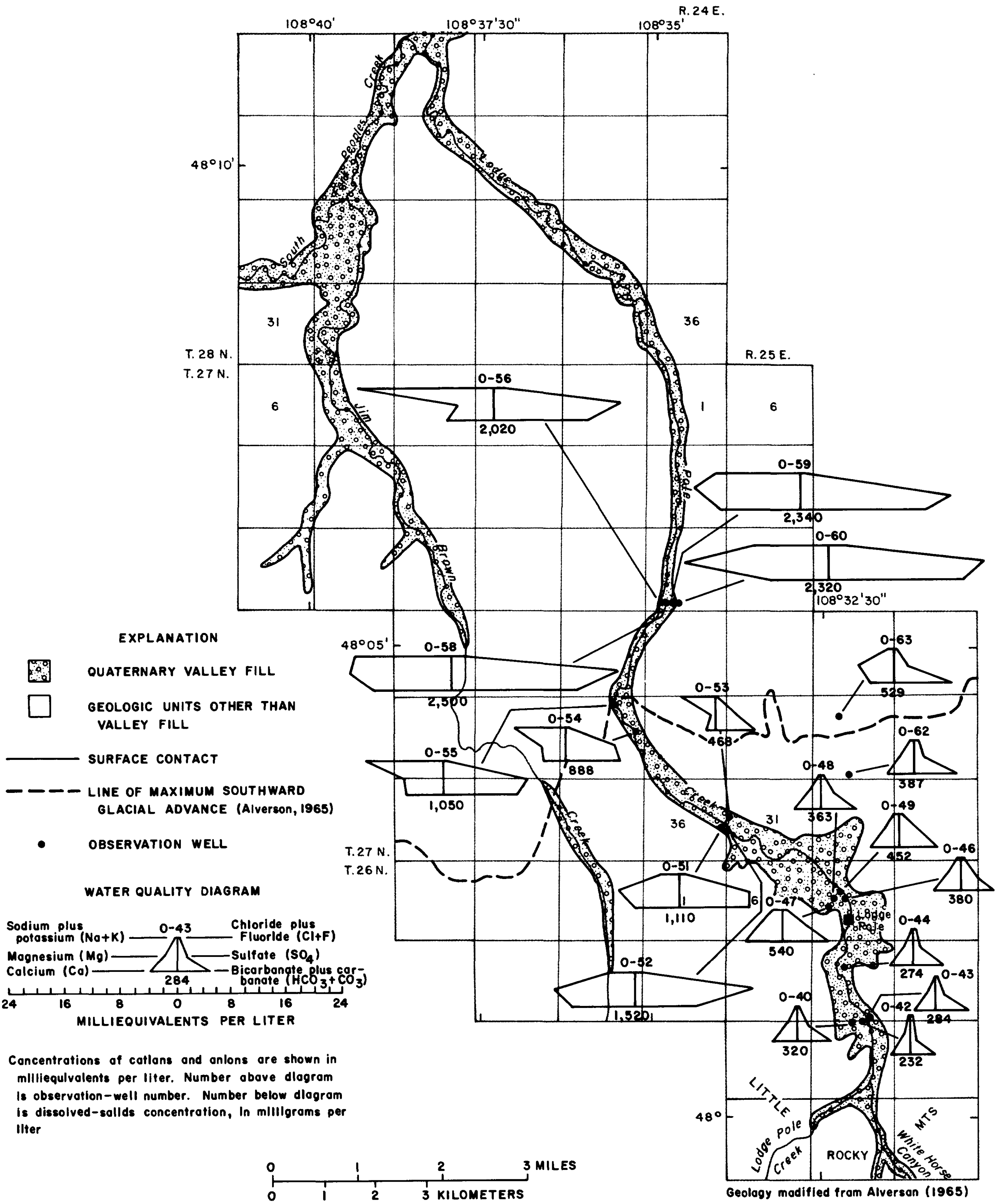


Figure 15.--Water-quality diagrams for water samples from selected observation wells along Lodge Pole Creek.

300 µg/L; and 10 have water with a manganese concentration larger than the SMCL of 50 µg/L. The large dissolved-solids, sulfate, iron, and manganese concentrations in ground water from most of the north basin might make the water undesirable for domestic use in that area.

Jim Brown, Big Warm, and Beaver Creek Valleys

Test drilling along Jim Brown Creek demonstrated a lack of continuous sand and gravel deposits beneath the valley (table 15). Observation wells O-35 through O-37 and test holes T-13 through T-21 are located along Jim Brown Creek valley (pl. 2). Well O-35 is completed in gravel directly overlying shale and would not produce water. Test hole T-14, about 200 ft southwest of well O-35, penetrates 8 ft of dry sand and gravel overlying shale at 23 ft below land surface. Although nearby private well P-108, which is 900 ft southeast of well O-35, produces 10 gal/min of water from a depth of 19-26 ft below land surface, test drilling did not detect a continuous aquifer. However, a large grove of aspens near the creek at location 26N24E02B indicates the presence of ground water in that area.

Field inspection of the drainage area and extent of valley fill along Big Warm Creek indicates lack of a significant ground-water resource along the valley. On the basis of this conclusion, Big Warm Creek valley was not investigated further.

Test drilling along Beaver Creek indicated the lack of continuous sand and gravel deposits in the valley-fill sequence (table 15). Observation wells O-64 through O-66 and test holes T-36 through T-43 are located along Beaver Creek valley (pl. 2). Well O-64 was drilled near the western, upgradient end of the valley fill along Beaver Creek where a large grove of willows indicates the presence of ground water near the surface. The well penetrates several layers of sand and gravel interbedded with clay and colluvium overlying shale at 52 ft below land surface. Well O-64 produces about 25 gal/min of water suitable for domestic, stock, or small-scale irrigation purposes. Subsequent drilling of test holes T-36 through T-39 about 1.4 mi downvalley denoted the absence of water-yielding sand and gravel in the valley-fill sequence at those locations. Wells O-65 and O-66 and test holes T-40 through T-43 near the east boundary of the reservation penetrate isolated, thin, and shallow sand and gravel layers having little potential for ground-water withdrawals.

POTENTIAL FOR ADDITIONAL GROUND-WATER WITHDRAWALS

The potential is good for additional withdrawals of water from the valley-fill aquifer along Little Peoples Creek. Considering the aquifer geometry shown in geologic sections A-A′, B-B′, and C-C′ (pl. 1) and an estimated porosity of 25 percent, the total volume of water in the aquifer of the south basin of Little Peoples Creek is about 10,000 acre-ft.

The aquifer test at well O-23 provides the only data that detail large-capacity withdrawals of water from the valley-fill aquifer along Little Peoples Creek. Whereas water levels in the pumped and observation wells continued to decline during the 1,450-min test (steady-state flow conditions were not achieved), data from test drilling, aquifer tests, and recharge-discharge estimates indicate that in some areas of the valley properly constructed wells might be capable of sustaining 150-250 gal/min during parts of the irrigation season. However, the data also indicate that pumping for irrigation would probably result in lowered water levels in the aquifer. Additional water withdrawals for domestic and stock use would probably not create this effect to a measurable degree. Lowered ground-water levels in the aquifer would probably result in two interrelated consequences: (1) increased leakage of more mineralized water from bedrock, and (2) increased infiltration of water from Little Peoples Creek.

Water-level measurements, water-quality data, and streamflow gain-loss measurements indicate leakage from bedrock along much of the Little Peoples Creek valley. The decline of water levels in the valley-fill aquifer caused by large-capacity pumping would effectively increase the hydraulic gradient from bedrock into the valley fill and thereby increase the inflow of potentially more mineralized water. Although the increased leakage from bedrock would provide some amount of water not otherwise available, the potential increase in dissolved-solids concentration might make the water unacceptable for certain uses.

The relation of streamflow and water-level fluctuations in selected wells indicates hydraulic connection between Little Peoples Creek and the unconfined part of the valley-fill aquifer. Thus, lower water levels in the aquifer as a result of pumping would increase infiltration from the creek. Although the water entering the aquifer from Little Peoples Creek would decrease the average dissolved-solids concentrations in the aquifer, the resulting decrease in streamflow might not be acceptable to downstream users who rely on the stream for stockwater.

The potential is limited for additional withdrawals of water from the valley-fill aquifer along Lodge Pole Creek. Although the estimated transmissivity of the aquifer in the south basin is sufficient to permit the development of wells capable of producing 250 gal/min, insufficient long-term recharge to the aquifer would severely limit the use of large-capacity wells. The quantity and quality of ground water available in the south basin, however, provide good potential for additional withdrawals for domestic and stock-watering use.

In the north basin of Lodge Pole Creek, the estimated transmissivity of the confined aquifer is not adequate to supply ground water to large-capacity irrigation wells. In contrast, the potential is excellent for development of small-yield flowing artesian wells for stock-watering purposes. However, the large dissolved-solids, iron, and manganese concentrations in ground water in the north basin exceed the SMCL's for those constituents and might make the water undesirable for domestic use in that area.

The limited extent of valley fill and recharge areas for Jim Brown and Big Warm Creek valleys restricts the potential for water withdrawals for irrigation in those valleys. In Beaver Creek valley, the potential for additional water withdrawals from the valley-fill aquifer is limited to the part of the valley upgradient from well O-64. There, the quantity and quality of the water is suitable for domestic, stock, or small-scale irrigation use. Test drilling downgradient from well O-64 indicates the potential for water withdrawals in that area of Beaver Creek valley is negligible.

SUMMARY AND CONCLUSIONS

The southern part of the Fort Belknap Indian Reservation has diverse physiography, drainage, and climate. Three physiographic units are present: (1) plains in the northern and central parts, (2) foothills surrounding the Little Rocky Mountains in the southern part, and (3) the Little Rocky Mountains uplift. Five principal creeks drain the northern flank of the Little Rocky Mountains: Little Peoples, Lodge Pole, Jim Brown, Big Warm, and Beaver Creeks. Of these, only Little Peoples and Lodge Pole Creeks have deposits of sand and gravel that are continuous along most of the length of the valleys.

The stratigraphy of the area is varied. Precambrian metamorphic rocks and Tertiary igneous rocks are exposed in the core of the Little Rocky Mountains. Paleozoic, Mesozoic, and Cenozoic sedimentary rocks are exposed on the flank of the mountains and on the surrounding plains. Unconsolidated deposits occur beneath terraces surrounding the Little Rocky Mountains and as Quaternary valley fill and glacial deposits.

The geometry, flow system, and water quality of the valley-fill aquifers along Little Peoples and Lodge Pole Creeks can be summarized as follows:

1. The valley fill overlies and is bounded laterally by shale except where the valleys cross the Eagle Sandstone and localized sandstone of the Judith River Formation. Hydraulic connection between the underlying sandstone and the valley fill is implied but not quantified by this report.

2. The principal aquifer in Little Peoples Creek valley is layered sand-and-gravel channel-fill deposits in the lower part of the valley-fill sequence. These deposits average about 20 ft in aggregate thickness in the center of the valley. In Lodge Pole Creek valley, the sand and gravel deposits are more randomly distributed, commonly occurring as multiple layers with limited hydraulic connection. The aquifer in both valleys is locally overlain or underlain by relatively impermeable clay and colluvium.

3. The valley-fill aquifers function essentially as unconfined aquifers in the southern, upgradient, unglaciated parts of the valleys and as confined aquifers in the northern parts, where they are overlain by glacial sediments.

4. Analysis of aquifer tests conducted along Little Peoples Creek results in calculated hydraulic-conductivity values of valley fill of 480, 300, 250, and 180 ft/d at wells located successively farther away from the mountain front. In valley fill along Lodge Pole Creek, analysis of aquifer tests results in calculated hydraulic-conductivity values of 760 ft/d in the unconfined, southern basin and about 180 ft/d near Lodge Pole.

5. Little Peoples and Lodge Pole Creek valley-fill aquifers are recharged by infiltration of streamflow, runoff, and precipitation, and by leakage of water from bedrock. The aquifers are discharged by leakage of water to streams, evapotranspiration, and outflow through valley fill at the downstream end of the study area. Discontinuous aquifer deposits may limit ground-water outflow in the Lodge Pole Creek valley.

6. In both valleys, water in wells near the mountain front is a calcium bicarbonate type, with dissolved-solids concentrations as small as 232 mg/L, whereas water in wells farther downgradient is a sodium sulfate or magnesium sulfate type with dissolved-solids concentrations as large as 11,500 mg/L. The increase in dissolved-solids concentration downflow in the aquifer probably results from a combination of leakage from bedrock, dissolution of minerals within the aquifer, and evapotranspiration. In the Lodge Pole Creek valley, the trend of increasing dissolved-solids concentrations also is related to limited flow through the confined part of the aquifer north of Lodge Pole.

The potential is good for additional withdrawals of water from the valley-fill aquifer along Little Peoples Creek. However, the development of additional wells capable of sustaining 150-250 gal/min for irrigation could lower water levels or hydraulic heads in the aquifer, increase leakage from bedrock, and increase infiltration from Little Peoples Creek, which may ultimately decrease streamflow. Although water-quality data indicate that the possible increase in dissolved-solids concentration caused by additional pumping would probably not preclude using the water for irrigation, the change of water quality in the aquifer might not be acceptable for use downgradient. Increased infiltration of water from Little Peoples Creek would generally improve water quality in the aquifer, but the resulting decrease in streamflow might not be acceptable to downstream users who rely on the stream for stockwater.

The potential is limited for additional withdrawals of water from the valley-fill aquifer along Lodge Pole Creek. Insufficient long-term recharge to the aquifer would severely limit the use of large-capacity wells. However, the potential is good for additional withdrawals in the southern, unconfined part of the aquifer for domestic and stock-watering use. Water quality in the northern confined part of the aquifer might be undesirable for domestic use.

Investigation of the Jim Brown, Big Warm, and Beaver Creek valleys indicated that none had sufficient aquifer thickness or recharge area to warrant the development of large-capacity irrigation wells. However, areas of Beaver Creek near the mountain front have the potential to support additional wells for domestic, stockwater, and small-scale irrigation use.

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SUPPLEMENTAL DATA

Table 12.--*Records of streamflow-measurement sites and gaging stations*

Little Peoples Creek		Lodge Pole Creek		Gaged basins outside study area (fig. 10)	
Site number	Location number	Site number	Location number	Site number	Location number
06154410	26N24E32BDD 01	06154430	26N25E05CDDC01	06154400	29N23E35C 01
S-1	26N24E32BBCA01	S-9	27N24E36DAAA01	06154490	30N25E25DAC 01
S-2	26N24E19CCCA01	S-10	27N24E26ADCD01	06154500	30N26E21BDD 01
S-3	26N23E24BDBA01	S-11	27N24E13CCDB01		
S-4	26N23E14ADAB01	S-12	27N24E01CDAB01		
S-5	26N23E01CABA01				
S-6	27N24E25CABC01				
S-7	27N23E14DDAD01				
S-8	27N23E09ADBC01				

Table 13.--*Records of wells*

Site number--numbering system described in text.
Location number--numbering system described in text.
Altitude of land surface--reported in feet above sea level.
Geologic unit--

Qvf	- Quaternary valley fill
QTt	- Quaternary and Tertiary terrace deposits
Kjr	- Upper Cretaceous Judith River Formation
Kcl	- Upper Cretaceous Claggett Shale
Ke	- Upper Cretaceous Eagle Sandstone
Kc	- Upper and Lower Cretaceous Colorado Group
KJke	- Lower Cretaceous to Middle Jurassic Kootenai Formation and Ellis Group

Depth of well--reported in feet below land surface.
Diameter of casing--reported in inches.
Type of finish--C, porous concrete; F, gravel, with perforations; G, galvanized iron; O, open end; P, perforated or slotted; S, stainless-steel screen; X, open hole.
Top of open interval--reported in feet below land surface.
Bottom of open interval--reported in feet below land surface.
Primary use of water--C, commerical; H, domestic; I, irrigation; P, public supply; S, stock; T, institution; U, unused.
Water level--reported in feet below or above (+) land surface.
Water-level source--D, driller; O, owner; R, reported; S, reporting agency.
Discharge--reported in gallons per minute.
Method of discharge measurement--B, bailer; E, estimated; O, orifice; R, reported; V, volumetric.
Onsite temperature--reported in degrees Celsius.
Onsite specific conductance--reported in microsiemens per centimeter at 25 degrees Celsius.
Symbols: -, --, no data or not applicable; <, less than.

Table 13.--*Records of wells*--Continued

Site number (pl. 2)	Location number	Altitude of land surface (feet)	Geologic unit	Depth of well (feet)	Diameter of casing (in.)	Type of finish	Top of open interval (feet)	Bottom of open interval (feet)	Primary use of water
B-1	26N24E31BDCD01	3,726	KJke	226	2	G	165	195	U
B-2	26N24E31BADC01	3,698	Kc	174	2	F	99	119	U
B-3	26N23E26ACDC01	3,634	Ke	144	2	P	122	132	U
B-4	26N23E23DCAD02	3,540	Ke	224	2	G	203	213	U
		--	--	--	-	-	--	--	-
B-5	26N23E23DCAD01	3,539	Ke	375	2	G	317	337	U
		--	--	--	-	-	--	--	-
B-6	26N23E23ACAC01	3,474	Ke	303	2	P	282	292	U
B-7	26N23E12DCBB01	3,391	Ke	94	2	G	73	83	U
		--	--	--	-	-	--	--	-
B-8	26N23E12DCBB02	3,405	Ke	214	2	G	193	203	U
O-1	25N22E12CABA01	3,490	QTt	67	2	F	52	57	U
O-2	26N24E31AAAA01	3,681	Qvf	83	2	F	68	78	U
O-3	26N24E30CBAC01	3,610	Qvf	28	2	F	23	28	U
O-4	26N24E30CBAA02	3,603	Qvf	21	2	F	15	21	U
O-5	26N24E30BDCB01	3,596	Qvf	45	2	F	40	45	U
O-6	26N24E30BDBA01	3,592	Qvf	45	2	F	35	45	U
O-7	26N24E30BADB01	3,590	Qvf	34	2	F	20	25	U
O-8	26N24E30BDAC01	3,595	Qvf	54	2	F	44	54	U
O-9	26N24E30BDAC02	3,594	Qvf	53	4	F	43	53	U
O-10	26N23E24BDBB01	3,464	Qvf	40	2	F	35	40	U
O-11	26N23E14BDBA01	3,373	Qvf	45	2	F	30	35	U
O-12	26N23E14ACBB01	3,373	Qvf	48	2	F	35	40	U
O-13	26N23E14ACBB02	3,372	Qvf	40	4	F	30	40	U
O-14	26N23E14ABCD01	3,374	Qvf	40	2	F	35	40	U
O-15	26N23E14ABDD01	3,376	Qvf	35	2	F	22	27	U
O-16	26N23E11ADAA01	3,304	Qvf	65	2	F	50	55	U
O-17	26N23E12ABAC01	3,302	Qvf	43	2	F	30	35	U
O-18	26N23E01DBCD01	3,276	Qvf	27	2	F	22	27	U
O-19	26N23E01BCCD01	3,264	Qvf	58	2	F	43	48	U
O-20	27N23E36CCCD01	3,236	Qvf	35	2	F	30	35	U
O-21	27N23E36CCDC01	3,241	Qvf	82	2	F	69	74	U
O-22	27N23E36CCDC02	3,240	Qvf	85	4	F	65	75	U
O-23	27N23E36CCDC03	3,240	Qvf	87	12	S	62	77	U
O-24	27N23E36CCDD01	3,241	Qvf	73	2	F	60	65	U
O-25	27N23E36CCDD02	3,242	Qvf	28	2	F	23	28	U
O-26	27N23E36CBBA01	3,214	Qvf	100	2	F	85	90	U
O-27	27N23E25BCCD01	3,165	Qvf	110	2	F	85	90	U
O-28	27N23E23AADC01	3,091	Kjr	130	2	F	120	130	U
O-29	27N23E23AAAA01	3,069	Qvf	88	2	F	70	80	U
O-30	27N23E10DDDD01	3,004	Qvf	97	2	F	80	85	U
O-31	27N23E09AADA01	2,959	Qvf	123	2	F	110	115	U
O-32	27N23E10BBBD01	2,965	Qvf	128	2	F	110	120	U
O-33	27N23E10BBBD02	2,965	Qvf	120	4	F	110	120	U
O-34	27N23E03CDCC01	2,988	Qvf	105	2	F	85	95	U
O-35	27N24E35CCAB01	3,360	Qvf	72	2	F	57	62	U
O-36	27N24E16BABC01	2,950	Qvf	24	2	F	11	14	U
O-37	28N24E32CCAA01	2,845	Qvf	113	2	F	94	103	U
O-38	26N25E20BABA02	3,630	Qvf	32	2	F	27	32	U
O-39	26N25E17DACB01	3,567	Qvf	55	2	F	40	45	U
O-40	26N25E17BAAA01	3,505	Qvf	65	2	F	50	55	U
O-41	26N25E17ABBB01	3,505	Qvf	55	2	F	50	55	U
O-42	26N25E17ABBB02	3,505	Qvf	54	4	F	44	54	U
O-43	26N25E08DCDC01	3,505	Qvf	55	2	F	40	45	U
O-44	26N25E08BDAC01	3,446	Qvf	60	2	F	45	50	U
O-45	26N25E05CAAA03	3,387	Qvf	68	2	F	50	58	U

Water level (feet)	Water-level source	Date water level measured	Dis-charge (gal/min)	Method of dis-charge measure-ment	Onsite temper-ature (°C)	Onsite spe-cific con-ductance (µS/cm)	Onsite pH (stand-ard units)	Date quality parameter measured	Site num-ber (pl. 2)
1.15	S	09-30-88	--	-	9.5	710	--	10-03-88	B-1
24.78	S	09-30-88	--	-	10.0	1,850	--	10-03-88	B-2
13.45	S	10-02-88	--	-	9.0	680	7.8	09-15-88	B-3
28.58	S	09-20-88	--	-	9.0	1,080	--	09-15-88	B-4
--	-	--	--	-	10.5	1,060	--	10-01-88	
+20.95	S	09-21-88	--	-	10.0	840	7.7	09-14-88	B-5
--	-	--	--	-	10.5	1,340	--	10-01-88	
28.82	S	10-02-88	--	-	10.0	775	--	10-03-88	B-6
31.13	S	10-02-88	--	-	9.0	1,140	--	09-20-88	B-7
--	-	--	--	-	10.5	1,280	--	10-02-88	
35.68	S	10-04-88	--	-	10.5	1,480	--	10-02-88	B-8
50.64	S	12-17-87	<1	E	--	--	--	--	O-1
45.17	S	08-26-87	--	-	9.0	480	7.5	08-26-87	O-2
26.22	S	08-26-87	<1	E	--	--	--	--	O-3
18.50	S	08-26-87	<1	E	--	--	--	--	O-4
13.74	S	08-26-87	--	-	9.0	477	7.6	08-26-87	O-5
11.8	S	08-26-87	--	-	--	--	--	--	O-6
7.91	S	08-26-87	--	-	9.5	813	7.3	08-26-87	O-7
16.61	S	08-26-87	20	E	--	--	--	--	O-8
12.79	S	08-26-87	60	O	9.0	471	7.4	10-17-87	O-9
20.05	S	08-26-87	--	-	8.5	572	7.3	10-14-87	O-10
19.99	S	08-27-87	--	-	8.5	1,550	7.2	10-14-87	O-11
19.39	S	08-27-87	--	-	--	--	--	--	O-12
19.10	S	08-28-87	70	O	7.5	1,150	7.3	10-19-87	O-13
21.91	S	08-27-87	--	-	9.5	570	7.4	10-14-87	O-14
--	-	--	1	E	--	--	--	--	O-15
4.08	S	08-27-87	20	E	7.5	620	7.3	10-15-87	O-16
15.95	S	08-27-87	10	E	9.0	13,000	7.5	10-15-87	O-17
7.17	S	08-27-87	10	E	9.5	6,620	7.3	09-14-87	O-18
7.22	S	08-27-87	20	E	8.5	1,620	7.4	09-12-87	O-19
1.34	S	08-26-87	10	E	9.0	1,550	7.4	09-12-87	O-20
4.48	S	08-26-87	40	E	--	--	--	--	O-21
3.88	S	08-26-87	50	E	9.0	985	7.2	09-14-87	O-22
3.32	S	06-22-88	270	O	8.5	970	7.3	06-23-88	O-23
4.72	S	08-26-87	5	E	8.5	713	7.3	09-12-87	O-24
16.08	S	08-26-87	--	-	9.0	3,030	7.3	09-12-87	O-25
14.27	S	08-28-87	20	E	8.5	881	7.5	09-13-87	O-26
16.78	S	08-27-87	--	-	9.5	953	7.5	09-13-87	O-27
44.24	S	08-27-87	--	-	10.0	1,260	7.6	09-13-87	O-28
22.64	S	08-27-87	10	E	10.5	993	7.5	09-13-87	O-29
8.43	S	08-27-87	--	-	9.0	1,550	8.2	09-11-87	O-30
+2.46	S	08-27-87	--	-	9.0	1,990	7.8	09-12-87	O-31
4.15	S	08-27-87	--	-	--	--	--	--	O-32
4.62	S	08-27-87	66	O	9.0	1,640	7.9	09-11-87	O-33
37.67	S	08-27-87	--	-	10.5	1,590	8.3	09-10-87	O-34
60.12	S	08-28-87	--	-	--	--	--	--	O-35
11.87	S	08-27-87	--	-	--	--	--	--	O-36
98.05	-	09-26-87	<1	E	--	--	--	--	O-37
32.00	S	08-30-87	<1	E	--	--	--	--	O-38
37.50	S	08-29-87	--	-	--	--	--	--	O-39
18.06	S	08-29-87	--	-	7.5	515	7.5	11-05-87	O-40
17.05	S	08-29-87	--	-	--	--	--	--	O-41
16.54	S	08-29-87	60	O	8.0	362	7.7	09-15-87	O-42
15.74	S	08-29-87	--	-	7.0	478	7.4	11-04-87	O-43
9.59	S	08-29-87	25	E	8.0	459	7.5	10-18-87	O-44
+2.50	S	08-28-87	30	E	--	--	--	--	O-45

Table 13.--*Records of wells*--Continued

Site number (pl. 2)	Location number	Altitude of land surface (feet)	Geologic unit	Depth of well (feet)	Diameter of casing (in.)	Type of finish	Top of open interval (feet)	Bottom of open interval (feet)	Primary use of water
O-46	26N25E05CAAA04	3,388	Qvf	60	4	F	50	60	U
O-47	26N25E05CACA01	3,389	Qvf	23	2	F	18	23	U
O-48	26N25E05CABD01	3,387	Qvf	69	2	F	56	61	U
O-49	26N25E05CAAA01	3,382	Qvf	64	2	F	51	56	U
O-50	26N25E05CAAA02	3,383	Qvf	40	2	F	35	40	U
O-51	27N24E36DAAC02	3,294	Qvf	85	2	F	70	75	U
O-52	27N24E36DAAC03	3,295	Qvf	43	2	F	38	43	U
O-53	27N25E31BCCD01	3,314	Qvf	97	2	F	84	89	U
O-54	27N24E26ADCD01	3,216	Qvf	87	2	F	74	79	U
O-55	27N24E26ABDC01	3,191	Qvf	86	2	F	71	76	U
O-56	27N24E13CCDB03	3,095	Qvf	38	2	F	26	31	U
O-57	27N24E13CCDB01	3,101	Qvf	54	2	F	45	50	U
O-58	27N24E13CCDB02	3,101	Qvf	55	4	F	45	55	U
O-59	27N24E13CCDA01	3,103	Qvf	65	2	F	52	57	U
O-60	27N24E13CDCB01	3,129	Kjr(?)	170	2	F	150	160	U
O-61	27N24E01CDAA01	2,972	Qvf	75	2	F	60	65	U
O-62	27N25E29CDDD01	3,410	Qvf	73	2	F	58	63	U
O-63	27N25E29BDBA01	3,340	Qvf	133	2	F	118	123	U
O-64	25N26E05BADB01	3,380	Qvf	62	2	F	47	52	U
O-65	25N26E22BBBB01	3,060	Qvf	34	2	F	18	24	U
O-66	25N26E15CCCA01	3,060	Qvf	17	2	F	9	14	U
P-1	26N23E30DBD 01	3,640	Qvf	63	4	-	63	--	U
P-2	26N24E31AAD 01	3,720	KJke	290	4	-	--	--	-
P-3	26N24E31AAD 02	3,720	KJke	215	6	P	94	215	H
P-4	26N24E30CDA 01	3,635	Qvf	40	4	-	30	40	U
P-5	26N24E30DDAB01	3,660	KJke	192	8	-	--	--	H
P-6	26N24E30DADC02	3,660	Qvf	--	6	-	--	--	P
P-7	26N24E30DADC01	3,660	KJke	--	-	-	--	--	P
P-8	26N24E30CBC 01	3,610	Qvf	40	4	-	29	40	U
P-9	26N24E30CBAD01	3,600	Kc	240	8	P	230	240	H
P-10	26N24E30DBC 01	3,635	Qvf	56	6	-	45	56	H
P-11	26N24E30DBB 01	3,635	Qvf	54	6	P	40	54	H
P-12	26N24E30DBD 02	3,645	Qvf	58	6	P	50	58	H
P-13	26N24E30DAB 01	3,640	Qvf	62	4	-	40	62	U
P-14	26N24E30ADC 01	3,625	Qvf	60	4	P	52	60	H
P-15	26N24E30CBAA01	3,600	Kc	289	8	-	--	--	H
P-16	26N24E30BCD 01	3,580	Qvf	35	4	-	--	--	H
P-17	26N24E30BDB 01	3,600	Qvf	39	4	P	34	39	H
P-18	26N24E30BDB 02	3,600	Qvf	28	6	-	--	--	H
P-19	26N24E30ACB 01	3,610	Qvf	65	4	P	58	65	H
P-20	26N24E30BBD 01	3,570	Qvf	26	4	-	--	--	H
P-21	26N24E30BAC 01	3,580	Qvf	--	-	-	--	--	H
P-22	26N24E19CDC 04	3,370	Qvf	37	4	P	27	37	H
P-23	26N24E19CDC 01	3,580	Qvf	25	4	P	--	--	H
P-24	26N24E19CDC 03	3,580	Kc	30	6	P	25	30	H
P-25	26N24E19CDC 02	3,580	Qvf	37	6	P	17	--	H
P-26	26N24E19CCD 01	3,560	Qvf	32	4	-	32	--	H
P-27	26N24E19BDCC01	3,580	Qvf	40	6	P	35	40	H
P-28	26N23E25AAA 01	3,540	Qvf	28	6	-	--	--	H
P-29	26N23E25AAA 02	3,540	Qvf	27	4	-	--	--	H
P-30	26N23E25AADA01	3,550	Qvf	35	6	P	30	35	H
P-31	26N23E24DDDB02	3,535	Qvf	25	6	P	22	25	H
P-32	26N23E24DDDB01	3,540	Qvf	32	-	-	--	--	H
P-33	26N23E24DDA 01	3,535	Qvf	45	6	P	22	45	C
P-34	26N24E19CCB 01	3,550	Qvf	32	4	-	32	--	H
P-35	26N24E19CCB 02	3,540	Qvf	32	6	O	--	--	H

Table 13.--*Records of wells*--Continued

Water level (feet)	Water-level source	Date water level measured	Dis-charge (gal/min)	Method of dis-charge measure-ment	Onsite temper-ature (°C)	Onsite spe-cific con-ductance (µS/cm)	Onsite pH (stand-ard units)	Date quality parameter measured	Site num-ber (pl. 2)
--	S	08-28-87	68	O	8.0	609	7.2	10-18-87	O-46
8.79	S	08-28-87	20	E	9.5	830	7.1	10-17-87	O-47
1.01	S	08-28-87	20	E	8.0	590	7.4	10-17-87	O-48
+4.96	S	08-28-87	20	E	7.5	710	7.4	10-17-87	O-49
1.24	S	08-28-87	15	E	7.5	615	7.4	10-17-87	O-50
+2.40	S	08-28-87	2	E	8.5	1,520	7.1	11-05-87	O-51
10.63	S	08-28-87	--	-	8.0	1,900	7.2	11-05-87	O-52
29.10	S	08-28-87	--	-	8.5	730	7.7	11-05-87	O-53
8.98	S	08-29-87	--	-	9.0	1,280	7.4	11-05-87	O-54
+15.17	S	08-30-87	80	E	8.5	2,170	7.1	11-05-87	O-55
9.23	S	08-29-87	15	E	8.5	2,690	7.0	11-04-87	O-56
15.08	S	08-29-87	20	E	--	--	--	--	O-57
15.11	S	08-29-87	55	O	9.0	3,020	6.8	10-16-87	O-58
15.60	S	08-29-87	20	E	8.5	2,900	6.8	11-04-87	O-59
15.67	S	08-29-87	25	E	9.0	2,850	6.8	11-04-87	O-60
62.85	S	08-30-87	1	E	--	--	--	--	O-61
22.55	S	08-29-87	10	E	8.0	613	7.5	11-04-87	O-62
91.99	S	08-29-87	2	E	8.5	869	7.3	11-04-87	O-63
5.03	S	08-30-87	25	E	8.0	440	7.5	11-03-87	O-64
12.71	S	08-30-87	2	E	10.0	2,520	7.2	11-03-87	O-65
4.44	S	08-30-87	2	E	10.0	680	7.3	11-03-87	O-66
47	D	01-01-61	10	-	--	--	--	--	P-1
32	D	12-01-60	4	R	--	628	--	10-25-73	P-2
53.19	S	08-15-73	6	R	--	720	--	08-15-73	P-3
22.00	S	01-01-61	2	-	--	--	--	--	P-4
--	-	--	4	R	--	822	--	10-25-73	P-5
64.75	S	11-03-88	--	-	10.5	980	6.8	11-03-88	P-6
+5.12	S	11-03-88	--	-	11.5	960	7.3	11-03-88	P-7
12	D	01-01-61	2	-	--	--	--	--	P-8
20.27	S	10-14-73	10	R	--	--	--	--	P-9
33.72	S	08-15-73	10	-	--	480	--	08-15-73	P-10
31.10	S	08-15-73	15	-	--	480	--	08-15-73	P-11
41.75	S	10-10-73	10	-	--	--	--	--	P-12
45.00	S	12-01-60	12	-	--	--	--	--	P-13
23.51	S	08-15-73	10	-	--	680	--	08-15-73	P-14
16.27	S	10-14-73	10	R	--	--	--	--	P-15
24	D	01-01-65	12	-	--	--	--	--	P-16
15.85	S	08-15-73	12	-	--	480	--	08-15-73	P-17
13	R	10-01-65	10	-	--	--	--	--	P-18
49	D	12-01-60	10	-	--	--	--	--	P-19
8	D	01-01-61	12	-	--	480	--	08-15-73	P-20
--	-	--	--	-	--	910	--	08-15-73	P-21
14	D	01-01-61	10	-	--	--	--	--	P-22
10.63	S	08-14-73	5	R	--	850	--	08-14-73	P-23
18	D	09-01-73	10	R	--	--	--	--	P-24
11.24	S	08-14-73	10	-	--	850	--	08-14-73	P-25
18	D	01-01-61	15	-	--	--	--	--	P-26
24.00	S	10-01-73	10	-	--	--	--	--	P-27
6.01	S	08-14-73	10	R	12.0	530	--	08-14-73	P-28
18	D	01-01-61	8	-	--	--	--	--	P-29
8	D	03-01-71	10	V	--	--	--	--	P-30
18	D	09-01-73	7	-	--	--	--	--	P-31
--	-	--	--	-	9.5	520	7.1	11-02-88	P-32
21.60	S	08-14-73	23	-	--	--	--	--	P-33
22	D	01-01-61	4	-	--	630	--	08-14-73	P-34
9.70	S	08-14-73	6	R	--	--	--	--	P-35

Table 13.--*Records of wells*--Continued

Site number (pl. 2)	Location number	Altitude of land surface (feet)	Geologic unit	Depth of well (feet)	Diameter of casing (in.)	Type of finish	Top of open interval (feet)	Bottom of open interval (feet)	Primary use of water
P-36	26N24E19CCB 03	3,540	Qvf	25	6	P	20	25	H
P-37	26N23E24DDB 01	3,520	Qvf	21	4	P	21	--	H
P-38	26N23E24DBD 02	3,500	Qvf	23	6	P	22	23	H
P-39	26N23E24DBD 01	3,500	Qvf	26	4	-	26	--	H
P-40	26N23E24DAB 01	3,510	Qvf	33	6	P	28	33	H
P-41	26N23E24CADD01	3,510	Qvf	40	4	-	34	40	H
P-42	26N23E24DBA 01	3,490	Qvf	21	4	-	--	--	U
P-43	26N23E24DBBC01	3,480	Qvf	40	6	P	35	40	H
P-44	26N23E24ACC 01	3,480	Qvf	32	4	-	--	--	H
P-45	26N23E24BDC 01	3,480	Qvf	31	4	-	--	--	U
P-46	26N23E24BDB 01	3,470	Qvf	34	4	-	34	--	H
P-47	26N23E24BBDD01	3,460	Qvf	26	6	-	--	--	H
P-48	26N23E23AAD 01	3,480	Ke	69	6	P	45	69	H
P-49	26N23E23AAD 02	3,460	Ke	48	6	-	--	--	P
P-50	26N23E24BBC 01	3,460	Ke	91	6	P	69	91	H
P-51	26N23E14DDD 01	3,430	Qvf	32	4	-	32	--	H
P-52	26N23E14DDA 04	3,420	Qvf	46	6	P	35	--	H
P-53	26N23E14DDA 01	3,425	Qvf	30	4	-	28	29	H
P-54	26N23E14DDA 05	3,420	Qvf	31	6	P	27	31	H
P-55	26N23E14DDB 01	3,415	Qvf	34	4	-	34	--	U
P-56	26N23E14DDB 02	3,420	Qvf	32	6	P	26	32	H
P-57	26N23E14DDA 03	3,415	Qvf	29	4	P	35	46	H
P-58	26N23E14DDA 02	3,420	Qvf	80	4	-	--	--	H
P-59	26N23E13CBC 01	3,420	Qvf	25	4	-	21	25	U
P-60	26N23E13CBB 01	3,410	Qvf	20	4	-	--	--	H
P-61	26N23E14DAAA01	3,400	Qvf	20	4	-	--	--	U
P-62	26N23E14ADD 02	3,400	Qvf	23	6	P	20	23	H
P-63	26N23E14ADD 01	3,400	Qvf	37	6	P	20	37	H
P-64	26N23E14ADCB01	3,390	Ke	180	6	-	--	--	H
P-65	26N23E14ADC 01	3,385	Qvf	25	4	-	21	25	H
P-66	26N23E14ADA 01	3,360	Qvf	40	4	-	21	40	U
P-67	26N24E17BAAD01	3,670	KJke	--	-	-	--	--	-
P-68	26N23E14ABCB01	3,370	Qvf	--	6	-	--	--	S
P-69	26N23E11DBC 02	3,345	Qvf	28	6	P	22	28	H
P-70	26N23E11DBC 01	3,345	Qvf	21	6	O	--	--	U
P-71	26N23E12CBB 01	3,330	Qvf	35	6	P	25	--	H
P-72	26N23E12ACA 01	3,320	Ke	37	6	P	13	37	S
P-73	26N23E12ADDD01	3,370	Qvf	45	6	F	20	--	H
P-74	26N23E11ABD 02	3,315	Qvf	21	4	-	--	--	H
P-75	26N23E11ABD 01	3,320	Qvf	46	6	P	36	--	H
P-76	26N23E02DDB 01	3,310	Kjr	76	6	P	27	76	H
P-77	26N23E02DAA 01	3,295	Qvf	120	6	P	26	--	H
P-78	26N23E01CBB 01	3,270	Kcl	132	4	X	60	132	-
P-79	26N23E01CBAB01	3,265	Qvf	55	4	-	--	--	H
P-80	26N23E01BDCC01	3,255	Qvf	50	-	-	--	--	H
P-81	26N23E02ADAD01	3,260	Qvf	--	6	-	--	--	H
P-82	26N23E01BCB 01	3,255	Qvf	35	4	-	--	--	H
P-83	26N24E05CBB 01	3,380	Kc	50	4	-	--	--	H
P-84	26N24E05CBC 02	3,380	Ke	100	6	P	50	100	H
P-85	26N24E05BBC 01	3,345	--	41	4	-	--	--	H
P-86	27N24E31DBA 01	3,290	Qvf	68	4	O	--	--	H
P-87	27N23E36CBD 01	3,210	Qvf	42	4	-	--	--	H
P-88	27N23E36CBD 02	3,205	Qvf	50	4	-	--	--	I
P-89	27N23E36CBD 03	3,200	Qvf	21	4	-	--	--	H
P-90	27N23E36CBDB01	3,210	--	70	6	G	--	--	H

Table 13.--*Records of wells*--Continued

Water level (feet)	Water-level source	Date water level measured	Discharge (gal/min)	Method of discharge measurement	Onsite temperature (°C)	Onsite specific conductance (µS/cm)	Onsite pH (standard units)	Date quality parameter measured	Site number (pl. 2)
15	D	09-01-73	10	-	--	--	--	--	P-36
12	D	01-01-61	7	-	--	600	--	08-14-73	P-37
12	S	10-01-73	10	-	--	--	--	--	P-38
15	R	01-01-61	12	-	--	--	--	--	P-39
11	D	08-01-65	10	-	--	530	--	08-14-73	P-40
22	D	03-01-61	15	R	--	1,800	--	08-09-69	P-41
9.00	S	01-01-61	15	-	--	--	--	--	P-42
26.45	S	10-01-73	10	-	--	--	--	--	P-43
18	R	01-01-61	8	-	--	--	--	--	P-44
24	D	01-01-61	10	-	--	--	--	--	P-45
26.40	D	01-01-61	12	-	--	600	--	08-09-73	P-46
15	R	07-01-65	8	-	--	720	--	08-09-73	P-47
45	D	04-01-68	5	R	--	--	--	--	P-48
21	D	04-01-69	5	R	--	--	--	--	P-49
4	D	11-01-72	10	R	--	--	--	--	P-50
24.80	R	01-01-61	8.0	-	--	--	--	--	P-51
21	D	04-01-68	14	-	--	--	--	--	P-52
17	D	01-01-61	10	-	--	--	--	--	P-53
20	R	12-01-72	10	-	--	--	--	--	P-54
27	D	01-01-61	5.0	-	--	--	--	--	P-55
25.00	S	10-01-73	10	-	--	--	--	--	P-56
5.17	S	08-09-73	10	-	--	1,550	--	08-09-73	P-57
28	D	01-01-61	1.0	-	--	--	--	--	P-58
13	R	01-01-61	4.0	-	--	--	--	--	P-59
12.12	S	07-17-73	12	-	--	640	--	07-17-73	P-60
14	D	03-01-61	7.0	-	--	--	--	--	P-61
15	R	09-01-73	10	-	--	--	--	--	P-62
11	R	10-01-73	10	-	--	--	--	--	P-63
--	-	--	--	-	10.5	1,500	9.0	11-03-88	P-64
18	R	01-01-61	8.0	-	--	680	--	07-17-73	P-65
14	R	01-01-61	2.0	-	--	--	--	--	P-66
--	-	--	--	-	--	687	--	10-25-73	P-67
24.74	S	11-04-88	--	-	9.0	1,010	7.2	11-04-88	P-68
13.69	S	08-09-73	10	-	--	690	--	08-09-73	P-69
15	D	07-01-65	8.0	-	--	--	--	--	P-70
11.22	S	07-17-73	15	-	--	--	--	--	P-71
13	D	03-01-70	8.0	R	--	--	--	--	P-72
11.68	S	08-15-73	20	-	--	659	--	10-25-73	P-73
5.00	S	01-01-61	2.0	-	--	--	--	--	P-74
4.19	S	08-09-73	10	-	--	--	--	--	P-75
14.07	S	07-17-73	10	R	--	1,190	--	10-25-73	P-76
20.17	S	08-14-73	6.0	-	--	4,280	--	10-25-73	P-77
43	D	12-01-60	4.0	R	--	--	--	--	P-78
4.55	S	07-17-73	6.0	-	--	800	--	07-17-73	P-79
--	-	--	3.0	-	7.5	790	--	08-08-73	P-80
22.68	S	11-02-88	--	-	10.5	2,150	7.4	11-02-88	P-81
2.30	S	07-17-73	12	-	--	1,460	--	07-17-73	P-82
33	D	01-01-61	5.0	R	--	--	--	--	P-83
30	D	11-01-72	10	R	--	--	--	--	P-84
18	O	02-01-61	8.0	-	--	--	--	--	P-85
26	R	02-01-61	3.0	-	--	--	--	--	P-86
10	-	07-01-61	15	-	7.5	842	--	10-25-73	P-87
--	-	--	50	-	8.0	--	--	10-01-73	P-88
9.00	S	03-01-61	15	-	--	--	--	--	P-89
--	-	--	32	V	7.5	1,400	7.2	10-31-88	P-90

Table 13.--*Records of wells*--Continued

Site number (pl. 2)	Location number	Altitude of land surface (feet)	Geologic unit	Depth of well (feet)	Diameter of casing (in.)	Type of finish	Top of open interval (feet)	Bottom of open interval (feet)	Primary use of water
P-91	27N23E35DABA01	3,270	Kjr	--	6	-	--	--	H
P-92	27N23E35ADD 01	3,250	Kjr	85	6	P	76	85	H
P-93	27N23E36BBCD01	3,190	Qvf	73	-	P	73	--	H
P-94	27N23E35AAAA01	3,195	Qvf	80	5	P	70	80	H
		--	--	--	-	-	--	--	-
P-95	27N23E34BCAB01	3,375	Kjr	232	6	P	150	232	S
P-96	27N23E25CBAD01	3,160	Qvf	68	6	-	--	--	H
P-97	27N23E14DDBD01	3,055	Qvf	85	6	P	79	85	H
P-98	27N23E14CAAD01	3,040	Qvf	67	6	P	57	67	H
P-99	27N23E14CADA01	3,040	Qvf	70	-	-	--	--	U
P-100	28N23E34AAD 01	2,905	Qvf	145	6	X	62	145	U
P-101	28N23E34AAD 02	2,900	Qvf	149	-	P	129	149	H
P-102	28N23E34AAAC01	2,902	Kjr	--	-	-	--	--	-
P-103	28N23E36BAB 01	2,860	Qvf	115	6	P	105	115	H
P-104	28N23E25ADDA01	2,840	Kjr	190	6	P	171	181	S
P-105	28N24E30BBCD01	2,858	--	--	-	-	--	--	-
P-106	28N24E29DBAB01	2,800	Qvf	127	6	-	--	--	S
P-107	26N24E02ACB 01	3,450	Ke	33	4	-	--	--	H
P-108	27N24E35CDC 01	3,375	Qvf	26	6	P	19	26	H
P-109	27N24E35CDBC01	3,480	Ke	--	-	-	--	--	-
P-110	26N25E20BABA01	3,620	Kc	80	6	-	--	--	H
P-111	26N25E20ABD 01	3,720	KJke	195	6	P	160	195	H
P-112	26N25E17CDD 01	3,610	KJke	180	6	P	156	180	H
P-113	26N25E17BCAB01	3,560	Qvf	29	4	-	--	--	H
P-114	26N25E08CCAA01	3,470	Qvf	55	6	P	40	55	H
P-115	26N25E08DBC 01	3,475	Qvf	45	4	-	--	--	H
P-116	26N25E08BDC 03	3,455	Qvf	30	6	P	25	30	H
P-117	26N25E08BDC 02	3,455	Qvf	31	4	-	--	--	H
P-118	26N25E08BDC 01	3,480	Qvf	39	4	-	--	--	H
P-119	26N25E08BCDB01	3,480	Qvf	49	6	P	43	49	U
P-120	26N25E08BCA 02	3,450	Qvf	47	6	P	41	47	H
P-121	26N25E08BDA 01	3,445	Qvf	38	4	-	--	--	H
P-122	26N25E08BDBC01	3,445	Qvf	34	6	O	--	--	H
P-123	26N25E08BAD 01	3,430	Qvf	40	4	-	--	--	H
P-124	26N25E08BCA 01	3,460	Ke	38	4	-	--	--	H
P-125	26N25E08BBDA01	3,450	Qvf	48	6	P	42	48	H
P-126	26N25E08BAB 01	3,430	Qvf	42	6	P	32	42	H
P-127	26N25E08BAB 02	3,430	Qvf	33	4	-	--	--	U
P-128	26N25E05CDC 03	3,420	Ke	76	4	-	--	--	U
P-129	26N25E05CDC 04	3,420	Ke	134	6	P	55	134	H
P-130	26N25E08ABA 01	3,430	Qvf	42	4	-	--	--	H
P-131	26N25E08ABA 02	3,430	Qvf	41	6	-	--	--	H
P-132	26N25E05DCC 01	3,415	Qvf	35	6	O	--	--	H
P-133	26N25E05CDC 01	3,430	Ke	75	4	-	--	--	U
P-134	26N25E05CDC 02	3,420	Ke	76	4	-	--	--	P
P-135	26N25E05CCB 01	3,440	Ke	42	4	-	--	--	H
P-136	26N25E05CDBD01	3,415	Kcl	--	-	-	--	--	-
P-137	26N25E05CCA 01	3,440	Ke	46	4	-	--	--	H
P-138	26N25E05CBC 01	3,380	Kc	50	4	-	--	--	H
P-139	26N25E05CDA 01	3,405	--	35	4	-	--	--	H
P-140	26N25E05CDA 02	3,405	Qvf	40	6	P	29	40	H
P-141	26N25E05CDA 03	3,400	Qvf	40	4	P	21	40	H
P-142	26N25E05CAD 02	3,395	Qvf	21	4	-	--	--	U
P-143	26N25E05CAD 03	3,395	Qvf	20	4	-	--	--	H
P-144	26N25E05CAD 01	3,395	Qvf	28	4	-	--	--	U
P-145	26N25E05CADA01	3,495	Qvf	39	6	O	--	--	H

Table 13.--*Records of wells*--Continued

Water level (feet)	Water-level source	Date water level measured	Discharge (gal/min)	Method of discharge measurement	Onsite temperature (°C)	Onsite specific conductance (µS/cm)	Onsite pH (standard units)	Date quality parameter measured	Site number (pl. 2)
53.84	S	11-03-88	--	-	11.0	1,110	7.2	11-03-88	P-91
46	D	10-01-73	15	R	--	--	--	--	P-92
--	-	--	50	-	--	--	--	--	P-93
--	-	--	60	-	8.5	848	--	03-29-73	P-94
--	-	--	--	-	8.5	--	--	07-12-73	
154	D	03-01-70	4	B	--	--	--	--	P-95
--	-	--	--	-	8.0	880	7.5	11-01-88	P-96
18.18	S	07-12-73	20	-	11.0	1,070	--	07-12-73	P-97
--	-	--	8	-	9.0	1,560	--	07-12-73	P-98
--	-	--	--	-	--	--	--	--	P-99
+43	D	08-01-73	500	-	--	--	--	--	P-100
+43	D	09-01-73	500	-	9.0	--	--	10-01-73	P-101
--	-	--	--	-	9.0	3,190	--	10-25-73	P-102
78.00	S	10-01-73	10	-	--	--	--	--	P-103
116	D	04-01-65	7	B	--	--	--	--	P-104
--	-	--	--	-	--	--	--	--	P-105
--	-	--	--	-	8.5	--	--	07-26-73	P-106
15	D	02-01-61	1	R	--	--	--	--	P-107
3.70	S	08-13-73	10	-	--	--	--	--	P-108
--	-	--	--	-	--	1,180	--	10-25-73	P-109
--	-	--	--	-	8.5	690	7.1	11-02-88	P-110
36	D	04-01-71	10	R	--	--	--	--	P-111
50	D	10-01-72	10	R	--	--	--	--	P-112
14	D	02-01-61	10	-	--	--	--	--	P-113
12	D	03-01-71	20	-	--	--	--	--	P-114
37	D	02-01-61	10	V	--	--	--	--	P-115
10	D	11-01-72	15	-	--	--	--	--	P-116
20	D	02-01-61	5	-	--	--	--	--	P-117
28	D	03-01-61	10	-	--	--	--	--	P-118
16	D	05-01-71	10	-	--	--	--	--	P-119
--	-	--	10	-	--	--	--	--	P-120
18	D	02-01-61	10	-	--	510	--	08-16-73	P-121
6.64	S	08-16-73	10	-	--	460	--	08-16-73	P-122
10	D	03-01-61	15	-	--	--	--	--	P-123
18	D	02-01-6I	5	V	--	--	--	--	P-124
8.15	S	08-16-73	10	-	--	560	--	08-16-73	P-125
5.08	S	08-16-73	10	-	--	790	--	08-16-73	P-126
7.50	D	02-01-61	5	V	--	--	--	--	P-127
51	D	02-01-61	2	R	--	--	--	--	P-128
9.93	S	08-16-73	--	-	--	2,850	--	08-16-73	P-129
12	D	02-01-61	7	-	--	--	--	--	P-130
12	D	11-01-72	15	-	--	--	--	--	P-131
12	R	07-01-65	10	-	--	540	--	08-16-73	P-132
18	D	03-01-61	2	R	--	--	--	--	P-133
35	D	02-01-61	.5	R	--	--	--	--	P-134
28	D	03-01-61	2	R	--	--	--	--	P-135
--	-	--	--	-	--	2,680	--	10-25-73	P-136
16	D	02-01-61	2	R	--	--	--	--	P-137
35	D	02-01-61	5	R	--	--	--	--	P-138
18	S	03-01-61	10	-	--	--	--	--	P-139
16.55	S	08-13-73	15	-	--	--	--	--	P-140
6	D	02-01-61	5	-	--	--	--	--	P-141
10	D	02-01-61	2	-	--	--	--	--	P-142
5	D	02-01-61	2	-	--	--	--	--	P-143
13	D	02-01-61	8	-	--	--	--	--	P-144
5.40	S	08-16-73	10	-	--	--	--	--	P-145

Table 13.--*Records of wells*--Continued

Site number (pl. 2)	Location number	Altitude of land surface (feet)	Geologic unit	Depth of well (feet)	Diameter of casing (in.)	Type of finish	Top of open interval (feet)	Bottom of open interval (feet)	Primary use of water
P-146	26N25E05CAA 03	3,390	Qvf	37	4	-	--	--	H
P-147	26N25E05ACAD01	3,410	QTt	30	4	-	--	--	H
P-148	26N25E05CAA 01	3,390	Qvf	43	4	-	--	--	H
P-149	26N25E05CAA 02	3,390	Qvf	38	4	X	--	--	H
P-150	26N25E05BDDA01	3,380	Qvf	25	6	-	--	--	H
P-151	26N25E05BDDA02	3,400	Qvf	30	6	P	26	30	H
P-152	26N25E05BDDD01	3,380	Qvf	41	6	P	40	--	H
P-153	26N25E06ACB 01	3,360	Qvf	32	4	-	--	--	H
P-154	27N25E32CCC 01	3,345	Qvf	21	4	-	--	--	H
P-155	27N25E31CDDB01	3,320	Qvf	37	6	-	--	--	H
P-156	27N24E36DAAC01	3,320	Qvf	30	6	P	27	30	H
P-157	27N24E26DADC01	3,220	Qvf	52	4	-	--	--	H
P-158	27N24E26ADCA01	3,210	Qvf	85	6	P	76	85	H
P-159	27N25E20BCD 01	3,250	Kjr	115	6	P	110	115	H
P-160	27N25E20BCA 01	3,240	Kjr	99	4	O	--	--	H
P-161	26N25E11CAC 01	3,260	Ke	40	4	-	--	--	H
P-162	26N25E13BBA 01	3,230	Ke	65	4	-	--	--	H
P-163	26N25E12CDC 01	3,210	Ke	79	4	-	--	--	H
P-164	26N25E12CAC 01	3,205	Qvf	29	6	P	24	29	H
P-165	26N25E01ACAB01	3,150	Kjr	90	6	P	80	90	H
P-166	27N25E25DACC01	2,980	Kjr	94	4	-	--	--	H
P-167	27N25E25DADB01	2,970	Qvf	97	6	P	90	97	H
P-168	27N26E29BCAC01	2,890	Qvf	104	6	P	97	104	H
P-169	27N26E29BCBB01	2,895	Qvf	109	6	P	101	109	H
P-170	27N26E18CBAB01	2,875	Qvf	90	4	O	88	90	H
P-171	27N26E17CBCB01	2,820	Qvf	21	4	O	--	--	H
P-172	27N26E17CBCD01	2,825	Qvf	30	4	P	26	30	H
P-173	27N26E21ACB 01	2,810	Kjr	533	3	P	415	533	U
P-174	27N26E22BCA 01	2,790	Qvf	8	36	O	--	--	S
P-175	26N26E33AAA 01	3,150	Qvf	42	4	-	--	--	H
P-176	26N26E33AAA 02	3,145	Qvf	42	6	P	37	--	H
P-177	25N26E05BAC 01	3,380	KJke	37	6	P	31	37	H
P-178	25N26E05DDBA01	3,280	Qvf	30	6	-	--	--	H
P-179	25N26E08ADAA01	3,460	Qvf	23	6	P	21	--	H
P-180	25N26E08ADD 02	3,230	Qvf	25	6	P	15	--	H
P-181	25N26E08ADDA01	3,230	Qvf	14	-	C	--	--	T
P-182	25N26E09BCC 01	3,215	Qvf	30	6	P	19	--	H
P-183	25N26E09CDB 01	3,180	Qvf	20	6	-	--	--	H
P-184	25N26E16BDA 01	3,130	Qvf	14	-	O	--	--	H
P-185	25N25E23ABC 01	3,560	Qvf	30	6	P	29	--	U
P-186	25N25E24DCBA01	3,400	Qvf	35	6	P	28	--	H

Table 13.--*Records of wells*--Continued

Water level (feet)	Water-level source	Date water level measured	Discharge (gal/min)	Method of discharge measurement	Onsite temperature (°C)	Onsite specific conductance (µS/cm)	Onsite pH (standard units)	Date quality parameter measured	Site number (pl. 2)
18	D	03-01-61	8	-	--	--	--	--	P-146
11	D	02-01-61	2	V	--	--	--	--	P-147
6	D	02-01-61	8	-	--	--	--	--	P-148
9	D	02-01-61	8	-	--	--	--	--	P-149
2.23	S	11-01-88	--	-	7.5	700	7.4	11-01-88	P-150
--	-	--	10	-	--	--	--	--	P-151
--	-	--	7	-	7.0	520	8.0	10-25-73	P-152
5.85	S	08-13-73	2	-	--	3,700	--	08-13-73	P-153
8.27	S	08-13-73	10	-	--	--	--	--	P-154
3.44	S	08-13-73	10	-	--	630	--	08-13-73	P-155
10	D	08-01-65	10	-	--	--	--	--	P-156
6.77	S	08-13-73	12	-	--	--	--	--	P-157
+1	R	05-01-71	10	-	--	1,230	--	08-13-73	P-158
68	R	04-01-71	--	-	--	--	--	--	P-159
65	R	02-01-61	2	R	--	--	--	--	P-160
20	D	02-01-61	2	V	--	--	--	--	P-161
5	D	02-01-61	3	R	--	--	--	--	P-162
4	D	02-01-61	10	R	--	--	--	--	P-163
13	D	08-01-65	8	-	--	--	--	--	P-164
77	D	08-01-65	6	R	--	--	--	--	P-165
56.39	S	07-25-73	8	V	--	1,480	--	07-25-73	P-166
53.09	S	07-25-73	10	-	--	--	--	--	P-167
3.40	S	07-25-73	40	-	--	3,000	--	07-25-73	P-168
5.79	S	07-25-73	20	R	10.5	--	--	07-25-73	P-169
--	-	--	2	-	--	--	--	--	P-170
3.03	S	07-01-73	2	-	--	--	--	--	P-171
9.20	S	07-01-73	6	B	--	--	--	--	P-172
150	D	10-01-59	12	B	--	--	--	--	P-173
6.40	S	07-25-73	--	-	--	--	--	--	P-174
18.00	S	03-01-61	101	-	--	--	--	--	P-175
9.00	S	11-01-72	15	-	--	--	--	--	P-176
15	D	05-01-71	10	R	--	--	--	--	P-177
--	-	01-01-65	5	R	--	--	--	--	P-178
11	D	06-01-65	10	-	--	--	--	--	P-179
12	D	03-01-71	8	-	--	--	--	--	P-180
10	D	01-01-42	25	R	--	--	--	--	P-181
6	D	06-01-65	10	-	--	--	--	--	P-182
12	D	07-01-65	6	-	--	--	--	--	P-183
10	D	09-01-58	200	-	--	--	--	--	P-184
--	O	06-01-65	10	-	--	--	--	--	P-185
14	O	07-01-65	6	-	--	--	--	--	P-186

Table 14.--*Records of test holes*

Site number--numbering system described in text.
Location number--numbering system described in text.
Altitude of land surface--reported in feet above sea level.
Deepest geologic unit penetrated--

- Kb - Upper Cretaceous Bearpaw Shale
- Kjr - Upper Cretaceous Judith River Formation
- Kcl - Upper Cretaceous Claggett Shale
- Kc - Upper and Lower Cretaceous Colorado Group
- KJke - Lower Cretaceous to Middle Jurassic Kootenai Formation and Ellis Group

Depth drilled--reported in feet below land surface.

Site number (pl. 2)	Location number	Altitude of land surface (feet)	Deepest geologic unit penetrated	Depth drilled (feet)	Date hole drilled
T-1	25N23E08AAAA01	3,650	Kjr	60	08-28-87
T-2	26N24E32BBBB01	3,700	KJke	80	07-06-87
T-3	26N24E30CCAC01	3,640	Kc	60	07-07-87
T-4	26N24E30BAAA01	3,600	Kc	40	07-09-87
T-5	26N23E14AACD01	3,380	Kc	20	07-11-87
T-6	27N23E36CCDA01	3,240	Kjr	130	07-12-87
T-7	27N23E36CDCD01	3,220	Kjr	80	07-13-87
T-8	27N23E13CCBC01	3,060	Kjr	80	07-21-87
T-9	27N23E13CCAB01	3,070	Kjr	80	07-21-87
T-10	27N23E09ACAD01	2,965	Kjr	125	07-23-87
T-11	27N23E09ADBB01	2,960	Kjr	130	07-23-87
T-12	27N23E09AADC01	2,940	Kjr	130	07-22-87
T-13	27N24E35CCBB01	3,400	KJke	40	08-19-87
T-14	27N24E35CCBA01	3,370	KJke	40	08-13-87
T-15	27N24E17DBAB01	2,990	Kjr	80	08-18-87
T-16	27N24E16BBDC01	2,970	Kjr	120	08-18-87
T-17	27N24E16BBDA01	2,960	Kjr	90	08-18-87
T-18	27N24E16BABD02	2,950	Kjr	40	08-18-87
T-19	27N24E16BABD01	2,950	Kjr	80	08-18-87
T-20	27N24E16BAAC01	2,980	Kjr	40	08-18-87
T-21	28N24E32CCBB01	2,855	Kjr	130	08-25-87
T-22	26N25E17CDCC01	3,640	KJke	35	08-30-87
T-23	26N25E05ACCB01	3,420	Kcl	35	07-26-87
T-24	27N24E36DADB01	3,320	Kcl	60	08-19-87
T-25	27N25E31CBBB01	3,310	Kcl	80	07-27-87
T-26	27N25E31CBBA01	3,300	Kcl	80	07-27-87
T-27	27N24E01CBCD01	3,000	Kjr	120	08-16-87
T-28	27N24E01CACC01	3,010	Kjr	120	08-15-87
T-29	27N24E01CDAB01	2,960	Kjr	65	08-15-87
T-30	27N24E01DCBC01	3,030	Kjr	140	08-15-87
T-31	27N24E01DDBC01	3,050	Kjr	190	08-16-87
T-32	27N25E29CDCD01	3,390	Kjr	130	08-17-87
T-33	27N25E19AABC01	3,210	Kjr	130	08-29-87
T-34	27N25E19ABDB01	3,240	Kjr	120	08-29-87
T-35	27N25E19AAAA01	3,230	Kjr	132	08-29-87
T-36	25N26E09CBBB01	3,220	Kc	20	08-27-87
T-37	25N26E09BCCD01	3,220	Kc	20	08-27-87
T-38	25N26E09BCBD01	3,220	Kc	20	08-27-87
T-39	25N26E09BCDB01	3,220	Kc	30	08-27-87
T-40	25N26E15CCAD01	3,070	Kc	40	08-26-87
T-41	25N26E15CACA01	3,070	Kb	40	08-26-87
T-42	25N26E15BDDD01	3,070	Kb	40	08-26-87
T-43	25N26E15ACBC01	3,070	Kb	20	08-26-87
T-44	26N26E33CDBD01	3,650	Kc	40	08-27-87

Table 15.--*Lithologic logs of selected observation wells and test holes*

[Particle-size descriptions are based on report of National Research Council (1947). Abbreviations: ft, feet; gal/min, gallons per minute; h, hours]

Description	Thickness penetrated (ft)	Bottom of interval below land surface (ft)
Site number: O-6		
Completed: July 8, 1987		
Alluvium:		
Soil and clay, brown	10	10
Gravel, loose; zones of cobbles; caving down-hole; losing circulation of drilling fluid	40	50
Colluvium:		
Gravel and clay, tight; minor quantity of white clay; poor returns because of uphole wash-in	15	65
Colorado Group:		
Shale, black, tight	32	97
Remarks: Set 20-slot screen at 35-45 ft. Well produced water with compressed air but water cleared slowly.		
Site number: O-8		
Completed: July 9, 1987		
Alluvium:		
Gravel, sand, and clay, tight	25	25
Gravel, loose; zones of cobbles; caving down-hole, losing drilling fluid	3	28
Clay, tight	2	30
Gravel, loose; fair potential for water production	18	48
Clay, tight; hard drilling	1	49
Gravel, loose; good potential for water production	6	55
Colorado Group:		
Shale, black, tight	5	60
Remarks: Set 20-slot screen at 44-54 ft. Well produced about 20 gal/min with compressed air.		
Site number: O-9		
Completed: July 10, 1987		
Alluvium:		
Gravel, sand, and brown clay, tight	25	25
Gravel, loose	3	28
Clay, tight	2	30
Gravel, loose	18	48
Clay, tight; hard drilling	1	49
Gravel, loose	6	55
Colorado Group:		
Shale, black, tight	5	60
Remarks: Set 20-slot screen at 43-53 ft. Well produced about 40 gal/min with compressed air.		

Description	Thickness penetrated (ft)	Bottom of interval below land surface (ft)
Site number: O-12		
Completed: July 10, 1987		
Alluvium:		
Clay, brown; includes minor quantity of white clay stringers	21	21
Gravel, loose; rounded to angular	21	42
Colorado Group:		
Shale, gray	10	52
Remarks: Set 20-slot screen at 35-40 ft with 8 ft of tail pipe. Well produced abundant water with compressed air.		
Site number: O-13		
Completed: August 28, 1987		
Alluvium:		
Soil and clay	21	21
Gravel and sand, loose; gravel 40 percent well-rounded, 40 percent subangular, and 20 percent subrounded	19	40
Colorado Group:		
Shale, gray	7	47
Remarks: Set 20-slot screen at 30-40 ft with no tail pipe. Well produced about 40-50 gal/min with compressed air; well water cleared after developing 2.5 h.		
Site number: O-19		
Completed: August 14, 1987		
Alluvium and glacial deposits:		
Soil and clay, brown, sticky	14	14
Gravel, loose, small; broken pieces, iron stained	4	18
Clay, gray, soft; smooth drilling	8	26
Gravel, loose (as above)	1	27
Clay, gray, gritty	13	40
Sand(?); no returns	2	42
Gravel, loose; larger and more rounded than above	7	49
Judith River Formation:		
Clay, soft; grading to hard at 52 ft; probably weathered shale	6	55
Shale	5	60
Remarks: Set 30-slot screen at 43-48 ft with 10 ft of tail pipe. Well produced about 20 gal/min with compressed air; well water cleared quickly.		
Site number: O-20		
Completed: July 12, 1987		
Alluvium and glacial deposits:		
Clay, brown	12	12
Sand, fine, gray	3	15
Clay, brown	3	18
Gravel, loose	2	20
Clay, gray, sandy	10	30
Gravel, loose	5	35
Judith River Formation:		
Shale, light-bluish-green, tight, sandy	20	55
Remarks: Set screen at 30-35 ft. Well produced about 10 gal/min with compressed air; well water cleared poorly.		

Table 15.--*Lithologic logs of selected observation wells and test holes*--Continued

Description	Thickness penetrated (ft)	Bottom of interval below land surface (ft)
Site number: O-21		
Completed: July 12, 1987		
Alluvium and glacial deposits:		
Clay, sandy, brown	18	18
Gravel, hematite stained	3	21
Clay, gray, sticky, gritty	34	55
Sand (?), no returns	5	60
Gravel, loose; losing circulation of drilling fluid	15	75
Judith River Formation:		
Shale, sandy, gray, very soft; drills similar to clay	20	95
Remarks: Set screen at 69-74 ft with 8 ft of tail pipe. Well produced about 40 gal/min with compressed air; well water cleared quickly.		
Site number: O-22		
Completed: July 13, 1987		
Alluvium and glacial deposits:		
Soil and clay, medium-brown	16	16
Gravel, loose	3	19
Clay, medium-brown; grading to sandy	36	55
Sand, poor returns	5	60
Gravel, loose	15	75
Judith River Formation:		
Shale, bluish-gray, sandy; very soft	20	95
Remarks: Set 20-slot screen at 65-75 ft with 10 ft of tail pipe. Well produced more than 50 gal/min with compressed air but well water cleared slowly because of loss of 8-10 bags of bentonite into aquifer during drilling.		
Site number: O-23		
Completed: October 14, 1987		
Alluvium and glacial deposits:		
Soil and clay	18	18
Gravel, loose	3	21
Clay, medium-brown	31	52
Sand	8	60
Gravel, loose	17	77
Judith River Formation:		
Shale, bluish-gray, sandy; very soft	10	87
Remarks: Set 60-slot stainless-steel screen at 62-77 ft with 10 ft of tail pipe.		

Table 15.--*Lithologic logs of selected observation wells and test holes*--Continued

Description	Thickness penetrated (ft)	Bottom of interval below land surface (ft)
Site number: O-24		
Completed: July 12, 1987		
Alluvium and glacial deposits:		
Soil and clay, brown	23	23
Gravel, small, sandy	5	28
Clay, brown, soft	17	45
Gravel, loose	2	47
Clay, brown	10	57
Sand, fine	3	60
Gravel, loose	3	63
Colluvium:		
Gravel, sand, and clay, tight	15	78
Judith River Formation:		
Shale, gray, sandy; soft weathered zone at top is clay	12	90

Remarks: Set 20-slot screen at 60-65 ft with 8 ft of tail pipe. Well produced about 5 gal/min with compressed air; well water would not clear.

Description	Thickness penetrated (ft)	Bottom of interval below land surface (ft)
Site number: O-26		
Completed: August 14, 1987		
Alluvium and glacial deposits:		
Soil and clay, brown; stiff, gray at base	19	19
Gravel, small to coarse, broken pieces	3	22
Clay, gray, silty; includes small gravel and coarse sand; softer than upper clay, grading to harder; drilling requires hard pull-down	58	80
Gravel, loose, small to coarse; losing circulation of drilling fluid	14	94
Claggett Shale:		
Shale, dark-gray, hard	16	110

Remarks: Set 30-slot screen at 85-90 ft with 10 ft of tail pipe. Well produced about 20 gal/min with compressed air; well water cleared quickly.

Description	Thickness penetrated (ft)	Bottom of interval below land surface (ft)
Site number: O-32		
Completed: July 23, 1987		
Alluvium and glacial deposits:		
Clay, silty; includes small gravel and coarse sand; oxidized brown at 0-30 ft then gray at 30-105 ft; possible sand layer at 65-70 ft	105	105
Gravel, loose, mostly well-rounded; smaller gravel than in other holes nearby, white clay stringers	17	122
Clay, gray, very sandy	10	132
Judith River Formation:		
Shale, black, hard	8	140

Remarks: Set 20-slot screen at 115-120 ft with saw cuts at 110-115 ft and 8 ft of tail pipe.

Description	Thickness penetrated (ft)	Bottom of interval below land surface (ft)
Site number: O-33		
Completed: July 24, 1987		
Alluvium and glacial deposits:		
Clay, silty; includes small gravel and coarse sand; oxidized brown at 0-42 ft then gray at 42-83 ft; fine, gray sand at 50-70 ft	95	95
Gravel, loose	20	115
Clay, tight	3	118
Gravel, loose	5	123
Judith River Formation:		
Shale, black, hard	12	135
Remarks: Set 20-slot screen at 110-120 ft.		
Site number: O-34		
Completed: July 24, 1987		
Alluvium and glacial deposits:		
Clay, silty; includes small gravel and coarse sand; oxidized brown at 0-42 ft then gray at 42-83 ft, few cobbles	83	83
Gravel, loose; losing circulation of drilling fluid	12	95
Clay, gray with blue tint, soft, very sandy	50	145
Judith River Formation:		
Shale, soft; grading to harder	5	150
Remarks: Set 20-slot screen at 90-95 ft with saw slots at 85-90 and 10 ft of tail pipe.		
Site number: O-35		
Completed: August 13, 1987		
Alluvium:		
Clay, silty, soft, sandy in parts; black at 0-5 ft, oxidized grayish-brown at 5-15 ft, gray at 15-55 ft; sandy and pebbly at 20-30 ft, siltier at 30-55 ft	55	55
Gravel, small to coarse; broken pieces, coarser at base	7	62
Ellis Group:		
Shale, dark-gray, firm; drilling with pull-down, possible sandstone at 70-72 ft	10	72
Remarks: Set 30-slot screen at 57-62 ft with 10 ft of tail pipe. Well would not produce water with compressed air; water level 3 ft above bottom of screen.		
Site number: O-41		
Completed: July 25, 1987		
Colluvium and alluvium:		
Soil and clay, medium-brown	8	8
Gravel, loose	13	21
Clay, medium-brown, soft	1	22
Gravel, sand, and clay, tight; need pull-down to drill	7	29
Clay, soft, gray with brown layers; includes coarse sand	6	35
Gravel, sand, and clay, tight	14	49
Gravel, loose	6	55
Colorado Group:		
Shale, black, hard	5	60
Remarks: Set 20-slot screen at 50-55 ft.		

Description	Thickness penetrated (ft)	Bottom of interval below land surface (ft)
Site number: O-42		
Completed: August 27, 1987		
Alluvium:		
Clay, dark-brown, silty, stiff, carbonaceous in parts	10	10
Gravel and sand	1	11
Clay, brown, silty, soft	11	22
Gravel and sand, as above	1	23
Clay, brown, silty, soft	2	25
Gravel and sand, as above	2	27
Clay, gray, stiff	8	35
Gravel, loose, fine to coarse; broken, subangular cobbles in part	19	54
Colorado Group:		
Shale, firm; slow drilling	2	56
Remarks: Set 20-slot screen at 44-54 ft. Well produced about 80 gal/min with compressed air; well water cleared after developing 1.5 h.		
Site number: O-45		
Completed: August 12, 1987		
Alluvium:		
Clay, gray, smooth	10	10
Gravel, fine to coarse, subangular	5	15
Clay, gray	5	20
Sand, fine; no returns	5	25
Clay, brown grading to gray, soft, gritty	15	40
Gravel (as above)	1	41
Clay, gray	4	45
Sand, fine; poor returns	9	54
Gravel (as above)	4	58
Claggett Shale:		
Shale, hard, black	13	71
Remarks: Set 20-slot screen at 50-55 ft with saw cuts at 55-58 ft and 10 ft of tail pipe. Well flowed barely at top of casing; produced about 30 gal/min with compressed air.		
Site number: O-46		
Completed: August 12, 1987		
Alluvium:		
Soil and clay; possible sand	40	40
Gravel, fine to coarse, subangular	1	41
Clay, gray	12	53
Gravel, loose	4	57
Claggett Shale:		
Shale, black, hard	3	60
Remarks: Set 20-slot screen at 50-60 ft.		

Description	Thickness penetrated (ft)	Bottom of interval below land surface (ft)
Site number: O-48		
Completed: August 12, 1987		
Alluvium:		
Soil and clay	25	25
Sand (?); no returns	1	26
Clay, tight; need pull-down to drill	15	41
Gravel, loose	3	44
Sand, gray, very fine; few thin clay layers; drills smooth, bit falls without pull-down	12	56
Gravel, loose	4	60
Claggett Shale:		
Shale, black, hard; need hard pull-down to drill	10	70
Remarks: Set 30-slot screen at 56-61 ft with 8 ft of tail pipe. Well produced about 20 gal/min with compressed air; well water was clear.		
Site number: O-53		
Completed: July 27, 1987		
Alluvium:		
Soil and clay, brown, soft, sticky at 0-20 ft; grading to gray and slightly harder but still no grit at 30 ft; getting harder and darker at 60 ft	83	83
Gravel, loose	6	89
Claggett Shale:		
Clay, grading to shale	5	94
Shale, black, hard, tight	14	108
Remarks: Set 20-slot screen at 84-89 ft with 8 ft of tail pipe.		
Site number: O-58		
Completed: August 11, 1987		
Alluvium and glacial deposits:		
Soil and clay	5	5
Gravel, loose, small	8	13
Clay, gray, gritty; includes coarse sand and small gravel	32	45
Gravel, loose, small, rounded to angular	7	52
Judith River Formation:		
Shale, dark-gray, gritty, hard	8	60
Remarks: Set 20-slot screen at 45-55 ft. Well produced about 50 gal/min with compressed air.		
Site number: O-61		
Completed: August 15, 1987		
Glacial deposits:		
Soil and clay, brown, hard, brittle, gritty	10	10
Gravel, sand, and clay, tight	6	16
Clay	24	40
Gravel, sand, and clay, tight; need pull-down to drill; few large cobbles; weathered rocks in returns, white clay as at well O-2, small broken gravel pieces	30	70
Judith River Formation:		
Shale, dark-gray, gritty; weathered on top	10	80
Remarks: Set 20-slot screen at 60-65 ft with 10 ft of tail pipe. Well produced about 1 gal/min with compressed air even after multiple backflushes; well water would not clear.		

Description	Thickness penetrated (ft)	Bottom of interval below land surface (ft)
Site number: O-62		
Completed: August 17, 1987		
Glacial deposits:		
Gravel, loose; coarse sand to fine gravel, 10 percent angular, 40 percent subrounded, and 50 percent rounded	31	31
Clay and gravel; alternating thin layers, gravel loose, hole caving during drilling	19	50
Gravel, sand, and clay, tight; includes clay lenses; need pull-down to drill	8	58
Gravel, sand, and clay lenses; drilled soft, gravel minor (20 percent), clay contains very coarse sandy, grading to minor quantities of gravel; clay sticky at 110-120 ft, hole stays open	65	123
Colluvium:		
Gravel, sand, and clay, very tight; includes abundant white clay; need hard pull-down to drill; drilling chatter, broken pieces	8	131
Judith River Formation:		
Shale, dark-gray, hard	9	140
Remarks: Set 20-slot screen at 58-63 ft with 10 ft of tail pipe and packer installed below wash-down valve. Well produced about 8-10 gal/min with compressed air; well water was clear.		
Site number: O-63		
Completed: August 17, 1987		
Glacial deposits:		
Soil and clay, light brown	3	3
Gravel, sand, and clay; angular, iron-stained rock chips; need pull-down to drill	17	20
Sand and gravel, loose; minor quantity of clay	12	32
Gravel, sand, and clay (as above), grading harder at 55 ft	28	60
Gravel, sand, and clay, very hard, abundant white clay; drilling chatter; need very hard pull-down to drill; mud is dark yellowish brown at 100 ft	44	104
Clay, gray, medium soft; includes coarse sand and small pebbles	14	118
Gravel, loose	4	122
Judith River Formation:		
Shale; weathered sandstone(?) at 122-127 ft; grading to hard brittle bluish-gray sandstone at 127-142 ft; extremely hard drilling, some clay or shale in sandstone	20	142
Remarks: Set 30-slot screen at 118-123 ft with 10 ft of tail pipe; developed with compressed air for 2 h. Well took about 30 gal/min from water truck but only produced 1-2 gal/min with compressed air.		
Site number: O-64		
Completed: August 27, 1987		
Alluvium:		
Soil, sand	5	5
Clay, brown, soft, sticky	14	19
Gravel, loose, small, subangular to subrounded	7	26
Clay	2	28
Gravel, loose (as above)	2	30
Clay (as above)	2	32
Colluvium and alluvium:		
Gravel, sand, and clay, tighter; abundant white clay	8	40
Gravel, loose (as above)	3	43
Clay	1	44
Gravel, loose (as above)	8	52
Colorado Group:		
Shale, very silty, medium-bluish-gray; need maximum pull-down to drill	18	70
Remarks: Set screen at 47-52 ft with 10 ft of tail pipe. Well produced about 25 gal/min with compressed air; well water was clear.		

Description	Thickness penetrated (ft)	Bottom of interval below land surface (ft)
Site number: O-65		
Completed: August 26, 1987		
Alluvium:		
Soil, clay, dark-gray; appears similar to shale	9	9
Gravel, loose	1	10
Clay, brown, sticky	5	15
Gravel, sand, and clay	4	19
Gravel, loose, large, very angular pieces	5	24
Bearpaw Shale:		
Shale, dark-gray	16	40
Remarks: Set 20-slot screen at 18.5-23.5 ft with 10 ft of tail pipe. Well produced about 2 gal/min with compressed air; well water was fairly clear.		
Site number: O-66		
Completed: August 26, 1987		
Alluvium:		
Soil, clay	9	9
Gravel, sand, loose, subangular to subrounded	4	13
Bearpaw Shale:		
Shale, medium-gray, soft; drills easily, smooth; layer of bentonite 30-35 ft	47	60
Remarks: Set screen at 9-14 ft with 3 ft of tail pipe and packer installed below wash-down-valve; well produced about 1-2 gal/min with compressed air; well water would not clear.		
Site number: T-14		
Completed: August 13, 1987		
Alluvium:		
Clay, silty, soft; dark-brown at 0-5 ft, mottled gray-brown at 5-15 ft	15	15
Gravel and sand, loose; interbedded with gray silty clay, gravel fine to coarse, broken pieces	8	23
Ellis Group:		
Shale, dark-gray, hard, tight	17	40
Remarks: Back-filled hole with cuttings and bentonite.		
Site number: T-27		
Completed: August 16, 1987		
Glacial deposits:		
Gravel, sand, and clay; soft sand at 70-73 ft, boulder gravel at 106-109 ft	115	115
Judith River Formation:		
Shale	5	120
Remarks: Back-filled hole with cuttings and bentonite.		

Description	Thickness penetrated (ft)	Bottom of interval below land surface (ft)
Site number: T-28		
Completed: August 15, 1987		
Glacial deposits:		
Gravel, sand, and clay; appears similar to till in nearby cutbank	87	87
Clay, gray, tight, no pebbles	11	98
Gravel, sand, and clay, very tight; need pull-down to drill	6	104
Judith River Formation:		
Shale; weathered at top grading to dark-gray, hard, and gritty	16	120
Remarks: Back-filled hole with cuttings and bentonite.		
Site number: T-29		
Completed: August 15, 1987		
Alluvium and glacial deposits:		
Soil and clay	3	3
Gravel, loose	7	10
Clay, gray; includes coarse sand and fine gravel; gets hard at 15-20 ft, need hard pull-down to drill	30	40
Gravel, sand, and clay, loose at 41-42 ft; tight, need hard pull-down to drill	23	63
Judith River Formation:		
Shale, gray, hard, tight, gritty	2	65
Remarks: Back-filled hole with cuttings and bentonite.		
Site number: T-30		
Completed: August 15, 1987		
Glacial deposits:		
Gravel, sand, and clay; rocky zones at 7-13 ft, 23-26 ft, and others; brown clay matrix at 0-75 ft and gray at 75-91 ft	91	91
Gravel, sand, and clay; similar to above but very hard and tight; need hard pull-down to drill	32	123
Judith River Formation:		
Shale	17	140
Remarks: Back-filled hole with cuttings and bentonite.		
Site number: T-31		
Completed: August 16, 1987		
Glacial deposits:		
Gravel, sand, and clay; mostly sandy clay with few gravel layers; brown at 0-75 ft and gray at 75-110 ft; gray clay is similar to shale bedrock but is softer and includes small pebbles	110	110
Judith River Formation:		
Shale, gritty, sandy; same color as overlying deposits but harder with no pebbles; hard sandstone(?) ledges at 152-153 ft, 161-162 ft, 176-177 ft	80	190
Remarks: Back-filled hole with cuttings and bentonite.		

Description	Thickness penetrated (ft)	Bottom of interval below land surface (ft)
Site number: T-33		
Completed: August 29, 1987		
Glacial deposits:		
Soil and clay, brown, tight	10	10
Gravel, sand, and clay, tight	5	15
Clay, light-gray-brown, includes coarse sand and pebbles, few cobbles, medium-gray sandy at 40-94 ft; drilling smooth, clay sticky	79	94
Gravel, sand, and clay, gravel small and angular, abundant white clay; need pull-down to drill	8	102
Clay, gray, soft	11	113
Judith River Formation:		
Shale, medium-gray; similar to clay above but harder and more brittle without pebbles	17	130
Remarks: Back-filled hole with cuttings and bentonite.		
Site number: T-34		
Completed: August 29, 1987		
Glacial deposits:		
Soil and clay, minor small gravel; brown at 0-50 ft and gray below 50 ft; very sandy with pebbles and few rocks; extremely hard gneiss or quartzite boulder at 63-64.5 ft, ruined drill bit, very slow penetration with new bit	72	72
Gravel, sand, and clay, tight	4	76
Clay, gray (as above) but gravel slightly smaller	39	115
Judith River Formation:		
Shale, dark-gray, tight	5	120
Remarks: Back-filled hole with cuttings and bentonite.		
Site number: T-35		
Completed: August 29, 1987		
Glacial deposits:		
Gravel, sand, and clay, varying quantities of small angular gravel	45	45
Clay, brown, with pebbles	10	55
Gravel, sand, and clay, almost loose at places	10	65
Clay, gray, with sand and pebbles; losing circulation of drilling fluid	51	116
Gravel, sand, and clay, tight; need pull-down to drill, poor returns	14	130
Judith River Formation:		
Shale	2	132
Remarks: Back-filled hole with cuttings and bentonite.		

Table 16.--*Records of water levels in monitoring wells*

[Water level--in feet below or above (+) land surface. MS, conditions of measurement. First column (M) is method of measurement--S, steel tape; V, calibrated electric tape. Second column (S) is site status--D, dry]

Site O-2

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 26, 1987	45.17	S	FEB 11, 1988	45.88	S	JUN 01, 1988	44.88	S	NOV 03, 1988	48.42	S
SEP 24	46.39	S	MAR 02	46.77	S	JUL 07	44.93	S	DEC 14	47.37	S
NOV 05	47.10	S	APR 06	47.47	S	AUG 10	47.22	S	JAN 11, 1989	48.24	S
DEC 04	47.42	S	MAY 04	45.23	S	SEP 07	47.80	S	FEB 22	46.51	S
JAN 13, 1988	47.05	S	05	45.20	S	OCT 05	48.33	S	MAR 29	47.37	S

HIGHEST 44.88 JUN 01, 1988
LOWEST 48.42 NOV 03, 1988

Site O-9

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 26, 1987	12.79	S	JAN 13, 1988	15.13	S	JUN 24, 1988	13.38	S	DEC 14, 1988	16.18	S
SEP 24	13.76	S	FEB 11	15.23	S	JUL 07	14.01	S	JAN 11, 1989	16.24	S
OCT 17	14.26	S	MAR 03	15.10	S	AUG 10	15.23	S	FEB 22	16.34	S
NOV 05	14.45	S	APR 06	15.11	S	SEP 07	15.89	S	MAR 29	15.68	S
18	14.57	S	MAY 04	15.44	S	OCT 05	15.98	S			
DEC 04	14.68	S	JUN 01	13.50	S	NOV 03	16.04	S			

HIGHEST 12.79 AUG 26, 1987
LOWEST 16.34 FEB 22, 1989

Site O-10

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 26, 1987	20.05	S	FEB 11, 1988	19.50	S	JUL 07, 1988	20.05	S	DEC 14, 1988	20.11	S
SEP 24	19.92	S	MAR 02	18.94	S	AUG 10	20.43	S	JAN 11, 1989	19.97	S
NOV 05	19.90	S	APR 06	19.27	S	SEP 07	20.63	S	FEB 22	20.08	S
DEC 04	20.08	S	MAY 05	19.70	S	OCT 05	20.41	S	MAR 29	19.38	S
JAN 13, 1988	19.78	S	JUN 01	19.33	S	NOV 03	20.17	S			

HIGHEST 18.94 MAR 02, 1988
LOWEST 20.63 SEP 07, 1988

Site O-13

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 28, 1987	19.10	S	JAN 13, 1988	22.28	S	JUN 01, 1988	18.94	S	NOV 03, 1988	21.94	S
SEP 24	20.67	S	FEB 11,	22.06	S	JUN 28	19.66	S	DEC 14	22.02	S
OCT 19	21.32	S	MAR 03	22.00	S	JUL 07	19.38	S	JAN 11, 1989	22.13	S
NOV 05	21.61	S	APR 06	21.71	S	AUG 10	20.52	S	FEB 22	22.22	S
DEC 04	21.97	S	MAY 05	21.08	S	SEP 07	21.36	S	MAR 29	21.96	S

HIGHEST 18.94 JUN 01, 1988
LOWEST 22.28 JAN 13, 1988

Site O-16

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 27, 1987	4.08	S	FEB 11, 1988	4.62	S	JUN 21, 1988	5.14	S	NOV 03, 1988	5.42	S
SEP 24	4.35	S	MAR 03	4.85	S	JUL 07	5.20	S	DEC 14	5.42	S
NOV 05	4.54	S	APR 06	4.92	S	AUG 10	5.49	S	JAN 11, 1989	5.23	S
DEC 04	4.68	S	MAY 05	5.25	S	SEP 07	5.68	S	FEB 22	4.75	S
JAN 13, 1988	4.69	S	JUN 01	5.79	S	OCT 05	5.50	S	MAR 29	4.77	S

HIGHEST 4.08 AUG 27, 1987
LOWEST 5.79 JUN 01, 1988

Site O-17

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 27, 1987	15.95	S	JAN 13, 1988	15.78	S	MAY 05, 1988	15.92	S	OCT 05, 1988	16.49	S
SEP 24	15.97	S	FEB 10	15.83	S	JUN 01	15.77	S			
NOV 05	15.86	S	MAR 02	15.86	S	AUG 10	16.50	S			
DEC 04	15.77	S	APR 06	15.87	S	SEP 07	16.62	S			

HIGHEST 15.77 DEC 04, 1987 JUN 01, 1988
LOWEST 16.62 SEP 07, 1988

Site O-18

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 27, 1987	7.17	S	JAN 13, 1988	6.27	S	MAY 05, 1988	6.91	S	SEP 07, 1988	8.50	S
SEP 24	7.11	S	FEB 10	6.10	S	JUN 01	7.11	S	OCT 05	7.59	S
NOV 05	6.67	S	MAR 02	5.85	S	JUL 07	7.78	S	NOV 03	7.21	S
DEC 04	6.56	S	APR 06	6.52	S	AUG 10	8.39	S	DEC 14	7.07	S

HIGHEST 5.85 MAR 02, 1988
LOWEST 8.50 SEP 07, 1988

Site O-19

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 27, 1987	7.22	S	FEB 11, 1988	7.05	S	JUL 07, 1988	7.84	S	DEC 14, 1988	7.63	V
SEP 14	8.29	S	MAR 03	7.01	V	AUG 10	7.93	S	JAN 11, 1989	7.56	V
24	7.26	S	APR 06	7.05	S	SEP 07	7.96	S	FEB 22	7.60	S
DEC 04	7.17	S	MAY 05	7.16	S	OCT 15	7.73	S	MAR 29	7.43	S
JAN 14, 1988	7.08	V	JUN 01	7.25	S	NOV 03	7.64	S			

HIGHEST 7.01 MAR 03 1988
LOWEST 8.29 SEP 14, 1987

Site O-22

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 26, 1987	3.88	S	FEB 11, 1988	3.77	S	JUN 21, 1988	3.92	S	NOV 03, 1988	4.09	S
SEP 14	3.93	S	MAR 03	3.76	S	JUL 07	4.32	S	DEC 14	4.14	S
NOV 05	3.92	S	APR 06	3.79	S	AUG 10	4.29	S	JAN 11, 1989	4.13	S
DEC 04	3.93	S	MAY 05	3.85	S	SEP 07	4.26	S	FEB 22	4.19	S
JAN 14, 1988	3.81	S	JUN 01	4.01	S	OCT 05	4.15	S	MAR 29	4.16	S

HIGHEST 3.76 MAR 03, 1988
LOWEST 4.32 JUL 07, 1988

Site O-25

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 26, 1987	16.08	S	FEB 11, 1988	15.54	S	JUL 07, 1988	15.85	S	DEC 14, 1988	15.20	S
SEP 14	16.13	S	MAR 03	15.53	S	AUG 10	16.11	S	JAN 11, 1989	14.96	S
24	16.14	S	APR 06	15.49	S	SEP 07	16.28	S	FEB 22	14.69	S
DEC 04	15.73	S	MAY 05	15.39	S	OCT 05	16.14	S	MAR 29	15.03	S
JAN 14, 1988	15.54	S	JUN 01	15.38	S	NOV 03	15.33	S			

HIGHEST 14.69 FEB 22, 1989
LOWEST 16.28 SEP 07, 1988

Site O-26

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 28, 1987	14.27	S	FEB 11, 1988	13.90	S	JUL 07, 1988	14.75	S	JAN 11, 1989	14.42	S
SEP 14	14.32	S	MAR 03	13.92	S	AUG 10	14.67	S	FEB 22	14.52	S
24	14.29	S	APR 06	13.94	S	SEP 06	14.55	S	MAR 29	14.51	S
NOV 05	14.15	S	MAY 05	13.98	S	OCT 05	14.41	S			
DEC 04	14.09	S	JUN 01	14.30	S	NOV 03	14.35	S			
JAN 14, 1988	13.93	S	21	14.47	S	DEC 14	14.43	S			

HIGHEST 13.90 FEB 11, 1988
LOWEST 14.75 JUL 07, 1988

Table 16.--*Records of water levels in monitoring wells*--Continued

Site O-27

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 27, 1987	16.78	S	FEB 11, 1988	17.59	S	JUN 21, 1988	17.70	S	NOV 03, 1988	17.66	S
SEP 24	17.91	S	MAR 03	17.60	S	JUL 07	17.74	S	DEC 18	17.71	S
NOV 05	17.82	S	APR 06	17.60	S	AUG 10	17.78	S	JAN 11, 1989	17.58	S
DEC 04	17.74	S	MAY 05	17.42	S	SEP 06	17.74	S	FEB 22	17.56	S
JAN 14, 1988	17.63	S	JUN 02	17.66	S	OCT 05	17.74	S	MAR 30	17.52	S

HIGHEST 16.78 AUG 27, 1987
LOWEST 17.91 SEP 24, 1987

Site O-29

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 27, 1987	22.64	S	FEB 11, 1988	22.42	S	JUL 07, 1988	22.54	S	DEC 14, 1988	22.51	S
SEP 24	22.47	S	MAR 03	22.40	S	AUG 10	22.61	S	JAN 11, 1989	22.41	S
NOV 05	22.46	S	APR 06	23.02	S	SEP 07	22.75	S	FEB 22	22.51	S
DEC 04	22.49	S	MAY 05	22.54	S	OCT 05	22.61	S	MAR 30	22.43	S
JAN 14, 1988	22.45	S	JUN 02	22.49	S	NOV 03	22.38	S			

HIGHEST 22.38 NOV 03, 1988
LOWEST 23.02 APR 06, 1988

Site O-30

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 27, 1987	8.43	S	FEB 11, 1988	8.01	S	JUL 07, 1988	8.50	S	DEC 14, 1988	8.53	S
SEP 24	8.38	S	MAR 02	7.99	S	AUG 10	8.74	S	FEB 22, 1989	8.26	S
NOV 05	8.29	S	APR 06	8.16	S	SEP 06	8.88	S	MAR 29	8.11	S
DEC 04	8.27	S	MAY 05	8.30	S	OCT 05	8.77	S			
JAN 13, 1988	8.15	S	JUN 02	8.33	S	NOV 03	8.60	S			

HIGHEST 7.99 MAR 02, 1988
LOWEST 8.88 SEP 06, 1988

Site O-33

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 27, 1987	4.62	S	JAN 14, 1988	4.42	S	JUN 02, 1988	4.28	S	NOV 03, 1988	4.49	S
SEP 11	4.66	S	FEB 11	4.62	S	JUL 07	4.25	S	DEC 14	4.47	S
24	4.68	S	MAR 02	4.32	S	AUG 10	4.53	S	FEB 22, 1989	4.32	S
NOV 05	4.45	S	APR 06	4.35	S	SEP 06	4.56	S	MAR 29	4.26	S
DEC 04	4.42	S	MAY 05	4.35	S	OCT 05	4.54	S			

HIGHEST 4.25 JUL 07, 1988
LOWEST 4.68 SEP 24, 1987

Site O-34

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 27, 1987	37.67	S	MAR 02, 1988	38.03	S	AUG 10, 1988	38.12	S	FEB 22, 1989	37.97	S
SEP 11	38.18	S	APR 06	38.00	S	SEP 06	38.13	S	MAR 29	37.90	S
24	37.97	S	MAY 05	38.01	S	OCT 05	38.13	S			
JAN 14, 1988	37.97	S	JUN 02	38.02	S	NOV 03	38.05	S			
FEB 11	37.73	S	JUL 07	38.05	S	DEC 14	38.12	S			

HIGHEST 37.67 AUG 27, 1987
LOWEST 38.18 SEP 11, 1987

Site O-39

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 29, 1987	37.50	S	FEB 10, 1988		SD	JUL 07, 1988		SD	DEC 14, 1988		SD
SEP 25	37.50	S	MAR 02		SD	AUG 09		SD	JAN 10, 1989		SD
NOV 05		SD	APR 05		SD	SEP 07		SD	FEB 22		SD
DEC 03		SD	MAY 04		SD	OCT 04		SD	MAR 30		SD
JAN 13, 1988		SD	JUN 01		SD	NOV 03		SD			

HIGHEST 37.50 SEP 25, 1987
LOWEST 37.50 SEP 25, 1987

Site O-42

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 29, 1987	16.54	S	FEB 10, 1988	42.41	S	JUL 07, 1988	38.82	S	JAN 10, 1989	49.86	S
SEP 25	20.55	S	MAR 02	44.34	S	AUG 09	40.46	S	FEB 22	50.03	S
NOV 05	27.45	S	APR 05	46.47	S	SEP 07	43.65	S	MAR 30	49.75	S
18	29.88	S	MAY 04	47.54	S	OCT 04	47.05	S			
DEC 03	32.49	S	JUN 01	40.28	S	NOV 04	49.04	S			
JAN 13, 1988	39.11	S	27	39.61	S	DEC 14	49.68	S			

HIGHEST 16.54 AUG 29, 1987
LOWEST 50.03 FEB 22, 1989

Site O-44

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 29, 1987	9.59	S	FEB 10, 1988	15.21	S	JUL 07, 1988	17.72	S	DEC 14, 1988	22.01	S
SEP 25	10.36	S	MAR 02	15.94	S	AUG 09	18.23	S	JAN 10, 1989	23.09	S
NOV 05	11.30	S	APR 05	17.29	S	SEP 07	18.80	S	FEB 22	24.65	S
DEC 03	12.19	S	MAY 04	18.46	S	OCT 04	19.40	S	MAR 30	25.22	S
JAN 13, 1988	13.98	S	JUN 01	16.48	S	NOV 04	20.39	S			

HIGHEST 9.59 AUG 29, 1987
LOWEST 25.22 MAR 30, 1989

Site O-45

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 28, 1987	+2.50	S	FEB 10, 1988	+2.52	S	JUL 07, 1988	+1.60	S	DEC 14, 1988	+1.64	S
SEP 25	+2.36	S	MAR 02	+2.68	S	AUG 09	+1.27	S	JAN 10, 1989	+1.42	S
NOV 05	+2.79	S	APR 05	+2.67	S	SEP 07	+.92	S	FEB 22	+1.32	S
DEC 03	+2.80	S	MAY 04	+2.40	S	OCT 04	+1.34	S	MAR 30	+1.67	S
JAN 13, 1988	+2.50	S	JUN 01	+2.35	S	NOV 03	+1.72	S			

HIGHEST +2.80 DEC 03, 1987
LOWEST +.92 SEP 07, 1988

Site O-50

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 28, 1987	1.24	S	APR 05, 1988	.79	S	AUG 09, 1988	1.96	S	MAR 30, 1989	2.42	S
SEP 25	1.29	S	MAY 04	1.07	S	SEP 07	2.10	S			
DEC 03	.99	S	JUN 01	1.24	S	OCT 04	1.77	S			
MAR 02, 1988	.89	S	JUL 07	1.70	S	NOV 03	1.54	S			

HIGHEST .79 APR 05, 1988
LOWEST 2.42 MAR 30, 1989

Site O-51

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 28, 1987	+2.40	S	JAN 13, 1988	+5.05	S	MAY 04, 1988	+6.59	S	SEP 07, 1988	+5.54	S
SEP 25	+2.82	S	FEB 10	+6.10	S	JUN 01	+6.79	S	OCT 04	+5.53	S
NOV 05	+2.94	S	MAR 02	+6.36	S	JUL 07	+6.38	S	NOV 03	+5.42	S
DEC 03	+3.00	S	APR 05	+6.56	S	AUG 09	+5.96	S	MAR 30, 1989	+5.79	S

HIGHEST +6.79 JUN 01, 1988
LOWEST +2.40 AUG 28, 1987

Site O-52

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 28, 1987	10.63	S	FEB 10, 1988	10.96	S	JUL 07, 1988	11.70	S	DEC 14, 1988	12.83	S
SEP 25	10.62	S	MAR 02	10.88	S	AUG 09	12.61	S	JAN 12, 1989	11.98	S
NOV 05	10.59	S	APR 05	10.94	S	SEP 07	13.28	S	FEB 22	11.85	S
DEC 03	10.58	S	MAY 04	10.97	S	OCT 04	13.37	S	MAR 30	11.53	S
JAN 13, 1988	9.24	S	JUN 01	11.13	S	NOV 03	13.30	S			

HIGHEST 9.24 JAN 13, 1988
LOWEST 13.37 OCT 04, 1988

Site O-53

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 28, 1987	29.10	S	APR 05, 1988	28.08	S	AUG 09, 1988	28.74	S	DEC 14, 1988	29.08	S
SEP 25	29.36	S	MAY 04	27.94	S	SEP 07	28.94	S	JAN 12, 1989	28.99	S
FEB 10, 1988	28.58	S	JUN 01	27.77	S	OCT 04	28.84	S	FEB 22	28.74	S
MAR 02	28.36	S	JUL 07	27.97	S	NOV 03	28.78	S	MAR 30	28.58	S

HIGHEST 27.77 JUN 01, 1988
LOWEST 29.36 SEP 25, 1987

Site O-54

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 29, 1987	8.98	S	FEB 10, 1988	6.76	S	JUL 07, 1988	16.73	S	DEC 14, 1988	8.03	S
SEP 25	6.81	S	MAR 02	6.65	S	AUG 09	13.32	S	JAN 10, 1989	7.90	S
NOV 05	6.28	S	APR 05	6.81	S	SEP 07	9.54	S	FEB 22	8.05	S
DEC 03	6.24	S	MAY 04	7.24	S	OCT 04	8.18	S	MAR 30	7.53	S
JAN 13, 1988	6.54	S	JUN 01	7.14	S	NOV 03	7.95	S			

HIGHEST 6.24 DEC 03, 1987
LOWEST 16.73 JUL 07, 1988

Site O-58

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 29, 1987	15.11	S	FEB 10, 1988	14.29	S	JUL 07, 1988	14.88	S	DEC 14, 1988	15.22	S
OCT 16	14.86	S	MAR 02	14.35	S	AUG 09	15.08	S	MAR 30, 1989	14.86	S
NOV 05	14.95	S	APR 05	14.54	S	SEP 07	15.18	S			
DEC 03	14.67	S	MAY 04	14.65	S	OCT 04	15.21	S			
JAN 13, 1988	14.48	S	JUN 01	14.67	S	NOV 04	15.18	S			

HIGHEST 14.29 FEB 10, 1988
LOWEST 15.22 DEC 14, 1988

Site O-60

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 29, 1987	15.67	S	FEB 10, 1988	15.67	S	JUN 01, 1988	15.89	S	OCT 04, 1988	17.95	S
SEP 25	15.67	S	MAR 02	15.64	S	JUL 07	16.70	S	NOV 03	17.86	S
OCT 16	15.68	S	APR 05	15.78	S	AUG 09	17.58	S	DEC 14	17.87	S
DEC 04	15.69	S	MAY 04	15.83	S	SEP 07	17.98	S	MAR 30, 1989	16.28	S

HIGHEST 15.64 MAR 02, 1988
LOWEST 17.98 SEP 07, 1988

Site O-61

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 29, 1987	62.85	S	JAN 13, 1988	64.48	S	MAY 04, 1988	63.76	S	SEP 07, 1988	64.74	S
SEP 25	64.55	S	FEB 10	64.76	S	JUN 01	64.55	S	OCT 04	65.10	S
NOV 05	64.75	S	MAR 02	64.79	S	JUL 07	64.76	S	MAR 30, 1989	68.80	S
DEC 04	63.78	S	APR 05	64.30	S	AUG 09	64.75	S			

HIGHEST 62.85 AUG 29, 1987
LOWEST 68.80 MAR 30, 1989

Site O-62

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 29, 1987	22.55	S	DEC 03, 1987	23.36	S	MAR 02, 1988	23.99	S	JUN 01, 1988	24.47	S
SEP 26	22.79	S	JAN 13, 1988	23.66	S	APR 05	24.20	S	JUL 07	24.68	S
NOV 05	23.14	S	FEB 10	23.88	S	MAY 04	24.34	S	AUG 09	24.90	S

HIGHEST 22.55 AUG 29, 1987
LOWEST 24.90 AUG 09, 1988

Table 16.--*Records of water levels in monitoring wells*--Continued

Site O-63

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 29, 1987	91.99	S	DEC 03, 1987	92.23	S	MAR 02, 1988	94.44	S	JUN 01, 1988	97.15	S
SEP 26	91.41	S	JAN 13, 1988	93.29	S	APR 05	95.50	S	JUL 07	98.18	S
NOV 05	91.90	S	FEB 10	95.14	S	MAY 04	96.27	S	AUG 09	99.00	S

HIGHEST 91.41 SEP 26, 1987
LOWEST 99.00 AUG 09, 1988

Site O-64

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 30, 1987	5.03	S	JAN 13, 1988	6.33	S	APR 06, 1988	6.81	S	SEP 08, 1988	6.61	S

HIGHEST 5.03 AUG 30, 1987
LOWEST 6.81 APR 06, 1988

Site O-63

DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS	DATE	WATER LEVEL	MS
AUG 30, 1987	12.71	S	JAN 13, 1988	13.92	S	APR 06, 1988	15.19	S	SEP 08, 1988	17.60	S

HIGHEST 12.71 AUG 30, 1987
LOWEST 17.60 SEP 08, 1988

Table 17.--*Physical properties and major-ion concentrations of ground water and streamflow*

[Analyses by Montana Bureau of Mines and Geology in accordance with methods defined by Skougstad and others (1979). Geologic unit: Qvf, Quaternary valley fill; Kjr, Upper Cretaceous Judith River Formation; Kcl, Upper Cretaceous Claggett Shale; Ke, Upper Cretaceous Eagle Sandstone; Kc, Upper and Lower Cretaceous Colorado Group; KJke, Lower Cretaceous to Middle Jurassic Kootenai Formation and Ellis Group. Depth of well, total: in feet below land surface. Bicarbonate and carbonate were determined by fixed endpoint titration (fet) in the laboratory (lab) or by incremental titration (it) onsite (fld). Abbreviations: °C, degrees Celsius; µS/cm, microsiemens per centimeter at 25 °C; mg/L, milligrams per liter. Symbols: <, less than; --, no data or not applicable; ND, not detected]

Site number	Geo-logic unit	Depth of well, total (feet)	Date	Tem-pera-ture, water (°C)	Onsite spe-cific con-duct-ance (µS/cm)	Onsite pH (stand-ard units)	Oxygen, dis-solved (mg/L)	Hard-ness, total (mg/L as $CaCO_3$)	Alka-linity (mg/L as $CaCO_3$)	Solids, sum of constit-uents, dis-solved (mg/L)	Cal-cium, dis-solved (mg/L as Ca)	Magne-sium, dis-solved (mg/L as Mg)
					<u>Ground-water sites</u>							
B-1	KJke	226	10-03-88	9.5	710	--	--	370	--	428	82	39
B-2	Kc	174	10-03-88	10.0	1,850	--	--	22	--	1,170	5.2	2.2
B-3	Ke	144	10-02-88	--	--	--	--	350	--	416	64	47
B-4	Ke	224	10-01-88	10.5	1,060	--	--	490	--	706	93	62
B-5	Ke	375	10-01-88	10.5	1,340	--	--	90	--	865	16	12
B-6	Ke	303	10-03-88	10.0	775	--	--	350	--	473	63	46
B-7	Ke	94	10-02-88	10.5	1,280	--	--	78	--	696	16	9.3
B-8	Ke	214	10-02-88	10.5	1,480	--	--	540	--	1,050	96	74
O-2	Qvf	83	10-15-87	9.0	480	7.5	8.0	260	240	287	71	21
O-5	Qvf	45	10-14-87	9.0	477	7.6	8.4	260	230	282	68	21
O-7	Qvf	34	10-14-87	9.5	813	7.3	5.6	440	350	529	100	44
O-9	Qvf	53	10-17-87	9.0	471	7.4	7.5	260	230	289	68	21
			06-24-88	--	--	--	--	260	--	256	68	22
O-10	Qvf	40	10-14-87	8.5	572	7.3	4.8	300	270	350	80	25
O-11	Qvf	45	10-14-87	8.5	1,550	7.2	6.0	730	380	1,140	150	86
O-13	Qvf	40	10-19-87	7.5	1,150	7.3	7.0	550	330	791	130	54
			06-28-88	8.0	1,240	7.2	--	580	--	788	140	58
O-14	Qvf	40	10-14-87	9.5	570	7.4	8.7	300	270	347	79	25
O-16	Qvf	65	10-15-87	7.5	620	7.3	7.0	310	280	377	83	26
O-17	Qvf	43	10-15-87	9.0	13,000	7.5	.2	2,300	690	11,500	160	450
O-18	Qvf	27	09-14-87	9.5	6,620	7.3	.1	1,400	480	5,510	240	180
O-19	Qvf	58	09-12-87	8.5	1,620	7.4	.5	650	400	1,200	130	79
O-20	Qvf	35	09-12-87	9.0	1,550	7.4	.2	590	370	1,100	130	62
O-22	Qvf	85	09-14-87	9.0	985	7.2	4.4	470	330	657	110	46
			10-16-87	8.0	965	7.3	4.4	470	330	662	110	46
O-23	Qvf	87	06-23-88	8.5	970	7.3	--	460	--	602	110	45
O-24	Qvf	73	09-12-87	8.5	713	7.3	5.0	360	310	464	93	32
O-25	Qvf	28	09-12-87	9.0	3,030	7.3	.5	1,100	530	2,380	190	150
O-26	Qvf	100	09-13-87	8.5	881	7.5	2.8	430	330	600	96	45
O-27	Qvf	110	09-18-87	9.5	953	7.5	ND	420	320	658	100	39
O-28	Qvf	130	09-13-87	10.0	1,260	7.6	ND	360	360	911	79	38
O-29	Qvf	88	09-13-87	10.5	993	7.5	.1	350	300	690	82	34
O-30	Qvf	97	09-11-87	9.0	1,550	8.2	.2	110	360	1,110	27	10
O-31	Qvf	123	09-12-87	9.0	1,990	7.8	.3	160	480	1,380	39	15
O-33	Qvf	120	09-11-87	9.0	1,640	7.9	.2	140	370	1,140	34	12
O-34	Qvf	105	09-10-87	10.5	1,590	8.3	.4	44	380	1,080	11	3.7
O-40	Qvf	65	11-05-87	7.5	515	7.5	6.9	270	240	320	74	20
O-42	Qvf	54	09-15-87	8.0	362	7.7	9.4	210	190	232	59	15
			06-27-88	7.0	435	7.6	--	220	--	234	62	16
O-43	Qvf	55	11-04-87	7.0	478	7.4	7.0	250	240	284	71	17
O-44	Qvf	60	10-18-87	8.0	459	7.5	6.5	240	230	274	69	17
O-46	Qvf	60	10-18-87	8.0	609	7.2	3.3	320	260	380	83	27
O-47	Qvf	23	10-17-87	9.5	830	7.1	1.8	450	340	540	110	42
O-48	Qvf	69	10-17-87	8.0	590	7.4	2.9	310	260	363	82	25
O-49	Qvf	64	10-17-87	7.5	710	7.4	.2	370	280	452	92	33
O-50	Qvf	40	10-17-87	7.5	615	7.4	2.0	330	270	378	87	26
O-51	Qvf	85	11-05-87	8.5	1,520	7.1	ND	820	500	1,110	140	110
			11-01-88	8.5	1,540	7.1	.3	810	490	1,110	140	110
O-52	Qvf	43	11-05-87	8.0	1,900	7.2	.1	1,100	410	1,520	190	140
O-53	Qvf	97	11-05-87	8.5	730	7.7	.1	130	280	468	34	12
O-54	Qvf	87	11-05-87	9.0	1,280	7.4	ND	350	400	888	65	44
O-55	Qvf	86	11-05-87	8.5	2,170	7.1	ND	720	620	1,050	130	93
			11-01-88	8.0	1,860	7.1	1.4	540	540	1,380	100	71
O-56	Qvf	38	11-04-87	8.5	2,690	7.0	.1	610	700	2,020	140	62
O-58	Qvf	55	10-16-87	9.0	3,020	6.8	.2	1,300	930	2,500	230	180

Sodium, dis- solved (mg/L as Na)	Sodium ad- sorp- tion ratio (SAR)	Potas- sium, dis- solved (mg/L as K)	Bicar- bonate, fet-lab (mg/L as HCO_3)	Bicar- bonate, it-fld (mg/L as HCO_3)	Car- bonate, fet-lab (mg/L as CO_3)	Sul- fate, dis- solved (mg/L as SO_4)	Chlo- ride, dis- solved (mg/L as Cl)	Fluo- ride, dis- solved (mg/L as F)	Bro- mide, dis- solved (mg/L as Br)	Silica, dis- solved (mg/L as SiO_2)	Nitro- gen, nitrate, dis- solved (mg/L as NO_3)	Phos- phorus, dis- solved (mg/L as P)	Site number
						<u>Ground-water sites</u>							
13	0.3	6.2	330	--	--	110	1.9	0.8	<0.1	6.9	.75	<0.10	B-1
430	42	2.4	710	--	--	350	4.4	1.2	<.1	8.3	.11	<.10	B-2
20	.5	2.7	310	--	--	120	2.9	1.0	<.1	--	.93	<.10	B-3
60	1	3.4	410	--	--	270	4.0	.5	<.1	14	.19	<.10	B-4
280	13	2.1	500	--	--	290	3.0	.2	<.1	8.5	.22	<.10	B-5
38	.9	2.7	370	--	--	120	2.5	.4	<.1	14	.54	<2.0	B-6
240	12	1.5	360	--	--	230	7.7	.2	<.1	9.4	.09	<.10	B-7
140	3	3.4	420	--	--	500	4.5	.6	<.1	13	.32	<.10	B-8
2.8	.1	1.6	280	290	--	34	.8	.3	<.1	11	.29	<.10	O-2
4.2	.1	1.9	270	276	--	37	.8	.3	<.1	12	.27	<.10	O-5
19	.4	3.9	410	422	--	130	2.6	.4	<.1	14	.61	<.10	O-7
6.1	.2	1.9	270	276	--	43	.8	.3	<.1	11	.22	<.10	O-9
4.9	.1	2.0	210	--	--	40	1.1	.3	<.1	11	.19	<.10	
11	.3	2.6	330	324	--	54	1.7	.3	<.1	13	.43	<.10	O-10
100	2	3.3	460	468	--	550	4.6	.4	<.1	14	.61	<.10	O-11
61	1	3.6	410	400	--	330	2.4	.4	<.1	14	.32	<.10	O-13
61	1	4.4	290	--	--	360	3.2	.2	<.1	14	.36	<.10	
10	.3	2.3	320	328	--	53	1.3	.3	<.1	13	.34	.10	O-14
15	.4	2.4	340	348	--	63	1.7	.3	<.1	13	.34	<.10	O-16
2,800	26	5.2	760	840	--	7,600	15	.5	<.1	10	.02	.10	O-17
1,200	15	6.8	550	584	--	3,500	15	1.4	<.1	14	.04	<.10	O-18
150	3	3.0	460	490	--	580	5.3	.4	<.1	14	.15	<.10	O-19
140	3	3.7	420	446	--	510	4.9	.6	<.1	13	.04	<.10	O-20
49	1	2.7	430	408	--	230	2.8	.4	<.1	14	.32	<.10	O-22
49	1	2.8	400	404	--	230	2.6	.4	<.1	14	.34	<.10	
48	1	2.9	330	--	--	220	2.7	.4	<.1	13	.43	<.10	O-23
25	.6	2.6	370	376	--	110	2.3	.4	<.1	14	.25	<.10	O-24
370	5	3.9	620	648	--	1,300	11	1.2	<.1	18	.03	<.10	O-25
50	1	2.5	400	402	--	190	2.4	.5	<.1	13	.27	<.10	O-26
67	1	3.3	380	396	--	230	3.0	.7	<.1	14	.03	<.10	O-27
170	4	4.2	420	440	--	380	4.5	.3	<.1	14	.02	<.10	O-28
100	2	4.5	350	368	--	260	3.7	.7	<.1	15	.03	<.10	O-29
340	15	2.5	400	440	--	490	11	.5	.2	10	.04	.10	O-30
400	14	3.6	520	590	--	560	9.1	1.1	<.1	15	.04	<.10	O-31
330	13	3.3	400	450	--	500	12	.6	.2	13	.03	<.10	O-33
360	25	2.1	440	438	--	430	12	.6	<.1	9.4	.02	<.10	O-34
12	.3	1.8	290	294	--	53	1.0	.2	--	13	.25	<.10	O-40
4.4	.1	1.5	230	236	--	22	.7	.1	.1	13	.08	<.10	O-42
4.7	.1	1.8	190	--	--	39	1.9	.2	<.1	12	.29	<.10	
4.9	.1	2.1	280	290	--	33	.5	.2	<.1	12	.04	<.10	O-43
5.5	.2	1.9	280	280	--	27	.7	.2	<.1	13	.13	<.10	O-44
13	.3	2.8	320	314	--	85	.6	.3	<.1	13	.23	<.10	O-46
18	.4	3.7	420	414	--	140	1.8	.3	<.1	14	.47	<.10	O-47
12	.3	2.4	310	314	--	71	.7	.3	<.1	13	.19	<.10	O-48
18	.4	3.3	340	338	--	120	.7	.3	<.1	13	.01	<.10	O-49
10	.3	2.6	330	336	--	71	.6	.3	<.1	14	.14	<.10	O-50
65	1	9.3	610	608	--	470	3.3	.4	<.1	12	.03	<.10	O-51
64	1	9.5	570	604	--	470	4.6	.6	<.1	11	.34	<.10	
86	1	8.5	480	502	--	820	4.1	.6	<.1	15	.04	<.10	O-52
120	5	3.9	330	346	--	110	1.3	.5	<.1	13	.03	<.10	O-53
180	4	6.3	480	488	--	340	2.4	.6	<.1	13	.05	<.10	O-54
290	5	9.4	750	762	--	120	4.8	.4	<.1	16	.04	<.10	O-55
260	5	9.0	610	661	--	590	4.4	.6	<.1	15	.21	<.10	
450	8	9.3	790	854	--	900	6.7	.3	<.1	15	.05	<.10	O-56
310	4	13	1,100	1,130	--	1,200	8.8	.4	<.1	19	.03	<.10	O-58

Table 17.--*Physical properties and major-ion concentrations of ground water and streamflow*--Continued

Site number	Geologic unit	Depth of well, total (feet)	Date	Temperature, water (°C)	Onsite specific conductance (µS/cm)	Onsite pH (standard units)	Oxygen, dissolved (mg/L)	Hardness, total (mg/L as $CaCO_3$)	Alkalinity (mg/L as $CaCO_3$)	Solids, sum of constituents, dissolved (mg/L)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)
						Ground-water sites--Continued						
O-59	Qvf	65	11-04-87	8.5	2,900	6.8	.1	1,400	900	2,340	230	190
O-60	Kjr(?)	170	11-04-87	9.0	2,850	6.8	.1	1,500	930	2,320	180	250
O-62	Qvf	73	11-04-87	8.0	613	7.5	2.2	320	300	387	81	29
O-63	Qvf	133	11-04-87	8.5	869	7.3	.1	460	440	529	78	64
O-64	Qvf	62	11-03-87	8.0	440	7.5	8.4	230	230	255	59	20
O-65	Qvf	34	11-03-87	10.0	2,520	7.2	.6	1,100	350	2,110	200	150
O-66	Qvf	17	11-03-87	10.0	680	7.3	.2	340	330	412	85	32
P-2	KJke	290	10-25-73	--	628	--	--	390	--	493	110	29
P-5	KJke	192	10-25-73	--	822	--	--	440	--	604	84	55
P-6	Qvf	--	11-03-88	10.5	980	6.8	--	480	300	668	100	54
P-7	KJke	--	11-03-88	11.5	960	7.3	--	470	300	642	98	54
P-32	Qvf	32	11-02-88	9.5	520	7.1	--	280	250	322	71	24
P-64	Ke	180	11-03-88	10.5	1,500	9.0	--	7	360	1,060	2.2	.3
P-67	KJke	--	10-25-73	--	687	--	--	370	--	485	85	39
P-68	Qvf	--	11-04-88	9.0	1,010	7.2	--	490	310	700	120	47
P-73	Qvf	45	10-25-73	--	659	--	--	300	--	457	52	41
P-76	Kjr	76	10-25-73	--	1,190	--	--	550	--	921	87	80
P-77	Qvf	120	10-25-73	--	4,280	--	--	650	--	3,480	130	79
P-81	Qvf	--	11-02-88	10.5	2,150	7.4	--	640	390	1,800	130	74
P-87	Qvf	42	10-25-73	7.5	842	--	--	350	--	576	69	44
P-90	--	70	10-31-88	7.5	1,400	7.2	4.6	560	360	911	120	60
P-91	Kjr	--	11-03-88	11.0	1,110	7.2	--	510	360	882	110	56
P-94	Qvf	80	03-29-73	8.5	848	--	--	340	--	591	61	45
P-96	Qvf	68	11-01-88	8.0	880	7.5	--	380	300	559	94	36
P-98	Qvf	67	07-12-73	9.0	1,560	--	--	150	--	1,130	29	19
P-102	Kjr	--	10-25-73	9.0	3,190	--	--	160	--	2,320	18	28
P-108	Qvf	26	08-13-73	--	630	--	--	310	--	414	59	40
P-109	Ke	--	10-25-73	--	1,180	--	--	44	--	793	6.7	6.7
P-110	Kc	80	11-02-88	8.5	690	7.1	--	360	270	439	87	34
P-136	Kcl	--	10-25-73	--	2,680	--	--	1,300	--	2,320	200	200
P-150	Qvf	25	11-01-88	7.5	700	7.4	2.4	360	290	442	94	31
P-152	Qvf	41	10-25-73	7.0	520	8.0	--	280	--	356	64	29
P-153	Qvf	32	08-13-73	--	3,700	--	--	1,500	--	3,240	220	240
						Streamflow sites						
06154410	--	--	11-04-86	8.0	462	--	--	--	--	--	--	--
	--	--	10-19-87	4.0	450	8.6	11.0	250	230	276	60	23
S-3	--	--	11-04-86	8.0	550	8.4	10.8	290	260	325	75	24
	--	--	10-19-87	3.0	559	8.4	11.9	290	260	348	76	25
S-5	--	--	10-19-87	4.0	685	8.5	11.8	340	290	438	84	31
S-7	--	--	10-19-87	3.5	735	8.6	13.6	340	290	459	80	34
06154430	--	--	10-20-87	5.0	545	7.9	9.6	280	270	319	79	20
S-10	--	--	10-20-87	2.5	810	8.2	12.7	400	320	492	97	39
S-11	--	--	10-20-87	2.5	852	8.5	12.8	410	320	548	90	44
S-12	--	--	10-20-87	4.5	960	8.3	14.2	430	330	623	87	52

Table 17.--*Physical properties and major-ion concentrations of ground water and streamflow*--Continued

Sodium, dis-solved (mg/L as Na)	Sodium ad-sorp-tion ratio (SAR)	Potas-sium, dis-solved (mg/L as K)	Bicar-bonate, fet-lab (mg/L as HCO_3)	Bicar-bonate, it-fld (mg/L as HCO_3)	Car-bonate, fet-lab (mg/L as CO_3)	Sul-fate, dis-solved (mg/L as SO_4)	Chlo-ride, dis-solved (mg/L as Cl)	Fluo-ride, dis-solved (mg/L as F)	Bro-mide, dis-solved (mg/L as Br)	Silica, dis-solved (mg/L as SiO_2)	Nitro-gen, nitrate, dis-solved (mg/L as NO_3)	Phos-phorus, dis-solved (mg/L as P)	Site number
						Ground-water sites--Continued							
260	3	13	990	1,100	--	1,100	6.5	.3	<.1	17	.04	<.10	O-59
220	3	13	1,080	1,140	--	1,100	6.4	.2	<.1	16	.04	<.10	O-60
11	.3	2.9	350	372	--	48	1.7	.2	<.1	24	1.1	<.10	O-62
21	.4	3.6	510	542	--	74	2.8	.7	<.1	15	.75	<.10	O-63
4.9	.1	1.6	270	278	--	21	.9	.2	--	11	.02	<.10	O-64
250	3	3.8	400	432	--	1,300	11	.4	<.1	16	.19	<.10	O-65
20	.5	2.7	400	406	--	57	1.6	.2	<.1	13	.02	<.10	O-66
7.3	.2	4.0	240	--	14	180	2.4	.5	--	11	.5	--	P-2
36	.8	6.0	290	--	0	270	1.8	.2	--	8.1	.14	--	P-5
38	.8	5.9	340	362	--	270	1.8	.1	<.1	7.9	.12	.10	P-6
38	.8	6.2	360	361	--	250	1.8	.1	<.1	5.1	.04	<.10	P-7
9.4	.3	2.2	300	311	--	47	1.1	.3	<.1	12	.36	<.10	P-32
370	65	.8	390	397	--	420	13	.2	<.1	8.4	.36	<.10	P-64
14	.3	3.0	200	--	0	230	3.9	.4	--	9.8	.34	--	P-67
51	1	3.0	370	378	--	280	2.6	.4	<.1	13	.56	<.10	P-68
53	1	3.0	--	--	--	160	3.3	.2	--	12	--	--	P-73
93	2	3.0	330	--	14	450	5.2	.7	--	11	--	--	P-76
870	15	6.0	480	--	0	2,100	21	.5	--	10	5.2	--	P-77
350	6	3.6	450	480	--	980	7.2	.8	<.1	12	.09	<.10	P-81
63	1	3.0	220	--	0	270	3.3	.4	--	14	.27	--	P-87
93	2	3.0	420	446	--	390	4.2	.4	<.1	13	.56	<.10	P-90
92	2	5.2	390	437	--	370	6.8	.4	<.1	14	.36	<.10	P-91
71	2	3.0	250	--	0	270	3.4	.5	--	14	--	--	P-94
46	1	3.2	350	372	--	180	2.7	.6	--	13	.08	<.10	P-96
330	12	3.0	400	--	0	530	9.6	.5	--	13	.02	--	P-98
740	26	6.0	600	--	42	1,100	27	1.1	--	17	.16	--	P-102
25	.6	3.0	290	--	0	130	2.2	.3	--	11	.11	--	P-108
290	19	1.0	530	--	33	150	1.8	.3	--	8.3	.11	--	P-109
13	.3	4.8	320	333	--	120	1.0	.9	<.1	5.9	.04	<.10	P-110
250	3	19	480	--	0	1,400	4.9	.2	--	9.1	.32	--	P-136
15	.4	2.8	340	351	--	110	1.1	.3	<.1	13	.27	<.10	P-150
18	.5	3.0	--	--	--	100	.9	.3	--	13	--	--	P-152
440	5	13	420	--	0	2,100	5.0	.2	--	10	.18	--	P-153
						Streamflow sites							
--	--	--	--	--	--	--	--	--	--	--	--	--	06154410
2.6	.1	1.6	280	256	--	26	.7	.2	<.1	11	.07	<.10	
8.3	.2	2.4	300	--	--	52	1.5	.4	<.1	11	.71	<.10	S-3
9.0	.2	2.6	310	296	--	52	1.3	.3	<.1	12	2.8	<.10	
21	.5	2.9	340	322	--	94	2.0	.4	<.1	12	.04	<.10	S-5
27	.7	3.0	350	328	--	110	2.2	.4	<.1	11	.02	<.10	S-7
6.9	.2	2.6	330	330	--	33	.8	.2	<.1	14	.02	<.10	06154430
24	.5	3.1	390	390	--	120	1.5	.4	<.18	9.0	.02	<.10	S-10
32	.7	3.5	390	352	--	150	1.7	.4	<.1	9.2	.02	<.10	S-11
51	1	4.7	410	388	--	200	2.8	.4	<.1	9.5	.01	<.10	S-12

Table 18.--*Trace-element concentrations of ground water and streamflow*

[Analyses by Montana Bureau of Mines and Geology in accordance with methods defined by Skougstad and others (1979). Geologic unit: Qvf, Quaternary valley fill; Kjr, Upper Cretaceous Judith River Formation; Kcl, Upper Cretaceous Claggett Shale; Ke, Upper Cretaceous Eagle Sandstone; Kc, Upper and Lower Cretaceous Colorado Group; KJke, Lower Cretaceous to Middle Jurassic Kootenai Formation and Ellis Group. Depth of well, total: in feet below land surface. Abbreviation: µg/L, micrograms per liter. Symbols: <, less than; --, no data or not applicable]

Site number	Geologic unit	Depth of well, total (feet)	Date	Aluminum, dissolved (µg/L as Al)	Boron, dissolved (µg/L as B)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)	Copper, dissolved (µg/L as Cu)	Iron, dissolved (µg/L as Fe)	Lithium, dissolved (µg/L as Li)
				<u>Ground-water sites</u>						
B-1	KJke	226	10-03-88	<30	140	<2	<2	<2	18	53
B-2	Kc	174	10-03-88	<30	1,900	<2	<2	<2	7	150
B-3	Ke	144	10-02-88	<30	160	<2	<2	<2	11	20
B-4	Ke	224	10-01-88	<30	--	<2	<2	<2	960	86
B-5	Ke	375	10-01-88	<30	1,100	<2	<2	<2	15	100
B-6	Ke	303	10-03-88	<30	170	<2	<2	<2	120	56
B-7	Ke	94	10-02-88	<30	200	<2	<2	<2	260	31
B-8	Ke	214	10-02-88	<30	380	<2	<2	<2	700	110
O-2	Qvf	83	10-15-87	<30	30	<2	<2	<2	<2	6
O-5	Qvf	45	10-14-87	<30	30	<2	<2	<2	<2	11
O-7	Qvf	34	10-14-87	<30	150	7	<2	<2	<2	54
O-9	Qvf	53	10-17-87	<30	40	<2	<2	<2	<2	13
			06-24-88	<30	80	<2	<2	2	5	13
O-10	Qvf	40	10-14-87	30	70	4	<2	<2	<2	16
O-11	Qvf	45	10-14-87	<30	280	5	<2	<2	<2	100
O-13	Qvf	40	10-19-87	<30	230	<2	<2	<2	6	63
			06-28-88	<30	350	3	2	10	22	70
O-14	Qvf	40	10-14-87	<30	80	5	<2	<2	<2	18
O-16	Qvf	65	10-15-87	<30	70	8	<2	<2	<2	20
O-17	Qvf	43	10-15-87	<30	2,500	5	<2	<2	56	520
O-18	Qvf	27	09-14-87	<30	30	<2	<2	<2	2,800	7
O-19	Qvf	58	09-12-87	<30	340	2	<2	2	<2	110
O-20	Qvf	35	09-12-87	<30	230	<2	3	10	500	92
O-22	Qvf	85	09-14-87	<30	120	<2	<2	5	<2	47
			10-16-87	<30	150	3	<2	<2	<2	47
O-23	Qvf	87	06-23-88	<30	200	3	2	4	16	48
O-24	Qvf	73	09-12-87	<30	690	<2	<2	4	<2	25
O-25	Qvf	28	09-12-87	<30	480	<2	<2	<2	1,000	210
O-26	Qvf	100	09-13-87	<30	130	<2	<2	<2	<2	60
O-27	Qvf	110	09-18-87	<30	100	<2	<2	2	95	44
O-28	Qvf	130	09-13-87	<30	340	<2	<2	<2	810	99
O-29	Qvf	88	09-13-87	<30	200	<2	<2	<2	160	72
O-30	Qvf	97	09-11-87	<30	360	17	<2	<2	30	72
O-31	Qvf	123	09-12-87	<30	1,000	<2	<2	<2	39	130
O-33	Qvf	120	09-11-87	<30	480	<2	<2	<2	29	81
O-34	Qvf	105	09-10-87	<30	470	<2	<2	<2	24	110
O-40	Qvf	65	11-05-87	<30	30	<2	<2	<2	<2	12
O-42	Qvf	54	09-15-87	<20	30	<2	<2	<2	<2	7
			06-27-88	<30	60	2	<2	3	<2	10
O-43	Qvf	55	11-04-87	<30	50	<2	<2	<2	<2	7
O-44	Qvf	60	10-18-87	<30	140	<2	<2	<2	<2	10
O-46	Qvf	60	10-18-87	<30	50	5	<2	<2	<2	27
O-47	Qvf	23	10-17-87	<30	100	3	<2	<2	<2	40
O-48	Qvf	69	10-17-87	<30	90	<2	<2	<2	21	23
O-49	Qvf	64	10-17-87	<30	60	<2	<2	<2	340	38
O-50	Qvf	40	10-17-87	<30	160	<2	<2	<2	86	24
O-51	Qvf	85	11-05-87	<30	220	<2	<2	<2	1,600	140
			11-01-88	<30	300	<2	<2	<2	1,600	140
O-52	Qvf	43	11-05-87	<30	330	<2	<2	3	1,300	200
O-53	Qvf	97	11-05-87	<30	120	<2	<2	<2	130	52

Manganese, dissolved (µg/L as Mn)	Molybdenum, dissolved (µg/L as Mo)	Nickel, dissolved (µg/L as Ni)	Silver, dissolved (µg/L as Ag)	Strontium, dissolved (µg/L as Sr)	Titanium, dissolved (µg/L as Ti)	Vanadium, dissolved (µg/L as V)	Zinc, dissolved (µg/L as Zn)	Zirconium, dissolved (µg/L as Zr)	Site number
				Ground-water sites					
35	<20	<10	<2.0	830	1	<1	3	<4	B-1
6	<20	<10	<2.0	150	<1	<1	6	<4	B-2
7	<20	<10	<2.0	540	<1	<1	560	<4	B-3
120	<20	<16	<2.0	950	2	1	610	<4	B-4
7	<20	<10	<2.0	360	<1	<1	12	<4	B-5
52	<20	<10	<2.0	990	<1	<1	560	<4	B-6
7	<20	<10	<2.0	160	<1	<1	4	<4	B-7
45	<20	<10	<2.0	1,400	<1	<1	390	<4	B-8
<1	<20	<10	<2.0	360	9	<1	<3	<4	O-2
<1	<20	<10	<2.0	410	10	<1	<3	<4	O-5
8	<20	<10	<2.0	720	9	<1	5	<4	O-7
<1	<20	<10	<2.0	450	8	<1	4	<4	O-9
1	<20	<10	<2.0	480	2	<1	4	<3	
<1	<20	<10	<2.0	440	7	<1	3	<4	O-10
1	<20	<10	<2.0	1,200	10	<1	6	<4	O-11
1	<20	<10	<2.0	740	20	<1	<3	<4	O-13
1	<20	<10	<1.0	840	7	3	<3	4	
<1	<20	<10	<2.0	430	7	<1	3	<4	O-14
<1	<20	<10	<2.0	480	8	<1	<3	<4	O-16
1,200	<20	10	<2.0	2,700	20	<1	6	<4	O-17
1,800	<20	<10	<2.0	3,100	10	<1	4	<3	O-18
<1	<20	<10	<2.0	1,300	20	<1	5	<4	O-19
850	<20	<10	3.0	1,300	10	6	3	7	O-20
<1	<20	<10	<2.0	800	10	<1	12	<4	O-22
<1	<20	<10	<2.0	770	10	<1	5	<4	
3	<20	<10	<2.0	790	6	3	<3	<4	O-23
<1	<20	<10	<2.0	590	10	<1	12	<4	O-24
600	<20	<10	<2.0	2,400	10	<1	5	<4	O-25
14	<20	<10	<2.0	780	10	<1	9	<4	O-26
760	<20	<10	<2.0	950	10	<1	3	<4	O-27
210	<20	<10	<2.0	1,200	9	<1	<3	<4	O-28
780	<20	<10	<2.0	1,200	10	<1	<3	<4	O-29
160	<20	<10	<2.0	430	2	<1	<3	<4	O-30
320	<20	<10	<2.0	650	5	<1	8	<4	O-31
350	<20	<10	<2.0	500	3	<1	9	<4	O-33
32	<20	<10	<2.0	220	4	<1	<3	<4	O-34
<1	<20	<10	<2.0	420	7	<1	3	<4	O-40
<1	<20	<10	<2.0	360	10	<1	4	<3	O-42
<1	<20	<10	<2.0	390	3	<1	<3	<4	
<1	<20	<10	<2.0	350	9	<1	3	<4	O-43
<1	<20	<10	<2.0	360	10	<1	4	<4	O-44
<1	<20	<10	<2.0	560	10	<1	4	<4	O-46
6	<20	<10	<2.0	570	10	<1	6	<4	O-47
2	<20	<10	<2.0	480	10	<1	<3	<4	O-48
28	<20	<10	<2.0	700	10	<1	<3	<4	O-49
73	<20	<10	<2.0	500	10	<1	3	<4	O-50
260	<20	<10	<2.0	980	<1	<1	5	<4	O-51
250	<20	<10	<2.0	980	8	<1	<3	<4	
240	<20	<10	<2.0	1,300	8	<1	6	<4	O-52
140	<20	<10	<2.0	460	5	<1	<3	<4	O-53

Table 18.--*Trace-element concentrations of ground water and streamflow*--Continued

Site number	Geo-logic unit	Depth of well, total (feet)	Date	Alum-inum, dis-solved (µg/L as Al)	Boron, dis-solved (µg/L as B)	Cadmium, dis-solved (µg/L as Cd)	Chro-mium, dis-solved (µg/L as Cr)	Copper, dis-solved (µg/L as Cu)	Iron, dis-solved (µg/L as Fe)	Lithium, dis-solved (µg/L as Li)
				Ground-water sites--Continued						
O-54	Qvf	87	11-05-87	<30	240	<2	<2	<2	1,000	130
O-55	Qvf	86	11-05-87	<30	340	<2	<2	<2	2,600	220
			11-01-88	<30	470	<2	<2	<2	2,200	210
O-56	Qvf	38	11-04-87	<30	460	<2	<2	<2	480	440
O-58	Qvf	55	10-16-87	<30	420	<2	<2	<2	2,000	600
O-59	Qvf	65	11-04-87	<30	410	<2	<2	<2	520	540
O-60	Kjr(?)	170	11-04-87	<30	290	<2	<2	<2	1,600	530
O-62	Qvf	73	11-04-87	<30	50	<2	<2	<2	<2	33
O-63	Qvf	133	11-04-87	<30	100	<2	<2	<2	<2	73
O-64	Qvf	62	11-03-87	<30	<20	<2	<2	<2	<2	5
O-65	Qvf	34	11-03-87	<30	370	<2	<2	4	<2	200
O-66	Qvf	17	11-03-87	<30	70	<2	<2	<2	29	20
P-2	KJke	290	10-25-73	--	--	--	--	--	<10	--
P-5	KJke	192	10-25-73	--	--	--	--	--	<10	--
P-6	Qvf	--	11-03-88	<30	320	3	<2	35	13	88
P-7	KJke	--	11-03-88	<30	320	2	<2	<2	2,700	91
P-32	Qvf	32	11-02-88	<30	120	<2	<2	19	23	15
P-64	Ke	180	11-03-88	<30	180	<2	<2	<2	3	59
P-67	KJke	--	10-25-73	--	--	--	--	--	<10	--
P-68	Qvf	--	11-04-88	<30	260	<2	<2	<2	130	45
P-73	Qvf	45	10-25-73	--	--	--	--	--	<10	--
P-76	Kjr	76	10-25-73	--	--	--	--	--	<10	--
P-77	Qvf	120	10-25-73	--	--	--	--	--	50	--
P-81	Qvf	--	11-02-88	<30	610	<2	<2	<2	1,000	140
P-87	Qvf	42	10-25-73	--	--	--	--	--	<10	--
P-90	--	70	10-31-88	<30	350	<2	<2	<2	4	75
P-91	Kjr	--	11-03-88	<30	290	<2	<2	<2	2,100	92
P-94	Qvf	80	03-29-73	--	--	--	--	--	<10	--
P-96	Qvf	68	11-01-88	<30	160	<2	<2	<2	300	38
P-98	Qvf	67	07-12-73	--	--	--	--	--	<10	--
P-102	Kjr	--	10-25-73	--	--	--	--	--	30	--
P-108	Qvf	26	08-13-73	--	--	--	--	--	<10	--
P-109	Ke	--	10-25-73	--	--	--	--	--	30	--
P-110	Kc	80	11-02-88	<30	130	<2	<2	<2	4,200	36
P-136	Kcl	--	10-25-73	--	--	--	--	--	90	--
P-150	Qvf	25	11-01-88	<30	100	<2	<2	<2	<2	35
P-152	Qvf	41	10-25-73	--	--	--	--	--	<10	--
P-153	Qvf	32	08-13-73	--	--	--	--	--	<10	--
				Streamflow sites						
06154410	--	--	11-04-86	--	--	--	--	--	--	--
	--	--	10-19-87	<30	30	<2	<2	<2	<2	7
S-3	--	--	11-04-86	<30	<20	<2	<2	<2	<2	11
	--	--	10-19-87	<30	190	2	<2	<2	<2	17
S-5	--	--	10-19-87	<30	70	<2	<2	<2	2	27
S-7	--	--	10-19-87	<30	90	<2	<2	<2	<2	31
06154430	--	--	10-20-87	<30	20	<2	<2	<2	14	13
S-10	--	--	10-20-87	<30	70	<2	<2	<2	3	45
S-11	--	--	10-20-87	<30	80	<2	<2	<2	<2	59
S-12	--	--	10-20-87	<30	100	<2	<2	<2	<2	87

Table 18.--*Trace-element concentrations of ground water and streamflow*--Continued

Manganese, dissolved (µg/L as Mn)	Molybdenum, dissolved (µg/L as Mo)	Nickel, dissolved (µg/L as Ni)	Silver, dissolved (µg/L as Ag)	Strontium, dissolved (µg/L as Sr)	Titanium, dissolved (µg/L as Ti)	Vanadium, dissolved (µg/L as V)	Zinc, dissolved (µg/L as Zn)	Zirconium, dissolved (µg/L as Zr)	Site number
				Ground-water sites--Continued					
230	<20	<10	<2.0	850	5	<1	5	<4	O-54
450	<20	<10	<2.0	1,700	<1	<1	<3	<4	O-55
340	<20	<10	<2.0	1,300	5	<1	<3	<4	
650	<20	<10	<2.0	1,900	10	<1	8	<4	O-56
330	<20	<10	<2.0	3,400	4	<1	22	<4	O-58
560	<20	<10	<2.0	3,300	5	<1	10	<4	O-59
210	<20	<10	<2.0	2,600	2	<1	11	<4	O-60
130	<20	<10	<2.0	560	6	<1	4	<4	O-62
2	<20	<10	<2.0	590	8	<1	5	<4	O-63
<1	<20	<10	<2.0	270	8	<1	3	<4	O-64
2	<20	<10	<2.0	2,100	<1	<1	9	<4	O-65
39	<20	<10	<2.0	460	10	<1	4	4	O-66
<10	--	--	--	--	--	--	--	--	P-2
<10	--	--	--	--	--	--	--	--	P-5
5	<20	<10	<2.0	1,000	9	<1	390	<4	P-6
98	<20	<10	<2.0	960	1	<1	1,500	<4	P-7
1	<20	<10	<2.0	420	7	<1	<3	<4	P-32
9	<20	<10	<2.0	65	<1	<1	<3	<4	P-64
<10	--	--	--	--	--	--	--	--	P-67
3	<20	<10	<2.0	740	<1	<1	4	<4	P-68
<10	--	--	--	--	--	--	--	--	P-73
20	--	--	--	--	--	--	--	--	P-76
80	--	--	--	--	--	--	--	--	P-77
170	<20	<10	<2.0	1,800	7	<1	<3	<4	P-81
<10	--	--	--	--	--	--	--	--	P-87
<1	<20	<10	<2.0	1,000	10	<1	<3	<4	P-90
400	<20	<10	<2.0	1,100	8	<1	<3	<4	P-91
<10	--	--	--	--	--	--	--	--	P-94
680	<20	<10	<2.0	850	1	<1	<3	<4	P-96
60	--	--	--	--	--	--	--	--	P-98
<10	--	--	--	--	--	--	--	--	P-102
120	--	--	--	--	--	--	--	--	P-108
<10	--	--	--	--	--	--	--	--	P-109
62	<20	<10	<2.0	610	10	<1	<3	<4	P-110
30	--	--	--	--	--	--	--	--	P-136
<1	<20	<10	<2.0	600	8	<1	<3	<4	P-150
<10	--	--	--	--	--	--	--	--	P-152
60	--	--	--	--	--	--	--	--	P-153
				Streamflow sites					
--	--	--	--	--	--	--	--	--	06154410
<1	<20	<10	<2.0	240	7	<1	<3	<4	
10	<20	<10	<2.0	440	9	<1	<3	<4	S-3
10	<20	<10	<2.0	430	3	<1	<3	<4	
24	<20	<10	<2.0	540	8	<1	<3	<4	S-5
5	<20	<10	<2.0	570	10	<1	<3	<4	S-7
72	<20	<10	<2.0	380	9	<1	<3	<4	06154430
7	<20	<10	<2.0	590	10	<1	<3	<4	S-10
3	<20	<10	<2.0	630	9	<1	<3	<4	S-11
5	<20	<10	<2.0	680	10	<1	<3	<4	S-12

Table 19.--*Drinking-water regulations for public water supply*[1],[2]

[MCL, Maximum Contaminant Level; SMCL, Secondary Maximum Contaminant Level; mg/L, milligrams per liter; µg/L, micrograms per liter; --, no regulation available or not applicable]

Water-quality characteristic	Maximum concentration or value for indicated regulation: National Primary Drinking-Water Regulation[3] (MCL)	National Secondary Drinking-Water Regulation[4] (SMCL)	Equivalent trace-element concentration[5] for MCL or SMCL (µg/L)
	Physical property (standard units)		
pH	--	6.5-8.5	--
	Common constituents (mg/L)		
Dissolved solids	--	500	--
Chloride	--	250	--
Fluoride	4.0	2.0	--
Nitrate (as N)	10	--	--
Sulfate	--	250	--
	Trace elements (mg/L)		
Aluminum	--	.05-.2	50-200
Cadmium	.005	--	5
Chromium	.1	--	100
Copper[6]	--	1.0	1,000
Iron	--	.3	300
Manganese	--	.05	50
Silver	--	.1	100
Zinc	--	5.0	5,000

[1] Regulations in effect as of July 30, 1992.
[2] Listed only for properties, common constituents, and trace elements analyzed in this report.
[3] U.S. Environmental Protection Agency (1991a).
[4] U.S. Environmental Protection Agency (1991b).
[5] The U.S. Geological Survey reports trace-element concentrations in micrograms per liter.
[6] Copper is covered by an "action level" of 1.3 mg/L (U.S. Environmental Protection Agency, 1991c).

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