PRELIMINARY ASSESSMENT OF THE GROUND-WATER RESOURCES OF THE ALLUVIAL AQUIFER, WHITE RIVER VALLEY, RIO BLANCO COUNTY, COLORADO

By William P. Van Liew and Marc L. Gesink

U.S. GEOLOGICAL SURVEY

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GLOSSARY

Terms defined in the GLOSSARY are underscored when first used in the report.

alluvium.--Clay, silt, sand, gravel and larger rocks deposited by flowing water in recent geologic time, usually in the valleys of rivers.

aquifer.--A geologic formation, group of formations, or part of a formation that transmits water readily and can supply wells or springs; may be regarded as an underground reservoir.

artesian condition.--The condition in which water in an aquifer overlain and confined by a relatively impermeable zone rises under pressure in a well or test hole that penetrates into the aquifer. Such a well is called an artesian well. If the water level in an artesian well stands above land surface, the well is a flowing artesian well.

drawdown, s.--The difference between (1) the water level in a well at a specific time after pumping has begun; and (2) the original water level in the well prior to pumping.

head.--The height above a standard reference point of the surface of a column of water (as in a well).

hydraulic conductivity, K.--The rate at which water flows through a unit area of aquifer measured at right angles to the direction of flow, under a unit hydraulic gradient.

hydraulic gradient.--The change in head per unit of distance in a given direction.

lithology.--The description of rocks on the basis of such characteristics as color, mineralogical composition, and grain size.

potentiometric surface.--An imaginary surface connecting points to which water would rise in wells that penetrate a given aquifer. When artesian conditions do not exist, the potentiometric surface is the same as the water table.

sodium adsorption ratio(SAR).--A measure of the ratio of sodium ions in a water sample to total cations in the sample.

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

where ion concentrations are expressed in milliequivalents per liter.

specific capacity.--The rate of discharge of water from a well divided by the drawdown of water level within the well; dependent on the time the well has been discharging.

specific electrical conductance.--A measure of the ability of a water to conduct an electrical current, herein referred to simply as "specific conductance." Specific-conductance values provide a measure of the dissolved mineral concentration in water, because chemically pure water itself has a very low specific conductance. Commonly, the concentration of dissolved solids (in milligrams per liter or parts per million) is about 65 percent of the specific conductance (in micromhos per centimeter at 25°C). However, this relation is not constant, and depends upon the kinds and relative concentrations of dissolved minerals in the water.

specific yield, S_y.--The ratio of (1) the volume of water a saturated material will yield by gravity drainage; to (2) the volume of material drained. This ratio is expressed as a decimal fraction or as a percentage.

storage coefficient, S.--The volume of water an artesian aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. When artesian conditions are not present, storage coefficient is equal to specific yield.

transmissivity, T.--The rate at which water flows through a section of aquifer whose height is the saturated thickness of the aquifer and whose width is unity, under a unit hydraulic gradient. Transmissivity is equal to horizontal hydraulic conductivity multiplied by the saturated thickness of the aquifer.

CONVERSION FACTORS

Inch-pound units used in this report may be converted to SI (International System of Units) by use of the following factors:

Multiply inch-pound unit	*By*	*To obtain SI unit*
acre-foot (acre-ft)	1,233	cubic meter
foot (ft)	0.3048	meter
foot per day (ft/d)	0.3048	meter per day
foot per mile	0.1894	meter per kilometer
foot squared per day (ft^2/d)	0.09290	meter squared per day
gallon per minute (gal/min)	0.06308	liter per second
gallon per minute per foot [(gal/min)/ft]	0.2070	liter per second per meter
inch (in.)	25.40	millimeter (mm)
micromho per centimeter at 25° Celsius (µmho)	1.000	microsiemen per centimeter at 25° Celsius
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called mean sea level.

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ABSTRACT

Ground water from the alluvium of the White River valley supplies municipal, industrial, domestic, and agricultural needs in northwestern Colorado. Development of the extensive energy resources in the White River basin will require additional water for associated industrial and municipal supplies. A preliminary study of the alluvial aquifer in the White River valley in Rio Blanco County, Colorado was conducted to assess the aquifer's extent and the occurrence, availability, and chemical quality of water in the aquifer.

The alluvial aquifer in the study area underlies 35 square miles. Aquifer width ranges from about 0.1 mile at several locations in the western part of the study area to about 1.5 miles in Agency Park and Powell Park and averages 0.5 mile. Saturated thickness ranges from zero along the valley sides at several locations to more than 140 feet in Agency Park and averages 22 feet.

In the eastern part of the study area, the alluvium consists predominantly of coarse sand and gravel alternating with thin layers of clay, silt, and sand. To the west, the alluvium consists of fine-grained sediments from land surface to several feet in depth, underlain by coarse sand and gravel containing interstitial fine-grained material. West of the Grand Hogback, fine-grained alluvium overlying the sand and gravel aquifer forms a semiconfining layer that causes the aquifer to be under artesian conditions in many places.

Yields of domestic and stock wells in the study area usually are less than 25 gallons per minute. Relatively expensive and efficient wells exist at two sites in the study area. At the Meeker municipal well field in Agency Park, wells reportedly could yield more than 1,000 gallons per minute each. At the Deserado coal-mine site near Rangely, wells were designed to allow a sustained yield of 130 to 145 gallons per minute each.

Based on the results of nine aquifer tests, transmissivity of the alluvial aquifer ranges from about 860 to about 93,000 feet squared per day, and hydraulic conductivity ranges from about 70 to about 1,550 feet per day. Transmissivity and hydraulic conductivity are greatest in Agency Park and least in western parts of the study area.

The estimated total volume of water in storage in the alluvial aquifer in the study area is 103,000 acre-feet. Southeast of Meeker, about 40,000 acre-feet of water are in storage in the alluvial aquifer.

Ground water in the eastern part of the study area is a calcium bicarbonate type; to the west, the ground water is a sodium sulfate type. Water in the alluvial aquifer is classified as very hard throughout the study area. West of Piceance Creek, water-quality standards for public-water supplies are exceeded for dissolved solids and sulfate. In the same area, large sodium-adsorption ratios combine with large dissolved-solids concentrations to make

the ground water unfit for irrigation purposes. Specific conductance of 115 water samples ranges from 400 to 14,000 micromhos per centimeter at 25° Celsius; in general, values increase from east to west and with increasing distance from the White River.

The results of this investigation are preliminary and are based mostly on data from existing wells and test holes. The variability in depth to bedrock and hydraulic properties of the aquifer need to be more accurately evaluated, especially southeast of Meeker and in the western part of Powell Park.

INTRODUCTION

Ground water from the alluvium of the White River valley supplies municipal, industrial, domestic, and agricultural needs in northwestern Colorado. The White River basin contains extensive energy resources consisting of oil shale, coal, natural gas, and oil. Additional water will be required in the future for energy-resource development and associated municipal and industrial supplies.

Purpose and Scope

This report presents the results of a study conducted to assess the areal extent, thickness, and lithologic characteristics of the alluvial aquifer in the White River valley, herein referred to as the White River alluvial aquifer, and to describe the occurrence, availability, and chemical quality of water in the aquifer. The results of this investigation are preliminary and are based mostly on data from existing wells and test holes.

Location

The White River and its tributaries drain an area in northwestern Colorado of about 3,800 mi^2, principally in Rio Blanco County (fig. 1). The area studied is the valley of the White River from about 7 mi southeast of the town of Meeker on the east to the town of Rangely on the west, an area of about 35 mi^2 (fig. 1).

Previous Investigations

Site-specific investigations of White River alluvium in the study area associated with four distinct projects have been conducted prior to this study. These projects are a water-supply study for the town of Meeker, studies of saline ground-water seepage from rocks underlying the Meeker dome about 3 mi east of Meeker, water-supply studies conducted prior to the opening of the Deserado coal mine, and studies of the alluvium as part of investigations for the proposed Taylor Draw dam and reservoir near Rangely.

In 1973, the town of Meeker retained Wright-McLaughlin Engineers (1974, 1975, 1976) to conduct a detailed study of the water-supply potential of the alluvial aquifer near Meeker. The study included geophysical exploration, test-hole drilling, extensive aquifer testing, and sampling of the ground

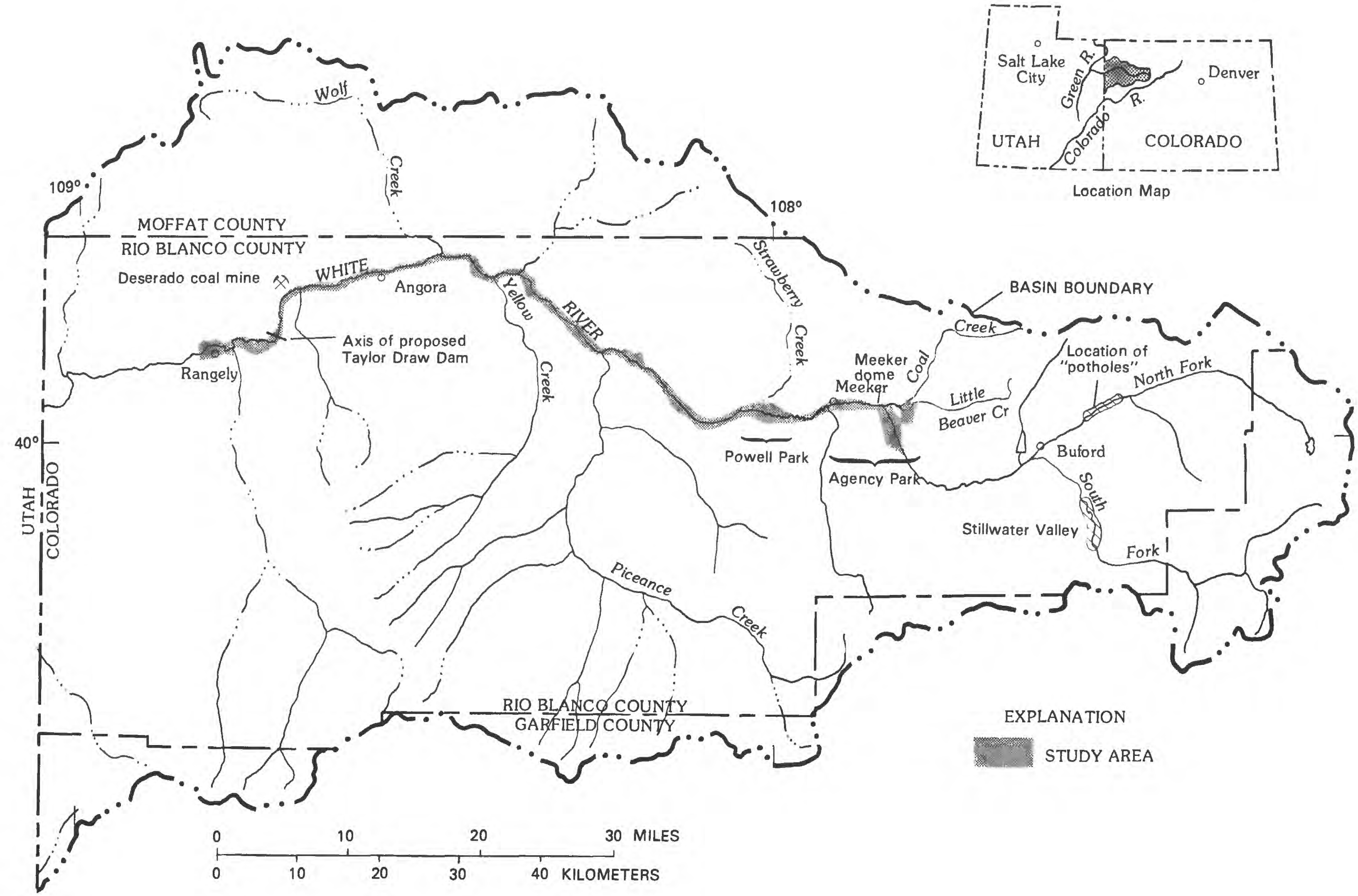


Figure 1.--White River basin, Colorado, showing location of study area.

water for laboratory analysis of water quality. The investigation culminated in the construction of a well field in the alluvial aquifer about 5 mi southeast of Meeker in Agency Park.

Hydrogeologic investigations of the Meeker dome have been conducted by consulting firms for the U.S. Bureau of Reclamation as part of an effort to decrease saline ground-water seepage into the White River. Nelson, Haley, Patterson, and Quirk, Inc. (1976) compiled a report that contains a listing of many wells in the area, well logs where available, and an exhaustive literature search. The firm of CH2M Hill Central, Inc. (1979, 1981) verified and quantified the salinity problem, supervised the plugging of abandoned exploratory wells contributing to the saline seepage, and monitored surface-water quality thereafter. Although the CH2M Hill reports principally describe the bedrock aquifers underlying the alluvium, they include some information about the extent and characteristics of the alluvial aquifer.

Vaughn Hansen Associates (1979) conducted a preliminary study of White River alluvium near the present site of the Deserado coal mine about 7 mi northeast of Rangely. The report includes several lithologic logs of holes drilled in the alluvium and the results of a reconnaissance alluvial-aquifer testing program. In the same area, Ford, Bacon and Davis Utah, Inc. (1981) investigated the extent and hydrologic properties of the alluvium by drilling several test holes and conducting aquifer tests. This study investigated the feasibility of providing a water supply for the mine and associated facilities from the White River alluvial aquifer.

Studies of White River alluvium also were conducted as part of investigations for the proposed Taylor Draw dam and reservoir about 5 mi east of Rangely. Woodward-Clevenger and Associates, Inc. (1972) conducted preliminary engineering and geologic studies that provide site-specific information on the thickness and lithology of alluvium at the proposed dam axis near Taylor Draw. More recent foundation investigations by Western Engineers, Inc. (1978) at Wolf Creek (about 19 mi northeast of Rangely) and at the Taylor Draw site (Western Engineers, Inc., 1980) also contributed hydrogeologic information about alluvium in the western part of the study area.

In addition, alluvium along the White River is shown on several geologic maps of parts of northwestern Colorado. One-by-two degree quadrangles by Tweto (1976), Tweto and others (1978), Rowley and others (1979), and Carrara (1980) are available, as are 7½-minute geologic quadrangles by Cullins (1971), Hail (1972, 1973, 1974), Pipiringos and Johnson (1975, 1976), and Barnum and Garrigues (1980).

Acknowledgments

The authors thank the residents of the study area who permitted access to and sampling from their wells; the U.S. Bureau of Reclamation, which provided geophysical equipment; and Adel A. R. Zohdy and Robert J. Bisdorf of the U.S. Geological Survey, who provided technical advice and computer programs that facilitated geophysical-data collection and interpretation.

GEOLOGIC SETTING

Physiography and Structure

Most of the White River basin is within the extreme northeastern part of the Colorado Plateau physiographic province, although the easternmost part of the basin is within the Southern Rocky Mountains physiographic province. Several major structural features extend into the drainage basin, including the White River uplift, the Grand Hogback monocline, the Piceance structural basin, and the Douglas Creek arch (fig. 2). The Meeker dome is a smaller, though significant, local feature 3 mi east of Meeker (fig. 2).

Bedrock Formations

Although rocks of Precambrian through Tertiary age are exposed in the White River basin (fig. 2), only Jurassic through Tertiary formations border and underlie the White River in the study area. These rocks include (in ascending order) the Morrison Formation, Dakota Sandstone, Mancos Shale, Mesaverde Group, Wasatch Formation, and Green River Formation (fig. 2).

The Morrison Formation, a variegated shale and mudstone of Jurassic age, is exposed within the study area only at the Meeker dome east of Meeker. The Cretaceous Dakota Sandstone, a light-gray to tan quartzose sandstone, underlies the easternmost part of the study area and also is exposed at the Meeker dome. Underlying Meeker and the rest of the alluvial aquifer in Agency Park is the Mancos Shale of Cretaceous age, a dark-gray marine shale. The Mowry Shale Member of the Mancos Shale, a silver-gray siliceous shale, and the Frontier Sandstone Member of the Mancos Shale, a tan calcareous sandstone, also are exposed southeast of Meeker. West of Meeker, the resistant light-brown to white sandstones and interbedded shales and coal layers of the Cretaceous Mesaverde Group form the Grand Hogback. West of the Grand Hogback, the Tertiary Wasatch Formation, a variegated claystone, siltstone, sandstone, and conglomerate, is exposed. The Tertiary Green River Formation is present farther west and consists of marlstone, oil shale, siltstone, and sandstone. In the western part of the study area the White River again flows over the Wasatch Formation, the Mesaverde Group, and, near Rangely, the Mancos Shale (fig. 2).

Alluvial Formations

Alluvium deposited by the White River and underlying its flood plain is probably of late Wisconsin age (J. W. Whitney, U.S. Geological Survey, oral commun., 1982). This alluvium is referred to as White River alluvium in this report because it is the most important constituent of the White River alluvial aquifer. Other unconsolidated deposits in the study area include tributary alluvium, alluvial fans, terrace alluvium, and colluvium.

White River alluvium consists principally of silty sand and rounded gravel and cobbles composed of fragments of rocks found east of the study area. These fragments usually are sandstone, quartzite, basalt, and granite. Tributary alluvium is composed of finer-grained material, mostly of local origin, confined to the valleys and mouths of relatively large tributaries

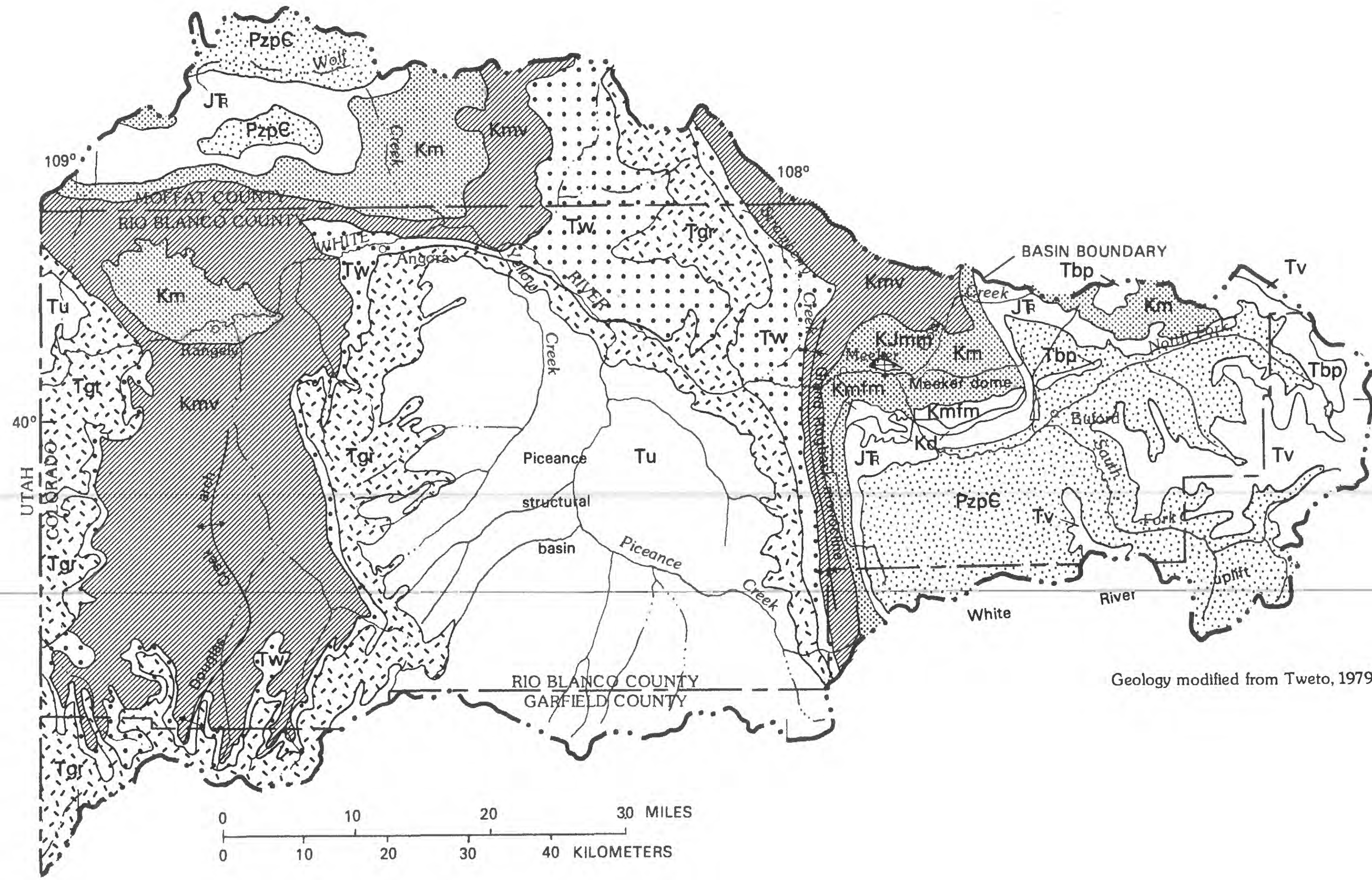


Figure 2.--Generalized structure and bedrock geology, White River basin, Colorado.

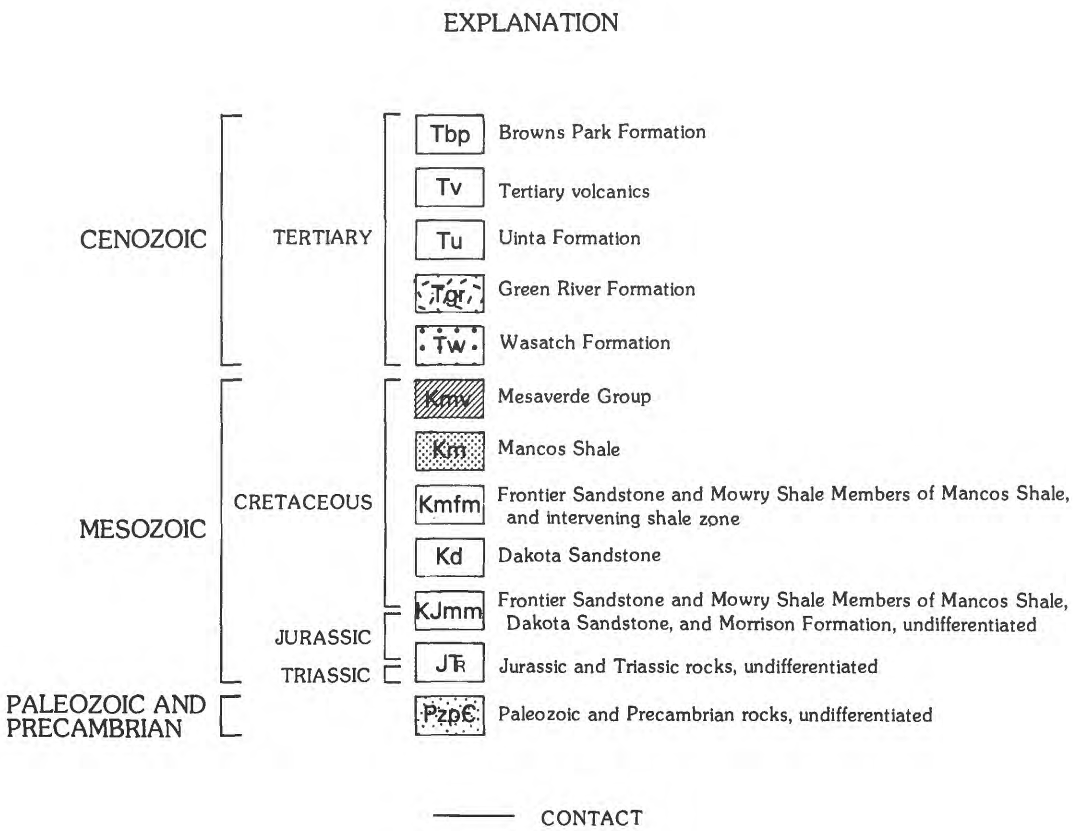


Figure 2.--Generalized structure and bedrock geology, White River basin, Colorado--Continued.

of the White River. Alluvial fans consist mainly of clay, silt, and sand deposited on the sides of the White River valley at the mouths of smaller tributaries, draws, and gullies. In some areas, fans from adjacent tributaries have coalesced, creating a continuous deposit that mantles the White River alluvium for miles. Terrace alluvium exists at low levels adjacent to the White River and at higher levels some distance from the river. The terrace deposits are remnants of former flood plains and are similar in composition to White River alluvium. Material found at the base of cliffs or steep valley walls that has slumped or fallen to the flood plain, known as colluvium, is found in significant quantities in the study area only near the Meeker dome.

METHODS OF STUDY

Several methods were used to acquire information for this report. Black-and-white aerial photographs at scales of 1:32,000 and color aerial photographs at scales of 1:12,000 were studied and annotated to delineate the extent of the valley-fill deposits. Geologic mapping was conducted in the field in some areas to check contacts plotted on the basis of aerial-photographic interpretation and to ascertain the hydraulic relationship between terrace alluvium and White River alluvium. Bulk samples of White River alluvium were collected at various sites and analyzed for grain-size distribution. An inventory of all known water wells, oil and gas wells, and test holes in the study area was compiled to provide information on ground-water quality, alluvial well yields, depth to bedrock, depth to water, and vertical lithologic changes within the alluvium. The inventory data are summarized in table 7 in the Supplemental Information section at the back of this report.

Two methods of surface-geophysical investigation were conducted to provide information on depth to bedrock in areas where inventory data were incomplete or not available. Vertical electrical-resistivity soundings conducted at 50 sites throughout the study area yielded useful data; however, seismic-refraction techniques produced no usable results. A summary of the theory, field procedure, and methods of interpretation involved in the vertical electrical soundings is given in the Supplemental Information section, followed by the interpreted depth to bedrock for each of the soundings (tables 8 and 9 in the Supplemental Information section at the back of this report).

Pumping tests were conducted at several sites to determine the hydraulic characteristics of certain areas of the alluvial aquifer and to obtain ground-water samples for chemical analysis of dissolved constituents. Procedures involved setting a submersible pump in the well to be tested, pumping the well at a nearly-constant rate for a specified period of time, and measuring water-level changes in the pumped well and in any nearby observation wells. The pumping rate was measured with an in-line flow meter and controlled with a gate valve in the discharge line. During some tests, pumping rate was checked by measuring the time to fill a bucket of known volume. At specified times after pumping began, water levels were measured with a steel tape or with an electric sounder. Temperature and <u>specific conductance</u> of the discharge water were measured throughout the test, and samples were sent to the laboratory for more detailed analysis. After the pump was shut off, the recovery of water levels in wells also was measured.

Aquifer-test data presented in this report were analyzed using the modified nonequilibrium "straight-line" method of Cooper and Jacob (1946), the recovery method of Theis (1935), or the Hantush modified method (Hantush, 1960) for leaky, artesian aquifers. An in-depth discussion of the methods used herein, including derivations of the pertinent equations, can be found in the references cited and in publications by Ferris and others (1962) and Lohman (1972).

DESCRIPTION OF THE WHITE RIVER ALLUVIAL AQUIFER

Lateral Extent and Saturated Thickness

The extent of the alluvial aquifer in the study area is shown on plates 1 through 4 (in the pocket at the back of this report). The lateral extent is delineated on plate 1. The altitude of the bedrock surface shown on plate 1 was compared with the altitude of the potentiometric surface (pl. 2) to determine the saturated thickness of the aquifer (pl. 3). Geohydrologic sections (pl. 4) show the variability in shape of the aquifer across the White River valley at selected locations.

The configuration of the bedrock surface beneath the alluvial aquifer shown on plate 1 and the configuration of the potentiometric surface of the alluvial aquifer (pl. 2) are interpretations based on a study of data for 231 wells and test holes, supplemented by 56 surface-geophysical soundings. Only 104 of the wells and test holes penetrated the underlying bedrock. Information on depth to water was obtained at 163 of the sites. The geophysical soundings provided information on depths to bedrock but not on depths to water. The interpretations made on the basis of these soundings have not been checked by test drilling and should be regarded only as generally representative of subsurface conditions. Consequently, the contours on plates 1 and 2 are preliminary, based on available data and the geologic processes that formed the valley and the alluvial aquifer, and are not intended to define subsurface conditions for site-specific use.

Some of the test holes, water wells, and geophysical soundings used to construct the cross sections (pl. 4) were near but not on the line of sections shown on plates 1 and 2. These were projected to the lines of section, as indicated on plate 4.

Terrace alluvium usually is hydrologically separate from White River alluvium in the study area, except at contact springs that occur seasonally at the base of the terrace deposits. Therefore, the lateral extent of the alluvial aquifer generally is confined to the limits of the flood plain. A possible exception may occur at section B-B' (pl. 1) about 5 mi west of Meeker, where the potentiometric surface appears to be continuous in the terrace alluvium and in the White River alluvium (pl. 4).

The extensive flood plain and terrace southeast of Meeker is known as Agency Park, and the wide flood plain west of the Grand Hogback is known as Powell Park (fig. 1 and pl. 1). Because the aquifer is relatively wide in these areas, the parks were the focus of more detailed study than elsewhere, and consequently, are discussed in greater detail in the report.

Local geology probably has contributed to the large width of the aquifer in Agency Park. As the river crosses the resistant Dakota Sandstone and emerges from the narrow canyon upstream from the park, it flows over the relatively weak members of the Mancos Shale (fig. 2). Here there was little resistance to lateral erosion so the valley widened. The valley also is narrow west of Meeker, where the river flows over the resistant formations of the Mesaverde Group at the Grand Hogback. The Mesaverde may have resisted downcutting by the river and thereby facilitated lateral erosion of the Mancos Shale to the east, furthering valley widening in the weaker shale above Meeker.

The presence of the Mancos Shale in Agency Park and its lack of resistance to downward erosion also may have contributed to the considerable thickness of the valley-fill alluvium southeast of Meeker. The lithologic log of Meeker municipal well B-1 (site 4 in table 7 and on pl. 1) indicates that the alluvium is at least 121 ft thick at the municipal well field. The log indicates that red sandstone bedrock was encountered at a depth of 121 ft and was penetrated 2 ft. However, this area is known to be underlain by the Mancos Shale, a dark-gray marine shale. Perhaps only a large sandstone boulder was penetrated during drilling, and the alluvium is thicker than 121 ft. Electrical-resistivity soundings conducted in this area indicated depths to bedrock ranging from 112 to more than 140 ft. One sounding indicated a depth to bedrock of 295 ft, which may be indicative of a buried channel; however, no test holes have been drilled to verify this value so it was not used in constructing the saturated-thickness map (pl. 3). Average saturated thickness southeast of the Meeker dome in Agency Park appears to be at least 54 ft, which is significantly greater than average values elsewhere in the study area.

East of and adjacent to Agency Park, in the drainage areas of Little Beaver and Coal Creeks (fig. 1 and pl. 1), is an area of 1.8 mi^2 that may be underlain by White River alluvium. The White River may have flowed through this area at one time rather than in its present channel. Lithologic logs of two water wells in this area (sites 19 and 20, table 7 and pl. 1) show that sand and gravel were penetrated from 0 to 80 ft in depth; however, two test holes elsewhere in this area (sites 21 and 22, table 7 and pl. 1) did not encounter sand and gravel. Useful subsurface data are scant in this area, and the origin of the unconsolidated deposits remains in question. Therefore, the limit of the alluvial aquifer there is delineated with dashes and queries on plate 1.

Between Meeker and Powell Park the aquifer averages 0.5 mi in width and 16 ft in saturated thickness. West of the Grand Hogback, where the relatively weak rocks of the Wasatch Formation underlie Powell Park, the average width of the aquifer is nearly 1 mi. Saturated thickness averages about 14 ft in the eastern part of the park, but preliminary geophysical and test-hole data seem to indicate that locally it may exceed 90 ft below the mouth of Strawberry Creek (pl. 3), as indicated by the logs for wells at sites 82 and 85 (table 7 and pl. 1).

The alluvial aquifer usually is less than 0.5 mi wide in the segment west of Powell Park to Taylor Draw, about 5 mi east of Rangely, except at the mouths of relatively large tributaries. Average saturated thickness in this segment is about 17 ft. From Taylor Draw to Rangely, where the river again flows over the Mancos Shale, the aquifer widens to more than 1 mi in places, but saturated thickness averages only about 14 ft.

Overall, aquifer width in the study area ranges from about 0.1 mi at each of several locations in the western part of the study area to about 1.5 mi in Agency Park and Powell Park and averages about 0.5 mi. Saturated thickness ranges from zero along the valley sides at each of several locations to more than 140 ft in Agency Park and averages 22 ft.

Lithologic Characteristics of the Alluvium

White River alluvium consists principally of fragments of rocks originating on the White River uplift that have been transported downstream by the White River. Tributary alluvium and alluvial fan material have been deposited in the White River valley from nearby sources to the north and south of the valley main stem. The particle sizes, sorting, and distribution of these materials are a function of the energy of the stream that deposited the material. Stream energy is partly dependent on the velocity of flow, which increases with increasing slope along the river valley. The present-day longitudinal slope of the White River valley in the study area is shown in figure 3.

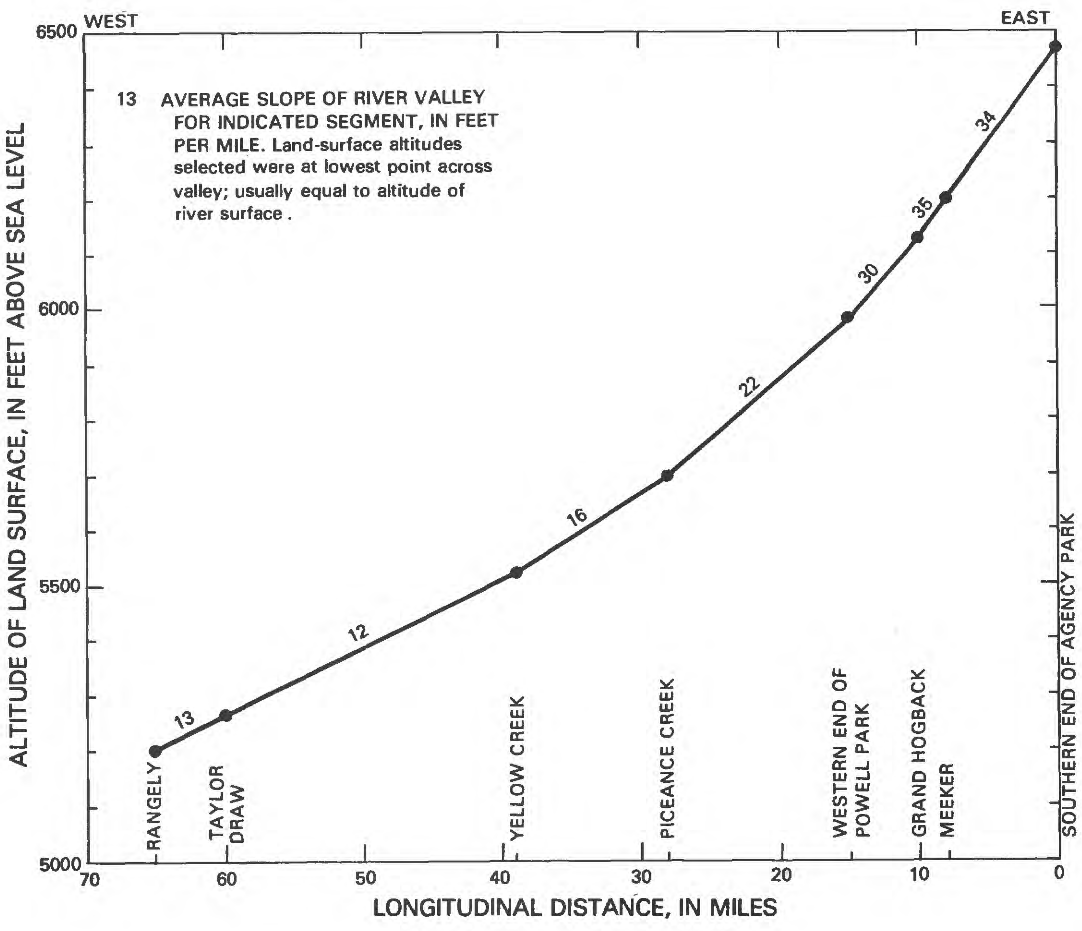


Figure 3.--Average longitudinal slope of the White River valley for selected segments.

Slope along the valley also influences stream morphology, which affects the lithology of alluvium in places. In the eastern part of the study area, valley slope is relatively steep and the White River is a braided stream. To the west, valley slope is more gentle and the White River is a meandering stream; point bars and oxbow lakes are common and backswamp areas are present. At the Meeker municipal well field in Agency Park (fig. 1), the relatively steep valley slope and braided-stream environment result in deposition of coarse-grained sand and gravel with alternating thin layers of fine-grained material such as clay, silt, and sand (fig. 4). To the west, near Angora, about 15 mi northeast of Rangely, the more gentle valley slope and meandering stream environment result in deposition of coarse sand and gravel overlain by fine-grained material from land surface to several feet in depth (fig. 5).

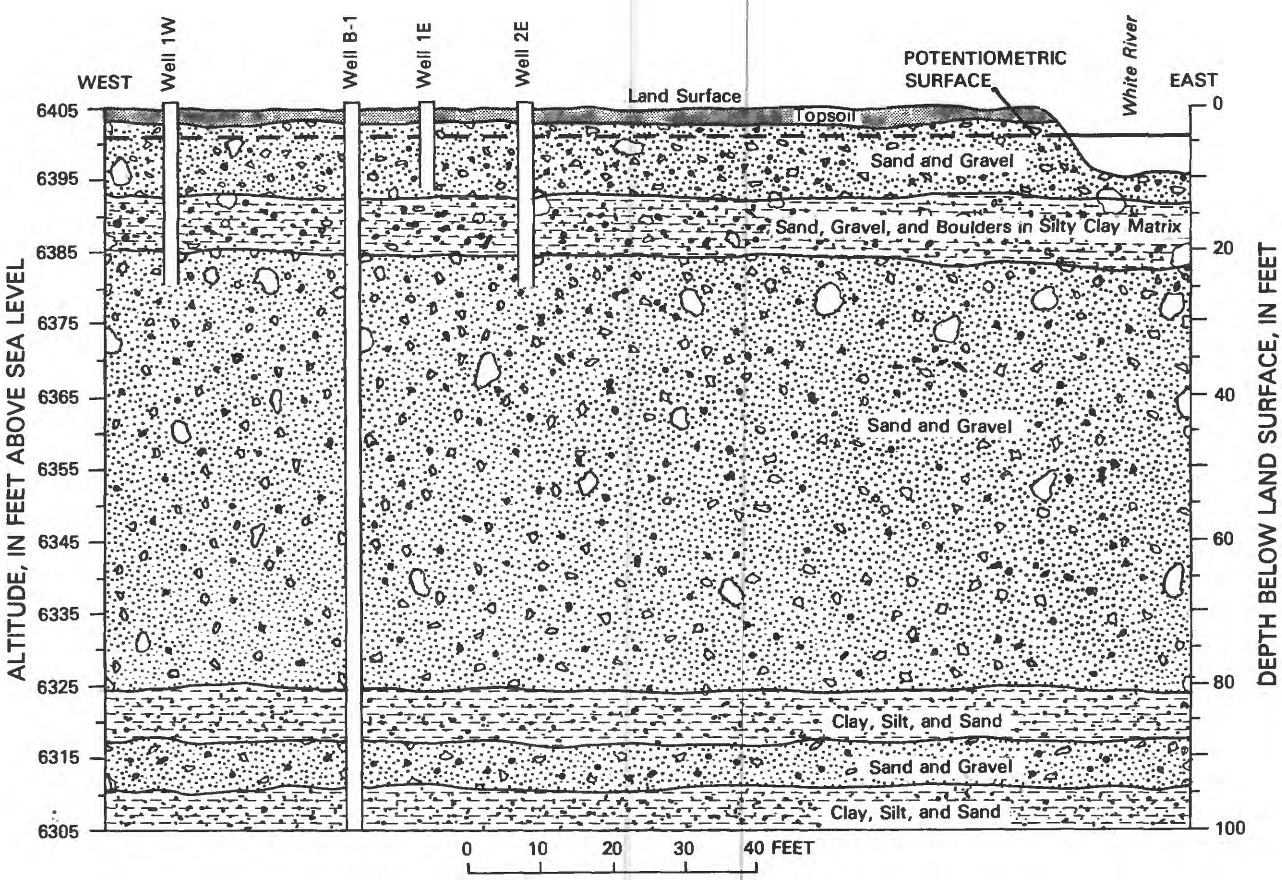


Figure 4.--Character of alluvium at the Meeker municipal well field in Agency Park. (Modified from Wright-McLaughlin Engineers, 1975.)

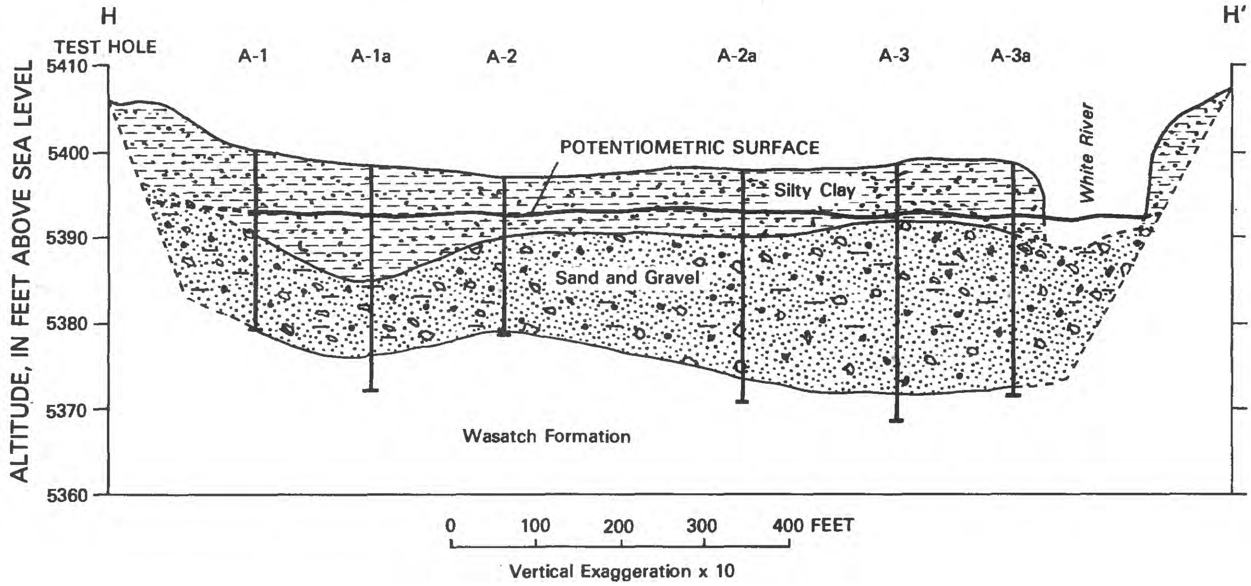
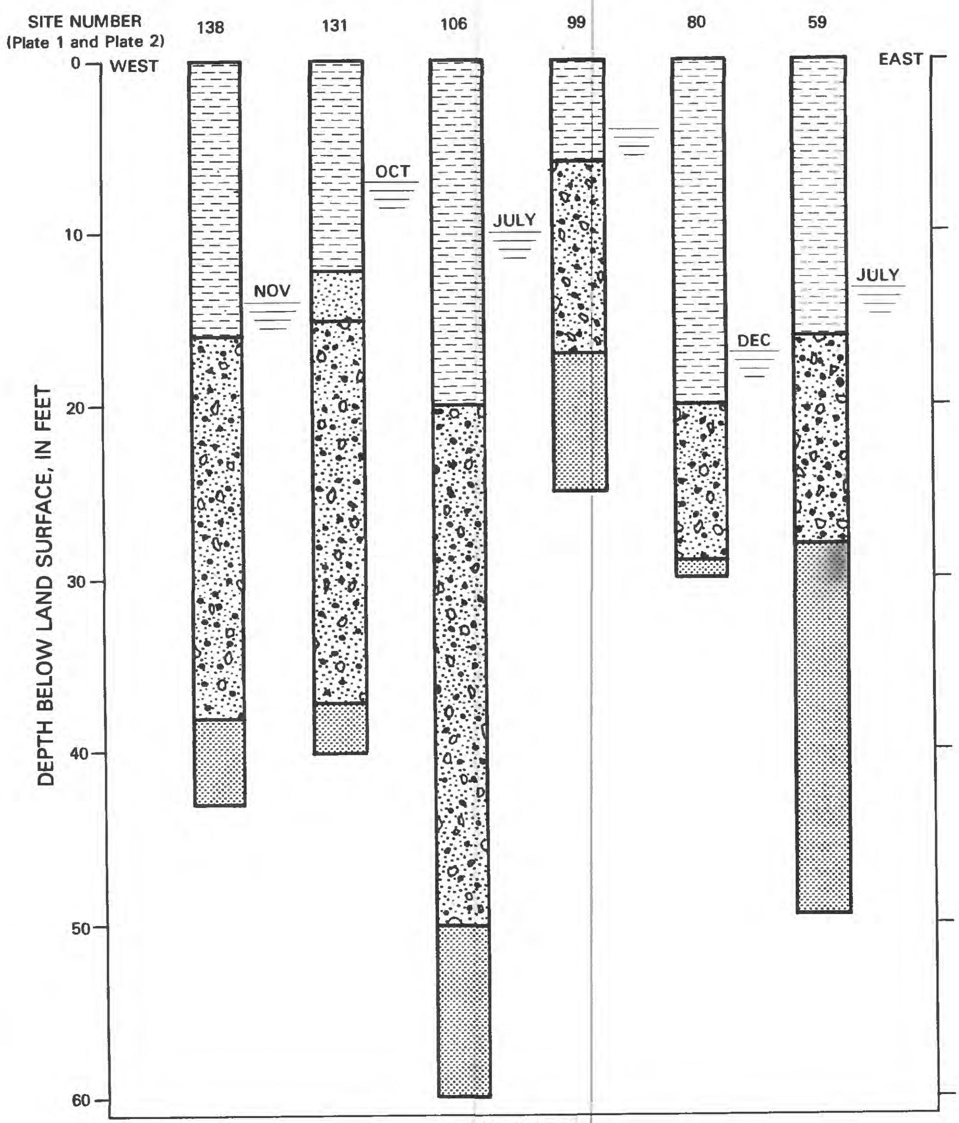


Figure 5.--Geologic section across the White River valley near Angora, 15 miles northeast of Rangely.

The composition of the coarse-grained deposits is different from one end of the study area to the other. (See "Grain-size Distribution Analyses of Alluvium" in Supplemental Information section, at back of report.) In Agency Park, the coarse alluvium is relatively free of fine-grained material; at the proposed Taylor Draw dam site, the coarse alluvium contains much interstitial fine-grained material. Such interstitial fine-grained alluvium is presumed to be present throughout the western part of the study area, especially west of the confluence of the White River and Yellow Creek, where the easily-erodable, fine-grained Mancos Shale outcrops in the hills to the north (fig. 2).

The lithologic characteristics described above have important hydrologic significance. The fine-grained material present from land surface to several feet in depth in the western part of the study area forms a semi-confining layer that causes the aquifer to be under artesian conditions completely across the valley in places (fig. 5) and at several other locations (fig. 6). Wells drilled at these locations encountered dry to very moist, silty, sandy, clay underlain by water-bearing sand and gravel deposits. When the sand and gravel aquifer was encountered, the water in the bore hole rose under artesian pressure up into the clay layer. The interstitial fine-grained alluvium present in the western part of the study area clogs the openings between the grains of the sand and gravel deposits and substantially decreases their ability to transmit water.



EXPLANATION

CLAY--Silty to very silty, slightly sandy to very sandy, fine-grained, contains organic matter from 0 to 3 feet in depth, tan to dark brown, dry to very moist.

SAND--Fine to medium-grained, tan, brown, reddish-brown, black, wet.

GRAVEL--Sandy to very sandy, "clean" to silty, white, tan, pink, brown, reddish-brown, black, wet.

BEDROCK--Shale or sandstone, brown, gray, grayish-blue.

OCT — STATIC WATER LEVEL IN WELL AND MONTH MEASURED. Left blank where date is unknown.

Figure 6.--Lithologic logs of selected wells and test holes showing water levels indicative of artesian conditions.

GROUND-WATER RESOURCES

Well Yields

Most wells completed in the White River alluvium are completed with torch-cut slots in metal well casing, hacksaw-cut slots in PVC casing, or solid casing open only at the bottom. This relatively inexpensive and inefficient type of construction usually limits the flow of water into a well so that its yield is small and the water level in the well declines quickly when the well is pumped. Consequently, well-yield data usually are a measure of well completion and not of the hydraulic properties of the aquifer.

Nonetheless, 75 domestic and stock wells were pumped to get a general idea of potential well yield and performance. Yields usually were less than 25 gal/min. East of Meeker, in Agency Park, average reported yield was about 17 gal/min. Between Meeker and Rangely, average reported yield was about 10 gal/min. A few wells in the study area yielded 60 gal/min, but only for several minutes continuously.

Specific capacity was computed for each of 27 wells, which were pumped for 15 min each. Average specific capacity was on the order of magnitude of 10 (gal/min)/ft of drawdown. No trends were detected with segment of river valley, presumably because of variations in well construction and development.

Relatively efficient and expensive wells, completed with stainless-steel, wire-wrapped screens designed specifically for the well and aquifer material at the site, produce water from the White River alluvial aquifer at the Meeker municipal well field in Agency Park and at the Deserado coal-mine site about 7 mi northeast of Rangely. Meeker municipal well B-1 produced a continuous, sustained yield of 550 gal/min for slightly more than 14 days, with a total drawdown of about 24 ft (Wright-McLaughlin Engineers, 1975). Therefore, the 14-day specific capacity of the well determined from this test was about 23 (gal/min)/ft of drawdown. Municipal wells B-2, B-3, and B-4 were each pumped at about 550 gal/min for 24 hr (Wright-McLaughlin Engineers, 1976). Reportedly each municipal well could yield more than 1,000 gal/min when pumping alone, but the four wells were designed to produce 2,340 gal/min when pumping simultaneously. In 1982, an additional municipal well, B-5, produced a continuous yield of 530 gal/min for 24 hr. At the Deserado coal-mine site, well WFU-1 was pumped at 103 gal/min for about 3 hr (Ford, Bacon and Davis Utah, Inc., 1981). Ford, Bacon and Davis Utah, Inc. (1981) stated that a long-term yield of 130 to 145 gal/min could be obtained from well WFU-1 without dewatering the aquifer below the top of the screen. At present, two water-supply wells yield 125 gal/min each and an additional well yields 90 gal/min at the mine site (Mike Weigand, Western Fuels-Utah, Inc., oral commun., 1983).

Yield and specific-capacity data for the municipal wells and the Deserado mine-site wells are summarized in table 1. Well B-4 had the greatest specific capacity of the Meeker municipal wells; therefore it was used as the lead well in the well field (Wright-McLaughlin Engineers, 1976). Data from well B-1 show that specific capacity decreased with increased pumping time and increased pumping rate. A step-drawdown test was conducted using well WFU-1 on November 6, 1980, in which the well was pumped at incrementally increasing rates for 1 hr each (Ford, Bacon and Davis Utah, Inc., 1981). Specific

Table 1.--*Yields and specific capacities for wells with stainless-steel, wire-wrapped screens*

[hr = hours; gal/min = gallons per minute; ft = feet; (gal/min)/ft = gallons per minute per foot of drawdown]

Location	Well	Date of testing	Time of continuous pumping (hr)	Pumping rate (gal/min)	Total drawdown (ft)	Specific capacity [(gal/min)/ft]
Meeker municipal	[1]B-1	05-28-75 to 06-11-75	338	550	24	23
well field in		06-12-75	2.5	560	18.3	31
Agency Park		03-01-76 to 03-02-76	8	304	8.6	35
	[1]B-2	01-07-76 to 01-08-76	24	558	9.35	60
	[1]B-3	01-20-76 to 01-21-76	24	548	10.5	52
	[1]B-4	02-29-76 to 03-01-76	24	554	8.0	69
	[1]B-5	09-20-82 to 09-21-82	24	530	21.66	24
Deserado coal-	[2]WFU-1	11-06-80	1.0	30	1.31	23
mine site		11-06-80	1.0	45	2.48	18
		11-06-80	1.0	60	3.81	16
		11-06-80	1.0	90	6.48	14
		11-07-80	3.0	103	8.41	12

[1]Results from Wright-McLaughlin Engineers, 1976.
[2]Results from Ford, Bacon and Davis Utah, Inc., 1981.

capacity decreased with each pumping step as shown in table 1. Ford, Bacon and Davis Utah, Inc. (1981) stated that a long-term specific capacity of 9 to 10 (gal/min)/ft should be expected for well WFU-1.

From the information collected and with consideration of the effects of variations in well construction, approximate potential well yields in the study area can be estimated. Southeast of Meeker, in Agency Park, where the saturated thickness exceeds 100 ft (pl. 3), efficiently constructed, screened wells that fully penetrate the aquifer can be expected to yield on the order of 1,000 gal/min for sustained periods of time. Shallower wells can be expected to yield from 100 to several hundred gal/min. West of Meeker, where the average saturated thickness of the aquifer is 15 to 20 ft (pl. 3), efficiently constructed, screened wells can be expected to yield on the order of 100 gal/min for sustained periods of time. Relatively inexpensively constructed wells can be expected to yield 50 to 100 gal/min for a few minutes and 25 gal/min or less for sustained periods of time.

Aquifer Hydraulic Characteristics

An evaluation of an aquifer as a source of water includes the determination of its ability to transmit and to store water. An aquifer's ability to transmit water is expressed by its hydraulic conductivity and its transmissivity. Hydraulic conductivity is a measure of the rate that water will flow through a unit area of aquifer under standard conditions. Transmissivity, which is equal to the horizontal hydraulic conductivity times the saturated thickness of the aquifer, is a more complete measure of the aquifer's ability to transmit water. The storage characteristics of an aquifer are expressed by the specific yield and storage coefficient. Specific yield is a measure of the storage capacity of a unit volume of aquifer. If the total volume of aquifer is known, the total volume of water in storage can then be calculated. Under artesian conditions, the storage characteristics of an aquifer are expressed by the storage coefficient, which is a measure of the water released from storage as the artesian pressure is lessened, while the aquifer remains "full" or saturated.

These hydraulic coefficients can be determined by analyzing data collected during aquifer tests. The analyses of aquifer tests conducted in the study area are contained in the Supplemental Information section at the back of this report. A summary of the results of these aquifer-test analyses is given in table 2. The locations of the test sites are shown on plate 2.

Based on aquifer testing at nine sites within the study area, the most transmissive part of the White River alluvial aquifer is southeast of Meeker, in Agency Park. Transmissivity values obtained from aquifer testing at the Meeker municipal well field are an order of magnitude greater than values obtained from aquifer tests conducted elsewhere in the study area (table 2). The aquifer is more transmissive in Agency Park because both saturated thickness and hydraulic-conductivity values are relatively large. The hydraulic-conductivity values for the Meeker municipal wells listed in table 2 were calculated using an aquifer saturated thickness of 60 ft because all 5 municipal wells were screened within the sand and gravel zone from 20 to 80 ft in depth (fig. 4).

Table 2.--*Summary of hydraulic coefficients obtained from aquifer-test analyses*
[ft^2/d = feet squared per day; (gal/d)/ft = gallons per day per foot; ft/d = feet per day; --- = not determined]

Aquifer-test site	Pumped well	Site number of pumped well (plate 2)	Transmissivity (ft^2/d)	Transmissivity [(gal/d)/ft]	Horizontal hydraulic conductivity (ft/d)	Storage coefficient	Remarks
Meeker municipal well field in Agency Park	[1]B-1	4	20,000	150,000	[2]330	---	
	[1]B-2	5	93,000	700,000	[2]1,550	---	
	[1]B-3	6	40,000	300,000	[2]670	---	
	[1]B-4	7	53,000	400,000	[2]880	---	
	B-5	10	10,000	78,000	[2]170	---	Pumping phase
			58,000	440,000	[2]970	---	Recovery phase
Powell Park	BC-1	81	1,700	13,000	---	---	Pumping phase
			2,100	16,000	---	---	Recovery phase
West of Powell Park, east of Piceance Creek	IS-1	89	3,300	25,000	210	---	Pumping phase
Angora cross section	A-2	119	860	6,400	70	$6x10^{-5}$	Pumping phase
Deserado coal-mine site	[3]WFU-1	138	3,300	25,000	140	$3x10^{-4}$	

[1]Results from Wright-McLaughlin Engineers, 1976.
[2]Based on aquifer saturated thickness equal to 60 feet (fig. 4).
[3]Results from Ford, Bacon and Davis Utah, Inc., 1981.

The test conducted at well BC-1 provides only an approximate indication of transmissivity in Powell Park, for two reasons. First, the alluvium at the well site tested is composed of material deposited from the Strawberry Creek drainage, which is probably more fine-grained than White River alluvium. Secondly, the well is located near the edge of the park, where the saturated thickness of the aquifer probably is less than average. Thus, transmissivity may be much greater elsewhere in the park, especially east of the confluence of the White River and Strawberry Creek where the alluvium probably is more coarse-grained, and at the center of the western end of the park where the saturated thickness is greatest (pl. 3).

The storage characteristics of the White River alluvial aquifer were less well-defined by aquifer testing. Storage coefficient or specific yield can be determined from an aquifer test by measuring water-level fluctuations in at least one observation well. Testing using wells at the Meeker municipal well field and wells BC-1 and IS-1 yielded no useful information for determining storage properties of the alluvium. The storage coefficients determined from tests using wells A-2 and WFU-1 are both indicative of artesian conditions (table 2). This is supported by lithologic logs for these wells (figs. 5 and 6), which show that the water level in each well stands above the sand and gravel layer, under artesian pressure. Aquifer tests using these two wells were not sustained long enough to dewater the sand and gravel aquifer at an observation well; therefore, the specific yield could not be determined.

Volume of Ground Water in Storage

In order to estimate the total volume of water in storage in the White River alluvial aquifer in the study area, a specific yield was estimated. Lohman (1972) states that the specific yield of most aquifers ranges from about 0.1 to 0.3 and averages about 0.2. A value of 0.2 was assumed for this aquifer, which means that the aquifer can yield a volume of water equal to approximately 20 percent of its volume. In the eastern part of the study area, especially in Agency Park, the water in storage in the coarse-grained gravel, cobbles, and boulders that comprise the alluvial aquifer may constitute more than 20 percent of the total volume of aquifer. To the west, however, saturated near-surface, fine-grained alluvium and interstitial fine-grained material within gravel zones may cause the average specific yield of the alluvium to be less than 20 percent.

The estimated volume of water in storage for each of several segments of the aquifer is shown in table 3. The average saturated thickness for each aquifer segment was determined from information on plate 3. However, there are insufficient data to determine average saturated thickness in the area east of Agency Park, in the Coal Creek and Little Beaver Creek drainages. Therefore, it was assumed that this area is underlain by alluvium with average saturated thickness of 44 ft, as in the rest of Agency Park. As shown in table 3, the estimated total volume of water in storage in the White River alluvial aquifer in the study area is 103,000 acre-ft. Southeast of Meeker, about 40,000 acre-ft of water are in storage in the alluvial aquifer.

Table 3.--*Average saturated thickness and estimated volume of water in storage for each of several aquifer segments*
[mi^2 = square miles; ft = feet; acre-ft = acre-feet]

Aquifer segment	Total area of segment (mi^2)	Average saturated thickness (ft)	Estimated volume of ground water in storage (acre-ft)
Agency Park	5.4	44	30,000
Area east of Agency Park, in the drainages of Coal Creek and Little Beaver Creek	1.8	[1]44	10,000
Meeker to Powell Park	1.3	16	3,000
Powell Park	5.4	22	15,000
Powell Park to Piceance Creek	5.2	17	11,000
Piceance Creek to Yellow Creek	4.0	17	9,000
Yellow Creek to Angora	3.5	18	8,000
Angora to Taylor Draw	3.1	18	7,000
Taylor Draw through Rangely	5.2	14	10,000
		Total volume = 103,000 acre-ft	

[1]Assumed

Stream-Aquifer Relations

The shape of the potentiometric surface contours on plate 2, concave downstream, indicates that water flows from the alluvium into the White River along most of the study area for most of the year. However, the hydraulic gradient from the alluvium to the stream can be reversed by pumping a well and inducing river water to flow through the alluvium and into the well. Meeker municipal well B-1 draws in water from the White River, as evidenced by the measured cone of depression of the well and water-quality measurements versus time while pumping the well (Wright-McLaughlin Engineers, 1975). Wright-McLaughlin Engineers (1975) reported that the travel time of water from the river to well B-1 while pumping the well was about 9 to 12 days. In addition, river water obtained from wells completed in alluvium is filtered naturally of suspended sediment and bacteriological contaminants.

Water Quality

Minerals and gases in an aquifer can be dissolved and transported by water moving through the system (Hem, 1970). Major ions are gases or mineral constituents dissolved from soils or rocks and present in relatively large quantities in the water. Concentrations of major ions in water are reported in milligrams per liter; 1 mg/L (milligram per liter) is virtually equal to one part per million by weight in most waters. Common major ions are listed below:

Cations (positive charge)	Anions (negative charge)
Calcium (Ca)	Bicarbonate (HCO_3)
Magnesium (Mg)	Chloride (Cl)
Potassium (K)	Sulfate (SO_4)
Sodium (Na)	

The types and concentrations of dissolved constituents in the ground water are the basis for the chemical classification of water in this report (table 4).

Table 4.--Chemical criteria used to classify water types and hardness
[mg/L = milligrams per liter; meq/L = milliequivalents per liter]

Water types[1]		Hardness[2]	
Cations (meq/L)	Anions (meq/L)	Range of hardness (mg/L as calcium carbonate)	Classification
Water type designated by single cation when that cation is 50 percent or more of the total cations; otherwise, water type designated by two cations of greatest percentage concentration.	Water type designated by single anion when that anion is 50 percent or more of the total anions; otherwise, water type designated by two anions of greatest percentage concentration.	Less than 60	Soft
		61-120	Moderately hard
		121-180	Hard
		More than 180	Very hard

[1]Modified from Piper and others, 1953, p. 26.
[2]Modified from Durfor and Becker, 1964, p. 27.

Water samples from the White River alluvial aquifer were obtained at 115 sites during 1978-83. Specific conductance was determined for all these samples; eight samples were sent to the laboratory for more detailed analysis of dissolved constituents. In addition, laboratory analyses were conducted on samples from four sites at the Meeker municipal well field (Wright-McLaughlin Engineers, 1976) and from one site near the Deserado coal mine (Ford, Bacon and Davis Utah, Inc., 1981).

Water type and hardness for each of the 13 samples for which detailed analyses were conducted are summarized in table 5. Based on this preliminary sampling, ground water in the eastern part of the study area is a calcium bicarbonate type, as evidenced by water from wells at sites 4, 5, 6, 7 and 10 in the Meeker municipal well field. To the west, the ground water becomes a sodium sulfate type. The well at site 41 (table 5 and pl. 2) yielded a calcium-magnesium sulfate type water. Magnesium, the co-dominant cation from the water in this well, was not dominant in any other sample and occurred elsewhere only in small concentrations except in one sample from the proposed Taylor Draw reservoir damsite. Water from the well at site 41 probably is affected by underflow from Fairfield Gulch (pl. 2), which originates in an area where rocks of the Mesaverde Group are exposed. Water in alluvium underlain by or composed of fragments of the Mesaverde Group typically is highly variable in chemical quality, probably because of the heterogeneous nature of the interbedded sandstones, shales, and coal layers of which the Mesaverde is composed.

The well at site 75 (table 5 and pl. 2) is located very close to the White River in Powell Park. Water type from this well is calcium bicarbonate. The well at site 89 (table 5 and pl. 2) yielded water of co-dominant cations and anions and may indicate an area of transition in water type. However, this well also is close to the White River and the sample collected for analysis may be indicative of a mixture of water originating in the surrounding hills and water from the river. West of this site, water from the alluvium is a sodium sulfate type, as evidenced by well water at sites 119 (the Angora site) and 138 (the Deserado coal-mine site). The dominant or co-dominant chloride anion at the Taylor Draw site probably is due to the effect of the underlying bedrock. Based on the samples collected, water in the White River alluvial aquifer can be classified as very hard throughout the study area (tables 4 and 5).

The suitability of ground water for various uses depends on the types and concentrations of chemical constituents the water contains. Water-quality standards for public-water supplies (Colorado Department of Health, 1977; U.S. Environmental Protection Agency, 1976a, 1976b, and 1977) and water-quality criteria for agricultural uses (Colorado Department of Health, 1978) are summarized in table 6. The standards for dissolved solids and sulfate are exceeded west of the confluence of the White River and Piceance Creek and at site 41. The standard for chloride is exceeded only in the samples affected by bedrock at the Taylor Draw site. The recommended limit for concentration of iron in public-water supplies is exceeded only at site 138, the Deserado coal-mine site. Boron concentration from site 119, the Angora site, is very near the limit for agricultural use. The complete chemical analyses for the aforementioned 13 samples of ground water are summarized in table 10 in the Supplemental Information section at the back of this report.

Dissolved-solids concentrations were compared with specific conductance values for those samples for which both measures exist, excluding the two samples affected by bedrock at the Taylor Draw dam site (fig. 7). From this relation, it is estimated that waters with specific-conductance values exceeding 745 µmho have concentrations of dissolved solids in excess of the recommended standard of 500 mg/L established by the U.S. Environmental Protection Agency (1977).

Table 5.--*Water type and hardness of ground-water samples*
[mg/L = milligrams per liter; $CaCO_3$ = calcium carbonate; Ca = calcium; HCO_3 = bicarbonate; Mg = magnesium; SO_4 = sulfate; Na = sodium; Cl = chloride]

Site number (plate 2)	Location within township, range, and section (see page 39)	Water type: Cation(s)	Water type: Anion(s)	Hardness (mg/L as $CaCO_3$)
[1]4	SC00109303BBB1	Ca	HCO_3	230
[1]5	SC00109303BBB2	Ca	HCO_3	260
[1]6	SC00109303BBB3	Ca	HCO_3	270
[1]7	SC00109303BBB4	Ca	HCO_3	210
10	SB00109333DCD1	Ca	HCO_3	300
41	SB00109428DBD1	Ca Mg	SO_4	1,400
75	SB00109526BCC1	Ca	HCO_3	290
89	SB00109531ACC1	Ca Na	HCO_3 SO_4	240
119	SB00210001ABB3	Na	SO_4	610
[2]138	SB00210111CAC1	Na	SO_4	700
Proposed Taylor Draw reservoir dam axis[3]	SB00210127D[4]	Na	SO_4 Cl	1,000
	SB00210127D[5]	Na	SO_4	180
	SB00210127D[6]	Na	Cl	160

[1]Data from Wright-McLaughlin Engineers, 1976; laboratory analyses by the Industrial Laboratories Co., Denver, Colo.

[2]Data from Ford, Bacon & Davis Utah, Inc., 1981; laboratory analyses by Ford Chemical Laboratory, Inc., Salt Lake City, Utah.

[3]Three separate samples were obtained from the site of the proposed Taylor Draw reservoir dam axis. A pit had been dug across the White River valley to bedrock to construct the dam foundation. The excavation was being dewatered by means of several wells and two sump pumps. The location of the excavation is at the site of cross-section I-I' (pls. 2 and 4).

[4]Sample collected from discharge pipe from three dewatering wells on upstream side of excavation and from sump pump at base of excavation, combined. Discharge was 150 gallons per minute. Quality of water may be affected by bedrock.

[5]Sample collected from water percolating into aforementioned sump from west side of excavation. Quality of water may reflect percolation from river channel.

[6]Sample collected from sump at east side of excavation. Water was coming from a hole in bedrock. Strong hydrogen-sulfide odor was noticed.

Table 6.--*Water-quality standards for public-water supplies and water-quality criteria for agricultural use*

[mg/L = milligrams per liter; µg/L = micrograms per liter]

Constituent	Standards for public-water supplies[1]	Criteria for agricultural use[2]	Some potential effects of using water with constituents in excess of standards or criteria[3]
pH (units)	6.5-8.5(R)	([4])	May increase toxicity of other constituents; corrosive.
Dissolved solids (mg/L)	500(R)	([5])	Unpleasant taste.
Chloride (mg/L)	250(R)	([4])	Unpleasant taste.
Fluoride (mg/L)	[6]1.8(M)	([4])	May cause dental fluorosis (mottling of teeth) especially in children.
Nitrite plus nitrate as nitrogen (mg/L)	[7]10(M)	100	May cause methemoglobinemia (blue-baby disease) in infants and young of warm-blooded animals.
Sulfate (mg/L)	250(R)	([4])	Temporary physiological (laxative) effect on people unaccustomed to drinking the water.
Iron (µg/L)	300(R)	([4])	Unpleasant taste; stains laundry and porcelain fixtures.
Boron (µg/L)	([8])	750	Toxic to sensitive plants.
Manganese (µg/L)	50(R)	200	Unpleasant taste; stains laundry and porcelain fixtures.

[1]R = recommended standard established by U.S. Environmental Protection Agency, 1977; M = Mandatory standard established by Colorado Department of Health, 1977; equivalent to mandatory standard established by U.S. Environmental Protection Agency, 1976b.

[2]Established by Colorado Department of Health, 1978; includes irrigation and stock watering.

[3]Adapted from U.S. Environmental Protection Agency, 1976a; 1976b.

[4]Numerical limit generally is not needed.

[5]Numerical limit may be required for certain cases; however, there are insufficient data for establishing a general criterion.

[6]Based on annual average of maximum daily air temperature. The range of fluoride concentration is from 1.4 mg/L at air temperatures ranging from 26.3°C to 32.5°C, to a fluoride concentration of 2.4 mg/L at an air temperature of 12.0°C and below.

[7]Standard and criteria are for nitrate only; however, because excessive concentrations of nitrite cause the same health problems, concentrations of nitrite plus nitrate are reported by the U.S. Geological Survey.

[8]No standard.

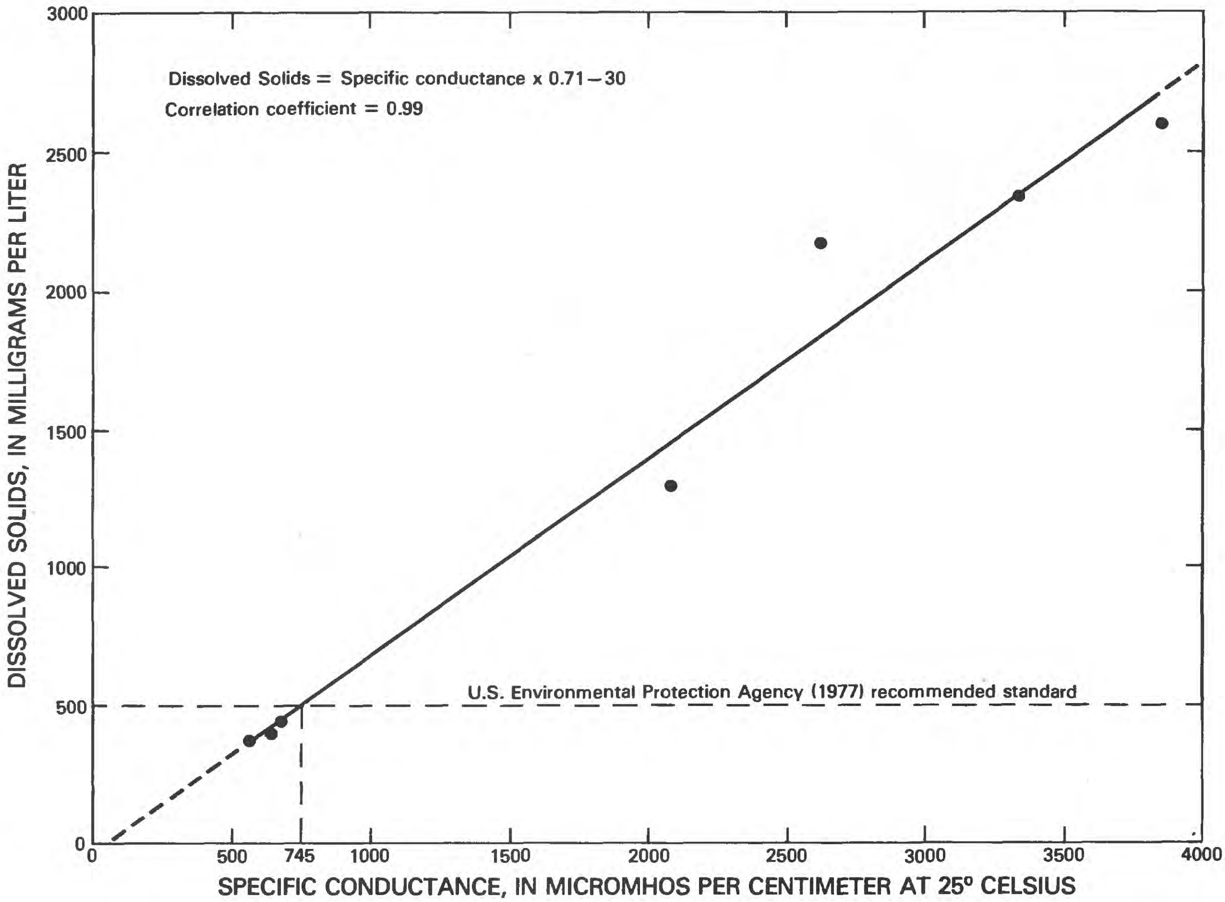


Figure 7.--Relation of dissolved solids to specific conductance in ground water.

Specific conductance of water from 112 wells and test holes completed in the White River alluvial aquifer is shown on plate 5 (in the pocket at the back of this report). Values ranged from 400 to 14,000 µmho; maximum, minimum, and mean values for each of several segments of the alluvial aquifer are summarized in figure 8. The smallest specific-conductance values were measured at the eastern end of the study area, in Agency Park, and the largest values were measured at the western end of the study area, near Rangely. Specific conductance of water from wells close to the White River generally was less than that from wells further from the river. Waters with specific conductance indicative of dissolved-solids concentrations within the U.S. Environmental Protection Agency's recommended limit were found throughout the study area except in the reach from Taylor Draw through Rangely (fig. 8). Dissolved-solids concentrations in the White River in the study area range from about 200 to 400 mg/L (Boyle and others, 1984). Therefore, it appears that properly placed wells in the alluvial aquifer can draw in river water with a smaller dissolved-solids concentration even in segments in which the average specific conductance of well waters sampled is indicative of dissolved-solids concentrations much greater than the recommended limit.

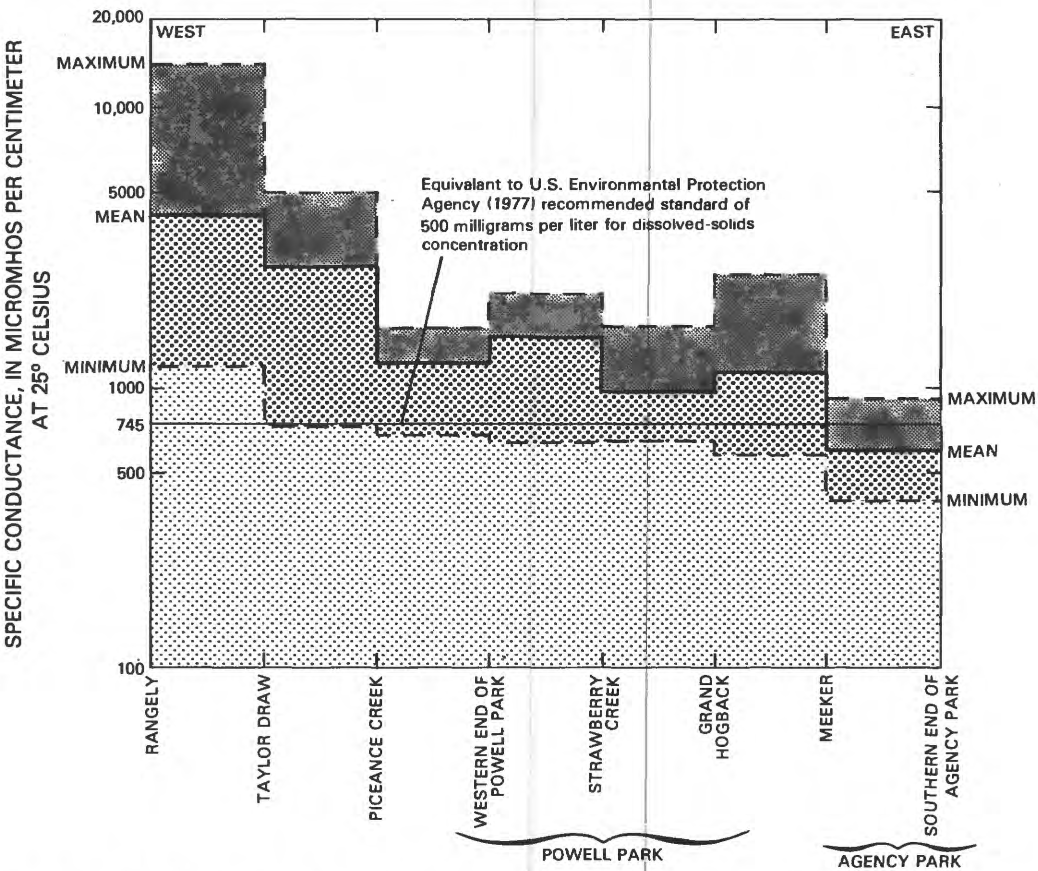


Figure 8.--Maximum, minimum, and mean values of specific conductance for water in each of several aquifer segments.

Average specific conductance of water from wells sampled that are completed in the alluvial aquifer in Agency Park was 600 µmho, indicative of a dissolved-solids concentration of about 400 mg/L, which is within the recommended limit for public-water supplies. However, wells that completely penetrate the alluvial deposits and also penetrate the underlying Mancos Shale yield water with larger specific-conductance values. For example, the well at site 31 (pl. 5 and table 7) just east of Meeker, penetrates 3 ft into the Mancos Shale. Water from this well had a specific conductance of 1,200 µmho.

The specific conductance of ground water from sites 16, 17, and 18 in the eastern part of Agency Park near Little Beaver Creek exceeded 1,000 µmho at each site (pl. 5 and table 7). Logs of materials penetrated during drilling of these wells are not available. Therefore, it is not known whether the source of water to these wells is from the alluvium, or if it is a mixture of water from the alluvium and water from a deeper bedrock source.

Ground water suitable for use as a public-water supply also exists in gravel deposits on the mesa south and west of the main valley of Agency Park, as evidenced by well water at site 33 (pl. 5 and table 7) which had a specific conductance of 700 µmho. These terrace gravels probably are replenished with water by seepage from irrigation ditches that cross the mesa. The availability, quality, and seasonal variability of the water contained in these terrace deposits were not investigated during this study.

Saline seepage from deep wells on the Meeker dome may have degraded water quality at depth in the alluvium nearby. However, the well at site 28, at the edge of the dome but south of the White River, which is 5 ft deep, yielded water with a specific conductance of 440 μmho. About 0.5 mi west, near the southwest edge of the dome, water from site 29, a 20-ft deep domestic well, had a specific conductance of 925 μmho. Therefore, the effect of saline seepage from deep wells on the Meeker dome probably is limited to the immediate vicinity of the dome.

Little is known about water quality in the alluvial aquifer near Meeker because town residents get their water from the municipal wells located 5 mi to the southeast rather than from local wells. West of Meeker, the White River flows over the Mesaverde Group at the Grand Hogback. Wells that penetrate the alluvium overlying the Mesaverde Group yield water of highly variable quality. Wells sampled on the valley flat relatively near the river yielded water with specific conductance ranging from 580 to 800 μmho. However, wells located on alluvial fans emanating from rocks of the Mesaverde Group can yield very mineralized water. For example, well water from site 41 (pl. 5 and table 7) had a specific conductance of 2,580 μmho.

The specific conductance of water samples from the alluvial aquifer in Powell Park ranged from 640 to 2,200 μmho. The water was less mineralized in the eastern part of Powell Park and became more mineralized in the vicinity of and west of the confluence of the White River and Strawberry Creek (pl. 5 and table 7). Again, wells near the White River yielded water with relatively small values of specific conductance, as evidenced by the well at site 75 (pl. 5 and table 7), which yielded water with specific conductance of 640 μmho.

Specific-conductance data are sparse between Powell Park and the confluence of the White River and Piceance Creek, where the valley is underlain by the Green River Formation. Specific conductance of well water sampled ranged from 680 μmho from the well at site 89 (pl. 5 and table 7), which is about 50 ft from the White River, to 1,650 μmho from each of two wells farther from the river.

West of the confluence of the White River and Piceance Creek, the valley is again underlain by rocks of the Wasatch Formation and the Mesaverde Group. Specific conductance of well water sampled ranged from 730 to 5,000 μmho, which demonstrates that water suitable for use as a public-water supply can still be obtained from wells close to the river, but that the overall mineralization of ground water in this area has increased significantly. Average specific conductance for this segment of valley was 2,730 μmho, which is more than double the average specific conductance to the east (fig. 8).

Water quality degrades appreciably immediately west of Taylor Draw, where the White River valley again is underlain by Mancos Shale. Specific conductance of well water sampled ranged from 1,200 to 14,000 μmho. Average specific conductance for this segment of valley was 4,150 μmho.

West of Piceance Creek, excessive salinity (as evidenced by large specific-conductance values) and large sodium adsorption ratios (table 10 and fig. 9) make the ground water undesirable for irrigation purposes. The sodium adsorption ratio (SAR) is a measure of the ratio of sodium ions to total cations (Hem, 1970). When both the SAR and the salinity of the water are relatively large, the water, if used for irrigation, may cause the soil to become hard and less permeable. Well water from sites 119 and 138 and from the least saline water from the Taylor Draw site have a high sodium (alkali) hazard and a high to very high salinity hazard (fig. 9). These waters also exceed the standard for sulfate concentration in drinking water, which can cause a temporary laxative effect on people unaccustomed to drinking the water.

NEED FOR ADDITIONAL STUDIES

The results of this investigation are of a reconnaissance level and are based mostly on data from existing wells and test holes. Additional studies are needed to describe the hydrology of the White River alluvial aquifer more thoroughly. The extent of the aquifer needs to be more well-defined, especially the depth to bedrock. The variability in transmissivity and storage characteristics of the alluvial aquifer and the yields of wells that penetrate it also need to be more accurately evaluated.

Agency Park has the greatest potential as a ground-water reservoir of any segment in the study area; therefore, it is a first priority for additional study. The depth to bedrock in the main valley of the park needs to be more well-defined by test-hole drilling. This would supplement surface geophysical surveys already completed and would confirm or disprove preliminary indications that a buried channel exists that may be filled with saturated alluvium nearly 300 ft thick.

East of and adjacent to Agency Park, in the drainages of Little Beaver and Coal Creeks, is an area about which little is known that may be a significant ground-water reservoir. The mesa south and west of the main valley of Agency Park is known to contain water of suitable quality for most uses. The areal extent, saturated thickness, and hydraulic characteristics of these two areas need to be determined, so that their storage and water-supply potential can be evaluated.

Preliminary data indicate that the alluvial aquifer in the western end of Powell Park is more than 100 ft thick. Test-hole drilling and subsequent aquifer testing would enable the water-supply potential of this area to be assessed.

In addition, vast quantities of water low in suspended and dissolved solids and free of bacteriological contamination probably exist in the White River alluvial aquifer east of the present study area, especially near the town of Buford, in Stillwater valley along the South Fork White River, and near the "potholes" along the North Fork White River (fig. 1). These areas need further investigation.

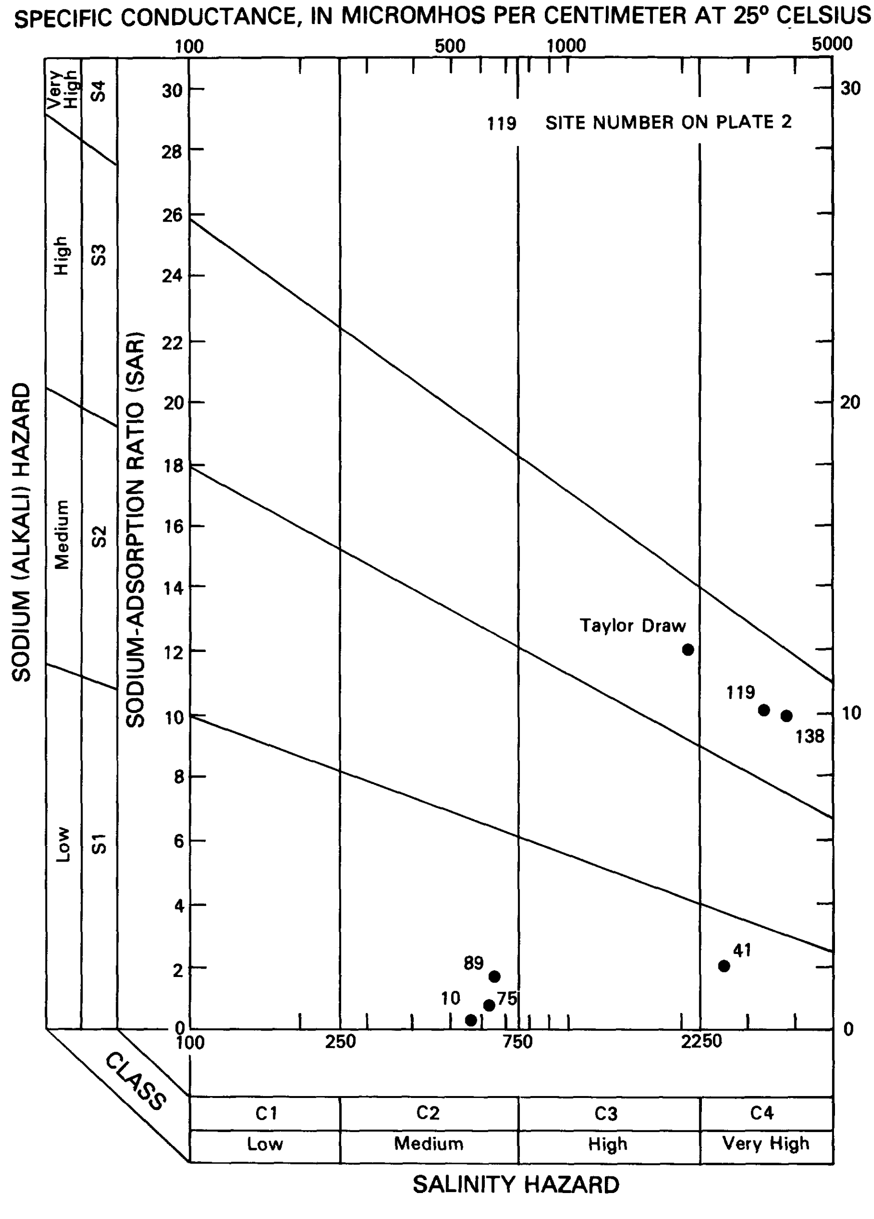


Figure 9.--Salinity hazard and sodium hazard for ground water if used for irrigation. (Modified from U.S. Salinity Laboratory Staff, 1954.)

SUMMARY AND CONCLUSIONS

The White River alluvial aquifer in the study area ranges in width from 0.1 mi at each of several locations in the western part of the study area to about 1.5 mi in Agency Park and Powell Park; average width is about 0.5 mi. In general, the aquifer is wide where underlain by the Mancos Shale or the Wasatch Formation and narrow where underlain by the Mesaverde Group or the Green River Formation. Saturated thickness ranges from zero along the valley sides at each of several locations to more than 140 ft in Agency Park; average saturated thickness is about 22 ft. Test-hole data at the Meeker municipal well field in Agency Park established a local saturated thickness of at least 114 ft. Vertical electrical-resistivity soundings indicate that the alluvial thickness exceeds this value nearby, and perhaps is 295 ft in one area. The area east of and adjacent to Agency Park, in the drainage areas of Little Beaver and Coal Creeks, may be underlain by 80 ft of White River alluvium in places; however, useful data are scarce and the limit of the White River alluvial aquifer is uncertain in this area. Preliminary test-hole data indicate that saturated thickness is greater than 90 ft in the western part of Powell Park. Near Rangely, the aquifer is about 1 mi wide, but saturated thickness averages only 14 ft.

Alluvium in the White River valley consists of fragments of rocks originating on the White River uplift, transported downstream by the White River; and of material from nearby sources to the north and south, transported into the valley via tributaries, draws, and gullies. In the eastern part of the study area, the alluvium consists predominantly of coarse-grained sand and gravel with alternating thin layers of fine-grained material such as clay, silt and sand. In the western part of the study area, the alluvium consists of clay, silt, and fine-grained sand from land surface to several feet in depth, underlain by coarse sand and gravel containing interstitial fine-grained sediments. West of the Grand Hogback monocline, the fine-grained alluvium overlying the sand and gravel aquifer forms a semi-confining layer that causes the aquifer to be under artesian conditions in many places. Wells drilled through this dry to very moist fine-grained layer encountered water in the underlying saturated sand and gravel aquifer, which rose under artesian pressure up into the fine-grained layer. The interstitial fine-grained alluvium present in the western part of the study area clogs the openings between grains of the sand and gravel deposits and reduces their ability to transmit water.

Yields of existing domestic and stock wells in the study area usually are less than 25 gal/min. Most of these wells are completed in a relatively inexpensive and inefficient manner so that the well inhibits the maximum yield obtainable more than the transmissive properties of the aquifer do. Relatively efficient and expensive wells, completed with stainless-steel, wire-wrapped screens designed specifically for the well and aquifer material at the site, produce water from the White River alluvial aquifer at the Meeker municipal well field in Agency Park and at the Deserado coal-mine site about 7 mi northeast of Rangely. The municipal wells in Agency Park reportedly could yield more than 1,000 gal/min each. At the Deserado coal-mine site, the wells were designed for a long-term yield of 130 to 145 gal/min each.

From the information collected and with consideration of the effects of variations in well construction, approximate potential well yields in the study area can be estimated. Southeast of Meeker, in Agency Park, where the saturated thickness exceeds 100 ft, efficiently constructed, screened wells that fully penetrate the aquifer can be expected to yield on the order of 1,000 gal/min for sustained periods of time. Shallower wells can be expected to yield from 100 to several hundred gal/min. West of Meeker, where the average saturated thickness of the aquifer is 15 to 20 ft, efficiently constructed, screened wells can be expected to yield on the order of 100 gal/min for sustained periods of time. Relatively inexpensively constructed wells can be expected to yield 50 to 100 gal/min for a few minutes and 25 gal/min or less for sustained periods of time.

Transmissivity of the White River alluvial aquifer in the areas tested ranges from about 860 to about 93,000 ft^2/d. Hydraulic conductivity of the aquifer in the areas tested ranges from about 70 to about 1,550 ft/d. Transmissivity and hydraulic conductivity values indicated by aquifer testing in Agency Park are much greater than values obtained from tests conducted elsewhere in the study area.

In general, hydraulic conductivity decreases to the west as the valley slope lessens and the low-energy environment of deposition results in more fine-grained sediments being deposited. Transmissivity is greatest where the saturated thickness of the alluvium is large and in the eastern part of the study area and least where the saturated thickness of the alluvium is small and in the western part of the study area. Transmissivity values are expected to be relatively large in the western part of Powell Park, where the saturated thickness of the alluvium is greater than 90 ft.

The estimated total volume of water in storage in the White River alluvial aquifer in the study area, based on the areal extent, saturated thickness, and an assumed average specific yield of 0.2, is 103,000 acre-ft. Southeast of Meeker, about 40,000 acre-ft of water are in storage in the alluvial aquifer.

Based on 13 samples, ground water in the eastern part of the study area is a calcium bicarbonate type; to the west, the ground water is a sodium sulfate type. Water in the aquifer is classified as very hard throughout the study area. Water-quality standards for public-water supplies for dissolved solids and sulfate are exceeded west of the confluence of the White River and Piceance Creek and in one well located on an alluvial fan emanating from rocks of the Mesaverde Group at the Grand Hogback. The recommended limit for concentration of iron in public-water supplies is exceeded at the Deserado coal-mine site. Dissolved-solids concentrations were compared with specific-conductance values for those samples for which both measures exist; waters with specific conductance exceeding 745 µmho have dissolved-solids concentrations in excess of the recommended standard of 500 mg/L. Specific conductance from 115 samples of water from the White River alluvial aquifer ranges from 400 to 14,000 µmho. Smallest values were measured at the eastern end of the study area in Agency Park and largest values were measured at the western end of the study area near Rangely. Average specific conductance of ground waters sampled west of the confluence of the White River with Piceance Creek is more than twice the average value obtained east of that confluence. The specific conductance of water from wells close to the White River is less than that from wells farther from the river; well water with specific conductance indicative of dissolved-solids concentrations within the recommended limit occurs as far west as the area from Piceance Creek to Taylor Draw. In the western part of the study area, large sodium-adsorption ratios and large dissolved-solids concentrations in the ground water combine to make the water unfit for irrigation purposes.

The results of this investigation are preliminary and are based mostly on data from existing wells and test holes. The variability in depth to bedrock and hydraulic properties of the aquifer need to be more accurately evaluated, especially southeast of Meeker and in the western part of Powell Park.

SELECTED REFERENCES

Alley, W. M., Britton, L. J., and Boyd, E. L., 1978, Reconnaissance evaluation of water resources for hydraulic coal mining, Grand Hogback coal field, Garfield and Rio Blanco Counties, Colorado: U.S. Geological Survey Open-File Report 78-885, 66 p.

Anonymous, 1975, Ground water and wells: St. Paul, Minn., Johnson Division, UOP Inc., 440 p.

Barnum, B. E., and Garrigues, R. S., 1980, Geologic map and coal sections of the Cactus Reservoir quadrangle, Rio Blanco and Moffat Counties, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-1179, scale 1:24,000, 2 sheets.

Bates, R. L., and Jackson, J. A., eds., 1980, Glossary of geology (2nd ed.): Falls Church, Va., American Geological Institute, 749 p.

Boettcher, A. J., 1972, Ground-water occurrence in northern and central parts of western Colorado: Colorado Water Conservation Board Water-Resources Circular 15, 25 p.

Boyle, J. M., Covay, K. J., and Bauer, D. P., 1984, Quantity and quality of streamflow in the White River basin, Colorado and Utah: U.S. Geological Survey Water-Resources Investigations Report 84-4022, 84 p.

Carrara, P. E., 1980, Surficial geologic map of the Vernal 1°x 2° quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Investigations Map I-1204, scale 1:250,000, 1 sheet.

CH2M Hill Central, Inc., 1979, Problem identification and quantification, Meeker Dome salinity investigation: Denver, Colo., U.S. Bureau of Reclamation, 202 p.

_____1981, Final report--problem verification program, Meeker Dome salinity investigation: Denver, Colo., U.S. Bureau of Reclamation, 341 p.

Colorado Department of Health, 1977, Primary drinking water regulations for the State of Colorado: Denver, Water Quality Control Division, 60 p.

_____1978, Water quality standards for Colorado: Denver, Water Quality Control Division, 47 p.

Colorado Water Conservation Board, 1966, Water and related land resources White River basin in Colorado: Denver, Colo., 92 p.

Cooper, H. H., Jr., and Jacob, C. E., 1946, A generalized graphical method for evaluating formation constants and summarizing well-field history: Transactions of the American Geophysical Union, v. 27, no. 4, p. 526-534.

Cullins, H. L., 1971, Geologic map of the Rangely quadrangle, Rio Blanco County, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ-903, scale 1:24,000, 1 sheet.

Dobrin, M. B., 1976, Introduction to geophysical prospecting (3rd ed.): New York, McGraw-Hill Book Co., Inc., 630 p.

Durfor, C. N., and Becker, Edith, 1964, Public water supplies of the 100 largest cities in the United States, 1962: U.S. Geological Survey Water-Supply Paper 1812, 364 p.

Ferris, J. G., Knowles, D. B., Brown, R. H., and Stallman, R. W., 1962, Theory of aquifer tests: U.S. Geological Survey Water-Supply Paper 1536-E, 174 p.

Ford, Bacon and Davis Utah, Inc., 1981, Feasibility of obtaining a groundwater supply from the White River alluvium for use at the Deserado Mine, Rio Blanco County, Colorado: Lakewood, Colo., Western Fuels Association, Inc., 77 p.

Freeze, R. A., and Cherry, J. A., 1979, Groundwater: Englewood Cliffs, N.J., Prentice-Hall, Inc., 604 p.

Gale, H. S., 1908, Geology of the Rangely oil district, Rio Blanco County, Colorado, with a section on the water supply: U.S. Geological Survey Bulletin 350, 61 p.

Gesink, M. L., 1983, Preliminary hydrogeologic investigations of the White River alluvial aquifer, Rio Blanco County, Colorado: Golden, Colo., Colorado School of Mines, unpublished Master's thesis, 212 p.

Giles, T. F., and Brogden, R. E., 1978, Selected hydrologic data, Yampa River basin and parts of the White River basin, northwestern Colorado and south-central Wyoming: U.S. Geological Survey Open-File Report 78-23, 106 p.

Hail, W. J. Jr., 1972, Preliminary geologic map of the Barcus Creek SE quadrangle, Rio Blanco County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-347, scale 1:24,000, 2 sheets.

_____1973, Geologic map of the Smizer Gulch quadrangle, Rio Blanco and Moffat Counties, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ-1131, scale 1:24,000, 1 sheet.

_____1974, Geologic map of the Rough Gulch quadrangle, Rio Blanco and Moffat Counties, Colorado: U.S. Geological Survey Geologic Quadrangle Map GQ-1195, scale 1:24,000, 1 sheet.

Hancock, E. T., and Eby, J. B., 1930, Geology and coal resources of the Meeker quadrangle, Moffat and Rio Blanco Counties, Colorado: U.S. Geological Survey Bulletin 812, p. 191-242.

Hantush, M. S., 1960, Modification of the theory of leaky aquifers: Journal of Geophysical Research, v. 65, no. 11, p. 3713-3725.

Hem, J. D., 1970, Study and interpretation of the chemical characteristics of natural water (2nd ed.): U.S. Geological Survey Water-Supply Paper 1473, 363 p.

Lincoln-DeVore Testing Laboratory, Inc., 1975, Subsurface soils investigations for proposed addition to wastewater disposal plant, Meeker, Colorado: Meeker, Colo., Town of Meeker, 28 p.

_____1980, Subsurface soils investigation, Meeker wastewater plant improvements, Meeker, Colorado: Meeker, Colo., Town of Meeker, 23 p.

Lohman, S. W., 1972, Ground-water hydraulics: U.S. Geological Survey Professional Paper 708, 70 p.

Lohman, S. W., and others, 1972, Definitions of selected ground-water terms--Revisions and conceptual refinements: U.S. Geological Survey Water-Supply Paper 1988, 21 p.

Murray, F. N., 1962, The geology of the Grand Hogback monocline near Meeker, Colorado: Boulder, Colo., University of Colorado, Unpublished Master's thesis, 114 p.

Nelson, Haley, Patterson, and Quirk, Inc., 1976, Meeker Dome project--hydrogeologic literature review: Salt Lake City, Utah, U.S. Bureau of Reclamation, v. 1, 60 p.; v. 2, 77 p.; v. 3, 129 p.; v. 4, 111 p.

Piper, A. M., Garrett, A. A., and others, 1953, Native and contaminated ground waters in the Long Beach-Santa Ana area, California: U.S. Geological Survey Water-Supply Paper 1136, 320 p.

Pipiringos, G. N., and Johnson, R. C., 1975, Preliminary geologic map of the Buckskin Point quadrangle, Rio Blanco County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-651, scale 1:24,000, 1 sheet.

_____1976, Preliminary geologic map and correlation diagram of the White River City quadrangle, Rio Blanco County, Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF-736, scale 1:24,000, 1 sheet.

Price, Don, and Arnow, Ted, 1974, Summary appraisals of the nation's ground-water resources; upper Colorado region: U.S. Geological Survey Professional Paper 813-C, 40 p.

Rowley, P. D., Tweto, Ogden, Hansen, W. R., and Carrara, P. E., 1979, Geologic map of the Vernal 1° x 2° quadrangle, Colorado, Utah, and Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF-1163, scale 1:250,000, 1 sheet.

Theis, C. V., 1935, The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground-water storage: Transactions of the American Geophysical Union, v. 16, p. 519-524.

Tweto, Ogden, 1976, Geologic map of the Craig 1° x 2° quadrangle, northwestern Colorado: U.S. Geological Survey Miscellaneous Investigations Map I-972, scale 1:250,000, 1 sheet.

Tweto, Ogden, compiler, 1979, Geologic map of Colorado: U.S. Geological Survey, scale 1:500,000, 1 sheet.

Tweto, Ogden, Moench, R. H., and Reed, J. C., Jr., 1978, Geologic map of the Leadville 1° x 2° quadrangle, northwestern Colorado: U.S. Geological Survey Miscellaneous Investigations Map I-999, scale 1:250,000, 1 sheet.

U.S. Bureau of Reclamation, 1974, Earth manual (2nd ed.): Washington, D.C., 810 p.

U.S. Environmental Protection Agency, 1976a (1977), Quality criteria for water: Washington, D.C., U.S. Government Printing Office, 256 p.

_____1976b [1977], National interim primary drinking water regulations: U.S. Environmental Protection Agency, Office of Water Supply, EPA-570/9-76-003, 159 p.

_____1977, National secondary drinking water regulations: Federal Register, v. 42, no. 62, Thursday, March 31, 1977, Part 1, p. 17143-17147.

U.S. Geological Survey, 1983, Water resources data, Colorado, water year 1982, v. 3: U.S. Geological Survey Water-Data Report CO-82-3, 366 p.

U.S. Salinity Laboratory Staff, 1954, Diagnosis and improvement of saline and alkali soils: U.S. Department of Agriculture Handbook 60, 160 p.

Vaughn Hansen Associates, 1979, Hydrologic inventory of the Moon Lake coal lease and adjacent areas, Rio Blanco County, Colorado: Lakewood, Colo., Western Fuels Association, Inc., 346 p.

Walton, W. C., 1970, Groundwater resource evaluation: New York, McGraw-Hill, Inc., 664 p.

Western Engineers, Inc., 1978, Preliminary geologic map--Wolf Creek, Rangely Project: Glenwood Springs, Colo., Colorado River Water Conservation District, scale 1:1,200, 1 sheet.

_____1980, Geologic report for the Taylor Draw Dam and Reservoir: Grand Junction, Colo., 145 p.

Woodward-Clevenger and Associates, Inc., 1972, Engineering and geologic investigations for Rangely Dam foundations, Rio Blanco County, Colorado: Glenwood Springs, Colo., Colorado River Water Conservation District, 37 p.

Wright-McLaughlin Engineers, 1974, White River alluvial aquifer preliminary hydrogeologic report: Meeker, Colo., Town of Meeker, 58 p.

_____1975, Groundwater development municipal well B-1: Meeker, Colo., Town of Meeker, 40 p.

_____1976, Meeker municipal well field White River alluvial aquifer completion report: Meeker, Colo., Town of Meeker, 62 p.

Zohdy, A. A. R., 1973, A computer program for the automatic interpretation of Schlumberger sounding curves over horizontally stratified media: U.S. Geological Survey Report USGS-GD-74-017, PB-232703, available only from U.S. Department of Commerce, National Technical Information Service, 25 p.

_____1974, A computer program for the calculation of Schlumberger sounding curves by convolution: U.S. Geological Survey Report USGS-GD-74-010, PB-232056, available only from U.S. Department of Commerce, National Technical Information Service, 11 p.

_____1975, Automatic interpretation of Schlumberger sounding curves using modified Dar-Zarrouk functions: U.S. Geological Survey Bulletin 1313-E, 39 p.

Zohdy, A. A. R., Eaton, G. P., and Mabey, D. R., 1974, Application of surface geophysics to ground-water investigations: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 2, Chapter D1, 116 p.

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SUPPLEMENTAL INFORMATION

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System of Locating and Numbering Data-Collection Sites

The U.S. Bureau of Land Management's system of land subdivision is used to locate and number data-collection sites (fig. 10). The first character is an S, which indicates that the site is located in the area covered by the Sixth principal meridian. The next letter denotes the quadrant formed by the intersection of the base line (parallel) with the principal meridian. The quadrants are designated A, B, C, or D in a counterclockwise manner with the northeast quadrant being A. The first three numbers designate the township, the next three designate the range, and the last two designate the section. Each section is then divided into quarters designated A, B, C, or D in a counterclockwise rotation, with the northeast quarter being A. This is done again for the quarter-quarter section and the quarter-quarter-quarter section. The three letters following the number designation of township, range, and section indicate the data-collection site position first in the quarter section, then in the quarter-quarter section, and then in the quarter-quarter-quarter section. The final number is the order in which the site in the designated quarter-quarter-quarter section was inventoried. A site numbered SB00408616CBA1 would be the first one located in the NE¼NW¼SW¼ sec. 16, T. 4 N., R. 86 W.

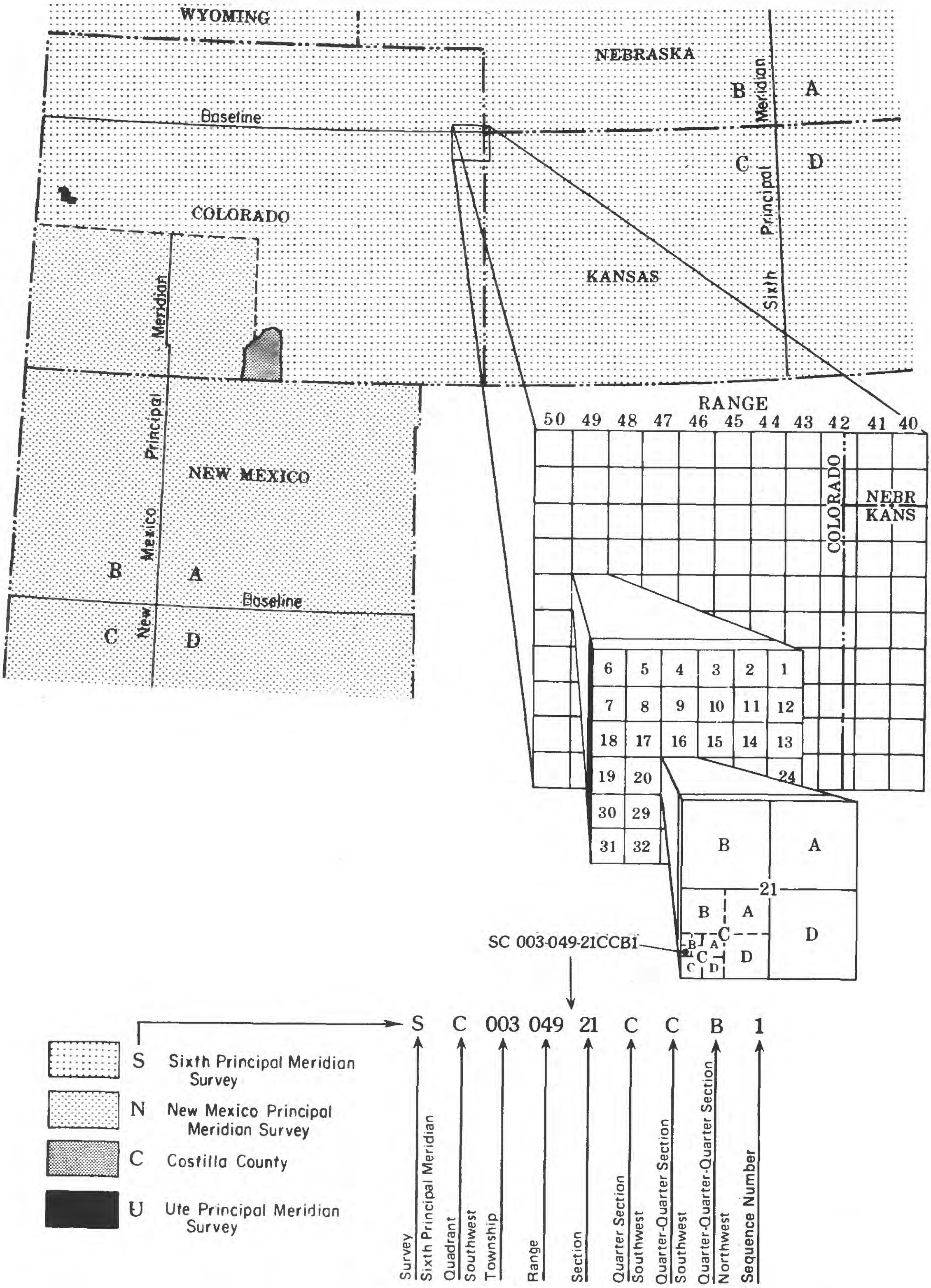

Figure 10.--System of locating and numbering data-collection sites using township, range, and section.

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Inventory Data From Wells and Test Holes

Table 7.--*Inventory data from wells and test holes*

[ft = feet; µmho = micromhos per centimeter at 25° Celsius; °C = degrees Celsius; --- = no data]

Site number[1]	Location within township, range, and section[2]	Altitude of land surface[3] (ft)	Depth of hole (ft)	Date construction completed[4]	Depth to water (ft)	Date of measurement[5]	Depth to bedrock[6] (ft)	Specific conductance (µmho)	Temperature (°C)	Date sample obtained	Owner[7]	Remarks[8]
1	SC00109310CAB1	6,510	45	1949	35	Aug. 1981	---	400	14	Aug. 1981	Isabel	
2	SC00109310BBB	6,470	30	1882	8	Aug. 1981	---	500	13	Aug. 1981	Isaac	
3	SC00109304DAB1	6,470	35	1955	---	---	---	420	12.5	Aug. 1981	Bachmann	
4	SC00109303BBB1	6,405	123	June 1974	7	June 1974	121	---	---	---	Town of Meeker	Municipal water-supply well B-1.
5	SC00109303BBB2	6,405	55	Jan. 1976	6	Jan. 1976	---	---	---	---	Town of Meeker	Municipal water-supply well B-2.
6	SC00109303BBB3	6,405	56	Jan. 1976	6	Jan. 1976	---	---	---	---	Town of Meeker	Municipal water-supply well B-3.
7	SC00109303BBB4	6,405	55	Jan. 1976	6	Feb. 1976	---	---	---	---	Town of Meeker	Municipal water-supply well B-4.
8	SC00109303BAA1	6,422	40	1965	11	Aug. 1981	40	610	15	Aug. 1981	Seely	
9	SC00109303ABA1	6,450	45	---	---	---	45	---	---	---	Seely	
10	SB00109333DCD1	6,403	56	Aug. 1982	2	Sept. 1982	---	564	9	Sept. 1982	Town of Meeker	Municipal water-supply well B-5.
11	SB00109334CAB1	6,435	80	Apr. 1982	---	---	60	---	---	---	Berthelson	
12	SB00109334CAA1	6,430	25	1918	9	Aug. 1981	---	560	14	Aug. 1981	Berthelson	
13	SB00109334CAA2	6,460	72	Oct. 1980	---	---	60	---	---	---	Berthelson	
14	SB00109333AA	6,395	23	May 1962	12	May 1962	>23	---	---	---	NT Cattle Company	
15	SB00109334BBC1	6,400	11	1953?	7	Aug. 1981	---	565	10	Aug. 1981	Atherton	
16	SB00109327ABD1	6,415	36	prior to 1960	-4	July 1982	---	1,200	11	Aug. 1981	Berthelson	Aquifer(s) penetrated unknown.
17	SB00109327ABC2	6,410	---	1972	flowing	1972	---	1,010	12.5	July 1982	Dodo	Aquifer(s) penetrated unknown.
18	SB00109327ABC1	6,410	58	prior to 1927	flowing	July 1982	---	1,190	10	July 1982	Dodo	Aquifer(s) penetrated unknown.
19	SB00109327BBD	6,405	100	June 1973	40	June 1973	80	---	---	---	Strang	Driller reported depth to water.
20	SB00109321DCC1	6,380	80	June 1973	45	June 1973	≥80	---	---	---	Strang	Driller reported depth to water.
21	SB00109321DCB	6,370	40	Aug. 1979	---	---	30	---	---	---	Strang	Data from CH2M Hill Central, 1979, TH-3.
22	SB00109321DBD	6,375	40	Aug. 1979	---	---	28	---	---	---	Strang	Data from CH2M Hill Central, 1979, TH-4.
23	SB00109328BCB1	6,355	12	1964	4	July 1979	---	680	9.5	June 1981	Nelson	
24	SB00109328BCC1	6,355	14	1935	7	July 1979	---	830	9.5	July 1979	Nelson	
25	SB00109329AAB	6,350	50	Aug. 1979	---	---	44	---	---	---	Prather	Data from CH2M Hill Central, 1979, TH-2.
26	SB00109320DDD	6,382	44	Sept. 1973	---	---	>44	---	---	---	Prather	USGS Prather #2.

Table 7.--*Inventory data from wells and test holes*

Site number[1]	Location within township, range, and section[2]	Altitude of land surface[3] (ft)	Depth of hole (ft)	Date construction completed[4]	Depth to water (ft)	Date of measurement[5]	Depth to bedrock[6] (ft)	Specific conductance (µmho)	Temperature (°C)	Date sample obtained	Owner[7]	Remarks[8]
27	SB00109320DDA	6,382	148	Sept. 1973	56	Sept. 1973	50	---	---	---	Prather	No alluvium. Water in bedrock. USGS Prather #1.
28	SB00109330AAB1	6,300	5	1963	3	Aug. 1981	---	440	15	July 1979	Russell	
29	SB00109319CDB1	6,285	20	1976	8	Aug. 1981	---	925	14	Aug. 1981	Pollard	
30	SB00109424CDA	6,255	7	Sept. 1960	7	Sept. 1960	---	---	---	---	Bates	
31	SB00109423DCA1	6,235	21	Apr. 1969	---	---	18	1,200	18.5	June 1980	WR Vet Clinic	
32	SB00109423DBC	6,239	31	Dec. 1960	---	---	27	---	---	---	Gentry	
33	SB00109426ADD1	6,390	25	June 1964	6	Dec. 1978	17	700	9	Dec. 1978	Vandiber	Penetrates terrace gravel and bedrock (Mancos Shale).
34	SB00109425DB	6,402	27	June 1968	dry	June 1968	25	---	---	---	Meeks	Penetrates terrace gravel and bedrock (Mancos Shale).
35	SB00109427DDC1	6,330	50	June 1978	12	June 1978	31	600	12	June 1980	Sikes	Penetrates terrace gravel and bedrock (Mancos Shale).
36	SB00109422DDD	6,210	12	Aug. 1977	3	Aug. 1977	>12	---	---	---	Nicholson	
37	SB00109422DD	6,215	20	Oct. 1976	9	Oct. 1976	>20	---	---	---	Marsh	
38	SB00109427AAB	6,205	7	May 1952	4	May 1952	6	---	---	---	State of Colorado	Division of Highways, 1952, structure D-5-N.
39	SB00109422DCD	6,200	30	---	3	---	25	---	---	---	Town of Meeker	Drilled by Lincoln-DeVore (1975) as test holes 1-4.
40	SB00109428DAC	6,180	46	Sept. 1981	18	Sept. 1981	>46	---	---	---	Schultz	
41	SB00109428DBD1	6,200	55	1964	18	June 1981	>55	2,580	11	June 1981	Schultz	Water level affected by intermittent flow from tributary.
42	SB00109433ABA1	6,175	250	June 1958	8	July 1979	---	975	12	July 1979	Dorrell	
43	SB00109428CAD	6,190	35	June 1981	---	---	30	---	---	---	Hilkey	
44	SB00109428CDB1	6,165	30	1879	15	Aug. 1979	---	860	13	Aug. 1981	Hilkey	
45	SB00109429DDB1	6,145	16	1959	8	Aug. 1979	---	800	---	Aug. 1981	Copeland	
46	SB00109429DDC2	6,140	25	---	---	---	---	580	11	July 1975	Limpus	
47	SB00109429DDC1	6,135	7	1959	4	Aug. 1979	---	790	---	Aug. 1981	Copeland	
48	SB00109429DCB1	6,155	50	May 1983	---	---	47	1,390	---	May 1983	Brown	
49	SB00109429DBC1	6,170	80	1962	41	July 1979	---	1,600	11	July 1981	Purkey	
50	SB00109429CDD	6,125	20	1936	---	---	14	---	---	---	State of Colorado	Division of Highways, 1936, structure D-5-I.
51	SB00109429CAD1	6,165	60	May 1983	>37	May 1983	56	---	---	---	Brown	
52	SB00109429CAC1	6,170	300	June 1983	---	---	65	---	---	---	Brown	
53	SB00109429CAB	6,190	112	1963	65	1963	68	---	---	---	Purkey	
54	SB00109429CDB1	6,138	30	---	17	Aug. 1979	---	750	14	July 1981	Watson	
55	SB00109430DAC1	6,110	17	---	6	Aug. 1979	---	850	12	July 1981	Woodward	

Table 7.--*Inventory data from wells and test holes*

Site number[1]	Location within township, range, and section[2]	Altitude of land surface[3] (ft)	Depth of hole (ft)	Date construction completed[4]	Depth to water (ft)	Date of measurement[5]	Depth to bedrock[6] (ft)	Specific conductance (µmho)	Temperature (°C)	Date sample obtained	Owner[7]	Remarks[8]
56	SB00109430DDA1	6,120	58	---	9	July 1981	---	950	11	July 1981	Woodward	
57	SB00109429CC	6,120	115	Aug. 1963	---	---	23	---	---	---	Purkey	
58	SB00109432BAC1	6,130	60	Jan. 1966	---	---	18	---	---	---	Wilson	
59	SB00109432BBD1	6,130	50	Sept. 1959	13	July 1979	28	675	15	July 1981	Wilson	
60	SB00109431AAA1	6,115	---	May 1981	12	May 1981	38	1,650	11	July 1981	Buckles	
61	SB00109430DDD2	6,110	30	1975	5	July 1979	---	1,675	10	July 1981	Buckles	
62	SB00109430DD	6,105	45	June 1966	---	---	30	---	---	---	Siuol Corp.	
63	SB00109431ABA1	6,105	18	June 1952	6	June 1952	---	---	---	---	Buckles	
64	SB00109430BB	6,120	210	May 1967	---	---	55	---	---	---	Turner	
65	SB00109536ADB1	6,115	53	1951	23	July 1981	---	700	12	July 1981	Taylor	
66	SB00109526AAA1	6,085	8	---	5	July 1981	---	---	---	---	Hartman	
67	SB00109525BBC1	6,060	15	1979	6	July 1981	---	650	14.5	July 1981	Orris	
68	SB00109525BCC1	6,050	6	May 1981	3	July 1981	---	---	14	July 1981	Guèvin	
69	SB00109526DAA1	6,050	12	1979	6	July 1981	---	740	14	July 1981	Owens	
70	SB00109525CBA1	6,055	8	---	5	July 1981	---	875	15	July 1981	Colbeth	
71	SB00109526CDD	6,035	1,985	Apr. 1970	---	---	0	---	---	---	---	Continental Energy Corporation, Halpen #2.
72	SB00109526ACD	6,042	4,420	Aug. 1958	---	---	>30	---	---	---	---	Phillips Petroleum, Mannel #2.
73	SB00109526ACB1	6,040	9	1979	2	July 1981	---	1,700	12	July 1981	Wollsey	
74	SB00109526BDB1	6,035	13	1979	8	July 1981	---	1,800	14	July 1981	Musselman	
75	SB00109526BCC1	6,023	5	Apr. 1980	3	July 1981	---	640	5.5	Apr. 1983	Hafkenschiel	
76	SB00109526CCA1	6,045	35	May 1972	20	July 1981	---	1,700	11	July 1981	Coryell	
77	SB00109527AAD1	6,030	35	1979	12	July 1981	---	1,300	10.5	July 1981	Bradfield	
78	SB00109527AAD	6,030	300	1979	---	---	63	---	---	---	Bradfield	Well has been backfilled and abandoned. Driller supplied information.
79	SB00109527AAA1	6,035	15	1979	14	July 1981	---	2,200	10.5	July 1981	Farris	
80	SB00109523CCC	6,060	30	Dec. 1981	17	Dec. 1981	29	---	---	---	McNeill	Driller supplied information.
81	SB00109522DCD1	6,050	50	1978	28	Jan. 1981	31	---	---	---	Conrado	Driller supplied information.
82	SB00109527ABB	6,046	17,030	Oct. 1957	---	---	≥140	---	---	---	---	Phillips Petroleum, Mannel #1.
83	SB00109527DBB	6,020	5,005	Dec. 1960	---	---	50	---	---	---	---	Alamo Corporation, #5 Powell Park Unit.
84	SB00109527CAA1	6,005	8	1975	5	July 1981	---	1,450	14.5	July 1981	Etchart	
85	SB00109527BCA	6,015	100	---	---	---	>100	---	---	---	---	Data from Bee Bee Drilling, Rangely, Colo.
86	SB00109528CA	6,000	34	July 1965	20	July 1965	≥30	---	---	---	Halandras	
87	SB00109528CCD1	5,975	32	1964	4	July 1981	---	1,650	11	July 1981	Halandras	

Table 7.--*Inventory data from wells and test holes*

Site number[1]	Location within township, range, and section[2]	Altitude of land surface[3] (ft)	Depth of hole (ft)	Date construction completed[4]	Depth to water (ft)	Date of measurement[5]	Depth to bedrock[6] (ft)	Specific conductance (µmho)	Temperature (°C)	Date sample obtained	Owner[7]	Remarks[8]
88	SB00109532BDA1	5,975	11	1971	7	July 1981	---	825	18.5	July 1981	Thomas	Water level may reflect return flow from irrigation ditch.
89	SB00109531ACC1	5,925	27	Mar. 1983	5	Mar. 1983	22	680	6	Mar. 1983	Shults	Test hole caved to 18 feet in depth.
90	SB00109531CAA1	5,955	19	July 1971	15	July 1981	---	---	---	---	Shults	An old well not in use. Water level does not represent potentiometric surface.
91	SB00109625CDA1	5,910	45	1945	19	July 1981	---	1,290	14	July 1981	Thomas	
92	SB00109623CDD	5,865	15	1945	8	Dec. 1973	---	---	---	---	Wheeler	Well has been destroyed.
93	SB00109623CDC2	5,865	38	1981	8	Aug. 1982	---	1,650	13	July 1982	Wheeler	Driller reported depth to bedrock.
94	SB00209736DBC	5,715	24	Jan. 1976	0	Jan. 1976	14	---	---	---	State of Colorado	Division of Highways, 1975, structure D-04-P.
95	SB00209734DAD	5,710	---	---	---	---	---	1,700	19	July 1982	Wheeler	
96	SB00209734DDA	5,700	3,701	Dec. 1952	---	---	35	---	---	---	---	Union Oil Company of California, Ivory #1.
97	SB00209728BDA1	5,660	13	---	---	---	13	---	---	---	Coastal Oil	
98	SB00209720CAB1	5,635	24	Oct. 1981	11	July 1982	---	3,810	20	July 1982	---	
99	SB00209720BCA	5,625	25	---	4	---	17	---	---	---	---	American Resources Management, #1 Parker Unit.
100	SB00209812DCC1	5,605	20	1967	9	July 1981	---	5,000	10	July 1981	Coastal Oil	
101	SB00209802DDD	5,590	30	1969	---	---	30	---	---	---	Musselman	Driller reported depth to bedrock.
102	SB00209804ABB1	5,530	10	1979	---	---	---	1,100	13	July 1981	Phillips Petroleum	
103	SB00209805BBB	5,525	250	Nov. 1979	---	---	50	---	---	---	Hay	
104	SB00309830DCC1	5,495	20	1940	13	July 1981	---	---	---	---	Phillips Petroleum	
105	SB00309926CCA2	5,465	27	July 1972	10	July 1972	---	1,300	15	July 1981	Caldwell	Driller reported depth to water.
106	SB00309926CCA1	5,465	60	July 1972	10	July 1972	50	1,750	11	July 1981	Caldwell	Driller reported depth to water.
107	SB00309927CCB	5,438	6	1978	4	1978	6	---	---	---	---	Data from Western Engineers, Inc., 1978.

Table 7.--*Inventory data from wells and test holes*

Site number[1]	Location within township, range, and section[2]	Altitude of land surface[3] (ft)	Depth of hole (ft)	Date construction completed[4]	Depth to water (ft)	Date of measurement[5]	Depth to bedrock[6] (ft)	Specific conductance (µmho)	Temperature (°C)	Date sample obtained	Owner[7]	Remarks[8]
108	SB00309927CCC	5,444	18	1978	9	1978	18	---	---	---	---	Data from Western Engineers, Inc., 1978.
109	SB00309927CCD	5,439	13	1978	6	1978	13	---	---	---	---	Data from Western Engineers, Inc., 1978.
110	SB00309927CCD	5,540	11	1978	dry	1978	11	---	---	---	---	Data from Western Engineers, Inc., 1978. On terrace.
111	SB00309933CAC1	5,440	26	1979	5	July 1981	22	2,400	11	July 1981	Cook	
112	SB00309932ACA1	5,475	35	1973	12	---	---	3,250	12	July 1981	Cook	On alluvial fan; depth to water reflects base flow in intermittent stream.
113	SB00309932CAB1	5,420	25	1950	10	---	---	2,100	12	July 1981	Cook	Depth to water reported by owner.
114	SB00309931DAC1	5,410	18	1950	6	July 1981	18	1,000	15	July 1981	Mahleres	Depth to bedrock reported by owner.
115	SB00309931DCB	5,410	14	Mar. 1982	4	July 1982	---	2,200	15	July 1982	Hutchinson	
116	SB00210001AAA1	5,410	29	1972	14	---	29	---	---	---	Powell	All information reported by owner.
117	SB00210001ABB1	5,400	21	June 1981	7	Apr. 1982	21	---	---	---	Powell	USGS A-1.
118	SB00210001ABB2	5,398	26	June 1981	6	Apr. 1982	22	---	---	---	Powell	USGS A-1a.
119	SB00210001ABB3	5,397	19	June 1981	5	Apr. 1982	18	3,340	6.5	Feb. 1983	Powell	USGS A-2.
120	SB00210001BAA1	5,398	27	June 1981	5	Apr. 1982	25	---	---	---	Powell	USGS A-2a.
121	SB00310036CDD1	5,399	30	June 1981	6	Apr. 1982	27	3,000	11	June 1981	Powell	USGS A-3.
122	SB00310036CDD2	5,399	27	June 1981	6	Apr. 1982	26	---	---	---	Powell	USGS A-3a.
123	SB00210002BCC2	5,400	18	1977	12	---	---	875	12	July 1981	Hume	Owner reported depth to water.
124	SB00210002BCC1	5,385	4	1950	3	---	---	4,000	15	July 1981	Hume	Owner reported depth to water.
125	SB00210003ACD1	5,375	14	1976	8	July 1981	14	730	16	July 1981	Cox	Owner reported depth to bedrock.
126	SB00210004DAC2	5,370	16	1954	6	July 1981	---	3,250	9	July 1981	Cox	
127	SB00210004DAC1	5,375	17	1954	11	July 1981	---	4,000	9	July 1981	Cox	
128	SB00210009BAB1	5,360	13	1979	9	July 1981	---	2,100	18	July 1981	Cox	
129	SB00210008BAD1	5,365	23	1900	17	---	---	3,600	13	July 1981	Gall	Owner reported depth to water.
130	SB00210007AAC1	5,345	30	1950	10	---	---	1,300	12	July 1982	Powell	Owner reported depth to water.

Table 7.--*Inventory data from wells and test holes*

Site number[1]	Location within township, range, and section[2]	Altitude of land surface[3] (ft)	Depth of hole (ft)	Date construction completed[4]	Depth to water (ft)	Date of measurement[5]	Depth to bedrock[6] (ft)	Specific conductance (µmho)	Temperature (°C)	Date sample obtained	Owner[7]	Remarks[8]
131	SB00210112BCC1	5,321	40	Oct. 1979	7	Oct. 1979	37	---	---	---	Western Fuels Assoc., Inc.	Data from Vaughn Hansen Associates, 1979; Qal-4.
132	SB00210112BCC2	5,315	30	Nov. 1980	13	Nov. 1980	25	---	---	---	Western Fuels Assoc., Inc.	Data from Ford, Bacon and Davis Utah, Inc., 1981; TH-2.
133	SB00210111ADA1	5,321	27	Sept. 1979	9	Oct. 1979	21	---	---	---	Western Fuels Assoc., Inc.	Data from Vaughn Hansen Associates, 1979; Qal-2.
134	SB00210111ADC1	5,320	28	Nov. 1980	6	Nov. 1980	22	---	---	---	Western Fuels Assoc., Inc.	Data from Ford, Bacon and Davis Utah, Inc., 1981; TH-1.
135	SB00210111DBB1	5,315	9	Nov. 1953	6	July 1981	---	2,500	11	July 1981	Staley	Data from Vaughn Hansen Associates, 1979; Qal-1.
136	SB00210111CAA1	5,320	28	Oct. 1979	6	Oct. 1979	26	5,000	16	Oct. 1979	Western Fuels Assoc., Inc.	Data from Vaughn Hansen Associates, 1979; Qal-6.
137	SB00210111CAA2	5,330	38	Oct. 1979	26	Feb. 1981	36	---	---	---	Western Fuels Assoc., Inc.	Data from Vaughn Hansen Associates, 1979; Qal-5.
138	SB00210111CAC1	5,319	43	Oct. 1980	14	Nov. 1980	38	3,780	11	Nov. 1980	Western Fuels Assoc., Inc.	Data from Ford, Bacon and Davis Utah, Inc., 1981; WFU-1.
139	SB00210111CAC2	5,316	40	Sept. 1979	12	Oct. 1979	37	5,000	---	Oct. 1979	Western Fuels Assoc., Inc.	Data from Vaughn Hansen Associates, 1979; Qal-3.
140	SB00210122AAC2	5,290	18	May 1981	6	June 1981	---	1,850	10	June 1981	Poole	
141	SB00210122ADA1	5,295	---	---	---	---	---	840	---	June 1981	Poole	
142	SB00210127ACA	5,270	>28	---	---	---	28	---	---	---	---	Data from Bee Bee Drilling, Rangely, Colo.
143	SB00210127ADB	5,270	>28	---	---	---	28	---	---	---	---	Data from Bee Bee Drilling, Rangely, Colo.
144	SB00210127ADA	5,275	>29	---	---	---	29	---	---	---	---	Data from Bee Bee Drilling, Rangely, Colo.

Table 7.--*Inventory data from wells and test holes*

Site number[1]	Location within township, range, and section[2]	Altitude of land surface[3] (ft)	Depth of hole (ft)	Date construction completed[4]	Depth to water (ft)	Date of measurement[5]	Depth to bedrock[6] (ft)	Specific conductance (μmho)	Temperature (°C)	Date sample obtained	Owner[7]	Remarks[8]
145	SB00210127ADA	5,280	>29	---	---	---	29	---	---	---	---	Data from Bee Bee Drilling, Rangely, Colo.
146	SB00210127ACD	5,270	>28	---	---	---	28	---	---	---	---	Data from Bee Bee Drilling, Rangely, Colo.
147	SB00210127ADC	5,270	>27	---	---	---	27	---	---	---	---	Data from Bee Bee Drilling, Rangely, Colo.
148	SB00210127ADC1	5,275	9	1971	3	July 1981	---	---	---	---	Conwell	
149	SB00210127ADD1	5,280	35	1976	7	July 1981	35	5,000	11.5	July 1981	Conwell	
150	SB00210127DCC	5,347	100	June 1972	---	---	0	---	---	---	---	Data from Woodward-Clevenger and Associates, 1972; DH-6.
151	SB00210127DCD	5,277	34	Aug. 1980	10	Aug. 1980	23	---	---	---	---	Data from Western Engineers, Inc., 1980; DH-3W.
152	SB00210127DCD	5,277	59	June 1972	10	June 1972	28	---	---	---	---	Data from Woodward-Clevenger and Associates, 1972; DH-3.
153	SB00210127DCD	5,278	15	Aug. 1980	10	Aug. 1980	---	---	---	---	---	Data from Western Engineers, Inc., 1980; AP-6.
154	SB00210127DDC	5,277	32	June 1972	---	---	28	---	---	---	---	Data from Woodward-Clevenger and Associates, 1972; DH-5.
155	SB00210127DDC	5,281	16	Sept. 1980	14	Sept. 1980	---	---	---	---	---	Data from Western Engineers, Inc., 1980; AH-2.
156	SB00210134AAB	5,281	35	June 1972	---	---	30	---	---	---	---	Data from Woodward-Clevenger and Associates, 1972; DH-4.
157	SB00210127DDC	5,281	14	Sept. 1980	13	Sept. 1980	---	---	---	---	---	Data from Western Engineers, Inc., 1980; AH-3.
158	SB00210127DDC	5,282	47	Aug. 1980	11	Aug. 1980	17	---	---	---	---	Data from Western Engineers, Inc., 1980; DH-2W.
159	SB00210127DDC	5,299	63	Aug. 1980	---	---	8	---	---	---	---	Data from Western Engineers, Inc., 1980; DH-1W. On terrace.

Table 7.--*Inventory data from wells and test holes*

Site number[1]	Location within township, range, and section[2]	Altitude of land surface[3] (ft)	Depth of hole (ft)	Date construction completed[4]	Depth to water (ft)	Date of measurement[5]	Depth to bedrock[6] (ft)	Specific conductance (μmho)	Temperature (°C)	Date sample obtained	Owner[7]	Remarks[8]
160	SB00210134BDA1	5,260	13	1958	8	July 1981	---	1,950	13	July 1981	Hefley	
161	SB00210134BDD1	5,275	22	May 1981	13	July 1981	---	1,200	14	July 1981	Moomey	
162	SB00210134CBD1	5,275	30	June 1980	21	June 1980	30	1,300	19	July 1981	Jackson	Owner reported depth to water and depth to bedrock.
163	SB00210134CBB	5,260	>2,600	---	---	---	55	---	---	---	---	Data from Front Range Oil and Drilling Co., #1 Kenny.
164	SB00210133ADB1	5,250	19	1940	8	July 1981	---	1,900	11	July 1981	Hefley	
165	SB00210133DAB1	5,265	40	1979	24	July 1981	---	---	---	---	Hefley	
166	SB00210133DBD	5,280	3,728	May 1969	---	---	50	---	---	---	---	Data from Twin Arrow Drilling, Hefley 1-33.
167	SB00210133CBA	5,255	>150	---	---	---	28	---	---	---	---	Oil well: #2 Clubine and Grinstead.
168	SB00210132ADD1	5,250	17	1980	8	June 1981	---	1,325	13	June 1981	Hazelwood	
169	SB00210132DDA1	5,285	76	Mar. 1977	54	June 1981	>50	3,500	15	June 1981	N and L Drilling	
170	SB00210132ACD1	5,260	15	1950	---	---	---	1,290	10	June 1980	Hazelwood	
171	SB00210131DBA1	5,230	47	Dec. 1972	---	---	32	---	---	---	Hejl	
172	SB00210131DCC	5,235	>18	---	---	---	18	---	---	---	---	Data from Bee Bee Drilling, Rangely, Colo.
173	SB00210131CDA1	5,232	46	Dec. 1972	---	---	40	3,100	14	July 1981	Hejl	Penetrates 6 feet into Mancos Shale.
174	SB00210131CAA1	5,227	16	1978	6	June 1981	---	4,200	12	June 1981	Polley	
175	SB00210131BDB1	5,230	21	1950	10	June 1981	---	2,400	12	June 1981	Stevens	
176	SB00210131BDC1	5,225	11	1979	6	June 1981	---	1,400	11	June 1981	Polley	
177	SB00210131CBC1	5,221	17	---	5	June 1981	---	---	---	---	Steele	
178	SB00210131BCC1	5,228	22	1950	10	June 1981	---	3,400	10	June 1981	Stevens	
179	SB00210131CCC	5,217	>16	---	---	---	16	---	---	---	---	Data from Bee Bee Drilling, Rangely, Colo.
180	SB00110106BAC1	5,245	32	1979	25	June 1981	32	---	---	---	Eddy	Owner reported depth to bedrock.
181	SB00110106BBA1	5,222	20	1965	4	June 1981	---	---	---	---	A-1 Tank Company	
182	SB00110106BBA2	5,225	40	1965	7	June 1981	---	---	---	---	A-1 Tank Company	
183	SB00110106BBD1	5,221	23	1968	10	June 1981	---	---	---	---	A-1 Tank Company	

Table 7.--*Inventory data from wells and test holes*

Site number[1]	Location within township, range, and section[2]	Altitude of land surface[3] (ft)	Depth of hole (ft)	Date construction completed[4]	Depth to water (ft)	Date of measurement[5]	Depth to bedrock[6] (ft)	Specific conductance (μmho)	Temperature (°C)	Date sample obtained	Owner[7]	Remarks[8]
184	SB00110106BCA1	5,220	11	1920	10	July 1981	---	---	---	---	Husky Oil Company	
185	SB00110106BCA2	5,230	30	Oct. 1972	16	July 1981	≥30	---	---	---	Bible Baptist Church	
186	SB00110106BCA3	5,240	39	1954	26	July 1981	39	3,500	12	July 1981	Bell	Owner reported depth to bedrock.
187	SB00110106BCB1	5,255	38	1959	34	June 1981	---	6,000	15	June 1981	Fetterolf	
188	SB00210236DAD1	5,225	15	1945	9	June 1981	---	1,400	15	June 1981	Steele	
189	SB00210236DAA1	5,226	14	1976	8	June 1981	---	1,250	13	June 1981	Steele	
190	SB00210236DAA2	5,227	29	1940	---	---	---	1,200	21	June 1981	Steele	
191	SB00210236DAB1	5,245	35	1950	32	July 1981	35	5,250	14	July 1981	Peacock	Owner reported depth to bedrock.
192	SB00210236DAB2	5,245	35	1979	32	July 1981	---	---	---	---	Peacock	
193	SB00210236DBA1	5,235	40	June 1976	26	---	40	1,700	15	June 1981	Thompson	Owner reported depth to bedrock and depth to water.
194	SB00210236DCC	5,212	>16	---	---	---	16	---	---	---	---	Data from Bee Bee Drilling, Rangely, Colo.
195	SB00110201BAA	5,211	>17	---	---	---	17	---	---	---	---	Data from Bee Bee Drilling, Rangely, Colo.
196	SB00110201BAC2	5,209	17	1952	12	June 1981	---	1,500	10	June 1981	Peel	
197	SB00110201BAC1	5,209	15	1968	12	June 1981	---	1,375	10	June 1981	Coy	
198	SB00110201BBD1	5,208	18	1975	11	June 1981	---	2,275	10	June 1981	Covington	
199	SB00110201BDB	5,214	>17	---	---	---	17	---	---	---	---	Data from Bee Bee Drilling, Rangely, Colo.
200	SB00110201BCA1	5,212	27	1946	20	June 1981	---	1,900	19	June 1981	Raamuaaen	
201	SB00110201BCA2	5,212	40	1942	13	June 1981	---	2,200	10	June 1981	Rasmussen	
202	SB00110201BCD1	5,230	38	1940	33	June 1981	---	14,000	15	June 1981	Steele	Owner reported depth to water.
203	SB00110201BCC3	5,220	18	1976	16	June 1981	---	9,300	15	June 1981	Rasmussen	
204	SB00110201BCC1	5,218	22	1976	18	June 1981	---	6,500	11	June 1981	Coy	
205	SB00110201BCC2	5,216	23	1940	18	June 1981	---	6,750	15	June 1981	Lollar	
206	SB00210235DAD1	5,200	10	1950	6	July 1981	---	14,000	13	July 1981	Graham	
207	SB00210235DDB1	5,201	12	1940	9	June 1981	---	13,000	11	June 1981	Cloward	
208	SB00210235DBC2	5,197	16	1960	7	June 1981	---	---	---	---	Coltharp Estate	
209	SB00210235CDD1	5,203	32	1960	12	June 1981	---	1,750	11	June 1981	Colthrap Estate	
210	SB00210235CDD6	5,204	14	1960	11	July 1981	---	---	---	---	Colthrap Estate	
211	SB00210235CDD3	5,203	12	1960	12	June 1981	---	---	---	---	Coltharp Estate	
212	SB00210235CDD4	5,202	14	1964	10	June 1981	---	---	---	---	Coltharp Estate	
213	SB00210235CDD5	5,198	16	1964	10	July 1981	---	2,100	11.5	July 1981	Coltharp Estate	
214	SB00210235CDC1	5,195	20	1960	11	June 1981	---	---	11	June 1981	Coltharp Estate	
215	SB00210235CAC1	5,195	11	May 1981	8	June 1981	---	2,050	12	June 1981	Allred	
216	SB00210235CDB1	5,193	13	1960	9	June 1981	---	---	---	---	Coltharp Estate	

Table 7.--*Inventory data from wells and test holes*

Site number[1]	Location within township, range, and section[2]	Altitude of land surface[3] (ft)	Depth of hole (ft)	Date construction completed[4]	Depth to water (ft)	Date of measurement[5]	Depth to bedrock[6] (ft)	Specific conductance (µmho)	Temperature (°C)	Date sample obtained	Owner[7]	Remarks[8]
217	SB00210235CBA	5,200	>1,970	---	---	---	25	---	---	---	---	Oil well: #3 Rector
218	SB00210235CCD	5,192	16	Nov. 1946	---	---	16	---	---	---	State of Colorado	Division of Highways, 1946, structure D-1-E.
219	SB00210235CCC1	5,190	16	1974	4	June 1981	---	2,200	11.5	June 1981	Meese	
220	SB00210235CCC2	5,190	20	1960	2	July 1981	20	3,610	16	July 1981	Menge	Owner reported depth to bedrock.
221	SB00210235CCC	5,187	>3,000	---	---	---	13	---	---	---	---	Data from Bee Bee Drilling, Rangely, Colo.
222	SB00110202AAB	5,205	>1,599	---	---	---	24	---	---	---	---	Oil well: #6 Georgianna E. White.
223	SB00110202ABA	5,200	>590	---	---	---	25	---	---	---	---	Oil well: #5 Georgianna E. White.
224	SB00110202ABD1	5,210	21	1977	16	June 1981	---	7,000	12	June 1981	Sinclair	
225	SB00110202ABD2	5,210	22	July 1981	17	June 1981	---	12,100	11	June 1981	Murphy	
226	SB00110202ABD	5,207	>17	---	---	---	17	---	---	---	---	Data from Bee Bee Drilling, Rangely, Colo.
227	SB00110202ABB	5,198	>1,965	---	---	---	30	---	---	---	---	Oil well: #2 W. H. Coltharp
228	SB00110202BAA1	5,202	19	1963	12	June 1981	---	5,900	11	June 1981	Coltharp Estate	
229	SB00110202BBA	5,194	>21	1981	---	---	21	---	---	---	---	Data from Bee Bee Drilling, Rangely, Colo.
230	SB00110202BBD1	5,200	40	1964	19	June 1981	---	5,000	11	June 1981	Hillis	
231	SB00110202BBC	5,189	>2,000	---	---	---	31	---	---	---	---	Oil well: #2 Jones.

[1]Site numbers correspond to the numbers appearing adjacent to data points on plates 1, 2, 3, and 5.

[2]Site locations are based on the U.S. Bureau of Land Management system of land subdivision, which is explained in the subsection entitled "System of Locating and Numbering Data-Collection Sites". Wells that could be located only within a quarter-quarter section have only two letters following the section number.

[3]In most cases, altitude of land surface values were obtained from U.S. Geological Survey 1:24,000 topographic maps, and consequently are approximations within 10 feet of the true altitudes. Altitudes are based on the National Geodetic Vertical Datum of 1929.

[4]Dates refer to the date well or test-hole construction was completed. Many dates were known only to the year.

[5]Dates refer to the date of water-level measurement in wells or test holes.

[6]Depth-to-bedrock values were obtained from lithologic logs or reliable reports from owners or driller.

[7]In most cases, names refer to the well owner. Infrequently, the lessee of the property is listed.

[8]Pertinent supplemental information is listed in this column. When appropriate, references also are cited from which the preceding data were obtained. When data were obtained from an oil-well log, the name of the well is listed.

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Surface Geophysics

Electrical Resistivity

Vertical electrical-resistivity soundings (VES) were used to obtain subsurface data throughout the study area. The soundings were based on a fundamental property of rocks known as resistivity, which governs the amount of current that passes through the rock when a specified potential difference is applied (Dobrin, 1976). Resistivity is a function of several variables, including porosity, moisture content, clay content, and concentration of dissolved electrolytes. Because individual resistivities are not unique to a given rock or sediment type, it is impossible to identify a given earth material solely from a resistivity value. Thus, interpretation of VES curves is based on resistivity contrasts between layers of rock rather than on absolute values of resistivity. A given VES curve can correspond to a variety of combinations of subsurface distributions of layer thicknesses and resistivities (Zohdy and others, 1974). For this reason, at least some soundings need to be conducted in the immediate vicinity of logged test holes. The lithologic logs of such test holes provide information on layer thicknesses, which, when compared with the geoelectric layers determined from the soundings, allow the interpreted true resistivity of each layer to be derived. The interpreted true resistivities then can be used to determine the thicknesses of similar layers in areas where drilling information is absent.

Data-collection procedures in the field involved applying a low-frequency current to the ground through current electrodes and measuring the resulting potential difference between potential electrodes. During a given sounding, the electrodes were moved progressively further apart to produce a series of apparent resistivity values that were used to derive the depths to various subsurface layers below the site.

VES curves were interpreted with the aid of two computer programs (Zohdy, 1973, 1974) that are based on techniques discussed in Zohdy (1975). Data were interpreted in the following manner. Observed apparent resistivity values were entered into the computer, which generated a plot of the field curve. Subsequently, the computer smoothed and digitized the data and calculated a theoretical sounding curve. The theoretical curve was compared with a user-selected model curve in the second computer program. The model curve that compared most favorably with the theoretical curve was used to infer layer thicknesses and their corresponding interpreted true resistivities.

Table 8.--*Results of vertical electrical-resistivity soundings*
[ft = feet]

Site number[1] (plate 1)	Location within township, range, and section[2]	Altitude of land surface[3] (ft)	Depth to bedrock[4] (ft)	Date sounding conducted	Remarks[5]
ER-1	SC00109310BDD	6,465	69	May 1982	
ER-2	SC00109310BDB	6,470	49	May 1982	
ER-3	SC00109303CDC	6,440	43	May 1982	
ER-4	SC00109303CBC	6,430	141	May 1982	
ER-5	SC00109304ACA	6,430	69	May 1982	
ER-6	SC00109303BBB	6,405	118	May 1982	
ER-7	SB00109333CDC	6,410	112	May 1982	
ER-8	SB00109333CDD	6,405	131	May 1982	
ER-9	SB00109333CDB	6,407	295?	May 1982	
ER-10	SB00109333DCD	6,408	72	June 1974	Performed by Wright-McLaughlin Engineers (1974) as ERS-7.
ER-11	SB00109333DAC	6,405	59	May 1982	
ER-12	SB00109333DAA	6,407	49	May 1982	
ER-13	SB00109334CBD	6,418	46	May 1982	
ER-14	SB00109333ADD	6,405	44	May 1982	
ER-15	SB00109333ABC	6,390	41	May 1982	
ER-16	SB00109333AAD	6,400	72	May 1982	
ER-17	SB00109328CCD	6,370	25	June 1974	Performed by Wright-McLaughlin Engineers (1974) as ERS-8.
ER-18	SB00109328CDB	6,380	72	May 1982	
ER-19	SB00109328DCA	6,387	36	May 1982	
ER-20	SB00109328BDC	6,365	72	May 1982	
ER-21	SB00109321DCA	6,372	17	May 1982	
ER-22	SB00109329ADA	6,350	33	May 1982	
ER-23	SB00109329BAC	6,325	53	May 1982	
ER-24	SB00109329BBD	6,325	61	1979	Performed by CH2M Hill Central (1979) as ER5.
ER-25	SB00109330AAB	6,305	49	May 1982	
ER-26	SB00109423DDA	6,235	26	July 1974	Performed by Wright-McLaughlin Engineers (1974) as ERS-2.
ER-27	SB00109428ADD	6,173	33	May 1982	
ER-28	SB00109428DDC	6,170	36	May 1982	
ER-29	SB00109431AAA	6,110	30	May 1982	
ER-30	SB00109536ABA	6,070	20	May 1982	
ER-31	SB00109526AAB	6,055	19	May 1982	
ER-32	SB00109526ADA	6,050	20?	May 1982	Depth-to-bedrock value unreliable.

Table 8.--*Results of vertical electrical-resistivity soundings*--Continued

Site number[1] (plate 1)	Location within township, range, and section[2]	Altitude of land surface[3] (ft)	Depth to bedrock[4] (ft)	Date sounding conducted	Remarks[5]
ER-33	SB00109525BCB	6,055	16	Mar. 1982	
ER-34	SB00109526DAA	6,045	20	May 1982	
ER-35	SB00109526DAD	6,045	23	May 1982	
ER-36	SB00109526DDB	6,045	25	May 1982	
ER-37	SB00109527DAB	6,015	23	May 1982	
ER-38	SB00109527DBA	6,010	16	May 1982	
ER-39	SB00109527BDB	6,010	49	May 1982	
ER-40	SB00109531ACC	5,930	26	Mar. 1982	
ER-41	SB00109625CDB	5,895	23	Mar. 1982	
ER-42	SB00209736CDA	5,720	30	Aug. 1982	
ER-43	SB00209736CDD	5,730	38	Aug. 1982	
ER-44	SB00109701BAB	5,735	23	Aug. 1982	
ER-45	SB00209720BDB	5,630	23	May 1982	
ER-46	SB00209720BDC	5,630	33	May 1982	
ER-47	SB00209720BCD	5,630	26	May 1982	
ER-48	SB00209812BAC	5,585	26	Mar. 1982	Difficult curve to model; depth is estimate.
ER-49	SB00209812BBA	5,585	30	Mar. 1982	Difficult curve to model; depth is estimate.
ER-50	SB00209812BBB	5,585	20	Mar. 1982	
ER-51	SB00209804ABB	5,530	46	Mar. 1982	Difficult curve to model; depth is estimate.
ER-52	SB00309830CDA	5,490	49	May 1982	
ER-53	SB00309830CAD	5,490	23	May 1982	Resistivity value seems small for a gravel.
ER-54	SB00309927CAD	5,450	43	May 1982	Resistivity value seems small for a gravel.

[1]ER indicates electrical-resistivity sounding.

[2]Site locations are based on the U.S. Bureau of Land Management system of land subdivision, which is explained in the subsection entitled "System of Locating and Numbering Data-Collection Sites."

[3]In most cases, altitude of land surface values were obtained from U.S. Geological Survey 1:24,000 topographic maps, and consequently are approximations within 10 feet of the true altitudes. Altitudes are based on the National Geodetic Vertical Datum of 1929.

[4]Depth-to-bedrock values are approximations based on interpretation of geophysical data.

[5]Pertinent supplemental information is listed in this column. When appropriate, this column also cites references from which the preceding data were obtained.

Seismic Refraction

Table 9.--*Results of seismic-refraction surveys*
[ft = feet]

Site number[1] (plate 1)	Location within township, range, and section[2]	Altitude of land surface[3] (ft)	Depth to bedrock[4] (ft)	Date survey conducted	Remarks[5]
SR-1	SB00109333AAA	6,410	>56	June 1974	Performed by Wright-McLaughlin Engineers (1974) as SS-3.
SR-2	SB00109424CDB	6,250	24	July 1974	Performed by Wright-McLaughlin Engineers (1974) as SS-1.

[1]SR indicates seismic-refraction survey.

[2]Site locations are based on the U.S. Bureau of Land Management system of land subdivision, which is explained in the subsection entitled "System of Locating and Numbering Data-Collection Sites."

[3]In most cases, altitude of land surface values were obtained from U.S. Geological Survey 1:24,000 topographic maps, and consequently are approximations within 10 feet of the true altitudes. Altitudes are based on the National Geodetic Vertical Datum of 1929.

[4]Depth-to-bedrock values are approximations based on interpretation of geophysical data.

[5]Pertinent supplemental information is listed in this column. When appropriate, this column also cites references from which the preceding data were obtained.

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Grain-size Distribution Analyses of Alluvium

Samples of alluvium were collected from the Meeker municipal well field near the eastern end of the study area and from the site of the proposed Taylor Draw dam near the western end of the study area. The distribution of particle sizes of each sample was determined by standard methods (U.S. Bureau of Reclamation, 1974). Grain-size distribution curves of these samples are shown in figures 11, 12, and 13.

The effective size (D_{10}), coefficient of uniformity (C_u), and coefficient of curvature (C_c) were determined for one sample in Agency Park and one sample near Rangely, each from a depth of about 8 ft (fig. 11 and 13). The D_{10} is an indicator of the quantity of fine-grained material in a sample; permeability generally increases as the D_{10} increases. The D_{10} is 6 to 7 times greater in the sample from Agency Park (fig. 11) than in the sample from the site of the proposed Taylor Draw dam (fig. 13). The C_u value is a measure of the range of particle sizes in a sample; for coarse-grained alluvium to be considered well-graded, C_u must be greater than 6. Both these samples easily comply with this criterion. The C_c value is a measure of the representation in the sample of all particle sizes within the range that are present; for alluvium to be considered well-graded, C_c must be between 1 and 3. The sample from Agency Park (fig. 11) contains sufficient quantities of all particle sizes within the range of particle sizes present to be considered well-graded; C_c equals 1.7. The sample from the site of the proposed Taylor Draw dam (fig. 13), however, does not meet this criterion; C_c equals 5.4. This is because of a paucity of particles from approximately 0.5 to 5 millimeters (mm) in diameter, as shown by the concave nature of the grain-size curve for this range of particle sizes. Such a sample is not considered well-graded, but instead is said to be gap-graded.

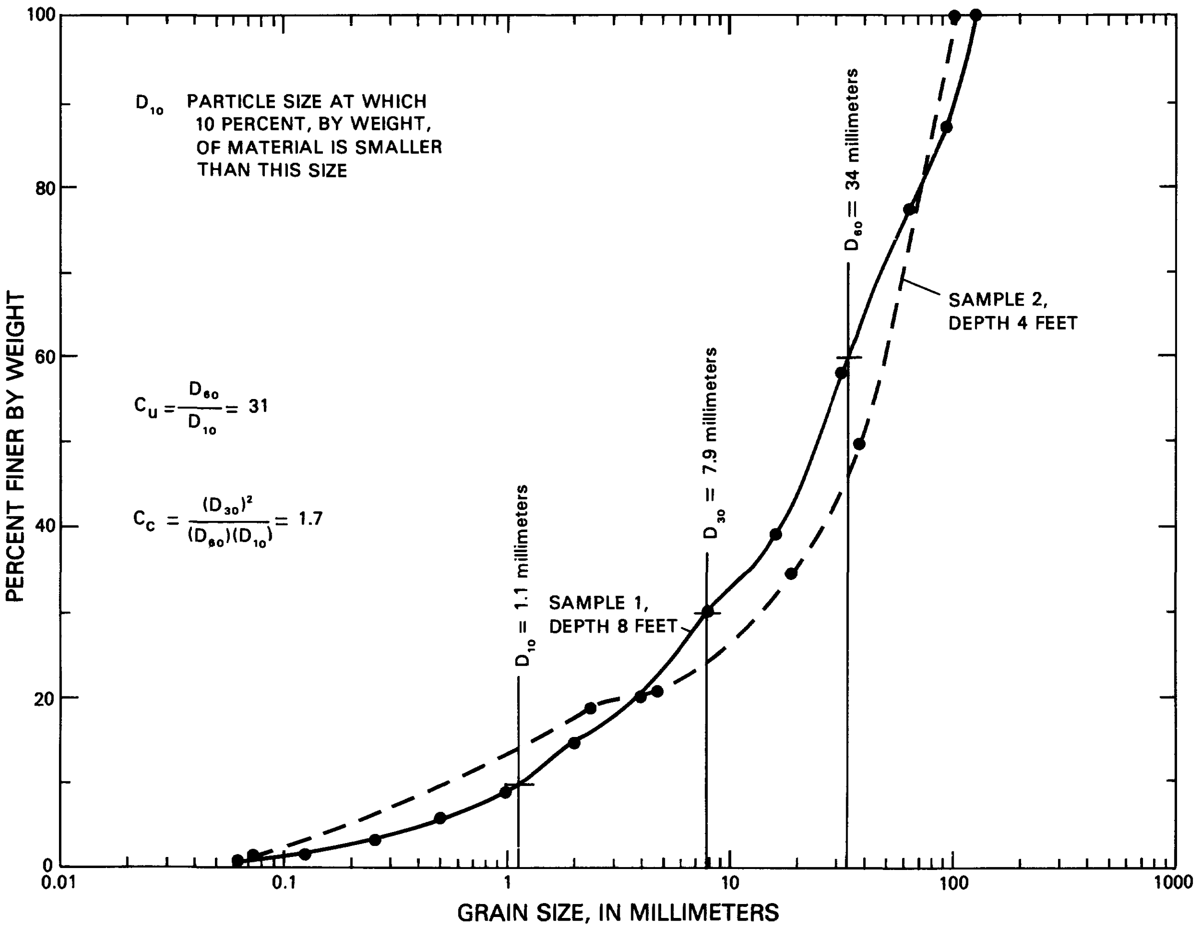

Figure 11.--Grain-size distribution curves of coarse-grained alluvium from the Meeker municipal well field in Agency Park.

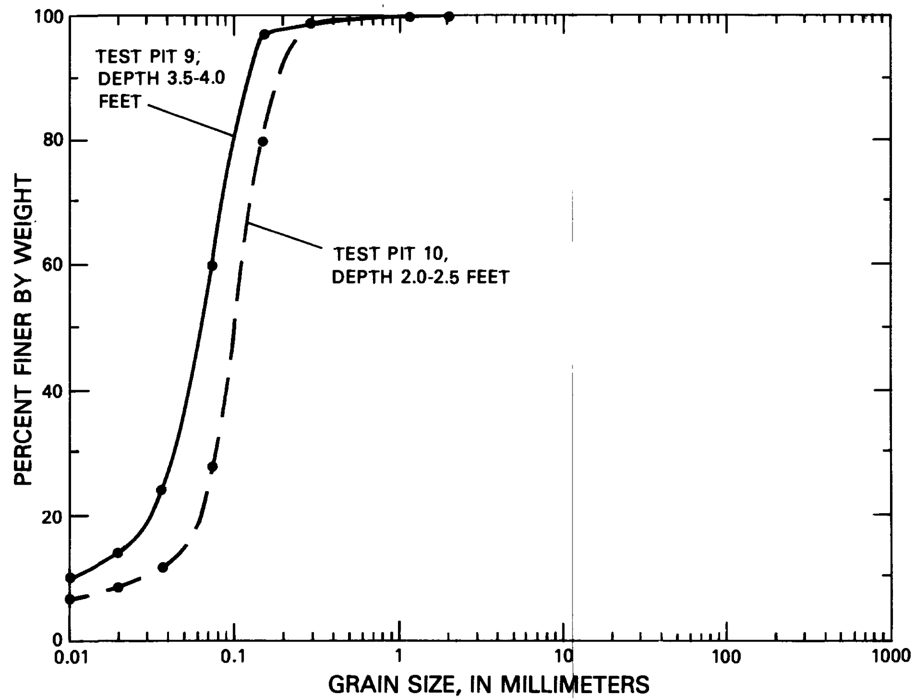

Figure 12.--Grain-size distribution curves of surficial fine-grained alluvium near Taylor Draw, 5 miles east of Rangely. (Based on data from Western Engineers, Inc., 1980.)

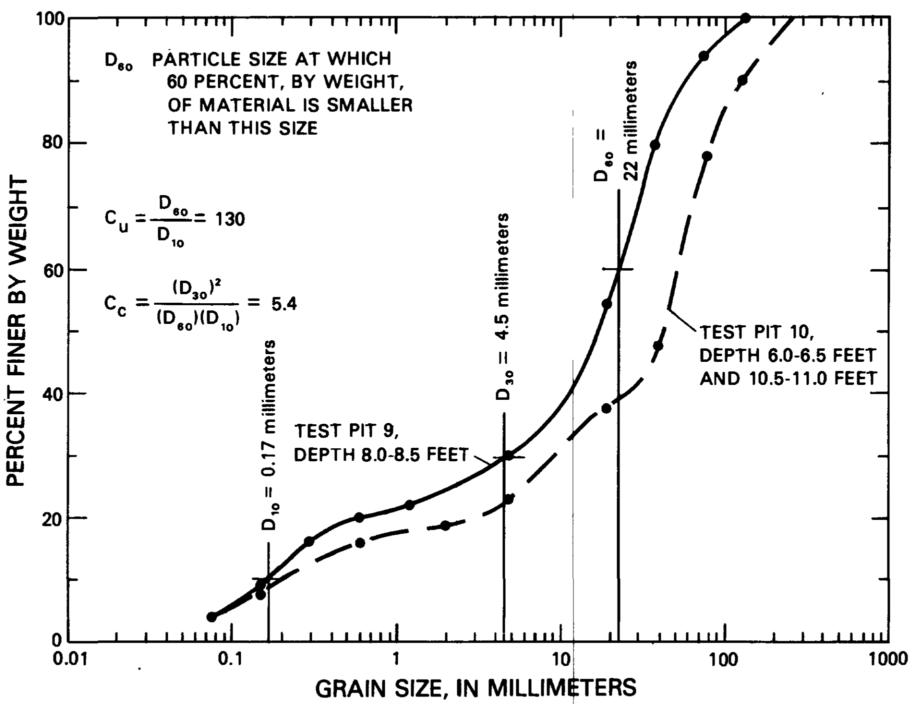

Figure 13.--Grain-size distribution curves of coarse-grained alluvium near Taylor Draw, 5 miles east of Rangely. (Based on data from Western Engineers, Inc., 1980.)

Analyses of Aquifer Tests

Meeker Municipal Well B-5

Well B-5 was drilled for the town of Meeker in September 1982, for municipal water supply. The well was drilled by the cable-tool method to a total depth of 56 ft in the White River alluvium and does not penetrate bedrock. Detailed lithologic information is not available from the driller's log of this well; however, a lithologic section of alluvium nearby is shown in figure 4. The saturated thickness of alluvium at the well site is approximately 120 ft, as indicated on plate 3.

An aquifer test was conducted using this well in September 1982, by Arix--A Professional Corporation of Grand Junction, Colo., with assistance from U.S. Geological Survey personnel. The well was completed for testing as shown in figure 14; no observation wells were used. Water-level changes in the pumped well during the pumping and recovery phases of testing are shown in figure 15. Drawdown aberrations at the indicated increments of time are due to well interference from the Meeker municipal well field, which is located nearby.

With consideration of the effects of well interference, transmissivity of the alluvial aquifer in the area of well B-5 was estimated. Analysis of time-drawdown data (fig. 16) resulted in an estimated value of transmissivity of 10,000 ft^2/d; however, analysis of the recovery phase of testing (fig. 17) indicated a transmissivity of 58,000 ft^2/d. The large discrepancy in the two calculated transmissivity values probably is due to violations of the assumptions inherent in the modified nonequilibrium method of analysis of Cooper and Jacob (1946) applied herein. The departures from ideal conditions probably are due to evacuation of water stored in the 16-in. diameter well bore, effects of vertical components of flow caused by partial penetration of the aquifer by the well, variations in discharge rate, delayed gravity drainage of water from aquifer storage, heterogeneity and anisotropy of the aquifer (as indicated in figure 4), and(or) effects of well losses created by the turbulent flow of water through the well screen. Because no array of observation wells was available to be monitored during testing, effects characteristic of individual departures from theoretical conditions could not be isolated.

Data from the recovery phase of testing show that the water level in the well surged to a level higher than the original static level within 2 min after cessation of pumping, declined about 1 ft in less than 1 more minute, and then began to rise slowly toward the original static level (fig. 17). This indicates that the water level immediately outside of the casing and screen during pumping probably was higher than the level in the well. However, the head loss across the screen is a constant for a constant discharge rate and is characteristic of the screen only. Therefore, the slope of the straight line used to determine transmissivity in figure 16 is not affected by such well losses; the line is only offset vertically by a constant amount.

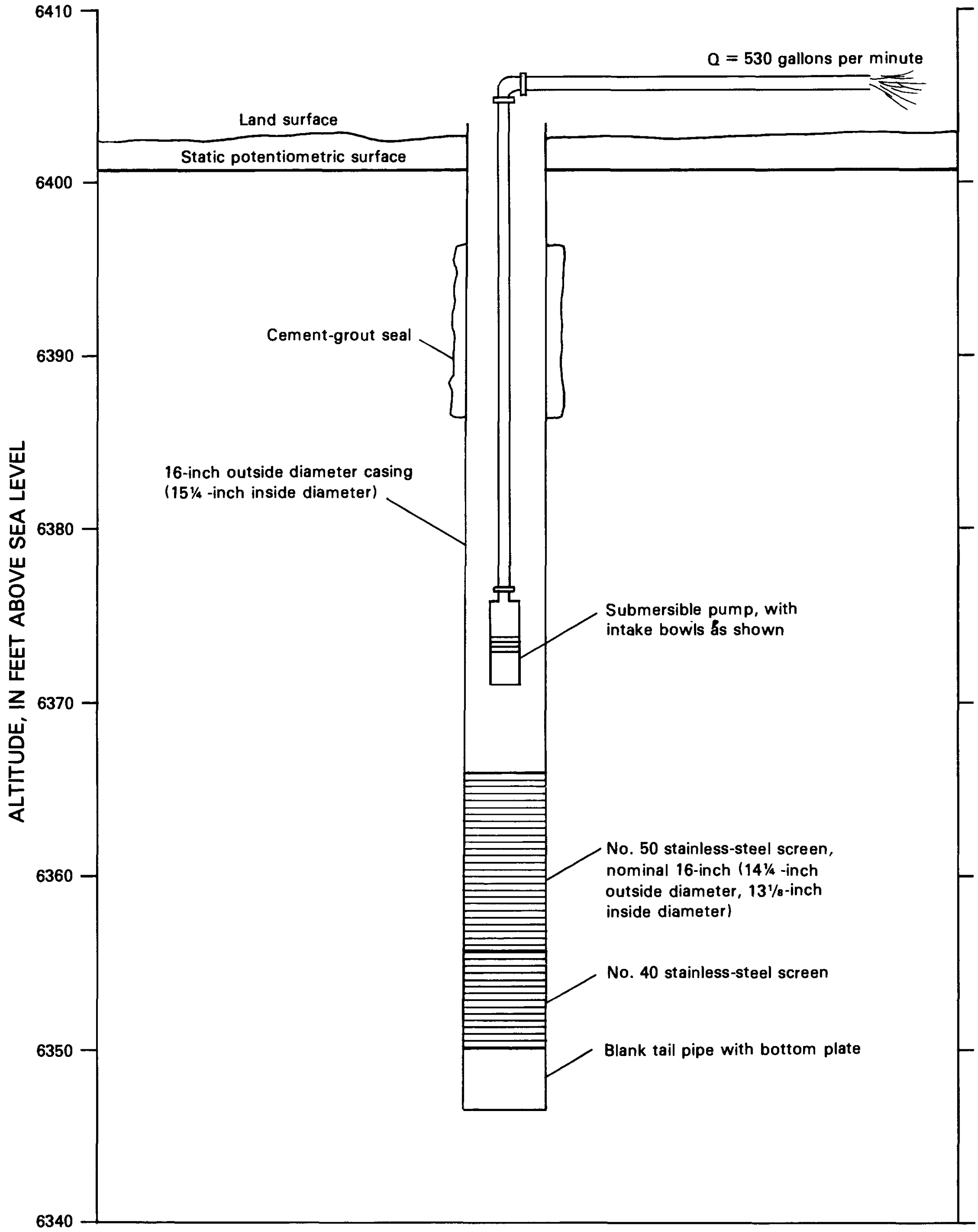

Figure 14.--Well completion for aquifer test at Meeker municipal well B-5 in Agency Park. (Modified from T. K. Kelly, Arix--A Professional Corporation, written commun., 1983.)

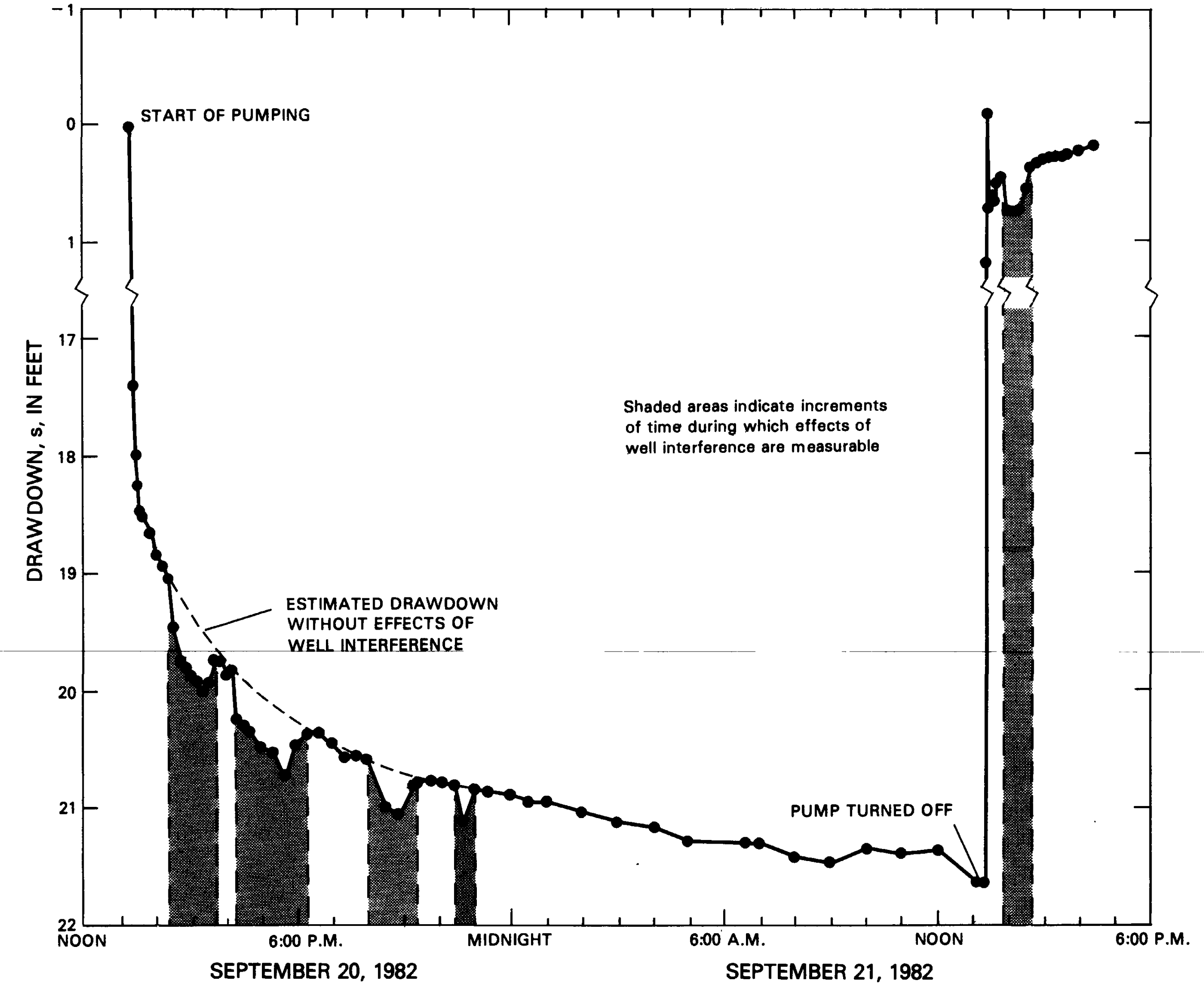

Figure 15.--Water-level changes in the pumped well during aquifer testing of Meeker municipal well B-5, September 20 to 21, 1982.

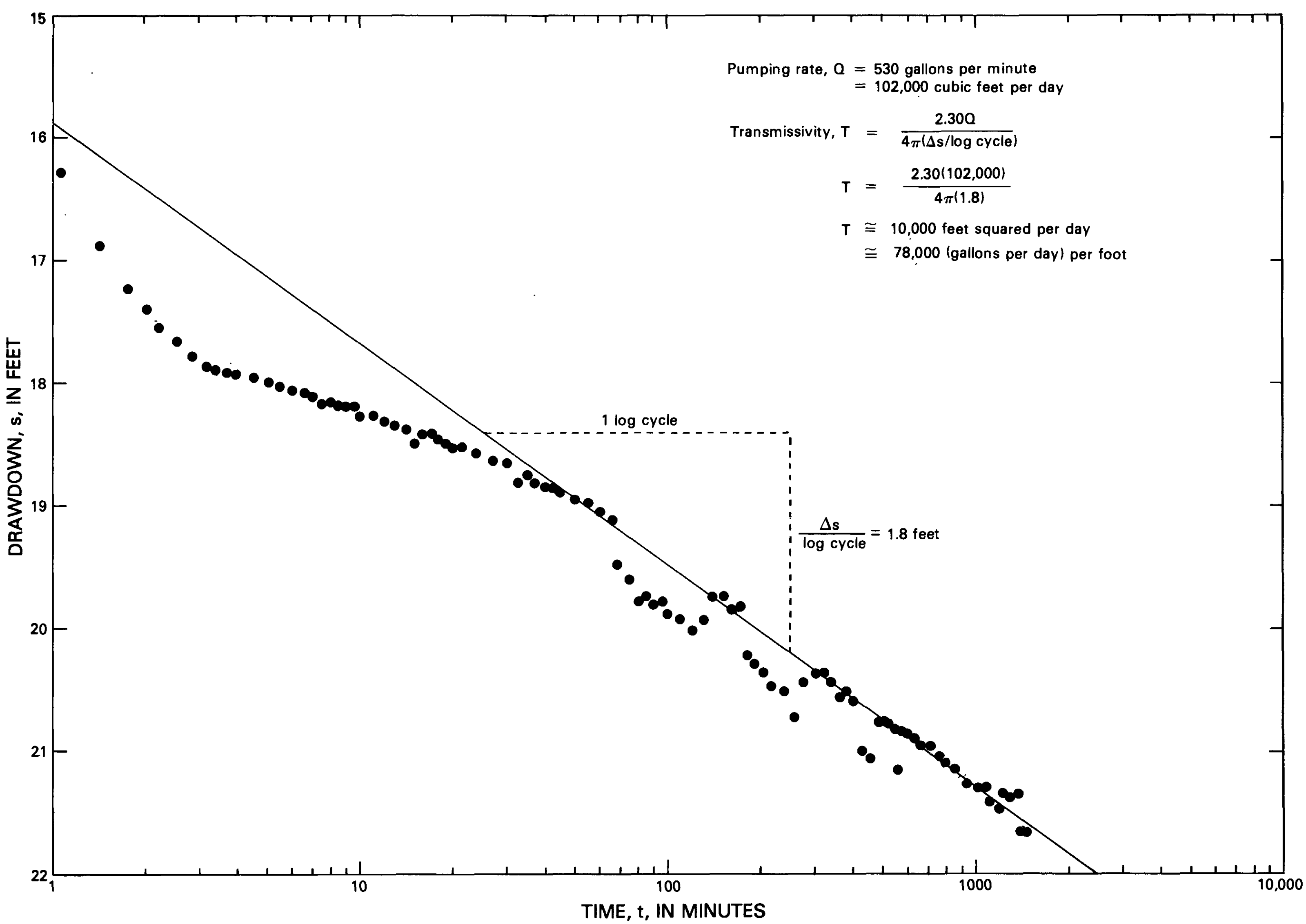

Figure 16.--Results of pumping phase of aquifer test using town of Meeker municipal well B-5, September 20 to 21, 1982.

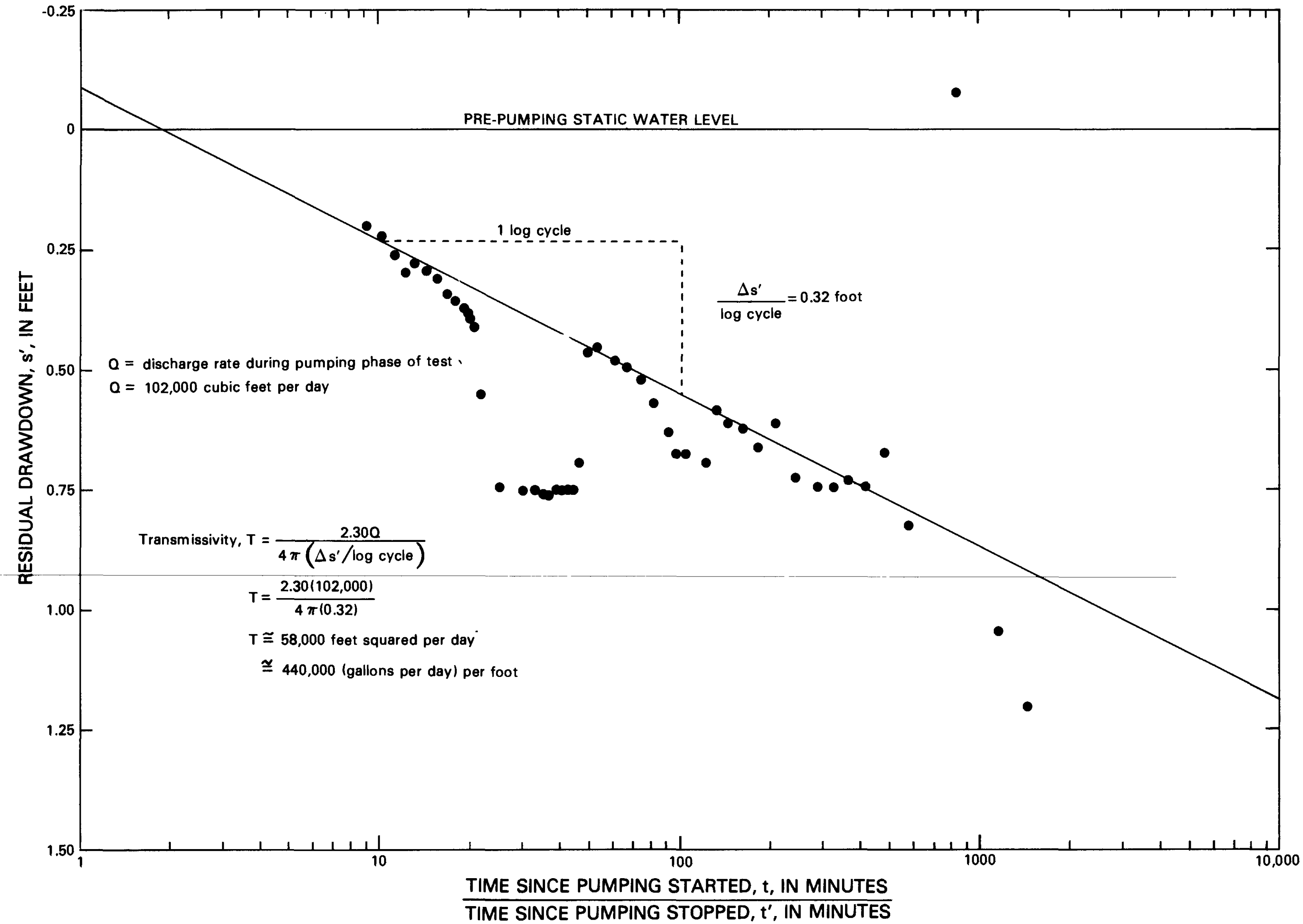

Figure 17.--Results of recovery phase of aquifer test using town of Meeker municipal well B-5, September 21, 1982.

Well BC-1

Well BC-1 was drilled by the cable-tool method in 1978 and provides a domestic supply of water to the Brian Conrado residence. Aquifer testing using this well was conducted by U.S. Geological Survey personnel in January 1981. The well is reportedly 60 ft deep and is cased with steel pipe, perforated from 5 to 50 ft in depth. Detailed lithologic information is not available for this well. The results of the aquifer test are shown in figures 18 and 19.

Test Hole IS-1

Test hole IS-1 was drilled in March 1983 by the rotary method using bentonitic slurry and a synthetic "mud" as drilling fluids. Fine-grained sediments were encountered from land surface to 6 ft, underlain by gravel and sand from 6 to 22 ft in depth. Bedrock was encountered at 22 ft; total depth of the test hole was 27 ft (fig. 20). After completion of drilling, the test hole was developed with air. Reported yield was about 300 gal/min. Perforated PVC casing then was installed from land surface to 17.9 ft in depth. Four days after drilling and development, the water level in the test hole was 5.46 ft below land surface.

On March 30, 1983, test hole IS-1 was pumped for 2 hr at 25 gal/min and allowed to recover for 2 hr. On the basis of water-level measurements obtained during pumping, transmissivity was calculated to be 3,300 ft^2/d (fig. 21). Transmissivity was not calculated from the recovery phase plot (fig. 22) because of violations of the assumptions inherent in the method of analysis. A "best-fit" straight line drawn through the data from $^{t}/_{t'} \cong 3$ to $^{t}/_{t'} \cong 150$ does not pass through $s' = 0$ at $^{t}/_{t'} = 1$; furthermore, the data at the smallest observed values of $^{t}/_{t'}$ do not fit such a straight line. This may be indicative of effects of storage in the well bore, and data at later times (that is, smaller values of $^{t}/_{t'}$) are needed to calculate transmissivity.

Angora Cross Section

Six test holes were drilled through the alluvium into bedrock in the White River valley near Angora by U.S. Geological Survey personnel in June 1981 (fig. 5). Test holes A-1, A-2, and A-3 were drilled by the rotary method using bentonitic slurry as drilling fluid; test holes A-1a, A-2a, and A-3a were drilled with 4-in. diameter, continuous-flight, solid augers. After completion of the drilling of each hole, casing was installed to the total depth of the remaining open hole. Some caving occurred in the sand and gravel zone. The rotary-drilled holes were cased with 4½-in. diameter, slotted, fiberglass pipe. The augered holes were cased with 2-in. diameter PVC pipe with hacksaw-cut perforations over selected intervals.

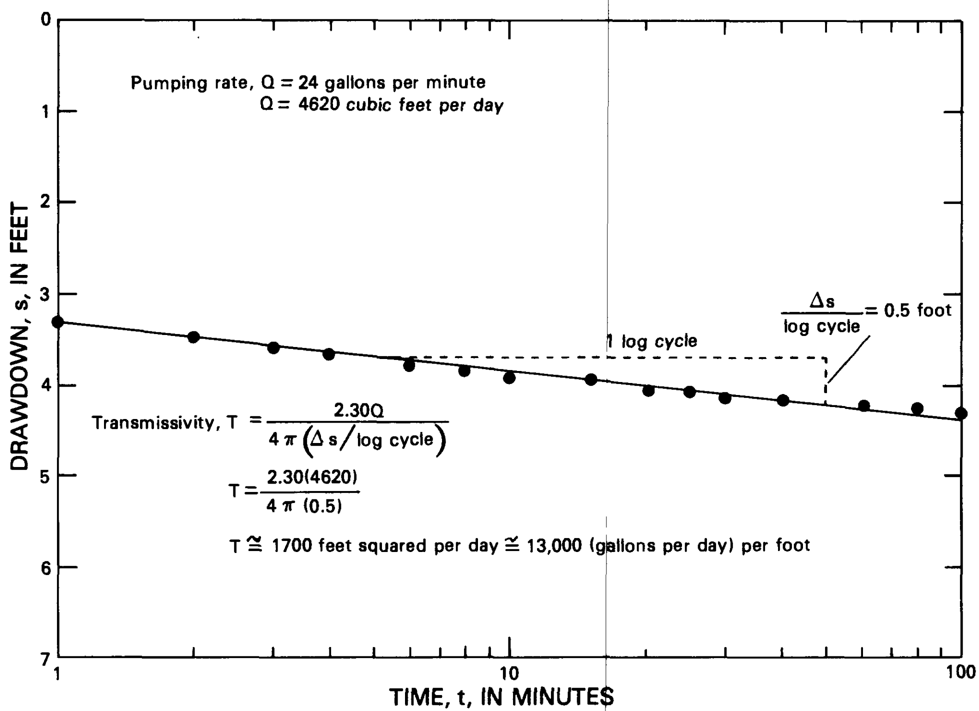

Figure 18.--Results of pumping phase of aquifer test using well BC-1, January 28, 1981.

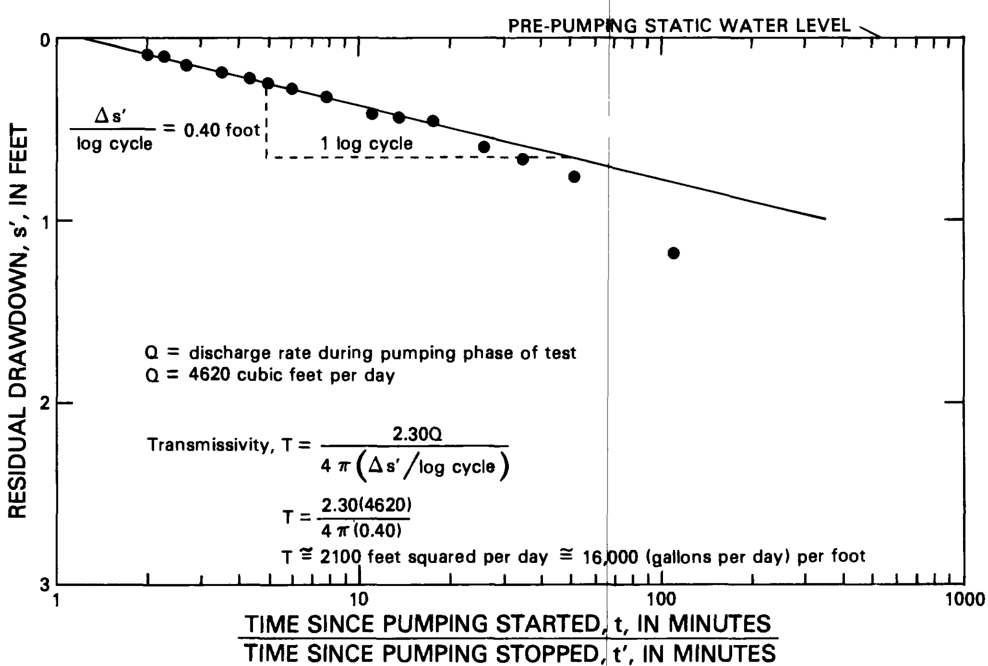

Figure 19.--Results of recovery phase of aquifer test using well BC-1, January 28, 1981.

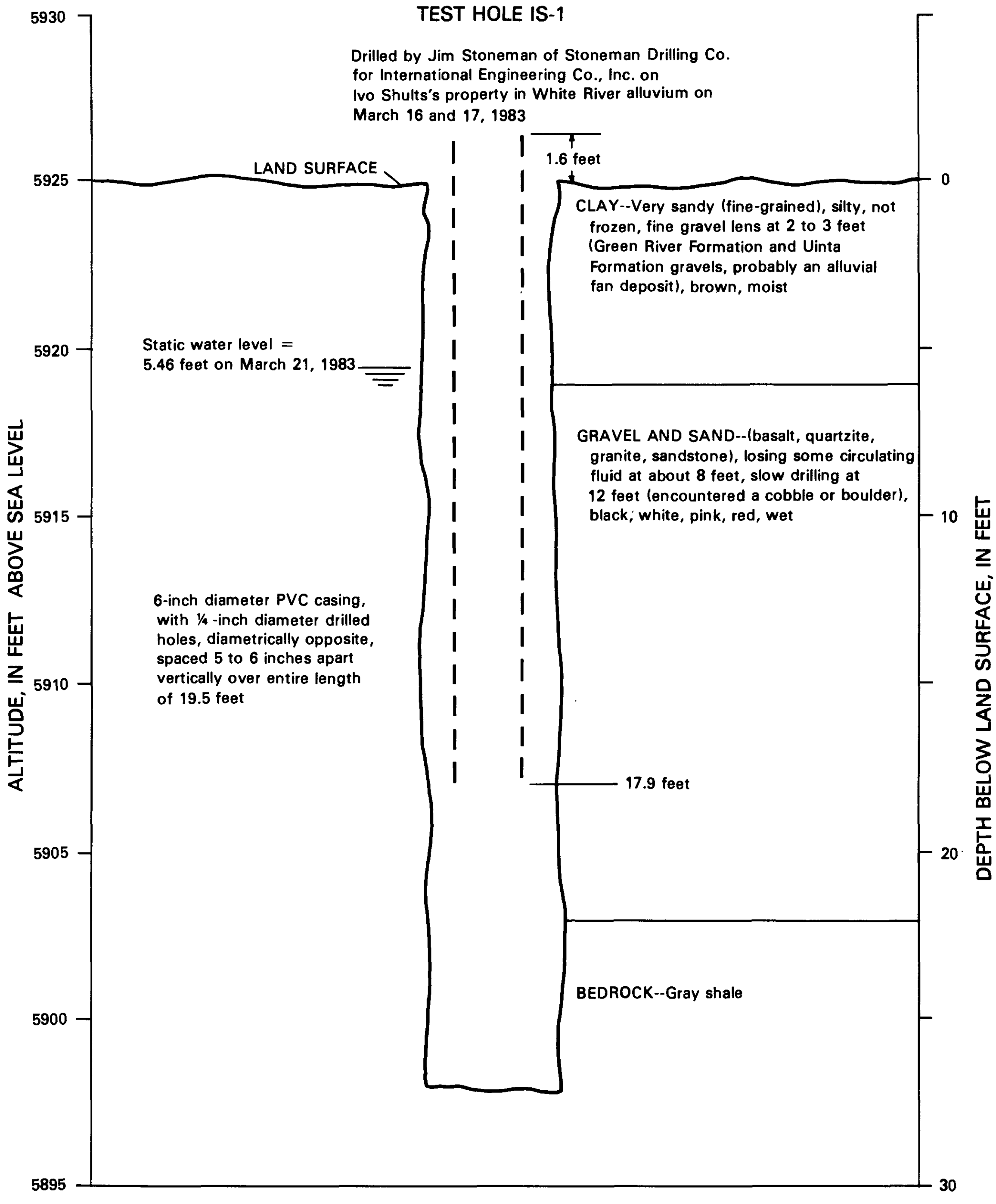

Figure 20.--Well completion of test hole IS-1, and lithology of sediments penetrated during drilling.

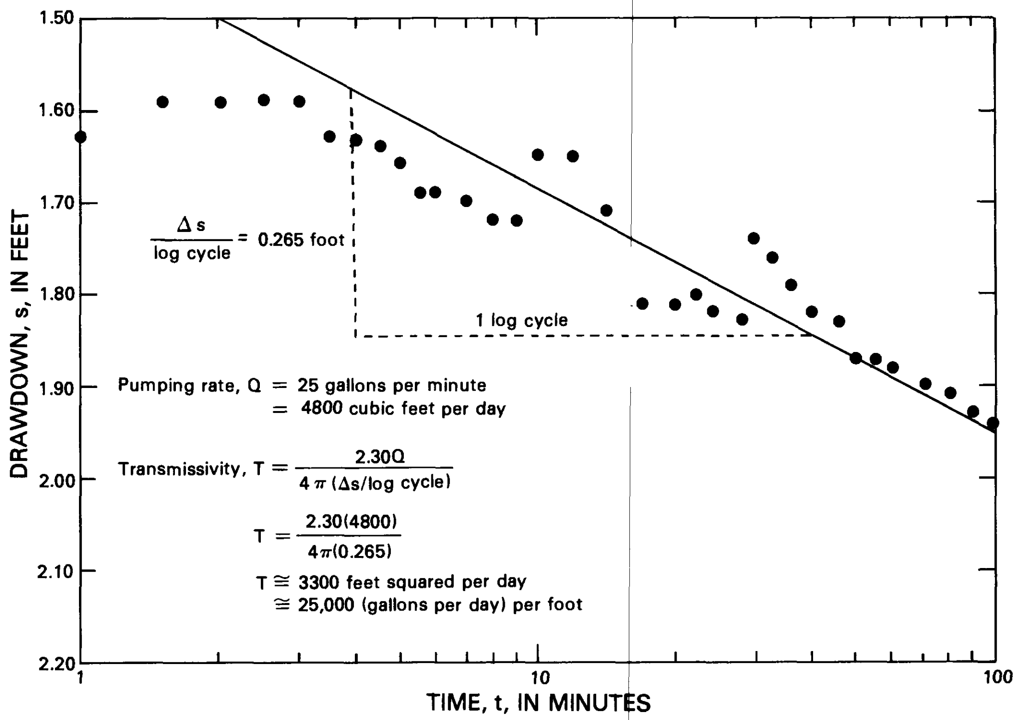

Figure 21.--Results of pumping phase of aquifer test using test hole IS-1, March 30, 1983.

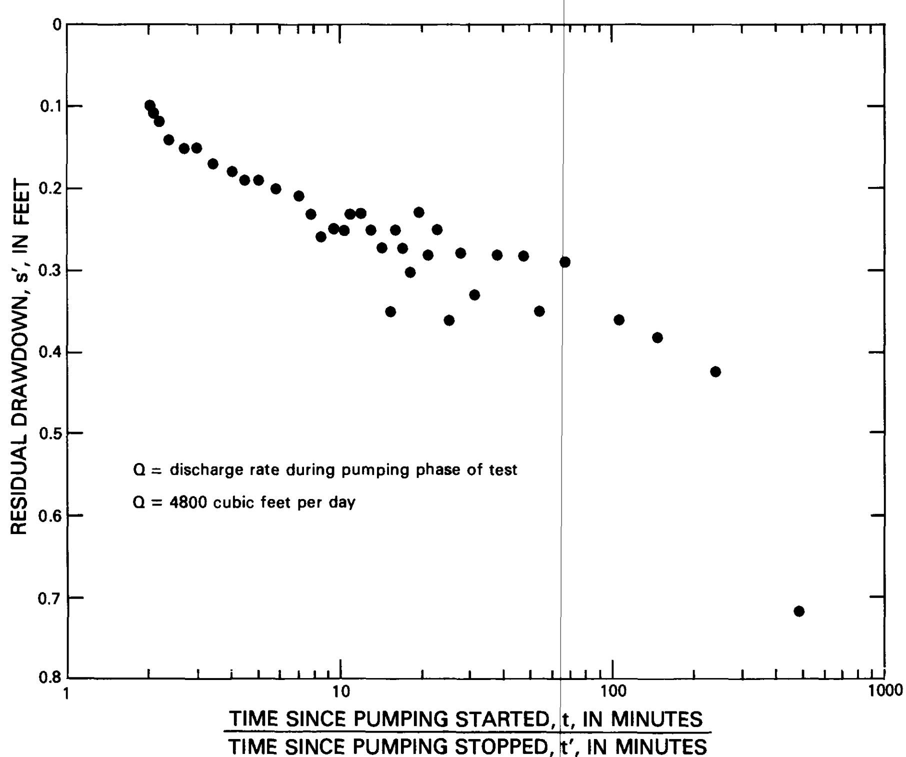

Figure 22.--Data from recovery phase of aquifer test using test hole IS-1, March 30, 1983.

Depth to static water level was measured in April 1982 in each of the six test holes. In all six holes, the altitude of the static water level was above the base of the surficial silty clay layer, indicating the presence of artesian conditions. The resultant potentiometric surface is shown in figure 5.

In February 1983, test hole A-2 was developed by pumping and intermittently returning the discharge into the test hole until the discharge water became colorless, indicating that the drilling mud had been flushed from the formation sediments. The aquifer was allowed to recover overnight, and then test hole A-2 was pumped for 1,210 min at 14 gal/min and allowed to recover for 1,530 min, while fluctuations in water level were monitored in the pumped test hole, A-2, and in the observation test holes, A-1, A-1a, and A-3.

Water-level changes due to pumping are shown in figure 23. No measurable drawdown occurred in test hole A-3; therefore, it is not shown. Total drawdown in test hole A-1 was only 0.19 ft, which is of limited value in computing the hydraulic parameters of the aquifer. Therefore, only test holes A-1a and A-2 were used in the aquifer test analysis presented herein. The well-completion status of these two test holes when the aquifer test was conducted is shown in figure 24.

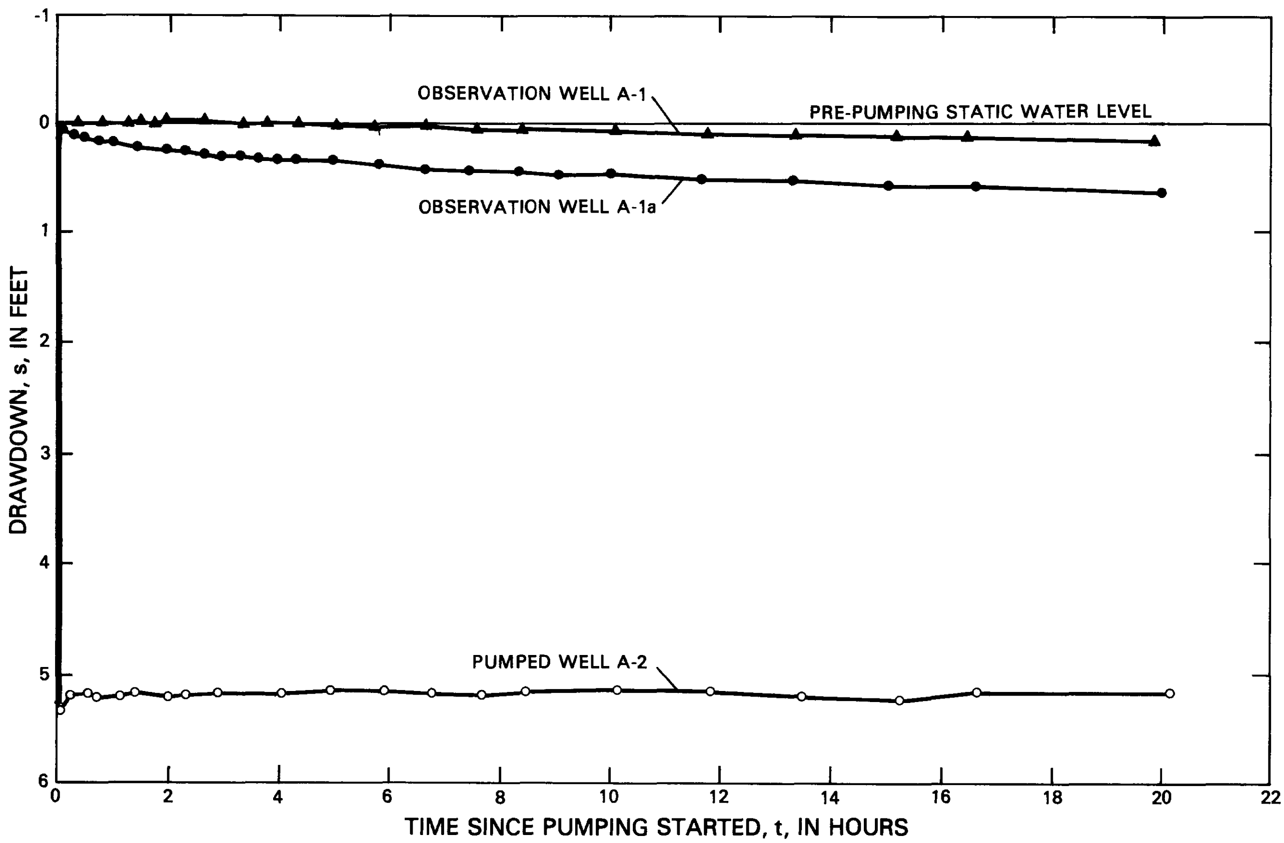

Figure 23.--Water-level changes during test pumping of well A-2 near Angora, February 11 to 12, 1983.

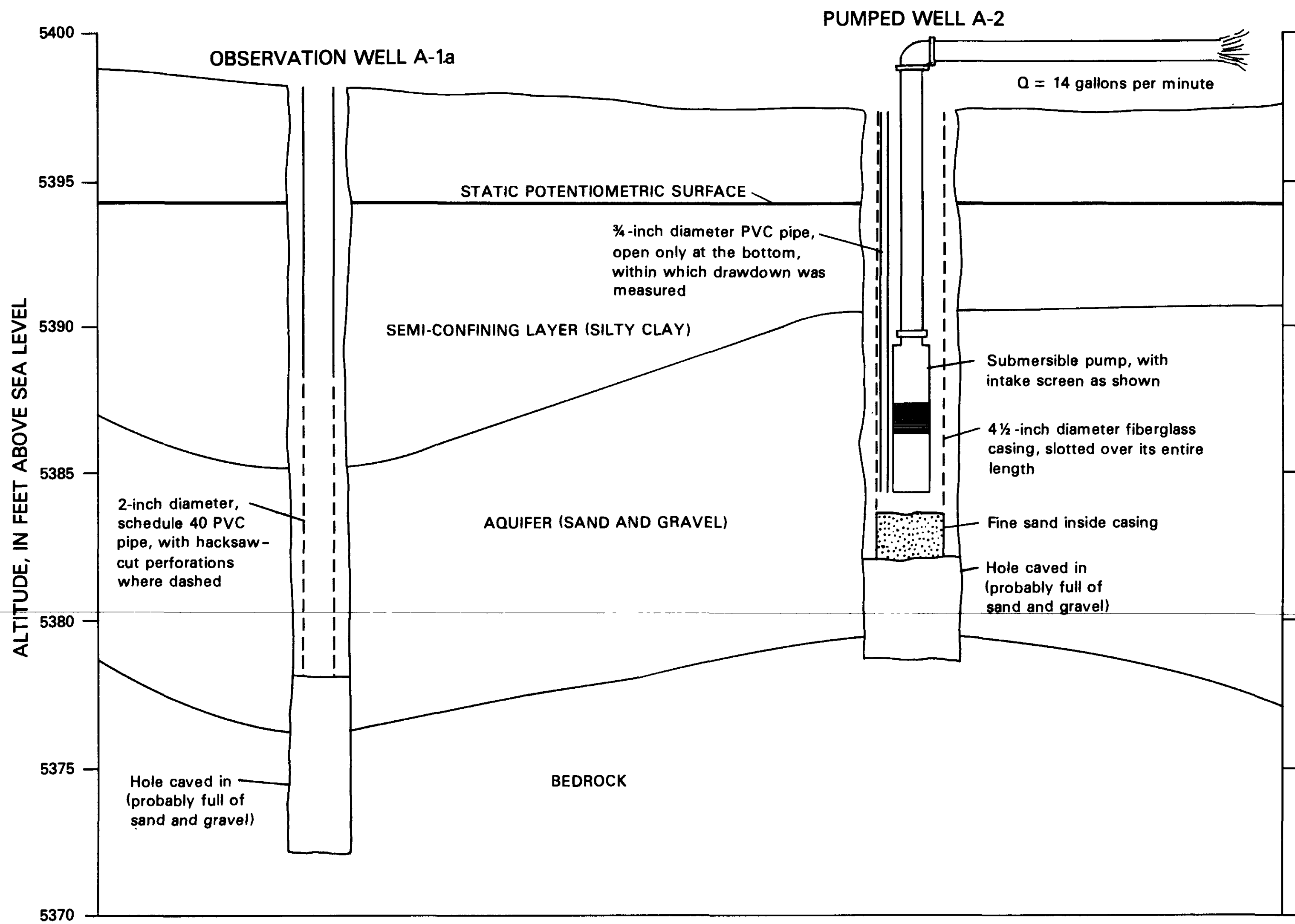

Figure 24.--Well completion for aquifer test near Angora.

The results of the analysis of the aquifer test are shown in figure 25. Transmissivity is calculated to be 860 ft^2/d and storage coefficient is computed as $6x10^{-5}$. About 5.3 ft of drawdown occurred in the pumped well about 1 min after pumping started and drawdown soon stabilized at 5.2 ft (fig. 23), indicating that the sand and gravel aquifer may have been recharged by leakage from the fine-grained sediments overlying it. The close match of the drawdown curve from observation well A-1a to the leaky artesian type curve at β=1.5 confirms this theory (fig. 25). Measurable drawdown first occurred in observation well A-1 after about 200 min of pumping. Therefore, the departure of the data from the type curve after about 300 min of pumping probably is due to the fact that the cone of depression had intercepted the relatively impermeable bedrock at the valley side (fig. 5). The result is that the aquifer cannot be treated as infinite in areal extent, and drawdown is greater than the theoretical drawdown predicted by the type curve for an infinite aquifer.

The data were fit to a leaky artesian curve with storage in the confining bed, which is one of a family of curves for different values of β. The β value is an indicator of the properties of the confining, fine-grained sediments. Specifically:

$$\beta = \frac{r}{4b}\left(\sqrt{\frac{K'S_s'}{KS_s}}\right),$$

where, in any consistent units,

- r = radial distance from the pumped well,
- b = thickness of the aquifer,
- K' = hydraulic conductivity of the confining layer,
- S_s' = specific storage of the confining layer (storage coefficient per vertical unit of thickness),
- K = hydraulic conductivity of the aquifer, and
- S_s = specific storage of the aquifer.

From this equation, $K'S_s' \cong 7x10^{-5}$, which is an indication of the hydraulic properties of the surficial fine-grained alluvium.

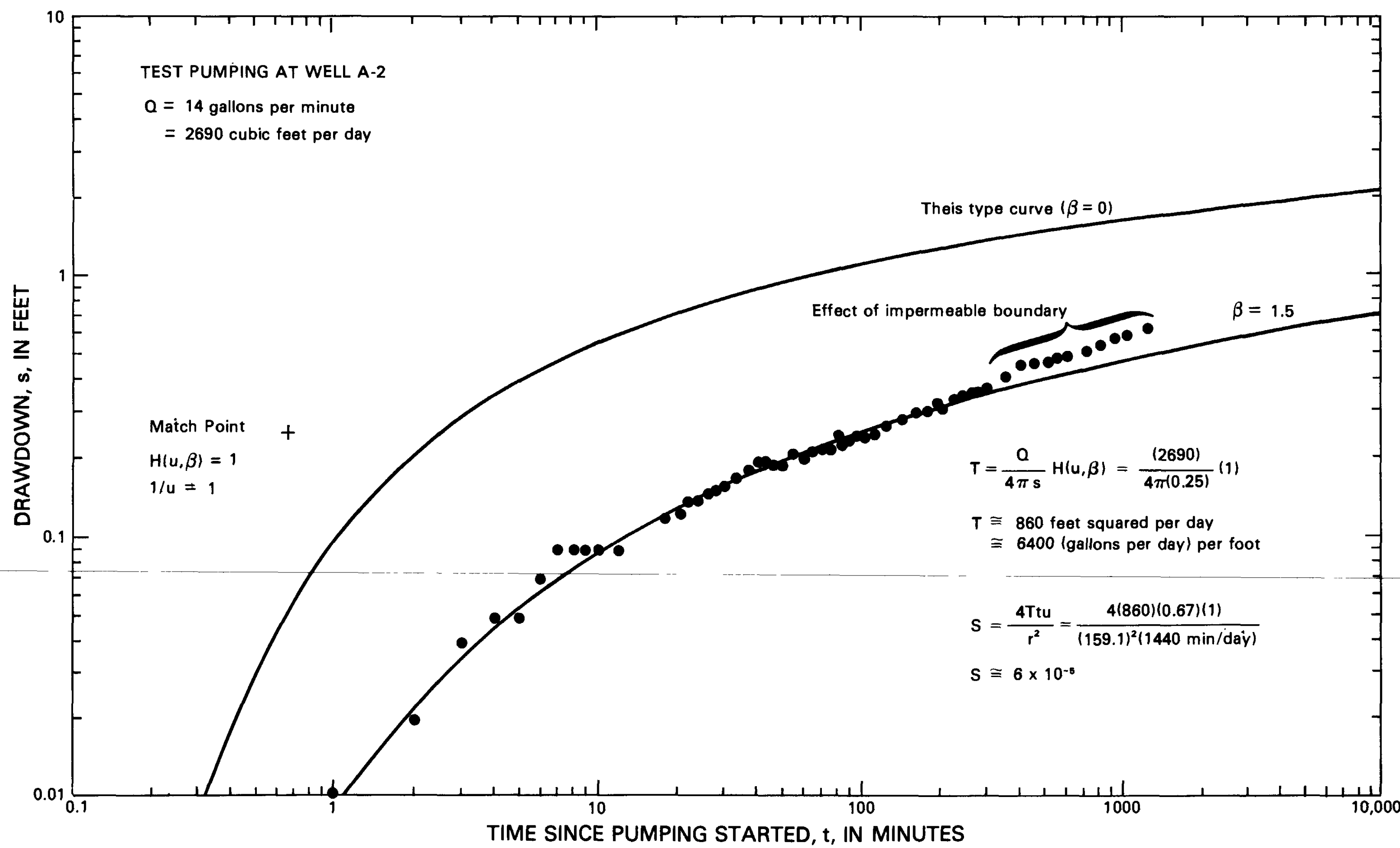

Figure 25.--Results of aquifer test using observation well A-la.

Tabulated Water-Quality Data

Table 10.--*Water-quality data of ground-water samples*

[m-d-y = month, day, year; °C = degrees Celsius; μmho = micromhos per centimeter at 25° Celsius; mg/L = milligrams per liter; μg/L = micrograms per liter; --- = no data]

Site number (plate 2)	Location within township, range, and section	Date of sample (m-d-y)	Water temperature (°C)	pH (standard units)	Specific conductance (μmho)	Dissolved solids, sum of constituents (mg/L)	Calcium, dissolved (mg/L as Ca)	Sodium, dissolved (mg/L as Na)	Sodium adsorption ratio
[1]4	SC00109303BBB1	03-01-76	---	7.7	---	290	78	20	0.6
[1]5	SC00109303BBB2	01-08-76	---	8.0	---	330	78	20	.5
[1]6	SC00109303BBB3	01-21-76	---	7.4	---	340	91	15	.4
[1]7	SC00109303BBB4	03-01-76	---	7.8	---	270	76	20	.6
10	SB00109333DCD1	09-21-82	9.0	8.0	564	372	87	11	.3
41	SB00109428DBD1	06-29-81	10.6	7.4	2,620	2,170	250	170	2.0
75	SB00109526BCC1	04-11-83	5.5	7.4	643	405	82	27	.7
89	SB00109531ACC1	03-30-83	5.5	8.0	675	438	66	52	1.6
119	SB00210001ABB3	02-12-83	6.5	7.6	3,340	2,330	110	580	10
[2]138	SB00210111CAC1	11-07-80	11	7.6	3,850	2,590	184	610	10
Proposed Taylor Draw reservoir dam axis[3]	SB00210127D[4]	04-05-83	8.0	8.4	8,640	5,760	33	1,700	23
	SB00210127D[5]	04-05-83	6.0	8.3	2,090	1,290	15	380	12
	SB00210127D[6]	04-05-83	11.0	8.4	7,720	4,460	11	1,700	58

Table 10.--*Water-quality data of ground-water samples*--Continued

Site number (plate 2)	Magnesium, dissolved (mg/L as Mg)	Potassium, dissolved (mg/L as K)	Bicarbonate, (mg/L as HCO_3)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Nitrogen, $NO_2 + NO_3$ dissolved (mg/L as N)	Nitrogen, NH_4 dissolved (mg/L as N)
[1]4	8.0	---	175	95	<1	0.1	19	[7]1.1	---
[1]5	16	---	190	95	14	.2	22	[7].8	---
[1]6	10	---	200	100	<1	.2	21	[7].6	---
[1]7	5.4	---	165	90	<1	.1	18	[7]1.2	---
10	19	1.2	222	120	4.5	.1	18	.27	<0.06
41	190	3.8	476	1,200	70	.2	20	7.8	.10
75	21	1.1	268	110	14	.2	17	<.10	<.02
89	19	1.7	220	160	16	.2	14	<.10	.09
119	81	4.0	895	930	160	.3	17	<.10	.31
[2]138	58	26	708	1,170	202	.6	---	[7]<.01	---
Proposed Taylor Draw reservoir dam axis[3]	230	3.9	760	2,100	1,300	.4	12	<.10	.69
	34	1.6	337	510	170	.5	10	<.10	.27
	33	5.1	935	540	1,700	1.1	11	<.10	1.0

Table 10.--*Water-quality data of ground-water samples*--Continued

Site number (plate 2)	Nitrogen, NH_4 + organic, dissolved (mg/L as N)	Phosphorus, ortho, dissolved (mg/L as P)	Alkalinity, (mg/L as $CaCO_3$)	Hardness, (mg/L as $CaCO_3$)	Hardness, noncarbonate (mg/L as $CaCO_3$)	Boron, dissolved (μg/L as B)	Iron, dissolved (μg/L as Fe)	Manganese, dissolved (μg/L as Mn)	Strontium, dissolved (μg/L as Sr)
[1]4	---	0.07	145	230	85	---	<50	<50	---
[1]5	---	<.03	150	260	110	---	<50	<50	---
[1]6	---	---	165	270	100	---	<50	<50	---
[1]7	---	<.03	135	210	75	---	<50	<50	---
10	0.7	.03	182	300	110	20	6	4	830
41	1.1	.01	390	1,400	1,000	200	120	---	---
75	.6	.05	220	290	73	20	---	---	640
89	.9	.02	180	240	65	40	---	---	660
119	1.0	<.01	734	610	0	740	---	---	1,500
[2]138	---	---	580	700	120	---	350	---	---
Proposed Taylor Draw reservoir dam axis[3]	1.6	.05	623	1,000	410	390	---	---	1,800
	.8	.02	276	180	0	140	---	---	380
	2.1	.09	766	160	0	620	---	---	870

[1]Data from Wright-McLaughlin Engineers, 1976; laboratory analyses by the Industrial Laboratories Co., Denver, Colo.

[2]Data from Ford, Bacon & Davis Utah, Inc., 1981; laboratory analyses by Ford Chemical Laboratory, Inc., Salt Lake City, Utah.

[3]Three separate samples were obtained from the site of the proposed Taylor Draw reservoir dam axis. A pit had been dug across the White River valley to bedrock to construct the dam foundation. The excavation was being dewatered by means of several wells and two sump pumps. The location of the excavation is at the site of cross-section I-I' (pls. 2 and 4).

[4]Sample collected from discharge pipe from three dewatering wells on upstream side of excavation and from sump pump at base of excavation, combined. Discharge was 150 gallons per minute. Quality of water may be affected by bedrock.

[5]Sample collected from water percolating into aforementioned sump from west side of excavation. Quality of water may reflect percolation from river channel.

[6]Sample collected from sump at east side of excavation. Water was coming from a hole in bedrock. Strong hydrogen-sulfide odor was noticed.

[7]Nitrogen, NO_3 only, dissolved (mg/L as N).