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GEOHYDROLOGIC DATA FROM THE PICEANCE CREEK BASIN BETWEEN THE WHITE AND COLORADO RIVERS, NORTHWESTERN COLORADO

By

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and

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United States Geological Survey

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in cooperation with

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ILLUSTRATIONS

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GEOHYDROLOGIC DATA FROM THE PICEANCE CREEK BASIN BETWEEN THE WHITE AND COLORADO RIVERS, NORTHWESTERN COLORADO

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INTRODUCTION

A study of the water resources in the Piceance Creek basin was begun in 1964 by the U.S. Geological Survey in cooperation with the Colorado Water Conservation Board. Interest in exploiting the extensive oil-shale deposits in the area prompted the study. The objectives of this investigation were to describe the water resources of the basin showing the availability, occurrence, and chemical properties of ground water and surface water. This description will be the basis for developing water supplies and for coping with water problems associated with the exploitation of the oil resources. This report presents the basic data collected and discusses the results of pumping tests made during the study. A subsequent report will describe the water resources. Additional data obtained from hydrologic tests conducted in USBM/AEC Colorado Core Holes No. 1 and No. 2 have been reported by Carroll, Coffin, Ege, and Welder (1967); Ege, Carroll, and Welder (1967); and Stead, Ege, and Welder (1967).

The Piceance Creek basin, a structural downwarp in northwestern Colorado, contains large accumulations of oil shale. Its axis extends northwestward from about 20 miles northwest of Gunnison to the vicinity of Rangely. This report pertains to that part of the basin between the Colorado and White Rivers (see fig. 1 and diagram on back cover), an area of about 1,600 square miles in parts of Rio Blanco, Garfield, and Mesa Counties.

Data collection points and sections are shown on plates 1 and 2. A diagrammatic section across the Piceance Creek basin is shown on figure 2. The water-bearing characteristics of the geologic formations and the logs of test holes drilled in the alluvium are presented in tables 1 and 2.

WELL-NUMBERING SYSTEM

The well and test-hole numbering system is based on the U.S. Bureau of Land Management system of land subdivision. The number shows the location of the well or test hole by quadrant, township, range, section, and position within the section. This method of well location is shown on figure 3. The capital letter at the beginning of the location number indicates the quadrant in which the well is located. Four quadrants are

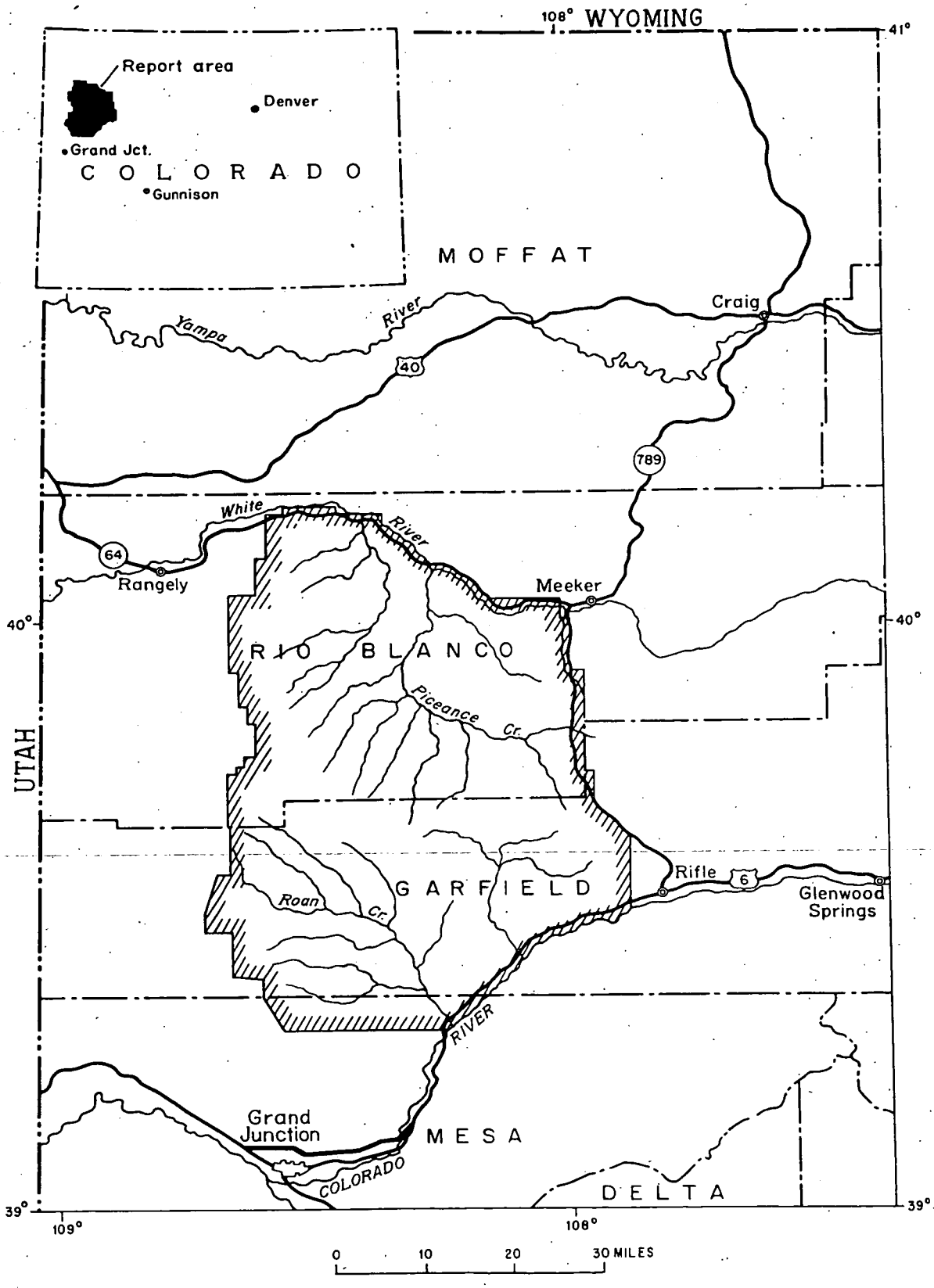

Figure 1.--Index map showing report area.

Table 1.--Summary of the water-bearing characteristics of the geologic formations

System	Series	Geologic unit		Thickness (feet)	Physical character	Water quality	Hydrologic character	Water supply
Quaternary	Recent and Pleistocene	Alluvium		0-140	Sand, gravel, and clay partly fill major valleys as much as 140 feet; generally less than one-half mile wide. Beds of clay may be as thick as 70 feet; generally thickest near the center of valleys. Sand and gravel contain stringers of clay near mouths of small tributaries to major streams.	Near the headwaters of the major streams, dissolved-solids concentrations range from 250 to 700 ppm. The water is generally a calcium magnesium bicarbonate type. In most of the area, dissolved solids range from 700 to as much as 25,000 ppm. Above 3,000 ppm the water is generally a sodium bicarbonate type.	Water is under artesian pressure where sand and gravel are overlain by beds of clay. Well yields will decrease with time because valleys are narrow and the valley walls act as relatively impermeable boundaries. Calculated coefficients of transmissibility range from 20,000 to 150,000 gpd per ft. The coefficient of storage averages 0.20.	Reported yields as much as 1,500 gpm.
Tertiary	Eocene	Green River Formation	Evacuation Creek Member	0-1,250	Intertonguing and gradational beds of sandstone, siltstone, and marlstone; contains pyroclastic rocks and a few conglomerate lenses. Forms surface rock over most of the area; thins appreciably westward.	Water ranges from 250 to 1,800 ppm dissolved solids. It is a mixed type water with no dominant cation or anion.	Beds of sandstone are predominantly fine grained and are poorly permeable. Water moves primarily through fractures. The part of the member higher than valley floors is mostly drained.	Reported to yield as much as 100 gpm. Member has not been thoroughly tested, and larger yields may be possible.
			Parachute Creek Member	500-1,800	Kerogenaceous dolomitic marlstone (oil shale) and shale; contains thin pyroclastic beds; fractured to depths of at least 1,800 feet. Abundant saline minerals in deeper part of the basin.	Water ranges in dissolved-solids content from 250 to about 63,000 ppm. Below 500 ppm, calcium is dominant cation; above 500 ppm, sodium is generally dominant. Bicarbonate is generally the dominant anion regardless of concentration. Fluoride ranges from 0.0 to 54 ppm.	Oil shale is relatively impermeable. Water moves through the fractures. Calculated coefficients of transmissibility range from 1,000 to 2,000 gpd per ft; storage coefficient is about 0.00001.	Estimated potential yields as much as 500 gpm.
			Garden Gulch Member	0-900	Papery and flaky marlstone and shale; contains some beds of oil shale and, locally, thin beds of sandstone.	One water analysis indicates dissolved-solids concentration of 12,000 ppm.	Relatively impermeable and probably contains few fractures.	Not known to yield water to wells.
			Douglas Creek Member	0-800	Sandstone, shale, and limestone; contains oolites and ostracods. Throughout most of the area the member is deeply buried. Sandstone forms prominent cliffs along the basin margin on the south and west; thins toward the deeper part of the basin where the member seems to grade into a finer grained facies.	The few analyses available indicate that dissolved-solids content ranges from 3,000 to 12,000 ppm. The type is either sodium bicarbonate or sodium chloride.	Relatively low permeability and probably little fractured.	Maximum yield is unknown, but probably less than 50 gpm.
			Anvil Points Member	0-1,870	Shale, sandstone, and marlstone grade within a short distance westward into the Douglas Creek, Garden Gulch, and lower part of the Parachute Creek Members. Beds of sandstone are fine grained.	Water is generally of a magnesium sulfate type and may range in dissolved-solids content from about 1,200 to 1,800 ppm.	Beds of sandstone are poorly permeable.	A few wells taping beds of sandstone yield less than 10 gpm; maximum potential yield is unknown. Springs yielding less than 100 gpm issue from fractures.
		Wasatch Formation		300-5,000	Clay, shale, lenticular sandstone; locally, beds of conglomerate and limestone. Beds of clay and shale are the main constituents of the formation. Contains gypsum.	Gypsum contributes sulfate to both surface-water and ground-water supplies.	Beds of clay and shale are relatively impermeable. Beds of sandstone are poorly permeable.	Not known to yield water to wells.

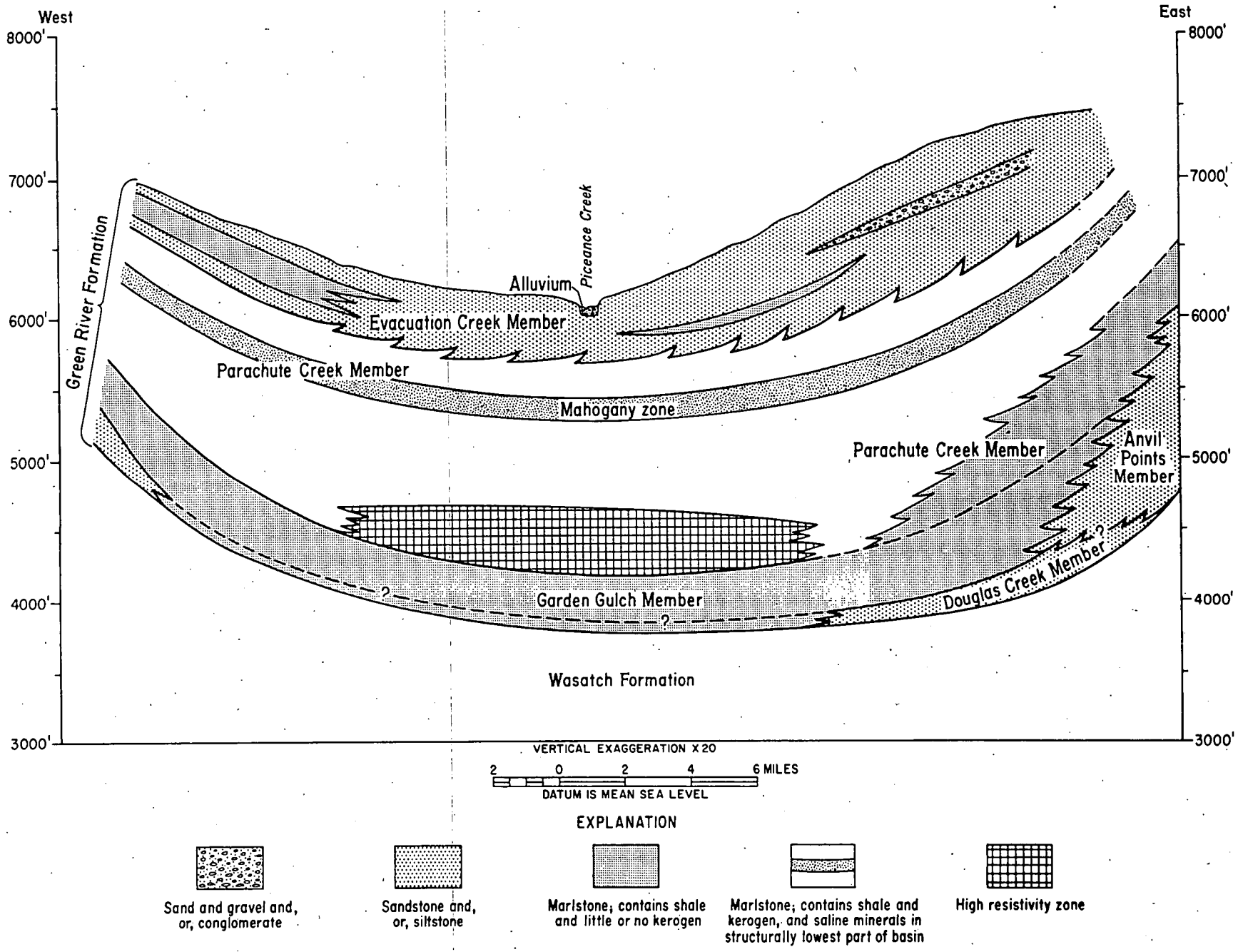

Figure 2. --Diagrammatic section across the Piceance Creek basin showing relations of members of Green River Formation.

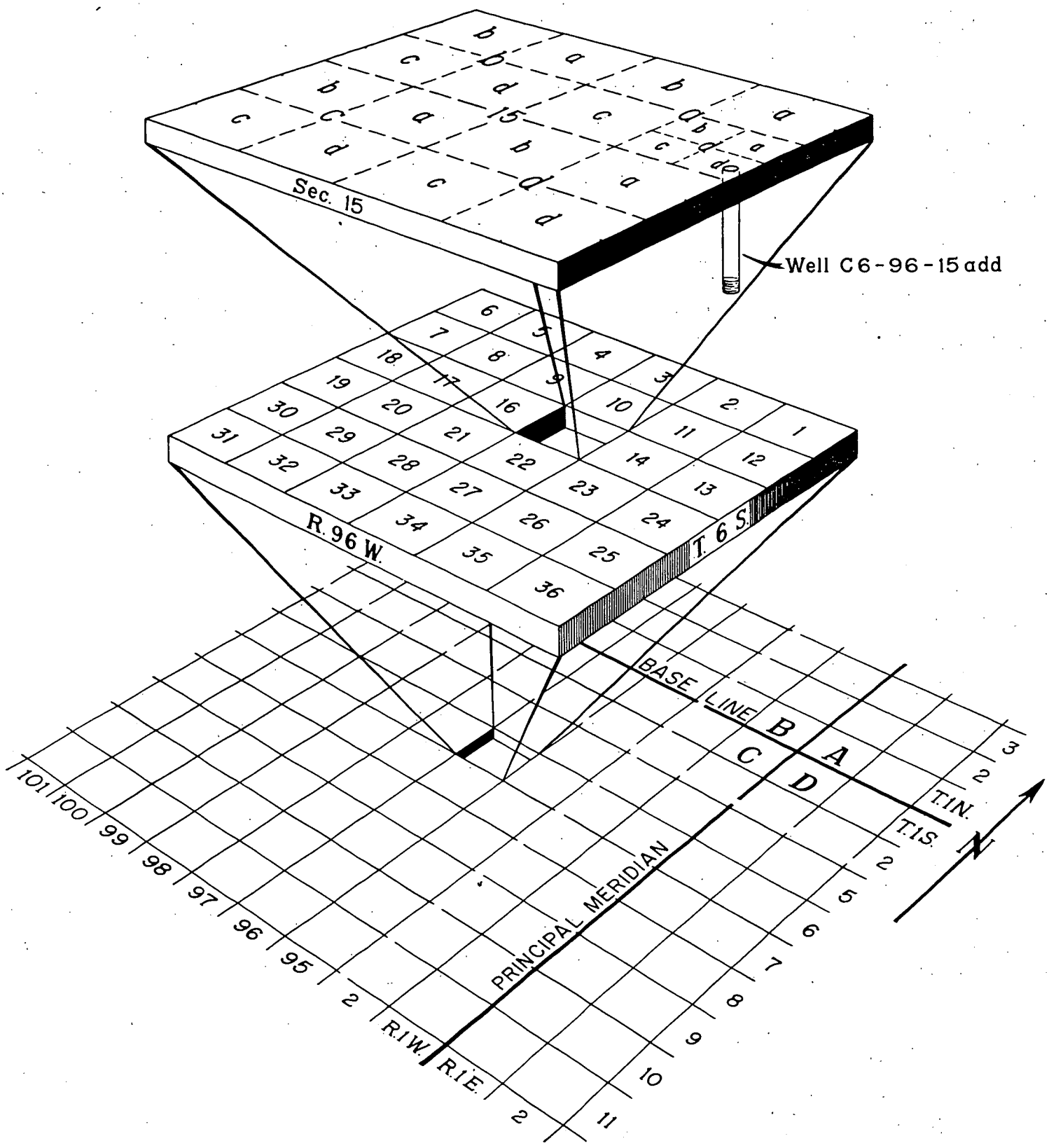

Figure 3. --System of numbering wells and test holes in Colorado.

formed by the intersection of the base line and the principal meridian--A indicates the northeast quadrant, B the northwest, C the southwest, and D the southeast. All wells and test holes in this report are located in either the northwest (B) or southwest (C) quadrant. The first numeral indicates the township, the second the range, and the third the section in which the well is located. Lowercase letters following the section number locate the well within the section. The first letter denotes the quarter section, the second the quarter-quarter section, and the third the quarter-quarter-quarter section. The letters are assigned within the section in a counterclockwise direction, beginning with "a" in the northeast quarter of the section. Letters are assigned within each quarter section and within each quarter-quarter section in the same manner. Where two or more locations are within the smallest subdivision, consecutive numbers beginning with 2 are added to the letters, starting with the second well, in the order in which the wells or test holes were inventoried. For example, C6-96-15add indicates a well in the southeast quarter of the southeast quarter of the northeast quarter of sec. 15, T. 6 S., R. 96 W. The absence of a number following the lowercase letters shows that this was the first well inventoried in the quarter-quarter-quarter section. The capital letter C indicates the township is south of the base line and that the range is west of the principal meridan.

AQUIFER TEST OF THE ALLUVIUM ALONG PICEANCE CREEK

Five test holes were drilled in a line about 5 miles above the mouth of Piceance Creek (B1-97-22) to determine the hydrologic character of the alluvium. (See fig. 4.) One of the test holes (TH 2) was later reamed, cased, and test pumped.

After test hole 2 was reamed to about 10 inches, an 8 1/8-inch ID (inside diameter) casing was set 104 feet below the land surface. The casing was open at the bottom and was perforated from 60 to 103 feet with 9 rows of torch-cut slots. The open area of the perforated interval (60-103 ft) was 4 percent.

Well development began by lowering the drill stem to a depth of about 100 feet and running clear water down the stem for 2 hours to flush the drilling mud from the well. The well was then pumped by forcing compressed air into the drill stem at an average rate of 400 cubic feet per minute. Next, the well was pumped for 30 minutes and allowed to recover for 15 minutes. These development steps were repeated for about 10 hours. During pumping, about 7 cubic yards of material ranging in size from silt to cobbles as large as 6 inches in diameter were blown from the casing. The well yielded about 200 gpm (gallons per minute) at the end of this stage of development.

For the second stage of development, a surge block fitted with a light-weight rubber gasket to assure a reasonably tight fit in the casing was attached to the drill stem just above the bit. The well was surged for

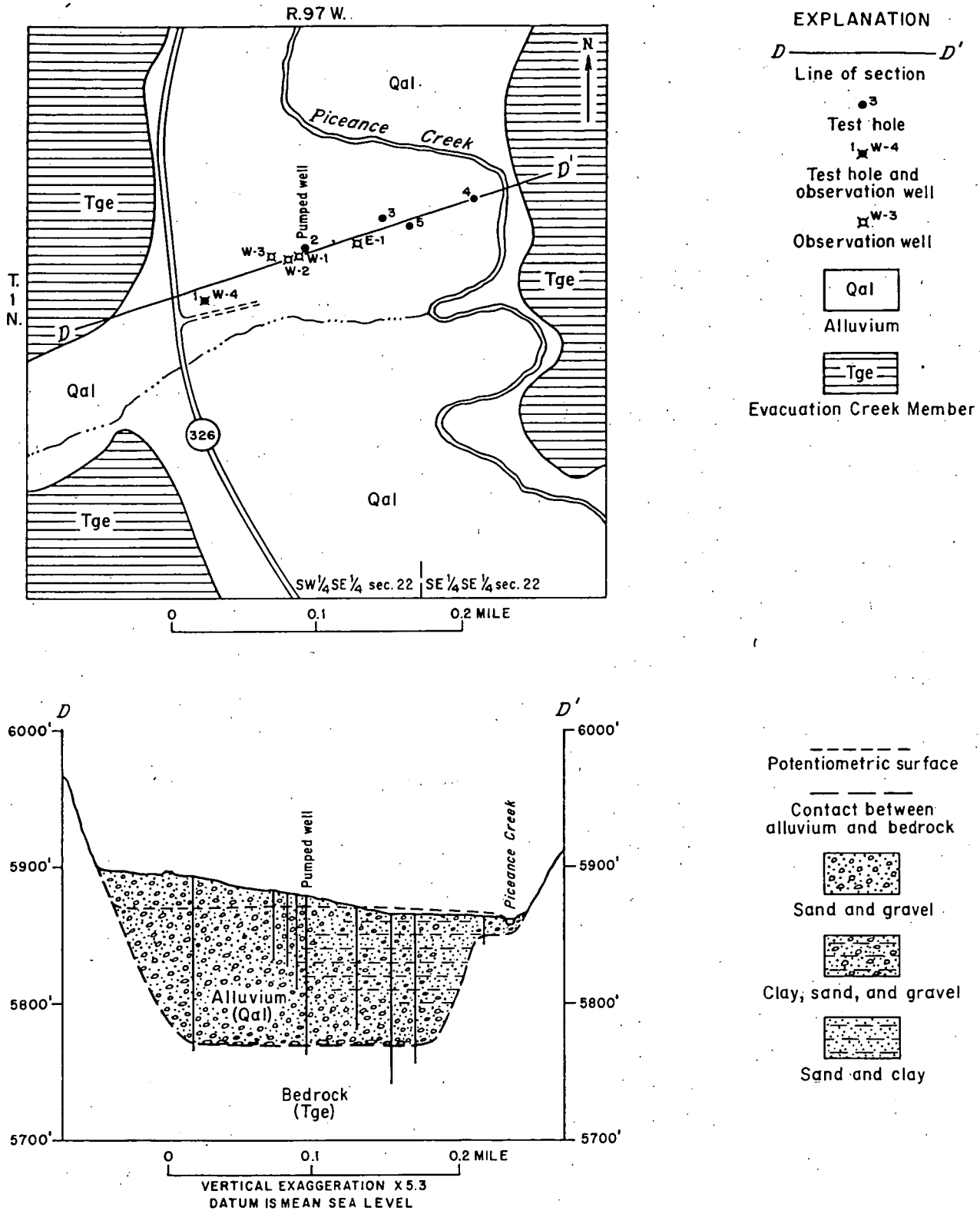

Figure 4. --Geologic map and section of pumping-test site along Piceance Creek (B1-97-22).

about 2 hours by slowly lowering and raising the drill stem. During the surging, air was forced down the drill stem occasionally to blow out the accumulated sand and silt at the bottom of the well. Surging was stopped when sand and silt ceased to accumulate. The surge block was removed, and the well was pumped intermittently with air for about 3 hours. During surging and during the last period of pumping, about a cubic yard of silt and sand was removed from the well. At the end of pumping, the well was yielding about 400 gpm of silty water.

At the end of development, a turbine pump was installed and the well was considered satisfactory for a pumping test. A production well would probably need a better screen and more development because the test indicated a large entrance loss in the pumped well.

Five observation wells were installed (fig. 4) by drilling 4-inch diameter holes and casing them with 1½-inch ID iron pipe and sandpoints 18 inches long. One of the pipes was installed at the site of one of the test holes (W-4). Clear water was pumped down the wells to flush the drilling mud from the hole. For about an hour, each of the wells was developed with compressed air, blowing water and mud to the surface between the pipe and the walls of the hole. After development, the wells would take clear water rapidly indicating good hydraulic connection between the wells and the aquifer.

Geology of the pumping-test site

The pumping-test site is underlain by alluvium composed principally of sand, gravel, and clay. The lithology is shown on figure 4 and is described in the logs of test holes in table 3.

Sand in the alluvium grades from very fine to very coarse and generally is more spherical than the gravel although generally not as well rounded. The gravel grades from very fine to very coarse and is composed of flat, rounded, oval-shaped pieces of marlstone, siltstone, and sandstone. Sorting of the sand and gravel is moderate to poor; however, the deposit is coarser near the base and 2 to 5 feet of cobble gravel generally overlies the bedrock (Evacuation Creek Member of the Green River Formation). Beds of sand and gravel contain minor amounts of clay and range in thickness from 25 to 120 feet. Commonly, the grains are very pale to pale yellowish orange above the water table and are stained bluish green below the water table.

Beds of clay are bluish gray, calcareous, and silty, and contain a few lenses and stringers of sand and gravel. They also contain much carbonized wood and many tiny clam and snail shells. The clay beds aggregate about 60 feet at the east edge of the alluvium and thin to the west, pinching out slightly west of the pumped well (fig. 4).

Water in the alluvium occurs under both water-table and artesian conditions (fig. 4). The permeability of the clay is much less than that of the sand and gravel, and where it confines water in underlying sand and gravel under enough pressure, water flows at the land surface when tapped by a test hole. Test holes 3 and 5 flowed briefly after being drilled, and water rose 3 to 4 feet above the land surface in the drill stem when drilling was stopped to add stems. Test hole 4 did not flow, which may indicate either that the alluvium has a water level lower than that in the main body of the alluvium or that the test hole caved and sealed itself when the drill stem was removed.

Water in the alluvium feeds Piceance Creek in the reach adjacent to the test site, as shown by small springs that issue into the streambed and by the altitude of the water level in W-1 (5,870.2 ft), which is 8.7 feet higher than the water level in Piceance Creek (5,861.5 ft).

Explanation of aquifer test

The pumping test was made on well B1-97-22dca (TH 2; fig. 4). Water levels were measured in five observation wells and the pumping well (figs. 5-10). The pumping rate ranged from 224 to 235 gpm and averaged 231 gpm for 8 days (Oct. 4-12, 1965). Pumping was interrupted for a short period once a day because the engine had to be shut off for refueling. At the start of the test, 98 feet of material was saturated at the pumped well.

Results of aquifer test

The pumping-test data were analyzed by the method developed by Theis (1935) and modified by Cooper and Jacob (1946). Figures 5 through 10 are semilog graphs of drawdown. Except for early data, the measurements ideally should plot in a straight line. Departures from a straight line indicate differences between the real hydrologic situation in the alluvium of Piceance Creek and the idealized hydrologic situation assumed by Theis (1935) and Cooper and Jacob (1946). The data falling on a straight line indicate when the aquifer was behaving as though it were infinite, homogeneous, and isotropic. Departures from this line were interpreted as follows:

1. Data above the straight line indicate that the drawdown was less than should be expected and that the aquifer was probably being recharged.

2. Data below the straight line indicate that drawdown was more than should be expected and that the cone of depression had reached the edge of the alluvium and the relatively impermeable Green River Formation.

3. Sharp fluctuations shown on figure 5 probably are caused by the interruptions in pumping.

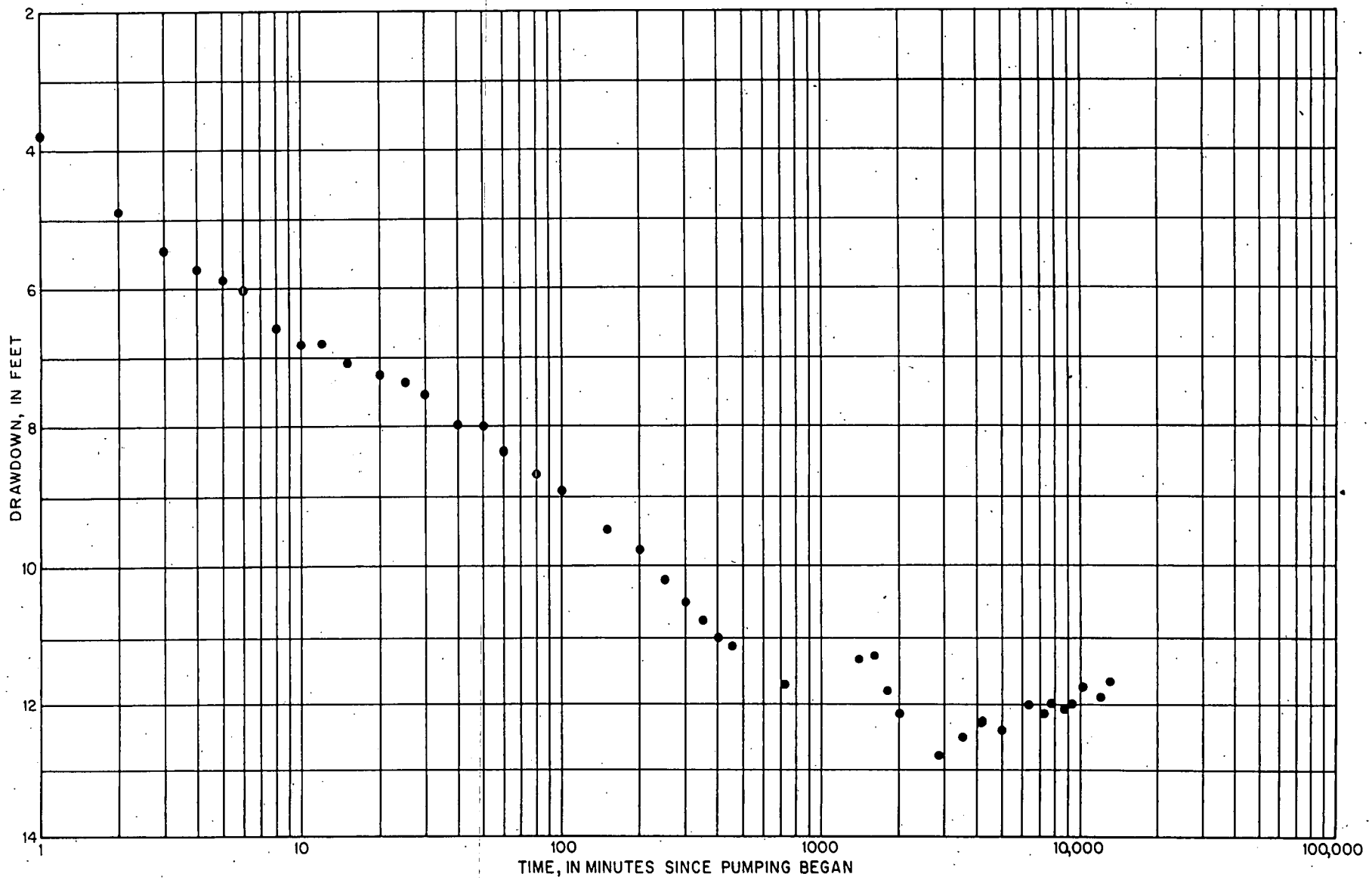

Figure 5.--Drawdown in well B1-97-22dca (pumped well).

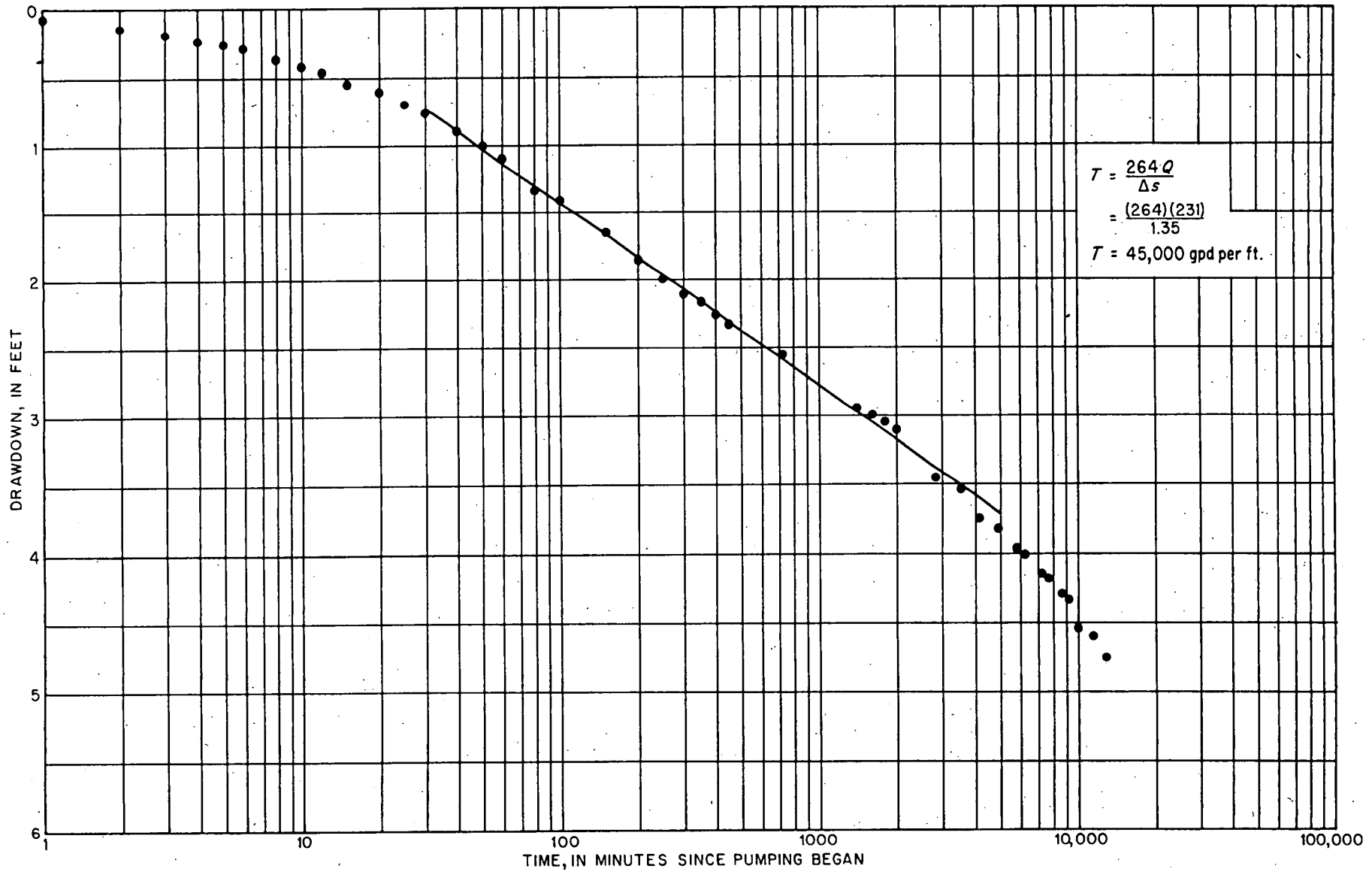

Figure 6. --Drawdown in well W-1.

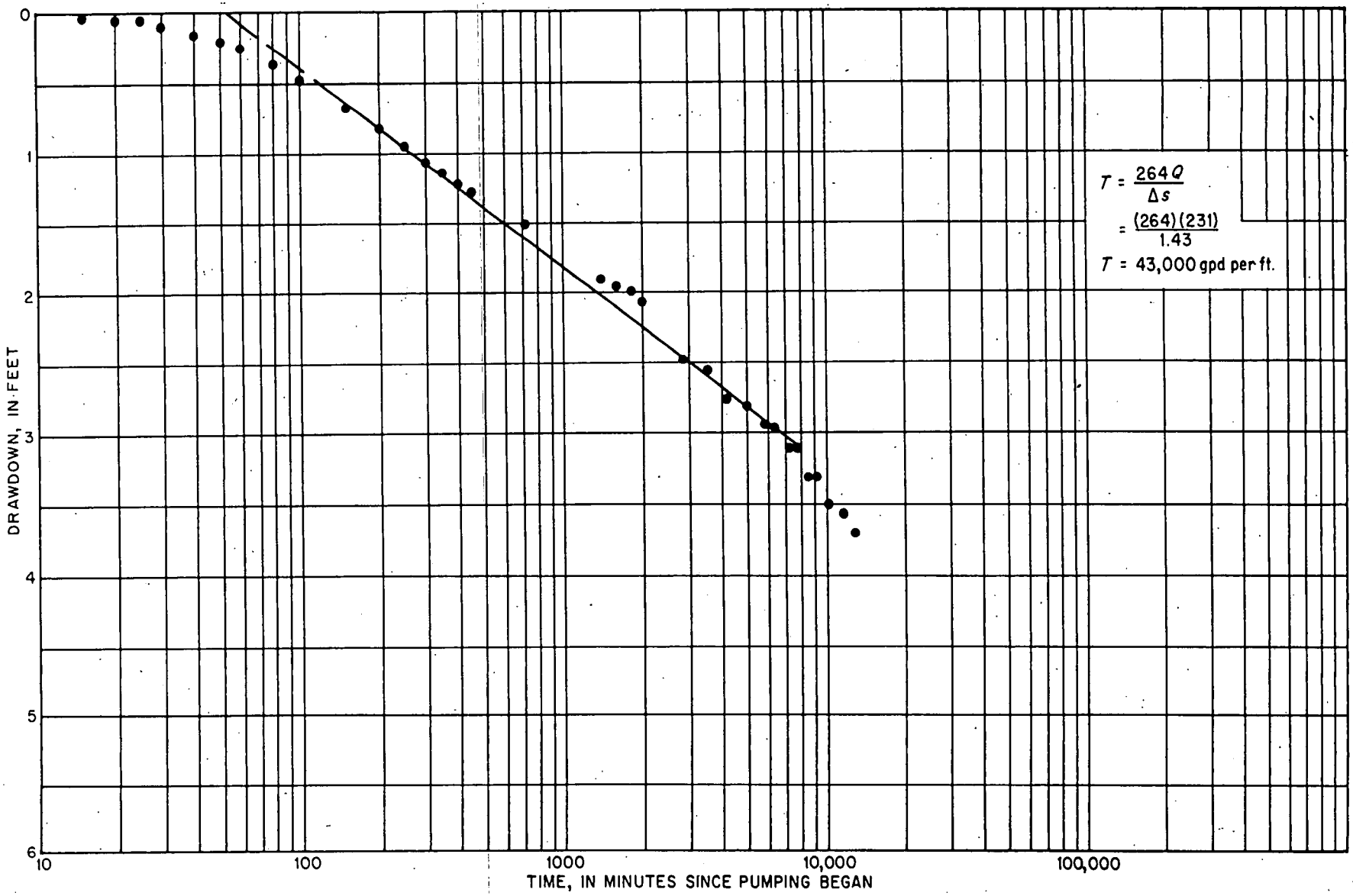

Figure 7. --Drawdown in well W-2.

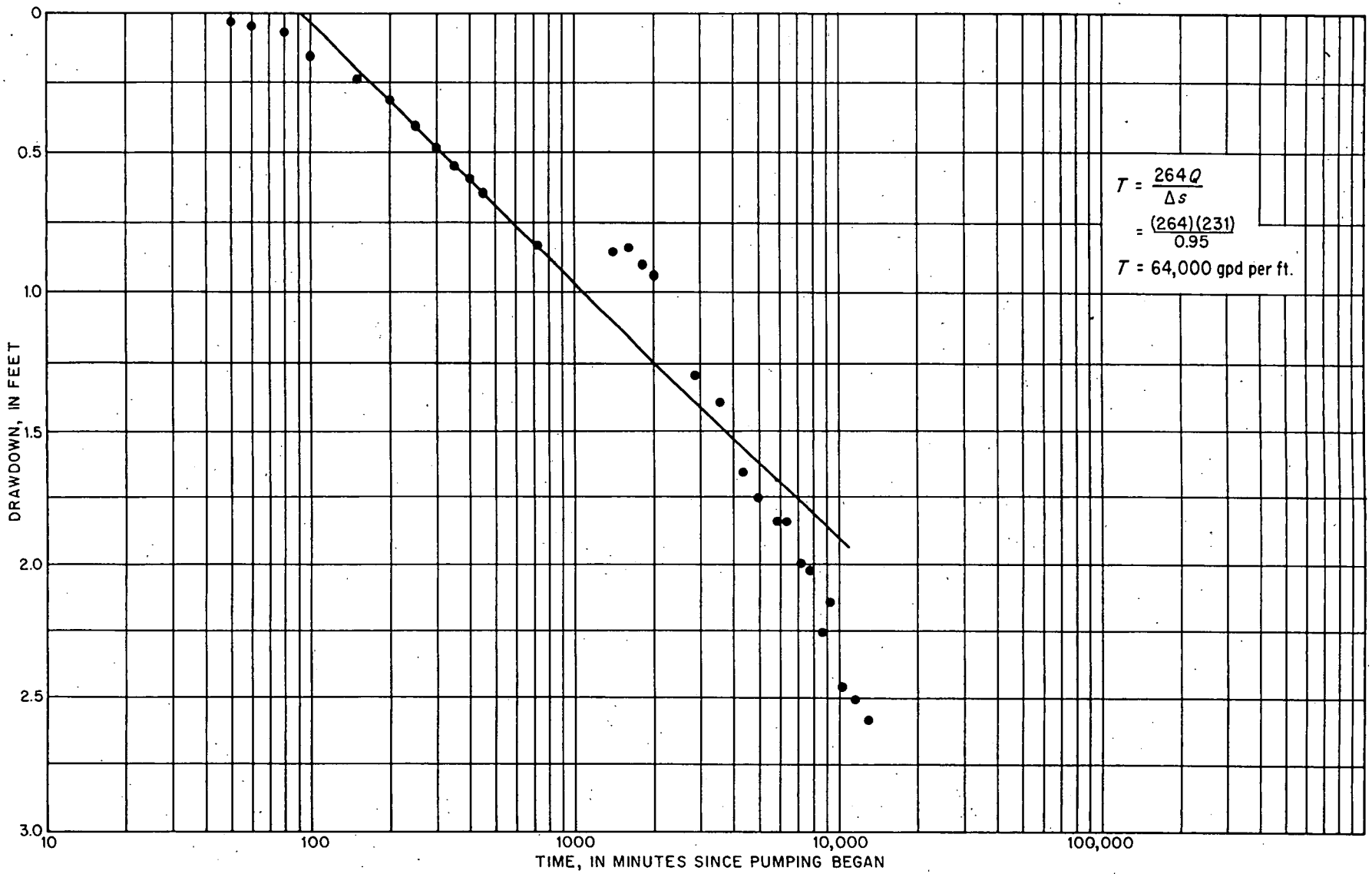

Figure 8. --Drawdown in well W-3.

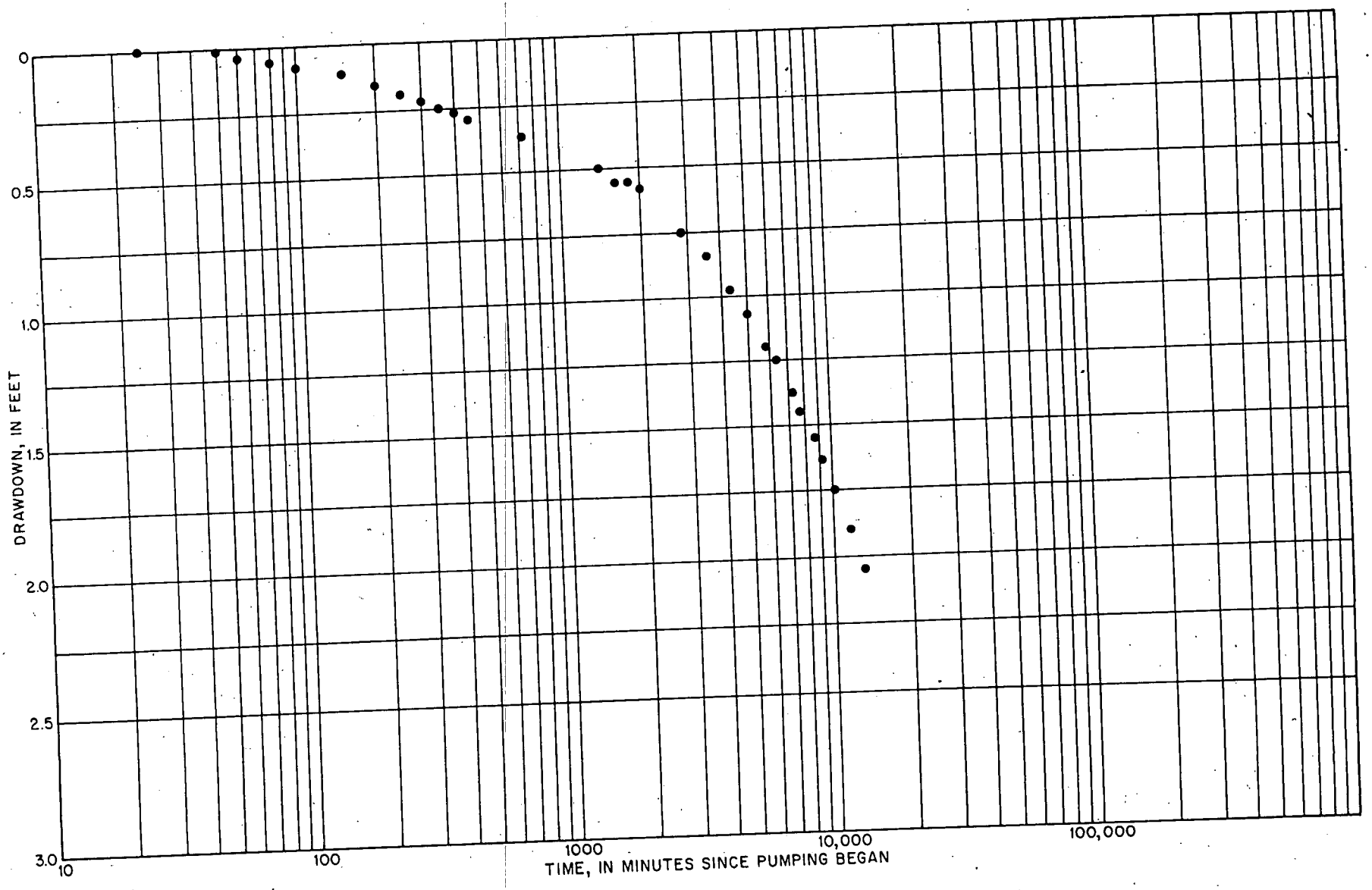

Figure 9.--Drawdown in well W-4.

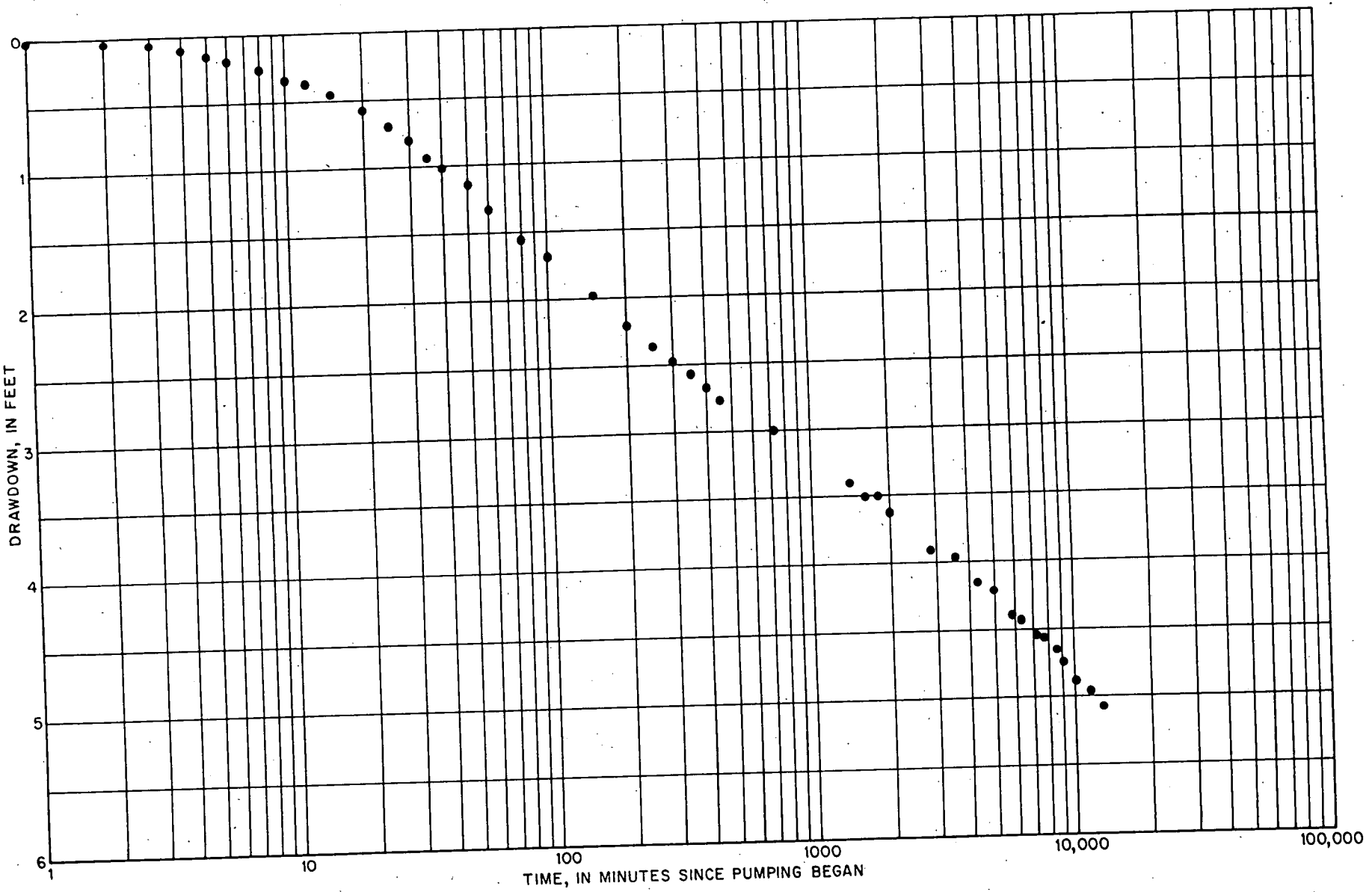

Figure 10. --Drawdown in well E-1.

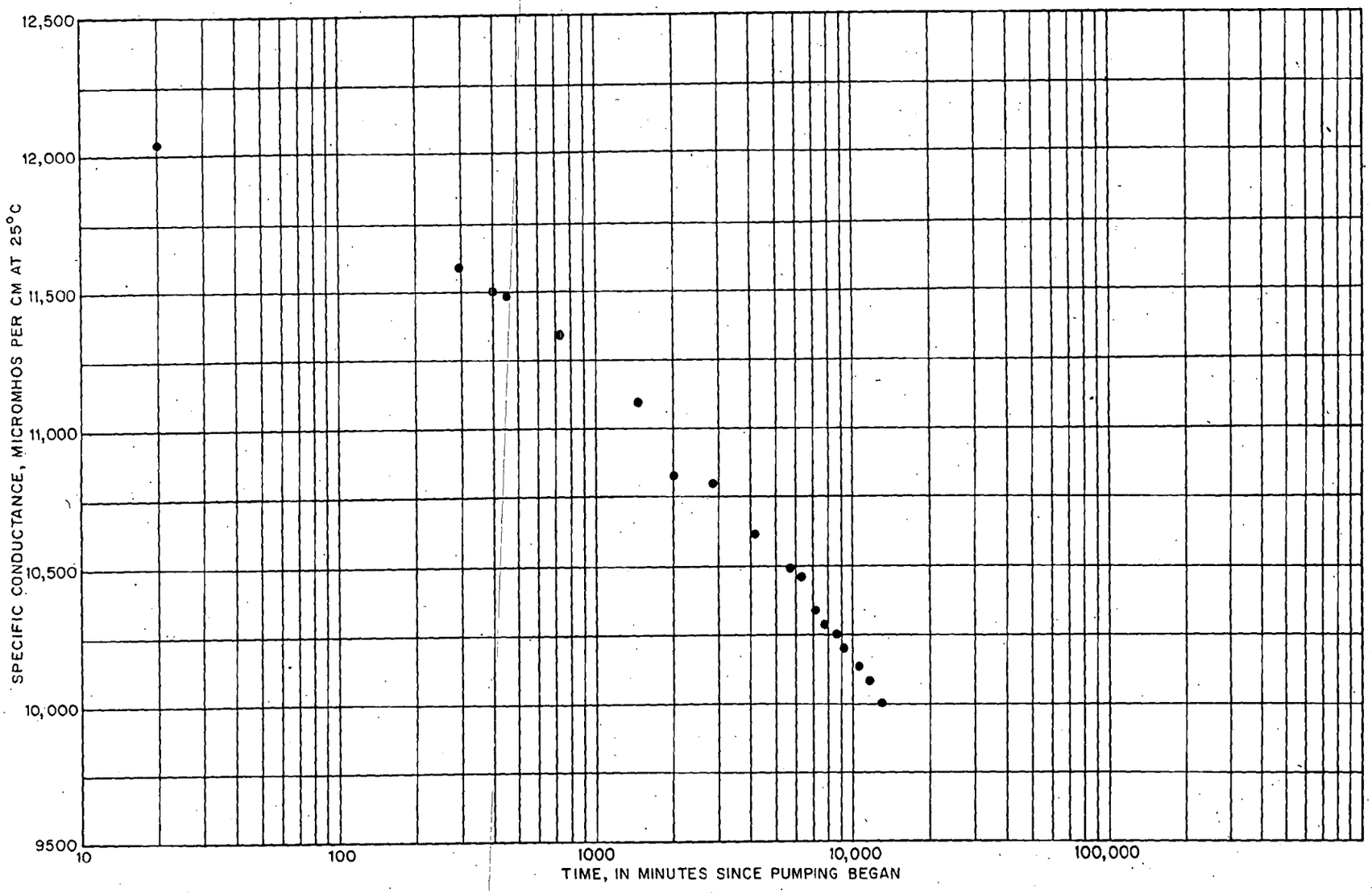

Figure 11. --Change in specific conductance of water during pumping test of well B1-97-22dca.

The transmissibility of the alluvial fill of Piceance Creek differs from place to place. The transmissibility of the alluvial aquifer near the pumped well is about 40,000 gpd per ft (gallons per day per foot). Data from observation wells near the pumped well (figs. 6, 7, 8) were considered least affected by differences in transmissibility and by boundaries. A higher transmissibility, however, is indicated by the logs of the test holes drilled west of the pumped well, and a lower transmissibility east of the pumped well. (See fig. 4.) The test-hole logs west of the pumped well contained fewer clay beds indicating the transmissibility may be as much as 100,000 gpd per ft. East of the pumped well, the logs contained more clay indicating the transmissibility may be as low as 20,000 gpd per ft. The average coefficient of storage probably is about 0.20.

During the pumping test, specific conductance of the water decreased from about 12,000 to 10,000 micromhos (fig. 11), which may indicate a layering of the water and subsequent mixing when pumped.

AQUIFER TESTS OF THE GREEN RIVER FORMATION

Information concerning the water-bearing character of the Green River Formation was obtained during this study from pumping and recovery tests of three wells that tap the formation. The results of these tests are given in the following paragraphs.

Recovery test of well C1-96-10dd

Well C1-96-10dd (pl. 1) was drilled in September 1957 as an oil test but was completed as a water well. The well is 3,000 feet deep, is cased and cemented to 1,000 feet below the land surface. It taps the Parachute Creek Member of the Green River Formation (table 1). Before the well was tested in October 1964, it flowed an average of 57 gpm for 3 months. The well was shut in, and head recovery was measured with an "ink-well" mercury gage designed and constructed by Lohman (1947a, 1947b). The calculated coefficient of transmissibility from the test was 2,000 gpd per ft (fig. 12).

Recovery test of well C3-96-10aa

Well C3-96-10aa (pl. 1) was also drilled as an oil test and subsequently was converted to a water well. The well reportedly was plugged at 1,300 feet below the land surface and is cased to 460 feet; it taps the Parachute Creek Member of the Green River Formation (table 1).

This well had been shut in for about a month, and the head was 100.3 feet above the land surface. The well was allowed to flow an average of 230 gpm for 1,330 minutes; measured discharge declined from 322 to 200 gpm. Maximum discharge was probably greater than maximum measured discharge because discharge could not be measured during the first 30 minutes of the test. The well was shut in, and recovery was measured with the "ink-well" mercury gage (fig. 13). The calculated coefficient of transmissibility was 2,000 gpd per ft.

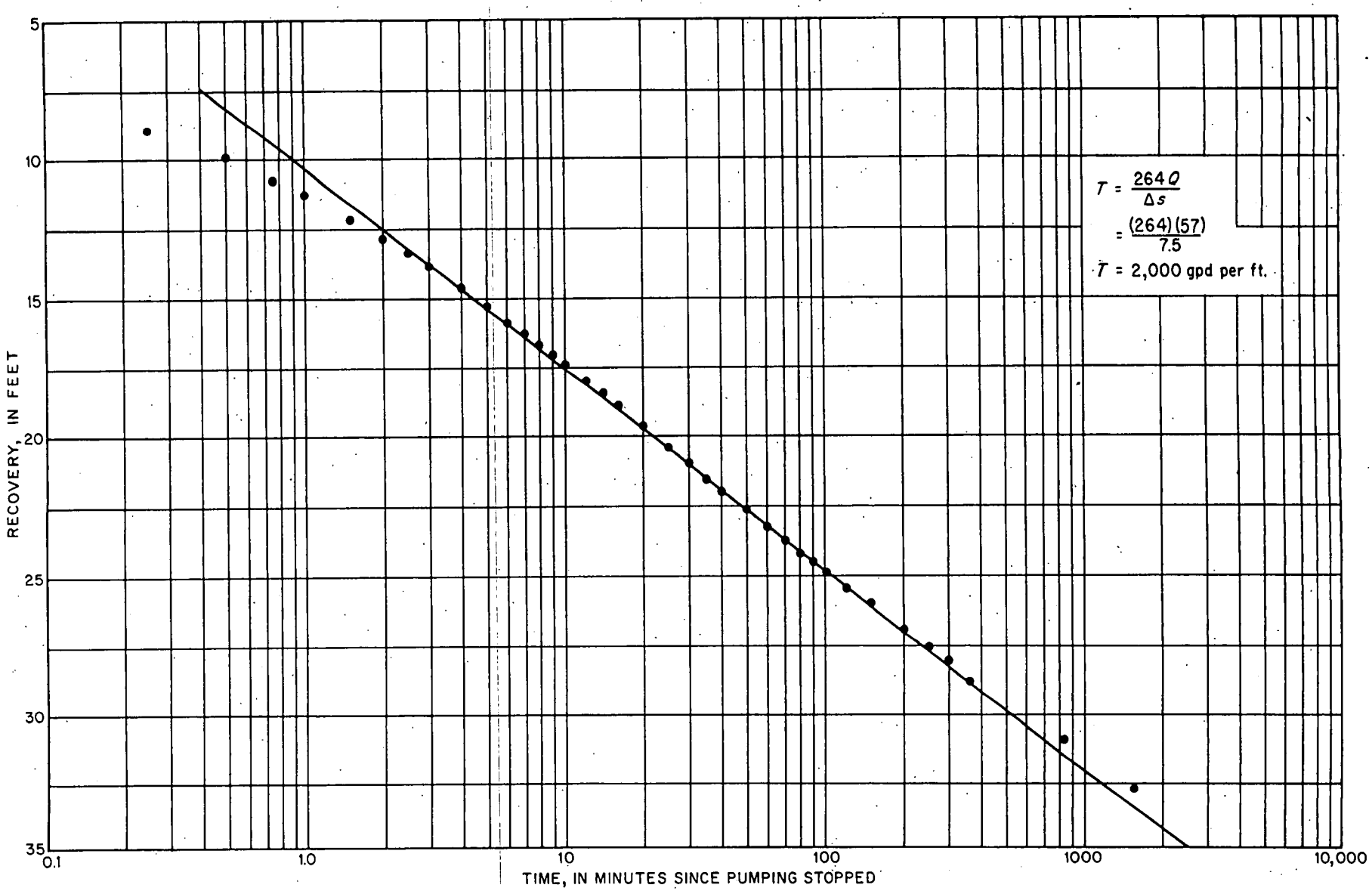

Figure 12.--Recovery in well C1-96-10dd (artesian well tapping Green River Formation).

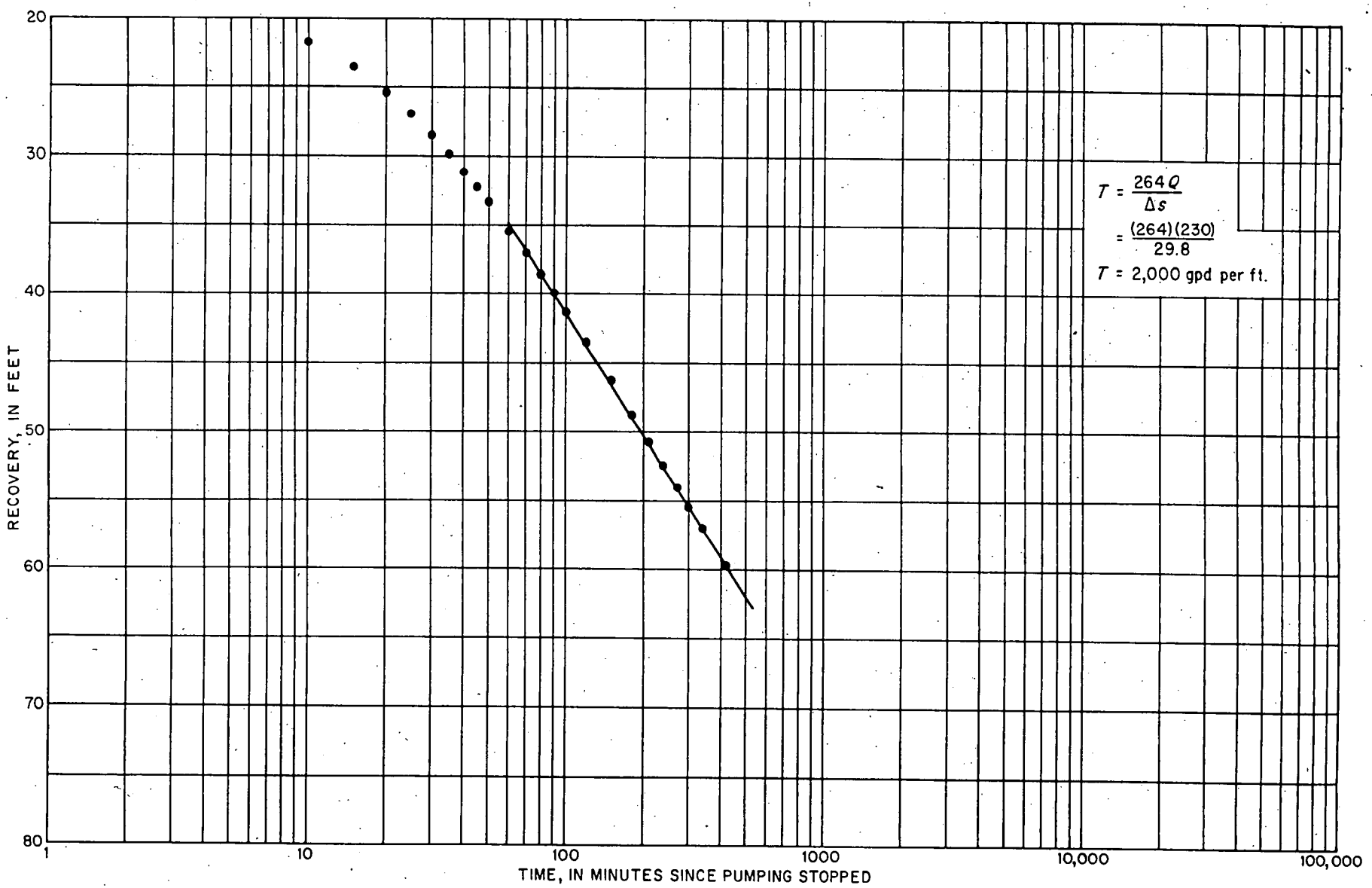

Figure 13.--Recovery in well C3-96-10aa (artesian well tapping Green River Formation).

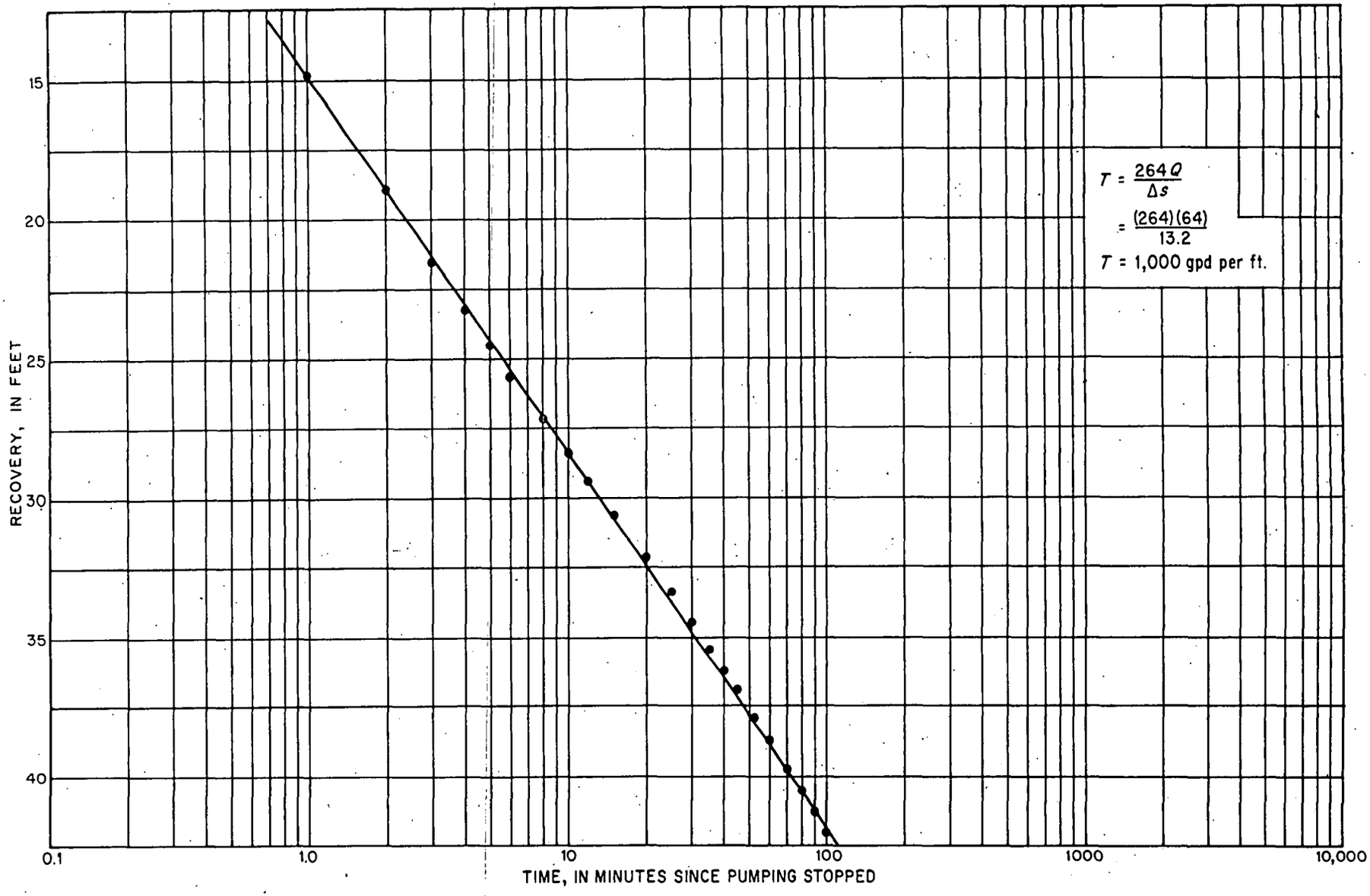

Figure 14. --Recovery in well C3-96-11ba (artesian well tapping Green River Formation).

Pumping test of well C3-96-11ba

Well C3-96-11ba (pl. 1) was drilled as a water well and reportedly is 1,000 feet deep. Records of casing the well are not available; however, it is cased at least to the top of the Parachute Creek Member of the Green River Formation (table 1). Although the well is equipped with a turbine pump, it flows continuously while not being pumped at an average rate of 20 gpm from the top of the casing, which is 2.5 feet above the land surface. During the test, the well was pumped an average of 64 gpm for 1,420 minutes, and then recovery was measured (fig. 14) for 100 minutes. The calculated coefficient of transmissibility was 1,000 gpd per foot. The storage coefficient (S) of 0.00001 was calculated from the water level measurements made in well C3-96-10aa while pumping well C3-96-11ba.

SUMMARY

Test drilling along the major drainages of the Piceance Creek basin in Rio Blanco and Garfield Counties indicates that the alluvium is as much as 140 feet thick and the saturated thickness may be as much as 100 feet. An aquifer test in the alluvium of Piceance Creek showed that after pumping a relatively short time, the hydrologic boundaries of the alluvium will affect drawdowns and well yields. The lithology of the alluvium determines the coefficients of transmissibility. In places where the alluvium contains clay beds, the transmissibility may be as low as 20,000 gpd per ft. In places where the alluvium is mainly sand and gravel, transmissibility may be 100,000 gpd per ft or greater. The coefficient of storage probably averages about 0.20. Thus, well yields depend largely on the lithology of the alluvium at the well, and the location of the well with respect to the hydrologic boundaries. Initial yields from properly located, developed, and constructed wells are estimated to be as much as 1,000 gpm.

Aquifer tests of the Parachute Creek Member of the Green River Formation indicate a range of transmissibility from 1,000 to 2,000 gpd per ft and a storage coefficient of 0.00001. Maximum well yields from this member are estimated to be as much as 500 gpm.

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APPENDIX

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Table 2.--Logs of test holes and observation wells drilled in the alluvium

Samples were described and formation names have been added by the authors. Test holes and observation wells were drilled in the alluvium along Piceance, Yellow, Parachute, and Roan Creeks. The lines are designated by letters (A-A') and are shown on Plates 1 and 2. Test hole and observation well numbers (shown after the location number) contain the letter designation of the line and the number of the hole on that line. Altitudes shown are for land surface at each site. Thickness is in feet. Depth is in feet below land surface.

	Thickness	Depth
B1-97-22dca. Alt. 5,878.2 ft. D-D', TH 2 (pumped well).		
Alluvium:		
Gravel, very fine to very coarse, subangular to rounded--composed of flat pieces of marlstone and siltstone--and very fine to very coarse sand; contains clay	16	16
Gravel, very fine to very coarse, angular to rounded--composed of flat pieces of marlstone, siltstone, and sandstone that are stained bluish green--and fine to very coarse sand; contains clay stringers	19	35
Clay, light-blue, silty, calcareous, and very fine to coarse angular to rounded gravel; contains very fine to very coarse sand (sand and gravel drill as though they are in stringers)	28	63
Gravel, very fine to very coarse, angular to rounded--composed of flat pieces of marlstone, sandstone, and siltstone--and fine to very coarse sand	44	107
Green River Formation (bedrock):		
Evacuation Creek Member:		
Siltstone, light-purplish-tan, sandy, calcareous, firmly cemented; contains black organic material (drills as though fractured)	8	115
B1-97-22dca2. Alt. 5,862.5 ft. D-D', TH 4.		
Alluvium:		
Sand, very fine to very coarse, and very fine angular to subrounded gravel; contains gray clay	8	8
Clay, light-bluish-gray, sandy, calcareous	3	11
Gravel, very fine to coarse, angular to rounded--composed of flat pieces of siltstone, marlstone, and sandstone--and very fine to very coarse sand; contains light-bluish-gray calcareous clay	4	15
Green River Formation(bedrock):		
Evacuation Creek Member:		
Siltstone, light-gray, calcareous; contains black organic material	5	20
B1-97-22dca3. Alt. 5,864.2 ft. D-D', TH 5.		
Alluvium:		
Clay, light-brown, sandy, calcareous	2	2
Clay, light-bluish-gray, sandy, calcareous; contains stringers of very fine to medium angular to well-rounded gravel, and sand	13	15
Clay, light-bluish-gray, firm, sandy, calcareous; contains black organic material and snail shells.	11	26
Clay, light-bluish-gray, firm, sandy, calcareous; contains stringers of fine to medium gravel	25	51
Gravel, very fine to very coarse, angular to rounded --composed of flat pieces of siltstone, sandstone, and marlstone that are stained bluish green--and light-bluish-gray sandy clay; contains very fine to very coarse sand.	6	57
Clay, light-gray to black, calcareous; contains much black organic material	4	61
Gravel, very fine to very coarse, angular to rounded--composed of flat pieces of siltstone, marlstone, and sandstone that are stained light bluish green--and very fine to very coarse sand.	35	96
B1-97-22dca3.--Continued		
Green River Formation (bedrock):		
Evacuation Creek Member:		
Siltstone, light-gray, calcareous; contains black organic material	14	110
B1-97-22dca4. Alt. 5,869.7 ft. D-D', Well E-1.		
Alluvium:		
Gravel, very fine to coarse, angular to subrounded--composed of flat pieces of sandstone, marlstone, and siltstone that are stained bluish green--and very fine to very coarse sand	14	14
Clay, light-bluish-gray, silty; contains very fine sand and thin stringers of gravel	4	18
Gravel, very fine to very coarse, angular to subrounded, and very fine to very coarse sand	2	20
Clay, light-bluish-gray, silty; contains very fine sand and thin layers of sandy gravel	42	62
Gravel, very fine to very coarse, angular to subrounded--composed of flat pieces of sandstone and marlstone that are stained light bluish green--and very fine to very coarse sand	28	90
B1-97-22dbd. Alt. 5,865.0 ft. D-D', TH 3.		
Alluvium:		
Gravel, very fine to very coarse, angular to subrounded--composed of flat pieces of marlstone and siltstone that are stained light greenish blue--and very fine to very coarse sand	11	11
Clay, light-blue, silty, calcareous, and stringers of very fine to very coarse angular to subrounded bluish-green-stained gravel; contains very fine to very coarse sand	22	33
Clay, light-blue and light-gray, silty, calcareous; contains black organic material and very fine sand	29	62
Gravel, very fine to very coarse, subangular to subrounded--composed of flat pieces of marlstone and sandstone that are stained light bluish-green--and very fine to very coarse sand; contains stringers of light-blue clay	20	82
Gravel, very fine to very coarse, angular to well rounded--composed of flat pieces of sandstone, marlstone, and siltstone--and fine to medium sand.	14	96
Green River Formation (bedrock):		
Evacuation Creek Member:		
Sandstone, light-gray, fine-grained, calcareous, firmly cemented	3	99
Siltstone, light-purplish-tan, calcareous, firmly cemented; contains black organic material	3	102
Sandstone, tan and light gray, medium-grained, calcareous, firmly cemented; contains a few black specks of organic material	6	108
Siltstone, light-tan, sandy, calcareous, firmly cemented; contains black organic material and pyrite veinlets	17	125
B1-97-22dcb. Alt. 5,891.9 ft. D-D', TH 1, Well W-4.		
Alluvium:		
Gravel, very fine to very coarse, subangular to well rounded--composed of flat pieces of siltstone, marlstone, and sandstone--and very fine to very coarse sand (gravel and sand are stained bluish green below 26 ft)	32	32
Gravel, fine to very coarse, angular to subrounded--composed of flat pieces of sandstone and marlstone--and fine to very coarse sand (all particles are stained bluish green, and gravel becomes better sorted below 65 ft; steady loss of drilling fluid 65-120 ft)	88	120
Green River Formation (bedrock):		
Evacuation Creek Member:		
Siltstone, light-lavender-brown, calcareous, firmly cemented; contains black organic material	5	125
B1-98-24aba. Alt. 6,022.4 ft. B-B', TH 1.		
Alluvium:		
Gravel, very fine to coarse, subangular to subrounded--composed of flat pieces of marlstone and sandstone--and fine to very coarse sand; contains light-tan sandy clay	20	20
Clay, light-tan, sandy, and very fine to coarse subangular to subrounded gravel; contains very fine to very coarse sand	12	32
Gravel, very fine to coarse, subangular to subrounded--composed of flat pieces of marlstone and sandstone--and light-tan silty clay; contains very fine to very coarse sand.	22	54
Gravel, very fine to very coarse, subangular to subrounded--composed of flat pieces of marlstone and sandstone--and light-tan sandy clay; contains very fine to very coarse sand and a few cobbles and boulders	29	83
Gravel, very fine to coarse, subangular to subrounded--composed of flat pieces of marlstone and sandstone--and very fine to very coarse sand; contains light-tan sandy clay (water level at 86 ft; steady loss of drilling fluid 70-129 ft)	19	102
Clay, gray, sticky	2	104
Gravel, very fine to very coarse, subangular to subrounded--composed of flat pieces of marlstone and sandstone--and very fine to very coarse sand; contains light-tan sandy clay	25	129
Green River Formation (bedrock):		
Evacuation Creek Member:		
Sandstone, dark-green, very fine-grained, calcareous, and interbedded light-green claystone	6	135
Siltstone, light-tan, calcareous	3	138
Sandstone, light-green, very fine-grained, calcareous, poorly cemented	9	147
Siltstone, light-brown, calcareous, well-cemented.	3	150
Sandstone, light-green, fine-grained, slightly calcareous, cementing firm to soft in thin layers; contains clay	4	154
Siltstone, light-tan, calcareous	11	165
B1-98-24aba2. Alt. 6,013.9 ft. B-B', TH 2.		
Alluvium:		
Clay, light-brown, sandy, calcareous; contains stringers of subangular to subrounded very fine to coarse gravel	34	34

Table 2.--Logs of test holes and observation wells drilled in the alluvium--Continued

	Thickness	Depth
B1-98-24aba2.--Continued		
Clay, light-brown, sandy, calcareous, and subangular to subrounded very fine to very coarse gravel; contains very fine to very coarse sand.	26	60
Clay, light-brown, sandy, calcareous; contains subangular to subrounded very fine to very coarse gravel (water level at 70 ft).	12	72
Sand, very fine to fine, and light-brown silty calcareous clay; contains stringers of gravel	14	86
Clay, greenish-brown, sandy, calcareous; contains stringers of subangular to subrounded very fine to very coarse gravel and very fine to very coarse sand	20	106
Gravel, very fine to very coarse, subangular to subrounded--composed of flat pieces of marlstone and sandstone--and fine to very coarse sand; contains light-brown sandy calcareous clay	13	119
Green River Formation (bedrock):		
Evacuation Creek Member:		
Sandstone, light-green, fine-grained, calcareous.	9	128
Siltstone, light-tan, calcareous; contains black organic material, firmly cemented	4	132
Siltstone, light-green, slightly calcareous, firmly cemented	1	133
Siltstone, light-tan, calcareous, firmly cemented.	1	134
Siltstone, light-green, slightly calcareous, firmly cemented	9	143
Siltstone, light-brown, calcareous, firmly cemented; contains much black organic material.	4	147
Sandstone, light-green, very fine-grained, calcareous, poorly cemented	5	152
Siltstone, light-tan, firmly cemented; contains laminae of black organic material	2	154
Sandstone, light-green, fine-grained, poorly cemented; contains a few medium-sized grains.	8	162
Siltstone, light-tan, calcareous; contains black organic material and some fine sand grains.	2	164
Sandstone, light-green, medium-grained, slightly calcareous, poorly cemented	9	173
Siltstone, light-brown, calcareous; firmly cemented; contains laminae of black organic material, and very fine sand	2	175
B1-98-24aba1. Alt. 6,004.5 ft. B-B', TH 3.		
Alluvium:		
Clay, light-brown, sandy, calcareous, and subangular to subrounded very fine to fine gravel; contains very fine to very coarse sand.	15	15
Clay, light-brown, sandy, calcareous; contains a little coarse subangular gravel	4	19
Clay, light-brown, sandy, calcareous	47	66
Clay, light-brown, sandy, calcareous, and very fine to fine subrounded to well-rounded gravel	5	71
Gravel, very fine to coarse, angular to well-rounded--composed of flat pieces of marlstone and sandstone--and light-brown sandy clay; contains very fine to very coarse sand	10	81
Gravel, very fine to very coarse, angular to well-rounded--composed of flat		

	Thickness	Depth
B1-98-24aba3.--Continued		
pieces of marlstone and sandstone--and fine to very coarse sand; contains a little light-brown clay	15	96
Green River Formation (bedrock):		
Evacuation Creek Member:		
Sandstone, greenish-brown, very fine-grained, calcareous	6	102
Siltstone, light-tan, calcareous, firmly cemented; contains laminae of black organic material	6	108
Siltstone, light-green, calcareous	5	113
Siltstone, light-tan, calcareous; contains black organic material	4	117
Sandstone, light-green, fine-grained, poorly cemented; contains clay and some thin well-cemented layers	19	136
Siltstone, light-tan, firmly cemented; contains laminae of black organic material, faces of small fractures are covered with pyrite	16	152
Sandstone, light-green, very fine-grained, poorly cemented, calcareous	3	155
B1-98-24abb. Alt. 6,011.2 ft. B-B', TH 4.		
Alluvium:		
Clay, brown, sandy, and fine to medium angular to subrounded gravel	25	25
Clay, brown, sandy	11	36
Clay, brown, sandy, and fine to medium subangular to rounded gravel; contains very fine to very coarse sand	5	41
Gravel, fine to medium, subangular to subrounded--composed of flat pieces of marlstone and sandstone--and clay	14	55
Gravel, very fine to very coarse, angular to subrounded--composed of flat pieces of marlstone and sandstone--and very fine to very coarse sand; contains silty clay.	48	103
Green River Formation (bedrock):		
Evacuation Creek Member:		
Siltstone, light-green, calcareous; contains black organic material	9	112
Siltstone, purplish-tan, calcareous	3	115
Sandstone, light-green, fine-grained, noncalcareous, well-cemented; contains layers of purplish-tan siltstone and layers of light-green clay	15	130
Sandstone, light-green, fine-grained, slightly calcareous, well-cemented; contains layers of siltstone	28	158
Siltstone, purplish-tan, calcareous	12	170
Sandstone, light-green, fine-grained, calcareous	5	175
B2-98-26acc. Alt. 5,837.4 ft. A-A', TH 2.		
Alluvium:		
Clay, light-brown, silty, calcareous	5	5
Clay, light-brown, silty, calcareous; contains very fine to medium rounded gravel	7	12
Clay, light-bluish-gray, smells of hydrogen sulfide; contains pieces of wood, tiny black organic pellets, and thin stringers of brown silty clay	19	31
Gravel, fine to medium, rounded	1	32

	Thickness	Depth
B2-98-26acc.--Continued		
Clay, light-bluish-gray, smells strongly of hydrogen sulfide; contains pieces of wood, tiny black organic pellets, and thin stringers of brown silty and sandy clay, (snail shells and organic matter become abundant below 60 ft).	54	86
Gravel, very fine to medium, rounded to well-rounded--composed of flat pieces of limestone and sandstone that are stained bluish green; contains very fine to very coarse sand.	10	96
Gravel, very fine to medium, rounded to well-rounded--composed of flat pieces of limestone and sandstone that are stained bluish green--and light-gray-bluish clay (drilled through wood between 96 and 98 ft; samples contain snail shells and fragments of bone)	21	117
Clay, light-bluish-gray, calcareous; contains stringers of brown silty and sandy clay that contain much organic material	5	122
Gravel, very fine to medium, rounded to well-rounded--composed of flat pieces of marlstone, sandstone, and oil shale--contains very fine to very coarse sand	4	126
Green River Formation (bedrock):		
Parachute Creek Member (?):		
Oil shale, brown, finely laminated with light-tan marlstone (oil shale grades to dark brown with light-tan laminations below 133 ft)	29	155
B2-98-26acc2. Alt. 5,837.9 ft. A-A', TH 3.		
Alluvium:		
Gravel, very fine to very coarse, subangular to subrounded--composed of flat pieces of marlstone and sandstone--contains gray clay	7	7
Clay, gray, silty; contains small roots and small shells.	5	12
Clay, dark-gray to black, silty, calcareous--contains roots, shells, and highly lignitic wood--contains very fine to fine subangular to angular gravel.	17	29
Gravel, very fine to very coarse, subangular to angular--composed of flat pieces of marlstone, sandstone, and siltstone that are stained greenish blue	10	39
Green River Formation (bedrock):		
Parachute Creek Member(?):		
Oil shale, light-brown, low-grade, finely laminated (losing drilling fluid 35-45 ft; upon completion of hole it began to flow 50-75 gpm of water at 50°F; specific conductance 2,600 micromhos; hole remained open to 29 ft)	6	45
B2-98-26bdd. Alt. 5,837.0 ft. A-A', TH 1.		
Alluvium:		
Clay, brown	7	7
Clay, blue, tough, calcareous, smells of hydrogen sulfide; contains fragments of rotten wood, tiny roots snail shells, and a few		

Table 2.--Logs of test holes and observation wells drilled in the alluvium--Continued

	Thickness	Depth
B2-98-26bdd.--Continued		
stringers of light-brown clay in the upper 28 feet	65	72
Gravel, fine to medium, rounded--composed of flat pieces of sandstone and marlstone that are stained dark greenish blue--contains stringers of clay from 72 to 97 feet	37	109
Green River Formation (bedrock):		
Parachute Creek Member(?):		
Oil shale, brown, low-grade (becomes blacker and higher grade below 115 ft)	26	135
B2-98-26bdd2. Alt. 5,837.5 ft. A-A', TH 5.		
Alluvium:		
Clay, light-brown, silty, calcareous; contains some very fine gravel.	10	10
Clay, light-bluish-gray, calcareous, smells of hydrogen sulfide; contains wood, roots, tiny insects or plants, shell fragments and shells and stringers of light-tan silty clay (thin stringer of gravel at 73 ft)	70	80
Sand, very fine to medium, stained bluish green; contains many small snails and clams	1	81
Gravel, very fine to coarse, angular to well-rounded--composed of flat pieces of marlstone and sandstone that are stained light to dark bluish green--and very fine to very coarse sand; contains light-purplish-gray clay (losing drilling fluid 90-95 ft)	9	90
Green River Formation (bedrock):		
Parachute Creek Member(?):		
Oil shale (fractured and weathered; sample return very poor; losing circulation)	10	100
B2-98-26bdd3. Alt. 5,837.2 ft. A-A', TH 4.		
Alluvium:		
Clay, light-brown, silty, calcareous	7	7
Clay, light-bluish-gray, calcareous; contains roots and other brown organic material, tiny black snails, and thin layer of coarse angular black-stained gravel at 18 feet	15	22
Gravel, very fine to very coarse, angular to rounded--composed of flat pieces of marlstone and sandstone that are stained dark greenish blue--contains light-bluish-gray calcareous clay	11	33
Green River Formation(bedrock):		
Evacuation Creek Member:		
Sandstone, yellowish-brown, fine-grained, calcareous, firmly cemented	6	39
Siltstone, light-tan, calcareous	11	50
C1-97-32add. Alt. 6,076.1 ft. E-E', TH 4.		
Alluvium:		
Clay, bluish-gray; contains much organic material and many tiny snail and clam shells	67	67
Gravel, fine to medium, rounded to well-rounded--composed of flat pieces of sandstone and marlstone that are stained bluish green--and fine to very coarse sand	5	72
Green River Formation (bedrock):		
Evacuation Creek Member:		
Siltstone, light-purplish-tan.	8	80
C1-97-32dbb. Alt. 6,091.5 ft. F-F', TH 1.		
Alluvium:		
Gravel, fine to medium, subangular to angular--composed of flat pieces of marlstone and sandstone--and brown silty clay	15	15
Gravel, fine to very coarse, angular to subrounded--composed of flat pieces of marlstone, sandstone, and siltstone--and fine to very coarse sand; contains a little clay (steady loss of drilling fluid 55-66 ft)	51	66
Green River Formation (bedrock):		
Evacuation Creek Member:		
Siltstone, light-purplish-tan, calcareous	4	70
C1-97-32dbc. Alt. 6,087.0 ft. F-F', TH 2.		
Alluvium:		
Clay, light-brown, sandy, calcareous	9	9
Clay, silty, calcareous; contains organic material	24	33
Gravel, fine to coarse, subangular to subrounded--composed of flat pieces of sandstone, marlstone, and siltstone--and silty brown clay	2	35
Clay, dark-gray; contains a little fine to coarse gravel	8	43
Gravel, fine to coarse, subangular to angular, and fine to coarse sand (losing drilling fluid 45-62 ft)	19	62
Green River Formation (bedrock):		
Evacuation Creek Member:		
Siltstone, light-purplish-tan, calcareous	3	65
C1-97-32dbc2. Alt. 6,084.8 ft. F-F', TH 3.		
Alluvium:		
Sand, light-tan, very fine; contains some brown clay.	4	4
Clay, brown, silty.	3	7
Clay, dark-gray, silty, calcareous; contains organic material.	4	11
Clay, dark-gray, silty, and fine to medium subangular to rounded gravel	15	26
Clay, brown, soft	5	31
Gravel, fine to coarse, angular to rounded--composed of flat pieces of marlstone, sandstone, and siltstone--and fine to coarse sand.	11	42
Clay, dark-gray to blue	11	53
Gravel, fine to coarse, angular to well-rounded--composed of flat pieces of sandstone, marlstone, and siltstone that are stained dark bluish green	11	64
Green River Formation (bedrock):		
Evacuation Creek Member:		
Siltstone, light-purplish-brown	6	70
C1-97-33bcc. Alt. 6,076.3 ft. E-E', TH 3.		
Alluvium:		
Clay, brown, sandy.	3	3
Gravel, fine to medium, well-rounded--composed of flat pieces of sandstone and marlstone that are stained bluish green--and fine to very coarse sand; contains dark-blue clay stringers.	8	11
Clay, dark-gray to blue, calcareous; contains black organic material and thin stringers of gravel	59	70
Gravel, fine to medium, rounded--composed of flat pieces of marlstone and sandstone that are stained dark bluish gray.	6	76
C1-97-33bcc.--Continued		
Green River Formation (bedrock):		
Evacuation Creek Member:		
Siltstone, light-purplish-brown.	9	85
C1-97-33cba. Alt. 6,087.4 ft. E-E', TH 1.		
Alluvium:		
Gravel, very fine to coarse, angular to subrounded--composed of flat pieces of sandstone and marlstone--and very fine to coarse sand; contains brown silty clay	30	30
Gravel, very fine to very coarse, angular to rounded--composed of flat pieces of marlstone and sandstone--and fine to coarse sand; contains cobbles and boulders (steady loss of circulation and hole caving from 35-80 ft; abandoned hole)	50	80
C1-97-33cbb. Alt. 6,077.7 ft. E-E', TH 2.		
Alluvium:		
Clay, brown, sandy, poorly consolidated	6	6
Clay, dark-bluish-gray, silty; contains much black organic material, and very fine to coarse angular to rounded gravel	30	36
Gravel, very fine to medium, subangular to subrounded--composed of flat pieces of sandstone and siltstone that are stained dark greenish blue--and very fine to very coarse sand; contains stringers of dark-gray clay	19	55
Gravel, fine to very coarse, angular to to rounded--composed of flat pieces of sandstone and marlstone that are stained greenish blue--and fine to very coarse sand	26	81
Green River Formation (bedrock):		
Evacuation Creek Member:		
Siltstone, purplish-tan, and purplish-tan marlstone; contains black organic material	19	100
Marlstone, dark-brown, laminated with layers high in organic material	10	110
C2-97-25cca. Alt. 6,303.1 ft. G-G', TH 1.		
Alluvium:		
Gravel, very fine to very coarse, subangular to subrounded--composed of flat pieces of siltstone, sandstone, and marlstone--and very fine to very coarse sand; contains a little sandy clay (losing drilling fluid 0-20 ft; lost circulation 20-55 ft)	113	113
Green River Formation (bedrock):		
Evacuation Creek Member:		
Siltstone, light-lavender-tan, calcareous, firmly cemented; contains black organic material	7	120
C2-97-25cca2. Alt. 6,292.5 ft. G-G', TH 2.		
Alluvium:		
Gravel, very fine to very coarse, subangular to subrounded--composed of flat pieces of sandstone, siltstone, and marlstone--and very fine to very coarse sand; contains cobbles and a little light-tan clay (becomes predominantly gravel and is better sorted below 80 ft; water level at 29 ft)	101	101

Table 2.--Logs of test holes and observation wells drilled in the alluvium--Continued

	Thickness	Depth
C2-97-25cca2.--Continued		
Green River Formation (bedrock):		
Evacuation Creek Member(?):		
Siltstone, light-lavender-tan, calcareous, firmly cemented; contains black organic material	12	113
Sandstone, light-olive-brown, fine-grained, calcareous, pooly cemented.	2	115
Siltstone, light-purplish-tan, firmly cemented; contains black organic material	68	183
Parachute Creek Member (?):		
Oil Shale, light-brown, slightly calcareous, thinly laminated with light-tan marl	4	187
Marlstone, light-olive-green, thinly laminated; contains thin laminations of oil shale	2	189
Oil shale, light-brown, slightly calcareous, thinly bedded with light-tan and light-olive-green marlstone.	5	194
Oil shale, light-brown, low-grade, slightly calcareous, thinly laminated with light-tan marlstone.	8	202
Siltstone, light-lavender-tan, firmly cemented; contains black organic material and laminations of light-brown oil shale	10	212
Marlstone, light-tan, silty	2	214
Siltstone, light-lavender-tan, firmly cemented; contains black organic material and pyrite veinlets	10	224
Marlstone, light-tan, silty	14	238
Oil shale, light-brown, low-grade, thinly laminated with light-tan marlstone; contains tiny veinlets of pyrite	25	263
Siltstone, tan, calcareous, well-cemented; contains black organic material	10	273
Marlstone, light-grayish-tan; contains light-brown laminations.	15	288
Marlstone, light-tan, silty; contains black organic material	15	303
C2-97-25ccd. Alt. 6,271.2 ft. G-G', TH 4.		
Alluvium:		
Gravel, very fine to coarse, subangular to subrounded--composed of flat pieces of marlstone, sandstone, and siltstone--and very fine to very coarse sand; contains brown sandy clay (water level at land surface)	13	13
Clay, dark-gray-blue, sandy, smells of hydrogen sulfide.	4	17
Gravel, very fine to medium, rounded--composed of flat pieces of limestone, sandstone, and siltstone that are stained dark greenish blue--and fine to very coarse sand; contains stringers of dark-blue and brown clay.	5	22
Clay, dark-blue-gray and fine to medium rounded gravel	17	39
Gravel, fine to coarse, rounded--composed of flat pieces of siltstone, limestone, and sandstone that are stained dark greenish blue--and fine to coarse sand	7	46
Gravel, fine to coarse, rounded--composed of flat pieces of limestone, sandstone, and siltstone that are stained dark greenish blue--and dark-bluish-gray clay	27	73
Gravel, fine to coarse, rounded--composed of flat		

	Thickness	Depth
C2-97-25ccd.--Continued		
pieces of sandstone, marlstone, and siltstone that are stained dark bluish green--contains cobbles.	4	77
Green River Formation (bedrock):		
Evacuation Creek Member:		
Sandstone, light-purplish-tan, very fine-grained, silty, calcareous.	15	92
Marlstone, brown, thinly laminated; contains black organic material	5	97
Siltstone, light-purplish-tan, sandy, firmly cemented	18	115
C2-97-25ccd2. Alt. 6,282.5 ft. G-G', TH 3.		
Alluvium:		
Gravel, very fine to very coarse, subangular to subrounded--composed of flat pieces of siltstone and sandstone--and very fine to very coarse sand; contains clay.	12	12
Clay, light-yellow-brown, very sandy, calcareous	2	14
Gravel, very fine to very coarse, subangular to subrounded--composed of flat pieces of limestone, siltstone, and sandstone--and very fine to very coarse sand; contains yellow-brown clay stringers.	7	21
Gravel, very fine to very coarse, subangular to subrounded--composed of flat pieces of siltstone, limestone, and sandstone--and fine to very coarse sand (below 55 ft sand and gravel are stained light greenish blue; water level at 25 ft).	66	87
Green River Formation (bedrock):		
Evacuation Creek Member:		
Siltstone, light-purplish-tan, calcareous, firmly cemented; contains black organic material	17	104
Sandstone, light-tan, fine-grained, silty, firmly to loosely cemented, calcareous; contains black organic material	16	120
C2-99-14bda. Alt. 6,724.7 ft. C-C', TH 1.		
Clay, sand, and gravel (artificial fill).	10	10
Alluvium:		
Soil, dark-brown	2	12
Gravel, very fine to coarse, subangular to subrounded--composed of flat pieces of siltstone, sandstone, and marlstone--and fine to very coarse sand; contains light-tan clay (steady loss of drilling fluid 15-20 ft)	8	20
Clay, light-yellowish-tan, sandy; contains very fine to coarse angular to subrounded gravel	5	25
Gravel, very fine to very coarse, subangular to subrounded--composed of flat pieces of sandstone and marlstone--and fine to very coarse sand (water level at 48 ft)	31	56
Green River Formation (bedrock):		
Evacuation Creek Member:		
Sandstone, yellowish-brown, fine- to medium-grained, poorly cemented, weathered and fractured (lost circulation 55-60 ft; lower 3 ft drilled hard, may be oil shale).	4	60
C2-99-14bdb. Alt. 6,708.8 ft. C-C', TH 2.		
Alluvium:		
Clay, dark-brown, sandy, calcareous; contains		

	Thickness	Depth
C2-99-14bdb.--Continued		
very fine to fine gravel	11	11
Clay, light-yellowish-brown, sandy; contains very fine to fine subangular to subrounded gravel.	8	19
Gravel, very fine to very coarse, subangular to subrounded--composed of flat pieces of siltstone, sandstone, and marlstone--and fine to very coarse sand; contains stringers of light-yellowish-brown and dark-gray clay (water level at 26 ft)	65	84
Clay, dark-gray to black, calcareous; contains much organic material.	2	86
Gravel, very fine to coarse, angular to well-rounded--composed of flat pieces of siltstone, marlstone, and sandstone that are stained bluish green--and very fine to very coarse sand	18	104
Green River Formation (bedrock):		
Parachute Creek Member(?):		
Siltstone, light-tan, calcareous; contains thin laminae of oil shale.	9	113
Marlstone, light-tan	3	116
Oil shale, brown, low-grade, thinly laminated with light-tan marlstone	7	123
Marlstone, light-tan, soft; contains thin layers of low-grade oil shale	39	162
Oil shale, light-brown, low-grade; contains thin laminae of marlstone.	16	178
C2-99-14bdb2. Alt. 6,707.9 ft. C-C', TH 3.		
Alluvium:		
Clay, light-tan, calcareous, and subangular to subrounded very fine to medium gravel	20	20
Clay, light-tan to brown, silty, calcareous; contains layers of organic material that are mainly roots and stems	11	31
Clay, light-bluish-gray, calcareous; contains organic material and layers of brown silt	6	37
Gravel, very fine to very coarse, subangular to subrounded--composed of flat pieces of limestone, siltstone, and sandstone that are stained greenish blue--and very fine to coarse sand; contains layers of gray calcareous clay	13	50
Green River Formation (bedrock):		
Parachute Creek Member(?):		
Oil shale, brown, thinly laminated with marlstone.	2	52
Marlstone, soft, thinly bedded, stained light greenish blue	6	58
Oil shale, light-brown, low-grade, thinly laminated with light-tan marlstone; badly fractured	5	63
Marlstone, dark-olive-green, silty (drills easily)	6	69
Oil shale, brown, low-grade, thinly laminated with light-tan marlstone; the edges of some fractures are stained green (drills hard in thin streaks)	34	103
Marlstone, light-tan; contains thin veins of calcareous white clay	3	106
Oil shale, light-tan, low-grade, thinly bedded with light-tan marlstone.	12	118
C6-96-34cac. Alt. 5,354.8 ft. H-H', TH 1.		
Alluvium:		
Gravel, very fine to very coarse, subangular to subrounded--composed of		

Table 2.--Logs of test holes and observation wells drilled in the alluvium--Continued

	Thickness	Depth
C6-96-34cac.--Continued		
flat pieces of limestone, sandstone, and oil shale--and silty light-brown clay; contains very fine to very coarse sand (lost circulation 0-20 ft)	23	23
Clay, light-brown, calcareous; contains very fine to very coarse sand and very fine to medium gravel	5	28
Gravel, fine to medium, subangular to subrounded--composed of flat pieces of limestone, sandstone, and oil shale--and very fine to very coarse sand; contains silty light-brown clay	12	40
Clay, light-brown, calcareous, and very fine to coarse subangular to subrounded gravel; contains very fine to very coarse sand and boulders below 51 feet (water level at 44 ft; drills as though sand and gravel are in layers interbedded with clay)	30	70
Gravel, very fine to medium, subangular to rounded--composed of flat pieces of limestone, sandstone, and oil shale--and very fine to very coarse sand; contains stringers of light-brown sticky clay (lost circulation 70-85 ft)	35	105
Gravel, fine to very coarse, subangular to subrounded--composed of flat pieces of oil shale, sandstone, and limestone--and medium to very coarse sand; contains cobbles and boulders (lost circulation 105-116 ft)	11	116
Wasatch Formation (bedrock):		
Siltstone, reddish-purple, sandy	9	125
C6-96-34cdb. Alt. 5,339.1 ft. H-H', TH 2.		
Alluvium:		
Gravel, very fine to coarse, subangular to subrounded--composed of flat pieces of sandstone, limestone, and oil shale--and very fine to very coarse sand; contains stringers of light-brown calcareous clay and a few oil-shale boulders	11	11
Clay, light-brown, sandy, calcareous	2	13
Gravel, very fine to medium, subangular to subrounded--composed of flat pieces of limestone, sandstone, and oil shale--and very fine to very coarse sand; contains calcareous sandy light-brown clay	3	16
Clay, light-brown, sandy, calcareous	3	19
Gravel, very fine to medium, subangular to subrounded--composed of flat pieces of limestone, oil shale, and sandstone--and very fine to very coarse sand; contains large amounts of clay	2	21
Clay, light-brown, calcareous; contains sand and very fine to medium subangular to subrounded gravel	7	28
Gravel, very fine to coarse, subangular to subrounded--composed of flat pieces of limestone, oil shale, and sandstone--and very fine to very coarse sand; contains stringers of light-brown calcareous clay and cobbles and boulders below 45 feet (steady loss of drilling fluid 35-60 ft)	34	62
C6-96-34cdb.--Continued		
Clay, light-brown, sandy, calcareous	2	64
Gravel, very fine to very coarse, subangular to subrounded--composed of flat pieces of oil shale, limestone, and sandstone--and fine to very coarse sand; contains cobbles, boulders, and a few 6-inch layers of clay (unable to drill below 98 ft, hole caved and circulation was lost; drilled hard as though bedrock may have been reached)	34	98
C6-96-34dbc. Alt. 5,330.5 ft. H-H', TH 3.		
Alluvium:		
Gravel, very fine to very coarse, angular to subrounded--composed of flat pieces of limestone, sandstone, and oil shale--and very fine to very coarse sand; contains stringers of calcareous sandy light-brown clay.	6	6
Clay, light-brown, sandy, calcareous, and very fine to coarse angular to subrounded gravel; contains fine to very coarse sand.	20	26
Gravel, very fine to very coarse, subangular to subrounded--composed of flat pieces of oil shale, limestone, and sandstone--and many stringers of calcareous sandy light-brown clay; contains fine to very coarse sand, cobbles, and boulders (steady loss of drilling fluid 50-60 ft)	37	63
Sand, fine to very coarse, and very fine to medium subrounded gravel; contains thin stringers of very fine to very coarse gravel	18	81
Gravel, very fine to very coarse, subangular to subrounded--composed of flat pieces of oil shale, limestone, and sandstone--and fine to very coarse sand	11	92
Wasatch Formation (bedrock):		
Clay, light-red, calcareous	8	100
C7-97-31ccc. Alt. 5,173.2 ft. J-J', TH 3.		
Alluvium:		
Gravel, very fine to very coarse, subangular to subrounded--composed of flat pieces of marlstone and sandstone--contains fine to coarse sand	10	10
Gravel, very fine to very coarse, angular to subrounded--composed of flat pieces of marlstone and sandstone--contains fine to coarse sand and calcareous silty brown clay (steady loss of drilling fluid from 0-25 ft)	24	34
Clay, brown, silty, calcareous, and layers of angular to subrounded very fine to coarse gravel composed of flat pieces of marlstone and sandstone (water level at 36 ft; hole caved badly between drill stem changes)	6	40
Gravel, very fine to medium, subangular to subrounded--composed of flat pieces of marlstone and sandstone--and fine to very coarse sand; contains a few thin layers of calcareous silty brown clay (steady loss of drilling fluid from 40-50 ft).	10	50
Gravel, very fine to coarse, subangular to subrounded--composed of flat pieces of marlstone and sandstone--and layers of calcareous silty brown clay; contains fine to very coarse sand	29	79
Clay, brown, silty, calcareous.	1	80
Gravel, very fine to very coarse, subangular to subrounded--composed of flat pieces of oil shale, marlstone, and sandstone--and fine to very coarse sand; contains a few thin layers of clay	30	110
Wasatch Formation (bedrock):		
Siltstone, light-green, calcareous.	5	115
Mudstone, light-green, slightly calcareous, fissile.	10	125
C7-97-31ccd. Alt. 5,190.7 ft. J-J', TH 2.		
Alluvium:		
Sand, fine to coarse, and subrounded to rounded very fine to medium gravel composed of flat pieces of marlstone and sandstone; contains thin layers of clay below 15 feet (hole caves between drill stem changes; water level at 51 ft)	100	100
Gravel, fine to very coarse, subrounded to rounded--composed of flat pieces of oil shale, marlstone, and sandstone--and fine to coarse sand; contains clay, cobbles, and boulders (lost drilling fluid 110-119 ft).	19	119
Wasatch Formation (bedrock):		
Claystone, purplish-brown, silty.	6	125
Claystone, green, silty (poor sample returns 119-135 ft).	15	140
C7-97-31cdc. Alt. 5,207.4 ft. J-J', TH 1.		
Alluvium:		
Sand, light-brown, fine to medium, subrounded to rounded; contains rounded gravel composed of flat pieces of sandstone and marlstone.	7	7
Gravel, fine to coarse, subrounded to rounded--composed of flat pieces of marlstone and sandstone; contains cobbles and fine to coarse sand	15	22
Sand, light-brown, very fine to coarse, subrounded to rounded; contains silt and fine gravel	18	40
Sand, very fine to coarse, angular to subrounded, and angular to subrounded very fine to coarse gravel composed of flat pieces of marlstone and sandstone; contains thin layers of silty brown clay (water level at 68 ft).	42	82
Gravel, very fine to coarse, angular to subrounded--composed of flat pieces of marlstone and sandstone--and very fine to very coarse sand	24	106
Gravel, very fine to very coarse, angular to subrounded--composed of flat pieces of marlstone, sandstone, and oil shale--and angular to subrounded very fine to very coarse sand; contains thin layers of silty light-brown clay	21	127
Sand, medium, and calcareous grayish-blue clay.	6	133
Gravel, fine to very coarse, angular to subrounded--composed of flat pieces of oil shale and marlstone--contains fine to coarse sand	6	139

Table 2.--Logs of test holes and observation wells drilled in the alluvium--Continued

	Thick-ness	Depth
C7-97-31cdc.--Continued		
Wasatch Formation (bedrock):		
Clay, dark-gray to blue, silty, calcareous	1	140
Sandstone, fine-grained, poorly cemented	3	143
Clay, dark-purple, noncalcareous, soft	3	146
Sandstone, light-greenish-blue, medium-grained, poorly cemented	4	150
C8-97-6bbb. Alt. 5,156.8 ft. J-J', TH 4.		
Alluvium:		
Gravel, very fine to coarse, subangular to rounded--composed of flat pieces of marlstone, sandstone, and oil shale--and fine to very coarse sand; contains thin layers of silty brown clay below 20 feet (hole caved badly between drill stem changes; water level at 15 ft)	45	45
Gravel, very fine to medium, subangular to subrounded--composed of flat pieces of marlstone, sandstone, and oil shale--and medium to very coarse sand (lost drilling fluid 45-60 ft).	15	60
Gravel, very fine to very coarse, angular to subrounded--composed of flat pieces of oil shale, marlstone, and sandstone--and fine to very coarse sand (unable to drill below 75 ft, hole caved and circulation was lost)	15	75

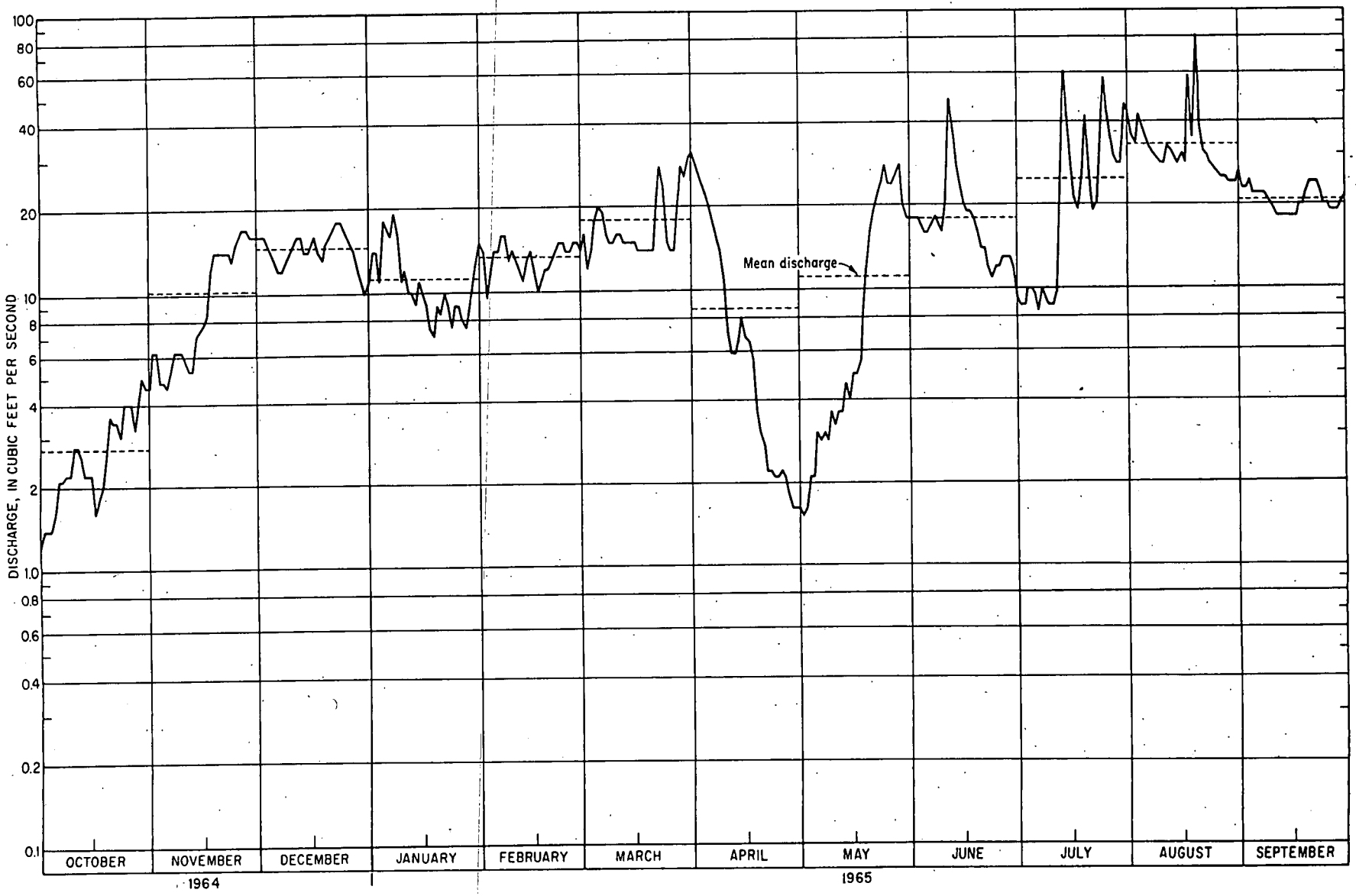

Figure 15.--Hydrograph of Piceance Creek, C1-97-32, Rio Blanco County, Colorado.

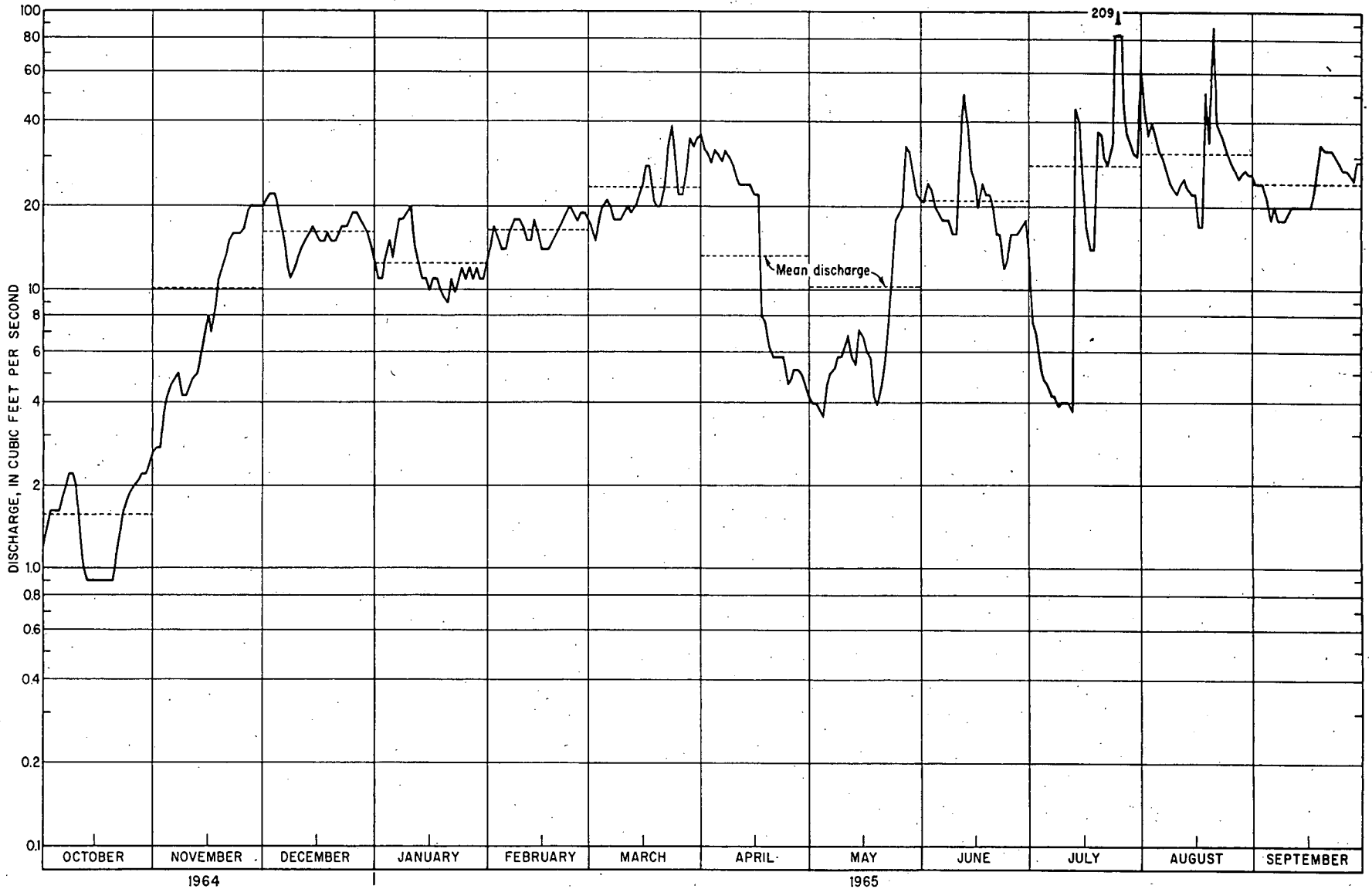

Figure 16.--Hydrograph of Piceance Creek, B1-97-2, Rio Blanco County, Colorado.

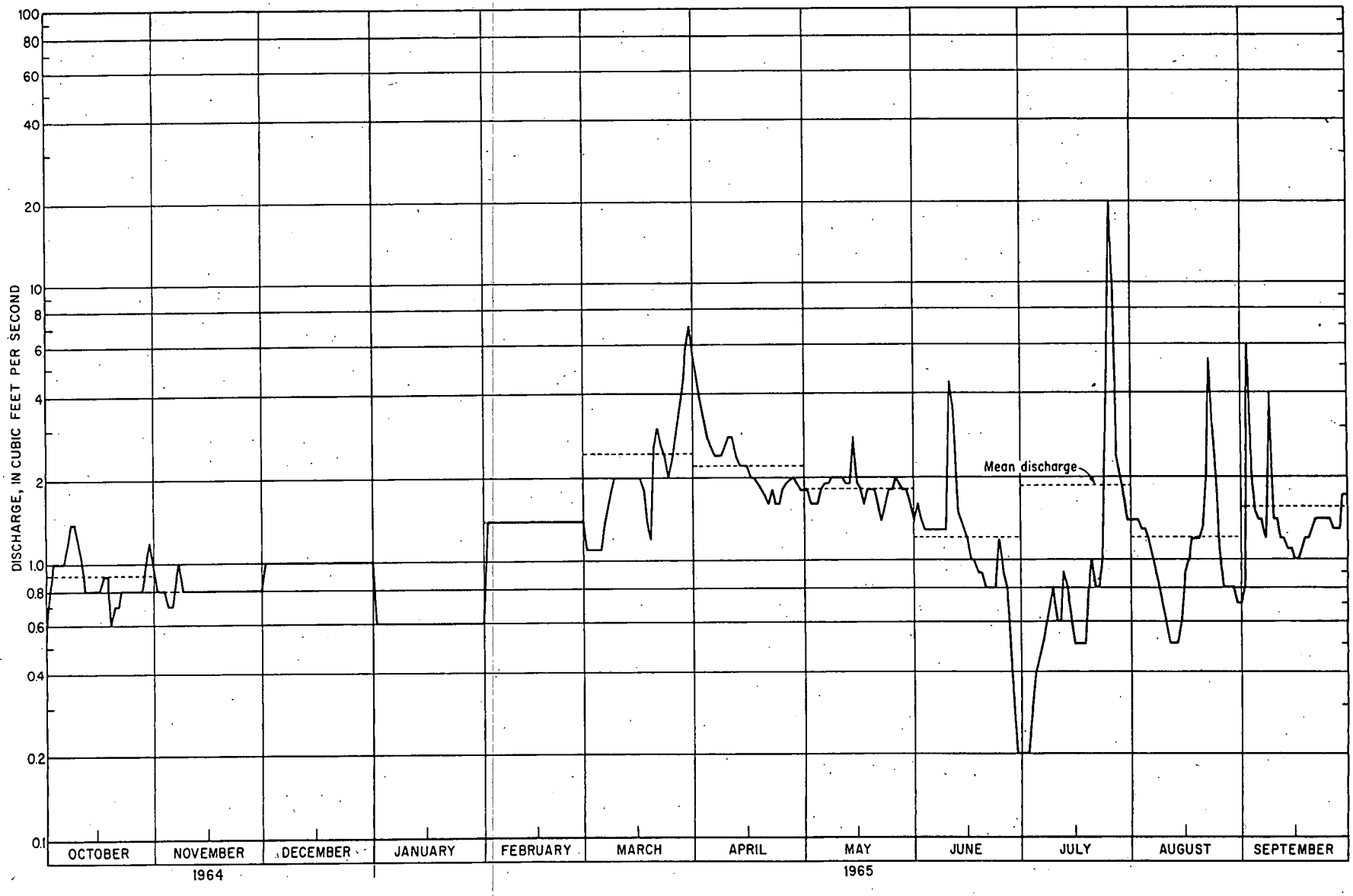

Figure 17.--Hydrograph of Yellow Creek, B2-98-4, Rio Blanco County, Colorado.

Figure 18.--Hydrograph of Parachute Creek, C5-96-36, Garfield County, Colorado.

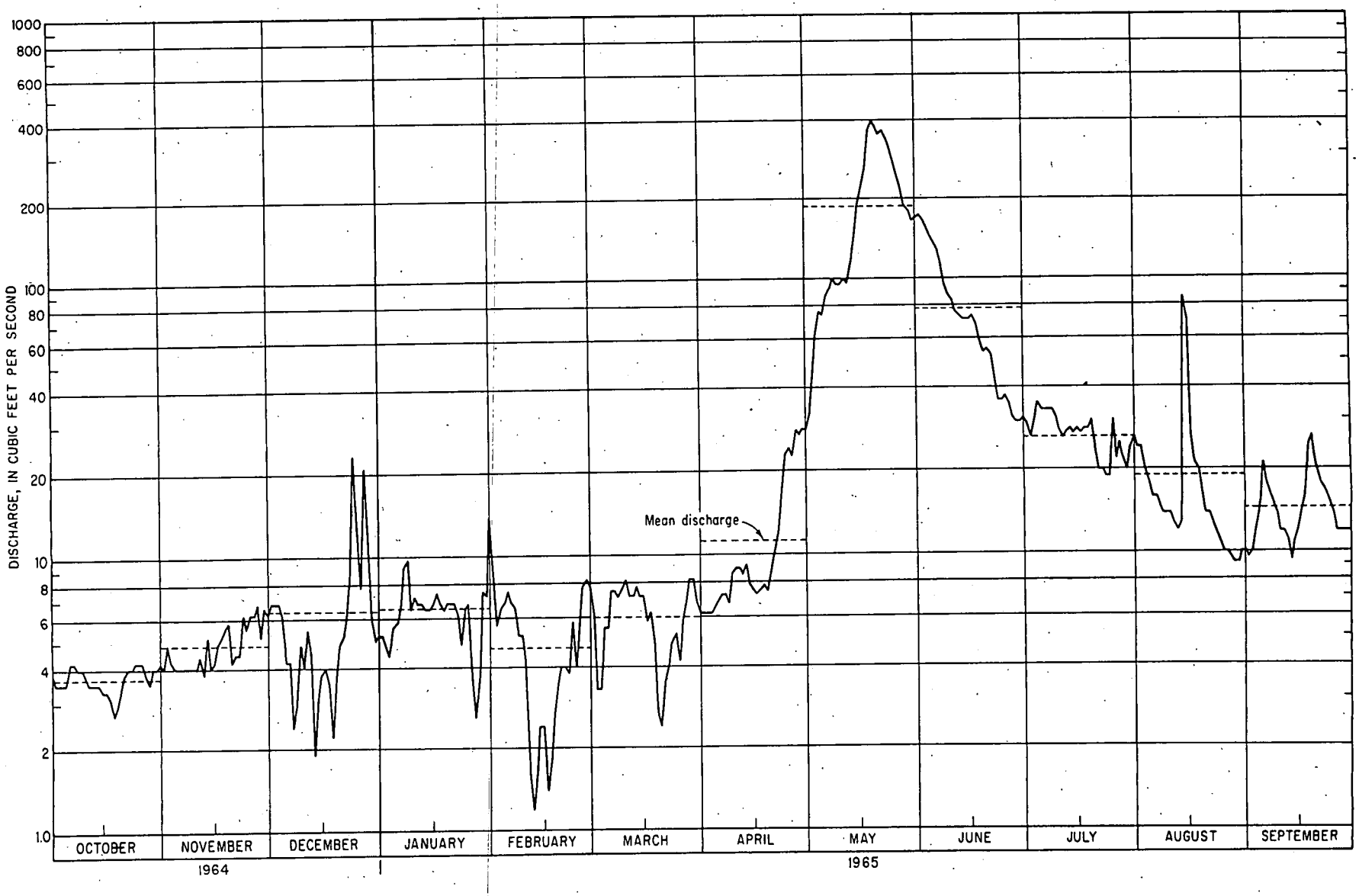

Figure 19.--Hydrograph of Roan Creek, C6-98-32, Garfield County, Colorado. (U. S. Geol. Survey, 1965).

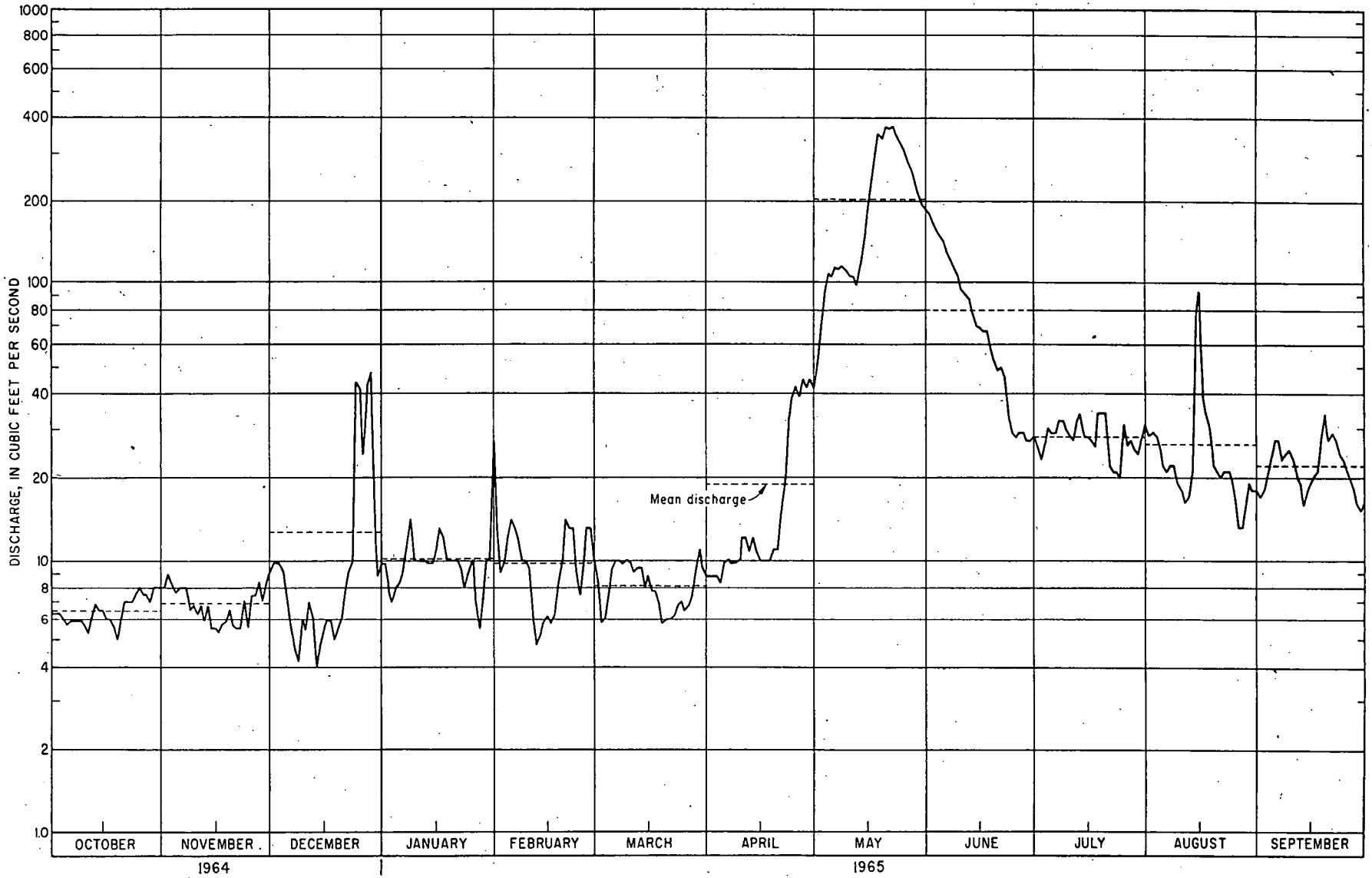

Figure 20.--Hydrograph of Roan Creek, C7-98-15, Garfield County, Colorado. (U. S. Geol. Survey, 1965).

Table 3.--Chemical analyses and related physical measurements of ground water

(Concentrations of dissolved constituents, dissolved solids, and hardness given in parts per million)

Location: See text for well-numbering system.

Geologic source: Tga, Anvil Points Member of the Green River Formation; Tgg, Garden Gulch Member of the Green River Formation; Tgp, Parachute Creek Member of the Green River Formation; Tge, Evacuation Creek Member of the Green River Formation; Qal, alluvium; for the description of the physical character of the water-bearing formations see table 1.

Depth of well: Depth of well given in feet below land surface; R, reported.

Iron (Fe): In solution at time of sampling.

Location	Geologic source	Depth of well (feet)	Date of collection	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated)	Hardness as $CaCO_3$	Noncarbonate hardness $CaCO_3$	Percent sodium	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
B1-97-11dc	Tgp	Spring	8-18-65	56	17	. .	42	98	516	0.8	1,030	19	640	47	2.5	0.1	0.40	1,890	508	0	69	9.9	2,690	8.4
-22ad	Qal	Spring	8-18-65	60	14	. .	0.0	24	10,100	31	23,300	1,110	155	1,660	32	55	4.9	24,600	98	0	99	444	28,800	8.5
-22da	Qal	Spring	10- 4-65	52	. .	. .	38	82	. .	. .	1,630	0	. .	88	. .	. .	. .	. .	430	0	. .	. .	2,970	8.2
-22dc	Qal	104	10-16-65	55	2.8	0.02	2.4	15	3,380	8.8	7,100	296	85	985	16	.5	1.1	8,290	66	0	99	181	12,000	8.4
-35ca	Qal(?), Tge(?)	Spring	10- 4-65	55	. .	. .	80	57	. .	. .	588	0	. .	14	. .	. .	. .	. .	436	0	. .	. .	1,230	8.0
B1-98- 8cd	Qal,Tge	183	10- 5-65	54	. .	. .	70	92	. .	. .	1,110	0	. .	14	. .	. .	. .	. .	552	0	. .	. .	2,700	7.6
-13db	Tge	2,600	6-16-65	50	15	. .	33	187	284	2.1	676	28	718	22	.4	5.8	.21	1,710	852	252	42	4.2	2,280	8.4
-18db	Qal,Tge	132	10- 5-65	54	. .	. .	127	132	. .	. .	816	0	. .	14	. .	. .	. .	. .	860	191	. .	. .	2,110	7.8
-24ac	Qal	80	10- 5-65	47	18	. .	116	156	292	1.9	748	12	854	28	.5	4.9	.27	1,850	930	297	41	4.2	2,410	8.3
B1-99- 2a	Qal,Tge	110	4- 8-65	46	18	. .	113	109	151	1.5	509	0	601	18	.6	14	.16	1,280	730	313	31	2.4	1,680	8.0
- 2a	Qal,Tge	110	10- 5-65	52	. .	. .	112	101	. .	. .	498	0	. .	18	. .	. .	. .	. .	694	286	. .	. .	1,650	8.0
- 4da	Tge,Tgp	171	4- 9-65	50	18	. .	101	92	125	1.0	443	0	492	18	1.0	11	.14	1,080	628	264	30	2.2	1,450	7.8
- 9cd	Qal,Tge(?)	. .	10- 5-65	52	. .	. .	56	46	. .	. .	446	0	. .	14	. .	. .	. .	. .	300	0	. .	. .	1,240	7.9
-20b	Tgp(?)	Spring	10- 5-65	52	. .	. .	144	95	. .	. .	570	0	. .	20	. .	. .	. .	. .	752	284	. .	. .	1,870	7.9
-26dd	Tge(?)	1,300R	10- 5-65	55	. .	. .	110	109	. .	. .	826	0	. .	12	. .	. .	. .	. .	725	48	. .	. .	2,040	7.6
B1-100-24b	Qal,Tgp	Spring	8-19-65	54	17	. .	73	90	119	.5	534	0	320	14	.7	25	1.1	923	552	114	32	2.2	1,380	8.1
B2-98-22cb	Tge,Tgp	Spring	9-23-64	53	15	.04	.0	99	3,910	8.8	1,260	4,150	65	746	6.9	14	2.1	9,630	408	0	95	84	12,800	8.5
-22ac2	Qal	45	6-22-65	50	17	. .	46	16.5	437	3.2	1,010	13	804	38	1.1	.1	.35	2,020	792	0	54	6.8	2,760	8.3
C1-96-10bd	Qal,Tge(?)	34	10- 9-64	49	17	.00	67	45	101	1.4	470	0	149	8.0	.3	9.3	.10	629	354	0	38	2.3	947	7.8
-10da	Tgp	3,000	8-17-65	80	12	. .	.0	7.1	246	.4	570	0	47	9.6	5.1	.2	.66	608	29	0	95	2.0	969	8.2
C1-97-11acd	Qal	68	10-25-65	52	18	. .	23	56	240	1.1	552	0	309	25	1.0	1.9	.11	946	290	0	64	6.1	1,380	8.2
-15db	Tge,Tgp	Spring	10- 8-65	50	. .	. .	32	56	. .	. .	1,090	49	. .	44	. .	. .	. .	. .	312	0	. .	. .	2,120	8.6
-28ab	Tgp	3,051	10-12-64	70	12	.04	.0	9.5	7,540	19	9,880	4,320	15	542	30	2.3	2.6	17,400	40	0	100	522	20,700	8.7
C1-99- 4bc	Qal	115	10- 7-65	51	1.1	. .	17	47	108	1.3	104	0	339	13	.0	.6	.04	578	234	149	50	3.1	909	7.5
- 4bc	Qal	115	10- 7-65	51	. .	. .	135	89	. .	. .	540	0	. .	16	. .	. .	. .	. .	702	259	. .	. .	1,570	7.7
- 6bc	Tge	Spring	10- 7-65	49	. .	. .	115	94	. .	. .	696	0	. .	18	. .	. .	. .	. .	674	103	. .	. .	1,580	8.0
-11aa	Qal	. .	10- 7-65	52	. .	. .	127	117	. .	. .	632	0	. .	17	. .	. .	. .	. .	796	278	. .	. .	1,870	7.7
C2-94-19c	Qal,Tga	58	8-27-65	50	31	. .	248	164	39	1.6	518	0	879	17	.5	1.0	.06	1,640	1,300	870	6	.5	1,980	7.5
-30c	Tga	205	8-27-65	48	14	. .	112	154	133	1.3	416	0	770	11	.7	.1	.08	1,400	910	569	24	1.9	1,830	7.6
C2-95-12d	Tga	203	8-27-65	49	40	. .	208	163	125	1.3	632	0	858	14	.3	4.1	.02	1,720	1,190	672	19	1.6	2,160	7.4
-23d	Tgp	75	8-27-65	48	27	. .	84	71	60	1.2	431	0	232	5.0	.7	4.4	.08	697	500	147	21	1.2	1,010	8.0
C2-96- 4cb	Tge	Spring	10- 8-65	47	. .	. .	59	29	. .	. .	376	0	. .	10	. .	. .	. .	. .	266	0	. .	. .	701	8.0
- 9cb	Tge	413	10- 8-65	. .	20	. .	46	19	55	1.3	324	0	34	10	.1	.8	.03	345	194	0	38	1.7	559	8.2
C2-97-27c	Qal(?), Tge(?)	Spring	8-17-65	47	. .	. .	114	109	. .	. .	556	0	. .	9.0	. .	. .	. .	. .	734	278	. .	. .	1,610	7.8
-30ad	Tge	Spring	10-13-64	45	15	.05	80	88	149	1.0	526	0	451	6.6	.1	.3	.12	1,050	562	131	37	2.7	1,450	7.9
C2-98- 9da	Tge	37	10- 8-65	48	16	. .	98	126	243	1.4	682	0	703	17	.3	3.4	.21	1,540	765	206	41	3.8	2,100	8.0
-10db	Qal,Tge(?)	Spring	10- 8-65	48	. .	. .	104	132	. .	. .	694	0	. .	20	. .	. .	. .	. .	804	235	. .	. .	2,160	7.8
-19ca	Qal(?), Tge(?)	Spring	8-17-65	47	. .	. .	98	110	. .	. .	540	0	. .	11	. .	. .	. .	. .	696	253	. .	. .	1,670	7.7
-28dd	Qal(?),Tge	Spring	8-20-65	47	16	.00	43	92	78	1.0	486	0	220	6.5	.4	6.3	.07	702	485	86	26	1.5	1,080	8.1
C2-99- 4cc	Tge(?), Tgp(?)	Spring	10- 7-65	47	17	. .	87	74	100	1.0	446	0	337	15	.2	3.6	.07	854	522	156	29	1.9	1,240	8.0
-12ac	Qal	Spring	10- 7-65	46	. .	. .	115	90	. .	. .	520	0	. .	14	. .	. .	. .	. .	658	231	. .	. .	1,530	7.7
-15dc	Qal	. .	10- 7-65	48	. .	.02	80	76	. .	. .	414	0	. .	14	. .	. .	. .	. .	512	98	. .	. .	1,280	7.9

Table 3.--Chemical analyses and related physical measurements of ground water--Continued

Location	Geologic source	Depth of well (feet)	Date of collection	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated)	Hardness as $CaCO_3$	Noncarbonate hardness $CaCO_3$	Percent sodium	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
C3-95-18ab	Tge	Spring	10- 5-65	49	13	. .	51	54	119	2.4	508	0	154	12	1.3	0.9	0.23	658	346	0	43	2.8	1,030	8.1
-31cc	Qal,Tge(?)	. .	9- 1-65	53	. .	. .	67	37	. .	. .	366	16	. .	7.5	. .	. .	. .	. .	322	0	. .	. .	850	8.4
C3-96- 5aa	Tge	Spring	10- 8-65	47	11	. .	94	78	117	1.2	500	0	365	10	.3	5.6	.09	928	555	145	31	2.2	1,330	8.1
-11ba	Tgp	1,000R	5- 7-62	70	13	0.01	8.0	3.4	684	1.2	1,610	63	4.1	30	30	.4	.92	1,630	34	0	98	51	2,500	8.3
-11ba	Tgp	1,000R	4-13-65	70	11	. .	4.0	3.4	. .	. .	1,510	112	10	28	26	1.3	. .	1,640	24	0	98	62	2,470	8.4
-11bb	Tgp	1,300	9-29-65	76	. .	. .	15	4.4	. .	. .	1,480	24	. .	106	. .	. .	. .	. .	56	0	. .	. .	2,530	8.3
C3-97-14cb	Qal(?),Tge	Spring	8-18-65	47	. .	. .	101	79	. .	. .	542	0	. .	9.0	. .	. .	. .	. .	578	133	. .	. .	1,360	8.0
-27cd	Qal(?),Tge	Spring	8-18-65	46	. .	. .	104	74	. .	. .	498	0	. .	8.0	. .	. .	. .	. .	566	158	. .	. .	1,240	7.8
C3-98-22db	Qal(?),Tge	Spring	8-17-65	46	. .	. .	123	66	. .	. .	460	0	. .	6.0	. .	. .	. .	. .	578	201	. .	. .	1,300	7.7
C4-94-34b	Qal,Tga	Spring	8- -65	45	. .	. .	73	38	. .	. .	422	0	. .	3.0	. .	. .	. .	. .	340	0	. .	. .	687	7.8
C4-95- 3ba	Qal(?),Tge(?), Tgp(?)	74	8-30-65	48	12	. .	53	28	66	.3	255	0	161	14	.8	.3	.04	460	248	39	37	1.8	703	8.1
- 8bb	Tge(?),Tgp(?)	99	8-31-65	48	23	. .	88	49	90	.0	408	0	244	6.4	.8	3.9	.08	706	420	85	32	1.9	1,040	7.7
-19cc	Qal,Tge	128	10-11-65	45	11	.00	29	34	125	.5	384	0	141	5.2	.1	.6	.05	535	210	0	56	3.8	892	8.1
C4-97-12db	Qal,Tge,Tgp	80	8-30-65	48	15	. .	112	75	106	.4	464	0	393	5.8	.7	4.8	.08	940	588	208	28	1.9	1,310	7.9
-31bd	Tge	Spring	8-18-65	43	. .	. .	59	33	. .	. .	332	0	. .	3.0	. .	. .	. .	. .	282	10	. .	. .	600	7.9
-33ca	Tge	Spring	8-18-65	45	. .	. .	75	38	. .	. .	380	0	. .	4.0	. .	. .	. .	. .	344	32	. .	. .	730	7.8
-33cb2	Qal	Spring	8-18-65	57	. .	. .	103	55	. .	. .	510	0	. .	6.0	. .	. .	. .	. .	486	68	. .	. .	1,030	7.5
C4-98-14cc	Tge(?)	Spring	8-17-65	45	. .	. .	95	81	. .	. .	396	0	. .	6.0	. .	. .	. .	. .	570	245	. .	. .	1,210	8.0
-17cb	Tge(?)	Spring	8-28-65	46	. .	. .	73	41	. .	. .	350	26	. .	6.5	. .	. .	. .	. .	352	22	. .	. .	836	8.4
-36aa	Tge	Spring	8-18-65	44	. .	. .	76	47	. .	. .	388	0	. .	3.0	. .	. .	. .	. .	382	64	. .	. .	850	8.1
C4-99-10ac	Tgp	Spring	10-12-64	45	18	.02	69	29	35	.4	374	0	80	2.0	.0	1.8	.05	419	294	0	21	.9	668	7.7
-10ac	Tgp	Spring	8-16-65	46	. .	. .	74	29	. .	. .	354	0	60	2.0	. .	. .	. .	. .	304	14	. .	. .	639	8.1
C5-94-14ab	Tge	Spring	8- -65	49	. .	. .	57	21	. .	. .	308	0	. .	2.0	. .	. .	. .	. .	228	0	. .	. .	505	7.5
C5-95-30c	Qal(?)	Spring	8-16-65	48	16	. .	51	38	41	1.5	345	0	64	4.8	.6	3.4	.06	390	282	0	24	1.1	629	7.9
C5-96- 1bd	Tge	Spring	8-27-65	46	. .	. .	51	33	. .	. .	310	0	. .	5.0	. .	. .	. .	. .	262	8	. .	. .	662	8.0
- 1bd2	Qal	Spring	8-27-65	51	. .	. .	39	33	. .	. .	266	0	. .	6.0	. .	. .	. .	. .	232	14	. .	. .	596	8.2
-36aaa	Qal	50R	8-13-65	53	. .	. .	70	50	. .	. .	400	0	. .	8.0	. .	. .	. .	. .	378	50	. .	. .	862	7.9
C5-97- 1c	Tgp	. .	8- -65	55	. .	. .	47	33	. .	. .	344	0	. .	5.0	. .	. .	. .	. .	254	0	. .	. .	679	8.0
-23bb	Tge	Spring	8- -65	55	. .	. .	58	18	. .	. .	332	0	. .	3.0	. .	. .	. .	. .	218	0	. .	. .	521	7.6
C5-98- 2ac	Tgp	Spring	8-30-65	43	. .	. .	59	30	. .	. .	324	0	. .	4.0	. .	. .	. .	. .	270	4	. .	. .	650	7.5
C6-95-12ba	Tgp	Spring	8-26-65	46	. .	. .	87	31	. .	. .	416	0	. .	2.0	. .	. .	. .	. .	344	3	. .	. .	621	7.7
C6-96-29da	Qal	33	10-12-65	55	21	. .	124	73	92	16	700	0	267	10	1.2	10	.17	958	610	36	24	1.6	1,410	7.8
C6-98-16aa	Qal	68R	10-13-65	. .	16	. .	63	52	75	2.5	446	0	141	11	.9	5.4	.16	586	372	6	30	1.7	918	7.9
-34cd	Qal	70R	10-12-65	57	18	. .	100	79	117	3.1	616	0	252	12	1.2	32	.23	918	575	70	31	2.1	1,370	7.9
C7-96-11aa	Qal	50R	10-12-65	. .	19	. .	170	122	198	5.2	656	0	793	18	.9	.4	.20	1,650	925	387	32	2.8	2,180	7.9
C7-97- 5ba	Qal(?)	Spring	10-11-65	50	6.8	. .	44	69	67	3.4	484	0	129	6.0	.6	1.5	.11	565	392	0	27	1.5	1,000	8.0
C7-98- 4ba	Qal	61R	10- 9-65	52	15	. .	96	90	149	2.3	598	0	424	10	.7	6.6	.22	1,090	610	120	35	2.6	1,530	8.0
- 8ab	Tgp(?), Tgg(?)	Spring	10- 9-65	. .	. .	. .	48	94	. .	. .	689	0	. .	14	. .	. .	. .	. .	506	0	. .	. .	1,840	8.1
-14ca	Qal	68R	10- 9-65	54	15	.15	144	170	396	3.8	737	0	1,220	35	.8	.7	.57	2,350	1,060	456	45	5.3	3,010	8.0
C7-99-26cc	Qal(?), Tgg(?)	Spring	10-11-65	50	. .	. .	91	73	. .	. .	512	0	. .	10	. .	. .	. .	. .	528	108	. .	. .	1,410	7.7
-27bd	Qal(?), Tgg(?)	Spring	10-11-65	47	16	. .	50	86	110	1.9	494	0	287	5.4	.3	.5	.10	800	478	73	33	2.2	1,220	8.1
C7-100-25db	Qal	Spring	10-11-65	48	. .	. .	86	57	. .	. .	496	0	. .	5.0	. .	. .	. .	. .	448	41	. .	. .	1,050	7.8
-35bb	Qal	Spring	10-11-65	51	. .	. .	72	57	. .	. .	424	0	. .	5.0	. .	. .	. .	. .	416	68	. .	. .	894	7.8
C8- 97- 7ab	Qal	75R	10- 9-65	54	16	. .	164	148	293	3.3	692	0	1,040	18	.8	5.5	.31	2,030	1,020	453	38	4.0	2,630	7.9

Table 4.--Chemical analyses and related physical measurements of surface water

(Concentrations of dissolved constituents, dissolved solids, and hardness given in parts per million)

Location: Locations are listed in downstream order. See text for well-numbering system. Discharge (cfs): Discharge measurements given in cubic feet per second; E, estimated.

Location	Discharge (cfs)	Date of collection	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (calculated)	Hardness as $CaCO_3$	Noncarbonate hardness $CaCO_3$	Percent sodium	Sodium adsorption ratio	Specific conductance (micromhos at 25°C)	pH
Piceance Creek																								
C4-95- 1aa	..	6- 8-65	..	..	..	..	126	33	..	..	328	0	..	6	..	..	..	..	260	0	..	..	736	7.8
	0.55	10- 6-65	40	..	..	..	75	52	..	..	418	0	..	13	..	..	..	..	402	59	..	..	1,050	8.0
C3-95-36cc	.5E	7-17-64	..	14	0.00	0.00	57	33	70	1.5	344	0	130	8.9	0.1	1.6	0.12	485	278	0	35	1.8	753	7.9
-26db	2.1	10- 6-65	47	..	..	..	75	34	..	..	356	0	..	9.5	..	..	..	..	324	32	..	..	812	8.0
- 9dc	2.0	10- 6-65	47	..	..	..	58	39	..	..	324	0	..	9.5	..	..	..	..	304	38	..	..	768	8.1
C3-96-11bd	9.1	10- 6-65	53	..	..	..	66	47	..	..	484	0	..	14	..	..	..	..	356	0	..	..	986	8.2
C2-97-36ba	11.9	10- 6-65	56	..	..	..	59	57	..	..	476	0	..	16	..	..	..	..	382	0	..	..	1,100	8.0
C2-96-32dd	2.5E	7-17-64	..	15	.00	.00	40	46	149	1.9	554	0	144	23	1.3	.5	.31	693	290	0	53	3.8	1,090	8.1
C2-97-16dc	4E	7-17-64	..	16	.00	.00	52	85	190	2.6	567	0	400	16	.5	1.0	.24	1,040	480	15	46	3.8	1,500	8.0
	..	6- 8-65	59	..	..	..	67	106	..	..	716	0	..	23	..	..	..	..	602	15	..	..	1,900	8.2
	15.6	10- 6-65	58	..	..	..	70	72	..	..	546	0	..	16	..	..	..	..	472	24	..	..	1,350	8.0
C1-97-32ad	17	6- 8-65	65	..	..	..	87	107	..	..	736	0	..	18	..	..	..	1,360	656	52	43	..	1,870	8.1
B1-97-35ca	2.5E	7-17-64	..	17	.00	.00	52	117	529	3.9	1,250	45	610	46	.4	1.3	.48	2,040	610	0	65	9.3	2,690	8.4
	..	3-24-65	37	..	..	..	64	73	..	..	808	0	..	20	..	..	..	A/1,150	460	0	..	..	1,680	8.1
	..	4-12-65	38	..	..	..	38	28	..	..	1,110	51	..	39	..	..	..	A/1,750	209	0	..	..	2,520	8.4
	..	6- 8-65	67	..	..	..	38	117	..	..	1,200	22	..	46	..	..	..	..	574	0	..	..	2,890	8.4
	17.0	10- 6-65	60	..	..	..	41	86	..	..	848	16	..	30	..	..	..	..	456	0	..	..	2,010	8.3
B1-97- 2ab	2E	7-17-64	..	11	..	..	12	95	1,240	6.4	2,540	182	479	208	2.5	2.3	.74	3,490	420	0	86	26	5,020	8.7
	32	3-24-65	36	..	..	..	56	68	..	..	1,010	0	..	45	..	..	..	A/1,380	420	0	..	..	2,010	8.2
	14	4-12-65	40	..	..	..	22	37	..	..	1,630	81	..	94	..	..	..	A/2,340	205	0	..	..	3,400	8.5
	18	6- 8-65	70	..	..	..	24	107	..	..	1,430	59	..	80	..	..	..	2,370	500	0	..	..	3,370	8.4
	19.3	10- 6-65	64	..	..	..	22	81	..	..	1,240	33	..	79	..	..	..	..	386	0	..	..	2,680	8.5
Black Sulphur Creek																								
C2-97-20c	1E	7-17-64	..	17	.00	.00	76	81	123	1.4	478	0	372	9.5	.3	.5	.15	916	525	133	34	2.3	1,330	7.8
Hunter Creek																								
C2-97-27ac	.5E	7-17-64	..	19	.00	.00	92	106	157	2.2	566	0	532	9.5	.2	1.2	.16	1,200	665	201	34	2.6	1,630	8.0
Yellow Creek																								
B1-98-12bb	..	5- 4-65	62	..	..	..	60	175	..	..	832	20	..	24	..	..	..	A/2,020	870	155	..	..	2,600	8.3
B2-98-26bb	..	5- 3-65	65	..	..	..	56	165	..	..	832	30	..	28	..	..	..	A/1,970	820	89	..	..	2,540	8.4
- 9ab	5E	3-24-65	33	12	..	..	36	63	424	..	936	16	363	69	..	3.1	..	1,420	350	0	72	9.9	2,100	8.3
	..	4- 8-65	50	..	..	..	18	59	..	..	1,420	102	..	112	..	..	..	A/2,530	288	0	..	..	3,500	8.5
	..	5- 4-65	65	..	..	..	20	151	..	..	1,600	98	..	128	..	..	..	2,750	670	0	..	..	3,740	8.6
Roan Creek																								
C6-99-29ab	3E	10- 9-65	54	..	..	..	..	..	..	..	..	..	146	..	..	..	..	..	..	..	..	..	816	..
C6-98-32bdd	2	10- 9-65	57	..	..	..	..	..	..	..	..	..	263	..	..	..	..	..	..	..	..	..	1,120	..
C7-98-22ab	5	10- 9-65	51	..	..	..	..	..	..	..	..	..	520	..	..	..	..	..	..	..	..	..	1,630	..
-25d	2E	10- 9-65	46	..	..	..	..	..	..	..	..	..	809	..	..	..	..	..	..	..	..	..	2,070	..
C8-97-18aa	.5E	10- 9-65	62	..	..	..	..	..	..	..	..	..	4,200	..	..	..	..	..	..	..	..	..	7,160	..

A/ Dissolved solids, residue on evaporation at 180°C.

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11. Pumping Tests in Colorado, by Woodrow W. Wilson. 1965. 361 p., 1 pl., 5 figs.