UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

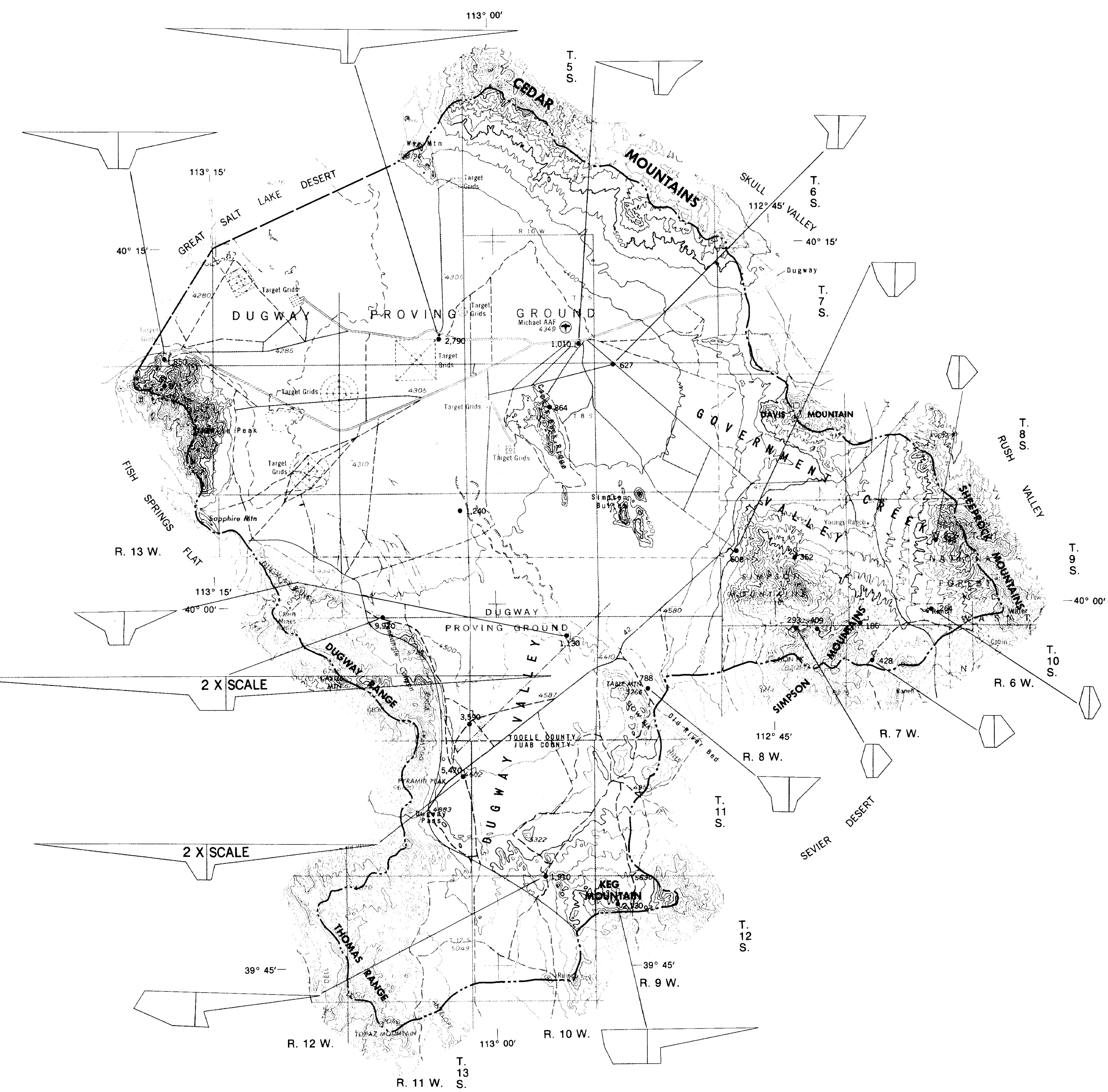
STATE OF UTAH
DEPARTMENT OF NATURAL RESOURCES

TECHNICAL PUBLICATION NO. 59
PLATE 1 1978

CONVERSION UNITS

Feet	Meters
4270	1301
4300	1310
4350	1325
4400	1341
4450	1356
4500	1371
4600	1402
4700	1432
4800	1463
4900	1493
5000	1524
5100	1554
5300	1615
5500	1676
5700	1737

Inches	Millimeters
6	152
8	203
10	254
12	304
16	406
20	508



EXPLANATION

GEOLOGY

(see table 2)

QUATERNARY	Qds	Eolian dune sand	*Permeable, may transmit water to underlying hydrogeologic units*
	Qag	Alluvium and colluvium	*Moderately to highly permeable, serve as recharge areas*
	Qlc	Alluvium and lacustrine deposits	*Low to high permeability, generally unsaturated*
QUATERNARY and TERTIARY	QTu	Older alluvium	*Slightly to highly permeable, constitutes the major aquifer in this area*
TERTIARY	Te	Extrusive igneous rocks	*Relatively impermeable except where fractured*
PALEOZOIC	Pzc / Pzq	Consolidated carbonate (Pzc) and quartzitic (Pzq) rocks	*Pzc — slightly to highly permeable depending upon extent of fractures and solution channels. Pzq — relatively impermeable except where fractured*
PRECAMBRIAN (?)	p€g	Intrusive igneous rocks	*Low permeability except where fractured*
PRECAMBRIAN		Quartzitic and related metasedimentary rocks undifferentiated	*Relatively impermeable except where fractured*

Approximate contact

Fault, dotted where concealed

Fault, inferred from geophysical evidence

Thrust fault, barbs on side of thrust sheet, dotted where concealed

HYDROLOGY

Steam-sampling and (or) miscellaneous-discharge measurement site (p. 13 and table 9)

2, C, L Well (table 6)

Flowing well

Abandoned well

2, C Spring (table 7)
Number by symbol refers to number of wells or springs at same location; C, indicates chemical analysis in table 9; L, indicates log of well in table 8

Reservoir (table 4)

8 Line of equal normal annual (1931-60) precipitation
Interval 2 and 4 inches (51 and 102 millimeters) (from U.S. Weather Bureau, no date)

Intersection of water table with land surface

Water-level contour (1976)
Interval 10, 50 and 100 feet (3, 15, and 30 meters). Datum is mean sea level. Arrows show general direction of ground-water movement

Drainage divide

Northwest boundary of study area

Base from U.S. Geological Survey 1:250,000 series: Delta and Tooele, Utah, 1953

HYDROGEOLOGY

5 0 5 10 MILES
5 0 5 10 KILOMETERS
CONTOUR INTERVAL 200 FEET (60 METERS)
DATUM IS MEAN SEA LEVEL

EXPLANATION

Dissolved solids, in milligrams per liter

Less than 500

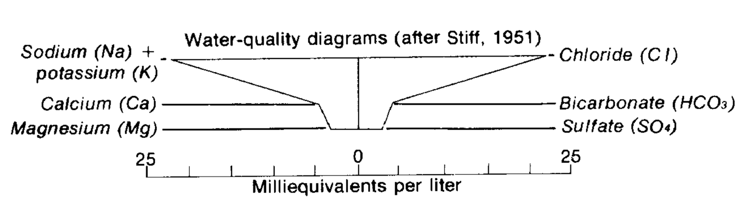
500-1000

1000-2000

2000-5000

More than 5000

293 Spring
2,790 Well
Number by symbol is dissolved solids, in milligrams per liter (from table 9)



Drainage divide

Northwest boundary of study area

CHEMICAL QUALITY OF WATER

Hydrogeology by Jerry C. Stephens and C. T. Sumsion, 1976; geology after Stokes (1964) with modifications by Jerry C. Stephens, 1976

DUGWAY VALLEY-GOVERNMENT CREEK AREA

STATE OF UTAH
DEPARTMENT OF NATURAL RESOURCES

Technical Publication No. 59

HYDROLOGIC RECONNAISSANCE OF THE DUGWAY VALLEY-GOVERNMENT CREEK AREA, WEST-CENTRAL UTAH

by

Jerry C. Stephens and C. T. Sumsion
Hydrologists, U.S. Geological Survey

Prepared by
the United States Geological Survey
in cooperation with
the Utah Department of Natural Resources
Division of Water Rights

1978

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ENGLISH-TO-METRIC CONVERSION FACTORS

Most values are given in this report in English units followed by metric units. The conversion factors used are shown to four significant figures. In the text, however, the metric equivalents are shown only to the number of significant figures consistent with the accuracy of the value in English units.

English Units (Multiply)	English Abbreviation	(by)	Metric Units (to obtain)	Metric Abbreviation
Acres		0.4047	Square hectometers	hm^2
Acre-feet	acre-ft	.001233	Cubic hectometers	hm^3
Cubic feet per second	ft^3/s	.02832	Cubic meters per second	m^3/s
Cubic feet per second per square mile	$(ft^3/s)/mi^2$	.01093	Cubic meters per second per square kilometer	$(m^3/s)/km^2$
Feet	ft	.3048	Meters	m
Feet per mile	ft/mi	.1894	Meters per kilometer	m/km
Gallons	gal	3.785	Liters	L
Gallons per minute	gal/min	.06309	Liters per second	L/s
Gallons per minute per foot	(gal/min)/ft	.2070	Liters per second per meter	(L/s)/m
Inches	in	25.40	Millimeters	mm
		2.540	Centimeters	cm
Miles	mi	1.609	Kilometers	km
Square miles	mi^2	2.590	Square kilometers	km^2

Chemical concentration and water temperature are given only in metric units. Chemical concentration is given in milligrams per liter (mg/L). For concentrations less than 7,000 mg/L, the numerical value is about the same as for concentrations in the English unit, parts per million.

Micrograms per liter (µg/L) is a unit expressing the concentration of chemical constituents in solution as weight (micrograms) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter.

Chemical concentration in terms of ionic interacting values is given in milliequivalents per liter (meq/L). Meq/L is numerically equal to the English unit, equivalents per million.

Water temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation: $°F = 1.8(°C) + 32$.

HYDROLOGIC RECONNAISSANCE OF THE DUGWAY VALLEY-
GOVERNMENT CREEK AREA, WEST-CENTRAL UTAH

by

Jerry C. Stephens and C. T. Sumsion
Hydrologists, U.S. Geological Survey

ABSTRACT

The Dugway Valley-Government Creek area covers about 890 square miles (2,300 square kilometers) in west-central Utah. Total annual precipitation on the area averages about 380,000 acre-feet (470 cubic hectometers). Most streams are ephemeral except for a few in their upper reaches--all are ephemeral below the altitude of about 6,000 feet (1,830 meters). Surface-water development and use in the area are insignificant.

Ground-water recharge from precipitation is about 7,000 acre-feet (8.6 cubic hectometers) annually. Recharge is from snowmelt and thunderstorms and occurs principally in coarse alluvium of higher valleys and lower mountain slopes above 6,000 feet (1,830 meters). About 5,000 acre-feet (6.2 cubic hectometers) of ground water enters the area annually from the Sevier Desert by way of the Old River Bed. Total estimated recharge is thus about 12,000 acre-feet (14.8 cubic hectometers) annually. Ground water moves generally northwestward to the Great Salt Lake Desert.

The estimated amount of water recoverable from storage in the upper 100 feet (30 meters) of saturated valley fill is about 3.8 million acre-feet (4,700 cubic hectometers).

Many of the 43 known springs in the area discharge from carbonate rocks and igneous extrusive rocks of the higher mountain ranges. Estimated discharge from springs is about 5,000 acre-feet (6.2 cubic hectometers) annually. At least half of this returns to the ground-water system by infiltration; the remainder is consumed by evapotranspiration.

Total discharge of ground water by evapotranspiration in areas of phreatophytes is estimated to average less than 1,000 acre-feet (1.2 cubic hectometers). Withdrawals from wells average about 300 acre-feet (0.4 cubic hectometers) annually, and nearly all is consumed by evapotranspiration.

The chemical quality of water in the area is extremely variable. Streamflow in the upper Government Creek area generally contains less than 500 milligrams per liter of dissolved solids and is calcium bicarbonate type water, whereas wells along the eastern base of the Dugway Range discharge water containing more than 5,000 milligrams per liter of dissolved solids in which sodium and chloride are the predominant ions. Most of the water in the area is satisfactory for livestock and, except for that in western and northern Dugway Valley, the water is generally satisfactory for irrigation.

Additional water supplies could be developed from surface- and ground-water sources. Before extensive development of water resources is undertaken, exploratory drilling and detailed water-quality investigations are needed to refine reconnaissance estimates and further define ground-water conditions.

INTRODUCTION

This report is the seventeenth in a series by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Rights, which describes the water resources of the western basins of Utah (fig. 1). The purpose of the report is to present hydrologic data for the Dugway Valley-Government Creek area, to provide an evaluation of present and potential water-resources development in the area, and to identify studies needed to improve understanding of the area's water supply. The area described in this report includes Dugway Valley and the Government Creek area, a total of about 890 mi^2 (2,300 km^2) in Tooele and Juab Counties in west-central Utah (fig. 1). The investigation on which the report is based consisted largely of a study of available file data for geology, climate, streams, wells, springs, water quality, and water use. These data were supplemented with data on physiography, vegetation, geology, and water sources obtained during brief field reconnaissances in 1974-76.

Several published reports listed in references cited contain information on the geology and water resources of the Dugway Valley-Government Creek area. Principal sources of basic hydrologic data are the files of the U.S. Geological Survey, the Utah State Engineer, and the Facilities Engineer, U.S. Army Dugway Proving Ground.

Most land in the Dugway Valley-Government Creek area is used principally for either military purposes or livestock grazing. Landownership is approximately as follows (Webster and Dunagan, 1970):

		Acres	Percentage of total
Federal:	U.S. Bureau of Land Management	310,000	54
	U.S. Army, Dugway Proving Ground	215,000	38
	U.S. Forest Service	10,000	2
State		30,000	5
Private		7,000	1
Total (rounded)		570,000	100

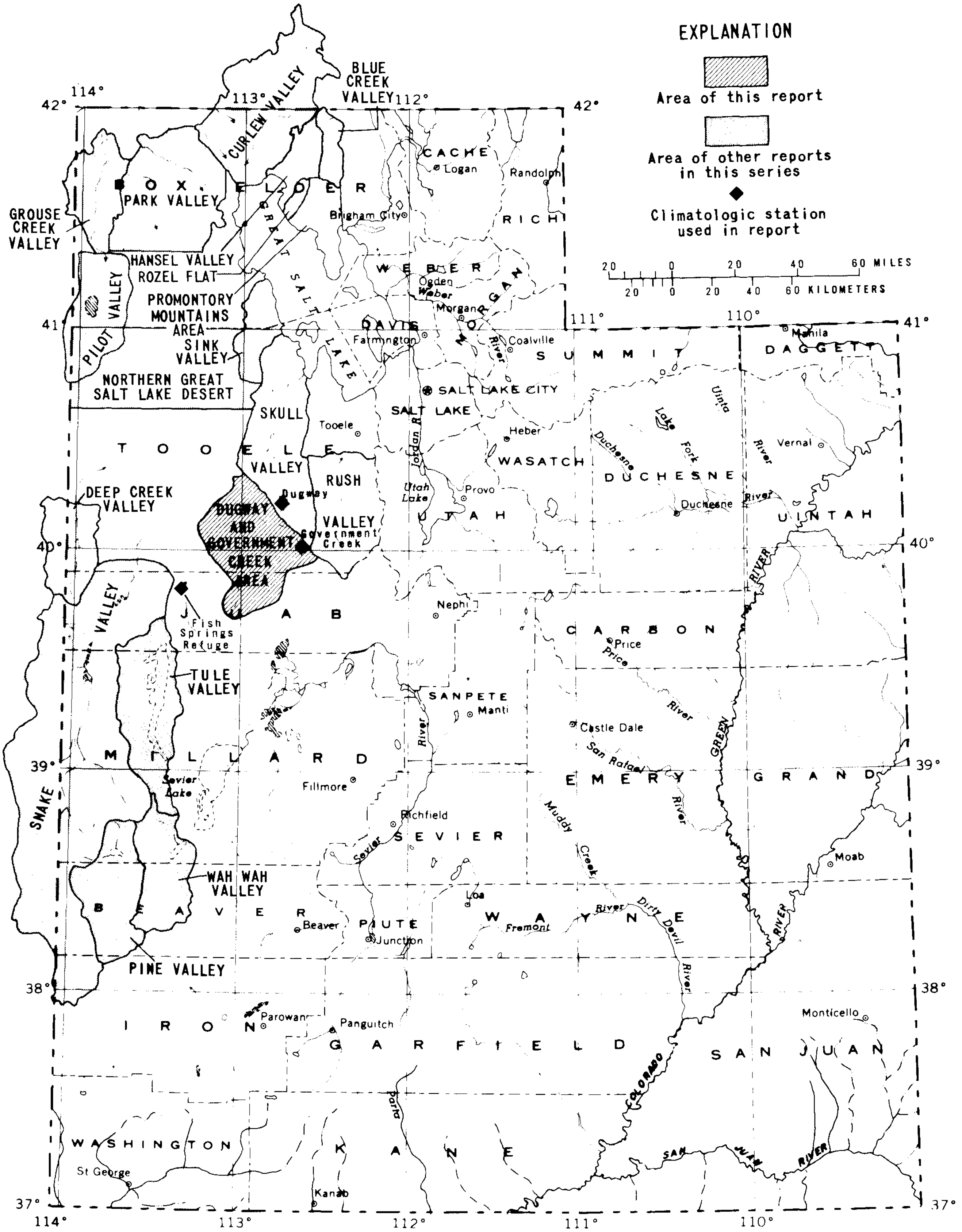

Figure 1.—Map showing location of the Dugway Valley-Government Creek area and areas described in other reports in this series.

The population of the Dugway Valley-Government Creek area is mostly transient and consists principally of seasonal graziers and employees of the U.S. Army, Dugway Proving Ground. The Proving Ground headquarters is in Skull Valley at Dugway, about 2 mi (3.2 km) from the northeast boundary of the report area. The few farms and ranches in the Old River Bed and upper Government Creek area are occupied only seasonally.

Physiography

The Dugway Valley-Government Creek area is bounded on the northeast, southeast, and southwest by drainage divides. The northwestern boundary was established for convenience along a line between Wig Mountain and Granite Peak (pl. 1). The entire area drains northwestward into the Great Salt Lake Desert.

Dugway Valley is separated from the Government Creek area by a topographic divide extending from the Simpson Mountains northwestward to Simpson Buttes and Camels Back Ridge (pl. 1). Northwestward from Camels Back Ridge, the two valleys merge into the Great Salt Lake Desert.

The Old River Bed, between the Simpson Mountains and Keg Mountain,[1] is a prominent trench crossing the divide between the Sevier Desert drainage and the Great Salt Lake Desert drainage. The river that formed the trench was a connecting link between two major parts of Lake Bonneville, a large freshwater lake that covered much of western Utah and adjacent parts of Idaho and Nevada during the Pleistocene Epoch. (See fig. 2.) During the recession of Lake Bonneville, the Old River Bed carried drainage from the Sevier Desert toward the Great Salt Lake Desert (Gilbert, 1890, p. 181-184). The drainageway is now blocked by mudflow deposits in sec. 28, T. 10 S., R. 9 W. (Mower and Feltis, 1968, p. 10), that form part of the divide between the two basins. The altitude at this location is about 4,500 ft (1,370 m), the lowest point on the Dugway Valley drainage divide.

Total relief in the study area is about 5,000 ft (1,520 m). Altitudes range from about 4,260 ft (1,300 m) on the desert floor in the northwestern part of the area to about 9,270 ft (2,820 m) in the Sheeprock Mountains at the eastern extremity. Most of the area below about 4,600 ft (1,400 m) is gently sloping to level as a result of planation and deposition by Lake Bonneville.

Climate

The climate of the Dugway Valley-Government Creek area is generally arid. Average annual precipitation ranges from less than 6 in. (127 mm) on the floor of the desert to slightly more than 20 in. (508 mm) in the Sheeprock Mountains (pl. 1). Overall average for the area is about 8 in. (200 mm).

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[1]Keg Mountain is named McDowell Mountains on many older maps.

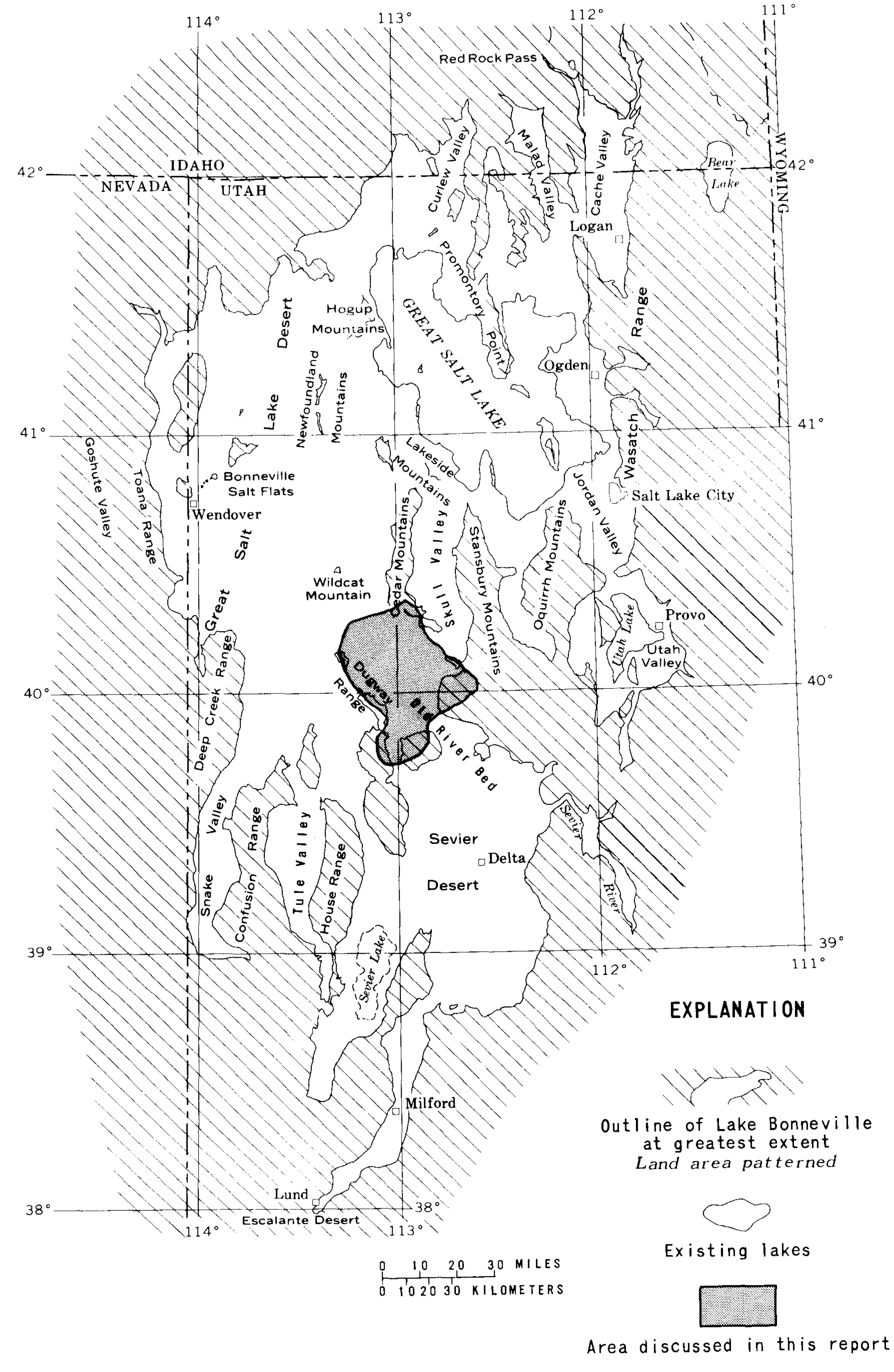

Figure 2.— Map of Lake Bonneville (after Crittenden, 1963).

Table 1.--Selected climatologic data for sites in and near the Dugway Valley-Government Creek area

(Data from U.S. Weather Bureau, 1937, 1957, 1962-66; U.S. Environmental Science Services Administration, 1967-70; and U.S. National Oceanic and Atmospheric Administration, 1971-76.)

[Site locations are shown in figure 1.]

Site:	Government Creek		Dugway		Fish Springs Refuge		
Altitude:	5,277 ft		4,340 ft		4,335 ft		
Period of record:	Jan. 1900-May 1950		Jan. 1951-Dec. 1975		July 1960-Dec. 1975		
Average monthly:	Precipitation (in.)	Temperature (°F)	Precipitation (in.)	Temperature (°F)	Precipitation (in.)	Temperature (°F)	Evaporation[1] (in.)
January	1.00	26.2	0.47	27.7	0.27	28.8	-
February	1.19	30.5	.52	34.5	.46	36.3	-
March	1.60	38.0	.54	40.2	.63	42.4	-
April	1.32	46.6	.79	48.6	1.06	49.7	7.26 (1)
May	1.45	54.8	.66	59.3	.76	61.2	11.17 (6)
June	.72	64.3	.65	68.8	1.02	70.0	12.82 (12)
July	.79	73.8	.42	78.5	.51	80.0	16.06 (12)
August	1.01	72.2	.49	75.9	.44	77.6	13.60 (12)
September	.70	62.1	.48	64.5	.58	66.1	9.90 (12)
October	1.15	49.9	.55	52.3	.71	53.6	5.95 (6)
November	.97	37.5	.54	38.8	.52	40.7	-
December	1.01	28.4	.57	28.9	.46	29.6	-
Average annual:	12.91	48.7	6.68	51.5	7.42	53.0	76.76
Maximum/minimum							
Period of record	-	105/-25	-	105/-22	-	109/-14	-
Annual	18.50/7.51	-	11.23/3.35	-	9.63/4.05	-	-
Monthly	4.29/0.00	-	2.37/0.00	-	2.94/0.00	-	19.68/-

[1] Number of years of record shown in parentheses.

Table 1 lists selected precipitation, temperature, and evaporation data for three climatologic stations in and near the area. (See fig. 1.) Data from the Government Creek station, which was discontinued in 1950, probably are representative of conditions in the foothills and lower slopes of the Simpson and Sheeprock Mountains. The data for the other two stations are assumed to reflect conditions similar to those of low-altitude parts of the Dugway Valley-Government Creek area. There are no nearby climatologic stations in the mountains at higher altitudes, but it is probable that areas of higher altitude differ from the area of the Government Creek station principally in having lower average temperatures and greater average precipitation. The seasonal distribution of precipitation and temperature probably differs little from that recorded at the Government Creek station.

Vegetation

Because of the general aridity, native vegetation in much of the Dugway Valley-Government Creek area consists of "salt-desert" shrubs that are typical of millions of acres of the Great Basin. Vegetation is scanty or absent on the alkali flats and sand dunes that comprise much of the desert floor--the vegetation that does exist is mostly shadscale (*Atriplex* sp.) and annual grasses. On the gravelly soils around the margins of the desert floor, a mixed association of shadscale and bunchgrasses predominates.

On the alluvial slopes adjacent to the mountains, sagebrush (*Artemisia* sp.) is the dominant vegetation below an altitude of about 6,000 ft (1,830 m). Above that altitude juniper (*Juniperus* sp.) and pinyon (*Pinus* sp.) are common on both alluvial and residual soils. Several types of deciduous shrubs grow in the uplands, especially on north-facing slopes in the Simpson and Sheeprock Mountains.

Rabbitbrush (*Chrysothamnus* sp.) and greasewood (*Sarcobatus vermiculatus*) grow locally in and along stream channels in the alluvium, especially in the Old River Bed and along Government Creek. Where moisture is perenially available in the vicinity of some springs and in areas where the water table is at or near the land surface, as along Government Creek in part of T. 9 S., meadowgrasses, greasewood, rabbitbrush, willow (*Salix* sp.), and other phreatophytes are common.

A few small plots of ground along both Government Creek and the Old River Bed have been cleared of native vegetation and converted to grass pastures or irrigated cropland. A total of less than 1 mi^2 (2.6 km^2) of land is presently used for such purposes.

Geology

Rocks ranging in age from Precambrian to Quaternary crop out in the Dugway Valley-Government Creek area. On the basis of lithologic and hydrologic similarities, these rocks are grouped into generalized hydrogeologic units, each of which affects the hydrologic system in the area. Table 2 gives a generalized description of the lithology and water-bearing characteristics of these units, and plate 1 shows their distribution.

Numbering system for hydrologic-data sites

The system of numbering hydrologic-data sites in Utah is based on the cadastral land-survey system of the U.S. Government. The number, in addition to designating a site as a well, spring, or miscellaneous site, describes its position in the land net. By the land-survey system, the State is divided into four quadrants by the Salt Lake base line and meridian, and these quadrants are designated by the uppercase letters A, B, C, and D, indicating the northeast, northwest, southwest, and southeast quadrants, respectively. Numbers designating the township and range (in that order) follow the quadrant letter, and all three are enclosed in parentheses. The number after the parentheses indicates the section, and is followed by three letters indicating the quarter section, the quarter-quarter section, and the quarter-quarter-quarter section--generally 10 acres (4 hm^2);[1] the letters a, b, c, and d indicate,

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[1]Although the basic land unit, the section, theoretically is 1 mi^2 (2.6 km^2), many sections are irregular. Such sections are subdivided into 10-acre (4-hm^2) tracts, generally beginning at the southeast corner, and the surplus or shortage is taken up in the tracts along the north and west sides of the section.

respectively, the northeast, northwest, southwest, and southeast quarters of each subdivision. The number after the letters is the serial number of the well or spring within the 10-acre (4-hm^2) tract; the letter "S" preceding the serial number denotes a spring. Thus (C-7-10)25 cdd-1 designates the first well constructed or visited in the SE¼SE¼SW¼ sec. 25, T. 7 S., R. 10 W. Other sites where hydrologic data were collected are numbered in the same manner, but no serial number is used. If a well or spring cannot be located within a 10-acre (4-hm^2) tract, one or two location letters are used. The numbering system is illustrated in figure 3.

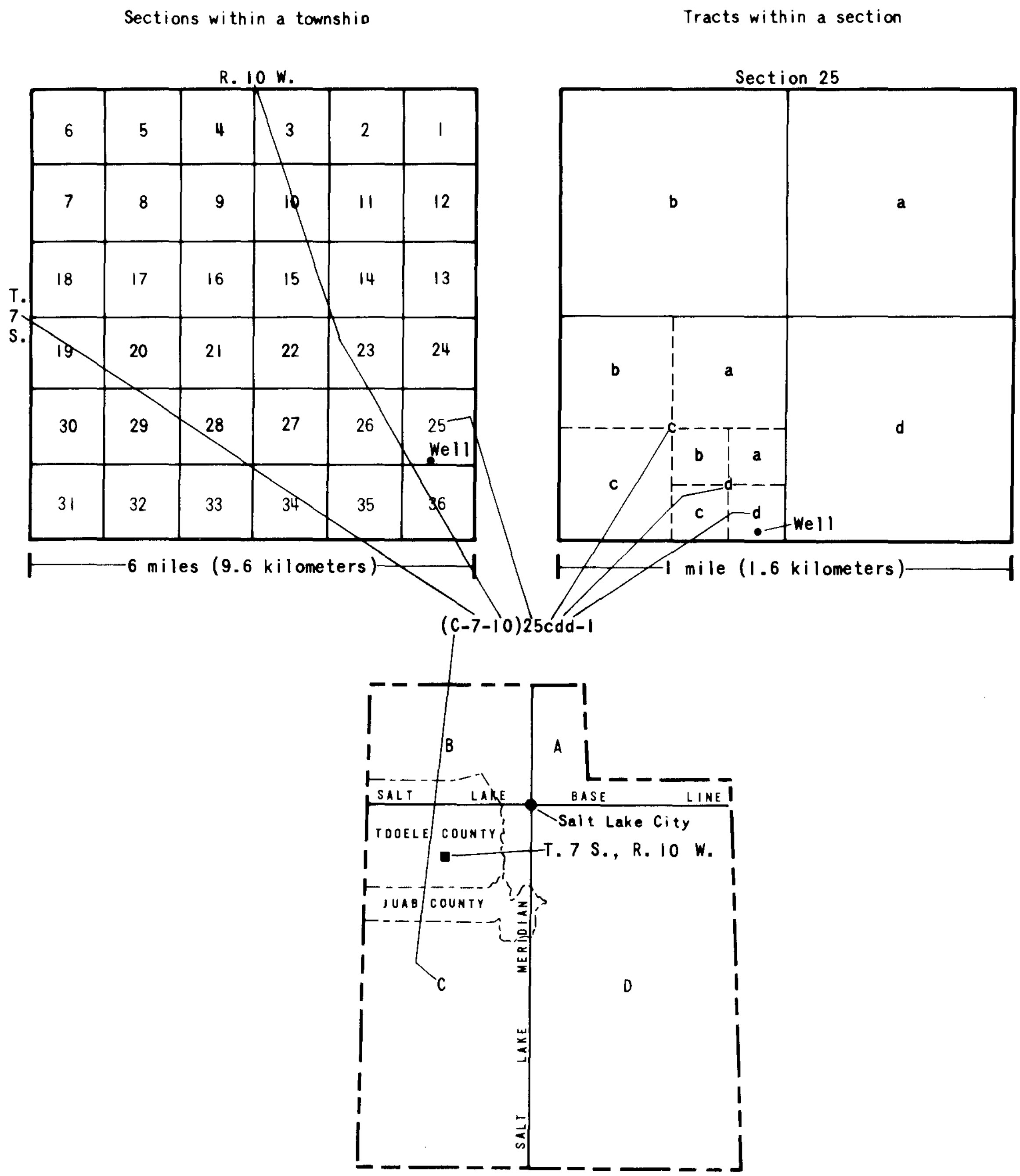

Figure 3.— Numbering system for hydrologic-data sites.

Table 2.--Generalized lithologic and water-bearing characteristics of hydrogeologic units

Age		Hydrogeologic unit and map symbol (pl. 1)	Description and extent	Water-bearing characteristics
CENOZOIC	Quaternary	Eolian dune sand (Qds)	Linear dunes and barchans along the margin of the Great Salt Lake Desert and south of the Cedar Mountains; and in discontinuous patches throughout the area; some dunes are stabilized by vegetation; predominantly fine to medium quartzose sand; maximum thickness about 50 ft (15 m).	Permeable, retaining sufficient moisture to support vegetation; generally unsaturated but locally may contain fresh, perched ground water during the spring or early summer; may transmit water to underlying hydrogeologic units; not an aquifer in this area.
CENOZOIC	Quaternary	Alluvium and colluvium (Qag)	Fluvial deposits of sand, gravel, and boulders in stream channels and near mountains; coalescing alluvial-fan deposits of generally coarse material along lower mountain slopes; maximum thickness less than 200 ft (60 m). Colluvial deposits of angular rock fragments locally on higher mountain slopes; maximum thickness less than 100 ft (30 m).	Moderately to highly permeable but too thin to store significant quantities of water; mostly unsaturated; only thickest deposits may be saturated in lower areas; accepts recharge from snowmelt, transmitting water to underlying hydrogeologic units; this and the underlying older alluvium (QTu) comprise an aquifer along mountain fronts and in higher valley areas.
CENOZOIC	Quaternary	Alluvium and lacustrine deposits (Qlc)	Fluvial and lacustrine marl, clay, silt, sand, and gravel; alluvium confined mostly to stream channels; lacustrine deposits in flat areas; includes some alluvial fans and slope wash; bars, spits, terraces, and deltas which were deposited in Pleistocene Lake Bonneville are composed chiefly of sand and fine gravel; maximum thickness probably less than 100 ft (30 m).	Low-to-high permeability, but generally unsaturated; locally may contain perched ground water during spring or early summer; where fairly permeable may accept recharge to the water table from snowmelt in the same manner as Qag; not an aquifer in this area.
CENOZOIC	Tertiary and Quaternary	Older alluvium (QTu)	Fluvial clay, sand, and gravel; unconsolidated to well-cemented with calcium carbonate; exposed in the higher part of the Government Creek area and underlies most of the alluvial and lacustrine deposits of the area; maximum thickness is probably more than 1,000 ft (300 m).	Slightly to highly permeable; yields of more than 1,000 gal/min (63 L/s) for irrigation reported in the Old River Bed area; constitutes the major aquifer in the Dugway-Government Creek area; water is brackish or saline in parts of the area.
CENOZOIC	Tertiary	Extrusive igneous rocks (Te)	Felsic to mafic lava, pyroclastic and ignimbrite deposits in most of the mountain ranges and probably interlayered locally with older alluvium in the subsurface.	Relatively impermeable except where fractured or clastic interlayers may be permeable; yield water to springs in the mountains where extensively fractured; accept recharge from snowmelt and transmit water to adjacent or underlying hydrogeologic units.
PALEOZOIC		Consolidated carbonate rocks, undifferentiated (Pzc)	Limestone and dolomite with subordinate shale and sandstone; range in age from Cambrian to Permian; constitute mountain ranges in large part; complexly folded and faulted.	Slightly permeable; local fractures and solution channels impart high permeability; yield fresh water to small springs; accept recharge as in Te.
PALEOZOIC		Consolidated quartzitic rocks, undifferentiated (Pzq)	Quartzite and sandstone with subordinate shale; of Cambrian and Ordovician ages; constitute parts of mountain ranges; complexly folded and faulted.	Where fractured, yield fresh water to small springs; otherwise relatively impermeable; accept recharge as in Te.
PRECAMBRIAN(?)		Intrusive igneous rocks (p€g)	Gneissic biotite granite cut by numerous granitic pegmatites; exposed at Granite Peak; complexly jointed and fractured.	Low permeability except where jointed or fractured; yield fresh water to at least one small spring; accept recharge as in Te.
PRECAMBRIAN		Quartzitic and related metasedimentary rocks, undifferentiated (p€u)	Argillite, quartzite, metaconglomerate, and related metamorphic rocks; complexly folded and faulted; exposed in mountain ranges in the southern and southeastern parts of the area.	Where fractured, yield small quantities of water to springs, otherwise relatively impermeable; where well-fractured, accept recharge as in Te.

WATER-RESOURCES APPRAISAL

Precipitation on the Dugway Valley-Government Creek area is the source of nearly all water available there. Total precipitation on the area is estimated to average about 380,000 acre-ft (470 hm^3) annually (table 3).

Table 3.--Estimated average annual precipitation and ground-water recharge

[Areas of precipitation zones measured from pl. 1]

Precipitation zone (inches)	Area (acres)	Precipitation		Recharge	
		Inches	Acre-feet	Percentage of precipitation	Acre-feet
		Areas of unconsolidated rocks			
Less than 6	60,000	5.5	27,500	0	0
6-8	280,000	7	163,000	minor	0
8-10	57,000	9	42,800	minor	0
10-12	25,000	11	22,900	1	230
12-16	19,000	14	22,200	5	1,100
16-20	1,500	18	2,250	8	180
Subtotal	442,500		280,650		1,510
		Areas of consolidated rocks			
6-8	78,000	7	45,500	minor	0
8-10	19,000	9	14,200	1	140
10-12	7,000	11	6,420	5	320
12-16	16,000	14	18,700	12	2,200
16-20	5,800	18	8,700	17	1,500
More than 20	2,700	21	4,720	25	1,200
Subtotal	128,500		98,240		5,360
Total (rounded)	570,000		380,000		7,000

Surface water

Most streams in the Dugway Valley-Government Creek area are ephemeral. A few streams draining the Simpson and Sheeprock Mountains have perennial flow in their upper reaches, but below an altitude of about 6,000 ft (1,830 m) even these become ephemeral.

Pismire Wash, the principal drainageway in Dugway Valley, extends generally northward from the Thomas Range for about 35 mi (56 km) before the channel loses its identity and disappears on the desert floor southeast of Granite Peak (pl. 1). Flow in Pismire Wash occurs only in direct response to thunderstorms or rapid snowmelt. The channel normally is dry through its entire length.

The Old River Bed, as previously described, is a relict drainageway blocked by mudflow deposits at the Dugway Valley drainage divide. An ephemeral stream channel is located on the broad, flat floor of this 50-100 ft (15-30 m) deep trench. Flow in the channel occurs principally in response to local thunderstorms and generally is of short duration.

Government Creek extends generally northwestward from its headwaters in the Simpson and Sheeprock Mountains for a distance of about 30 mi (48 km) before the channel disappears on the desert floor (pl. 1). Several minor headwater tributaries of Government Creek originate as discharge from springs in the mountains and may have perennial flow for short distances below the springs.

A reach of Government Creek in sec. 28, T. 9 S., R. 7 W., has perennial flow where the channel intersects the water table. The flow originates at (C-9-7)28cad as seepage in the bottom of the channel, which is incised 10-15 ft (3-5 m) below the adjacent land surface. Flow increases downstream and was estimated to be about 50 gal/min (3 L/s) in the channel at (C-9-7)28bca on May 6, 1976. On this date, the flow disappeared into the coarse sand and gravel deposits on the channel floor about 0.6 mi (1 km) downstream from the point of origin. Vegetation in and along the channel indicates that flow is perennial in this reach, and several minor springs and seeps are present at the same and slightly higher altitudes on the bottom and along the margins of the valley.

Several small impoundments have been constructed in the Dugway Valley-Government Creek area to intercept local runoff and store it for stock use. Table 4 lists selected stock ponds and reservoirs presently used in the area. Except for the reservoir at (C-9-9)11bbb that is supplied by diverted springflow, these reservoirs store water only infrequently. Runoff from winter and early spring snowmelt supplies most of the water; summer and fall thunderstorms are less dependable local sources of supply to some of the reservoirs. Large evaporation losses in the hot, dry summer rapidly deplete the volume of water in storage, as well as concentrating the mineral solids dissolved in the water.

Table 4.--Selected data for stock ponds and reservoirs

Location: See section on numbering system for hydrologic-data sites.
Altitude: Approximate altitude of outlet, in feet above mean sea level; interpolated from U.S. Geological Survey topographic maps.

Location	Name	Altitude	Remarks
(C-9-9)11bbb	-	4,470	Supplied by pipeline from Simpson Springs.
28dac	South Simpson Reservoir	4,510	On desert floor; supplied by local runoff; chemical analysis in table 9.
(C-9-10)21ddb	-	4,370	In channel of Old River Bed; chemical analysis in table 9.
(C-10-7)4dca	-	6,040	Small impoundment on tributary of Government Creek.
(C-10-8)7cbd	-	5,210	Developed from natural depression on Lake Bonneville shoreline; supplied by runoff from Simpson Mountains.
(C-10-10)23ca	North Table Mountain Reservoir	4,515	On tributary to Old River Bed; chemical analysis in table 9.
(C-11-9)7cd	Slow Elk Reservoir	4,870	On tributary to Old River Bed; supplied by runoff from Keg Mountain.
(C-11-10)5abb	East Dugway Reservoir	4,540	Supplied by ditch diversion from Pismire Wash; chemical analysis in table 9.
(C-11-11)12ac	Monument Reservoir	4,620	On Pismire Wash tributary.
23bd	Bittner Knoll Reservoir	4,840	On Pismire Wash tributary from Thomas Range.
(C-12-10)19ac	East Topaz 2 Reservoir	5,040	On Pismire Wash tributary.

The only surface-water developments in the area, other than livestock reservoirs, are small diversions of water for irrigation from Lee Creek and from springs on the south side of the Sheeprock Mountains in the Sevier Desert drainage basin. Water from Lee Creek, a tributary of Government Creek, is diverted in the headwaters area in the southern part of T. 9 S., Rs. 7 and 8 W., and transported northward by pipeline a distance of 4-5 mi (6-8 km) for irrigation of pastureland near Government Creek in sec. 7, T. 9 S., R. 7 W. Flow in the pipeline at (C-9-7) 7dac on July 15, 1964, was estimated to be 100 gal/min (6.3 L/s); no additional data are available from which to estimate the quantity of water diverted.

An open, unlined ditch about 3 mi (5 km) long carries water from springs in S½ sec. 31, T. 9 S., R. 6 W., in the Sevier Desert drainage basin, across the divide into the valley of Government Creek. The water is used for irrigation of pastureland in sec. 34, T. 9 S., R. 7 W. The quantity of water diverted by this ditch is unknown; discharge at (C-10-7)1daa, near the crest of the drainage divide, was estimated to be 75 gal/min (4.7 L/s) on May 6, 1976.

Estimates of discharge at miscellaneous sites in the area are given in the following table:

Location	Description	Estimated discharge (gal/min) and date	Remarks
(C-9-7)7dac	Pipeline	100 (7-15-64)	Diversion from Lee Creek and unnamed tributary; chemical analysis in table 9.
28bc	Government Creek	100 (7-17-64) 50 (5-6-76)	In area of ground-water inflow; chemical analysis in table 9.
30cd	Pipeline	450 (7-15-64)	Diversion from Lee Creek.
(C-10-7)1daa	Ditch	75 (5-6-76)	Diversion from springs in Sheeprock Mountains in Sevier Desert drainage; specific conductance and temperature in table 9.
(C-10-8)1bd	Lee Creek	100 (7-15-64)	Chemical analysis in table 9.

The U.S. Geological Survey operated a crest-stage gage on Government Creek at (C-8-8)36ab during 1960-70. Annual maximum discharges calculated from records for this period (U.S. Geol. Survey, 1974, p. 1118) are:

Date	Discharge (ft^3/s)	Date	Discharge (ft^3/s)
1960	0	1966	0
Aug. 12, 1961	370	1967	4.5
Feb. 11, 1962	188	Aug. 21, 1968	26
1963	0	1969	0
June 18, 1964	11	July 22, 1970	93
Aug. 13, 1965	143		

Drainage area above the gage site is 59 mi^2 (153 km^2). The maximum discharge of record (370 ft^3/s or 10.5 m^3/s) on August 12, 1961, was thus equivalent to 6.3 $(ft^3/s)/mi^2$ $[0.07(m^3/s)/km^2]$.

Because of the general aridity of the area and the permeable alluvial deposits at the base of the mountain ranges, which rapidly absorb streamflow, runoff from the Dugway Valley-Government Creek area to the Great Salt Lake Desert is minor. Some overland runoff from local thunderstorms flows onto the desert; but the surface gradient toward the northwest is very slight, the few channels that exist are small and discontinuous, and evaporation rates are high (*cf.* Fish Springs Refuge evaporation records, table 1). Thus, essentially all the estimated 380,000 acre-ft (470 hm^3) of precipitation that falls in the area each year is consumed by evapotranspiration within the area, except for the quantity that infiltrates to recharge the ground-water system.

Ground water

The major source of ground water for wells in the Dugway Valley-Government Creek area is the saturated older alluvium (pl. 1; table 2). Springs in the area yield water mainly from fractured consolidated rocks in the mountain ranges. A few springs in the upper Government Creek area yield water from older alluvium.

Recharge

Ground-water recharge from precipitation in the Dugway Valley-Government Creek area is estimated to average about 7,000 acre-ft (8.6 hm^3) annually (table 3). It is derived mainly from snowmelt and thunderstorms. The principal recharge areas are in the coarse alluvial deposits in the valleys and lower mountain slopes above an altitude of about 6,000 ft (1,830 m). Most rainfall from summer storms at lower altitudes is consumed directly by evapotranspiration.

Some ground water enters the Dugway Valley area as subsurface inflow from the Sevier Desert drainage basin through the Old River Bed. The water moves principally through coarse-grained alluvium deposited by the ancient stream. The amount of inflow is not known precisely, but it is estimated to be less than 5,000 acre-ft (6.2 hm^3) per year (Mower and Feltis, 1968, p. 49). Total estimated recharge from precipitation and inflow is thus about 12,000 acre-ft (14.8 hm^3) annually.

Storage

Under natural conditions, a ground-water system is in dynamic equilibrium; long-term average annual recharge and discharge are equal, and the amount of ground water in transient storage remains nearly constant. Changes in the volume of ground water in storage result in corresponding changes in discharge from springs and water levels in wells.

Available data are inadequate to detect long-term trends in the discharge of springs in the Dugway Valley-Government Creek area. The water-level record for well (C-10-9)4bda-1 for March 1965 through March 1976 shows no discernible trend that might be indicative of a long-term change in storage in the ground-water reservoir. Ground-water development by man is relatively minor, amounting to only about 2.5 percent of the estimated average annual recharge. (See p. 16.) Thus, it is probable that in the Dugway Valley-Government Creek area, seasonal and annual changes tend to balance out in the long-term average, and a natural dynamic equilibrium prevails in the ground-water system.

The total volume of ground water in storage in the area is unknown. Recoverable ground water in storage is that part of the stored water that will drain by gravity from the ground-water reservoir as water levels are lowered. It is the product of the specific yield[1] of the reservoir rocks, the saturated thickness, and the area.

An estimated 3.8 million acre-ft (4,700 hm^3) might be recovered from the valley fill in the area overlain by dune sand, lacustrine deposits, and older alluvium (Qds, Qlc, and QTu on pl. 1). This estimate is based on (1) an assumed average specific yield of 10 percent; (2) a uniform dewatering of the upper 100 ft (30 m) of saturated material; and (3) an area of about 380,000 acres (154,000 hm^2) underlain by the ground-water reservoir.

The volume of water stored in the igneous, consolidated sedimentary, and metasedimentary rocks exposed in and underlying the area cannot be reliably estimated because storage is principally in fractures, joints, or solution openings (table 2) whose presence, size, and degree of interconnection are not readily apparent. Near-surface storage in these rocks, where they are exposed in the mountains, frequently is short term. Recharge from rainfall and snowmelt fills the openings, but

[1]Specific yield of a rock or soil is the ratio of the volume of water it will yield by gravity after being saturated, to the volume of the rock or soil.

gravity rapidly drains them to intermittent springs and seeps. In the subsurface beneath the valley fill, the consolidated rocks may be permanently saturated, but the volume of void space filled with ground water is unknown.

Discharge

Most ground-water discharge from the Dugway Valley-Government Creek area is by subsurface outflow northwestward into the Great Salt Lake Desert.

Some ground water is discharged by evapotranspiration, mostly by phreatophytes in the upper part of the Government Creek area. In the remaining area, the depth to ground water generally is too great, or the water too saline, to support phreatophytes. Total annual direct discharge by evapotranspiration in the area is estimated to average less than 1,000 acre-ft (1.2 hm^3).

Withdrawal of water from four wells in the lower part of the Government Creek area averaged about 228 acre-ft (0.28 hm^3) annually from 1967 to 1975 (table 5). Most of the water is used for road construction and maintenance, or similar uses, and nearly all the water ultimately is consumed by evaporation. These four wells are the only ones in the area for which withdrawal data are available. Total annual discharge of ground water by withdrawal from all wells in the area (table 6) is estimated to average about 300 acre-ft (0.4 hm^3), and essentially all this water is consumed by evapotranspiration.

Springs in the area discharge an estimated 5,000 acre-ft (6.2 hm^3) of ground water annually. At least one-half of this amount probably returns to the ground-water reservoir downgradient by infiltration in the channels of streams fed by large-discharge springs, such as (C-9-7)35b-S and (C-10-8)3aba-S1 (table 7). The remainder is consumed by evapotranspiration near the point of discharge. Thus, net discharge of ground water by springs as evapotranspiration may average about 2,500 acre-ft (3.1 hm^3) annually.

Because the ground-water system in the Dugway Valley-Government Creek area apparently is in a state of long-term balance between recharge and discharge, the volume of subsurface outflow to the Great Salt Lake Desert across the northwestern boundary of the area represents the difference between average annual recharge and estimated discharge by other means. Thus, the subsurface outflow is estimated to average about 8,000 acre-ft (10 hm^3) annually--the approximate difference between estimated recharge of 12,000 acre-ft (14.8 hm^3) and estimated discharge by direct evapotranspiration (1,000 acre-ft or 1.2 hm^3), withdrawals from wells (300 acre-ft or 0.4 hm^3), and net discharge of springs (2,500 acre-ft or 3.1 hm^3).

Table 5.--Withdrawal of water from selected wells in the Government Creek area, 1967-75

Year	(C-7-9)32ccd-1: Dugway Proving Ground Well 5		(C-7-10)25ccd-2: Dugway Proving Ground Well 28	
	Thousands of gallons	Acre-ft	Thousands of gallons	Acre-ft
1967	8,793	27.0	74,347	228.2
1968	12,447	38.2	48,386	148.5
1969	14,591	44.8	41,430	127.1
1970	13,315	40.9	38,453	118.0
1971	18,464	56.7	36,408	111.7
1972	29,940	91.9	27,716	85.1
1973	32,734	100.5	25,091	77.0
1974	35,135	107.8	12,254	37.6
1975	41,127	126.2	0	0
Total	206,546	634.0	304,085	933.2
Average	22,950	70.4	33,787	103.7

Year	(C-7-10)25cdd-1: Dugway Proving Ground Well 2		(C-7-10)36bab-1: Dugway Proving Ground Well 3	
	Thousands of gallons	Acre-ft	Thousands of gallons	Acre-ft
1967	1,567	4.8	6,052	18.6
1968	0	0	24,476	75.1
1969	2,197	6.7	27,775	85.2
1970	249	.8	22,789	69.9
1971	7	.02	25,365	77.8
1972	0	0	32,487	99.7
1973	0	0	12,056	37.0
1974	0	0	3,399	10.4
1975	0	0	0	0
Total	4,020	12.3	154,399	473.7
Average	447	1.4	17,155	52.6

Summary of conditions in hydrogeologic units

Valley-fill deposits.--Eolian dune sand, alluvium, colluvium, lacustrine deposits, and possibly some extrusive igneous rocks compose the valley fill in the Dugway Valley-Government Creek area (table 2). Of these, the older alluvium (QTu, table 2) is the principal aquifer. The other hydrogeologic units in the valley fill contain water locally but are not significant aquifers. All wells presently in use (table 6) and several springs (table 7) in the area discharge water from the older alluvium.

Drillers' logs of wells (table 8) indicate that layers of sand and gravel, some as much as 150 ft (46 m) in thickness, are present under much of the area. These layers are commonly mixed or interbedded with clay; and they are present, at least locally, to a depth of nearly 1,000 ft (300 m). They supply most of the water withdrawn from wells completed in the older alluvium. Lacustrine deposits that overlie the older alluvium and mantle most of the lowlands may yield water where they are saturated. However, because these deposits consist principally of silt, clay, and marl, they yield water too slowly to be developed by wells; and the water generally is saline.

Water levels in wells finished in the older alluvium range from slightly above land surface in the northwestern part of the area to a depth of more than 290 ft (88 m) below land surface in the upper part of the Government Creek area (pl. 1; table 6). The water table intersected by the channel of Government Creek at (C-9-7)28, at an altitude of about 5,770 ft (1,760 m), probably is the regional water table, as indicated by the water-level contours on plate 1. It is possible, however, that the water table in this area is perched, and that the regional water table is at a lower altitude. More detailed investigation, including the drilling of test holes, would be required to substantiate more fully the interpretation given on plate 1.

Under most of the valley floor, ground water is confined (under artesian conditions) or partially confined below one or more layers of lacustrine silt or clay. Ground water in the older alluvium in and near recharge areas is unconfined (under water-table conditions).

In general, ground water moves from recharge areas in and near the Simpson and Sheeprock Mountains and the upper part of the Government Creek area westward or northwestward to the Great Salt Lake Desert (pl. 1). The hydraulic gradient generally is in accordance with the topographic gradient, both averaging about 40 ft/mi (7.6 m/km) between the Sheeprock Mountains and the Great Salt Lake Desert.

Yields of wells in the valley fill are generally greater where the wells penetrate coarse materials. The coarser materials (mainly coarse sand, gravel, and cobbles) are near the mountains and within the Old River Bed. Finer materials (mainly clay, silt, and fine sand) predominate in the lower valleys, principally in the northwestern part of

Quality relative to source

Water samples from streams in the Dugway Valley-Government Creek area contained dissolved solids in amounts ranging from 325 to 381 mg/L; the range for reservoir samples was 529 to 1,330 mg/L; for spring samples, 186 to 2,130 mg/L; and for samples from wells, 619 to 10,200 mg/L (table 9).

In general, both surface and ground water in the upper Government Creek area east of about the middle of R. 8 W. contain less than 500 mg/L of dissolved solids (table 9 and pl. 1). Predominant ions in the water in this area are calcium and bicarbonate.

Downgradient in the Government Creek area, concentrations of dissolved solids in the ground water gradually increase, as do the relative proportions of sodium and chloride. Predominant ions in water from wells north and west of Camels Back Ridge are sodium and chloride. Concentrations of dissolved solids in water samples from this area range from about 1,000 mg/L at well (C-7-10)25ccd-1 to 2,790 mg/L at well (C-7-11)26daa-1 (table 9 and pl. 1).

Ground-water inflow from the Sevier Desert drainage basin in the Old River Bed area contains about 800 mg/L of dissolved solids. Additional minerals are dissolved from the containing rocks as the water moves downgradient through the valley fill, and the concentration of dissolved solids gradually increases to about 2,000 mg/L in the area where the Old River Bed channel loses its identity on the desert floor (pl. 1).

With the exception of part of the Old River Bed, ground water in the valley fill in Dugway Valley generally contains more than 1,000 mg/L of dissolved solids. Predominant ions in the water are sodium and chloride. Locally, near the eastern base of the Dugway Range, wells in valley fill yield water containing 5,000 to more than 10,000 mg/L of dissolved solids.

The extent of the area where the concentration of dissolved solids is in excess of 5,000 mg/L is unknown. The most saline water came from well (C-9-11)32dda-1, which is near the trace of an inferred fault. (See pl. 1 and table 9.) Water from well (C-11-11)12aba-1, while not as saline, has a temperature of 49.0°C (120°F). This suggests that the water has circulated to considerable depth before discharging from the well. Thus, the area in which ground water contains in excess of 5,000 mg/L of dissolved solids, probably reflects a major fault zone and is limited to a rather narrow, north-to-northwest-trending band along the eastern base of the Dugway Range where saline water is moving upward from considerable depth.

Springs on the north side of Keg Mountain, in and near the extensive volcanic rock outcrops, yield sodium calcium chloride type water. The water generally contains about 2,000 mg/L of dissolved solids (table 9 and pl. 1).

Water samples from four reservoirs on or near the desert floor (table 9) contained dissolved solids in concentrations ranging from 529 to 1,330 mg/L. Although evaporation during prolonged storage rapidly increases the salinity of water in these shallow reservoirs, it is believed that direct runoff in much of Dugway Valley and the lower Government Creek area probably contains 500 mg/L or more of dissolved solids. Windblown salt particles and saline dust from the desert floor, as well as local evaporation products, accumulate on the surface. Rainfall and snowmelt dissolve this material rapidly. Stephens (1974, p. 24) found a similar situation in the Newfoundland Mountains in the northern Great Salt Lake Desert, where water consisting principally of direct snowmelt contained dissolved solids in excess of 500 mg/L.

Quality relative to use

A detailed evaluation of water quality relative to the many possible uses of water is beyond the scope of this report. Therefore, the discussion that follows concerns water quality with respect only to principal present uses of water in the Dugway Valley-Government Creek area.

The principal uses of water in the area are for institutional supply at Dugway Proving Ground and for livestock and irrigation supplies. The water supplies of Dugway Proving Ground are treated as necessary to meet the requirements of the intended use. Therefore, the natural chemical characteristics are significant principally as they relate to determining treatment procedures and costs.

Livestock grazing in the area is confined mainly to sheep and cattle, although wild horses range through the foothills and isolated mountains. Most water sources for which analyses are given in table 9 are satisfactory for general livestock and wildlife supplies, although water such as that from well (C-9-11)32dda-1 might be too saline for horses, cattle, and certain wildlife. Hem (1970, p. 324) lists the following upper limits of dissolved-solids concentrations for use in watering stock: Horses, 6,435 mg/L; cattle (beef), 10,100 mg/L; and sheep (adult), 12,900 mg/L. In the Dugway Valley-Government Creek area, numerous water sources of satisfactory quality are available for both domestic animals and wildlife, so that the chemical quality of any individual supply generally is not a limiting factor.

Water-quality characteristics widely used for evaluating water for irrigation are: (1) the concentration of dissolved solids, as indicated by the specific conductance, which determines the salinity hazard; (2) the relative proportion of sodium (Na) to other cations in the water, as indicated by SAR (sodium-adsorption ratio), which determines the sodium hazard; and (3) the concentration of boron and other elements toxic to certain plants. Hem (1970, p. 324-333) and U.S. Salinity Laboratory Staff (1954) provide more detailed discussions of the relationship of quality of water to agricultural use.

Specific conductance of water samples in the Dugway Valley-Government Creek area ranges from 343 to 16,200 micromhos/cm at 25°C (table 9). Sodium-adsorption ratios range from 0.9 to 36. Water with specific conductance greater than about 5,000 micromhos/cm at 25°C or with sodium-adsorption ratio greater than about 30 seldom is suitable for irrigation under any conditions. On this basis, water in most of western and northern Dugway Valley probably is unusable for irrigation.

On the basis of specific conductance values, sodium-adsorption ratios, and the classification system developed by the U.S. Salinity Laboratory Staff (1954, p. 79-81), water samples from streams (table 9) all had low sodium hazard and medium salinity hazard. Reservoir samples had low-to-high sodium hazard and medium-to-high salinity hazard. About 85 percent of the ground-water samples in the areas shown on plate 1 as having dissolved-solids concentrations less than 2,000 mg/L have low sodium hazard, and the samples are about equally divided between the medium- and high-salinity hazard classes.

Boron concentrations in water samples ranged from 20 to 1,100 µg/L (table 9). Samples from three reservoirs and from three wells (table 9) exceeded the permissible limit of 330 µg/L established by the U.S. Salinity Laboratory Staff (1954, p. 67) for crops most sensitive to boron in irrigation water. All other water samples for which boron was analyzed contained the element in amounts below this limit.

Potential for development of additional water supplies

Additional water supplies could be developed from both surface- and ground-water sources in the Dugway Valley-Government Creek area. The potential for development of surface water, however, is relatively slight. Water could be supplied to locations on the desert floor and lower mountain slopes by pipelines constructed to divert flow from headwater reaches of streams, such as Indian and Lee Creeks in the Simpson Mountains, where perennial flow is sustained by ground-water discharge. The quantity of water that could be diverted would be small but adequate for dependable livestock supplies at numerous locations.

Many springs, especially in the Simpson and Sheeprock Mountains, could be improved to provide additional water. Installation of underground collector systems in some spring-discharge areas would capture water now being consumed by evapotranspiration and make it available for use locally or for diversion to other locations. Other springs could be improved by simply diverting the flow by pipeline, thus capturing water presently being lost by evapotranspiration.

Additional wells could be constructed to obtain water from the valley fill. Yields of 10 gal/min (0.6 L/s) or more probably could be obtained from properly constructed wells nearly anywhere in the Government Creek area and the Old River Bed, or on the alluvial slopes on the western side of the Simpson Mountains. The most promising areas, however, are near Government Creek in T. 9 S., R. 7 W., and in the Old River Bed in Tps. 9 and 10 S., Rs. 9 and 10 W.

Because the chemical quality of ground water in the area is variable, the quality requirements of the intended use should be considered in locating potential well sites. Wells at most locations on the desert floor would yield water of acceptable chemical quality for livestock, but the quality would not be suitable for domestic or irrigation use without treatment.

The principal long-term effect of increased consumptive use of water on the hydrologic system in the Dugway Valley-Government Creek area would be a reduction in the quantity of subsurface outflow to the Great Salt Lake Desert. Diversions from springs and perennial reaches of streams in the mountains would have little net effect on the system--only the place of consumption would be changed.

SUMMARY AND NEEDS FOR FUTURE STUDIES

An estimated 380,000 acre-ft (470 hm^3) of precipitation falls annually on the Dugway Valley-Government Creek area. Annual runoff to the Great Salt Lake Desert, to which the area drains, is negligible. Streams in the area are ephemeral, except for a short reach of Government Creek where the channel intersects the water table and short headwater segments of a few streams in the Simpson and Sheeprock Mountains where perennial springs sustain streamflow. Stream diversions for irrigation are minor, and reservoirs only occasionally intercept and store local runoff for use by livestock.

Annual ground-water recharge from local precipitation is estimated to average about 7,000 acre-ft (8.6 hm^3). Principal recharge areas are in the coarse alluvial deposits above 6,000 ft (1,830 m) in altitude. Ground-water inflow to Dugway Valley from the Sevier Desert drainage is estimated to average about 5,000 acre-ft (6.2 hm^3) annually.

The total volume of ground water in storage in the area is unknown. It is estimated, however, that about 3.8 million acre-ft (4,700 hm^3) might be recovered by gravity drainage to wells if the upper 100 ft (30 m) of saturated material were dewatered.

Discharge of ground water by wells probably averages no more than 300 acre-ft (0.4 hm^3) annually. Springs discharge an estimated 5,000 acre-ft (6.2 hm^3) of water annually, but about one-half of this amount probably returns to the ground-water reservoir by infiltration in streambeds. An estimated 8,000 acre-ft (10 hm^3) of ground water is discharged annually from the area by subsurface outflow to the Great Salt Lake Desert.

Most wells in the area are completed in valley fill, and well yields up to 400 gal/min (25 L/s) are reported. Most springs are in the mountains and have yields of less than 100 gal/min (6 L/s), although yields up to 2,000 gal/min (126 L/s) are reported from springs issuing from carbonate rocks in the Simpson Mountains.

The chemical quality of water in the area is extremely variable. Streamflow in the upper Government Creek area generally contains less than 500 mg/L of dissolved solids and is calcium bicarbonate type water, whereas wells along the eastern base of the Dugway Range discharge water containing more than 5,000 mg/L of dissolved solids in which sodium and chloride are the predominant ions. Most of the water in the area is satisfactory for livestock and, except for western and northern Dugway Valley, the water is generally satisfactory for irrigation.

Before extensive development of the water resources of the area is undertaken, additional hydrologic data are needed to refine the estimates made in this reconnaissance and to provide a basis for planning. The most significant data deficiencies would be met by a program that included:

1. Exploratory drilling and investigations of water quality in the valley fill, especially in western and northern Dugway Valley. Geologic and hydrologic conditions need to be defined in order to understand and evaluate the extent and significance of the saline water found in this area.

2. Aquifer tests and drilling in the upper part of the Government Creek area and in the Old River Bed. Detailed knowledge of geohydrologic conditions is needed to better evaluate ground-water quantity, quality, and availability in these two areas that appear to have the greatest potential for additional development of the resource.

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[1] See references to U.S. Weather Bureau for data published prior to 1967.

[2] See references to U.S. Environmental Science Services Administration and U.S. National Oceanic and Atmospheric Administration for data published after 1966.

Table 6.--Records of wells

Location: See section on numbering system for hydrologic-data sites.
Owner and local name (in parentheses): DPG, Dugway Proving Ground; US BLM, U.S. Bureau of Land Management; FERA, Federal Emergency Rehabilitation Administration.
Altitude of land-surface datum: Above mean sea level, as interpolated from U.S. Geological Survey topographic maps.
Geologic source of water: See table 2 for explanation of symbols and description of lithologic units.
Water level: Depth below land-surface datum, except +, above land-surface datum. All depths reported except m, measured by U.S Geological Survey personnel.
Method of lift: N, none; P, piston pump; T, turbine pump.
Yield: Rate - Reported except m, measured, and e, estimated, by U.S. Geological Survey personnel.
Use of water: I, irrigation; S, stock; T, institutional; U, unused.
Remarks and other data available: C, chemical-quality data in table 9; L, driller's log in table 8; SpC, reported specific capacity in gallons per minute per foot of drawdown at yield rate given.

Location	Owner and local name	Year constructed	Altitude of land surface datum (ft)	Depth of well (ft)	Geologic source of water	Casing diameter (in.)	Depth of perforated interval (ft)	Water level		Method of lift	Yield		Use of water	Water temperature (°C)	Remarks and other data available
								Depth (ft)	Date		Rate (gal/min)	Date			
(C-7-9)32ccd-1	US Army (DPG Well 5)	1944	4,359	355	QTu	10	320-355	26	6-19-44	T	300	9-29-64	T	14.0	SpC 22.2 at 200 gal/min on 6-19-44; C, L.
(C-7-10)25ccd-1	US Army (DPG Well 1)	1935	4,339	317	QTu	8,6	290-317	3.49	11- 2-39	T	180	10- 6-54	T	13.5	C, L.
25ccd-2	US Army (DPG Well 28)	1959	4,339	336	QTu	16,12	280-333	6	4- -59	T	130	9-29-64	T	13.5	Drilled to 343 ft, plugged back to 336 ft; SpC 29.1 at 335 gal/min, 17.7 at 530 gal/min during testing; C, L.
25cdd-1	US Army (DPG Well 2)	1942	4,341	328	QTu	10,6	160-328	6.83m	9-30-43	T	170	9-15-60	T	13.5	C, L.
36bab-1	US Army (DPG Well 3)	1945	4,341	330	QTu	12,10	300-330[1]	12	10- -45	T	330	9-29-65	T	14.0	C, L.
(C-7-11)25ccb-1	US Army (DPG Well 15)	1950	4,307	444	QTu	-	-	-	-	N	-	-	U	-	Well abandoned because of brackish water; L.
26daa-1	US Army (DPG Well 17)	1951	4,310	320	QTu	6	288-320[2]	+1.5	4- 6-51	-	162	4- 6-51	-	-	Drilled to 1,003 ft, plugged back to 320 ft; SpC 3.2, C, L.
26dad-1	US Army (DPG Well 16)	1951	4,310	292	QTu	12	270-290	+1.5	3-11-51	-	75[3]	11- 3-53	-	21.0	SpC 3.8 at 400 gal/min on 3-11-51; C, L.
(C-7-12)5cab-1	US Army (DPG Well 11)	1944	4,282	315	QTu	12	295-315	20	9- -44	N	-	-	U	-	Abandoned because of saline water.
(C-7-13)34adc-1	US Army (DPG Well 10)	1944	4,350	155	QTu	12	135-155	70.45m	8-15-44	-	172	10- 3-59	T	18.5	SpC 20 at 240 gal/min on 8-15-44; C, L.
(C-8-7)30dbb-1	US BLM	1947	5,150	490	QTu	8	-	292 288.85m	8- -53 9-17-56	N	21	1947	U	-	Abandoned; L.
(C-8-9)5bba-1	US Army (DPG Well 4)	1942	4,357	170	QTu	10,6	150-170	20	8- -42	T	25	11- 4-53	T	13.0	C, L.
(C-8-10)10dda-1	US Army (DPG Well 7)	1942	4,370	120	QTu and Pzc	8	100-120	60	10- 8-42	-	13	9-11-56	-	12.0	C, L.
17abc-1	US Army (DPG Well 9)	1943	4,339	35	Pzc	8	([4])	24.69m	6- 6-51	N	-	-	U	-	L.
17baa-1	US Army (DPG Well 8)	1943	4,336	230	QTu	8,6	210-230	20.66m	6- 6-51	N	-	-	U	-	Water reported saline; L.
(C-8-11)17dbc-1	US Army (DPG Well 25)	1955	4,320	193	QTu	10	72-168	19.54m	11- 1-55	N	-	-	U	-	Water was used for highway construction; reportedly not potable; L.
(C-9-7)7aac-1	James Ranch	-	5,350	([5])	-	6	-	-	-	P	-	-	U	-	
(C-9-8)18bac-1	US Army (DPG Well 14)	1943	4,820	75	Qag	8	55-75	50	4- 9-43	N	-	-	U	-	Destroyed; L.
18bac-2	US Army (DPG Well 13)	1943	4,820	75	Qag	8	55-75	50	8- 2-43	N	-	-	U	-	Do.
(C-9-9)13aba-1	US Army (DPG Well 12)	1945	4,600	520	QTu	10,8, 6,4	480-520	150	7-14-45	-	-	-	-	-	L.
(C-9-11)1ddb-1	US Army (DPG Well 22)	1954	4,395	210	QTu	8	100-200	86.31m	11- 1-55	N	245e	9-24-64	U	15.5	Water was used for highway construction; C, L.
16add-1	US Army (DPG Well 24)	1954	4,338	200	QTu	10	-	30	9- -54	-	-	-	-	-	L.
32dda-1	US BLM (Fandangle Well)	1952	4,480	202	QTu	8,6	169-202	170	4-18-52	P	8m	12-29-65	S	19.5	C, L.
(C-9-12)1dac-1	US Army (DPG Well 23)	1954	4,316	210	QTu	10	-	14	9- -54	-	-	-	-	-	L.
9aaa-1	US BLM (FERA Well 52)	1935	4,309	407	QTu	6	316-350	15	7- 8-35	P	30	7- 8-35	S	13.0	L.
25cba-1	Shell Oil Co.	1969	4,458	307	QTu	8	183-300	160	10-10-69	N	50	10-10-69	-	-	L.
(C-10-9)4bda-1	US BLM (FERA Well 36)	1935	4,525	555	QTu	8,6	-	189.40m	3- 1-76	N	30	2- -35	U	-	Observation well; L.
8ccc-1	US BLM (Riverbed Trail Well)	1957	4,407	130	QTu	-	-	80	1957	T	75e	12-24-64	S	15.5	C.
21acc-1	C. A. Snarr	1964	4,427	127	QTu	16	51-98	50	3- 9-64	T	40	3- 9-64	I	-	Drilled to 159 ft, plugged back to 127 ft; C, L.
(C-10-10)2dcc-1	Fenn Bros.	1973	4,425	235	QTu	16	105-215, 220-235[6]	98	10- 6-73	T	300	10- 6-73	I	18.0	C, L.
2ddc-1	do.	1973	4,430	375	QTu	16	120-265, 271-375[7]	109.28m	8-25-75	T	300	7-18-73	I	21.0	L.
31bbb-1	US BLM (FERA Well 38)	1935	4,524	551	QTu	8,6	-	190	3- 5-35	P	15e	12-29-65	S	24.5	C, L.
(C-11-11)12aba-1	US BLM (Dugway Topaz Well)	1949	4,602	306	QTu	6	-	273.68m 273.52m	3-19-65 10- 9-69	-	18	11-28-49	S	([8])	Used as observation well 1965-69; C, L.

[1] Open hole 320-330 ft.
[2] Open hole 300-320 ft.
[3] Yield 12.5 gal/min by flow reported 3-11-51.
[4] Open-end casing, not perforated.
[5] Unable to reach bottom at 201 ft on 5-6-76.
[6] Open hole 220-235 ft.
[7] Open hole 271-375 ft.
[8] Reported estimated temperature 49.0°C (Stautz and Carr, 1964, p. 5)

Table 7.--Records of springs

(All springs supply water for livestock and wildlife.)

Location: See section on numbering system for hydrologic-data sites.
Owner and local name (in parentheses): US BLM, U.S. Bureau of Land Management; USFS, U.S. Forest Service.
Altitude of land surface: Feet above mean sea level, interpolated from U.S. Geological Survey topographic maps.
Geologic source of water: See table 2 for explanation of symbols and description of lithologic units.
Discharge: Estimated, except r, reported and m, measured; <, less than.
Remarks and other data available: C, chemical-quality data in table 9; K, specific conductance, in micromhos per centimeter at 25°C.

Location	Owner and local name	Altitude of land surface (ft)	Geologic source of water	Discharge: Rate (gal/min)	Discharge: Water temperature (°C)	Discharge: Date of observation	Remarks and other data available
(C-5-10)34cba-S1, S2, S3	US Army (Cane Springs)	5,780-5,820	Te	<1	10.5	5-12-76	Improved spring with pipeline to stock troughs; C.
(C-6-10)4ddb-S1	US Army (Bitter Spring)	5,055	Te	<1	-	-	
5aaa-S1,S2	US Army (Orr Springs)	5,090-5,145	Te	<1	-	-	
(C-8-13)3dad-S1	US Army (Stagecoach Canyon Spring)	4,870	pCg	10r 30	- 13.5	3-28-50 5-12-76	Improved spring; C.
(C-9-6)19ccc-S1	USFS	6,980	Pzq	-	-	-	
31bba-S1	USFS (Middle Canyon Spring)	7,240	QTu	-	-	-	
31cbd-S1	USFS	7,210	QTu	([1])	-	-	Flow diverted from Sevier Desert drainage to Government Creek drainage; used for irrigation and stock.
31dcc-S1	do	7,320	pCu	([1])	-	-	Do.
31dda-S1	do	7,600	pCu	([1])	-	-	Do.
(C-9-7)11cdd-S1	USFS (Copper Spring)	6,560	Pzq	1	-	3-30-65	Improved spring with pipeline to storage tanks; C.
25bbb-S1	USFS	6,470	QTu	-	-	-	Improved spring with pipeline to storage tanks.
25dda-S1	do	7,080	QTu	-	-	-	
28bc-S	-	5,700	QTu	1.5 1	18.0	7-17-64 3-30-65	In channel of Government Creek; C.
28cac-S1	-	5,770	QTu	40	18.0	7-17-64	Formerly domestic supply for ranch; C.
28cac-S2	-	5,770	QTu	5	9.5	5- 6-76	Issues from coarse white sand in bottom of headbox; piped to downstream ranch for domestic, stock, and irrigation use; K=900.
30cad-S1	-	6,060	Te	-	-	-	In channel of Lee Creek.
30cda-S1	-	6,080	Te	-	-	-	Do.
31dbb-S1	US BLM	6,310	Te	.2	26.0	7-15-64	C.
33bda-S1	-	5,540	QTu	-	-	-	In channel of Government Creek.
35b-S	Wright Ranch	6,200	QTu	100	19.0	7-20-64	Used for irrigation and stock; C.
36daa-S1	USFS (Mud Spring)	7,020	QTu	-	-	-	
(C-9-8)15dbc-S1	US BLM (Winter Springs-west)	6,000	pCu	([2])	-	-	Improved spring with pipeline to tank at (C-8-8)35aac; C.
15dbd-S1	US BLM (Winter Springs-east)	6,030	Te	([2])	-	-	Do.
18adb-S1	US BLM (Simpson Springs-north)	5,070	Pzq	4m	13.0	12-29-65	Improved spring; supplies public campground; formerly supplied Pony Express station; C.
18adc-S1	US BLM (Simpson Springs-south)	5,100	Pzq	-	-	-	C.
35abd-S1	US BLM	6,780	pCu	-	-	-	
36dbd-S1	State of Utah	6,420	Pzq	-	-	-	
(C-10-6)6dbb-S1	USFS	7,300	pCu	([1])	-	-	Flow diverted from Sevier Desert drainage to Government Creek drainage; used for irrigation and stock.
(C-10-7)5c-S	US BLM	-	Te	-	-	-	C.
8cac-S1	US BLM (Cherry Springs-west)	6,490	Pzc	1	-	7-17-64	C.
8cad-S1	US BLM (Cherry Springs-east)	6,460	Te	40	10.0	7-17-64	C.
17a-S	US BLM	6,400	Te	.5	15.0	8-19-64	Improved spring; C.
17bab-S1	do	6,555	Te	7.5	-	7-17-64	C.
(C-10-8)1bdb-S1	do	6,670	Pzc	-	-	-	
2dba-S1	State of Utah	6,900	Pzq	100	9.5	7-15-64	C.
3aba-S1	- (Indian Springs-east)	6,680	Pzc	([3])	16.0	9-15-65	C.
3abb-S1	- (Indian Springs-west)	6,580	Pzc	([3])	-	9-15-65	C.
4abb-S1	US BLM	6,050	Pzc	35	10.5	7-20-64	C.
5dba-S1,S2	US BLM (Coyote Springs-north)	5,710-5,740	Pzq	250	-	1955	
5dbd-S1	US BLM (Coyote Springs-south)	5,710	Pzq	-	-	-	
(C-10-11)27cbd-S1	US BLM (Straight Canyon Spring)	5,620	Pzc	.03m	-	9- 8-56	
(C-11-10)34dcd-S1	US BLM (Flint Spring)	5,250	Te	-	-	-	Improved spring with pipeline to storage tanks.
(C-12-9)8bbc-S1	US BLM (Keg Spring)	5,790	Te	-	-	-	Improved spring with pipeline to storage tank; C.
(C-12-10)23bbc-S1	US BLM	5,600	Te	-	-	-	

[1] Combined flow of four springs estimated 75 gal/min in diversion ditch on drainage divide at (C-10-7)1daa on 5-6-76; K=390.
[2] Combined flow of two springs reported 3 gal/min on 12-29-65.
[3] Combined flow of two springs estimated 2,000 gal/min on 9-15-65.

Table 8.--Selected drillers' logs of wells

Well-numbering system described in text.
Altitudes are in feet above mean sea level for the land surface at the well.

Material	Thickness (ft)	Depth (ft)
(C-7-9)32ccd-1. Log by T. L. Coates. Alt. 4,359.		
Clay	50	50
Gravel	40	90
Gravel and clay	45	135
Sand, white; water	35	170
Clay	5	175
Gravel	145	320
Sand, white; water	10	330
Gravel	25	355
(C-7-10)25ccd-1. Log by H. M. Robinson. Alt. 4,339.		
Surface material	3	3
Clay, white	15	18
Sand	2	20
Clay, blue, sandy	70	90
Clay, blue	70	160
Sand	5	165
Clay, blue	45	210
Clay, brown	32	242
Clay, blue	48	290
Sand; water	27	317
(C-7-10)25ccd-2. Log by J. S. Lee and Sons Drilling Co. Alt. 4,339.		
Clay	4	4
Sand	3	7
Sand and clay; salty water at 19 ft	12	19
Clay, brown, sandy; salty water	71	90
Clay, blue	58	148
Clay, brown	10	158
Sand and some clay; water at 160 ft	42	200
Sand, fine, loose	10	210
Clay, sandy	22	232
Clay, sand, and gravel	23	255
Clay and gravel, hard; water at 280 ft.	47	302
Sand and gravel; water	5	307
Clay, brown	4	311
Sand and gravel; water	32	343
Depth of finished well 336 ft		
(C-7-10)25cdd-1. Log by T. L. Coates. Alt. 4,341.		
Clay, yellow; salty water at 38 ft	55	55
Clay and sand	11	66
Clay, blue	94	160
Sand; water	8	168
Clay, blue	12	180
Clay and sand	55	235
Gravel, brown; water	93	328
(C-7-10)36bab-1. Log by T. L. Coates. Alt. 4,341.		
Clay, yellow; salty water at 60 ft	70	70
Clay, sandy	45	115
Clay, blue	45	160
Sand; water	9	169
Clay, blue	21	190
Clay, sandy	58	248
Gravel, brown; water	82	330
(C-7-11)25ccb-1. Log by Robinson Drilling Co. Alt. 4,307.		
Clay, gray, soft	10	10
Sand	55	65
Clay, blue	10	75
Sand and fine gravel; brackish water	40	115
Clay, blue	15	130
Sand and fine gravel	27	157
Clay, blue	18	175
Sand and fine gravel	17	192
Clay, blue	43	235
Clay, red	8	243
Sand and fine black gravel; fresh water	2	245
Sand, fine, loose	20	265
Clay, red	5	270
Clay, blue and brown	20	290
Clay, blue and brown, with sand and gravel	13	303
Clay and sand, red, with gravel	7	310
Sand, fine	10	320
Clay, blue	2	322
Clay, blue, sandy	29	351
Clay, blue	39	390
Gravel, fine to medium	2	392
Clay, blue	35	427
Gravel, fine to coarse	6	433
Clay, blue, sandy	11	444
(C-7-11)26daa-1. Log by Robinson Drilling Co. Alt. 4,310.		
Clay, sandy	8	8
Gravel	5	13
Clay, sandy	5	18
Gravel, small	19	37
Clay, blue, sandy	2	39
(C-7-11)26daa-1 - Continued		
Sand and gravel	5	44
Clay and gravel	4	48
Sand and gravel	15	63
Clay	7	70
Clay and sand	18	88
Sand, coarse, and gravel	33	121
Clay, soft, and sand	15	136
Sand and gravel	25	161
Clay, soft, sandy	5	166
Clay, blue, hard	11	177
Sand, coarse	24	201
Clay, sandy	6	207
Clay, hard	10	217
Clay and fine gravel	40	257
Gravel	16	273
Clay and gravel	5	278
Sand, coarse; water	26	304
Clay, sandy	13	317
Clay, hard	3	320
Clay, sandy	40	360
Clay	4	364
Clay, hardpan, and some gravel	18	382
Clay and gravel	230	612
Clay	30	642
Clay and gravel	70	712
Clay, hard	6	718
Clay and gravel	2	720
Clay, hard	66	786
Clay and gravel	106	892
Clay, sandy	8	900
Clay and gravel	41	941
Clay, very hard	3	944
Clay, soft	7	951
Clay, hard	8	959
Clay, soft	11	970
Clay, hard	20	990
Clay, soft	13	1,003
Depth of finished well 320 ft		
(C-7-11)26dad-1. Log by Robinson Drilling Co. Alt. 4,310.		
Clay, gray	20	20
Sand and fine gravel	12	32
Clay, blue	8	40
Sand	34	74
Sand and fine gravel	26	100
Sand	20	120
Clay, blue	15	135
Sand and coarse gravel	15	150
Sand, fine, and gravel	5	155
Clay, blue	20	175
Sand	22	197
Clay, blue	18	215
Clay, blue, sand, and gravel	40	255
Sand	20	275
Clay, red, sand, and gravel	10	285
Sand, fine, and gravel	7	292
(C-7-13)34adc-1. Log by Robinson Drilling Co. Alt. 4,350.		
Soil and small boulders	7	7
Clay, sand, and small boulders	75	82
Clay, sand, and larger boulders; water.	3	85
Clay, sand, and boulders	25	110
Clay, sand, and boulders, cemented	35	145
Bedrock, granitic	10	155
(C-8-7)30dbb-1. Log by L. E. Hale Alt. 5,150.		
Clay	36	36
Gravel	2	38
Clay and sand	262	300
Hardpan; water	1	301
Clay, red, and sand; gravel at 490 ft	189	490
(C-8-9)5bba-1. Log by T. L. Coates. Alt. 4,357.		
Clay, yellow	50	50
Gravel	15	65
Sand	25	90
Clay, blue	45	135
Sand, white, and shells	20	155
Clay	5	160
Gravel; water	10	170
(C-8-10)10dda-1. Log by T. L. Coates. Alt. 4,370.		
Clay, yellow	65	65
Sand; water	40	105
Rock, black (Upper Cambrian carbonates, undifferentiated); water	15	120
(C-8-10)17abc-1. Log by T. L. Coates. Alt. 4,339.		
Clay; hard rock (Upper Cambrian carbonates, undifferentiated); water at 35 ft	35	35
(C-8-10)17baa-1. Log by T. L. Coates. Alt. 4,336.		
Clay	35	35
Sand	10	45
Clay, blue	10	55
Gravel	67	122
Clay, blue	38	160
Sand; salty water	70	230
(C-8-11)17dbc-1. Log by J. S. Lee and Sons. Alt. 4,320.		
Clay, sandy	10	10
Clay, gray	11	21
Silt, fine	36	57
Clay, gray	15	72
Sand and gravel; water	17	89
Clay	11	100
Conglomerate; water	5	105
Clay, red	27	132
Sand and gravel; water	10	142
Clay, green	25	167
Sand and gravel; water	1	168
Clay, green	25	193
(C-9-8)18bac-1. Log by T. L. Coates. Alt. 4,820.		
Gravel and boulders; water at 50 ft	75	75
(C-9-8)18bac-2. Log by T. L. Coates. Alt. 4,820.		
Gravel and boulders; water at 50 ft	75	75
(C-9-9)13aba-1. Log by T. L. Coates. Alt. 4,600.		
Sand, gravel, cobbles, and boulders	328	328
Clay and coarse gravel	152	480
Clay, yellow	10	490
Sand; water	30	520
(C-9-11)1dbb-1. Log by J. S. Lee and Sons Drilling Co. Alt. 4,349.		
Soil	2	2
Sand	23	25
Clay	58	83
Sand, fine	15	98
Gravel; water	72	170
Clay, sandy	10	180
Sand	10	190
Gravel; water	15	205
Clay, blue	5	210
(C-9-11)16add-1. Log by J. S. Lee and Sons Drilling Cq. Alt. 4,338.		
Clay, gray-to-brown, silty	40	40
Sand, medium, and fine gravel	20	60
Clay, tan, sandy	40	100
Clay, silty, "sticky"	10	110
Clay, tan, medium sandy	10	120
Clay, tan, fine sandy	10	130
Clay, tan-brown, fine sandy	10	140
Clay, fine sand, and fine gravel	20	160
Clay, blue, silty, "sticky"	40	200
(C-9-11)32dda-1. Log by L. E. Hale. Alt. 4,480.		
Gravel	55	55
Hardpan	3	58
Clay and gravel	24	82
Sand	9	91
Clay	69	160
Hardpan	4	164
Gravel	6	170
Hardpan	2	172
Sand and gravel; water	30	202
(C-9-12)1dac-1. Log by J. S. Lee and Sons Drilling Co. Alt. 4,316.		
Clay, gray-brown, silty	28	28
Clay, brown, sandy	12	40
Sand, fine-to-coarse, and fine gravel	20	60
Clay, gray, silty	10	70
Clay, blue-gray, silty, "sticky"	10	80
Sand, medium-coarse, and fine gravel	10	90
Sand, fine, and very fine gravel	10	100
Sand, medium-coarse, and fine gravel	10	110
Silt and fine sand	20	130
Sand and medium-coarse gravel	10	140
Clay, gray, silty, "sticky"	10	150
Clay, gray, sandy	30	180
Sand and fine gravel	20	200
Clay, gray, and medium sand	10	210
(C-9-12)9aaa-1. Log by Robinson Drilling Co. Alt. 4,309.		
Clay, yellow, soft	8	8
Clay, brown	4	12
Clay, yellow, sandy, loose	23	35

Material	Thickness (ft)	Depth (ft)
(C-9-12)9aaa-1. - Continued		
Clay, gray, soft	16	51
Sand unsorted, clean	8	59
Clay, yellow, soft	16	75
Sand, fine, loose	10	85
Sand, very fine, clean	37	122
Clay, light-gray, soft	6	128
Sand, fine, and gravel	87	215
Clay, green	46	261
Sand, very fine, loose	51	312
Sand and gravel, loose	38	350
Sand, loose	48	398
Clay, gray, soft	9	407
(C-9-12)25cba-1. Log by Jensen Drilling Co. Alt. 4,458.		
Gravel, cobbles, and boulders	98	98
Clay and gravel	17	115
Clay, gravel, and boulders	68	183
Sand and gravel; water	45	228
Clay and gravel	12	240
Gravel; water	20	260
Clay and gravel	25	285
Gravel; water	25	310
Depth of finished well 307 ft.		
(C-10-9)4bda-1. Log by Coxe and Clarkson Drilling Co. Alt. 4,525.		
Clay, yellow, loamy	10	10
Clay, blue and yellow, sandy	165	175
Gravel, coarse, dry	25	200
Clay, brown, sandy, and gravel	30	230
Gravel, coarse, dry	35	265
Clay, sand, and gravel; alternating layers	190	455
Sandstone, red	10	465
Clay and gravel conglomerate	60	525
Gravel; water	30	555
(C-10-9)21acc-1. Log by E. Comer. Alt. 4,427.		
Clay, tan	34	34
Clay, tan, and gravel	50	84
Clay, tan, sand, and gravel; water	14	98
Clay, tan	7	105
Clay, gray	22	127
Clay, variegated blue, gray, tan, and red	32	159
Depth of finished well 127 ft.		
(C-10-10)2dcc-1. Log by G. Mosely. Alt. 4,425.		
Silt	80	80
Clay	5	85
Sand and boulders	5	90
Clay, conglomertic	5	95
Sand, gravel, and boulders; water	10	105
Clay and gravel	5	110
Clay	15	125
Clay, blue; water	2	127
Sand and boulders; water	41	168
Sand, fine, cemented	20	188
Hardpan	17	205
Sand and boulders; water	10	215
Clay, blue	20	235
(C-10-10)2ddc-1. Log by G. Mosely. Alt. 4,430.		
Silt	80	80
Sand and gravel	5	85
Sand and boulders	5	90
Clay and sandy clay	10	100
Clay and coarse gravel	15	115
Sand and boulders; water	20	135
Sand; water	15	150
Clay, "sticky"	5	155
Clay, sand, and coarse gravel; water	40	195
(C-10-10)2ddc-1. - Continued		
Clay	10	205
Sand and boulder conglomerate; hardpan	5	210
Clay, brown	10	220
Clay, blue	130	350
Clay and sand	20	370
Clay, blue	5	375
(C-10-10)31bbb-1. Log by Coxe and Clarkson Drilling Co. Alt. 4,524.		
Clay, light-brown	85	85
Gravel; dry	35	120
Sand, loose	20	140
Clay, brown, soft	55	195
Gravel and boulders; dry	35	230
Clay, white	13	243
Clay, red sand, and gravel	152	395
Gravel, coarse; water	80	475
Sandstone, red	8	483
Clay, dark-blue	12	495
Gravel, coarse; water	56	551
(C-11-11)12aba-1. Log by J. P. Feighny. Alt. 4,602.		
Clay	16	16
Gravel	52	68
Clay	44	112
Clay and gravel	48	160
Gravel and boulders	27	187
Clay and gravel	29	216
Boulders	26	242
Clay	30	272
Boulders	15	287
Sand and gravel; water	3	290
Boulders; water	4	294
Gravel; water	12	306

Location: See section on numbering system for hydrologic-data sites.
Source: Name listed for surface-water sources; hydrogeologic-unit symbol listed for ground-water sources. See table 2 for explanation of symbols and description of lithologic units.
Dissolved sodium and dissolved potassium: Where no value is given for potassium, sodium plus potassium values are reported as sodium.

Location	Date of collection	Source	Temperature (°C)	Milligrams per liter: Dissolved silica (SiO_2)	Dissolved calcium (Ca)	Dissolved magnesium (Mg)	Dissolved sodium (Na)	Dissolved potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Dissolved sulfate (SO_4)	Dissolved chloride (Cl)	Dissolved fluoride (F)	Dissolved nitrate (NO_3)	Dissolved phosphate (PO_4)	Dissolved boron (B)	Dissolved iron (Fe)	Dissolved manganese (Mn)
																		STREAMS
(C-9-7)																		
7dac-1	7-15-64	Lee Creek[1]	18.5	13	45	21	48	0.9	231	0	30	62	0.1	0.1	0.30	50	370	10
	3-30-65		8.5	12	63	22	44	1.1	288	0	30	58	.3	.4	.25	50	120	20
28bc-1	7-17-64	Government Creek	28.5	16	42	16	54	1.7	182	0	26	81	.3	.5	-	60	220	10
(C-10-7)																		
1daa-1	5- 6-76	Diversion ditch[2]	16.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(C-10-8)																		
1bd-1	7-15-64	Lee Creek	21.5	13	54	18	45	1.2	244	0	30	56	.0	.2	-	60	470	240
																		RESERVOIRS
(C-9-9)																		
28dac-1	7-28-64	South Simpson Reservoir	19.5	25	29	15	341	25	468	0	50	325	0.5	2.5	-	560	100	40
(C-9-10)																		
21ddb-1	9- 1-64	(3)	13.5	13	13	12	448	21	664	0	161	285	2.2	.7	-	1,100	1,400	10
(C-10-10)																		
23ca-1	7-28-64	North Table Mountain Reservoir	21.5	20	33	10	137	29	365	0	19	99	.3	1.9	-	310	170	0
(C-11-10)																		
5abb-1	7-28-64	East Dugway Reservoir	23.5	33	36	10	121	11	194	0	173	43	.8	.3	.06	460	440	40
																		WELLS
(C-7-9)																		
32ccd-1[4]	12- 4-45	QTu	-	47	49	29	122		223	-	50	190	0.3	3.7	-	-	10	-
	12-12-55		13.0	56	44	29	130	8.6	224	0	48	198	.2	5.5	-	-	-	-
	9-29-64		14.0	44	48	27	131		226	0	51	194	.4	4.7	-	-	-	-
(C-7-10)																		
25ccd-1[4]	12- 4-45	QTu	-	50	43	21	288		255	-	95	360	.3	5.8	-	-	10	-
	10- 6-54		13.5	45	38	21	300	11	261	0	91	362	.2	8.0	-	-	-	-
25ccd-2[4]	10- 3-59	QTu	14.0	48	34	19	323	11	261	0	88	390	.4	8.2	-	-	-	-
	9-29-64		13.5	42	34	19	326		262	0	90	395	.2	5.5	-	-	-	-
25cdd-1[4]	10-15-52	QTu	12.0	44	27	15	319	12	270	0	87	370	.5	6.9	-	-	-	-
	9-15-60		13.5	45	27	13	326	11	261	0	86	370	.6	6.0	-	-	-	-
36bab-1[4]	12- 4-45	QTu	-	46	29	16	334		266	-	90	390	.5	1.5	-	-	10	-
	12-12-55		12.0	54	32	18	314	13	267	0	89	378	.4	9.5	-	-	-	-
	9-29-65		14.0	42	32	16	333		239	16	84	392	.7	5.2	-	-	-	-
(C-7-11)																		
26daa-1	7-27-51	QTu	-	58	36	23	974	41	173	0	68	1,500	.3	1.8	-	-	-	-
	10-15-52		-	31	25	16	949	47	162	0	52	1,450	.6	.4	-	-	70	0
26dad-1	7- -51	QTu	-	56	34	22	694	30	151	0	83	1,050	.5	1.3	-	-	50	-
	7-31-51		-	56	33	19	682	31	170	0	81	1,050	.6	.8	-	-	60	80
	10-15-52		-	52	36	22	638	35	168	0	87	970	.5	.3	-	-	80	0
	11- 3-53		20.0	66	37	24	620	35	168	0	91	970	.5	.3	-	-	50	0
(C-7-13)																		
34adc-1	3-28-50	QTu	-	20	72	26	514	13	242	0	142	760	3.2	1.7	-	80	-	-
	9-18-57		-	19	140	42	730	6.8	237	0	258	1,180	2.9	9.9	-	-	0	0
	10- 3-59		18.5	16	147	44	739	6.9	239	0	240	1,180	4.0	7.1	-	-	40	0
	4- 3-75		14.0	19	93	32	540	7.0	242	0	160	850	2.6	(5)	.06	-	150	10
(C-8-9)																		
5bba-1	11- 4-53	QTu	13.0	34	18	16	191	30	204	16	21	242	.7	.2	-	-	70	-
(C-8-10)																		
10dda-1[4]	9-11-56	QTu and Pzc	12.0	49	59	38	178	19	231	0	70	325	.3	5.9	-	-	0	-
(C-9-11)																		
1ddb-1	9-24-64	QTu	15.5	31	88	58	286		266	0	97	538	.4	.0	-	-	-	-
32dda-1[4,6]	2-24-64	QTu	-	36	409	149	2,920	258	283	0	164	5,570	1.8	1.6	-	1,100	-	-
	12-29-65		19.5	28	406	145	2,820	271	251	0	158	5,520	2.0	3.6	.01	1,000	9,600	220
(C-10-9)																		
8ccc-1[4]	12-24-64	QTu	15.5	38	102	37	155	10	196	0	82	363	.5	3.3	-	150	160	10
21acc-1[7]	8- 8-71	QTu	-	37	82	36	140	8.0	185	1.6	71	286	.3	3.0	.1	200	200	0
(C-10-10)																		
2dcc-1	9-18-74	QTu	18.0	38	87	38	250	24	205	0	92	490	.5	(8)	.09	210	160	10
31bbb-1[4]	3-31-65	QTu	24.5	19	105	34	1,080	99	188	0	62	1,890	2.0	.4	.03	360	-	-
	12-29-65		24.5	45	106	34	1,060	109	200	0	61	1,870	2.1	8.2	.10	1,100	610	50
(C-11-11)																		
12aba-1[4,9]	12-24-64	QTu	-	28	176	53	1,680	137	248	0	95	2,960	2.7	6.3	.00	560	-	-
																		SPRINGS
(C-5-10)																		
34cba-S[10]	11-12-71	Te	-	55	130	33	140	11	314	0	70	360	0.2	(11)	-	-	20	40
(C-8-13)																		
3dad-S1	3-28-50	pCu	-	20	85	22	202	10	222	0	72	348	2.0	.6	-	80	50	-
(C-9-7)																		
11cdd-S1[12]	8-12-64	Pzq	-	5.5	56	18	43	.5	265	0	25	49	.1	1.4	-	90	-	0
	3-30-65		-	12	59	18	39	.7	266	0	27	39	.3	4.0	.00	50	-	30
28bc-S	7-17-64	QTu	18.0	23	85	26	68	2.0	343	0	30	113	.1	1.8	-	120	90	0
	3-30-65		-	23	86	26	67	2.2	346	0	36	106	.4	1.6	.00	80	160	30
28cac-S1	7-17-64	QTu	18.0	22	78	21	59	1.9	306	0	30	95	.3	2.0	-	100	110	30
31dbb-S1	7-15-64	Te	26.0	5.7	14	16	36	.6	95	10	18	45	.3	.1	-	60	550	10

for selected water sources
Survey unless otherwise noted]

Micrograms per liter							Milligrams per liter				Specific conductance (micromhos per centimeter at 25°C)	pH	Percent sodium	Sodium-adsorption ratio
							Hardness as $CaCO_3$		Dissolved solids					
Dissolved copper (Cu)	Dissolved lead (Pb)	Dissolved zinc (Zn)	Dissolved lithium (Li)	Dissolved strontium (Sr)	Dissolved bromide (Br)	Dissolved iodide (I)	Calcium, magnesium	Noncarbonate	Residue on evaporation at 180°C	Sum of determined constituents				
0	0	90	0	0	100	10	200	11	327	335	585	8.0	34	1.5
20	10	50	0	100	200	10	248	11	381	374	648	8.0	28	1.2
10	0	120	0	0	200	20	171	22	325	330	572	8.0	40	1.8
-	-	-	-	-	-	-	-	-	-	-	390	-	-	-
0	0	80	0	0	100	20	210	10	338	339	587	7.7	32	1.4
20	40	70	0	1,000	400	140	134	0	1,070	1,050	1,750	7.6	82	13
30	10	160	0	100	600	280	82	0	1,330	1,290	2,120	8.1	90	21
0	10	80	0	0	300	50	124	0	545	530	874	7.8	65	5.4
0	20	130	0	0	200	120	133	0	529	525	749	7.6	64	4.6
-	-	-	-	-	-	-	242	59	664	601	1,070	7.8	52	3.4
-	-	-	-	-	-	-	229	46	627	629	1,070	7.3	54	3.7
-	-	-	-	-	-	-	232	47	619	611	1,020	8.0	55	3.8
-	-	-	-	-	-	-	194	0	1,020	989	1,750	7.5	76	7.5
-	-	-	-	-	-	-	182	0	997	1,000	1,740	7.5	77	9.7
-	-	-	-	-	-	-	163	0	1,040	1,050	1,840	7.8	80	11
-	-	-	-	-	-	-	161	0	1,040	1,040	1,780	7.9	81	11
-	-	-	-	-	-	-	129	0	995	1,010	1,730	7.9	83	12
-	-	-	-	-	-	-	123	0	1,010	1,010	1,740	7.8	84	13
-	-	-	-	-	-	-	138	0	1,040	1,040	1,790	7.6	84	12
-	-	-	-	-	-	-	154	0	1,030	1,040	1,780	7.7	80	11
-	-	-	-	-	-	-	146	0	1,090	1,040	1,820	8.5	83	12
-	-	-	-	-	-	-	184	42	-	2,790	4,880	8.4	90	31
-	-	-	-	-	-	-	128	0	-	2,590	4,690	8.2	91	36
-	-	-	-	-	-	-	176	52	-	2,050	3,610	8.4	88	24
-	-	-	-	-	-	-	160	21	-	2,040	3,650	8.1	88	23
-	-	-	-	-	-	-	180	43	-	1,890	3,400	7.9	87	21
-	-	-	-	-	-	-	191	54	1,930	1,930	3,500	7.9	85	20
-	-	-	-	-	-	-	286	88	1,670	1,670	2,990	7.2	79	13
-	-	-	-	-	-	-	524	330	2,590	2,510	4,400	7.6	79	-
-	-	-	-	-	-	-	550	354	2,600	2,500	4,440	7.5	79	-
-	-	-	-	-	-	-	360	170	1,850	1,830	3,290	7.7	76	12
-	-	-	-	-	-	-	111	0	668	669	1,150	8.6	75	9.0
-	-	-	-	-	-	-	304	115	864	858	1,480	7.4	54	4.4
-	-	-	-	-	-	-	458	240	1,240	1,230	1,940	7.7	58	5.8
-	-	-	-	-	-	-	1,640	1,400	9,970	9,680	15,900	7.6	76	31
30	170	2,700	2,800	12,000	-	-	1,610	1,400	10,200	9,500	16,200	7.3	76	31
40	0	40	0	1,300	1,000	50	406	245	999	890	1,550	7.6	45	3.3
0	0	0	-	-	-	-	352	-	-	788	1,360	8.2	53	3.2
-	-	-	-	-	-	-	370	210	-	1,130	2,050	7.7	57	5.6
0	40	-	1,000	4,200	3,300	180	400	246	3,460	3,390	5,980	7.7	82	23
20	90	770	900	2,500	-	-	404	240	3,590	3,400	6,230	7.4	81	23
-	-	-	2,200	7,700	6,600	350	658	454	5,470	5,280	9,030	8.2	81	28
-	-	-	-	-	-	-	460	200	1,060	954	1,740	7.5	45	2.8
-	-	-	-	-	-	-	302	120	-	871	1,560	7.5	58	-
0	10	-	0	0	100	30	214	0	338	331	576	7.6	30	1.3
20	0	-	0	0	100	20	220	2	337	331	563	7.8	28	1.1
0	0	80	0	0	300	30	318	37	528	519	898	7.7	32	1.7
10	50	60	0	500	400	0	320	36	541	519	875	7.7	31	1.6
10	0	120	0	0	200	20	282	31	465	461	790	7.9	31	1.5
0	0	30	0	0	100	10	99	5	186	194	343	9.1	44	1.6

Location	Date of collection	Source	Temperature (°C)	Milligrams per liter														
				Dissolved silica (SiO_2)	Dissolved calcium (Ca)	Dissolved magnesium (Mg)	Dissolved sodium (Na)	Dissolved potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Dissolved sulfate (SO_4)	Dissolved chloride (Cl)	Dissolved fluoride (F)	Dissolved nitrate (NO_3)	Dissolved phosphate (PO_4)	Dissolved boron (B)	Dissolved iron (Fe)	Dissolved manganese (Mn)
																	SPRINGS--	
(C-9-7)																		
35b-S	7-20-64	QTu	19.0	14	50	8.0	28	2.8	189	0	17	38	0.1	0.3	-	60	110	10
(C-9-8)																		
15dbc-S1	7-20-64	pCu	-	12	51	11	57	1.2	222	0	17	69	.1	2.0	-	50	250	10
and	3-31-65	and	-	12	52	9.1	55	1.1	208	0	26	67	.4	2.1	0.00	70	0	20
15dbd-S1[13]	12-29-65	Te	-	-	-	-	-	-	-	-	-	-	-	-	.01	100	680	10
18adb-S1[4]	7-30-64	Pzq	17.0	15	86	16	121	2.1	321	0	34	182	.2	.3	-	110	320	10
	2-21-73		-	15	85	16	120	2.3	309	0	34	180	.4	([14])	.03	-	30	0
18adc-S1	2-21-73	Pzq	-	13	90	18	140	2.0	334	0	44	200	.3	([15])	.03	-	30	0
(C-10-7)																		
5c-S	8-12-64	Te	18.5	8.4	40	16	43	1.1	212	0	14	54	.2	.1	-	80	80	20
8cac-S1	7-17-64	Pzc	-	13	60	25	44	4.3	304	0	26	60	.4	.3	-	80	90	10
8cad-S1	7-17-64	Te	10.0	11	55	22	35	.9	266	0	22	47	.0	1.0	-	20	80	10
17a-S	8-19-64	Te	15.0	16	61	13	48	.6	256	0	19	58	.2	1.1	-	60	820	90
17bab-S1	7-17-64	Te	-	16	69	27	53	1.2	330	0	28	75	.4	.1	-	70	70	30
(C-10-8)																		
2dba-S1	7-15-64	Pzq	9.5	16	70	27	46	.7	348	0	28	55	.3	.2	-	70	120	50
3aba-S1	7-15-64	Pzc	15.0	11	51	19	30	1.1	246	0	18	40	.0	2.4	-	20	230	40
and																		
3abb-S1	9-15-65		16.0	5.6	38	19	33		192	8	19	40	-	.2	-	-	-	-
4abb-S1	7-20-64	Pzc	10.5	13	77	28	46	1.2	360	0	39	54	.3	.2	-	60	110	20
(C-11-10)																		
34dcd-S1	9- 1-64	Te	-	30	309	61	293	8.3	124	0	160	982	1.1	1.0	-	250	-	-
(C-12-9)																		
8bbc-S1[9]	7-30-64	Te	-	16	226	112	271	4.3	193	0	152	920	.1	1.1	-	190	-	-

[1] Sample collected from irrigation pipeline; source of water from Lee Creek and tributary. See Waddell (1967, table 1) for additional analyses of samples from this pipeline system.
[2] Ditch carries water diverted from springs in Sheeprock Mountains in Sevier Desert drainage.
[3] Reservoir constructed in channel in Old River Bed.
[4] See Waddell (1967) for additional analyses.
[5] Dissolved nitrate (NO_3) + nitrite (NO_2) as N, 0.60 mg/L.
[6] Sample collected 12-24-64 from storage tank; sample collected 12-29-65 directly from pump discharge pipe.
[7] Analyses by Utah Division of Health; also included (in micrograms per liter): arsenic, 0; barium, 0; cadium, 0; selenium, 0; silver, 0.
[8] Dissolved nitrate (NO_3) + nitrite (NO_2) as N, 3.1 mg/L.
[9] Sample collected from storage tank.
[10] Sampling point unknown. Sample may be composite from three springs at location given.
[11] Dissolved nitrate (NO_3) + nitrite (NO_2) as N, 0.00 mg/L.
[12] Samples collected from pipeline at (C-9-7)9dd.
[13] Samples collected from storage tank overflow at (C-8-8)35aac.
[14] Dissolved nitrate (NO_3) + nitrite (NO_2) as N, 0.24 mg/L.
[15] Dissolved nitrate (NO_3) + nitrite (NO_2) as N, 0.52 mg/L.

selected water sources--Continued

Micrograms per liter							Milligrams per liter							
							Hardness as $CaCO_3$		Dissolved solids					
Dissolved copper (Cu)	Dissolved lead (Pb)	Dissolved zinc (Zn)	Dissolved lithium (Li)	Dissolved strontium (Sr)	Dissolved bromide (Br)	Dissolved iodide (I)	Calcium, magnesium	Noncarbonate	Residue on evaporation at 180°C	Sum of determined constituents	Specific conductance (micromhos per centimeter at 25°C)	pH	Percent sodium	Sodium-adsorption ratio
Continued														
0	0	80	0	0	100	70	158	3	264	252	421	7.6	27	1.0
20	0	2,000	0	0	200	50	172	0	324	333	581	7.3	42	1.9
30	10	1,100	0	0	300	20	168	0	352	328	573	7.4	41	1.8
40	20	1,600	0	200	-	-	-	-	-	-	589	-	-	-
0	0	70	0	0	400	80	280	17	620	617	1,090	7.4	48	3.1
-	-	-	-	-	-	-	280	25	-	606	1,100	7.4	48	3.1
-	-	-	-	-	-	-	300	25	-	674	1,200	7.4	50	3.5
0	0	10	0	0	100	80	164	0	286	283	492	7.9	36	1.5
0	10	70	0	0	200	20	254	5	379	384	664	7.6	27	1.2
0	0	40	0	0	100	20	228	10	318	326	566	7.8	25	1.0
0	10	-	0	0	200	40	204	0	345	345	588	7.9	34	1.5
0	0	80	0	0	200	10	282	11	428	435	746	7.4	29	1.4
0	30	50	0	0	200	20	284	0	409	416	698	7.6	26	1.2
0	0	60	0	0	100	20	207	5	293	295	520	8.0	24	.9
-	-	-	-	-	-	-	176	5	246	257	492	8.4	29	1.1
10	0	170	0	0	100	10	308	13	426	437	732	7.7	24	1.1
-	-	-	0	2,200	1,000	160	1,020	921	-	1,910	3,370	7.4	38	4.0
-	-	-	0	7,500	2,000	150	1,020	867	-	1,810	3,220	7.4	36	3.7

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