STATE OF NEVADA
RTMENT OF CONSERVATION AND NATURAL RESOURCES
Carson City

View of Snake Valley with Wheeler Peak in background.

Photograph by F. Eugene Rush

WATER RESOURCES-RECONNAISSANCE SERIES

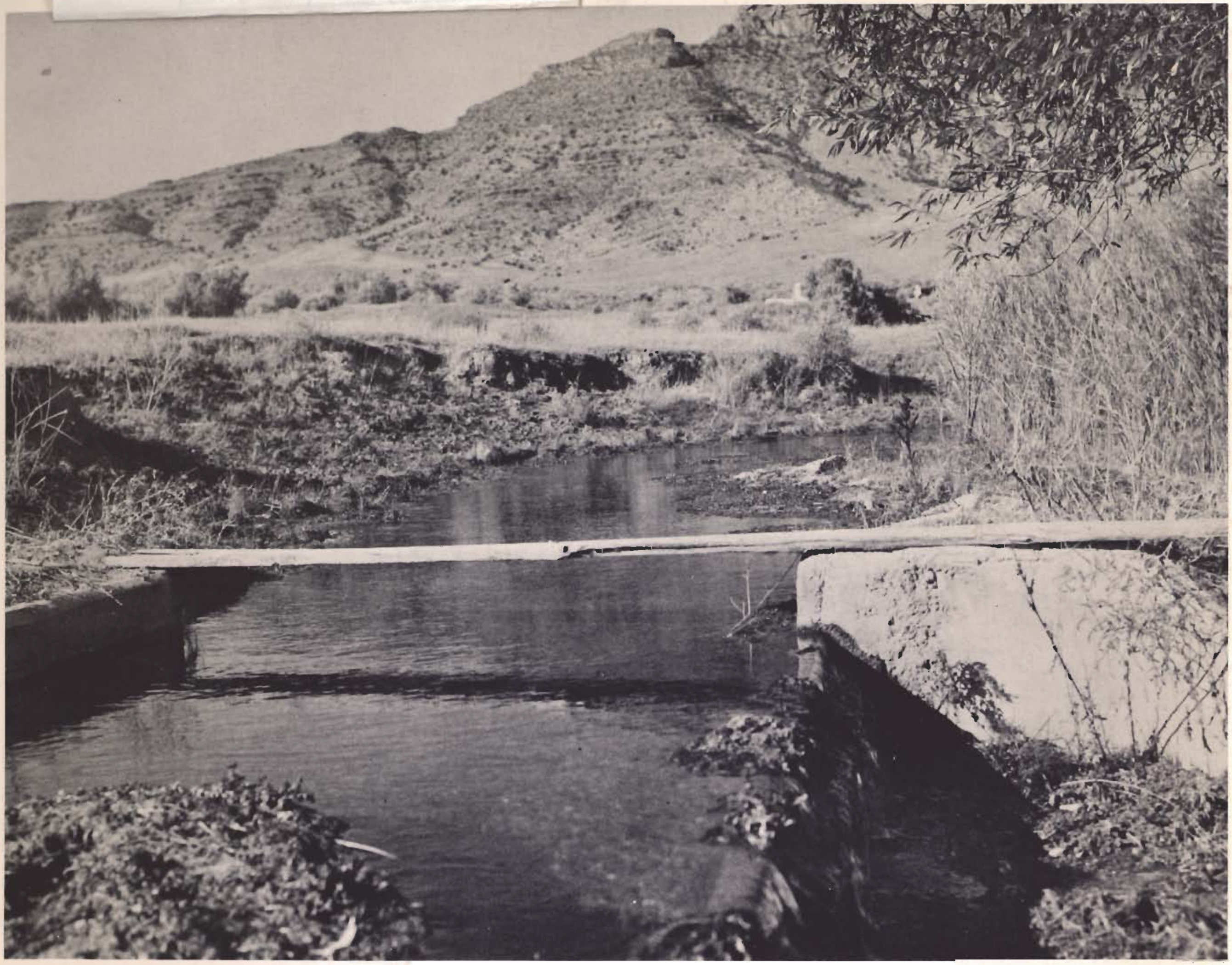
REPORT 34

WATER-RESOURCES APPRAISAL OF THE SNAKE VALLEY AREA, UTAH AND NEVADA

By
James W. Hood
and
F. Eugene Rush
Geologists

Prepared cooperatively by the
Geological Survey, U.S. Department of Interior

NOVEMBER 1965



View of the Big Spring area of southern Snake Valley.

Photograph by F. Eugene Rush

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Present development of water in the Snake Valley area is limited mainly to use of creeks and springs in the Callao, Trout Creek, and Baker-Garrison-Big Spring Creek area. These supplies are supplemented by pumping from wells at Callao, Baker, and Garrison during dry years. Water from wells is used for irrigation at Eskdale and Partoun. Potential development of ground water is large because little of the perennial yield, an estimated 80,000 acre-feet, is utilized.

INTRODUCTION

Purpose and Scope of the Study

Ground-water development in Nevada and Utah has shown a substantial increase in recent years. Part of the increase is due to the effort to bring new land into cultivation and part is due to the need to supplement surface-water supplies. As such development efforts increase, there is a corresponding increase in the demand for water-resources information in both States.

To meet the need for information in Nevada, legislation was enacted in 1960 specifically to provide for reconnaissances of ground-water basins in the State. The Utah State Engineer, recognizing the lack of information in the western basins of Utah, began a similar program in 1964. In both States, the studies are made in cooperation with the U.S. Geological Survey. The purpose of such studies is to provide water-resources information to the public and to assist the State Engineers in their administration of the water laws of their respective states. The scope of the studies includes appraisals and information on (1) climate, (2) geologic environment, (3) extent of the hydrologic systems, (4) ground water in storage, (5) water quality, (6) areas of potential development, (7) existing and potential problems, and (8) needs for additional study.

Interest in water resources in general currently includes many areas and is expanding to additional areas almost continuously. Thus, the emphasis of the reconnaissances is to provide as quickly as possible a general appraisal of the water resources in particular valleys, generally in the order of urgency of need. Ultimately, information will be available for practically all valleys in Nevada and western Utah. For this reason, each study is severely limited in time. Fieldwork in the Snake Valley area required about 4 weeks during the period June through December 1964.

This report continues the Water Resources-Reconnaissance Series of reports issued by the State of Nevada and is the first of a similar series to be included in the Technical Publication Series issued by the State of Utah.

A list of previously published reports and a map (fig. 7) showing the location of the areas covered in the Nevada Water Resources - Reconnaissance Series are in the back of the report.

WATER RESOURCES APPRAISAL OF THE SNAKE VALLEY AREA, UTAH AND NEVADA

By

James W. Hood and F. Eugene Rush

SUMMARY

The Snake Valley area is a north-trending narrow depression that extends about 135 miles along the central Nevada-Utah border. The area covers about 3,480 square miles. Within the area, the principal ground-water reservoir is in the unconsolidated deposits of Quaternary and Tertiary age that underlie about 1.2 million acres. Carbonate rocks of Paleozoic age may form another reservoir system and locally may control the movement of ground water.

Water in the Snake Valley area is derived mostly from precipitation in the surrounding mountains; however, about 4,000 acre-feet is estimated to enter the area as ground-water underflow from adjacent Spring Valley, Nevada. The Deep Creek and Snake Ranges produce most of the runoff and ground-water recharge. The estimated average annual runoff from the mountains above an altitude of 7,000 feet is 58,000 acre-feet. Of this amount, 38,000 acre-feet, is generated in Nevada. Much of the runoff percolates into the alluvium recharging the ground-water reservoir. The estimated average annual ground-water recharge is 105,000 acre-feet, including the inflow from Spring Valley. Of the recharge, 65,000 acre-feet is generated in Nevada.

Evapotranspiration of ground water is estimated to be 80,000 acre-feet per year. The subsurface outflow northward to the Great Salt Lake Desert in the alluvium is estimated to be 10,000 acre-feet per year. The difference between the identified discharge and the recharge, about 15,000 acre-feet per year, may be the amount of the ground-water flow from the valley fill to the carbonate-rock reservoir. Discharge from wells in 1964 was about 7,000 acre-feet.

The recoverable ground water stored in the uppermost 100 feet of saturated alluvium is estimated to be at least 12 million acre-feet. The preliminary estimate of the perennial yield of the Snake Valley area is about 80,000 acre-feet.

The chemical quality of all water samples from the alluvial area south of the Great Salt Lake Desert indicated that the ground water is generally suitable for irrigating crops and for domestic use. Most samples had a low to moderate salinity hazard and a low sodium hazard.

Acknowledgments

The authors wish to express their appreciation to D. O. Moore, who made measurements of stream discharge in the summer of 1964 and who provided the synthesis of surface-water runoff in the Snake Valley area. Residents of the valleys were most kind and helpful in providing general information with regard to water sources and utilization.

A part of the basic data in this report was obtained from records of soil and moisture program of the Department of the Interior, some of which were summarized by Snyder (1963).

Location and General Features

The Snake Valley area is mainly in Utah and extends into the eastern part of Nevada. It is enclosed by latitudes 37°55' and 40°N. and longitudes 113°20' and 114°15' W. (See figs. 1 and 2.) The area is in the western parts of Iron, Beaver, Millard, Juab, and Tooele Counties, Utah, and in northeastern Lincoln and eastern White Pine Counties, Nevada. The south end of the area is about 10 miles north of Modena, Utah, and the north end opens into the Great Salt Lake Desert, about 60 miles south-southeast of Wendover, Utah. The principal communities are Partoun, and Garrison, Utah, as shown on plate 1.

The Snake Valley area, as defined in this study, is a long, narrow continuous depression that trends northward a distance of about 135 miles. Its maximum width between topographic divides, measured near Garrison, is 43 miles. The valleys composing the area cover about 3,480 square miles.

Although the report area is a continuous depression, the approximate southern one-third is called Hamlin Valley. Several tributary valleys are separately named; these include Antelope Valley, Ferguson Desert, and Pleasant Valley (pl. 1).

Principal access to the Snake Valley area is by U. S. Highway 6-50 which crosses Snake Valley near Baker, Nevada and State Highways 73 (Nevada) and 21 (Utah) as shown on figure 2. Improved roads extend to various parts of the area. Numerous unimproved trails lead to most of the tributary valleys.

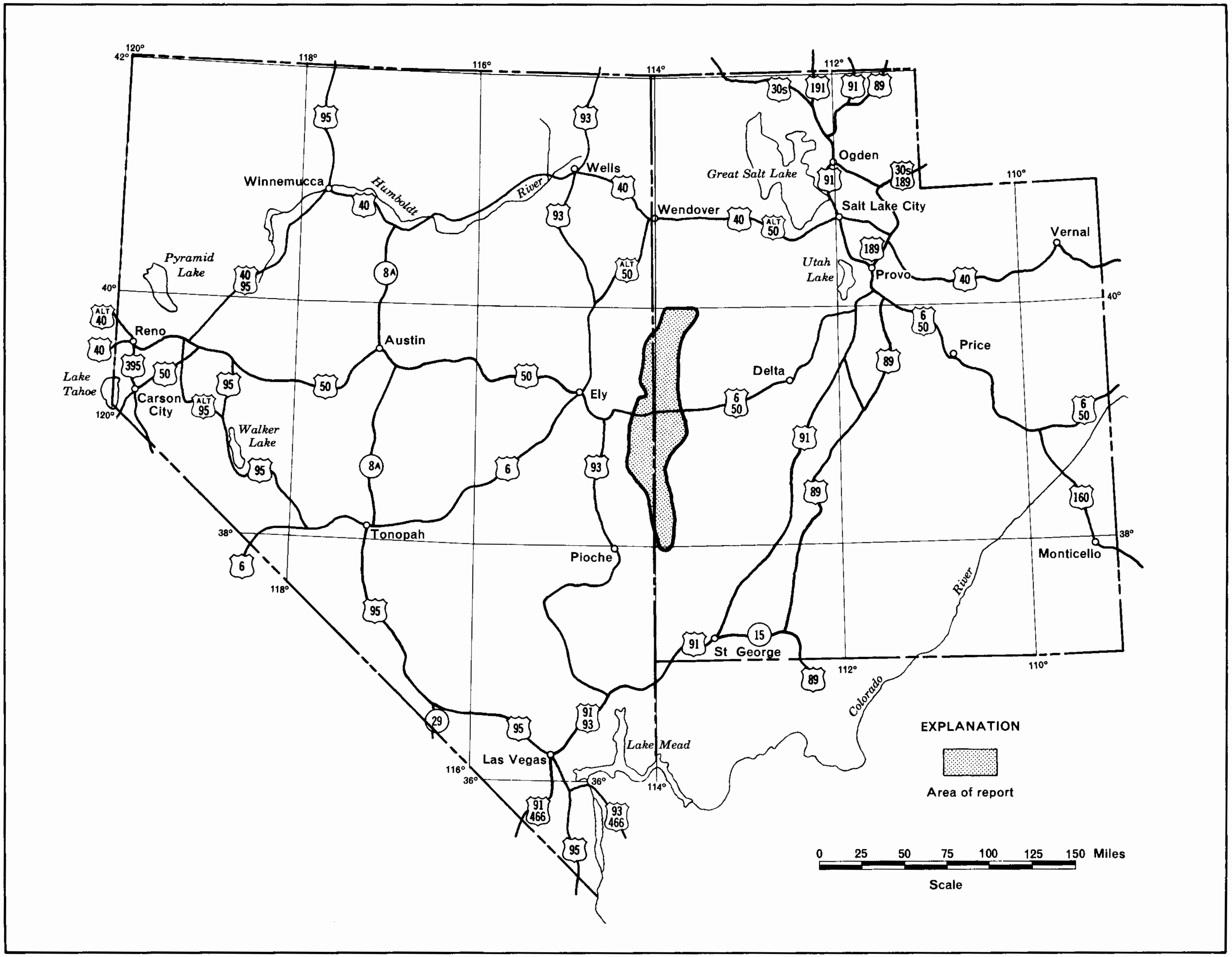

Figure 1.—Map of Nevada and Utah showing the area described in this report.

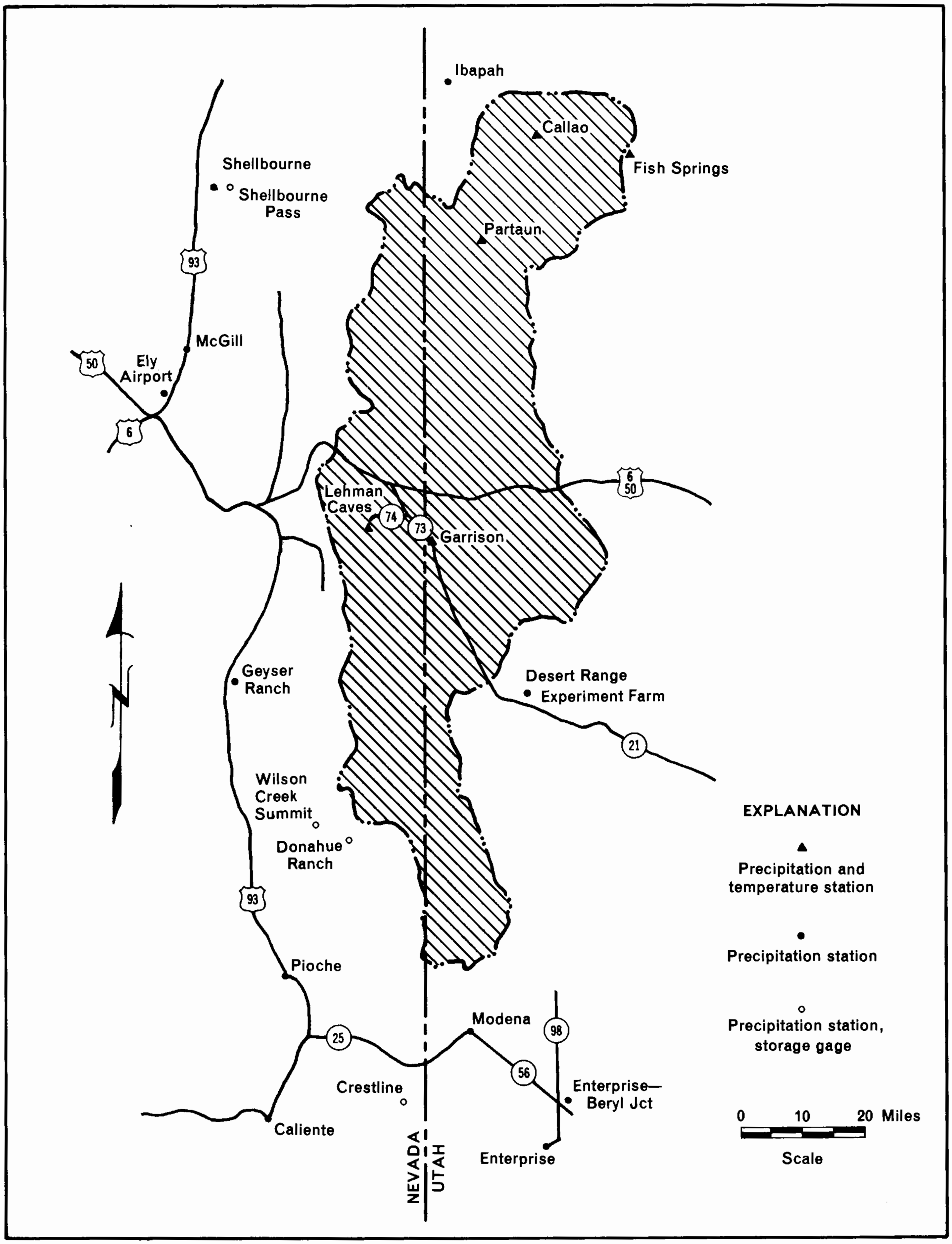

Figure 2.—Locations of weather stations

Physiography and Drainage

The Snake Valley area is a western tributary in the complex comprising the Great Salt Lake drainage basin, which is a broad expanse of saltflats and marshes. This area is in the eastern part of the Great Basin section of the Basin and Range physiographic province. Snake Valley is separated from Spring Valley, Nevada, and Pine Valley, Utah, by relatively low divides in the mountains that bound the area. The study area is bounded on the west by the Deep Creek Range and Kern Mountains, the Snake and Wilson Creek Ranges, and the White Rock Mountains. The eastern boundary is comprised of the Fish Springs and Confusion Ranges, the Tunnel Spring Mountains, and the Needle Range. The Burbank Hills lie entirely within the report area between Antelope Valley and the Ferguson Desert.

The highest peaks are along the western boundary in the massive upland parts of the Deep Creek and Snake Ranges. Haystack Peak in the Deep Creek Range has an altitude of 12,101 feet, and the range has extensive areas above 10,000 feet. In the northern Snake Range, Mount Moriah reaches 12,050 feet. The highest peak in the area is Wheeler Peak, 13,063 feet, in the southern Snake Range. Lincoln Peak reaches 11,509 feet. The mountain areas are extensively mantled with forests, and the Wheeler Peak area shows the effects of glaciation. A remnant icefield is on the north side of the peak.

By contrast, the highest peaks of the eastern mountains are relatively low and have little forest cover. The top of the Fish Springs Range reaches 8,525 feet; in the Confusion Range, the altitude of King Top is 8,300 feet. The highest peak in the Tunnel Spring Mountains has an altitude of 8,457 feet, and in the Needle Range, the highest peak is at 9,785 feet.

For the purposes of this report, the floor of the Snake Valley area is divided into three segments: A southern part, Hamlin Valley and the Big Spring Creek area south of Garrison; a central part, the Snake Valley area from Garrison to Trout Creek; and a northern part, north of Trout Creek. The highest valley floor is in southern Hamlin Valley at an altitude of about 6,600 feet. The floor descends northward to 5,200 feet near Garrison, 4,680 feet at Trout Creek, and about 4,250 feet in the Great Salt Lake Desert.

Snake Valley has a continuous slope northward, but it contains no modern, well-defined stream channel that extends the length of the valley. Numerous small tributary valleys debouch into the main valley, but in a short distance lose their integrity on the alluvial slopes upstream from the valley axis.

Climate

Precipitation differs widely from one part of the area to another. The valley floors as a whole are semiarid, whereas the highest parts of the mountain area are humid to subalpine. Maps by Hardman (1936) in Nevada and the U.S. Weather Bureau (1963) in Utah show that the precipitation pattern is related to the topography: The stations at high altitudes generally receive more precipitation than those at low altitudes. The Great Salt Lake Desert near Callao receives an average annual precipitation of 5 to 6 inches whereas the uppermost slopes of the Deep Creek Range receive 20 to 30 inches. Precipitation in the high mountains consists of considerable amounts of winter snow that produce spring runoff and of rain from local summer storms. In the lowlands, about 50 percent of the precipitation is from summer thunderstorms.

Precipitation data have been recorded at 11 stations in and close to the study area. An additional nine stations provide data in the region surrounding the study area and are useful in establishing both the long-term trend of precipitation and the altitude-precipitation relationship. These 20 stations are shown in figure 2 and are listed in table 1. Figure 3 shows the monthly distribution of precipitation at Callao, a low-altitude station, and at Lehman Caves, Nevada, an intermediate-altitude station. It can be seen that the intermediate-altitude station receives more precipitation in the winter, but both show the effects of summer thunderstorms.

Recorded annual precipitation varies greatly at most of the stations. Callao, for example, received 0.94 inches in 1953 and 9.03 inches in 1945. Ibapah in adjacent Deep Creek Valley received 3.20 inches in 1953 and 27.02 inches in 1941. Lehman Caves has a recorded minimum of 7.37 inches and a maximum of 19.20 inches. The long-term pattern is illustrated in the records from Modena, Utah, and McGill, Nevada. (See figure 4.) The annual variation of precipitation with altitude ranges from 14.11 inches at Wilson Creek to 4.51 inches at Callao.

Temperature data have been recorded in Snake Valley at Lehman Caves, Garrison, Partoun, and recently at Callao. Nearby temperature stations include Ibapah, Modena, Pioche, and Fish Springs Wildlife Refuge. The average annual temperature in most of the valleys is about 50°F. Brief records suggest that the average annual temperature at the edge of the Great Salt Lake Desert is on the order of 53°F. The coldest average monthly temperatures are 22°-32°F in January, and the warmest are 69°-77°F in July.

With regard to agricultural practice, however, the length of the growing season is of particular importance. Because the definition of killing frost differs with the type of crop, the U.S. Weather Bureau (1951-65) publishes freeze data that include the number of days between the last spring minimum and the first fall minimum for temperatures of 32°F, 28°F, and 24°F. These data for the period 1950-63 are shown in table 2 for four stations in the Snake Valley area and two stations near the area.

Table 1.--Average monthly and annual precipitation at various stations in and near the Snake Valley area, Nevada and Utah.

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
						NEVADA							
Caliente[1]	.79	.73	.92	.80	.46	.36	.67	.90	.56	.92	.77	.80	8.66
Crestline[2]	--	--	--	--	--	--	--	--	--	--	--	--	10.88
Donahue Ranch[3]	--	--	--	--	--	--	--	--	--	--	--	--	12.78
Ely Airport[4]	.64	.66	.92	.70	.92	.61	.56	.44	.59	.43	.52	.57	7.57
Geyser Ranch[5]	.59	.82	.72	.61	.51	.40	.79	.83	.47	.64	.71	.66	7.75
Lehman Caves[6]	.95	1.21	1.57	1.25	1.15	.70	.62	1.03	.70	1.32	1.22	.92	12.64
McGill[7]	.72	.71	.76	.99	1.07	.77	.69	.85	.58	.77	.57	.67	9.15
Pioche[8]	1.45	1.28	1.39	1.15	.51	.32	.85	1.14	.80	1.09	.96	1.26	12.48
Schellbourne[9]	.32	.46	.34	.38	.68	.46	.50	1.06	.50	.16	.16	.65	5.76
Schellbourne Pass[10]	.94	1.21	1.31	1.24	1.58	.53	.52	.93	.78	.56	.73	.69	11.02
Wilson Creek Summit[11]	1.62	1.68	1.34	1.09	1.25	.64	.84	1.24	.78	1.03	1.68	.92	14.11
						UTAH							
Callao[12]	.33	.28	.35	.52	.54	.50	.23	.48	.30	.37	.38	.23	4.51
Desert Range Experimental Farm[13]	.35	.32	.45	.62	.51	.51	.76	.64	.43	.58	.36	.21	5.89
Enterprise[14]	2.02	1.74	1.83	.99	.87	.46	1.17	1.36	1.20	1.19	1.15	1.17	15.15
Enterprise-Beryl Junction[15]	.64	.62	.94	.87	.50	.49	.67	1.12	.57	1.16	.87	.72	9.17
Fish Springs[16]	--	--	--	--	--	--	--	--	--	--	--	--	8.
Garrison[17]	.66	.38	.90	.42	.68	.38	.32	.59	.49	.81	.72	.36	6.71
Ibapah[18]	.70	.97	1.07	1.24	1.59	.94	.80	1.01	.61	.98	.65	.67	11.23
Modena[19]	.81	.82	1.01	.77	.72	.38	1.09	1.28	.96	.97	.61	.69	10.11
Partoun[20]	.32	.42	.45	.50	.66	.59	.44	.42	.32	.41	.44	.24	5.21

NEVADA

1. Altitude 4,402 feet. Location sec.8, T.4 S., R.67 E. Period of record 25 years, 1939-63.
2. Altitude 5,982 feet. Location sec.26 T.3 S., R.70 E. Period of record 7 years, 1957-64. Storage gage
3. Altitude 6,825 feet. Location sec.29, T.5 N., R.69 E. Period of record 5 years, 1959-64. Storage gage
4. Altitude 6,257 feet. Location sec.35, T.17 N., R.63 E. Period of record 16 years, 1948-63.
5. Altitude 6,020 feet. Location sec.13, T.9 N., R.65 E. Period of record 14 years, 1943-53, 1961-63.
6. Altitude 6,825 feet. Location sec.15, T.13 N., R.69 E. Period of record 23 years, 1938-48, 1952-63.
7. Altitude 6,340 feet. Location sec.28, T.18 N., R.64 E. Period of record 50 years, 1913-63.
8. Altitude 6,110 feet. Location sec.22, T.1 N., R.67 E. Period of record 25 years, 1939-63.
9. Altitude 6,720 feet. Location sec.11, T.22 N., R.64 E. Period of record 5 years, 1953-55, 1958-59.
10. Altitude 8,150 feet. Location sec.8, T.22 N., R.65 E. Period of record 9 years, 1955-63. Storage gage
11. Altitude 7,100 feet. Location sec.26, T.6 N., R.67 E. Period of record 10 years, 1954-63. Storage gage

UTAH

12. Altitude 4,339 feet. Location sec. 1, T.11 S., R.17 W. Period of record 25 years, 1939-63.
13. Altitude 5,252 feet. Location sec.33, T.25 S., R.17 W. Period of record 10 years, 1953-58, 1960-63.
14. Altitude 5,275 feet. Location sec.14, T.37 S., R.17 W. Period of record 31 years, 1906-23, 1925, 1927-29, 1954-58, 1960-63.
15. Altitude 5,220 feet. Location sec.33, T.35 S., R.16 W. Period of record 17 years 1941-51, 1956-57, 1960-63.
16. Altitude 4,350 feet. Location sec.25, T.11 S., R.14 W. Period of record 3 years, 1961-63.
17. Altitude 5,275 feet. Location sec.1, T.22 S., R.19 W. Period of record 11 years, 1952-55, 1957-63.
18. Altitude 5,288 feet. Location sec.16, T.9 S., R.19 W. Period of record 58 years, 1903-42, 1946-63.
19. Altitude 5,466 feet. Location sec.36, T.34 S., R.19 W. Period of record 63 years, 1901-63.
20. Altitude 4,750 feet. Location sec.33, T.13 S., R.18 W. Period of record 13 years, 1951-63.

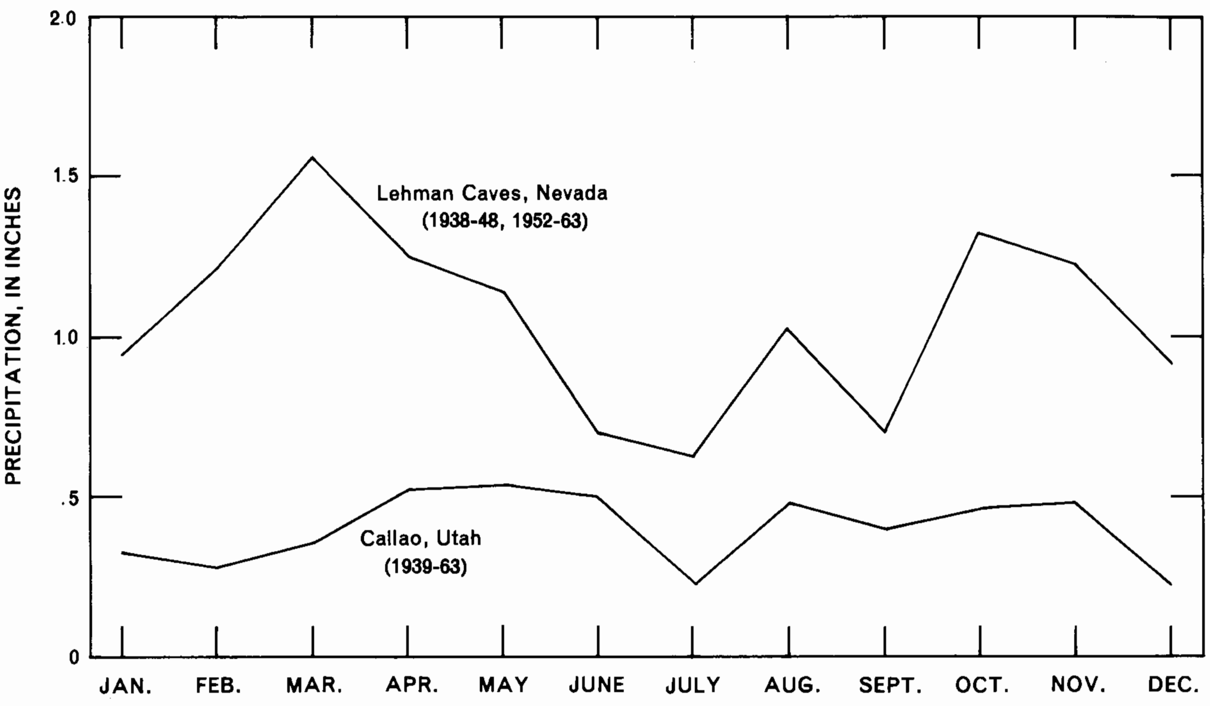

Figure 3.—Average monthly precipitation at two stations

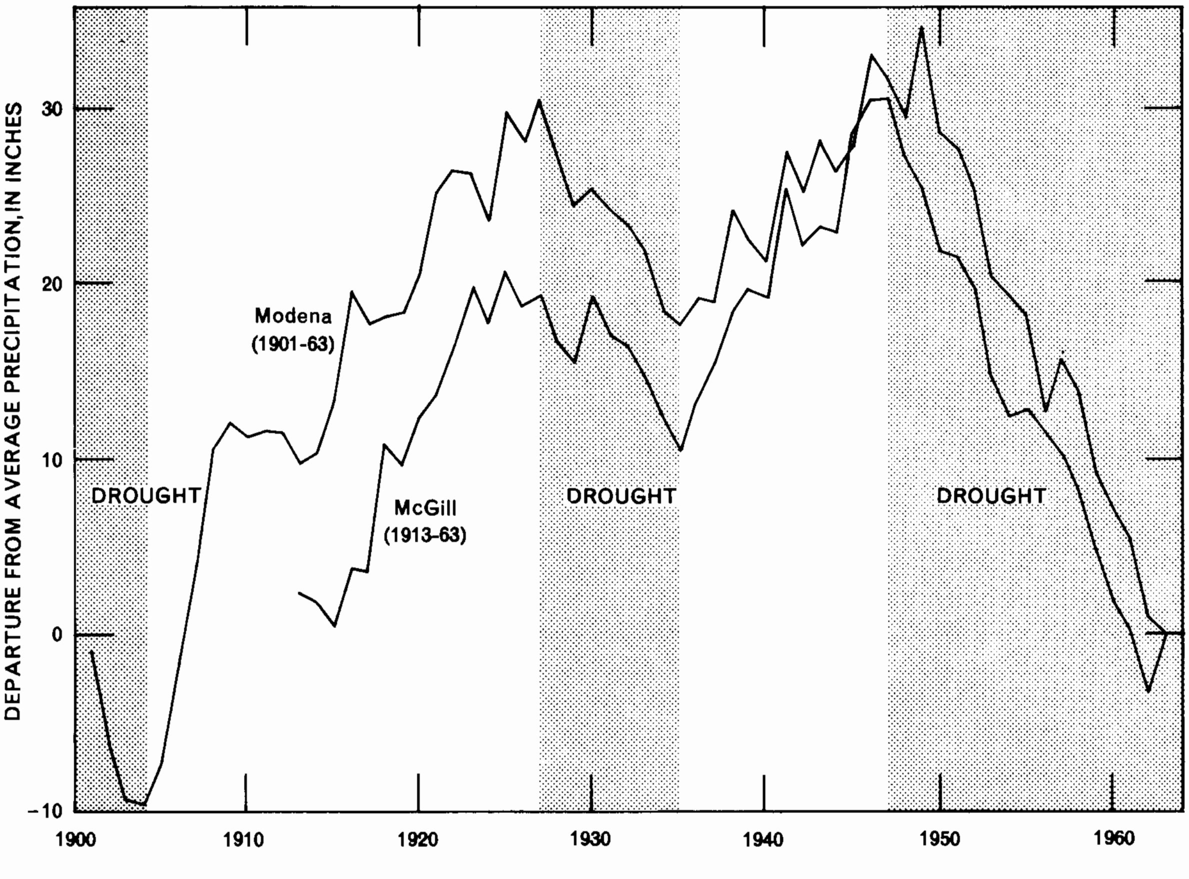

Figure 4.—Cumulative departure from average annual precipitation at Modena, Utah and McGill, Nevada

The growing season is about the same length at most stations in the study area; crops experiencing a killing frost of 28°F have an average growing season of about 150 days. If crops were grown in southern Hamlin Valley, the season might be appreciably shorter, owing to the high altitude of the valley floor. The growing season is somewhat shorter on the valley floors than on the adjacent upper alluvial slopes, as indicated by the record for Partoun, Garrison, and Lehman Caves.

The semiarid climate on the valley floor and the high summer temperature cause high evaporation rates, as suggested by the brief record obtained at Fish Springs Wildlife Refuge, as follows (evaporation in inches):

	May	June	July	Aug.	Sept.	Oct.
1962	---	---	---	---	11.70	7.96
1963	---	11.76	19.68	14.97	8.95	7.63
1964	12.47	12.07	18.41			

These data show that the annual pan evaporation rate probably is in excess of 75 inches and that the annual evaporation from any open bodies of water probably would amount to 60 inches or more. Thus the potential evaporation is 5 to 10 times the annual precipitation, inferring that most summer precipitation on the valley floors evaporates quickly and is not available for plant use or recharge to the groundwater reservoir.

Table 2.--Number of days between the last spring minimum temperature and the first fall minimum at six selected stations in and near the Snake Valley area 1950-63.
(U.S. Weather Bureau 1951-64)

Year	Gallao	Fish Springs WLR	Garrison	Partoun	Pioche	Lehman Caves
			Number of days between temperatures of: 32°F or below			
1950	-	-	-	132	147	35
1951	-	-	-	122	173	140
1952	-	-	149	193	173	151
1953	-	-	96	124	146	123
1954	-	-	120	106	136	110
1955	-	-	127	114	143	116
1956	-	-	-	-	152	152
1957	-	-	122	113	134	96
1958	-	-	140	130	178	139
1959	-	-	113	113	131	129
1960	-	-	110	122	144	138
1961	-	148	114	112	148	134
1962	71	148	115	85	142	141
1963	167	188	154	153	-	172
Average	-	-	124	125	150	127
			28°F or below			
1950	-	-	-	150	185	177
1951	-	-	-	177	175	155
1952	-	-	183	207	210	202
1953	-	-	127	145	162	127
1954	-	-	-	185	176	112
1955	-	-	143	142	170	143
1956	-	-	-	-	163	153
1957	-	-	142	145	190	128
1958	-	-	147	147	179	151
1959	-	-	129	131	178	131
1960	-	-	163	148	164	167
1961	-	170	142	143	165	135
1962	-	221	154	112	180	148
1963	186	192	192	186	-	172
Average	-	-	152	155	177	150

Table 2.--(continued).

Year	Callao	Fish Springs WLR	Garrison	Partoun	Pioche	Lehman Caves
			24°F or below			
1950	-	-	-	150	198	185
1951	-	-	-	207	223	192
1952	-	-	189	220	232	207
1953	-	-	142	146	173	164
1954	-	-	-	185	177	176
1955	-	-	162	143	197	143
1956	-	-	-	182	204	164
1957	-	-	212	160	227	179
1958	-	-	177	177	224	177
1959	-	-	161	131	209	162
1960	-	-	188	188	204	187
1961	-	196	170	143	188	170
1962	-	229	168	154	232	201
1963	192	212	192	192	-	192
Average	-	-	176	170	207	179

Designation of Wells and Springs

In this report the number assigned to a well or spring on plate 1 is both an identification number and a location number. The number is based on the common method of subdividing Federal Lands in the western United States. In Nevada, the numbers are referenced to the Mount Diablo base line and meridian, and in Utah to the Salt Lake base line and meridian.

A typical Nevada number consists of three units; the first is the township north or south of the Mount Diablo base line, and the second unit, separated from the first by a slant line, is the range east of the Mount Diablo meridian. The third unit, separated from the second by a dash, is the section in the township, and the section number is followed by a lower case letter that indicates the quarter section; finally the letter is followed by a number that indicates the order in which the well was recorded in the quarter section: The letters a, b, c, and d designate, respectively, the northeast, northwest, southwest, and southeast quarters of the section.

In Utah, wells and locations are numbered according to a system that was devised cooperatively by the Utah State Engineer and the Geological Survey in about 1935. The system is illustrated in figure 5. The complete well number comprises letters and numbers that designate consecutively the quadrant and township (shown together in parentheses by a capital letter designating the quadrant in relation to the base point of the Salt Lake base and meridian, and numbers designating the township and range); the number of the section; the quarter section (designated by a letter); the quarter of the quarter section; the quarter of the quarter-quarter section; and finally, the particular well within the 10-acre tract (designated by a number). By this system the letters, A, B, C, and D designate, respectively, the northeast, northwest, southwest, and southeast quadrants of the standard base and meridian system, and the letters a, b, c, and d designate the northeast, northwest, southwest, and southeast quarters of the section. Number (B-2-2) 12dcd-2 designates well 2 in the SE1/4SW1/4SE1/4 sec. 12, T. 2 N., R. 2 W., the letter B showing that the township is north of the Salt Lake base line and the range is west of the Salt Lake meridian; and the number (D-3-2) 34bca-1 designates well 1 in the NE1/4SE1/4NW1/4 sec. 34, T. 3 S., R. 2 E. Springs and sampling sites are also numbered using this system, but the designation number within a 10-acre tract is omitted.

Wells on plate 1 are identified only by the section number, quarter-section letters and serial number. The township in which the well is located can be determined by the township and range numbers shown on the margins of plate 1.

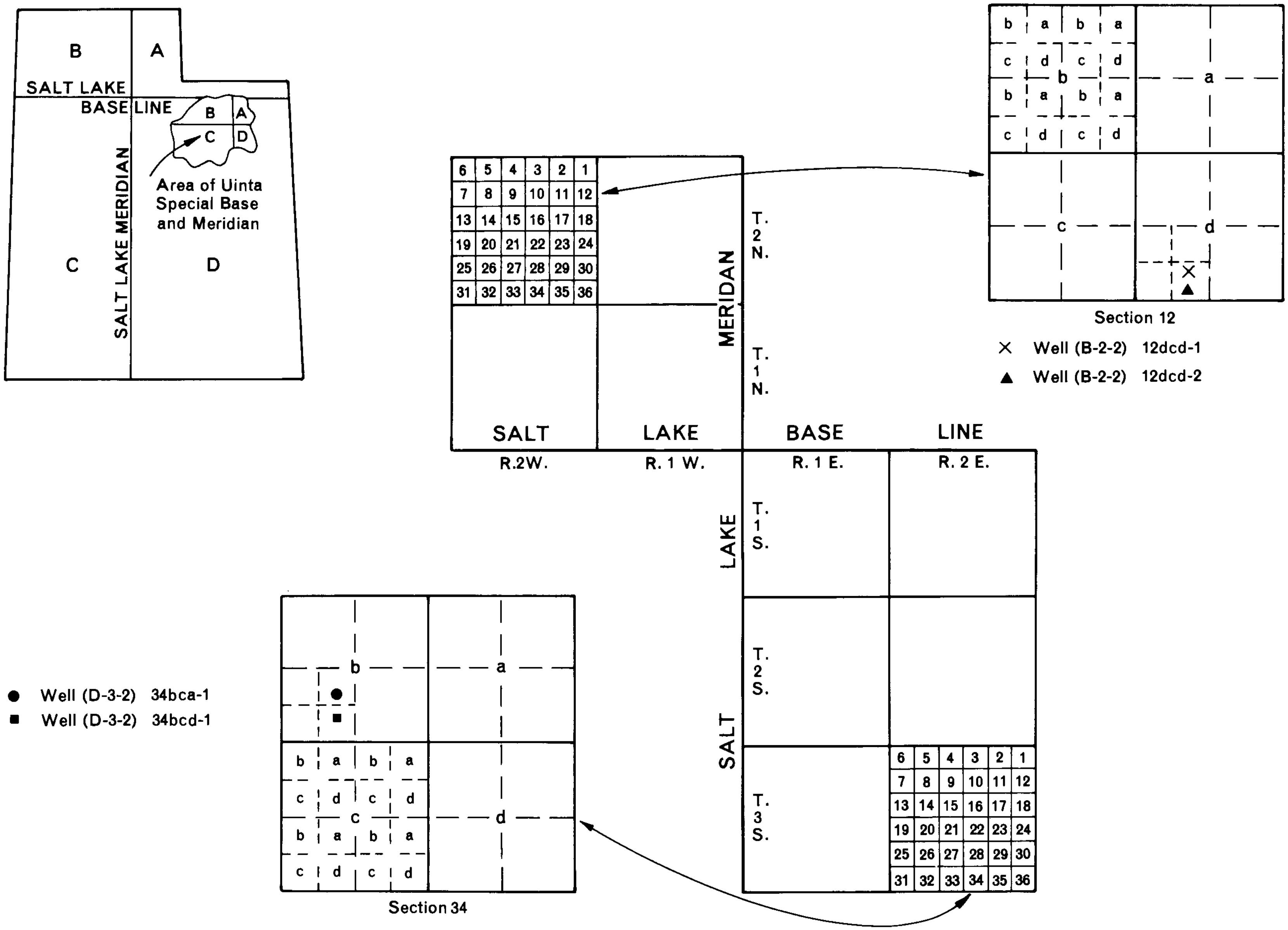

Figure 5.—Well-numbering system used in Utah

GENERAL HYDROGEOLOGIC FEATURES

The geology shown on plate 1 is based largely on the geologic maps of northwestern and southwestern Utah (Stokes, 1963), the reconnaissance geologic map of Lincoln County, Nevada (Tschanz and Pampeyan, 1961), and the preliminary geologic map of the Wheeler Peak quadrangle, Nevada (Whitebread and others, 1962). The data shown in these, together with field data, have been modified to emphasize the relation of geology to hydrology.

Geomorphic Features

The mountains of the report area are complexly folded and faulted blocks of sedimentary, igneous, and metamorphic rocks. The present topographic relief is largely the result of movement along north-trending faults.

Erosional debris washed from the mountains has formed large alluvial fans along the mountain fronts. These fans coalesce laterally and form an undulating slope, or alluvial apron, the width of which is related to the drainage area that contributed the erosional debris. In narrow sections of the valley, as in central Hamlin Valley and the area immediately south of Garrison, the fans extending inward from opposite sides nearly merge along the axis of the valley. In the area near Garrison and locally to the north more fan material was contributed from the west, and the valley, therefore, is assymetric, with its axis near the east side.

Much of the lowland was shaped during Pleistocene time when Snake Valley was occupied by Lake Bonneville. The high lake level, as determined from relic shore features, is shown on plate 1. At the north end of the valley near Callao, alluvial material derived from the adjacent mountains was formed into numerous spits and gravel bars. One of the largest features of this type is a spit extending from the Deep Creek Range eastward into the valley lowlands south of Callao. Prominent wave-cut cliffs were cut on the Deep Creek Range at Callao and wave-cut platforms were cut on the extrusive igneous rocks east of Trout Creek and on the sedimentary rocks in the Conger Range near Eskdale. Other lake features are found as far south as U.S. Highway 50.

The lowest parts of the floor of Snake Valley, particularly in the central area between Eskdale and Trout Creek, and east of Callao are relatively level and flat. These are the areas in which fine-grained lake-bottom deposits were emplaced.

Lithologic and Hydrologic Features of the Rocks

In this report, the rocks of the Snake Valley area are divided into two major groups, designated as consolidated rocks and valley fill. The consolidated rocks are divided into three units: Paleozoic sedimentary rocks which are mainly carbonates; Cretaceous and Tertiary extrusive igneous rocks; and Tertiary, Jurassic, and Precambrian intrusive igneous rocks and Precambrian metasedimentary rocks. Their distribution is shown on plate 1.

The intrusive igneous rocks, largely granite and monzonite, and metasedimentary rocks crop out mainly in the Deep Creek Range and in the northern part of the Snake Range. Whitebread and others (1962) infer that the intrusive rocks underlie a substantial part of the southern Snake Range. These rocks are of low permeability, occupy areas where precipitation is at a maximum, and contribute to runoff by inhibiting infiltration. The low permeability also contributes to the occurrence of ephemeral springs that result from near-surface infiltration and subsequent nearby discharge downgradient.

The extrusive igneous rocks consist of basaltic lava in the vicinity of Trout Creek and may act as a recharge conveyance medium. At the south end of the Snake Valley area, extrusive igneous rocks of Tertiary age crop out in large parts of the Needles Range and adjacent ranges. They are largely ignimbrites of daeitic composition that rest unconformably on mainly sedimentary rocks of Paleozoic age. (See Mackin, 1963). As a result of subsequent faulting, the extrusive rocks now cap the mountains and may also underlie parts of the valley fill in Hamlin Valley. The permeability of the extrusive rocks near Hamlin Valley probably is low, and as a result they probably do not contain major aquifers. They do contribute recharge to the valley fill by enhancing overland flow of runoff and possibly by some spring flow.

The sedimentary rocks of Paleozoic age appear to be a part of the regional hydrologic system because they are mainly carbonate rocks. Through similar rocks in eastern and southern Nevada interbasin flow of ground water takes place. As plate 1 shows, these rocks crop out in a large part of the mountain areas, and it is known that they underlie at least a part of the valley fill along the edges of the Snake Valley area. Detailed geologic maps (see source materials cited in Stokes, 1963) and field observations show that the consolidated sedimentary rocks have been strongly deformed by folding and repetitive faulting ranging in type from northtrending normal faults to low angle thrust faults. Steep dips are common, and cross faulting is found in many areas.

The consolidated sedimentary rocks generally have had their primary permeability considerably reduced by consolidation, cementation, or other alteration. However, because they subsequently have been fractured repeatedly by folding and faulting, secondary openings have been developed through which water can be transmitted. Further, the fractures and joints in the carbonate rocks, which comprise the largest part of the thick section, have been enlarged locally by solution as water moves through them, as indicated by the caves, sinks, and springs in the area. Solution openings are not necessarily restricted to the vicinity of present day recharge areas and outcrop of these rocks; rather, they may occur wherever the requisite conditions have occurred at any time since deposition of the carbonate rocks.

A sinkhole in the SE1/4NW1/4NW1/4 sec. 8, T. 19 S., R. 18 W., north-northeast of Eskdale, illustrates the results of solutional activity. The sink is at an altitude of 5,140 feet, just below the relic shoreline of Lake Bonneville. The area is a platform cut by the lake on carbonate rocks; the present surface is smooth, and the drainage area around the sink is less than a quarter of a square mile. Precipitation in the area is low, and the sink apparently receives little runoff. The sink existed prior to Lake Bonneville, because the sink was filled with fine-grained lake deposits, a part of which still are present in one side. The sink, however, is open and exhibits at least a second generation of activity which appears to result from solution at depth and partial subsidence of the surficial rock.

Subsurface evidence of solution opening in the carbonate rocks is available from detailed records of oil test wells (C-15-17)8baa, (C-16-17)8cbb, and (C-22-19)3dac, all of which were drilled into the consolidated rocks of Paleozoic age. In the first of the three, considerable permeability is indicated by loss of circulation of the drilling mud in several zones extending down to about 5,900 feet. Open cavities were found at 1,004-1,008, and 3,207-3,208 feet, and extreme difficulty was experienced in cementing the zones 864-888 and 1,004-1,031 feet. Formation water from several drill-stem tests as deep as 5,777 feet reportedly was fresh, which suggests relatively deep circulation of ground water. (See table 8 for analysis of a sample from (C-15-17)8baa in zone 5,447 to 5,484 feet.) In oil test well (C-16-17)8cbb, similar losses in mud circulation are reported for zones as deep as 8,052 feet, and a formation test of the zone 2,335-2,410 feet reportedly recovered clear fresh water.

In the Burbank Hills, permeable zones were encountered in carbonate rocks in oil test well (C-22-19)3dac from the land surface to a depth of about 2,800 feet. Extreme difficulty in cementing was experienced at about 1,200 feet and from 1,966-2,364 feet. In the latter zone open cavities as deep as 12 feet reportedly were found in the zone 1,982-2,050 feet. Almost all formation water recovered from test as deep as 6,522 feet reportedly had low chloride concentrations, on the order of 100 ppm, again suggesting deep circulation of ground water through the carbonate rocks.

The principal significance, then, of solution openings is that they facilitate the transmission of ground water through carbonate rocks. The fractures and solution openings are extensively developed in the consolidated rocks on each side of the valley. The consolidated sedimentary rocks conduct water to overflow points, such as Warm Springs (C-15-19)31bc and Big Springs 10/70-33bl, west of the fill. They also apparently receive outflow from parts of the valley fill along the east side of the Snake Valley area. The places of final discharge have not been determined. Other large springs, such as the Bishop Spring area and Willow Springs at Callao, may rise from the carbonate rocks, but it seems more likely that the latter two spring areas have their sources in the valley fill.

The clastic rocks of Paleozoic age exposed in the mountains have little primary permeability, but the degree to which they have been fractured indicates that they probably can transmit moderate quantities of ground water through the fractures.

The valley fill in the Snake Valley area is of Tertiary and Quaternary age and has its origin as outwash from the mountain, lake deposition, and a small amount of eolian deposition. The fill, however, has not been divided in plate 1, because it functions as a hydrologic unit.

The valley fill consists mainly of alluvium, colluvium, and lake deposits that predate Lake Bonneville. The maximum known thickness is about 4,200 feet in oil test well (C-20-19)19dc. The character of the upper part of the fill is shown in drillers' logs of wells (table 10) which show that it contains interbedded sand and gravel, and a considerable amount of clay. Some of the gravel is well cemented. (See well (C-18-19)20ddd2, table 9.) The valley fill beneath the alluvial fans has been faulted. (See pl. 1).

The deposits of Lake Bonneville are only a small part of the valley fill. They in part are coarse-grained shore facies, but the bulk of the lake deposits probably are silt and clay that cause the artesian conditions noted in the vicinity of Partoun, Trout Creek, and Callao. Recent alluvium occupies the present stream channels.

The valley fill as a unit comprises the principal ground-water reservoir, and the upper part of the fill contains aquifers that have appreciable permeability and thus yield water freely to wells.

WATER-RESOURCES APPRAISAL

Water in the Snake Valley area is derived from precipitation, surface streams, and ground water from wells and springs, all of which are important sources in their respective areas. The following discussion attempts to identify and measure those parts of the general hydrologic cycle that occur in the Snake Valley area.

Surface Water

General Conditions

A part of the precipitation that falls in the mountains of the Snake Valley area moves to lower elevations mainly by overland flow. On the alluvial slopes of the valley, most surface water is lost by infiltration and by evapotranspiration in areas both of cultivated and of native vegetation. A small part of the runoff reaches the playas and is evaporated there. As a consequence, the area has no well-defined modern axial stream channel that extends throughout its length. Most tributary valleys contain only intermittent streams, and most of these flow only in response to snowmelt and to infrequent summer thunderstorms.

Of the 14 perennial streams in the valley, Warm and Big Spring Creeks are directly sustained by spring flow. The remaining 12 creeks all head in the high mountains on the western side of the Snake Valley area. Big Wash and Snake, Baker, and Lehman Creeks head in the southern Snake Range. Silver and Hendrys Creeks head in the northern Snake Range; and Birch, Trout, Granite, Cedar, Thomas (called Tom's Creek locally), and Basin Creeks head in the Deep Creek Range.

The water in the perennial streams is derived from high-altitude snowmelt rainfall and ground-water sources, and flows downward across the consolidated rocks of the mountains and onto the adjacent alluvial fans. Although the maximum flow of the streams may occur at various points upstream from the bedrock-valley fill contact, it is assumed here that the maximum flow is at the heads of the fans.

In addition to flow from the mountain canyons, occasional flow may be locally developed on the alluvial fans and the lowlands in response to heavy precipitation from thunderstorms.

Available Records

Gaging stations were operated on Baker and Lehman Creeks where they leave the mountains during the period December 1947 through September 1955, and continuous discharge records were accumulated during that period. Prior to that time, streamflow records were collected for Baker Creek from August 1913 to November 1916. In 1959, the station on Baker Creek was equipped with a crest-stage gage, and measurements have been made periodically since then.

For Trout Creek, continuous records have been accumulated from December 1958 to the present. Table 3 summarizes the recent records for the stations on Baker, Lehman, and Trout Creeks. For the periods, Baker Creek has the highest rate of annual flow, averaging 6,200 acre-feet. Lehman Creek and Trout Creek average 5,400 and 3,100 acre-feet per year, respectively. May, June, and July are the periods of peak flow; during these months the creeks are fed by snowmelt. After this period the flow is much less, averaging between 1.5 and 4 cfs. This flow is mostly from ground-water sources.

In addition to the continuous records, crest-stage gages have been maintained and measurements of flow have been made on Thomas Creek near Callao, since December 1958, and on two unnamed creeks south-east of Garrison since July 1960.

For the purpose of this study measurements were made on Warm, Smith, Hampton, Hendrys, Silver, Strawberry, Snake, and Big Spring Creeks. These measurements together with data from the other stations were used to synthesize the average annual runoff in the Snake Valley area.

Runoff

The amount of overland flow that reaches the alluvial fans cannot be computed directly owing to the scarcity of available data. An estimate of the average annual runoff in the Snake Valley area system, however, was made using the methods of Moore (Eakin and others, 1965) in the upper Reese River valley. Moore noted that runoff in Nevada can be divided into three general types that are related to the variations in precipitation with altitude of the land surface. One type of runoff is characterized by being composed largely of high-altitude spring snowmelt and has a peak flow of short duration. The second type is that in which the principal runoff is derived from snowmelt at moderate altitudes, but the snowmelt occurs during the winter, thus providing a low continuous flow and a proportionally reduced peak runoff. The third type is that in the lower, warmer areas in which high intensity storms produce high rates of runoff for short periods that are separated by periods of little or no flow. An additional type of runoff is base streamflow mostly from ground-water sources. The Snake Valley area has runoff characteristics (table 3) of the latter three types.

Table 3.--Summary of streamflow, in cfs, at gaging stations in the Snake Valley area, Nevada and Utah

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Year cfs	Year Acre/feet year
Baker Creek at Narrows near Baker, Nev. for the water year 1948-55														
Average	2.98	2.82	2.12	1.87	1.66	1.95	5.23	23.9	36.6	13.7	5.89	3.48	8.53	6,200
Max. month	3.80	3.23	2.45	2.16	2.35	2.66	9.65	65.1	90.5	39.2	12.0	5.25	a19.6	a 14,200
Min. month	2.40	2.30	1.69	1.50	1.07	1.23	2.36	3.64	12.2	6.40	3.66	2.43	b 3.37	b 2,800
Lehman Creek near Baker, Nev. for the water years 1948-55														
Average	2.90	2.61	2.00	1.74	1.63	1.91	4.50	20.1	29.1	13.3	6.12	3.64	7.49	5,420
Max. month	3.80	3.23	2.45	2.16	2.35	2.72	9.65	65.1	90.5	39.2	12.0	5.25	a19.6	a 14,200
Min. month	2.2	2	1.62	1.40	1.07	1.23	1.85	3.64	11.9	6.40	3.66	2.43	3.67	b 2,660
Trout Creek near Callao, Utah for the water years 1959-64														
Average	1.49	1.52	1.25	1.14	1.26	1.52	4.37	13.9	17.6	4.59	1.90	1.46	4.34	3,100
Max. month	1.79	1.77	1.49	1.54	1.54	1.82	11.1	21.6	34.6	7.68	2.72	2.01	a 6.25	a 4,500
Min. month	1.25	1.30	1.09	.96	1.02	1.13	2.09	4.29	3.66	1.49	.98	.96	b 1.75	b 1,300

a. Maximum recorded water year.

b. Minimum recorded water year.

The estimated average annual runoff from the mountains, above an altitude of 7,000 feet in the Snake Valley area (table 4), was derived by D. O. Moore by field inspection and measurements of streamflow, computation of the precipitation falling in each 1,000-foot altitude zone above 7,000 feet, and inspection of the existing gaging station records. Because of local variations in geology, vegetation, and soils, the general runoff coefficients developed by Moore (Eakin and others, 1965) were adjusted accordingly, based on the streamflow measurements. The values obtained then were adjusted from current year to long-term average annual flow.

Table 4 presents the estimated runoff by areas of approximately similar characteristics. It should be noted that about 18 percent of the upland area produces about 50 percent of the 58,000 acre-feet of estimated average annual runoff. The high runoff areas are the Deep Creek Range and the Wheeler Peak area of the Snake Range. About 38,000 acre-feet of the runoff is generated in Nevada and 20,000 acre-feet in Utah.

Much of the runoff infiltrates into the alluvium, much of which percolates to the water table and recharges the ground-water reservoir. Some of the runoff is utilized for irrigation and some adds to the soil moisture and is evaporated or supports native vegetation.

Table 4.--Estimated average annual runoff, in acre-feet, in the Snake Valley area above an altitude of 7,000 feet

Runoff area	Area		Estimated runoff	
	Acres	Percent of total	acre-feet	Percent of total
Hamlin Valley (south of T.9 N., Nevada)	87,000	19	7,000	12
East side of Snake Valley area (T.24 S., Utah, north to Great Salt Lake Desert)	27,000	6	1,000	2
West side of Snake Valley area				
North of Trout Creek (Middle of T13 S., to T9 S., Utah)	42,000	9	14,000	24
North of Mill Creek to Trout Creek (T.14 N., Nevada northward)	203,000	45	11,000	19
Mill Creek - Big Wash (Middle of T.12 N., to T.14 N., Nevada)	38,000	9	17,000	29
Big Wash - Big Spring (T.10 N., to middle of T.12 N., Nevada)	53,000	12	8,000	14
Total (rounded)	450,000	100	58,000	100

Ground Water

Occurrence

Source.--Ground water in the Snake Valley area is mainly derived from precipitation within the drainage basin. A small amount of ground water, however, enters Hamlin Valley from Spring Valley, Nevada, beneath the low carbonate-rock surface divide between the Snake and Wilson Creek Ranges (Rush and Kazmi, 1965).

Most of the ground water in the valleys is derived from snowmelt and rainfall above altitudes of 6,000 feet. There, the quantity of precipitation generally exceeds the losses from evapotranspiration. Water in the mountains partly infiltrates the consolidated rocks and partly collects in streams that discharge onto the adjoining alluvial fans. Much of the water thus developed is lost to evapotranspiration before and after infiltration, some adds to the soil moisture, and a part percolates to the water table.

Little of the precipitation that falls on the land surface below 6,000 feet reaches the water table, because there most precipitation occurs in small amounts that is held by the alluvium as soil moisture and then discharged by evapotranspiration. In the altitude zone between 6,000 and 5,200 feet small amounts of water from intense local storms may reach the water table where the surficial alluvium is coarse-grained. Below 5,200 feet, however, it is believed that little or no recharge occurs, because the surficial or near-surface deposits are lake deposits. Although the near-shore lake deposits are coarse-grained, most of the lake-bottom deposits probably are silt and clay which have a low permeability and inhibit downward percolation.

Occurrence.--Ground water occurs under both confined (artesian) and unconfined (water-table) conditions in the Snake Valley area. Artesian conditions that result in hydrostatic head above the land surface are abundantly illustrated by both spring flow and flowing wells in the reach of Snake Valley from Callao southward to Big Spring, southwest of Garrison. Wells flow from depths as shallow as 90 feet at Callao, 120 feet at Trout Creek, and 100 feet in the Baker area; and several flowing wells are 400 to 600 feet deep. (See table 9.) In the Callao and Trout Creek-Partoun area shallow flowing wells exist only in the lowest part of the valley, but to the south, flowing wells exist along the Gandy-Garrison road and in the Baker area at elevations well above the lowest part of the valley.

Spring flow also indicates that artesian conditions occur in areas where there presently are no wells. The Willow Springs area in sec. 36, T. 10 S., R. 17 W., near Callao, and the spring at the old Miller Ranch in T. 14 S., R. 18 W. (Meinzer, 1911, p. 132), the Bishop and Knoll Spring areas (vicinity of Tps. 16 and 18 S., R. 18 W.) and the

Big Spring (10/70-33bl) (table 9) all show that the deeper valley fill contains water under artesian pressure. The temperature of water from these springs is 64 to 68°F or 10 to 20°F above the range of the average annual air temperature; thus, the source aquifer of the spring water is moderately deep.

Unconfined conditions occur both at the edges of the valley fill, where recharge takes place, and in the shallowest parts of the valley fill along the axis of the main valley, north of Hamlin Valley. The shallow water-table zone is supplied partly by upward leakage, but it also receives some recharge from springs and streamflow, particularly from the west side of the valley. The shallow water is discharged mainly by phreatophytes and evaporation from playas, but also by cool gravity springs and seeps in drainage channels and at the edges of playas.

Thickness of the reservoir.--The total thickness of unconsolidated fill in the Snake Valley area is known only in a few places, mainly at the edges of the valley and in tributary valleys. The deepest known well drilled in valley fill is oil test (C-20-19)19dc, which penetrated about 4,200 feet of Tertiary and Quaternary deposits. The well on the Baker Ranch, 13/70-10a2, was drilled in fill to a depth of 1,082 feet and ended in valley fill. Elsewhere the maximum depth of wells are: 407 feet in southern Hamlin Valley, 270 feet in the immediate "Burbank" area, 167 feet near Garrison, 400 feet near Eskdale, 640 feet between Gandy and U.S. Highway 6, 150 feet near Partoun, 400 feet near Trout Creek settlement, and 220 feet at Callao.

Wells that reportedly penetrated bedrock include: (C-20-19)19dc, bedrock at 4,200 feet; a well in the SE1/4NW1/4 sec. 7, T. 22 S., R. 19 W., at the south side of Garrison (Meinzer, 1911, p. 134), bedrock at 200 feet; (C-22-19)13aab at west side of Burbank Hills, top of limestone at 247 feet; and (C-22-16)7ccc in the upper Ferguson Desert, top of limestone at 519 feet. To the north, quartzite(?) was reported at 158 feet in well (C-13-18)33dcc near Trout Creek; lava at 220 feet in well (C-13-16)6cc (table 10); and hard rock was reported at about 300 feet (Meinzer, 1911, p. 134) in a well in sec. 13, T. 11 S., R. 15 W., immediately adjacent to the Fish Springs Range.

Movement

Valley fill.--Movement of ground water appears to be generally northeastward from the Snake Range to an ultimate discharge area--the Great Salt Lake Desert. This general routing appears to involve not only the recharge, upward leakage, and discharge that is common in many basins in Nevada and Utah, but possibly lateral and downward leakage from the east edge of Snake Valley fill into permeable zones in the carbonate rocks.

Plate 1 shows, by means of contours the routing of ground water in parts of the valley where control is available. The largest part of recharge occurs along the west side of the valley at the bases of the Deep Creek and Snake Ranges, where both overland flow of surface water and sub-surface flow of ground water in parts of the consolidated rocks reaches and enters the valley fill.

Ground water in the fill moves from its recharge area, generally northeastward across the valley. In passing through the fill the ground water loses a part of its volume by evapotranspiration in the areas of phreatophytes and small saltflats, both by direct use of spring and well water and by upward leakage from deep to shallow aquifers and thence to the land surface. In the Callao area, the ground water moves out to the area of the Great Salt Lake Desert. Along much of the length of the Confusion Range, the Burbank Hills, and the lower parts of the Needles Range, however, the east edge of the valley fill receives little recharge and there may be ground-water losses into the consolidated rocks, in parts of the mountainous areas.

Ground-water loss from the valley fill is specifically indicated by the water levels in wells in that part of Snake Valley east of Garrison and in the adjoining Ferguson Desert. The altitude of water levels in wells (C-20-17)9c, (C-21-17)8dcc, and (C-21-18)10cdd, 12ccd, and 17ad, together indicate that the water table in the area slopes eastward from about 5,000 to about 4,850 feet and thus that ground water is flowing in that direction, or that water is progressively being lost from the valley fill to the underlying or adjacent bedrock. The lowering of water levels eastward also is supported by the record of well (C-22-16)19b which was reported to be entirely dry to a total depth of 680 feet (altitude of the bottom of the hole was about 4,650 feet).

Both north and south of the Ferguson Desert, few data are available but the same conditions may prevail.

Carbonate rocks.--Movement of ground water through carbonate rocks of eastern and southeastern Nevada has been identified (Rush, 1964, and Rush and Kazmi, 1965). The Snake Valley area shares with these parts of Nevada a common geologic and physiographic environment. The limited data available for this report suggests that such movement of ground water may occur in the report area. Water from Snake and Hamlin Valleys may enter the carbonate rocks from precipitation and from the valley fill and be transmitted northeastward and northward to the Great Salt Lake Desert. Future studies will be needed to further refine this assumption.

Estimated Average Annual Recharge

Precipitation in the drainage area and ground-water inflow from Spring Valley appear to be the main sources of recharge to ground water in the Snake Valley area. The estimate of the average annual rate of recharge to the ground-water reservoir is based on a method described by Eakin and others (1951, p. 79-81). This method assumes that a fixed percentage of the average annual precipitation recharges the ground-water reservoir. Hardman (1936) showed that the general distribution of the average annual precipitation in Nevada is closely related to distribution with altitude; that is, lands at equivalent altitudes generally receive equivalent amounts of precipitation.

In the Snake Valley area, the distribution of precipitation varies slightly from that assumed in the "standard" method established by Eakin. The data for 20 stations in and near the Snake Valley area were used to obtain the general relation between precipitation and altitude and table 5 summarizes the precipitation and the computations of recharge.

The estimated average annual precipitation over the Snake Valley drainage area is about 2,000,000 acre-feet, but only an estimated 5 percent, or 100,000 acre-feet, reaches the ground-water system in the valley fill and carbonate rocks. In addition to the recharge from precipitation, Rush (1965) estimated that approximately 4,000 acre-feet per year of ground-water underflow moves through the carbonate rocks from the southeastern end of Spring Valley to the northern end of Hamlin Valley. Thus, the estimated total recharge to the Snake Valley area is about 105,000 acre-feet per year. Of this amount, about 65,000 acre-feet originates from precipitation in Nevada, 40,000 acre-feet in Utah.

Table 5.--Estimated average annual precipitation and ground-water recharge in the Snake Valley area, Nevada and Utah

Precipitation zone (feet)	Area (acres)	Estimated annual precipitation				Estimated recharge from precipitation	
		Range (inches)	Average[1] (inches)	Average (feet)	Average (acre-feet)	Percentage of precipitation	(acre-feet per year)
Above 9,000	83,900	>18	20	1.67	140,000	21	29,400
8,000 to 9,000	127,000	16-18	17	1.42	180,000	14	25,200
7,000 to 8,000	240,000	13-16	14.5	1.21	290,000	8	23,200
6,000 to 7,000	601,000	11-13	12	1	331,000 a 270,000	5 a 1	16,600 2,700
5,000 to 6,000	767,000	8-11	9.5	.79	606,000	1	6,100
below 5,000	412,000	<8	6	.5	206,000	0	0
Total (rounded)	2,230,000				2,000,000		100,000
Estimated ground-water underflow from southern Spring Valley to northern Hamlin Valley.							+4,000
Estimated average annual recharge from all sources, in the Snake Valley area (rounded).							105,000

[1] Based on general relation shown by 20 stations listed in table 1.

a. In Hamlin Valley, 1 percent of 270,000 acre-feet used for zone, because most of that area is alluvium.

Estimated Average Annual Discharge

The general relations between recharge and discharge in the Snake Valley area have been little disturbed by man's activities. The use of surface water for irrigation has only changed the final point of discharge of that water; and the rate of use of ground water for stock and domestic supplies is insignificant when compared with the magnitude of the rate of natural discharge. Ground water from wells is used for irrigation, generally as a supplement to surface-water supplied; the quantity pumped is estimated to be only about 7,000 acre-feet per year. The two principal means of natural discharge from the Snake Valley area are evapotranspiration and ground-water outflow to the Great Salt Lake Desert.

Natural discharge by evapotranspiration.--Much of the ground water discharged by evapotranspiration is consumed by phreatophytes, which are in the lowlands of Snake Valley wherever the depth to water does not exceed about 50 feet. The principal phreatophytes are greasewood, rabbitbrush, and meadow grasses. Saltbush occurs only along the edges of the few playa areas and near the Great Salt Lake Desert. Other phreatophytes, such as saltcedar and cottonwood, occur locally near springs and old ranch sites.

Greasewood and rabbitbrush appear in the Snake Valley area lowlands and western slopes largely as a mixture that is poorly watered. The plants do not grow densely, are low in habit, and have a dry, dull appearance. Interspersed along the valley are a few areas in which the plants receive more water and therefore by contrast, are bigger and much greener. Some greasewood and rabbitbrush also appear in the dry uplands and valley floors that are well above the water table, living on soil moisture.

A small area of mixed meadow and rabbitbrush is in the area east of Big Spring, south of Garrison. This area is watered in part by spring flow and in part by very shallow ground water. Meadows along Big Spring Creek adjacent to this area are watered by spring flow. These wet meadowlands together with those near the Bishop Springs and the playas as far north as Trout Creek probably represent the areas that have the maximum evapotranspiration discharge rate in the valley.

The playas from Trout Creek southward to the Bishop Springs area are dry salt-encrusted flats during the summer months, but during the remainder of the year contain small and shallow bodies of water that discharge water directly by evaporation. To the north is a similar large tract of land in the edge of the Great Salt Lake Desert that has a relatively dry surface during the summer. In general it develops only a moist or damp surface in the winter, because water levels range from near the surface to as much as 30 feet below the surface. The area of the desert included in table 6 is that which is directly in the Snake

Valley drainage area, but the size of the area that discharges water from Snake Valley is unknown and may be larger.

The estimated average annual ground-water discharge by evapotranspiration is on the order of 80,000 acre-feet from about 320,000 acres of land, or an average use of about one-fourth acre-foot per acre per year. The basis for the estimates is shown in table 6.

Outflow.--Ground-water outflow in the alluvium from the Snake Valley area to the Great Salt Lake Desert is small, probably on the order of 10,000 acre-feet per year. This computed amount is based on an estimated coefficient of transmissibility of 100,000 gpd (gallons per day) per foot of the alluvium, an alluvial area width of 7 miles near Trout Creek, the narrowest part of northern Snake Valley, and a down-valley component of the ground-water gradient near Trout Creek of about 12 feet per mile.

Leakage of ground water from the alluvial fill to the carbonate rocks on the east side of Snake Valley is inferred from water-level contours on plate 1. It seems possible that this leakage may involve large amounts of ground water, but the amount has not been determined directly. Because the natural recharge and discharge are equal over the long term, the average annual discharge, taken to be equal to the recharge, may be on the order of 105,000 acre-feet per year. However, above identified quantities of natural discharge total only 90,000 acre-feet. The leakage of ground water from the alluvial fill to the carbonate rock system may be the difference in the two quantities or about 15,000 acre-feet per year. Because of the limited accuracy of the methods of estimating recharge and discharge, the value of the flow to the carbonate rocks should be considered only an approximation and the true value may be somewhat larger or smaller.

Total discharge.--The estimated total discharge of ground water from the Snake Valley area in 1964 includes about 7,000 acre-feet of pumpage from wells and 105,000 acre-feet of evapotranspiration and outflow, or a total of between 110,000 and 120,000 acre-feet.

Table 6.--Estimated annual natural ground-water discharge by evapotranspiration in the Snake Valley area, Nevada and Utah

Phreatophyte	Area (acres)	Depth to water (feet)	Evapotranspiration	
			Acre-feet per acre	Acre-feet (rounded)
Mixture of meadow grass and rabbitbrush	3,300	2-10	0.5	1,700
Wet meadow	11,000	0-5	1.75	19,000
Mixed greasewood and rabbitbrush	240,000	10-50	.2	50,000
Evaporation from:				
Playas that are flooded part of year	3,200	0-15	.75	2,400
Playa (Great Salt Lake Desert) that rarely is flooded, but has shallow water table	60,000	0-30	.1	6,000
Totals (rounded)	320,000			80,000

Storage

Under native conditions, the ground-water system is in dynamic equilibrium; long-term average annual natural recharge and discharge are equal, and the amount of ground-water in transient storage remains nearly constant. Development of irrigation wells in the Snake Valley area has not appreciably altered the natural balance. Comparison of water-level changes with precipitation (fig. 6 and table 7) shows that in general water-level changes follow precipitation changes.

Recoverable ground water in storage in the valley fill 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 of the reservoir, the saturated thickness, and the area. The specific yield of the uppermost 100 feet of saturated valley fill in the Snake Valley area, though unknown, probably is at least 10 percent. The saturated unconsolidated fill underlies about 1,200,000 acres, and therefore, the estimated volume of recoverable water stored in the upper 100 feet of saturated fill is at least 12 million acre-feet, or approximately 100 times the estimated annual recharge. It is known that the valley fill is much thicker in some places and probably is more extensive; the storage figure of 12 million acre-feet, therefore, probably is a minimum figure.

Table 7.--Records of water levels in observation wells in the Snake Valley area, Nevada and Utah

Date measured	Depth to water below land surface (feet)[1]
(C-11-16)6cbc4	
10-20-52	+ 3.7
10-31-56	+ 2.7
12-08-58	+ 2.5
10-14-59	+ 1.9
3-31-60	+ 2.1
11-16-60	+ 1.9
4-12-61	+ 1.8
10-24-61	+ 1.9
10-23-62	+ 2.6
3-08-63	+ 2.1
10-14-64	+ 2.5
(C-11-17)1bdc1	
11-18-38	4.0
9-18-41	3.0
10-11-43	2.7
10-12-45	2.5
11-22-48	3.8
10-20-52	1.6
11-02-54	4.3
10-31-56	4.5
10-24-57	4.1
12-08-58	4.5
10-14-59	5.2
3-31-60	5.1
11-16-60	5.3
4-12-61	5.3
10-24-61	5.3
5-10-62	3.0
10-23-62	4.2
3-08-63	4.7
10-14-64	4.9
(C-13-18)23aab2	
11-18-38	6.7
10-01-42	5.6
11-22-48	8.0
11-02-54	9.5
10-24-57	6.6
12-08-58	10.3
11-16-60	14.1
10-24-61	14.3
10-23-62	6.4
3-08-63	9.5
3-15-64	9.8
10-14-64	7.5
(C-13-18)33dcc1	
11-07-50	10.2
10-08-51	11.3
10-21-52	10.5
5-04-53	9.1
10-19-53	10.4
11-02-54	12.2
10-31-56	11.8
10-24-57	11.1
12-08-58	10.9
10-14-59	11.8
3-31-60	10.7
11-16-60	11.2
4-12-61	15.0
10-24-61	11.5
5-10-62	15.1
10-23-62	15.1
10-23-62	11.7
3-08-63	10.7
3-15-64	11.4
10-14-64	11.9
(C-13-18)34ccc1	
10-08-51	2.9
10-21-52	1.0
10-31-56	1.3
10-24-57	1.3
12-08-58	1.1
10-14-59	1.5
3-31-60	.8
11-16-60	1.3
4-12-61	1.0
10-24-61	1.8
10-23-62	2.1
3-08-63	1.2
3-15-64	1.2
10-14-64	2.0
(C-17-19)4add1	
10-10-51	10.9
10-19-53	9.6
11-16-60	.8
4-12-61	.1
10-21-61	.1
10-23-62	.1
3-08-63	.1
(C-18-19)20dad1	
11-30-37	31.9
9-13-40	31.8
11-22-48	29.5
10-19-53	27.3
11-03-54	29.2
10-31-56	28.8
12-08-58	25.4
10-14-59	29.0
11-16-60	28.9
4-12-61	28.1
10-24-61	28.0
10-23-62	26.9
3-08-63	27.5
3-15-64	27.6
10-14-64	26.4
(C-18-19)20ddd1	
11-30-37	31.4
11-17-38	30.2
11-01-39	30.4
9-13-40	31.0
9-18-41	27.2
8-07-42	23.6
10-01-42	26.2
10-12-43	28.6
10-03-44	25.3
10-12-45	24.0
10-11-46	26.6
10-11-47	24.9
11-22-48	27.9
10-18-49	25.42
11-09-50	28.2
5-26-51	28.6
10-21-52	23.9
11-03-54	28.9
10-31-56	29.2
10-24-57	29.1
12-08-58	29.2
10-14-59	25.0
3-31-60	25.6
11-16-60	25.8
4-12-61	25.9
10-24-61	26.2
5-10-62	25.4
10-23-62	25.7
3-08-63	26.2
3-15-64	25.9
(C-22-19)6bac1	
11-08-50	49.0
10-10-51	54.6
10-22-52	39.2
10-20-53	56.4
11-03-54	50.7
10-31-56	51.7
10-24-57	52.5
10-14-59	61.6
11-16-60	63.3
10-24-61	62.6
10-23-62	53.1
3-08-63	51.5
3-15-64	53.7
10-15-64	50.6
(C-22-19)6bccc1	
11-17-36	58.0
11-17-38	54.5
9-13-40	62.9
11-23-48	65.0
10-10-51	70.9
10-22-52	55.2
10-05-53	72.6
11-03-54	67.0
10-24-57	69.6
10-14-59	77.0
11-16-60	77.4
11-23-62	67.2
3-08-63	68.7
3-15-64	71.3
10-15-64	67.6
(C-23-19)19cdb1	
11-16-36	15.4
12-01-37	16.3
11-17-38	15.8
11-01-39	16.0
9-13-40	16.0
9-18-41	15.7
10-01-42	15.2
10-12-43	15.0
10-03-44	14.6
10-12-45	13.7
10-11-46	12.6
10-10-47	13.8
11-23-48	14.6
11-08-50	14.3
10-10-51	13.8
10-22-52	13.8
10-20-53	12.3
11-03-54	13.1
10-30-56	13.3
10-24-57	12.1
10-14-59	13.2
3-31-60	12.8
11-16-60	13.3
4-12-61	12.0
10-23-61	11.6
5-10-62	11.6
10-23-62	11.9
3-08-63	12.1
3-15-64	12.1
10-15-64	11.9
(C-23-19)20dbb1	
11-08-50	15.2
10-10-51	15.7
10-22-52	17.4
11-03-54	16.2
10-30-56	15.8
10-24-57	16.3
10-14-59	15.7
3-31-60	15.6
4-12-61	15.5
10-24-61	15.7
10-23-62	17.5
3-08-63	17.9
3-15-64	15.3
10-15-64	15.4

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1. Water levels above land surface are preceded by a + (plus sign)

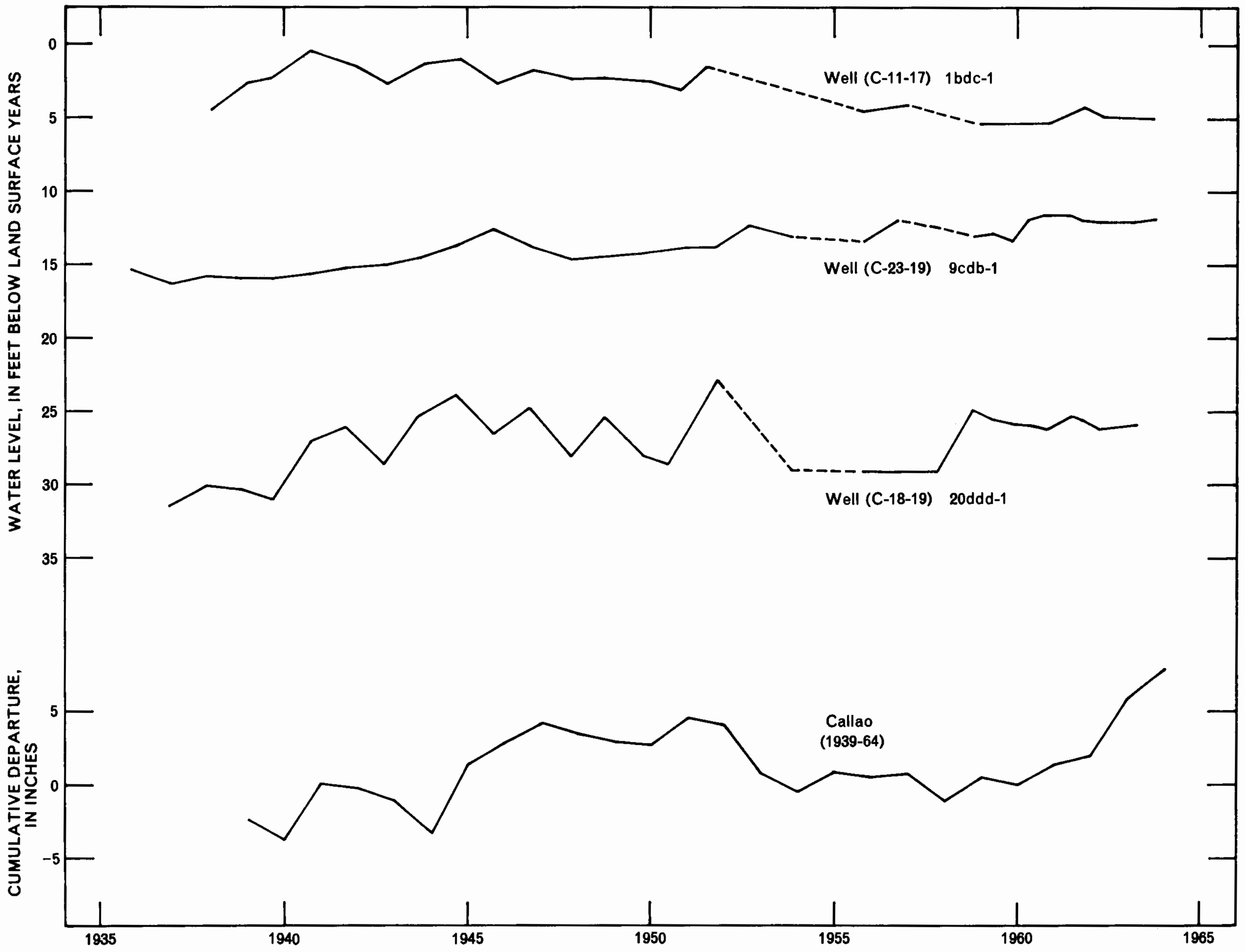

Figure 6.—Fluctuations of water levels in selected wells and the cumulative departure from average annual precipitation at Callao

Perennial Yield

The perennial yield of a ground-water reservoir is the maximum amount of water of usable chemical quality that can be withdrawn economically each year for an indefinite period of years. The perennial yield cannot exceed the natural discharge; moreover, the yield will be limited to the amount of natural discharge that can economically be salvaged for beneficial use.

In the Snake Valley area, the maximum amount of natural discharge that is available for salvage is the estimated evapotranspiration loss of 80,000 acre-feet per year (table 6) plus outflow from the valley. If pumping wells are drilled near areas of evapotranspiration, the bulk of the 80,000 acre-feet per year now lost could be salvaged. Because the hydraulics of the inferred interaquifer flow from the valley fill to the carbonate rocks is poorly understood and because much of the interaquifer flow may occur close to the mountains, salvage of this outflow may be severely limited.

The salvage of natural discharge by the lowering of water levels appears to be most feasible in the central part of Snake Valley from the vicinity of Trout Creek southward to the vicinity of Garrison and Baker. Near the Great Salt Lake Desert, water levels could be lowered somewhat, but when the cones of depression of water levels around the areas of development reaches the saltflats, further lowering would be accompanied by the threat of brine encroachment from the slatflat area. In Hamlin Valley water levels are deeper and pumping lifts would be less economical.

Based on these considerations, it seems doubtful that more than 80,000 acre-feet of ground water could be diverted to beneficial use, and the recovery of even this amount would require a carefully spaced network of wells to lower the water levels uniformly enough to eliminate the losses of ground water by evapotranspiration. Thus, the preliminary estimate of perennial yield of the Snake Valley area is about 80,000 acre-feet. This would leave unused virtually all of the estimated 12 million acre-feet of water in storage in the upper 100 feet of saturated fill.

Chemical Quality

All natural waters contain dissolved mineral matter. Precipitation contains minute amounts, and as soon as it falls upon the land surface, the water acquires an increasingly larger burden of dissolved solids. Water plays an important part in the decomposition of rocks. The salt beds and saline lakes that occupy the lower tracts in some closed basins in Nevada and Utah are the accumulations of erosional products that were dissolved from the rocks in surrounding areas. Deposition of minerals from ground water plays a part both in the accumulation of valuable mineral deposits and in the deterioration of agricultural land.

Water acts primarily as a solvent; dissolved carbon dioxide from the air and organic matter in the soil greatly increases the dissolving power of ground water. The amount of dissolved solids in natural water also is a function of both the nature of the rock through which it moves and of the amount of time during which the water is in contact with the rock. Thus, water in the recharge area generally has a low mineral content. Water in fine-grained deposits generally contains a larger mineral load than that in coarse-grained rocks, owing mainly to the slow movement in the former deposits.

The use of water for irrigation and by phreatophytes tends to increase the mineral load. The plants discharge water to the atmosphere but leave the dissolved solids which may be redissolved and returned to the aquifer, only to be again brought to the surface and further concentrated.

Eleven water samples were taken during the study of the Snake Valley area. These together with 16 other samples (table 8) provide a basis for a partial appraisal of the suitability of the water for agricultural and domestic use. The sampling sites selected and those analyses available represent all parts of the area and a few places in the adjacent mountains.

According to the U. S. Salinity Laboratory Staff (1954), among the most significant factors with regard to chemical suitability of water for irrigation are the dissolved-solids content, the relative proportion of sodium to other cations, and the concentration of elements and compounds that are toxic to plants. Dissolved-solids content is commonly expressed as the salinity hazard and is defined in terms of the specific conductance of the water as follows.

Salinity hazard	Specific Conductance (micromhos at 25°C)	Classification
Low	0 - 250	C1
Medium	250 - 750	C2
High	750 - 2,250	C3
Very high	Greater than 2,250	C4

Table 8.--Chemical analyses, of water samples from wells, springs, and a stream in the Snake Valley area, Nevada and Utah

/Chemical constituents in parts per million/

(Analyses by U.S. Geological Survey, except as noted. Source: F, field analysis at Carson City, Nev.; S, analysed at Sacramento laboratory; R, reported by outside source; SL, analysed at Salt Lake City Laboratory. Owner: BLM, Bureau of Land Management).

Location	Owner or name	Date of collection	Temperature (°F)	Calcium	Magnesium (Mg)	Sodium plus potassium (Na+K)	Bicarbonate (HCO_3)	Sulfate (SO_3)	Chloride (Cl)	Fluride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$		Percent sodium	SAR	Specific conductance (Micromhos at 25°C)	pH	Source of analysis
														Calcium magnesium	noncarbonate					
								NEVADA												
8/69-15b1		11- 3-64	52	41	21	23	220	35	16	-	-	-	-	189	-	-	0.7	419	8.2	F
8/69-36a1		do.	-	38	16	29	192	36	21	-	-	-	-	162	-	-	1.0	397	8.1	F
9/70-34d1		do.	-	41	14	20	152	40	28	-	-	-	-	162	-	-	.7	383	8.1	F
10/70-33b	Big Spring	do.	64	47	20	5.9	238	8.0	3.7	0.2	2.2	0.0	216	198	3	5		401	7.8	S
								UTAH												
(C-11-15)30dcb	B.L.M.	1939(?)	-	-	-	-	-	1,220	2,210	-	-	-	10,100	-	-	-	-	-	-	R
(C-11-16) 6cbc-4	Delmont Trim	11- 2-54	-	30	8.1	29	93	19	52	-	1.6	-	212	198	-	37	-	360	-	SL
(C-13-18)28ccc	Partoun School	10-18-49	-	48	23	113	254	90	110	1.2	0.0	.20	541	214	6	53	-	897	7.6	SL
28da	Fred Newbold	12- 8-64	-	62	22	28	88	38	49	-	-	.55	248	175	72	38	1.2	339	7.7	SL
35c	Nathan Hale	10-18-49	-	35	6.6	-	68	250	20	.6	.4	.03	308	114	0	56	-	489	7.8	SL
(C-14-18)3ddc-7	do.	10-25-57	-	35	20	45	252	27	25	-	.7	-	301	172	0	-	-	-	-	SL
(C-15-17)8baa	B.L.M.-oil test	1952	-	86	8	579	212	889	290	-	-	-	1,960	-	-	-	-	-	-	R
(C-15-19)31bc	Warm Springs	11- 4-64	81	50	19	33	250	24	24	.8	2.7	.1	298	205	0	23		505	7.8	S
(C-16-18)22cab	Twin Springs	10-15-64	68	62	31	61	312	66	63	-	.2	-	436	280	24	32	1.6	739	7.6	SL
(C-18-18)16abb	Knoll Springs	do.	67	63	28	57	317	58	52	-	.3	-	412	270	10	31	1.5	688	7.6	SL
(C-18-19)29ddd-2	J. D. Hill	10-24-57	73	28	9.0	28	159	10	18	-	.9	-	186	106	0	-	-	327	-	SL
28bbb	do.	11-14-57	72	18	7.3	52	150	21	29	-	1.7	-	222	75	0	-	-	352	-	SL
(C-20-19)6bcc	Glenn Bellander	11-10-64	56	38	14	17	160	16	31	-	-	-	-	154	-	-	.6	359	7.4	F
7bbd	Marcus Sorenson	11- 3-54	-	36	13	14	164	16	17	-	1.8	-	196	143	9	18	-	330	7.4	SL
14b	G.S. Quate	11-29-27	-	47	19	16	232	15	15	-	.1	-	240	195	-	-	-	-	-	SL
15bdc-1	-	10-21-55	56	44	10	24	178	12	23	.3	.7	-	230	151	5	25	-	355	7.9	SL
(C-21-17) 8dcc	B.L.M.	-	-	-	-	2.3	-	96	80	-	-	-	614	-	-	-	-	-	-	R
(C-22-19) 6bcc-1	Dennis Smith	10-24-57	-	72	20	23	315	21	16	-	12	-	335	262	4	-	-	572	7.4	SL
(C-23-19) 9	Burbank Spring	11- 3-54	57	81	32	14	222	157	8.0	-	.7	-	419	334	152	8	-	687	7.4	SL
20bac-1	Arvilla Davies	10-24-57	-	33	44	124	389	81	89	-	4.1	-	613	264	0	-	-	1,030	7.3	SL
		10-15-64	-	-	-	-	-	-	95	-	-	-	-	-	-	-	-	934	-	SL
(C-32-19)10bba	-	11-17-62	47	34	2.7	12	93	9.1	22	.2	.6	.03	152	96	20	-	-	224	7.3	SL
Surface Water																				
(C-11-17)20aaa	Thomas Creek at Highway	10-15-64	-	-	-	-	-	-	18	-	-	-	-	-	-	-	-	176	-	SL

The sodium, or alkali hazard, refers to effects of the relative proportion of sodium to other cations in the irrigation water on the soils to which the water is applied. The hazard may be evaluated by reference to the percent of sodium (% Na) and the amount of dissolved solids (or the specific conductance), or more directly by the sodium adsorption ratio (SAR), which reflects the effect of exchangeable sodium on the physical conditions of the soil, as follows:

Sodium hazard	Range of SAR at Specific conductance of		Classification
	100	2,250	
Low	0 - 10	0 - 4	S1
Medium	10 - 18	4 - 9	S2
High	18 - 26	9 - 14	S3
Very high	26	14	S4

On the basis of specific conductance, two of the 25 sources sampled in or near the area were class C-1, 19 were class C-2, 3 were in class C-3, and one near the Great Salt Lake Desert was in class C-4. Of the seven samples for which SAR was computed all were in class S-1. Water from the oil test in the Confusion Range would be classed as C-4 and probably S-3 or S-4. The six samples for which boron was determined all contained low concentrations that would have little toxic effect on boron-sensitive crops.

The sample having the lowest specific conductance was the surface water from Thomas Creek which heads in the Deep Creek Range southwest of Callao. This and the sample from southern Hamlin Valley were the only two that were classed as C-1, but it is likely that other mountain streams, upland wells, and springs would have a similar classification.

The chemical quality of the samples obtained indicates that in most of the Snake Valley area ground water is surprisingly uniform in concentration and distribution of constituents. Most samples were mixed calcium-magnesium-sodium bicarbonate waters, but a few samples near the recharge areas or near the edges of the valley are calcium-magnesium bicarbonate water. Well (C-13-18)35c near the center of the valley yields a sulfate water, and the sample from oil test (C-15-17)8baa deep in Paleozoic carbonate rocks is a sodium sulfate water.

Near the Great Salt Lake Desert, however, most shallow waters are sodium chloride type: that from well (C-11-15)30dcb is an example which falls into class C-4. In the same area several other wells are reported to be too salty for use by stock.

The saline playas in the vicinity of Gandy and Trout Creek apparently are surface phenomena and it is probable that the shallowest water around them is saline.

A large variation in ground-water temperature was measured in the Snake Valley area. Most of the variation in water from wells can be attributed to the depths from which the water is obtained. The mean annual air temperature on the floor of Snake Valley ranges from about 48°F to 53°F. From the land surface downward the temperature increases fairly uniformly as shown in the following tabulation.

Well	Depth of water-bearing zone (feet)	Temperature
8/69-15h1	110	52
(C-22-19)6bcc	120	52
(C-14-18)3	110	54
(C-13-18)35c	140	55
(C-20-19)6bcc	200	57
(C-13-18)33dcc-1	158	59
(C-20-19)7bbd-1	90-280	59
(C-20-19)7aab-1	212-569	60
(C-18-19)28bbb	540-640	72

Differences in temperature at equivalent depth are due to the rate of ground-water circulation and to differences in land-surface elevations among the wells.

As Meinzer (1911, p. 133) notes, the temperature relations cited indicate that most of the large springs discharge water that comes from considerable depth. The temperature of water from most of them is well above the average air temperature:

Spring	Temperature	Location
Twin Springs, Bishop Springs area	68°F	(C-16-18)22cab (Utah)
Knoll Springs	67°F	Tps. 16 and 18S., R. 18 W. (Utah)
Big Spring	64°F	10/70-33bl (Nev.)

In the case of the springs also, the rate of circulation affects temperature, and the larger springs tend to be warmer than similar small adjacent springs, as in the Bishop Spring area.

Some springs that have exceptionally high temperatures discharge water that apparently has circulated near a source of heat such as igneous rock or an active fault zone. Warm Springs (81°F) at Gandy and Hot Springs (near boiling) at the north end of the Fish Springs Range (Meinzer, 1911, p. 133) appear to be in this category.

Development

Present Development

The active use of the waters of the Snake Valley area for stock-raising and agricultural purposes started before 1903. Meinzer (1911, p. 129-139) noted that in 1905, irrigation from wells was practiced at Callao; water from Big Spring Creek (called Lake Creek by Meinzer) was used at the Burbank settlement south of Garrison and at Garrison. Garrison also received water from Snake Creek. He implied that Baker Creek water also was used. Water from the mountains was used at ranches along the road from Garrison to Gandy, and at Gandy the flow of Warm Springs provided irrigation water to nearby ranches. Spring and surface water was used in Pleasant Valley, and the flow of Birch and Trout Creeks was diverted to the Trout Creek settlement. Thomas and Basin Creeks were diverted for irrigation at Callao. In 1905, the available surface water and spring flow had not been fully utilized.

Since 1905 development of water supplies in the valley has been slow and sporadic, and the main agricultural areas were first supplied with surface water and spring flow in the areas noted by Meinzer. The flow of Basin and Thomas Creeks is diverted to lands in parts of secs. 1, 2, and 11, T. 11 S., and parts of secs. 35 and 36, T. 10 S., R. 17 W., at Callao. Water from Cedar and Granite (?) Creeks and probably from spring flow apparently supplies a small amount of land in the vicinity of secs. 28 and 35, T. 12 S., R. 17 W. The flow of Trout and Birch Creeks is diverted to lands at the Trout Creek settlement. Surface water in Pleasant Valley, at the south end of Deep Creek Range, apparently is consumed locally by crop lands on the valley floor, well above the lowlands of Snake Valley.

The spring flow of Warm Creek supplies small areas of farmland at Gandy. Flow from Grass, Hampton, and Hendrys Creeks apparently supplies small amounts of water to widely separated small farm tracts along the Gandy-Garrison Road. Water in Silver Creek, Miller Basin Wash, Strawberry Creek, and other streams near U. S. Highway 6 apparently is distributed to lands along the narrow stream channels on the upper parts of the alluvial fans. Lehman and Baker Creeks supply water to land at the mouth of the canyon in the vicinity of sec. 12, T. 13 N., R. 65 E., to Baker, and to farms in the general area of secs. 3, 4, 10, and 11, T. 13 N., R. 70 E.

At Garrison, farms in sec. 31, T. 21 S., and sec. 6, T. 22 S., R. 19 W., receive surface water directly from Snake Creek and Big Wash and from Pruess Lake. Pruess Lake impounds water that results largely from spring flow in Big Spring Creek and partly from runoff in the area to the south. The valley flat of Big Spring Creek is irrigated from the flow of Big Spring and other springs; the most heavily irrigated parts extend from secs. 25 and 35, T. 23 S., through secs. 31, 19, 20, and 17 to sec. 9, T. 23 S., R. 19 W.

In all of the areas described, with the exception of Trout Creek, Gandy, and Big Spring Creek areas and possibly the narrow upland valleys, the year to year variations in streamflow have required that surface water be supplemented with ground water from wells. The fluctuation in surface-water supply also has caused some fluctuation in the amount of land farmed.

Other than the use of perennial flow for farming, surface water in the Snake Valley area is used only for stock supplies where the Bureau of Land Management and local ranchers have installed catchment reservoirs.

Stock-well drilling, mainly by the Bureau of Land Management, increased slightly in the 1930's and 1950's. Well development for irrigation and domestic needs also increased slightly during the middle to late 1930's, but the drilling of deep and large-diameter wells mainly followed in the period 1947-60. The development of modern irrigation wells was mainly in the area of Baker, Garrison, near Eskdale in Tps. 19 and 20 S., R. 19 W., at scattered farms on the Gandy Road, and in the vicinity of Partoun. At Callao, 30 or more small-diameter flowing wells are used for irrigation and domestic purposes.

Withdrawals from wells for irrigation purposes in 1964 were not precisely inventoried; the following approximations are believed to indicate the order of magnitude:

Area	Acreage	Ground-water use, in acre-feet	Remarks
Callao	1,000	1,000	Supplement to surface supplies.
Partoun	200	600	Much land fallow.
Gandy	600+	---	Spring supplies only.
Gandy-U.S. Highway 50, including Eskdale	900	3,600	Mostly from wells.
Baker	2,500	800	Supplement to surface supplies.
Garrison-Burbank	6,400	600	Do.
Total (rounded)	12,000	7,000	

Potential Development

The available data indicate that dependable surface-water and spring supplies are fully utilized in the Snake Valley area. Further study, however, may reveal that such supplies could be extended by further improvements in management efficiency.

The storm and snowmelt runoff that now is not usable for systematic crop irrigation appears to be the main additional source of surface water that can be developed. Such floodflow is intermittent and unpredictable in frequency and duration; and its utilization would require that it be impounded for direct use on lands or that it be applied to areas in which it would enter the ground as recharge. The water could then be recovered by wells as needed. Ideally, an extension of the dual supply operation practiced in the Garrison-Baker area would be best--irrigation from surface water when available and from wells during dry periods. Such practice would be most feasible along the west side of Snake Valley.

The use of water from wells for irrigation in the Snake Valley area is not yet extensive, and further development is feasible, providing that adequate areas of suitable soils are present.

Some areas can be deleted from consideration owing to adverse conditions. In most of Hamlin Valley, Antelope Valley, and the Ferguson Desert the depth to water is 100 to 300 feet or more, and the cost of pumping water for irrigation in the typical livestock operation would be high. The same condition appears to exist on the higher terraces of Snake Valley north of Trout Creek.

In the Callao area, the area subject to ground-water development is limited to a narrow belt that lies between the poor soils and saline water of the Great Salt Lake Desert and the steep slopes of the alluvial fans along the mountains. In this area, it has been demonstrated that artesian wells can be obtained; but if heavy pumping caused water levels to decline greatly, this could create a potential for migration of saline water from the desert area.

The area of maximum potential ground-water development extends from the north end of T. 9 N., R. 70 E., in Nevada, northward along Big Spring Creek to the Baker-Garrison area and from that area along the width of the central part of Snake Valley to the narrows at Trout Creek. In the central part of the valley, as the present pattern of use and this study has shown, the western side of the valley presents the optimum conditions for development of additional water supplies, but the production of water from valley fill close to the eastern side between Trout Creek and the Burbank Hills also appears to be possible.

Much of the area described as subject to development of ground-water supplies also is the main area of natural discharge by phreatophytes, and therefore, the lowering of water levels by properly spaced wells might eventually salvage a considerable quantity of water. If the discharge by evapotranspiration were reduced by only half in the central part of Snake Valley, the quantity salvaged would be on the order of 25,000 acre-feet.

If the perennial yield is 80,000 acre-feet, this amount, if withdrawals were evenly distributed in the area considered, might allow the additional development of about 25,000 acres of land, assuming the duty of water to be about 3 acre-feet per acre.

It is possible that ground-water development could affect the discharge of some of the springs in Snake Valley, depending on the location and extent of the development.

PROPOSALS FOR ADDITIONAL STUDIES

Suggestions for future studies are listed below:

1. A comprehensive inventory of the water resources of the valley is needed, including data on all existing wells, springs, and streams, both in the valley proper and in the mountain uplands.

2. A systematic geologic study of the valley fill should be made to aid the evaluation of the aquifer framework and its relation to the carbonate-rock aquifers.

3. After study of existing records, several test holes should be drilled at selected sites to evaluate the relation between the valley-fill and the carbonate-rock aquifers. At least one such site should be in Hamlin Valley, one in the central Ferguson Desert, and one near Knoll Springs.

4. Existing surface-water observations should be continued, and additional temporary gaging sites selected for systematic observations. Such stations would have to be operated for several years each in order to accumulate adequate records. The flow of both surface streams and the large springs should be measured.

5. Water-level measurements should be continued in selected observation wells to provide information on changes of ground water in storage, and the annual discharge from all wells and springs should be measured. Such data will be necessary to future evaluation of water development in the valley.

Table 9.--Records of selected wells and springs in the Snake Valley area, Nevada and Utah.

Owner and/or name: BLM, Bureau of Land Management
Altitude: estimated from topographic maps
Measuring point: TC, top of casing; HC, hole in casing: HPB, hole in pump base; PC, plug in casing
Water level: In Utah, water levels are reported as depth below land surface; M, measured; R, reported

Use: PS, public supply; D, domestic; I, irrigation; O, observation; S, stock; Ind, industrial; U, unused
Remarks: Number is log number in the files of the Nevada In Utah, number is the claim (C) or application number in the files of the State Engineer of Utah.

Spring or well number and location	Owner and/or name	Date drilled	Depth (feet)	Diameter of casing (inches)	Principal water-bearing zone (feet)	Altitude	Measuring point		Water level			Temperature	Use	Remarks
							Description	Above land surface (feet)	below land surface (feet)	M or R	Date			
							NEVADA							
8/69-15b1	Dearden	--	110	6	--	5,750	TC	1.0	75.2 77.6	M M	7-15-64 9-03-64	52	S	Windmill
8/69-36a1	BLM, Rosencran well	8-1947	225	6	217-219	5,770	TC	1.0	153.3	M	3-18-47	--	S	549 Windmill
8/70-6b1	BLM, Monument well	6-1947	164	6	152-164	5,670	TC	.6	91.6	M	8-18-47	--	S	548 Windmill
8/70-21a1	Sidney Ashdown, tail well	1933	153	8	--	5,710	TC	.5	128.6	M	11-03-64	--	S	Gasoline engine
9/70-34d1	Lee and Dearden, Millers Crossing well	6-1947	217	8	195-198	5,690	TC	.8	109.4	M	8-18-47	--	S	79
10/70-11d1	Delbert Covington	7-1953	100	16	44- 50	5,300	--	--	9	R	7-19-53	--	U	2337 Casing pulled, well abandoned
10/70-12b1	Delbert Covington	7-1953	80	16	29- 38	5,490	--	--	14	R	7-24-53	--	I	2338
10/70-25d1	Delbert Young	7-1953	70	16	11- 32	5,525	--	--	7	R	8-03-53	--	S	2335 Windmill
10/70-33b1	Big Spring	--	--	-	--	5,580	--	--	flowing	-	--	64	I	Estimated flow 8 cfs (11-3-64)
12/70-11c1	Nevada Fish and Game Commission	5-1955	32	6	26- 32	5,850	TC	1.4	8 6.9	R M	6-01-55 11-03-64	--	U	3077
13/69-11a1	Jeannette Griggs	7-1957	29	72x72	--	6,300	--	--	25	R	4-30-58	Cool	D	4337 Handpump
13/70-3d1	Baker Ranch	4-1950	470	24,16, 10	186-195	5,270	--	--	flowing	R	6-23-50	--	I	1420
13/70-4d1	Glen M. Bellander	4-1951	153	12	at 153	5,300	--	--	44	R	5-11-52	--	I	1645
13/70-4d2	Baker Ranch	7-1948	331	20	230-312	5,300	-- TC	-- 1.5	8 10.1	R M	8-20-48 9-22-49	Cold	I	606 Test pumped 1,500 gpm
13/70-9b1	Forest Service Ranger Station	7-1953	88	6	80- 85	5,350	--	--	18	R	7-30-53	Cool	D	2350 At Baker, Nevada
13/70-9c1	Harry Hesselgisser	7-1952	84	6	--	5,350	--	--	51	R	7-11-52	--	S	1981 At Baker, Nevada
13/70-10a1	Baker Ranch	6-1948	104	20	50- 70	5,220	--	--	flowing	R	7-04-48	Cold	I,S	587 Small flow
13/70-10a2	Baker Ranch	6-1951	1,082	16,12, 10	--	5,220	--	--	--	-	--	--	I	1746 Cased to 1075 feet
13/70-14c1	Hilman D. Smith	11-1949	415	10,6	184-186	5,200	--	--	flowing	R	11-27-49	Cool	S,D	1150 Flowing 20 gpm with a static head of 28 feet
13/70-16c1	Fred L. Gregory	4-1953	154	6	100-104	5,400	--	--	39	R	5-06-53	Cool	U	2219
13/70-35a1	BLM, State Highway well	12-1947	158	6	146-155	5,330	TC	2.5	99.6	M	12-15-47	--	S	431
13/71-19b1	BLM	10-1947	82	6	68- 75	5,160	--	--	25	R	10-24-47	--	S	245
14/69-24a1	Baker Junction Service	4-1958	70	8	45- 60	5,680	--	--	27	R	5- 7-58	--	D	4103
14/70-27c1	BLM	7-1951	130	6	at 130	5,300	--	--	86	R	7-30-51	Cool	S	1730
14/70-31c1	John Szydlowski	10-1950	65	6	63- 65	5,620	--	--	25	R	10-14-50	Cool	D	1483
19/69-15c1	George Eldridge	7-1953	28	6	18- 28	7,180	--	--	9	R	7-18-53	Cool	S	2304
							UTAH							
(C-10-17)1adb	--	1949	143	6	133-143	4,330	--	--	25	R	--	--	S	A20683. Water-bearing formation is gravel.
(G-10-17)1d	--	--	220	-	--	4,330	--	--	dry	R	--	--	-	--
(C-10-17)13cca	--	1958(?)	60	6	28-39±	4,650	--	--	20-30	R	--	--	-	A29571
(C-11-15)21cd	--	--	--	-	--	4,350	--	--	--	-	--	--	-	Water is too saline for use by stock
(C-11-15)24ca	--	--	300	-	--	4,340	--	--	--	-	--	--	-	do.
(C-11-15)30dcb	BLM	2-1935	112	8,6 4½	70-112	4,420	--	--	30.9 31-2 31.0	M M M	11-02-39 9-13-40 8-07-42	--	S	Casing: 8-inch to 33 feet; 6-inch to 112 feet and 46 feet of 4½-inch. Reported yield was 25 gpm. Water is brackish. See log.
(C-11-16)6cbc4	Delmont Trim	7-1934	90	2½	--	4,346	TC	0.0	+3.8	M	10-20-52	--	S,I	C4578. Yield estimated 1 gpm in Oct. 1952.
(C-11-16)6cc	Mr. Christensen	--	20+	48	--	4,350	HC	4.0	19.7 18.7 21.9 20.4	M M M M	11-18-38 10-12-45 11-22-48 11- 2-54	--	S	Dug well. Casing installed in 1942(?).
(C-11-17)1bdc1	Drought Relief Administration	1934	221	4	--	4,330±	TC	1.0	4.0	M	11-18-38	--	O	C8190

Table 9.--(Continued)

Spring or well number and location	Owner and/or name	Date drilled	Depth (feet)	Diameter of casing (inches)	Principal water-bearing zone (feet)	Altitude	Measuring point		Water level			Temperature	Use	Remarks
							Description	Above land surface (feet)	below land surface (feet)	M or R	Date			
(C-11-17)2c	Callao Water Co.	8-1934	222	4	--	4,420	--	--	5	R	1934	--	D,S	In August 1934 report yield was 10 gpm. The well supplied 75 people and 200 head of atock. See log.
(C-12-17)33		--	50	-	--	4,700	--	--	-	-	--	--	S	--
(C-12-17)34add		--	175	6	--	4,560	--	--	80	R	--	--	D,S	--
(C-13-16)6cc	BLM Hole-in-the wall well	10-1962	252	6	--	4,660	--	--	210	R	--	--	S	Water first found at 218 feet where well was bailed at 40 gpm. Water level could not be bailed down when wall was 252 feet deep. Sae log.
(C-13-18)13d	David Howells	--	400	2	--	4,680	--	--	+ 3.3(+) + 2.9(+) + 6.0(+) + 6.9	M M M M	11-18-38 9-13-40 10-01-42 10-03-44	--	D,S	Flow estimated less than 0.1 gpm on 11-18-38.
(C-13-18)14ddc	Will Parker	1933	33	20,8	18- 23	4,720	TC	1.2	14.4 14.6 18.1 14.7 18.4	M M M M M	11-18-39 10-03-44 11-22-48 11-07-50 11-02-54	--	D,S	Dug to 20 feet. 8-inch bored to 23 feet. Windmill.
(C-13-18)23aab1	Charles Nielson	--	300	3,2	--	4,720	--	--	17+	-	11-18-38	--	D,S	Jetted to 450 feet. Casing: 3-inch to 270 feet and 180 feet of 2-inch. Water in several beds was under pressure when installed. Well flowed for 2-3 hours.
(C-13-18)23aeb2	Charles Nielson	1933	30	10	--	4,720	TC	0.8	6.7	M	11-18-38	--	D,S	Well bored to 40 feet. Handpump. Water is hard.
(C-13-18)28ccc	Partoun School	--	36	2	--	4,820	--	--	31	R	--	--	-	
(C-13-18)28da	Roland Newbold	1959	120	12	--	--	--	--	31	R	1964	--	I	Cased to 100 ft. Estimated yield 150 gpm
(C-13-18)33dcc1	Samuel Rohrbach	8-1950	158	12	--	4,760	--	--	10.2	M	11-07-50	59	D,S,I	A19740. See log.
(C-13-18)34ccc1	F. W. Fink	--	147	10	--	4,750	--	--	1.0	M	10-21-52	--	D,S,I	A19750
(C-13-18)35c	Nathan Hale	--	140	6	--	4,730	--	--	+ 5.1	M	10-18-49	55	-	
(C-14-18)3	Nathan Hale	1938	110	3	--	--	--	--	+ 3.4 + 5.1 + 5.1	M M M	11-18-38 9-18-41 10-03-44	54	S	A12809. Southern most of 3 wells drilled in 1938, and south of 6-inch well. Flow estimated 4 gpm in 1938.
(C-14-18)3	Nathan Hale	1938	130	6	--	--	--	--	+ 4.6	M	11-18-38	54	S,I	A12809. Northern most of 3 wells. Flowed 14 gpm in 1938.
(C-14-18)3ddc7	Nathen Hale	1948	120	6	--	4,740	--	--	+ 6.1	M	10-18-49	55	D,I	A19596-7.
(C-14-18)4bdb1	Walter P. Faber	5-1948	70	10,6	--	4,780	--	--	13.3	M	11-06-50	-	D,S	A19741
(C-14-18)4dbb1	--	--	--	9	--	--	--	--	--	-	--	-	I	Irrigates 60 acres of hay.
(C-14-18)5c	--	--	70	-	--	4,820	--	--	60	R	--	-	D	
(C-15-17)8baa	BLM	7-1952	6,200	-	--	5,530	--	--	--	-	--	-	U	Oil test. Standard Oil-Sinclair Desolation Unit 1. Extensive loss of drilling fluid in carbonate rocks. See chemical analysis of water from Guilmette Ls. 5,447-5,484 feet.
(C-15-18)11cd	BLM Confusion well	9-1962	485	-	--	5,180	--	--	Dry	R	--	-	-	Seep of black water at 300 feet. See log.
(C-15-19)31bc	Warm Springs	--	--	-	--	5,300	--	--	flowing	-	--	81	I,S	Water issues from multiple openings in distorted limestone on west side of valley. Water irrigatea fields in vicinity of Gandy. Estimated flow: 8cfs on 11-3-64.
(C-16-17)8cbb	BLM	--	9,058	-	--	5,768	--	--	--	-	--	-	U	Oil test. Gulf Oil Corp. Bishop Springs Unit 1. Fresh water reported in zone at altitude of about 4,500 ft.
(C-16-18)16dad	Foote Reservoir Springs	--	--	-	--	4,825	--	--	flowing	-	--	-	S,I	Part of Bishop Spring area. Three or more artesian spring pools enclosed by reservoir embankment, equipped with outlet works. Ditch flow northward to irrigated hay field. Estimated flow: 3cfs on 10-15-64.
(C-16-18)22csb	Twin Springs	--	--	-	--	4,812	--	--	flowing	-	--	68	S	Part of Bishop Springs area. Two artesian spring pools which discharge northwestward into natural hay meadow. Estimated yield: 4 cfs on 10-15-64.
(C-16-19)2baa	Cold Spring	--	--	-	--	4,860	--	--	--	-	--	-	S,I	
(C-16-19)4add1	J. H. Singleton	1917	33	36	--	4,940	--	--	31.6 29.6	M M	11- 2-39 9-13-40	-	U	C6827
(C-17-19)4add1	Joe Eldridge	--	640	16	--	4,880	TC	1.0	10.9 0.1	M M	10-10-51 10-14-64	-	S,I	A19261. Irrigates 100 acres.

Table 9.--(Continued)

Spring or well number and location	Owner and/or name	Date drilled	Depth (feet)	Diameter of casing (inches)	Principal water-bearing zone (feet)	Altitude	Measuring point		Water level			Temperature	Use	Remarks
							Description	above land surface (feet)	Below land surface (feet)	M or R	Date			
(C-17-19)21	Kell Springs	--	--	-	--	4,930	--	--	flowing	-	--	--	S	Estimated flow 120 gpm.
(C-18-16)31	Conger Spring	--	--	-	--	--	--	--	flowing	-	--	--	S	Estimated flow 1 gpm.
(C-18-18)8a	Spring	--	--	-	--	--	--	--	flowing	-	--	--	S	Estimated flow 2 gpm.
(C-18-18)16abb	Knoll Springs	--	--	-	--	4,880	--	--	flowing	-	--	67	S	One of a series of artesian springs that issue from the tops of low mounds which roughly aligned in a northward direction. Estimated flow: 3 gpm on 10-15-64.
(C-18-19)20dad1	Mrs. Ward Robinson	--	100	6	--	4,955	TC	0.8	31.9	M	11-30-37	--	D,S	Windmill.
(C-18-19)20ddd1	Louise Robinson	1925	90	6	--	4,965	TC	0.8	31.4	M	11-30-37	--	D,S	C7420
(C-18-19)20ddd2	J. D. Hill	1956	560	16,8	490-520	--	--	--	flowing	-	--	72	1,S	Drilled to 580 feet. Casing: 16-inch to 316 feet, 8-inch from 280 to 560 feet. Flow estimated 75 gpm on 10-24-57. Well drilled mainly in cemented gravel. Hole did not cave after drilling.
(C-18-19)28bbb	J. D. Hill	1957	640	16,8	--	4,960	--	--	flowing	-	--	72	1	Well was being drilled when inventoried in 1957. Casing: 16-inch to 80 feet. 480 feet of open hole. First flow at 540-580 feet. When well flows, flow of well at 20ddd decreases.
(C-19-19)26acd	Flanders	1960	112	16	--	--	--	--	--	-	--	--	1	Irrigaces 40 acres of hay. Equipped with turbine and diesel engine.
(C-19-19)35dcd	Eskdale Development Company	--	--	12	--	--	--	--	10.6	M	2-25-65	--	PS	Supplies 40 people in summer; 80 in winter.
(C-20-17)9c	BLM	--	760	-	--	5,490	--	--	600	R	--	--	S	
(C-20-19)1bcc	BLM	--	--	4	--	4,985	--	--	+12.2	M	5-26-51	62	S	Estimated flow: 1 gpm on 5-26-51.
(C-20-19)1cba	Melvin Peterson	--	--	-	--	4,990	--	--	--	-	--	--	1	Equipped with turbine and diesel engine. Irrigates 320 acres.
(C-20-19)6bbb	Glenn Bellander	--	180	10	--	5,080	--	--	--	-	--	--	1	Well flows when not pumped. Drawdown: 35-40 feet while pumping 650 gpm on 10-21-52. Pumped with turbine and diesel engine. Well 50 feet west is affected by pumping.
(C-20-19)6bcc	Glenn Bellander	1915	200	3	--	5,080	--	--	+ 7.4 + 6.6 + 8.0	M M M	10-17-36 9-18-41 10-12-45	57	S	Flowed 36 gpm on 11-17-36.
(C-20-19)7aab1	G. S. Quate	4-1932	569	6	320-321	--	--	--	+ 8.6 + 7.4 + 8.4 + 8.0	M M M M	11-17-36 9-13-40 10-12-45 11-23-48	60	U	Casing: 6-inch to 40 feet. Clay and fine sand main material encountered. Flow of 7 gpm at 212 feet. Flow of 75 gpm at 312 feet. Pulled pipe back to 40 feet and flow decreased to final reported value of 7 gpm.
(C-20-19)7bbd1	Marcus Sorenson	1915	280	6,3	--	5,090	--	--	+ 4.3 + 6.4 + 3.0	M M M	11-17-36 10-12-45 11-05-54	59	U	Casing to 90 feet.
(C-20-19)14bbb	Glenn Bunker	--	--	10	--	5,000	--	--	--	-	--	--	1	Irrigated 140 acres of hay.
(C-20-19) 14b	G.S. Quate	--	--	60	--	--	--	--	--	-	--	--	1	Dug well.
(C-20-19)15bdc	--	--	--	--	--	--	--	--	--	-	--	--	1	Estimated yield: 4 cfs on 10-21-55.
(C-20-19)16bdc	Fred G. Schumaker	1928	40	16	--	5,025	--	--	12.5 14.1 14.7	M M M	11-17-36 11-01-39 9-18-42	--	U	C4024. Was equipped with centrifugal pump and gasoline engine.
(C-20-19)19dc	BLM	6-1956	4,211	-	--	5,079	--	--	--	-	--	--	U	Oil test. Shell Oil Co. Baker Creek Unit 1. Tertiary valley fill to about 4200 ft.
(C-20-19)21b	--	--	66	-	--	5,030	--	--	20	R	--	--	I	
(C-21-17)8dcc	BLM	7-1935	316	6	--	5,070	--	--	224	R	--	--	S	Reported yield: 25 gpm. See log.
(C-21-18)10cdd	--	--	66	-	--	5,035	--	--	65	R	--	--	S	
(C-21-18)12ccd	BLM	8-1958	205	6	130-132 203-205	5,050	--	--	105	R	--	--	S	Casing: 6-12 to 154 feet. First water at 130 feet. Reported yield: 12 gpm when drilled. See log.
(C-21018)17ad	BLM	2-1958	166	4	74- 76	5,040	--	--	52	R	--	--	S	Reported yield: 17 gpm when drilled.
(C-21-19)31d	Jim Dearden	1946	80	8	--	5,230	--	--	30	R	--	--	D,S	Windmill
(C-21-19)31dcc	Jim Dearden	6-1946	175	16	--	5,230	--	--	24	R	--	--	-	A17356. See log.

Table 9.--(Continued)

Spring or well number and location	Owner and/or name	Date drilled	Depth (feet)	Diameter of casing (inches)	Principal water-bearing zone (feet)	Altitude	Measuring point		Water level			Temperature	Use	Remarks
							Description	Above land surface (feet)	Below land surface (feet)	M or R	Date			
(C-22-16)7ccc	BLM	3-1935	550	-	--	5,250	--	--	Dry	-	--	--	-	See log.
(C-22-16)19b	BLM	--	680	-	--	5,325	--	--	Dry	-	--	--	-	
(C-22-16)20	--	--	100	-	--	5,320+	--	--	Dry	-	--	--	-	
(C-22-19)3dac	BLM	3-1951	6,955	-	--	6,232	--	--	-	-	--	--	U	Oil test, Standard Oil of California, Burbank Unit 1. Extensive loss of circulation of drilling mud in carbonate rocks.
(C-22-19)6b	Cecil Rowley	--	75	-	--	--	--	--	52.4 52.2 61.0 Dry at 68	M M M M	8- 8-42 10-12-45 10-18-49 11- 8-50	--	D	A19667
(C-22-19)6bac1	Lee Dearden	1950	167	16	--	5,250	HPB	1.5	49.0	M	11- 8-50	--	I	A17881. Reported yield: 2200 gpm.
(C-22-19)6bca1	Vivian Dearden	1950	111	16	53-111(?)	--	--	--	53.4	M	11- 8-50	--	I,S	A17849. Reported yield: 444 gpm on 4-26-50.
(C-22-19)6bca2	Vivian Dearden	5-1950	100	6	--	--	--	--	51	R	--	--	-	
(C-22-19)6bcc	Dennis Smith	1934	120	5½	100-120	5,276	TC	.8	58.0	M	11-17-36	52	D,S	Windmill with pump jack and gasoline engine.
(C-22-19)9	Burbank Spring	--	--	-	--	5,400	--	--	flowing	-	--	57	-	Flows to Lake Creek below reservoir.
(C-23-19)9cc	Fred Loper	--	30	5½	9- 21	--	--	--	8.6 7.5 4.7	M M M	11-16-36 10- 1-42 10-15-46	-	U	Dug well cased with 5½-inch casing to 30 feet. Well plugged in 1947.
(C-23-19)9cdb-1	Thomas Dearden	1931	270	5½	--	5,405	TC	1.1	15.4	M	11-16-36	-	U	
(C-23-19)13aab	BLM	1-1935	540	6	--	5,930	--	--	476	R	--	-	-	Casing: 6-inch to 493 feet. Reported yield: 1 gpm. See log.
(C-23-19)20bac1	Arvilla Davies	--	40	6	--	5,410	HC	-4.0	15.2	M	11- 8-50	-	D,S	Equipped with pressure pump and electric motor.
(C-23-19)24dcc	BLM	--	472	5	--	5,780	--	--	--	-	--	-	S	
(C-24-18)20bcc	Elmer and William Davies	1-1950	360	6	--	5,810	--	--	Dry	-	--	-	-	See log.
(C-24-18)27a	BLM	--	500	-	--	5,920	--	--	Dry	-	--	-	-	
(C-24-18)29b	BLM(?)	--	936	-	--	5,880	--	--	Dry	-	--	-	-	
(C-24-19)3db	--	9-1958	172	6,4	--	5,558	--	--	138	R	--	-	-	See log.
(C-30-19)21cab	BLM(?)	--	215	12	--	6,325	--	--	170	R	--	-	S	Equipped with 3-inch turbine and diesel engine.
(C-32-19)10bba	--	--	--	-	--	6,700	TC	2	+7.0(+)	M	11-27-62	47	S	Estimated yield: 2 gpm. This may be end of pipe line although no ditching is seen.
(C-32-19)21aba1	--	--	38M	-	--	6,800	T of timber	0	16.9	M	11-27-62	-	U	Dug well. Windmill
(C-32-19)21aba2	--	--	61M	-	--	6,800	T of concrete	0	57.8	M	11-27-62	-	U	Dug well. Hand pump.
(C-32-19)25aaa	--	--	40M	-	--	--	--	--	Dry	-	--	-	U	
(C-32-19)22ddb	O. J. Hulet	1963	407	8	380- 95	6,800	PC	1.0	335	M	12-16-64	-	S	Windmill

Table 10.--Selected drillers' logs of wells in the Snake Valley area, Nevada and Utah

NEVADA

	Thickness (feet)	Depth (feet)
8/69-36al		
Clay, sandy	170	170
Sand, water-bearing	15	185
Clay, sandy	32	217
Sand, water-bearing	2	219
Clay, sandy	6	225
8/70-6al		
Clay, sandy, cemented	85	85
Clay, sandy, soft	67	152
Sand, water-bearing	12	164
9/70-34dl		
Clay, sandy	105	105
Clay, sandy, soft	3	108
Clay, sandy	84	192
Hardpan	3	195
Sand and gravel, water bearing	3	198
Clay, sandy	19	217
10/70-12bl		
Topsoil	3	3
Clay, white	15	18
Gravel, water-bearing	4	22
Clay	7	29
Gravel	9	38
Clay	4	42
Clay and gravel	5	47
Clay	15	62
Hardpan	3	65
Clay	15	80
10/70-29dl		
Clay	8	8
Gravel, water-bearing	16	24
Clay	6	30
Hardpan	4	34
Sand, fine	6	40
Clay	20	60
Gravel	2	62
Clay, sandy	6	68
12/70-11cl		
Soil	8	8
Gravel, cemented	18	26
Sand and gravel	6	32
13/70-4bl		
Clay, black	10	10
Gravel, water-bearing	12	22
Clay	2	24
Gravel, water-bearing	101	125
Clay	3	128
Gravel, water-bearing	52	180
Clay	6	186
Gravel	96	282
Clay	3	285
Gravel, water-bearing	75	360
Clay	36	396
Sand, fine	74	470
13/70-10a2		
Soil	15	15
Boulders and gravel	65	80
Gravel	70	150
Clay, yellow	15	165
Gravel	155	320
Clay	20	340
Gravel	510	850
Clay, hard	50	900
Sand with hard clay streaks	130	1030
Sand and gravel	30	1060
Clay with sand streaks	22	1082
13/70-14cl		
Clay	7	7
Gravel, water-bearing	6	13
Gravel and clay mixed	17	30
Clay	6	36
Conglomerate	9	45
Clay, sandy	12	57
Sand, water-bearing	1	58
Clay, sandy	18	76

	Thickness (feet)	Depth (feet)
13/70-14cl (con't)		
Hardpan	2	78
Clay, sandy	15	93
Conglomerate	10	103
Sand, water-bearing	3	106
Clay, sandy	24	130
Hardpan	2	132
Clay, sandy	18	150
Clay, sticky	13	163
Sand, flowing-water (2 1/2 gpm)	2	165
Clay, sandy	19	184
Sand, flowing-water (15 gpm)	2	186
Clay, sandy	39	225
Sand, flowing-water (1 gpm)	1	226
Clay, sandy	20	246
Hardpan	5	251
Clay, sandy	99	350
Hardpan	1	351
Clay, sandy	64	415
13/70-35al		
Gravel and clay	92	92
Clay, sandy	34	126
Hardpan	2	128
Clay, water-bearing	7	135
Clay, sandy, cemented	11	146
Sand and gravel, water-bearing	9	155
Clay	3	158
14/69-24al		
Clay and boulders	27	27
Clay and cemented	18	45
Clay, white with gravel mixed	25	70
14/70-28al		
Clay	3	3
Sand and clay	57	60
Sand and gravel, cemented	39	99
Sand and gravel, water-bearing	1	100
Clay, sandy	22	122
Sand and gravel, cemented	8	130

	Thickness (feet)	Depth (feet)
19/69-15cl		
Clay	16	16
Boulders	2	18
Gravel and rock, water-bearing	10	28

UTAH

(C-11-15)30dcb		
Sand and gravel	5	5
Sand, dry	31	36
Sand, little water	19	55
Clay, yellow	10	65
Clay, sandy		
Sand, water	17	112
(C-11-17)2c		
Clay	8	8
Sand. Some water	12	20
Clay	8	28
Gravel	50	78
Hardpan	2	80
Gravel, main supply of water	55	135
Sand	15	150
Gravel, coarse	40	190
Sand	2	192
Gravel	30	222
(C-13-16)6cc		
Sand and gravel, loose	15	15
Gravel and clay, firm brown	15	30
Lava - gravel	40	70
Clay, lava, and limestone	45	115
Lava, gravel, & clay	105	220
Lava	32	252
(C-13-18)33dccl		
Clay loam	13	13
Clay, sandy, water	13	26
Gravel, fine	8	34
Clay, packed, & gravel	11	45
Gravel, pea	3	48
Clay	19	67
Gravel	7	74

	Thickness (feet)	Depth (feet)
(C-13-18)33dccl (con't)		
Clay, packed, & gravel	18	92
Gravel, fine	16	108
Clay, compact	9	117
Sand and gravel	11	128
Clay, compact	7	135
Sand and gravel	14	149
Rock, sand, & gravel	9	158

At 152 ft., depth to water was 10 ft. Beneath white quartzite ledge in gravel at 158 ft. Depth to water was 7 ft. After perforation, depth to water was 10 ft.

	Thickness (feet)	Depth (feet)
(C-15-18)11cd		
Sand and gravel, to 1/2 inch	15	15
Gravel, cemented	55	70
Granite, decomposed gray	165	235
Shale, black, soft decomposed	80	315
Granite, hard, gray	100	415
Granite, hard light brown	55	470
Granite, hard red to gray	15	485
(C-21-17)8dcc		
Soil and brown clay	16	16
Gravel, cemented blue lime	44	60
Gravel, coarse cemented and boulders	40	100
Boulders, lime	80	180
Gravel, cemented, and sand	80	260
Quicksand	4	264
Sand, coarse, water	43	307
Sand, medium	9	316
(C-21-18)12bc		
Clay, sandy	130	130
Sand, & gravel, water	2	132
Clay, sandy	13	145
Hardpan	3	148
Clay, white chalky	2	150
Clay, cemented, sandy	53	203
Sand and gravel	2	205
(C-21-18)17ad		
Clay, white sandy	57	57
Clay, brown sandy	17	74
Sand & gravel, water	2	76
Clay, brown sandy	77	153
Gravel(?), hard white consolidated	13	166
(C-21-19)31dccl		
Clay	24	24
Sand & gravel, water	3	27
Gravel & clay, mixed	18	45
Gravel, coarse, & sand, water	9	54
Gravel & clay, mixed	14	68
Gravel & boulders water	6	74
Gravel & clay, mixed	10	84
Clay, sticky	1	85
Clay, hard, cemented, sandy	53	138
Clay, sandy	10	148
Clay, hard, cemented, sandy	27	175
(C-22-16)7cc		
Soil & lime boulders	55	55
Gravel, cemented	425	480
Sand, medium hard	39	519
Limestone, hard gray	31	550
(C-22-19)6bacl		
Clay, sandy	31	31
Sand & gravel, cemented	15	46
Clay, sandy	13	59
Sand & gravel. Water	11	70
Clay, sandy	4	74
Sand and gravel	8	82
Clay, sandy	8	90
Sand and gravel	5	95
Clay, sandy	6	101
Hardpan	4	105
Sand and gravel	8	113

	Thickness (feet)	Depth (feet)
(C-22-19)6bacl (con't)		
Sand & gravel, cemented	6	119
Sand and gravel	3	122
Clay, sandy	3	125
Sand and gravel	1	126
Clay, sandy	2	128
Sand and gravel	1	129
Clay, sandy	1	130
Sand and gravel	1	131
Clay, sandy	3	134
Hardpan	3	137
Sand and gravel	4	141
Clay, sandy	3	144
Sand and gravel	1	145
Clay, sandy	1	146
Sand and gravel	1	147
Clay, cemented sandy	20	167
(C-22-19)6bca-2		
Clay	23	23
Clay, cemented sandy	26	49
Clay, sandy	12	61
Sand and gravel	4	65
Clay, sandy	11	76
Sand, & gravel, water	6	82
Clay, sandy	18	100

	Thickness (feet)	Depth (feet)
(C-23-19)13aab		
Soil	21	21
Limerock and conglomerate in alternating layers	226	247
Limestone	293	540
(C-24-18)20bccl		
Clay	8	8
Conglomerate	12	20
Clay, sandy	55	75
Clay, sticky	118	193
Limestone	167	360
(C-24-19)3db		
Soil, sandy	4	4
Gravel, hard cemented, and clay	65	69
Soil, medium hard, sandy	14	83
Sand & gravel, cemented	14	97
Rock	47	144
Sand and gravel, water	1	145
Clay, sandy, medium hard	25	170
Sand & gravel, water	2	172

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UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF UTAH
STATE ENGINEER

STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

Base: From Army Map Service 1:250,000 Series; Caliente (1954), Cedar City (1962), Delta (1962), Ely (1959), Lund (1956), and Richfield (1963)

Hydrogeology by James W. Hood and F. Eugene Rush, 1964; partly adapted from Stokes (1963), Tschanz and Pampeyan (1963), and Whitebread and other

PLATE 1.—GENERALIZED HYDROGEOLOGIC MAP OF SNAKE VALLEY, WHITE PINE, LINCOLN, IRON, BEAVER, MILLARD, TOOELE AND JUAB COUNTIES, UTAH AND NEVADA

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