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GEOLOGY AND WATER RESOURCES OF THE SPANISH VALLEY AREA, GRAND AND SAN JUAN COUNTIES, UTAH

by

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ABSTRACT

The Spanish Valley area covers about 144 square miles on the western slopes of the La Sal Mountains in southeastern Utah; within it, Spanish Valley comprises about 18 square miles. Altitudes of land surface within the area range from about 3,950 feet at the Colorado River near Moab to 12,646 feet at Mount Mellenthin in the La Sal Mountains. Principal streams in the area are Mill and Pack Creeks; they join near Moab, and Mill Creek enters the Colorado River.

The climate ranges from arid and semiarid in the canyons and valleys at lower altitudes to generally humid and cool in the higher parts of the La Sal Mountains. The precipitation at Moab is fairly evenly distributed throughout the year, but slightly more falls during the winter than during the summer. Mean annual precipitation is about 8 inches at the city of Moab in Spanish Valley, and the weighted normal annual precipitation on the entire Spanish Valley area is about 15 inches.

Sedimentary formations exposed in the area range in age from Middle Pennsylvanian to Holocene, attaining a total maximum exposed thickness of nearly 6,400 feet. They are intruded by igneous stocks, laccoliths, sills, and dikes of Tertiary age which form the La Sal Mountains. The unconsolidated valley fill of Pleistocene and Holocene age in Spanish Valley attains a maximum thickness of more than 360 feet.

Little of the precipitation on Spanish Valley enters the ground-water system. Snowfall in the upland areas melts slowly and contributes most of the ground-water recharge by movement through sandstones of the Glen Canyon Group to the valley fill of Spanish Valley. Ground water occurs under water-table conditions in the valley fill, which consists generally of gravelly sand. The long-term specific yield of the valley fill is estimated to be about 0.25, and total ground-water storage about 200,000 acre-feet. Aquifer characteristics vary throughout the valley. Well yields may be as much as 1,000 gallons per minute with but 35 feet of drawdown in the valley fill. Where sandstones of the Glen Canyon Group are intensely fractured northeast of Spanish Valley, they yield large quantities of ground water to springs and wells.

Inflow to the Spanish Valley area is about 115,000 acre-feet annually from precipitation; of this, about 28,000 acre-feet is discharged annually from Spanish Valley by surface streams and from the ground-water reservoir, and the remainder is discharged by evapotranspiration in the Spanish Valley area.

Annual recharge to and discharge from the ground-water basin in Spanish Valley are estimated to be 14,000 acre-feet. Only 3,300 acre-feet is used for beneficial purposes in the valley. Of the remainder, ground-water outflow to the Colorado River is estimated to be 8,000 acre-feet, and about 3,000 acre-feet is consumed in an area of phreatophytes and hydrophytes.

Predictions of the effects of water levels that would be caused by continuation of withdrawals at nearly the 1969 rate or by a threefold increase in rate of withdrawal were made by means of an electric analog model of Spanish Valley. The predictions indicate that existing water levels in the valley would be least affected if any additional withdrawal of ground water were at the northwest end of the valley. The additional amount of ground water which could be diverted for beneficial use from present consumptive use in the area of phreatophytes and hydrophytes is estimated to be 190 acre-feet per year.

The chemical quality of water in the Spanish Valley area is generally good. Mill Creek contains water of better chemical quality than does Pack Creek, but both are used as a source of water for irrigation. Ground water in the valley fill in the southeast part of Spanish Valley contains the greatest concentration of dissolved solids in the area and is not suitable for public supply. Ground water entering Spanish Valley from the northeast through sandstones of the Glen Canyon Group is of suitable chemical quality for public supply. Natural mixing of the two types of water results in a progressive northwestward decrease in the concentration of dissolved solids in the ground water in the valley fill.

INTRODUCTION

Location and extent of the area

The Spanish Valley area covers about 144 square miles on the western slopes of the La Sal Mountains in southeastern Utah; within it, Spanish Valley comprises about 18 square miles. Altitudes of land surface within the area range from about 3,950 feet at the Colorado River near Moab to 12,646 feet at Mount Mellenthin in the La Sal Mountains. Principal streams in the area are Mill and Pack Creeks; they join near Moab, and Mill Creek enters the Colorado River.

The Mill Creek-Pack Creek drainage basin extends from southeast to northwest between a drainage divide along the lofty crests of the La Sal Mountains and a base level at the meanders of the turbid Colorado River. The drainage basin covers about 144 square miles in southeastern Utah (pl.1).

At the west edge of the drainage basin, the elongate, crag-walled trough that forms Spanish and Moab Valleys covers about 18 square miles. The northwestern, topographically lower, part of the trough in the vicinity of the city of Moab is known as Moab Valley, and the southeastern part of the trough is known as Spanish Valley. Spanish and Moab Valleys are not topographically or geologically separable; they are in this report referred to as Spanish Valley, and the entire Mill Creek-Pack Creek drainage basin, for purposes of this report, is referred to as the "Spanish Valley area."

The area is within Tps. 25-28 S., Rs. 21-24 E., Salt Lake Base Line and Meridian. It is covered by the following U.S. Geological Survey 15-minute topographic quadrangle maps: Moab, Utah; Castle Valley, Utah; Polar Mesa, Utah-Colo.; La Sal Junction, Utah; and La Sal, Utah-Colo. (p. 1).

U.S. Highway 160 traverses Spanish Valley and passes through the city of Moab. Many secondary and unpaved roads provide access to nearly all parts of the Spanish Valley area. About 245 miles of major State and Federal highways link the area with Salt Lake City.

Purpose and scope

This water-resources investigation was initiated in order to provide an estimate of the average annual water yield of the Mill Creek-Pack Creek drainage basin, the parts of that total yield available as surface water and ground water, the amount of ground water that might be recovered for beneficial use, and the effect of this use on the usable ground-water storage within the valley fill in Spanish and Moab Valleys. Detailed information has been sought which is basic to the establishment of sound policies for the development and management of water resources. The investigation was carried out as part of water-resources investigations in Utah with the Utah Division of Water Rights, Department of Natural Resources. Fieldwork was done during the period July 1967-November 1969.

Previous investigations

A general description of the geology and possibilities of oil occurrence in part of the Spanish Valley area, including some references to water, is given by Baker (1933).

The structural and igneous geology of the La Sal Mountains is described in detail by Hunt (1958).

Quaternary stratigraphy and the Pleistocene-Holocene physiographic development of the La Sal Mountains area, including Spanish Valley, is given a detailed analytical description by Richmond (1962).

A regional study of the Upper Colorado River Basin by Iorns, Hembree, and Oakland (1965) supplies basic data and summarizes the quantitative and qualitative hydrology of a region in which Spanish Valley is centrally located.

A reconnaissance survey of regional ground-water data by Feltis (1966) describes the occurrence and quality of water in bedrock aquifers of eastern Utah, including the Spanish Valley area.

Acknowledgments

Cooperation and assistance by H.D. Donaldson, H.E. Staker, and others in the Utah Division of Water Rights is gratefully acknowledged. Appreciation is due many residents of Moab and Spanish Valley for their gracious contributions of information and other assistance.

Well- and spring-numbering system

The system of numbering wells and springs in Utah is based on the cadastral land-survey system of the Federal Government, and the number describes the location of the well or spring within the land net. By this system, the State is divided into four quadrants by the Salt Lake Base Line and Meridian. The quadrants are designated A, B, C, and D; indicating the northeast, northwest, southwest, and southeast quadrants, respectively. The quadrant letter is followed by numbers indicating the township and range (in that order); the quadrant letter, township, and range are separated by dashes and enclosed in parentheses. A number following the parentheses designates the section, and is followed by three letters indicating the quarter section (generally 160 acres), quarter-quarter section (40 acres), and quarter-quarter-quarter section (10 acres) in which the well or spring is located. A number following the section subdivisions is the serial number of the particular well or spring in the given 10-acre tract; springs are designated by the letter S preceding the serial number. If a well or spring cannot be located to the nearest 10 acres, the serial number is omitted; but the S designating a spring is retained at the end of the number. Thus well number (D-26-21)1bda-1 is the first well constructed or visited in the NE¼SE¼NW¼ sec. 1, T. 26 S., R. 21 E. The well- and spring-numbering system is illustrated in figure 1.

Use of metric units

In this report, concentrations of dissolved solids and individual ions determined by chemical analysis and the temperatures of air and water are given in metric units. This change from reporting in English units has been made as a part of a gradual change to the metric system that is underway within the scientific community. The change is intended to promote greater uniformity in reporting of data. Chemical data for concentrations are reported in milligrams per liter (mg/l) rather than in parts per million (ppm), the units used in earlier reports in this series. For concentrations less than 7,000 mg/l, the number reported is about the same as for concentrations in parts per million.

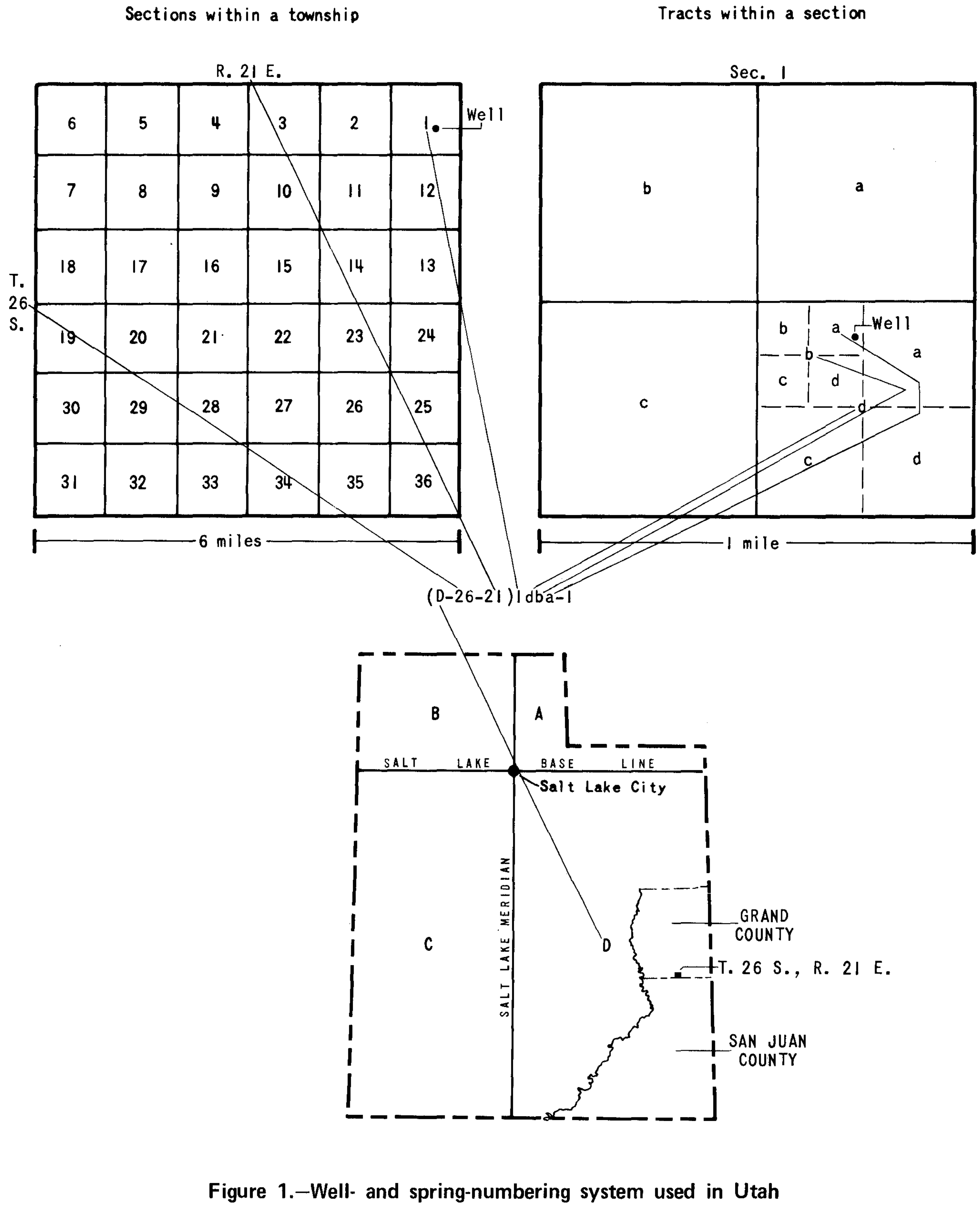

Figure 1.—Well- and spring-numbering system used in Utah

Water temperature is reported in degrees Celsius (°C), but the customary English unit of degrees Fahrenheit (°F) follows in parentheses in the text. Air temperature is reported in °F, but the equivalent temperature in °C follows in parentheses in the text for easier comparison with water temperature in tables. The reporting of temperatures in both metric and English units is done to assist those readers who are not familiar with the Celsius temperature scale. The following conversion table will also help to clarify the relation between degrees Fahrenheit and degrees Celsius:

TEMPERATURE-CONVERSION TABLE

Temperatures in °C are rounded to nearest 0.5 degree. Underscored temperatures are exact equivalents. To convert from °F to °C where two lines have the same value for °F, use the line marked with an asterisk (*) to obtain equivalent °C.

°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
-20.0	-4	-10.0	14	0.0	32	10.0	50	20.0	68	30.0	86	40.0	104
-19.5	-3	-9.5	15	+0.5	33	10.5	51	20.5	69	30.5	87	40.5	105
-19.0	-2	-9.0	16	1.0	34	11.0	52	21.0	70	31.0	88	41.0	106
-18.5	-1	-8.5	17	1.5	35	11.5	53	21.5	71	31.5	89	41.5	107
-18.0 *	0	-8.0 *	18	2.0 *	36	12.0 *	54	22.0 *	72	32.0 *	90	42.0 *	108
-17.5	0	-7.5	18	2.5	36	12.5	54	22.5	72	32.5	90	42.5	108
-17.0	1	-7.0	19	3.0	37	13.0	55	23.0	73	33.0	91	43.0	109
-16.5	2	-6.5	20	3.5	38	13.5	56	23.5	74	33.5	92	43.5	110
-16.0	3	-6.0	21	4.0	39	14.0	57	24.0	75	34.0	93	44.0	111
-15.5	4	-5.5	22	4.5	40	14.5	58	24.5	76	34.5	94	44.5	112
-15.0	5	-5.0	23	5.0	41	15.0	59	25.0	77	35.0	95	45.0	113
-14.5	6	-4.5	24	5.5	42	15.5	60	25.5	78	35.5	96	45.5	114
-14.0	7	-4.0	25	6.0	43	16.0	61	26.0	79	36.0	97	46.0	115
-13.5	8	-3.5	26	6.5	44	16.5	62	26.5	80	36.5	98	46.5	116
-13.0	9	-3.0	27	7.0	45	17.0	63	27.0	81	37.0	99	47.0	117
-12.5	10	-2.5	28	7.5	46	17.5	64	27.5	82	37.5	100	47.5	118
-12.0 *	10	-2.0 *	28	8.0 *	46	18.0 *	64	28.0 *	82	38.0 *	100	48.0 *	118
-11.5	11	-1.5	29	8.5	47	18.5	65	28.5	83	38.5	101	48.5	119
-11.0	12	-1.0	30	9.0	48	19.0	66	29.0	84	39.0	102	49.0	120
-10.5	13	-0.5	31	9.5	49	19.5	67	29.5	85	39.5	103	49.5	121

For temperature conversions beyond the limits of the table, use the equation C = 0.5556 (F - 32) and F = (1.8) (°C) + 32. The formulae say, in effect, that from the freezing point of water (0°C, 32°F) the temperature in °C rises (or falls) 5° for every rise (or fall) of 9°F.

GEOGRAPHY

Physiography and drainage

The Spanish Valley area is centrally located in the Canyon Lands section of the Colorado Plateaus physiographic province, as delineated by Fenneman and Johnson (1946). Marked contrasts in landforms and colors characterize the area, from the summits and slopes of the La Sal Mountains to the steep-walled canyons and the floor of Spanish Valley. Richmond (1962, p. 6) finds the area to have six physiographic subdivisions: (1) igneous mountains, (2) hogbacks, (3) plateaus, (4) cuestas, (5) pediments, and (6) canyons.

The high, eastern divide of the area is at or near the crest of the laccolithic La Sal Mountain group. The highest peak on the drainage divide is Mount Mellenthin, which reaches an altitude of 12,646 feet. Glaciation during Pleistocene and Holocene times has eroded cirques near the summits and deposited thin moraines on the higher slopes of the mountains.

The dioritic-intrusive stocks of Tertiary age exposed in the mountain groups are rimmed by hogbacks of Triassic and Jurassic sandstone formations. The hogbacks generally are covered by colluvium except at their ridge tops and where they are breached by transverse streams and canyons.

West of the mountains, the hogbacks give way to gently sloping cuestas and pediments, which are dissected by steep-walled sandstone canyons. Some of the west-trending canyons, such as the North Fork of Mill Creek, cross the generally northwest-trending structure of the area obliquely, suggesting superposition of the canyon streams on the sandstone strata from an earlier alluvial cover. The dissected cuestas and pediments yield to sandstone mesas adjacent to Spanish Valley.

Spanish Valley resembles a structural trough, but it has a more complex geologic history (Baker, 1933, p. 63-67). It contrasts in origin and in all dimensions with the deep meandering canyons that dissect the higher terrain. The rectilinear, northwest-trending valley is about 13½ miles in length and averages about 1½ miles in width. Its surface has an average slope of about 120 feet per mile.

Stream patterns are dendritic in the upper reaches of the Spanish Valley area. In lower parts of the area they assume a roughly parallel pattern, with the exceptions noted above, which appear to be related to regional structure. The lowest altutude is about 3,950 feet, at the Colorado River.

Climate

Topographic influence

The region about the La Sal Mountains is endowed with a broad range of climate. Differences in altitude and the influence of mountains on the movement of air masses and storms have more effect on the climate than does the small range of geographic latitude. Pacific air masses and storms dominate the regional weather during October-April; warm, moisture-laden air masses from the Gulf of Mexico may traverse the region in the summer. Summer weather produces less frequent but more intense storms.

The higher parts of the La Sal Mountains are comparatively wet and cool; their slopes and adjacent plateaus are drier and subject to wide variations in temperature diurnally and seasonally. The semiarid and arid canyons and valleys at lower altitudes, also subject to wide variations of diurnal and seasonal temperatures, endure hot, dry summers and cold winters which are almost equally dry.

Precipitation

The U.S. Environmental Science Services Administration[1] maintains a weather station about 4 miles northwest of Moab (Moab 4 NW) to record daily temperatures and precipitation. Mean annual precipitation at Moab 4 NW for the period 1900-68 is 8.18 inches (fig. 2). Precipitation figures for higher parts of the Spanish Valley area are interpolated from isohyetal maps prepared by the U.S. Weather Bureau (1963). Average precipitation over the drainage basin is given in table 1.

Table 1.—Average annual precipitation and potential evapotranspiration

Altitude, in thousands of feet	Percent of area	Average precipitation (in.)	Weighted average precipitation (in.)	Average potential evapotranspiration[1] (in.)	Weighted average potential evapotranspiration (in.)
11-12.6	2.7	32.0	0.9	24.0	0.7
10-11	6.5	28.7	1.9	26.4	1.7
9-10	7.1	24.2	1.7	28.6	2.0
8-9	9.6	20.1	1.9	31.0	3.0
7-8	16.0	16.2	2.6	33.6	5.4
6-7	11.6	12.8	1.5	36.5	4.2
5-6	26.8	10.3	2.8	43.1	11.5
3.9-5	19.7	8.6	1.7	53.6	10.6
Weighted mean			15.0		39.1

[1]Equivalent lake evaporation (Blaney and Criddle, 1962).

From May through September, average precipitation ranges from less than 4 inches near Moab to more than 10 inches in the La Sal Mountains; it falls mainly as locally occurring thunderstorms, which may produce flash floods in some small streams. Much of the winter precipitation falls as snow, particularly at higher altitudes in the La Sal Mountains. From October through April, average precipitation ranges from less than 6 inches near Moab to more than 20 inches at higher altitudes. The weighted mean annual precipitation in the Spanish Valley area is about 15 inches.

The greatest total annual precipitation recorded near Moab is 15.96 inches in 1918 and again in 1927; the least total annual precipitation recorded is 3.02 inches in 1956. Mean annual precipitation near Moab for 69 years of record (1900-1968) is 8.18 inches; mean monthly precipitation near Moab is shown in figure 2.

[1]Prior to July 1965, the U.S. Weather Bureau.

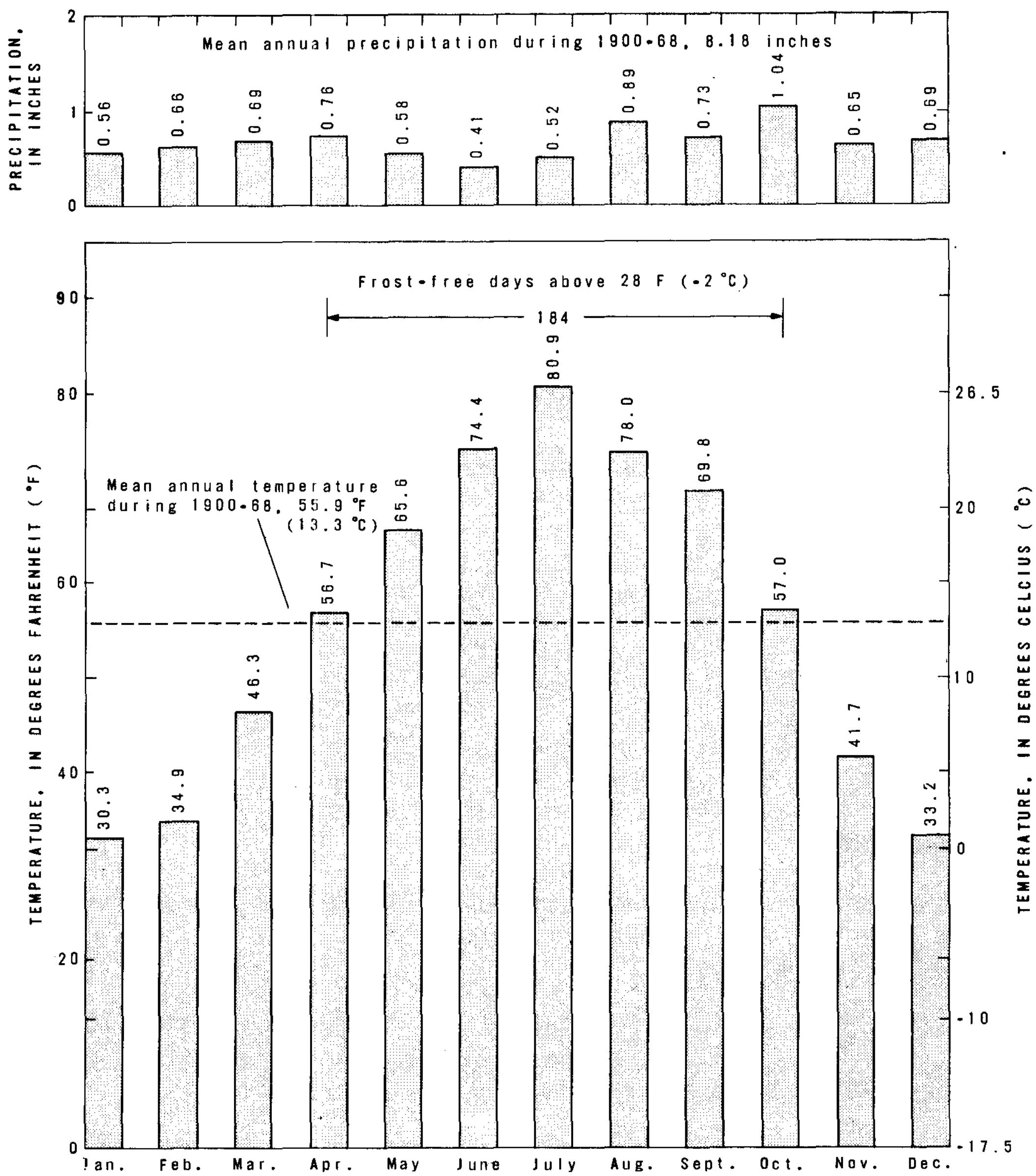

Figure 2.—Mean monthly and annual precipitation, temperature, and frost-free season at Moab (alt. 3,965 ft).

Temperature

Diurnal temperature changes near Moab are about 20°F (11°C) in winter and usually about 40°F (22°C) but may be as much as 50°F (28°C) during the summer. Daytime temperatures during the winter may be as high as 70°F (21°C), but often the temperature may not rise above freezing for as long as a week or more at a time. The lowest temperature recorded near Moab is -24°F (-31°C). During the summer, daytime temperatures may reach or exceed 100°F (38°C); the maximum recorded near Moab is 113°F (45°C). The mean annual temperature near Moab is 55.9°F (13.3°C); mean monthly temperatures near Moab are shown in figure 2.

Evapotranspiration

In the hydrologic regimen of a drainage basin, evapotranspiration constitutes the bulk of consumptive use (water loss). It includes water loss through transpiration by all types of vegetation and evaporation from land, vegetation, and water surfaces. Potential evapotranspiration is defined by Thornthwaite (1948, p. 55-94) as the water loss that will occur if there is no deficiency of soil water. Determination of potential evapotranspiration for the Spanish Valley area follows the method developed by Blaney and Criddle (1962).

Weighted mean annual potential evapotranspiration for the Spanish Valley area is about 39 inches (table 1). Potential evapotranspiration ranges from about 54 inches near Moab (below 5,000 ft) to about 24 inches near the summits of the La Sal Mountains (above 11,000 ft). These values for potential water loss are, of course, much greater than actual water loss, about 87,000 acre-feet per year, as there is a nearly continuous deficiency of soil water in this arid environment.

Vegetation

The differences in climate provided by nearly 8,700 feet of relief in the Spanish Valley area give rise to irregularly overlapping zones of vegetation related to prevailing temperatures and precipitation, and hence to altitude. On north-facing slopes the zones are lower and on south-facing slopes higher.

The lowermost zone, a sagebrush-grass association, ranges in altitude from less than 4,000 feet to about 7,000 feet. Phreatophytes are present along the Colorado River and the lower reaches of Mill Creek within this zone.

A mountain-brush zone ranging in altitude from about 5,500 to 9,500 feet consists of shrub types transitional between the sagebrush-grass association and coniferous forest. It includes a scrub oak-mountain mahogany climax and a pinyon-juniper climax.

From altitudes of about 8,000 to 11,500 feet are ill-defined zonations of montane and subalpine forest. These may be grouped as subalpine forest and consist mainly of an aspen-meadow climax and a spruce-fir climax.

Timberline ranges in altitude from about 11,000 to 11,500 feet. Above timberline to the mountain summits, an alpine-meadow or alpine-tundra zone prevails.

Vegetation species and associations typical of these zones are described in more detail by F.A. Branson (*in* Iorns and others, 1965, p. 80-81).

Population and economy

The first settlement of Spanish Valley was attempted in 1855 near the present site of Moab by 41 Mormon pioneers; their works included construction of an irrigation canal. Shortly after its inception, this settlement was abandoned for about 20 years, after which time the farming and grazing community was re-established. By 1879 two irrigation canals had been constructed to divert water from Mill Creek.

In 1950 the population of Moab was 1,274. Its economy stimulated by the nearly explosive growth of the mining industry, Moab attained a population of approximately 5,000 by 1956. By 1960 the population had decreased to 4,682. At the time of this water-resources investigation (1970), the population is reported to be about 6,500; and it is increasing due to a resurgence of mining activity, tourism, and other favorable economic factors.

GENERAL GEOLOGY

Throughout the Spanish Valley area geologic controls on all aspects of drainage-basin hydrology are readily apparent. Landforms affect the pattern and amount of precipitation. Relief and land-surface materials regulate runoff, infiltration, and evapotranspiration. Geologic structural and stratigraphic characteristics control the recharge and subsequent movement of ground water.

The sedimentary formations exposed in the area attain a maximum total thickness of nearly 6,400 feet. The oldest rocks exposed (near Moab) are contorted evaporites and shales in the Paradox Member of the Hermosa Formation of Middle and Upper Pennsylvanian age. The pliable Paradox rocks are not in proper stratigraphic position in this locality; they appear to have been extruded upward through fault zones at the northeast and southwest margins of Spanish Valley. Formations overlying the Paradox are in proper stratigraphic sequence and span geologic ages from Middle Pennsylvanian through Cretaceous. The La Sal Mountains represent igneous stocks, including laccoliths, sills, and dikes of Tertiary age injected through and into the stratigraphic sequence. Extensive surficial deposits of Quaternary age overlie the higher parts of the area as an irregular, discontinuous veneer. Quaternary deposits in Spanish Valley attain considerable thickness, over 360 feet in some places. The geologic formations are summarized in table 2.

This report deals with those geologic features most directly related to stream discharge and ground-water occurrence. More comprehensive geologic information, upon which many hydrologic interpretations in this report are based, is available in publications by Baker (1933), Hunt (1958), Richmond (1962), and Iorns and others (1965). A generalized geologic map of the Spanish Valley area is shown on plate 1.

Geologic structure

The La Sal Mountains are igneous structural domes; exposed at their summits are the stocks from which laccoliths, sills, and dikes originated. Sedimentary formations dip away from hogbacks that skirt the exposed stocks; their dips decrease with increased distance from the hogbacks, and the formations become nearly horizontal at some of the mesas adjacent to Spanish Valley.

Table 2.--Generalized geologic section for the Spanish Valley area

[Adapted from Hunt (1958), Richmond (1962), and Stokes (1964)]

System	Series	Group	Formation	Member	Thickness (ft)	Lithology and water-bearing characteristics
Quaternary	Holocene		Gold Basin Formation		0-360+	Eolian and fluvial silt and sand; rounded to subrounded gravel, cobbles, and boulders in a clean sandy matrix; poorly sorted angular to subangular alluvial-fan debris in a clayey, silty, and sandy matrix; terrace deposits; sandy colluvium; and glacial deposits in the high plateaus and mountain areas. In Spanish Valley, eolian and alluvial deposits or formations (undifferentiated) compose the principal water-bearing material and source of ground water.
			Unconformity			
	Pleistocene		Beaver Basin Formation			
			Unconformity			
			Placer Creek Formation			
			Unconformity			
			Harpole Mesa Formation			
			Unconformity			
Tertiary			Igneous intrusive rocks of the La Sal Mountains			Igneous rocks; mostly diorite, monzonite, and syenite porphyry that intrude older sedimentary formations as dikes, sills, stocks, and laccoliths. Precipitation may enter these rocks where they are intensely fractured and subsequently recharge adjacent permeable sedimentary rocks.
			Unconformity			
Cretaceous	Upper Cretaceous		Mancos Shale	Unnamed upper shale member	410-800+	Dark-gray and gray-brown marine shale with discontinuous thin beds of gray sandstone; relatively impermeable; does not yield water in this area.
				Ferron Sandstone Member		Tan and gray thin-bedded fine-grained sandstone and sandy shale, about 160 ft thick; permeable, but not known to yield water in this area.
				Unnamed lower shale member		Dark-gray and gray-brown marine shale with discontinuous thin beds of gray sandstone; relatively impermeable; does not yield water in this area.
	Lower Cretaceous		Dakota Sandstone		50-120	Rust-brown and yellowish-brown carbonaceous sandstone with interbeds of dark-gray siltstone and lenticular tan conglomeratic sandstone; permeable, but not known to yield water in this area.
			Unconformity			
			Burro Canyon Formation		50-250	Light-gray silicified sandstone; lenticular conglomeratic brownish-gray crossbedded sandstone with thin interbeds of green mudstone; and thin sparse beds of gray limestone; has a low intrinsic hydraulic conductivity, but yields water to springs where the beds are intensely fractured.
Jurassic	Upper Jurassic		Morrison Formation	Brushy Basin Shale Member	250-450	Variegated red, green, and purple mudstone with sandy clay; and greenish-gray bentonite with interbeds of conglomeratic sandstone; has a low intrinsic hydraulic conductivity and is not known to yield water in this area.
				Salt Wash Sandstone Member	60-220	Tan to gray well-sorted fluvial cross-bedded sandstone with interbeds of red and gray mudstone; permeable in part, but not known to yield water in this area.
			Unconformity			
		San Rafael Group	Summerville Formation		0-50	Red thin-bedded sandstone; red sandy mudstone; red shale; and thin gray limestone layers with some large gray-white to red chert concretions; has a low intrinsic hydraulic conductivity, and is not known to yield water in this area.
			Entrada Sandstone	Moab Member	300-550	Pale-tan to grayish-white massively cross-bedded medium-grained sandstone; permeable, but not known to yield water in this area.
				Slick Rock Member		Light-tan to red eolian sandstone; permeable, but not known to yield water in this area.
				Dewey Bridge Member		Light-red aqueous siltstone and fine-grained sandstone, contorted beds common; permeable, but not known to yield water in this area.
			Unconformity			
	Lower Jurassic	Glen Canyon Group	Navajo Sandstone		300-400	Pale yellowish-orange to pale reddish-brown fine- to medium-grained sandstone with eolian cross beds, and sparse thin lenticular beds of gray sandy limestone; intrinsic hydraulic conductivity not great, but yields water to wells and springs where intensely fractured.
Triassic(?)	Upper Triassic(?)		Kayenta Formation		230-270	Irregular beds of red, tan, gray, and lavender shale, siltstone, and sandstone; locally has thin- to medium-beds of tan-weathering gray silty limestone; an aquitard and permeable in part, but not known to yield water in this area.

Table 2.--Generalized geologic section for the Spanish Valley area - Continued

System	Series	Group	Formation	Member	Thickness (ft)	Lithology and water-bearing characteristics
Triassic	Upper Triassic	Glen Canyon Group	Wingate Sandstone		275-350	Medium-reddish-orange fine-grained sandstone in tabular sets of massive eolian cross strata; permeability not great, but where intensely fractured yields water to springs; has potential for moderate yields of water to wells.
Triassic	Upper Triassic		Chinle Formation	Church Rock Member	170-270	Reddish-brown and variegated gray-brown siltstone; reddish-gray sandstone; gray-green conglomeratic sandstone; lenticular conglomerate; sparse intrastratal laminae of gypsum; low intrinsic hydraulic conductivity, not known to yield water in this area.
Triassic	Upper Triassic		Chinle Formation	Moss Back Member	30-80	Gray to greenish-gray thinly to thickly cross-bedded fine-grained sandstone; layers of siltstone, calcareous sandstone, and conglomerate; lignitic debris, pyrite, and other metallic deposits common; permeable, but not known to yield water in this area.
			Unconformity			
Triassic	Middle(?) and Lower Triassic		Moenkopi Formation		470-530	Mostly reddish-brown laminated to thin-bedded siltstone and gray fine-grained micaceous sandstone; sparse thin lenses of white cherty limestone; sparse thin layers of quartz-granule conglomerate; current-ripple marks, mud cracks, intrastratal laminae of gypsum, and gypsum veinlets common; low intrinsic hydraulic conductivity; not known to yield water in this area.
			Unconformity			
Permian			Cutler Formation	Unnamed arkosic member	250-700+	Red, brown, and dark-red fluvial arkose and arkosic conglomerate; red arkosic sandstone with massive crossbedding; and tabular-bedded red-brown siltstone and sandstone with sparse thin layers of lacustrine limestone; yields water to a few wells for domestic use in Spanish Valley, but is not an important aquifer in this area.
Permian / Pennsylvanian	Upper Pennsylvanian		Rico Formation		200-450+	Reddish-brown and greenish-gray fine- to medium-grained cross-bedded fluvial sandstone; gray thin- to thick-bedded cherty marine limestone; and reddish-gray micaceous siltstone; the sandstones are permeable but the formation has a generally low intrinsic hydraulic conductivity, and is not known to yield water in this area.
Pennsylvanian	Upper and Middle Pennsylvanian		Hermosa Formation	Unnamed upper member	800+(?)	Bluish-gray marine limestone and dolomite containing gray and red chert; gray fine-grained micaceous cross-bedded sandstone and siltstone; reddish-gray sandy shale and sandstone; and gray arkosic conglomerate; not known to yield water in this area.
Pennsylvanian	Upper and Middle Pennsylvanian		Hermosa Formation	Paradox Member	2,000+(?)	Light-colored salt, gypsum, anhydrite, and other evaporites; black shale, dark-gray sandy shale, gray sandstone, and gray dolomitic marine limestone; not known to yield water in this area.
			Unconformity			
Precambrian						Metamorphic complex of gneisses, schists, and similar rock types with associated intrusive rocks; not known to yield water in this area.

Spanish Valley outwardly resembles a structural trough, although its configuration and origin are more complex. The valley is superimposed on the Moab anticline and the Spanish Valley-Pack Creek syncline described by Baker (1933, p. 64-67). The northwest-trending axes of these contiguous structures are roughly alined with the trend of laccoliths of the southern group of La Sal Mountains. The Moab anticline is most perceptible at the northwest end of Spanish Valley. Fault zones parallel to the anticline have displaced its limbs. The anticlinal crest, which is nearly coincident with the axis of the valley basin, has been removed by erosion. The Spanish Valley-Pack Creek syncline becomes perceptible near the central part of the valley and southeastward. It lies along a faulted monocline which plunges rather steeply beneath the alluvium of Spanish Valley from the northeast. Displacement along this fault zone is as much as 1,500 feet; it decreases southeastward.

Spanish Valley has an irregular bedrock floor in which probable faulting is concealed by alluvium. The greatest thickness of alluvium in the valley penetrated by wells is slightly more than 360 feet.

Principal aquifers

Although many of the rocks in the Spanish Valley area are capable of transmitting and yielding small quantities of water, only the Wingate and Navajo Sandstones of the Glen Canyon

Group and the unconsolidated Quaternary deposits within Spanish Valley are sufficiently important as aquifers in the area to warrant further description.

Wingate Sandstone

The Wingate Sandstone of Late Triassic age consists of uniform medium-reddish-orange fine-grained sandstone occurring in the tabular sets of massive eolian cross-strata. In the Spanish Valley area, the Wingate ranges in thickness from about 275 to 350 feet. On the southwest side of the valley, it forms abrupt, high, desert-varnished cliffs that display large conchoidal fracture surfaces. The Wingate is also present on the northeast side of the valley and is exposed at the fault zone east of Moab and in the deeply incised upper reaches of the Mill Creek drainage. Intrinsic permeability of the Wingate is not great because of the fineness of its constituent sands. It is a competent formation, however, and where intensely fractured it yields moderate quantities of water to springs and has an equally great potential for yields to wells. The chemical quality of spring water from the Wingate is excellent.

Navajo Sandstone

The Navajo Sandstone of Jurassic and Triassic (?) age is predominantly pale yellowish-orange to pale reddish-brown, fine- to medium-grained eolian sandstone. Weakly bonded by calcium carbonate, it weathers to gracefully rounded landforms, which display conspicuous eolian cross-strata. The Navajo contains sparse thin lenticular beds of gray, sandy limestone. The lower formational contact of the Navajo is gradational, and it also intertongues with the underlying Kayenta Formation of Late Triassic (?) age. The Navajo lies unconformably beneath the Entrada Sandstone. The Navajo caps the abrupt cliffs on the southwest side of Spanish Valley and is also present over a large area northeast of the valley where it forms bluffs and underlies mesas. Along the northeast side of the valley it plunges beneath the alluvial surface in a monoclinal fold. The Navajo ranges in thickness from about 300 to 400 feet in the Spanish Valley area. The intrinsic permeability of the Navajo is not great because of the fineness of its constituent sands. It is a competent formation, however, and where intensely fractured, yields water to springs and wells. The chemical quality of water from the Navajo is excellent in this area.

Quaternary deposits

The Quaternary deposits of the Spanish Valley area consist of unconsolidated sediments of diverse origin and manner of deposition. Richmond (1962) divides these deposits into four geologic formations. In ascending order they are the Harpole Mesa and Placer Creek Formations of Pleistocene age, the Beaver Basin Formation of Pleistocene and Holocene age, and the Gold Basin Formation of Holocene age (table 2). Separated by unconformities, the formations are further divided into members and facies (Richmond, 1962, p. 17-84).

The water-bearing characteristics of the unconsolidated deposits in Spanish Valley cannot be directly related to specific formations, members, or facies. For the purpose of this investigation, therefore, the Pleistocene and Holocene formations are considered as a single undivided unit. With few exceptions, wells in the valley withdraw ground water from these unconsolidated Quaternary deposits. The thickness of saturated deposits in the valley is about 360 feet in a few places; average thickness of the saturated deposits is about 70 feet.

WATER RESOURCES

Precipitation, which falls mostly as rain in Spanish Valley and the lower canyons and as rain and snow in the upland areas, is the source of all water in the Spanish Valley area. In the higher areas, some of the snowmelt and rain from low-intensity storms infiltrates the ground and enters the ground-water system. Infiltration and stream runoff account for a small part of the annual precipitation; evapotranspiration consumes the greater part. A summary of the hydrologic balances for the ground-water basin in Spanish Valley and for the entire Spanish Valley area is given in table 3.

Table 3.—Summary of the hydrologic balance for the ground-water basin in Spanish Valley and for the Spanish Valley area

		Acre-feet per year
Ground-water basin in Spanish Valley:		
Recharge		14,000[1]
Discharge		
Ground-water outflow		8,000
Net ground-water withdrawal use		6,300
Total discharge (rounded)		14,000
Spanish Valley area:		
Inflow		
Weighted mean precipitation (15 in.)		115,000
Outflow		
Water yield		
Surface runoff		14,000[2]
Ground-water discharge from Spanish Valley (includes base flow)		14,000
Subtotal	(3.6 in.)	28,000
Water loss		
Consumptive use	(11.4 in.)	87,000[3]
Total	(15 in.)	115,000

[1]Assumed to equal the total discharge..

[2]Average discharge of Mill Creek and Pack Creek plus gain of Mill Creek from the gaging sites to the confluence of Mill Creek with the Colorado River.

[3]Assumed to equal difference between inflow and outflow.

Volume of precipitation

Average annual precipitation on the entire Spanish Valley area is estimated to be about 115,000 acre-feet. Of this, about 15,000 acre-feet falls on and near the floor of Spanish Valley (below about 5,500 ft altitude) mostly as rain. On the mesas, plateaus, and mountains (above about 5,500 ft altitude) approximately 100,000 acre-feet of precipitation falls annually, much of it as snow. Weighted mean annual precipitation on the drainage basin, about 15 inches, was determined from data compiled by the U.S. Weather Bureau (1963). Isohyets of normal annual precipitation (1931-60) are shown on plate 2.

Surface water

Continuous records of stream discharge are available for Mill Creek near Moab for the water years 1950-68 and for Mill Creek at Sheley Tunnel, Pack Creek near Moab, and Pack Creek at the M4 Ranch for water years 1954-59 (table 4). Stream discharge was measured intermittently during the investigation at the irrigation diversion site of upper Pack Creek, the Pack Creek diversion ditch near the irrigated area northwest of the old county airport in the SW¼SE¼SW¼ sec. 36, T. 26 S., R. 23 E., lower Pack Creek near its confluence with Mill Creek, and Mill Creek near its confluence with the Colorado River.

The combined average annual discharge of Mill Creek near Moab and Pack Creek near Moab is about 13,000 acre-feet (table 4). Stream-discharge measurements of Mill Creek near its confluence with the Colorado River indicate a gain of about 1,400 acre-feet downstream from the gaging sites of table 4. The annual stream discharge from the Spanish Valley area is thus about 14,000 acre-feet (table 3).

Table 4.—Stream discharge at gaged sites in the Spanish Valley area.

Station No. 1835. Mill Creek at Sheley Tunnel, near Moab, Utah

Location.—Lat 38°29′00″, long 109°24′25″, in NW¼NE¼SE¼ sec. 5, T. 27 S., R. 23 E., on left bank 9 miles southeast of Moab.

Drainage area.—27.4 sq mi upstream from gage site.

Records available.—October 1954 to September 1959.

Gage.—Water-stage recorder. Altitude of gage is 5,400 ft (from topographic map).

Average discharge.—5 years (1954-59), 8,280 acre-ft per year (11.43 cfs).

Extremes.—1954-59: Maximum discharge, 405 acre-ft per day (204 cfs) Aug. 30, 1957, gage height 3.97 ft (from rating curve extended above 96 cfs on basis of logarithmic plotting); minimum recorded, 4.2 acre-ft per day (2.1 cfs) Apr. 5, 1955.

Remarks.—Small diversion near headwaters for irrigation.

Monthly and yearly mean discharge (1954-59), in acre-feet and cubic feet per second

Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
465	349	367	352	304	344	621	1,689	1,795	866	615	491	8,280 acre-ft
7.56	5.87	5.97	5.72	5.43	5.59	10.44	27.47	30.17	14.41	10.00	8.25	11.43 cfs

Station No.1840. Mill Creek near Moab, Utah

Location.—Lat 38°33'40", long 109°30'50", in NW¼NW¼NE¼ sec. 8, T. 26 S., R. 22 E., on right bank 0.5 mile downstream from North Fork, 1.5 miles southeast of Moab, and 3.5 miles upstream from mouth.

Drainage area.—74.9 sq mi upstream from gage.

Records available.—October 1914 (fragmentary), November 1914, February to September 1915, October to November 1915, February to March 1916, June 1916 to June 1917, April to July 1918 (fragmentary), April to July 1919, July 1949 to September 1968.

Gage.—Water-stage recorder and sharp-crested weir. Altitude of gage is 4,240 ft (from topographic map). Prior to Apr. 28, 1918, staff gage; from Apr. 28, 1918 to Aug. 2, 1919, and July 1949 to Mar. 15, 1962, water-stage recorder; 0.4 mile upstream at various datum sites.

Average discharge.—19 years (1949-68), 10,140 acre-ft per year (14.00 cfs).

Extremes.—1949-68: Maximum recorded discharge, about 10,140 acre-ft per day (5,110 cfs) Aug. 21, 1953 (gage height 10.74 ft from flood mark, site and datum then in use); maximum gage height 11.6 ft Aug. 26, 1961, site and datum then in use; minimum discharge recorded, 0.4 acre-ft per day (0.2 cfs) Feb. 15, 1964.

Remarks.—Records good except for those for period of no gage-height record which are poor. Small diversions near headwaters for irrigation.

Monthly and yearly mean discharge (1949-68), in acre-feet and cubic feet per second

Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
662	567	558	527	526	583	957	1,693	1,522	866	953	723	10,140 acre-ft
10.77	9.53	9.08	8.57	9.39	9.48	16.08	27.53	25.58	14.08	15.60	12.15	14.00 cfs

Station No. 1845. Pack Creek at M4 Ranch, near Moab, Utah

Location.—Lat 38°26'10", long 109°21'15", in SE¼NW¼SE¼ sec. 23, T. 27 S., R. 23 E., on left bank half a mile upstream from M4 Ranch and 14 miles southeast of Moab.

Drainage area.—15.8 sq mi upstream from gage.

Records available.—October 1954 to September 1959.

Gage.—Water-stage recorder and concrete control. Altitude of gage is 6,140 ft (from topographic map).

Average discharge.—5 years (1954-59), 1,840 acre-ft per year (2.54 cfs).

Extremes.—1954-59: Maximum discharge, 2,390 acre-ft per day (1,200 cfs) July 26, 1955, gage height 9.02 ft (from rating curve extended above 80 cfs on basis of slope-area measurement of peak flow); minimum, 0.6 acre-ft per day (0.3 cfs) Sept. 2, 4, 1956.

Remarks.—During periods of average or less than average streamflow, the entire discharge is diverted to irrigation about 2 miles downstream from the gage.

Monthly and yearly mean discharge (1954-59), in acre-feet and cubic feet per second

Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
55	51	47	44	46	54	82	476	664	187	79	54	1,840 acre-ft
0.89	0.86	0.76	0.72	0.82	0.88	1.38	7.74	11.16	3.04	1.28	0.91	2.54 cfs

Station No. 1850. Pack Creek near Moab, Utah

Location.—Lat 38°32′25″, long 109°30′00″, in NE¼NE¼SW¼ sec. 16, T. 26 S., R. 22 E., on left bank 3.5 miles southeast of Moab.

Drainage area.—57.4 sq mi upstream from gage.

Records available.—October 1954 to September 1959.

Gage.—Water-stage recorder and concrete control. Altitude of gage is 4,390 ft (from topographic map).

Average discharge.—5 years (1954-59), 2,910 acre-ft per year (4.02 cfs).

Extremes.—1954-59: Maximum discharge, 1,012 acre-ft per day (510 cfs) Oct. 8, 1954, gage height 4.05 ft (from rating curve extended above 60 cfs on basis of slope-area measurement of peak flow); minimum, 1.39 acre-ft per day (0.7 cfs) Aug. 27, 1956.

Remarks.—In this lower part of Pack Creek, perennial flow rises about 1.5 miles upstream from the gage.

Monthly and yearly mean discharge (1954-59), in acre-feet and cubic feet per second

Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	The year
201	206	231	240	244	258	224	426	513	129	126	114	2,910 acre-ft
3.27	3.46	3.76	3.90	4.35	4.20	3.67	6.93	8.62	2.10	2.05	1.92	4.02 cfs

Mill Creek

The Mill Creek drainage basin occupies about 80 square miles of the northern part of the Spanish Valley area. The length of the main channel of Mill Creek is about 24 miles, and the average gradient is about 270 feet per mile; in Spanish Valley, however, the gradient is about 64 feet per mile. The stream gage at Mill Creek near Moab is about 3.5 miles upstream from the mouth of the creek; it records stream discharge from about 75 square miles of drainage basin. The gaging site on Mill Creek at Sheley Tunnel was about 9 miles upstream from the gage near Moab.

Throughout its length, Mill Creek is a gaining stream. Records for water years 1950-67 indicate that for about 80 percent of the time the average daily discharge at Mill Creek near Moab equaled or exceeded 8 cfs (cubic feet per second) (about 5,800 acre-ft per yr). The latter figure is probably a good approximation of the base flow of Mill Creek near Moab. The base flow of the creek is derived mainly from sandstone strata of the Glen Canyon Group. Average monthly and yearly discharge of Mill Creek near Moab and at Sheley Tunnel is given in table 4.

Pack Creek

The Pack Creek drainage basin occupies about 64 square miles of the southern part of the Spanish Valley area. The main channel of Pack Creek is about 23 miles long, and it has an average gradient of about 480 feet per mile in Spanish Valley, however, the gradient is about 120 feet per mile. The inactive stream gage on Pack Creek near Moab is about 4.3 miles above the mouth; it recorded stream discharge from about 57 square miles of drainage basin. The inactive gaging site at the M4 Ranch is at the southeast end of Spanish Valley, about half a mile upstream from the ranchhouse.

The upper part of Pack Creek, from its origin at Barber and Pack Creek Springs, (D-27-24)30bbc-S1 and 24dcc-S1, is a gaining stream to within a short distance of the site of its diversion for irrigation. The entire discharge of upper Pack Creek is diverted by ditch to the irrigated area northwest of the old county airport in secs. 35 and 36, T. 26 S., R. 22 E., where the water infiltrates the permeable alluvium or is discharged by evapotranspiration; there is no surface return flow from irrigation. Thus Pack Creek channel is dry between the diversion site and the springs near Moab City Park in secs. 15 and 22, T. 26 S., R. 22 E., except during infrequent and brief occurrences of heavy runoff. Lower Pack Creek, from its perennial source at the springs near Moab City Park to its confluence with Mill Creek, is a gaining stream. Average monthly and yearly discharge figures of the gaging stations on Pack Creek for the period 1955-59 are given in table 4.

Colorado River

The Colorado River is base level for the Spanish Valley area. The nearest gaging station on the Colorado River is near Cisco, Utah, about 30 miles upstream from Spanish Valley. For 57 years of record (1911-68), the average discharge of the Colorado River near Cisco is about 7,725 cfs. The average discharge of the Colorado River at Spanish Valley is estimated to be less than 1 percent more than the average discharge near Cisco; the river has only a few small perennial tributaries between these localities. Where it passes the northeast end of Spanish Valley, the Colorado River receives the discharge of Mill Creek and ground-water outflow from Spanish Valley. This combined discharge increases the average flow of the Colorado River by less than one-half of 1 percent.

Ground water

Essentially all ground-water use in the Spanish Valley area is in Spanish Valley. The principal source of the ground water used in the valley is the gravelly sand that constitutes the valley fill. A secondary source of ground water is from the relatively small area of intensely fractured sandstones of the Glen Canyon Group adjacent to Spanish Valley on the northeast, northeast of the Moab City Park. Ground water occurs in other places but is available in such relatively small amounts as to be nonutilitarian. Records of 232 selected wells are given in table 9 and records of selected springs in table 10.

Recharge

In upland parts of the Spanish Valley area, water from snowmelt and from low-intensity rainfall infiltrates the surface cover of soils, eolian sand, glacial moraine, and colluvium. Such water descends as ground-water recharge into a ground-water system in the sandstones of the Glen Canyon Group. The ground water seeps through fractures or pore spaces in the sandstones in a general southwestward direction toward Spanish Valley. Some of the ground water reappears at the land surface as base flow in either Mill or Pack Creeks or as spring discharge on the northeast side of Spanish Valley and some enters the fill in Spanish Valley by subsurface flow. After entering the valley fill, the ground water flows generally northwestward as indicated by arrows in the ground-water contours on plate 2, finally discharging as outflow to the Colorado River.

The total recharge on the upland areas is not directly measurable. It may be assumed equal to the sum of (1) the base flow of Mill Creek (5,800 acre-ft per yr or about 8 cfs), (2) total discharge of the springs at the northeast side of the valley (2,200 acre-ft per yr or about 3 cfs), and (3) recharge to the ground-water basin in Spanish Valley by underflow (assumed to be equal to discharge), mostly from the Glen Canyon Group (14,000 acre-ft per yr or about 19 cfs). Total recharge on upland areas is thus 22,000 acre-feet per year or about 30 cfs.

The recharge to the ground-water basin in Spanish Valley is assumed to be approximately the same as the discharge from the basin. This is the sum of ground-water outflow to the Colorado River and the ground water discharged by consumptive use. Recharge to the basin thus computed is about 14,000 acre-feet per year or 19 cfs.

Water levels

Ground-water levels are nearer the land surface at the northwest end of Spanish Valley than they are elsewhere in the valley. The water table in the valley rises southeastward, but water levels become progressively deeper because the land surface rises more rapidly in the same direction. Altitudes of water levels are shown by contours on plate 2, where the depth to water may be obtained by subtracting water-level altitudes from land-surface altitudes. Irregularities in spacing of the water-level contours (differences in hydraulic gradient) are reflections of diversities in hydraulic conductivity and rates of subsurface recharge to the valley. The comparatively low hydraulic gradient in the vicinity of the old county airport and the Grand County-San Juan County boundary may indicate an area of increased recharge to the valley basin, or it may be due to a local concentration of more uniformly coarse aquifer materials.

Water-level contours, where projected into the area underlain by the Glen Canyon Group northeast of the valley, trend generally northeastward. The contours suggest that the direction of ground-water movement in the Glen Canyon Group is from the La Sal Mountains toward the northwest, paralleling the movement of water in the fill in Spanish Valley. Water-level contours are not extended far beyond the valley on plate 2 because of sparse water-level data in the uplands area.

Water-level changes in selected observation wells in Spanish Valley are shown in figure 3. The maximum seasonal water-level change observed was a rise of 5.8 feet in well (D-26-22)17dbc-1, and the maximum yearly water-level change observed was a rise of 6.7 feet in well (D-26-22)22dcd-1. The length of record available is not sufficient to indicate any upward or downward trend of water levels in the valley.

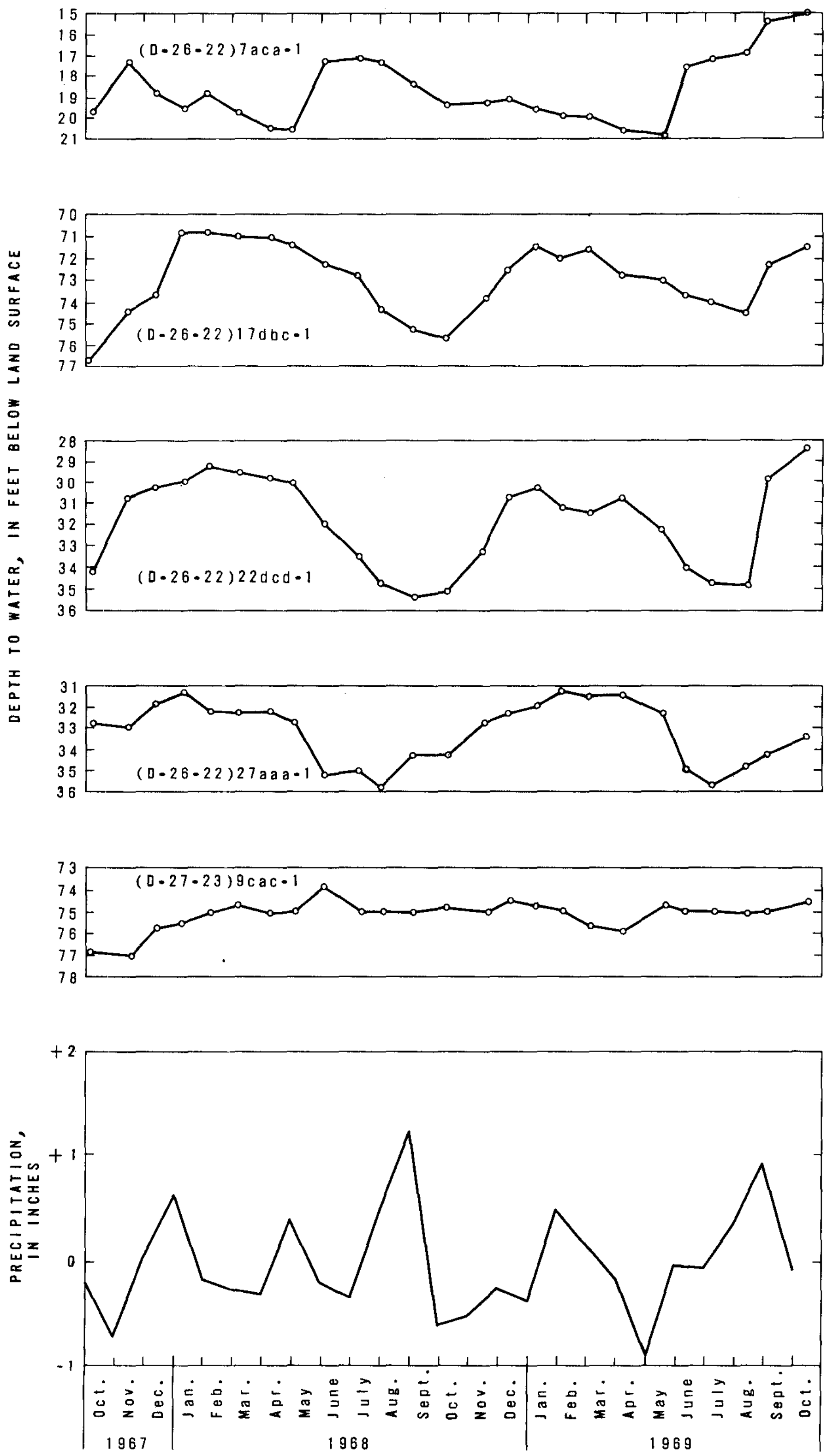

Figure 3.—Monthly changes in water levels in selected wells and departures from the 1931-60 normal monthly precipitation at Moab, October 1967-September 1969.

Storage

The fill in Spanish Valley underlies about 11,500 acres. Wells and test holes that fully penetrate the fill indicate that it has a maximum thickness of about 360 feet, and that ground water in the fill occurs under water-table conditions. The average saturated thickness of the fill is about 70 feet; thus the approximate total volume of saturated fill is about 800,000 acre-feet.

The fill may be described generally as a gravelly sand. An analysis of 202 well logs, mostly from drillers' records, indicates that the fill has approximately the following textural composition:

7 percent clay
4 percent silt
50 percent sand
23 percent fine-to-medium gravel
16 percent coarse gravel

Selected drillers' logs of seventeen wells are given in table 8. Based on the preceding characteristics, it is estimated that the apparent specific yield of the fill (Ferris and others, 1962, p. 77-78) ranges from 0.10 to 0.15. In other areas of similar deposits, however, specific yield has been observed to increase during an extended period of pumping (Lugn and Wenzel, 1938, p. 89-96; Williams and Lohman, 1949, p. 213, 220). The long-term specific yield of the saturated gravelly sand in Spanish Valley, therefore, is believed to be about 0.25 (Johnson, 1967, p. 4, 68-71). Thus, the total volume of ground water theoretically recoverable from storage is estimated to be about 200,000 acre-feet. Assuming a long-term practicable withdrawal of about one-third of the total ground water in storage, the volume recoverable from storage in the fill in Spanish Valley is about 70,000 acre-feet.

Well and aquifer characteristics

Wells are concentrated at the central and northwest part of Spanish Valley where requirements for municipal and domestic use and irrigation by ground water are greatest. Well yields from the valley fill are as much as 1,000 gpm (gallons per minute) with but 35 feet of water-level drawdown [(D-26-22)35abd-1] and as little as 8 gpm with 110 feet of drawdown [(D-26-22)16cab-1]. Most of the wells in Spanish Valley supply water for domestic use. The average yield of 170 of the domestic wells listed in table 8 is about 24 gpm; they range in yields from 6 to 150 gpm. Relatively few wells are used solely for irrigation in Spanish Valley. The average yield of 14 of the irrigation wells listed in table 8 is about 220 gpm; they range in yields from 100 to 1,000 gpm. The average yield of five public-supply wells listed in table 9 is about 800 gpm; they range in yields from 100 to 2,445 gpm. The well yielding 2,445 gpm is in fractured Navajo Sandstone of the Glen Canyon Group.

Aquifer characteristics of the fill in Spanish Valley determined on the basis of bailing 16 wells and pumping two wells are given in table 5. From the results it may be inferred that the transmissivity of the valley fill is variable. The average transmissivity determined from the 18 wells is about 6,000 cubic feet per day per foot. The transmissivity values in table 5 were determined on the basis of specific capacities observed in the wells tested. Such tests involve head

Table 5.—Aquifer characteristics of the valley fill

[Transmissivity estimated from specific capacity according to the method of Theis (1963, p. 332-336). Hydraulic conductivity is assumed equal to transmissivity divided by saturated thickness.]

Well number	Specific capacity (gpm/ft of drawdown)	Transmissivity (cubic ft per day per ft)	Saturated thickness (ft)	Hydraulic conductivity (cubic ft per day per square ft)
(D-25-21)36cda-1	41	8,000	225	36
(D-26-22)6cbb-1	36	7,000	140	49
6cbb-2	20	3,700	125	29
7bac-1	25	4,300	125	35
8cba-1	20	3,700	40	94
8dcb-1	30	5,700	50	115
16cdd-1	36	7,000	65	107
17aac-1	48	8,700	50	174
17aad-1	18	3,100	70	44
17ada-2	10	1,600	50	32
17cab-1	20	3,700	50	75
20acd-1	20	3,700	30	124
21bdd-1	20	3,600	50	72
22cbb-1	32	5,700	75	76
22cbd-1	60	11,600	100	116
22dcb-1	90	13,900	105	132
35abd-1	30	4,700	120	39
35bdd-2	30	5,700	160	36
Averages (rounded)	30	6,000	90	80

losses as the water moves through perforations in the well casing; thus the real transmissivity of the aquifer is undoubtedly considerably higher than indicated. Based on a comparison of similar well determinations with aquifer data obtained from pumping tests in basin fill elsewhere in Utah (R.W. Mower, oral commun., 1970), it is believed that a more realistic average value for the transmissivity of the fill in Spanish Valley is about 10,000 cubic feet per day per foot.

Several public-supply wells and domestic wells withdraw water from the Navajo Sandstone northeast of the Moab City Park in secs. 15 and 22, T. 26 S., R. 22 E. The Navajo in this area is shattered by faulting and jointing, and it has an estimated transmissivity of about 6,000 cubic feet per day per foot. The transmissivity of the less-disturbed Navajo in the uplands northeast of the locally shattered area is relatively slight, however, and it is estimated to be about 1,200-1,500 cubic feet per day per foot.

Discharge

Ground water is discharged from Spanish Valley by evapotranspiration from areas of water-loving plants (phreatophytes and hydrophytes); outflow to the Colorado River; consumptive use of water withdrawn for irrigation, public supply, and domestic use, and sewage discharge from municipal and domestic water systems to the Colorado River. Total ground-water discharge from the valley is estimated to be about 14,000 acre-feet per year.

Phreatophytes and hydrophytes flourish in a meadowland of about 1,280 acres at the northwest end of the valley adjacent to the Colorado River (pl. 2). Phreatophytes predominate in this area; the most common types are willow (*Salix* sp.), saltcedar or tamarisk (*Tamarix gallica*), cottonwood (*Populus* sp.), and giant reed grass (*Phragmites communis*). Hydrophytes are represented mostly by horsetail (*Equisetum* sp.), meadowgrass (*Glyceria* sp.), and cattail (*Typha latifolia*). Areas of open water occur in lower parts of the meadowland, mainly during the dormant season. Annual use of ground water by phreatophytes and hydrophytes is estimated to be about 3,000 acre-feet (about 2.4 acre-ft per acre).

The discharge of ground water by outflow to the Colorado River was estimated by using an adaptation of Darcy's law (Darcy, 1856),

$Q = 0.0084\ T\ I\ W$, in which

Q = discharge in acre-feet per year;

0.0084 is a conversion factor of cubic feet per day to acre-feet per year;

T = 16,000 cubic feet per day per foot, the estimated average transmissivity of the fill in Spanish Valley where the average thickness of the saturated fill is about 140 feet (at the middle of line A - A′ on pl. 2);

I = 71 feet per mile, the gradient of the water table between the water-level contours at altitudes of 3,950 and 4,050 feet (the measured line of gradient is 1.4 miles, shown as A - A′ on pl. 2); and

W = 1.2 miles, the average width of the valley throughout the length of the line of gradient A - A′; thus

$Q = 0.0084 \times 16{,}000 \times 71 \times 1.2 = 11{,}000$ acre-feet per year.

Thus the outflow to the Colorado River is 11,000 acre-feet per year minus the 3,000 acre-feet per year consumed in the area of phreatophytes and hydrophytes in the northwest end of the valley, or about 8,000 acre-feet per year.

Ground water is withdrawn from wells for domestic use mostly throughout the northwestern part of Spanish Valley, whereas the irrigation and public-supply wells, which withdraw the greatest volumes of water, are in the central part of the valley (table 9). Withdrawals are greatest during the growing season from April to October when irrigation wells are pumped, domestic pumping is increased, and public-supply wells are pumped to supplement supplies from springs.

The total annual ground-water withdrawal for domestic and public supply and irrigation is about 5,200 acre-feet per year. Of this, about 3,800 acre-feet is withdrawn for irrigation, about 1,200 acre-feet for public supply, and about 200 acre-feet for domestic use.

Ground water withdrawn for irrigation in Spanish Valley is applied to two large areas totaling about 740 acres—an area of about 290 acres south of Moab City Park and an area of about 450 acres northwest of the abandoned county airport (pl. 2). The principal crop is alfalfa. Smaller areas irrigated with ground water are scattered throughout the northwestern part of Spanish Valley, but the total area in the valley irrigated with ground water does not exceed 1,000 acres. The amount of irrigated land in the valley does not change significantly from year to year. The soil of Spanish Valley is generally coarse, and infiltration loss during irrigation is estimated to be about 50 percent. The volume of ground water withdrawn for irrigation is estimated to be about 3,800 acre-feet per year. Thus, the consumptive use of ground water for irrigation is about 1,900 acre-feet annually, and the remaining 1,900 acre-feet is returned to the aquifer by infiltration.

The public-supply system of Moab obtains water from two wells, (D-27-22)22aad-1 and (D-26-22)15dca-1, and five springs, (D-25-21)35aaa-S1, (D-26-22)15cbb-S1, (D-26-22)15cdc-S1, and (D-26-22)22aaa-S1 and S2. The wells are used mainly during the summer months to supplement water supplies from the springs. The system has been metered since February 1968, and withdrawals of ground water, in acre-feet, during 1968-69 are tabulated as follows:

	1968 (incomplete)	1969
Wells	281	535
Springs	603	665
Total	884	1,200

The 1,200 acre-feet metered during 1969 is assumed to be a representative figure for annual withdrawal for public supply.

Withdrawal of ground water from privately owned wells, mainly for domestic use, is estimated to be about 200 acre-feet per year in Spanish Valley.

The consumptive use of water used for public and domestic supplies is assumed to be about 25 percent of the water withdrawn. Thus, of the 1,400 acre-feet of water withdrawn annually, about 350 acre-feet is consumed. Almost all the remainder, however, is discharged as treated sewage to the Colorado River.

In summary, the annual discharge of ground water from Spanish Valley is estimated to be:

8,000 acre-feet by outflow to the Colorado River
3,000 acre-feet by evapotranspiration in area of phreatophytes and hydrophytes
1,900 acre-feet by consumptive use in irrigation
1,400 acre-feet withdrawn for public and domestic supplies and either consumed or discharged as treated sewage to the Colorado River
14,000 acre-feet total (rounded)

Additional development

Additional ground water could be withdrawn in Spanish Valley by diverting part of the outflow to the Colorado River, by diverting part of the water consumed by evapotranspiration in the northwestern end of the valley, or by withdrawing water from storage in the valley fill throughout the valley. Any of these actions would affect water levels in the valley. Predictions of the effects on water levels that would be caused by continuation of withdrawals at essentially the 1969 rate or increasing the withdrawals threefold were made by means of an electric analog model of the valley.

The analog model was designed and constructed during the early stages of the investigation, and in addition to use for predictive purposes it was used to verify or reject hydrologic interpretations while the investigation was in progress. Flow of ground water is simulated by flow of electrical current through conductors in the analog model. The time ratio of ground-water change to analog-model change is in years to seconds. Analogies exist between the volume rate of flow and electrical current, hydraulic potential and electrical potential, transmissivity and electrical conductance, ground-water storage and electrical capacitance, and in the length of an aquifer segment represented by a conductance element. When valid data are supplied, the analog model may be used to simulate ground-water withdrawals under varying conditions of recharge and discharge (Wykoff and Reed, 1935, and Skibitzke, 1960).

Of seven data-processing runs on the analog model, runs 6 and 7 gave results that most closely represented hydrologic conditions in Spanish Valley. Results of the two runs are given as simulated water-level changes on plate 3. The simulated pumping locations were arrayed as nodes to represent average values for different areas rather than for specific wells (table 6). This was done in order to simulate the effects of large numbers of domestic wells in some areas and to simulate the effects of irrigation and public supply wells where they would have the greatest influence on water levels.

Run 7 on plate 3 shows the change in water levels that is predicted after 10 years of simulated ground-water withdrawals at the rate of 3,810 acre-feet per year. This rate is about 15 percent greater than the net rate of withdrawal during 1969 (1,400 acre-feet for domestic and public supply and 1,900 acre-feet for irrigation). Run 6 shows the change in water levels that is predicted after 10 years of simulated ground-water withdrawal at the rate of 9,440 acre-feet per year, about three times the net withdrawals during 1969.

As shown by both runs on plate 3, the greatest predicted changes in water levels are in the central part of Spanish Valley; and little or none of the simulated source of the water withdrawn is from outflow to the Colorado River or water consumed by evapotranspiration in the northwestern end of the valley. It is apparent, therefore, that if some of the outflow to the Colorado River or some of the water consumed by evapotranspiration is to be diverted by means

Table 6.—Simulated discharge and assumed transmissivity at nodes representing simulated pumping in the analog model.

Node No.	Analog discharge, in millions of gallons per day — Run 6	Analog discharge, in millions of gallons per day — Run 7	Assumed average transmissivity, in cubic feet per day per foot
1	0.016	0.007	
2	.063	.025	
3	.063	.025	
4	.063	.025	
5	.016	.007	
6	.063	.025	
7	.063	.025	
8	.063	.025	5,000
9	.016	.007	
10	.063	.025	
11	.063	.025	
12	.016	.007	
13	.063	.025	
14	.063	.025	
15	.016	.007	
16	.005	.002	
17	.019	.008	
18	.019	.008	
19	.016	.369	
20	.005	.002	
21	.104	.042	
22	.005	.002	
23	.019	.008	
24	.019	.008	7,600
25	.019	.008	
26	.916	.369	
27	.019	.008	
28	.019	.008	
29	.104	.042	
30	.916	.369	
31	.104	.042	
32	.005	.002	
33	.019	.008	
34	.019	.008	
35	.005	.202	
36	.117	.047	
37	.500	.202	
38	.500	.202	
39	.117	.047	
40	.500	.202	5,200
41	.500	.202	
42	.117	.047	
43	.500	.202	
44	.500	.202	
45	.500	.202	
46	.117	.047	
Totals (rounded)	8.43	3.40	

of withdrawals from additional wells, these wells should be in the northwestern part of the valley where simulated water-level changes on plate 3 are less than 5 feet. Thus by dispersing some of the ground-water withdrawals from the central part of Spanish Valley to the northwestern part, water will be salvaged for beneficial use in the valley, water-level declines in the central part of the valley will be lessened, and lowering of future pumping levels in the valley generally will be kept to a minimum.

The maximum amount of ground water that could be diverted annually in the Spanish Valley area is about 11,000 acre-feet—3,000 acre-feet now being consumed in the area of phreatophytes and hydrophytes and 8,000 acre-feet now being discharged from the lower end of Spanish Valley by outflow to the Colorado River. Some of the 11,000 acre-feet could be recovered for beneficial use in Spanish Valley by additional pumping in the northwestern part of the valley in or near the area of phreatophytes and hydrophytes (pl. 2). The amount of ground water that could thus be diverted from consumptive use by the phreatophytes and hydrophytes to beneficial use is estimated to be a maximum of about 190 acre-feet per year (pl. 3).

Quality of Water

Surface Water

A summary of the chemical classification of surface waters for irrigation in Spanish Valley is given in figure 4 and table 7. The U.S. Salinity Laboratory Staff (1954) used the sodium-adsorption ratio (SAR) as a method of predicting the sodium (or alkali) hazard in the use of water for irrigation. SAR is calculated by dividing the sodium concentration by the square root of one-half the calcium and magnesium concentration (all concentrations are in milliequivalents per liter). The interpretation of the low-, medium-, and high-salinity hazards and the low-sodium hazard indicated by figure 4 are defined by the U.S. Salinity Laboratory Staff as follows:

Low-salinity water can be used for irrigation with most crops on most soils with little likelihood that soil salinity will develop. Some leaching is required, but this occurs under normal irrigation practices except in soils of extremely low permeability.

Medium-salinity water can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control.

High-salinity water cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.

Low-sodium water can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. However, sodium-sensitive crops such as stone-fruit trees may accumulate injurious concentrations of sodium.

The specific conductances of surface waters at selected sites in the Spanish Valley area are shown on plate 2. Specific conductance is a convenient rapid determination for estimating the concentration of dissolved solids in water, the concentration of dissolved solids (in milligrams per liter) generally being about 65 percent of the specific conductance (in micromhos per centimeter at 25°C).

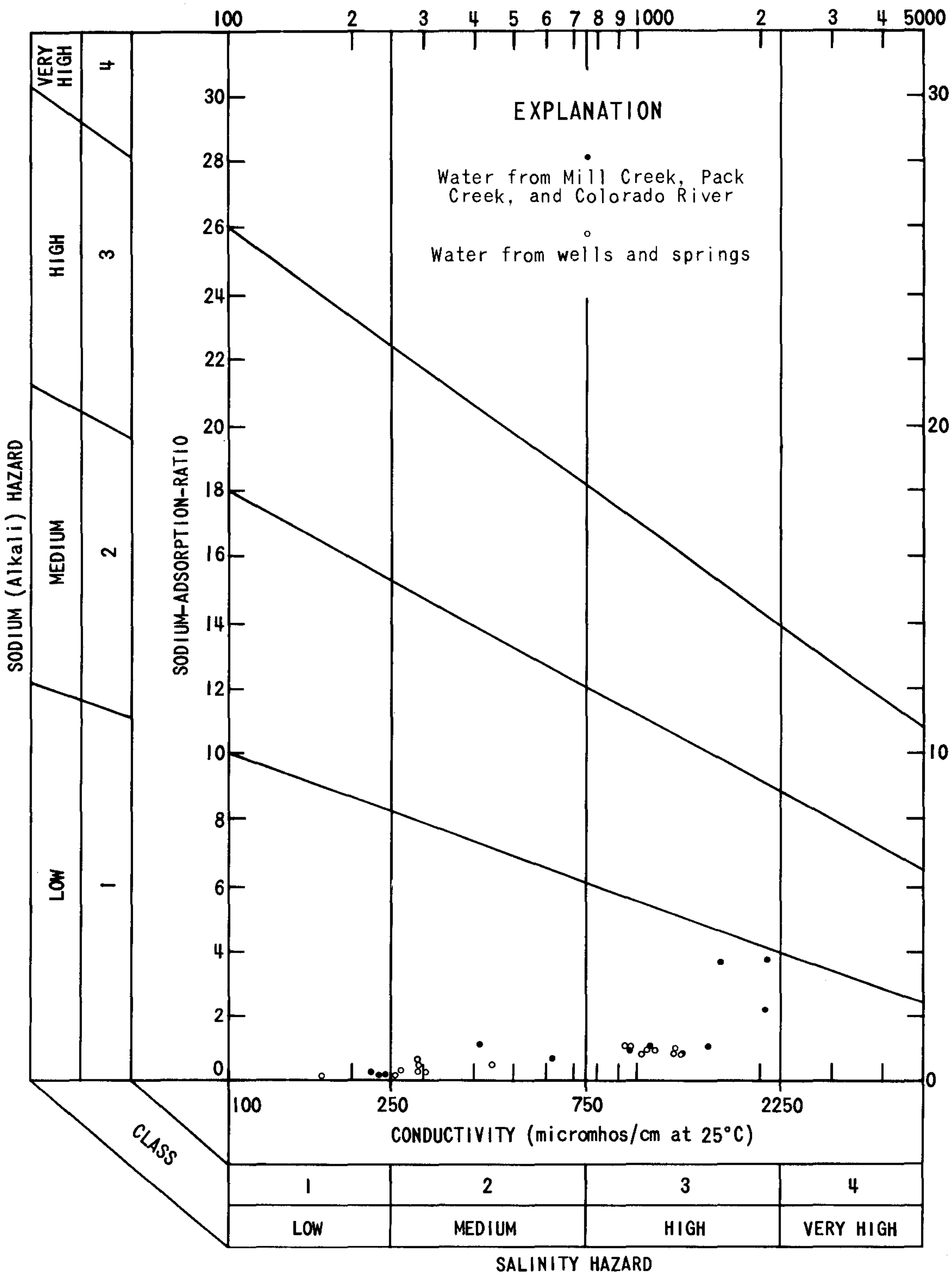

Figure 4.—Chemical classification of water for irrigation.

Table 7—Suitability of surface waters for irrigation

Adapted from Iorns and others (1965, p. 176)

Source	Date	Water discharge: Cubic feet per second	Water discharge: Classification	Specific conductance (micromhos per cm at 25°C)	Percent sodium	Sodium adsorption ratio	Classification After U.S. Salinity Laboratory Staff (1954)
Colorado River above Mill Creek, near Moab, Utah	7-2-49	22,900[1]	High	410	31	1.1	C2-S1
	9-1-49	1,920[1]	Low	2,100	31	2.3	C3-S1
	Jan. 16-18, 21-24, 26, 1952	3,300[1]	Medium	1,590	46	3.7	
Mill Creek at Sheley Tunnel near Moab, Utah	9-1-49	6.0[1]	Low	230	7	.2	C1-S1
Mill Creek near Moab, Utah	8-22-56	6.8	Low	247	6	.1	
	10-26-57	13[2]	Medium	238	6	.1	
	5-9-58	63[2]	High	200	---	---	
Pack Creek at M4 Ranch, near Moab, Utah	8-6-58	1.4[2]	---	963	17	.9	C3-S1
Pack Creek near Moab, Utah	7-2-49	.5[1]	Low	1,530	17	1.0	
	5-8-58	8.8[2]	---	612	15	.6	C2-S1
	8-6-58	1.5[2]	---	1,080	18	1.0	C3-S1
Mill Creek at mouth, near Moab, Utah	9-28-48	2.5	Low	1,290	14	.8	
Colorado River below Mill Creek, near Moab, Utah	9-28-48	2,400[1]	Low	2,100	42	3.8	

[1] Estimated.

[2] From gage height or measurement at time of sampling.

The specific conductances of surface waters in the Spanish Valley area were measured during February 1969, a time of year when discharge of the streams is generally low (table 4) and the concentrations of dissolved solids in the streams as indicated by specific conductance, is most nearly representative of base flow (Hem, 1959, p. 42). During the period of measurement, the specific conductance of water in Mill Creek near its source at Warner Lake was 170 micromhos per centimeter (pl. 2). The specific conductance of the water increased with increasing distance from its source, mainly due to ground-water inflow, and it was 245 micromhos per centimeter before flowing into Spanish Valley. From that point to the confluence of Mill Creek with the Colorado River, the specific conductance of water in the creek increased to 760 micromhos per centimeter. This increase was caused by ground-water inflow in Spanish Valley and from lower Pack Creek, both of which contain considerably more dissolved solids than does the water in Mill Creek. Before it enters Spanish Valley, the water in Mill Creek has a low-salinity hazard and low-sodium hazard for irrigation. By the time it discharges into the Colorado River, the creek water has a high-salinity hazard (table 7).

The specific conductance of water in upper Pack Creek near its source at Pack Creek Spring in February 1969 was 1,220 micromhos per centimeter, and it showed little change as far as the irrigated area near the old county airport. The conductance increases somewhat downstream from the airport due to return flow from irrigation, and throughout its course Pack Creek has a high-salinity hazard and low-sodium hazard for irrigation (table 7).

Water is not diverted from the Colorado River for any use in Spanish Valley; near Moab it has a medium-to-high salinity hazard and a low-sodium hazard for irrigation (table 7).

Ground water

Ground water from selected sources in the Spanish Valley area contains concentrations of dissolved solids ranging from 101 to 1,040 milligrams per liter (table 11). The principal dissolved constituents in the water are calcium, magnesium, sodium, bicarbonate, sulfate, and chloride. The concentrations (in milliequivalents per liter) of these constituents in selected samples are shown by modified Stiff diagrams on plate 2 (Stiff, 1951, p. 15-17).

Ground water in and near the southeastern part of Spanish Valley contains relatively high concentrations of calcium and sulfate, as indicated by Stiff diagrams of water samples from well (D-27-23)23cab-1 and Pack Creek Spring, (D-27-23)24dcc-S1 (pl. 2) and analyses in table 11. Ground water of this chemical quality has a high-salinity hazard and a low-sodium hazard for irrigation and contains more than twice the concentrations of sulfate and dissolved solids that are recommended for drinking-water supplies by the U.S. Public Health Service (1962). The source of the ground water in and near the southeastern part of Spanish Valley probably is recharge from permeable units of the Morrison Formation of Late Jurassic age and formations of Cretaceous age (pl. 1).

Selected ground-water samples from the Navajo and Wingate Sandstones that were collected in the upland areas northeast of Spanish Valley contain lower concentrations of dissolved solids than does ground water at the southeastern part of Spanish Valley. Stiff diagrams of water samples from public-supply wells (D-26-22)15dca-1 and (D-26-22)22aad-1 and from spring (D-26-22)14acc-S1, and chemical analysis of a sample from spring (D-26-22)15cbb-S1 indicate that the principal dissolved constituents of water from the sandstones are calcium and bicarbonate (pl. 2 and table 11). Ground water from these wells and springs is satisfactory for public supply and has a medium-salinity hazard and low-sodium hazard for irrigation (fig. 4 and table 11). As water from the sandstone aquifers enters the valley fill, it mixes with and dilutes the ground water in the valley fill. Mixing of the two types of water is irregular but becomes progressively more apparent northwestward through Spanish Valley as indicated by Stiff diagrams of water samples from wells (D-26-22)21baa-2, (D-26-22)7bad-1, and (D-26-21)1dcc-1 (pl. 2). Analyses of water samples of these wells in table 11 show a decrease in the concentration of dissolved solids between the southeastern well and the northwestern well.

Although Spanish Valley is underlain at depth by evaporite deposits of the Paradox Member of the Hermosa Formation, no saline water or brine has been observed in the valley fill. The valley fill is separated from the underlying Paradox by relatively impervious shale and anhydrite as shown in the driller's log of well (D-25-21)26dcc-2 (table 8). The black shale directly underlying the valley fill contains some thin anhydrite layers, but the principal evaporite deposits of the Paradox are about 435 to 540 feet beneath the base of the fill near Moab.

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BASIC DATA

Table 8.--Selected drillers' logs of wells in Spanish Valley

Altitudes are in feet above sea level for land surface at well.
Thickness in feet.
Depth in feet below land surface.

Material	Thickness	Depth
(D-25-21)26dcc-2. Log by E. J. Mayhew. Alt. 3,970 ft.		
Mud, sand, and gravel	42	42
Gravel; water bearing	84	126
Clay and gravel	58	184
Gravel; water bearing	142	326
Sand; water bearing; base of fresh-water zones	39	365
Sandstone and black shale	35	400
Gypsum and black shale	103	503
Shale, black	4	507
Andyrite and black shale	80	587
Anhydrite, black shale, and sandstone	148	735
Anhydrite and black shale	54	789
Anhydrite	93	882
Salt	54	936
Anhydrite and shale	107	1,043
Salt	777	1,820
Salt, anhydrite, and carbonaceous shale	15	1,835
Salt	1,365	3,200
(D-25-21)35dca-1. Log by H. E. Beeman. Alt. 3,965 ft.		
Sand, red	38	38
Gravel	7	48
(D-26-21)1bac-1. Log by H. E. Harrison. Alt. 3,990 ft.		
Soil	5	5
Sand; water bearing	34	39
Sand and gravel; water bearing	5	44
(D-26-21)1ddb-1. Log by W. Tuy. Alt. 4,060 ft.		
Sand	5	5
Clay	3	8
Sand, gravel, and cobbles; water bearing	22	30
(D-26-21)1ddc-1. Log by T. White. Alt. 4,075 ft.		
Sand	20	20
Gravel; water bearing	15	35
Cobbles; water bearing	18	53
Gravel; water bearing	27	80
(D-26-22)7bdc-2. Log by C. E. Harrison. Alt. 4,125 ft.		
Soil	5	5
Sand	23	28
Clay, yellow	4	32
Cobbles; water bearing	19	51
Sand; water bearing	2	53
(D-26-22)7ddb-1. Log by E. L. Christensen. Alt. 4,210 ft.		
Sandy soil	50	50
Quicksand; water bearing	35	85
Gravel; water bearing	6	91
(D-26-22)16ccb-1. Log by H. E. Beeman. Alt. 4,430 ft.		
Sand, red	45	45
Gravel, coarse	15	60
Sand, red	25	85
Gravel; water bearing	19	104
(D-26-22)17acb-1. Log by J. Zimmerman. Alt. 4,370 ft.		
Soil and red sand	16	16
Clay	53	79
Quicksand	9	88
Clay	47	135
Quicksand; water bearing	10	145
Gravel; water bearing	9	154
(D-26-22)21bad-1. Log by J. Zimmerman. Alt. 4,500 ft.		
Sand	8	8
Clay, sand, and gravel	22	30
Sand; water bearing	10	40
Gravel and sand; water bearing	16	56
Gravel; water bearing	6	62
(D-26-22)22cba-1. Log by H. E. Beeman. Alt. 4,550 ft.		
Soil and sand	40	40
Conglomerate; water bearing	41	81
(D-26-22)22ddc-1. Log by H. E. Beeman. Alt. 4,600 ft.		
Sand, red	35	35
(D-26-22)22ddc-1 - Continued		
Sand and gravel; water bearing	85	120
Clay	5	125
(D-26-22)35acd-1. Log by J. Zimmerman. Alt. 4,760 ft.		
Gravel and boulders	145	145
Gravel; water bearing	10	155
Clay	5	160
Gravel; water bearing	50	210
(D-26-22)35bab-2. Log by H. E. Beeman. Alt. 4,700 ft.		
Cobbles	140	140
Dark sand and gravel	61	201
(D-27-22)1bbb-1. Log by C. M. Conway. Alt. 4,820 ft.		
Soil	5	5
Sand, gravel, and cobbles	195	200
Gravel	30	230
Sand	5	235
Sand; water bearing	45	280
Sand, hard	70	350
(D-27-22)1bda-1. Log by J. Zimmerman. Alt. 4,880 ft.		
Boulders	15	15
Sand, gravel, and boulders	130	145
Clay	6	151
Shale	13	164
Shale, white	8	172
Shale, red	9	181
Sand, white, hard; water bearing	8	189
Boulders	3	192
(D-27-22)1cdd-1. Log by C. E. Harrison. Alt. 4,920 ft.		
Soil	8	8
Gravel	97	105
Shale, hard	18	115
Gravel and boulders	30	145
Sandstone, red, broken; water bearing	155	300
Sand; water bearing	10	310

Table 9.--Records of selected wells in the Spanish Valley area

Location: See text for well-numbering system.
Aquifer: Qvf, valley fill; JTrn, Navajo Sandstone; Trw, Wingate Sandstone; Pc, Cutler Formation.
Water use: C, commercial; H, domestic; I, irrigation; N, industrial; P, public supply T, institution; U, unused; Z, mining.
Other data available: C, chemical analysis in table 11; D, driller's log of well available from files of Utah Department of Natural Resources, Division of Water Rights, or the U.S. Geological Survey; L, driller's log of well in table 8.

Location	Owner or name	Year drilled	Depth of well	Casing		Aquifer	Altitude above sea level (feet)	Water level (in feet below land surface)	Date of measurement	Yield		Use of water	Other data available
				Diameter (inches)	Depth (feet)					Rate (gpm)	Draw-down (feet)		
(D-25-21)													
26dcc-1	Suburban Gas Co.	1962	55	7	45	Qvf	3,990	-	-	25	0	H	C,D
26dcc-2	do	1960	3,200	9	1,260	Qvf	3,970	-	-	-	-	U	D,L
27dda-1	Bureau of Reclamation	1957	10	3	1	Qvf	3,950	4	June 1957	-	-	U	D
28adb-1	Atomic Energy Commission	1954	114	6	-	Qvf	4,060	24	May 1954	11	2	N	D
28add-1	Bureau of Land Management Park well	1940	67	8	53	Qvf	3,990	42	Jan. 1940	20	-	U	D
28dab-1	Morrison-Knudsen Co.	1961	130	8	118	Qvf	4,080	89	Oct. 1967	18	11	Z	D
34bbd-1	Embar Oil No. 1	1928	5,345	12	-	Qvf	3,965	85	Oct. 1967	-	-	U	D
35bbb-1	Bureau of Reclamation	1957	10	3	1	Qvf	3,955	2	June 1957	-	-	U	D
35bdd-1	GLC Oil Test	1942	1,700	10	408	Qvf	3,955	-	-	-	-	U	D
35daa-1	E. Thompson	1956	57	7	45	Qvf	3,980	9	July 1956	20	13	H	D
35dac-1	Utex Explor. Co.	1959	45	6	10	Qvf	3,960	0	Oct. 1967	-	-	H	D
35dca-1	V. McElbaney	1956	48	6	40	Qvf	3,965	-	-	20	-	H	D,L
35dca-2	J. W. Estes	1964	45	6	45	Qvf	3,965	-	-	20	0	H	D
36cac-1	Utex Explor. Co.	1961	90	6	24	Qvf	3,995	17	Oct. 1967	70	-	H	D
36cad-1	C. A. Steen	1955	200	6	140	Qvf	4,080	-	-	-	-	H	D
36cbd-1	J. Hudson	1968	85	6	82	Qvf	3,985	12	Aug. 1968	45	8	H	D
36ccd-1	L. L. Taylor	1956	65	10	53	Qvf	3,980	-	-	30	-	I	D
36cda-1	Utex Explor. Co.	1959	84	6	-	Qvf	4,000	14	Oct. 1967	82	2	H	D
36cdb-1	W. K. Alexander	1963	60	6	54	Qvf	3,985	-	-	15	0	H	D
36cdc-1	Grand County	1956	89	7	69	Qvf	3,990	20	Oct. 1967	-	40	P	D
36dcc-1	A. Day	-	60	6	48	Qvf	4,035	42	Oct. 1967	25	3	H	D
(D-26-21)													
1abc-1	R. Miller	1964	80	6	58	Qvf•	4,030	-	-	50	0	I	D
1abd-1	C. H. Berhardt	1954	47	6	40	Qvf	4,030	16	June 1954	20	9	H	D
1aca-1	Grand County	1954	60	6	50	Qvf	4,030	20	June 1954	36	10	T	D
1ada-1	L. E. Baldwin	1954	43	6	40	Qvf	4,070	7	May 1954	10	-	H	D
1bab-1	J. E. Kirby	1954	48	6	42	Qvf	3,990	15	June 1954	15	-	H	D
1bac-1	V. C. Johnson	1956	44	6	38	Qvf	3,990	8	Nov. 1956	20	10	H	D,L
1bad-1	V. L. Carroll	1956	51	7	44	Qvf	3,995	7	June 1956	20	13	H	D
1bbb-1	H. M. Knight	1954	48	6	42	Qvf	3,980	12	Oct. 1964	12	9	H	D
1bbb-2	J. L. Rauer	1950	40	7	-	Qvf	3,980	7	June 1950	10	1	H	D
1bda-1	J. Turner	1954	45	5	40	Qvf	4,060	-	-	15	-	H	D
1bda-2	L. Scorup	1955	60	6	-	Qvf	4,005	20	Oct. 1967	36	10	H	D
1caa-1	S. Sears	1968	85	10	-	Qvf	4,000	6	July 1968	110	18	H	D
1cbb-1	D. Borwick	1955	62	6	22	Qvf	4,020	26	Oct. 1967	50	-	H	D
1cbc-1	M. Bullick	1955	50	6	40	Qvf	4,035	35	Oct. 1967	36	10	H	D
1dab-1	J. C. Burgess	1954	59	6	-	Qvf	3,990	16	May 1954	14	-	H	D
1dab-2	do	1955	42	6	-	Qvf	3,990	10	Oct. 1967	36	5	H	D
1dac-1	L. Dull	1964	36	6	-	Qvf	4,060	-	-	25	0	H	D
1dba-1	J. C. Burgess	1957	40	6	30	Qvf	3,990	6	Mar. 1957	36	0	H	D
1dba-2	W. R. McConkie	1954	41	6	30	Qvf	4,030	12	-	11	-	H	D
1dba-3	A. Georgedes	1962	87	7	-	Qvf	4,050	12	May 1962	36	14	H	D
1dbb-1	E. E. Provonsha	1954	37	7	-	Qvf	4,035	7	July 1954	15	8	H	D
1dbb-2	V. Grow	1956	28	6	20	Qvf	4,000	12	Oct. 1967	24	0	H	D
1dcc-1	Desert Lodge	1961	50	7	43	Qvf	4,045	18	Oct. 1961	21	0	C	C,D
1dcc-2	G. A. Larsen	1964	60	6	40	Qvf	4,045	28	Dec. 1964	-	-	I	D
1ddb-1	E. Anderson	1964	30	5	23	Qvf	4,060	25	Oct. 1967	-	-	I	D,L
1ddc-1	Grand County	1966	80	9	60	Qvf	4,075	18	May 1966	-	-	T	D,L
(D-26-22)													
6bbb-1	J. E. Riley	1954	51	6	-	Qvf	4,320	12	Sept. 1954	15	-	H	D
6cba-1	J. Youvan	1955	128	6	120	Qvf	4,090	20	Sept. 1955	36	50	H	D
6cba-2	G. E. Lile	1955	59	6	53	Qvf	4,110	12	Sept. 1955	20	8	H	D
6cbb-1	M. Bentley	1955	30	6	25	Qvf	4,080	20	July 1955	36	0	H	D
6cbb-2	D. O'Laurie	1956	30	6	22	Qvf	4,090	20	June 1956	20	0	H	D
6cbb-3	L. A. McCormick	1955	93	6	73	Qvf	4,100	80	Nov. 1955	8	0	H	D
6cbc-1	H. E. Provonsha	1955	46	6	-	Qvf	4,080	4	July 1955	36	26	H	D
6cbc-2	D. Provonsha	1956	85	9	70	Qvf	4,075	10	Apr. 1956	15	5	H	D
7aca-1	City of Moab	1956	222	12	-	Qvf	4,160	22	Apr. 1956	100	108	P	D
7aca-2	do	1956	245	12	24	Qvf	4,160	20	Oct. 1967	250	80	P	D
7bac-1	Helca Subdivision	1964	108	8	-	Qvf	4,125	-	-	25	0	H	C,D
7bad-1	Hecla Mine Co.	1955	80	6	70	Qvf	4,125	10	May 1955	36	10	H	D
7bbd-1	D. Young	1956	59	7	50	Qvf	4,110	20	July 1956	20	3	H	D
7bcb-1	M. L. Walston	1964	46	8	-	Qvf	4,100	-	-	15	0	H	D
7bcc-1	B. E. Kinney	1955	50	6	40	Qvf	4,130	30	Oct. 1967	36	10	H	D
7bdc-1	J. W. Taylor	1959	47	6	41	Qvf	4,140	15	Mar. 1959	6	20	H	D
7bdc-2	P. C. Steinke	1956	53	7	51	Qvf	4,125	20	May 1956	20	5	H	D,L
7cab-1	Moab Lanes	1960	50	7	44	Qvf	4,160	15	Oct. 1967	15	10	C	D
7cab-2	R. L. Dalton	1959	47	6	-	Qvf	4,160	25	Aug. 1959	10	5	H	D
7cac-1	K. Westwood	1954	42	6	-	Qvf	4,215	35	Sept. 1954	10	0	H	D
7cad-1	M. Smith	1954	31	6	-	Qvf	4,200	19	Sept. 1954	10	0	H	D
7cbc-1	R. Starbuck	1954	70	6	-	Qvf	4,180	10	May 1954	10	-	H	D
7cbd-1	First Assembly of God Church	1963	83	6	75	Qvf	4,205	-	-	303	3	T	D

Location	Owner or name	Year drilled	Depth of well	Casing: Diameter (inches)	Casing: Depth (feet)	Aquifer	Altitude above sea level (feet)	Water level (in feet below land surface)	Date of measurement	Yield: Rate (gpm)	Yield: Draw-down (feet)	Use of water	Other data available
(D-26-22)													
7dbc-1	T. Anderson	1961	50	7	40	Qvf	4,175	15	June 1961	14	22	H	D
7dbc-2	D. Gordon	1961	47	7	39	Qvf	4,175	18	June 1961	28	15	H	D
7dbc-3	Basin Indust. Co.	1961	57	7	51	Qvf	4,200	23	Feb. 1961	5	20	C	D
7dbc-4	J. A. Fullmer	1961	65	6	55	Qvf	4,200	35	July 1961	10	55	H	D
7dbd-1	V. Lehr	1961	45	9	39	Qvf	4,200	13	June 1961	4	30	H	D
7dbd-2	W. Irish	1959	120	7	-	Qvf	4,195	26	Aug. 1959	3	19	H	D
7dcd-1	G. Holyoak	1961	45	7	39	Qvf	4,275	12	Feb. 1961	10	8	H	D
7dda-1	D. J. Barnes	1954	80	7	55	Qvf	4,230	35	Sept. 1954	20	15	H	D
7ddb-1	W. F. Sanders	1954	91	6	85	Qvf	4,210	50	Oct. 1954	25	10	H	D,L
7ddb-2	N. Dull	1964	60	6	55	Qvf	4,230	-	-	10	20	H	D
7ddd-1	A. Holyoak	1955	70	8	53	Qvf	4,140	0	Sept. 1955	15	20	I	D
8caa-1	R. Phillips	1969	180	6	40	JTrn	4,330	-	-	35	-	H	D
8cba-1	O. Murphy	1948	50	6	35	Qvf	4,240	26	Oct. 1948	20	1	H	D
8cba-2	do	1954	75	6	-	Qvf	4,240	65	Oct. 1967	25	0	H	D
8cbc-1	Moab Uranium Co.	1954	34	6	-	Qvf	4,210	22	Nov. 1954	10	2	C	D
8cbc-2	H. Jeffries	1954	58	6	-	Qvf	4,210	18	Oct. 1967	15	-	H	D
8cbc-3	G. Hayes	1963	101	7	-	Qvf	4,210	26	Dec. 1963	30	35	H	D
8cca-1	K. Cooper	1961	31	6	25	Qvf	4,220	12	Mar. 1961	14	3	H	D
8ccd-1	W. L. Coalson	1960	54	7	48	Qvf	4,240	18	Apr. 1960	8	33	H	D
8cdc-1	M. Dalley	1958	38	6	34	Qvf	4,250	15	Aug. 1958	6	19	-	D
8cdc-2	C. Kimball	1963	168	6	165	Qvf	4,260	-	-	20	30	H	D
8cdc-3	S. A. Swink	1964	42	6	-	Qvf	4,260	20	-	20	0	H	D
8cdd-1	W. F. Coalson	1958	51	6	35	Qvf	4,270	20	Oct. 1967	7	25	H	D
8cdd-2	J. A. King	1957	115	6	65	Qvf	4,260	2	Oct. 1967	10	68	H	D
8dcb-1	V. J. Murphy	1953	105	6	80	Qvf	4,280	60	Dec. 1953	30	0	H	D
8dcc-1	J. E. Graham	1966	52	6	-	Qvf	4,280	-	-	10	0	H	D
15bcc-1	A. N. Ray	1960	60	5	-	Qvf	4,520	28	Sept. 1960	15	7	H	D
15bdb-1	L. Kisida	1964	160	8	-	JTrn	4,610	-	-	10	-	H	D
15dab-1	Texas Gulf Sulphur Co.	1964	187	6	147	JTrn	4,680	125	Mar. 1969	25	0	H	D
15dca-1	City of Moab	1969	185	14	98	JTrn	4,600	54	Mar. 1969	2,445	36	P	C,D
16acc-1	W. G. Harrison	1956	75	6	-	Trw	4,400	30	Feb. 1956	30	25	H	D
16acd-1	M. D. Anderson	1964	100	6	10	Trw	4,450	60	Oct. 1967	-	-	H	D
16ada-1	W. S. Christensen	1955	26	5	19	JTrn	4,500	15	Mar. 1955	36	0	H	D
16adc-1	J. I. Winder	1966	85	-	-	JTrn	4,460	-	-	15	0	H	D,L
16add-1	P. Shumway	1959	50	-	30	Qvf	4,500	6	Dec. 1959	30	0	H	D
16bdb-1	A. R. Shumway	1956	75	6	-	Trw	4,360	32	Feb. 1956	36	23	H	D
16cab-1	D. G. Farnsworth	1965	120	6	60	Trw	4,380	-	-	8	110	H	D
16cad-1	L. D. Shumway	1965	46	6	40	Qvf	4,400	-	-	10	20	H	D
16ccb-1	R. Beeman	1967	104	6	90	Qvf	4,430	-	-	20	0	H	D
16ccb-2	C. Kretzer	1962	51	6	45	Qvf	4,450	40	Oct. 1967	-	-	H	D
16ccc-1	J. Dowd	1959	78	9	-	Qvf	4,450	35	Oct. 1968	25	15	I	
16ccd-1	L. G. Shumway	1955	40	6	30	Qvf	4,460	15	June 1955	36	0	H	D
16ccd-2	M. Randall	1963	54	6	-	Qvf	4,460	-	-	30	10	H	D
16cdb-1	J. E. Purchell	1960	40	6	30	Qvf	4,450	25	Dec. 1960	30	0	H	D
16cdc-1	L. H. Cole	1954	65	5	-	Qvf	4,470	20	Nov. 1954	-	-	H	D
16dab-1	D. O'Laurie	1955	110	8	-	Trw	4,440	70	Feb. 1955	24	0	H	D
16dca-1	F. Kerby	1962	69	8	-	Qvf	4,440	26	Mar. 1962	24	2	I	D
16dcd-1	E. Brown	1962	57	7	50	Qvf	4,470	-	-	20	7	H	D
16ddc-1	R. Randall	1963	53	6	48	Qvf	4,460	-	-	25	0	H	D
16ddd-1	J. L. Winbourne	1962	254	8	-	Qvf	4,470	16	Mar. 1962	32	4	H	D
16ddd-2	Ace Turner	1962	60	6	52	Qvf	4,470	-	-	60	10	H	D
17aab-1	L. F. Newman	1963	140	6	-	JTrn	4,400	115	Sept. 1963	15	0	H	D
17aac-1	P. H. Stocks	1954	42	6	32	Qvf	4,420	10	Dec. 1954	48	0	H	D
17aac-2	W. R. Enright	1961	45	6	20	Qvf	4,310	20	July 1961	30	0	H	D
17aac-3	J. Patrick	1960	33	7	27	Qvf	4,310	12	Oct. 1967	12	8	H	D
17aac-4	M. J. Ambrose	1957	42	6	32	Qvf	4,340	12	Feb. 1957	20	-	H	D
17aad-1	D. E. Johnson	1956	40	6	-	Trw	4,340	26	Mar. 1956	36	2	H	D
17aba-1	H. Sargeant	1957	120	8	-	Trw	4,320	54	Apr. 1957	20	41	-	D
17aba-2	H. Oliver	1961	58	7	50	Qvf	4,300	13	Feb. 1961	7	41	H	D
17aba-3	do	1962	100	7	89	Trw	4,310	51	Oct. 1962	32	0	H	D
17abb-1	J. R. Nicol	1956	42	6	37	Qvf	4,290	14	Dec. 1956	16	8	H	D
17acb-1	D. J. Tanner	1961	154	7	-	Qvf	4,370	126	Dec. 1961	7	25	H	D,L
17acc-1	C. S. Thompson	1961	206	6	-	Qvf	4,380	80	Oct. 1967	7	0	H	D
17acd-1	W. Coalson	1960	108	6	79	Qvf	4,380	23	Apr. 1960	6	62	H	D
17ada-1	D. Wimmer	1964	201	7	-	Qvf	4,340	88	May 1964	12	60	H	D
17ada-2	J. L. Starbuck	1957	42	6	37	Qvf	4,310	16	Mar. 1957	20	2	H	D
17ada-3	J. D. Romero	1957	42	6	37	Qvf	4,310	15	Apr. 1957	20	3	H	D
17adb-1	R. L. Christensen	1955	42	7	30	Qvf	4,320	8	Nov. 1955	20	-	H	D
17adc-1	M. Beeson	1957	36	6	26	Qvf	4,380	20	July 1957	30	4	H	D
17adc-2	E. Tomsic	1956	69	6	59	Qvf	4,380	12	Sept. 1956	8	40	H	D
17bdd-1	O. E. Boulder	1955	83	9	75	Qvf	4,390	40	Sept. 1955	15	20	H	D
17cab-1	I. Stewart	1959	170	6	160	Qvf	4,420	150	Dec. 1959	20	0	H	D
17dba-1	C. L. Relitz	1969	197	6	-	Qvf	4,400	70	Feb. 1969	16	0	H	D
17dbb-1	H. Cleveland	1963	211	6	-	Qvf	4,400	-	-	15	35	H	D
17dbc-1	Garrett Freight Lines Co.	1954	153	6	123	Qvf	4,450	77	Oct. 1967	14	25	H	C,D
18abd-1	I. W. Allen	1949	280	6	90	Pc	4,400	78	June 1949	15	6	H	D
20aac-1	M. C. Tangreen	1963	120	7	117	Qvf	4,510	-	-	15	0	H	D
20acd-1	R. L. Robson	1959	133	6	-	Pc	4,580	118	Oct. 1967	20	0	H	D
20ada-1	M. A. Coalson	1958	113	6	107	Qvf	4,550	110	Nov. 1958	7	0	H	D
20adb-1	D. Carlin	1962	150	6	140	Pc	4,550	-	-	-	-	-	D

Table 9.--Records of selected wells in the Spanish Valley Area - Continued

Location	Owner or name	Year drilled	Depth of well	Casing		Aquifer	Altitude above sea level (feet)	Water level (in feet below land surface)	Date of measurement	Yield		Use of water	Other data available
				Diameter (inches)	Depth (feet)					Rate (gpm)	Draw-down (feet)		
(D-26-22)													
21aac-1	K. Allred	1964	65	6	-	Qvf	4,500	-	-	35	0	H	D
21abd-1	V. L. Davis	1964	64	8	56	Qvf	4,500	-	-	28	0	H	D
21aca-1	L. W. Scorup	1959	63	6	53	Qvf	4,510	35	Aug. 1959	20	15	H	D
21aca-2	L. C. Davis	1960	63	7	57	Qvf	4,500	29	Dec. 1960	12	21	H	D
21acb-1	R. Coalson	1958	65	6	57	Qvf	4,530	19	Nov. 1958	10	16	H	D
21acd-1	W. F. Coalson	1958	60	6	53	Qvf	4,540	21	Nov. 1958	10	19	H	D
21adb-1	J. O. Rossiter	1958	56	6	51	Qvf	4,510	18	Nov. 1958	10	12	H	D
21adb-2	G. Gordon	1960	65	7	59	Qvf	4,510	32	Mar. 1960	14	22	H	D
21baa-1	R. J. Oviatt	1961	55	7	-	Qvf	4,480	28	Apr. 1961	20	11	H	D
21baa-2	W. J. Jones	1966	66	10	54	Qvf	4,480	-	-	70	10	I	C,D
21bab-1	R. E. McCormick	1960	54	6	-	Qvf	4,490	33	Oct. 1960	-	-	-	D
21bad-1	D. Oliver	1961	62	7	56	Qvf	4,500	31	June 1961	20	5	H	D,L
21bbb-1	J. M. Adkinson	1961	32	6	26	Qvf	4,470	21	Mar. 1961	12	0	-	D
21bbc-1	P. Rockwell	1961	71	6	-	Qvf	4,500	60	Feb. 1961	10	5	H	D
21bdd-1	C. Story	1962	87	7	77	Qvf	4,550	-	-	20	5	H	D
21bdd-2	O. Sheets, Jr.	1966	67	6	-	Qvf	4,540	-	-	15	0	H	D
21daa-1	K. L. Young	1960	57	7	51	Qvf	4,580	29	Mar. 1960	11	7	H	D
21daa-2	V. P. Welch	1961	72	9	64	Qvf	4,560	27	Apr. 1961	30	10	H	D
21daa-3	K. L. Young	1962	57	7	51	Qvf	4,580	31	Dec. 1962	16	10	H	D
21dad-1	C. R. Wildersen	1967	95	6	89	Qvf	4,600	-	-	20	0	H	D
21dba-1	T. E. Ferron	1961	65	11	55	Qvf	4,570	24	Feb. 1961	16	10	I	D
21dba-2	do	1965	75	6	65	Qvf	4,570	25	Dec. 1965	15	0	H	D
22aab-1	City of Moab	1961	106	12	20	JTrn	4,590	31	Mar. 1969	1,000	40	P	C,D
22aad-1	do	1962	238	13	114	JTrn	4,590	1	Aug. 1962	250	129	P	C,D
22add-1	E. R. Carter	1964	105	9	64	JTrn	4,610	-	-	50	0	H	D
22add-2	E. L. Schumaker	1964	112	8	-	JTrn	4,610	-	-	150	30	H	D
22bcc-1	R. W. Musselman	1965	65	6	-	Qvf	4,540	-	-	25	0	H	D
22bcc-2	K. Slany	1962	75	6	-	Qvf	4,490	37	Dec. 1962	14	2	H	D
22bcc-3	D. Provonsha	1964	60	6	-	Qvf	4,540	-	-	15	15	H	D
22bda-1	R. Ritchie	1965	80	6	-	Trw	4,480	-	-	25	0	H	D
22cac-1	G. M. White	1963	100	6	95	Qvf	4,550	-	-	30	0	H	D
22cad-1	J. Halverson	1961	69	9	59	Qvf	4,570	31	Apr. 1961	60	8	H	D
22cba-1	D. Tangreen	1966	81	6	69	Qvf	4,550	-	-	20	0	H	D,L
22cba-2	L. Spencer	1961	72	7	60	Qvf	4,510	23	Oct. 1967	50	6	H	D
22cbb-1	E. Scharf	1962	87	9	80	Qvf	4,560	36	Dec. 1962	32	0	H	D
22cbb-2	T. R. Pogue, Jr.	1967	82	6	-	Qvf	4,550	-	-	-	-	H	D
22cbc-1	R. A. Kyle	1967	87	8	87	Qvf	4,580	-	-	25	0	H	D
22cbd-1	H. E. Beeman	1961	72	7	60	Qvf	4,570	26	Mar. 1961	60	1	H	D
22cbd-2	J. Krist	1969	119	8	-	Qvf	4,555	24	Mar. 1969	25	0	H	D
22cda-1	H. E. Thomas	1965	65	6	-	Qvf	4,580	-	-	20	0	H	D
22cdd-1	C. E. Hunton	1963	100	6	94	Qvf	4,580	-	-	25	4	H	D
22daa-1	B. A. Broughton	1969	200	12	77	JTrn	4,475	28	Mar. 1969	200	20	I	D
22dbd-1	G. M. White	1961	126	16	-	Qvf	4,570	32	Aug. 1961	300	39	I	D
22dcb-1	do	1961	130	16	21	Qvf	4,580	21	Oct. 1967	90	0	I	D
22dcc-1	H. E. Beeman	1962	84	8	75	Qvf	4,590	-	-	30	0	H	D
22dcc-2	C. Duren	1962	75	6	65	Qvf	4,580	-	-	25	0	H	D
22dcc-3	M. Schermerhorn	1963	77	6	66	Qvf	4,590	-	-	25	0	H	D
22dcc-4	H. E. Beeman	1967	80	8	-	Qvf	4,590	-	-	30	0	H	D
22dcd-1	G. M. White	1959	70	16	-	Qvf	4,580	34	Oct. 1967	100	51	I	C,D
22ddc-1	do	1968	125	12	70	Qvf	4,600	31	Mar. 1968	-	-	I	D,L
23ccb-1	J. E. Kerby	1962	110	7	75	Qvf	4,620	-	-	25	0	H	D
23ccc-1	J. Payne	1961	104	8	45	Qvf	4,610	2	Oct. 1967	450	58	I	D
26ccc-1	J. Doud	1955	120	9	-	Qvf	4,700	40	-	20	20	H	D
27aaa-1	C. J. Meador	1960	60	7	47	Qvf	4,610	33	Oct. 1967	-	-	H	D
35abd-1	R. L. Holyoke	1961	205	16	165	Qvf	4,730	135	Oct. 1961	1,000	35	I	D
35abd-2	do	1959	182	9	140	Qvf	4,730	125	Feb. 1959	55	30	H	D
35acd-1	N. Murphy	1961	210	16	-	Qvf	4,760	140	Oct. 1961	700	50	I	D,L
35acd-2	do	1956	185	7	160	Qvf	4,760	140	Jan. 1956	20	10	H	D
35ada-1	L. W. Bull	1962	185	6	-	Qvf	4,740	154	Feb. 1962	7	0	H	C,D
35adc-1	S. Sommerville	1963	173	7	171	Qvf	4,760	160	Oct. 1967	15	0	H	D
35bab-1	J. W. Vancil	1962	288	7	-	Qvf	4,710	110	Nov. 1962	20	0	H	D
35bab-2	C. E. McClellon	1964	201	7	-	Qvf	4,700	-	-	35	0	H	D,L
35bad-1	R. R. Rutt	1967	261	8	157	Qvf	4,730	-	-	-	-	H	D
35bdb-1	W. W. Williams	1964	295	7	-	Qvf	4,740	138	July 1964	15	22	H	D
35bdd-1	R. C. Pogue	1959	140	5	130	Qvf	4,750	128	July 1959	20	0	H	D
35bdd-2	J. Callor	1963	247	6	230	Qvf	4,740	-	-	30	0	H	C,D
35bdd-3	M. J. Eldredge	1962	250	7	-	Qvf	4,740	124	July 1962	21	0	H	D
35daa-1	S. Sommerville	1964	178	7	-	Qvf	4,780	-	-	15	0	H	D
35daa-2	do	1956	170	6	156	Qvf	4,780	158	Sept. 1956	7	4	H	D
35dbb-1	D. L. Hammer	1962	186	7	-	Qvf	4,760	118	Oct. 1967	20	0	H	D
(D-26-23)													
10ccb-1	F. Shields	1953	445	6	-	JTrn	6,880	410	Aug. 1953	.5	-	I	D
12aba-1	J. W. Corbin	1953	450	6	-	JTrn	7,690	395	Sept. 1953	2	-	I	D
12cca-1	do	1966	1,100	19	-	Qvf	7,460	850	Jan. 1966	-	-	I	D
(D-27-22)													
1abb-1	Bureau of Land Management	1936	315	4	298	Qvf	4,860	245	Dec. 1936	3	5	U	D
1bbb-1	do	1941	350	6	-	Qvf	4,820	200	May 1941	18	0	U	D,L
1bda-1	Moab Airport	1956	192	7	155	Qvf	4,880	181	Oct. 1967	7	0	U	D,L
1cdd-1	W. D. Moore	1951	310	6	-	Pc	4,920	165	Sept. 1951	20	-	U	D,L
2dbd-1	Bureau of Land Management	1938	315	6	275	Qvf	4,940	284	Nov. 1938	9	-	U	D
(D-27-23)													
6dad-1	do	1941	455	6	-	Qvf	5,060	390	Nov. 1941	15	-	U	D
9cac-1	-	-	96	8	96	JTrn	5,280	77	Nov. 1967	-	-	U	
9cdb-1	N. S. Christensen	1953	298	8	-	JTrn	5,360	-	-	-	-	U	D
23cab-1	D. H. Brownell	1963	84	9	65	Qvf	6,040	29	Oct. 1967	100	34	H	C,D

Table 10.--Records of selected springs in the Spanish Valley area

Location: See text for spring-numbering system.
Aquifer: Qvf, valley fill; Kbc, Burro Canyon Formation; JTrn, Navajo Sandstone; Trw, Wingate Sandstone.
Discharge: Measured unless indicated by e, estimated.
Water use: I, irrigation; P, public supply; R, recreation; S, stock, U, unused.
Other data available: C, chemical analysis in table 11.

Location	Name	Altitude (feet)	Aquifer	Discharge (gpm)	Date measured	Temperature (°C)	Water use	Other data available
				GRAND COUNTY				
(D-25-21)26bdc-S1	Lions Club Spring	4,160	Trw	7	Jan. 1968	17	R	C
35aaa-S1	Skakel Spring	4,000	Trw	240e	Oct. 1967	14	P	C
(D-26-22)7cca-S1	Jackson Reservoir Spring	4,240	Trw	24	Mar. 1968	16	I	C
14acc-S1	Deep Cut Spring	4,640	JTrn	90	Nov. 1968	16	U	C
15cbb-S1	Birch Spring	4,480	Trw	90e	Oct. 1967	14	P	C
15dbc-S1	1/Moab Spring No. 1	4,480	JTrn	50	Mar. 1969	14	P	
22aaa-S1	1/Moab Spring No. 2	4,600	JTrn	300	Mar. 1969	14	P	
22aaa-S2	1/Moab Spring No. 3	4,600	JTrn	333	Mar. 1969	14	P	
(D-26-24)28aba-S1	Warner Lake Spring	9,370	Kbc	200e	July 1967	7	R	C
				SAN JUAN COUNTY				
(D-26-23)3ccc-S1	Sand Pot Spring	5,600	JTrn	12e	Nov. 1968	16	U	
(D-27-23)24dcc-S1	Pack Creek Spring	6,400	Qvf	200e	Apr. 1968	16	I	C
(D-27-24)30bbc-S1	Barber Spring	6,700	Qvf	30e	Apr. 1968	14	S	C

1/ Also known as Sommerville or White Springs.

Table 11.--Chemical analyses of water from selected wells and springs

Location: See text for well- and spring-numbering system.
Aquifer: Qvf, valley fill; Kbc, Burro Canyon Formation; JTrn, Navajo Sandstone; Trw, Wingate Sandstone.
Sodium: Where no value is shown for potassium, sodium and potassium are calculated and reported as sodium.

Location	Aquifer	Date of collection	Temperature (°C)	Milligrams per liter																Specific conductance (micromhos per cm at 25°C)	Sodium-adsorption ratio	pH
				Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Ca,Mg Hardness as $CaCO_3$	Noncarbonate hardness as $CaCO_3$	Dissolved solids Deter-mined	Dissolved solids Calcu-lated			
											WELLS											
(D-25-21) 26dcc-1	Qvf	9- 5-68	16	14	0.04	46	23	13	2.3	220	0	38	14	0.5	1.3	0.04	212	32	256	260	440	0.4	8.0
(D-26-21) 1dcc-1	Qvf	7- 8-69	15	9.1	.21	29	16	6.8	1.1	127	0	38	3.2	.3	1.0	.07	136	32	169	167	286	.3	7.9
(D-26-22) 7bad-1	Qvf	9- 5-68	16	19	.00	112	57	41	2.4	312	0	300	20	.8	9.0	.07	516	260	749	714	1,020	.8	7.8
15dca-1	JTrn	3- 6-69	15	7.7	.57	30	16	5.4	1.2	121	0	48	2.4	.4	.9	.06	140	41	154	173	268	.2	8.0
17dbc-1	Qvf	7- 9-68	16	10	1.3	98	51	44	2.1	168	0	370	17	.6	2.8	.00	454	316	701	680	961	.9	7.5
21baa-2	Qvf	7- 8-69	10	14	.15	120	45	46	2.2	198	0	352	30	.5	13	.03	486	324	772	720	1,040	.9	7.9
22aab-1	JTrn	11-19-68	13	9.5	.09	30	13	6.5	1.0	124	0	38	2.7	.3	1.3	.04	128	26	218	163	273	.3	7.6
22aad-1	JTrn	11-19-68	15	11	.17	32	14	7.6	1.0	128	0	39	2.9	.4	.1	.03	136	31	166	171	286	.3	7.4
22dcd-1	Qvf	7- 9-68	16	14	.02	107	38	48	2.2	218	0	303	16	.5	12	.00	422	243	664	648	930	1.0	7.6
35ada-1	Qvf	7- 8-69	14	17	.10	180	38	54	2.1	243	0	450	30	.5	26	.11	608	409	962	917	1,230	1.0	7.6
35bdd-2	Qvf	9- 5-68	10	14	-	144	28	43	2.1	264	0	305	11	.9	11	.06	476	260	739	689	984	.9	7.7
(D-27-23) 23cab-1	Qvf	4-30-68	13	9.2	.00	190	42	50	1.8	226	0	545	16	1.2	.5	.07	648	463	1,020	967	1,240	.9	7.6
											SPRINGS											
(D-25-21) 26bdc-S1	Trw	10- 8-58	17	11		33.	10	18	-	132	0	36	12	-	0.8	-	124	16	-	186	298	0.7	8.1
35aaa-S1	Trw	10-19-67	14	11	0.00	32	12	13	0.6	128	0	31	14	0.3	.7	0.01	128	23	168	178	296	.5	7.5
(D-26-22) 7cca-S1	Trw	3- 7-68	16	11	.03	102	47	46	2.1	168	0	370	18	.7	4.6	.03	448	310	717	684	954	.9	7.9
14acc-S1	JTrn	11-19-68	16	8.9	-	35	16	5.3	1.2	184	0	11	2.7	.1	.4	.04	152	1	171	171	306	.2	7.6
15cbb-S1	Trw	10-19-67	14	8.9	.00	35	12	8.2	.5	132	0	39	4.3	.3	.5	.00	136	28	172	174	295	.3	7.6
(D-26-24) 28aba-S1	Kbc	7- 8-69	7	8.0	.08	21	8.3	1.9	.6	94	0	10	1.2	.5	.6	.06	86	9	101	98	170	.1	7.7
(D-27-23) 24dcc-S1	Qvf	4-30-68	13	17	.00	189	37	49	2.7	200	0	561	16	1.4	1.1	.05	624	460	995	972	1,220	.9	7.8
(D-27-24) 30bbc-S1	Qvf	4-30-68	14	19	.00	194	38	54	2.0	136	0	610	16	1.9	1.3	.04	640	528	1,040	1,000	1,240	.9	7.5

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