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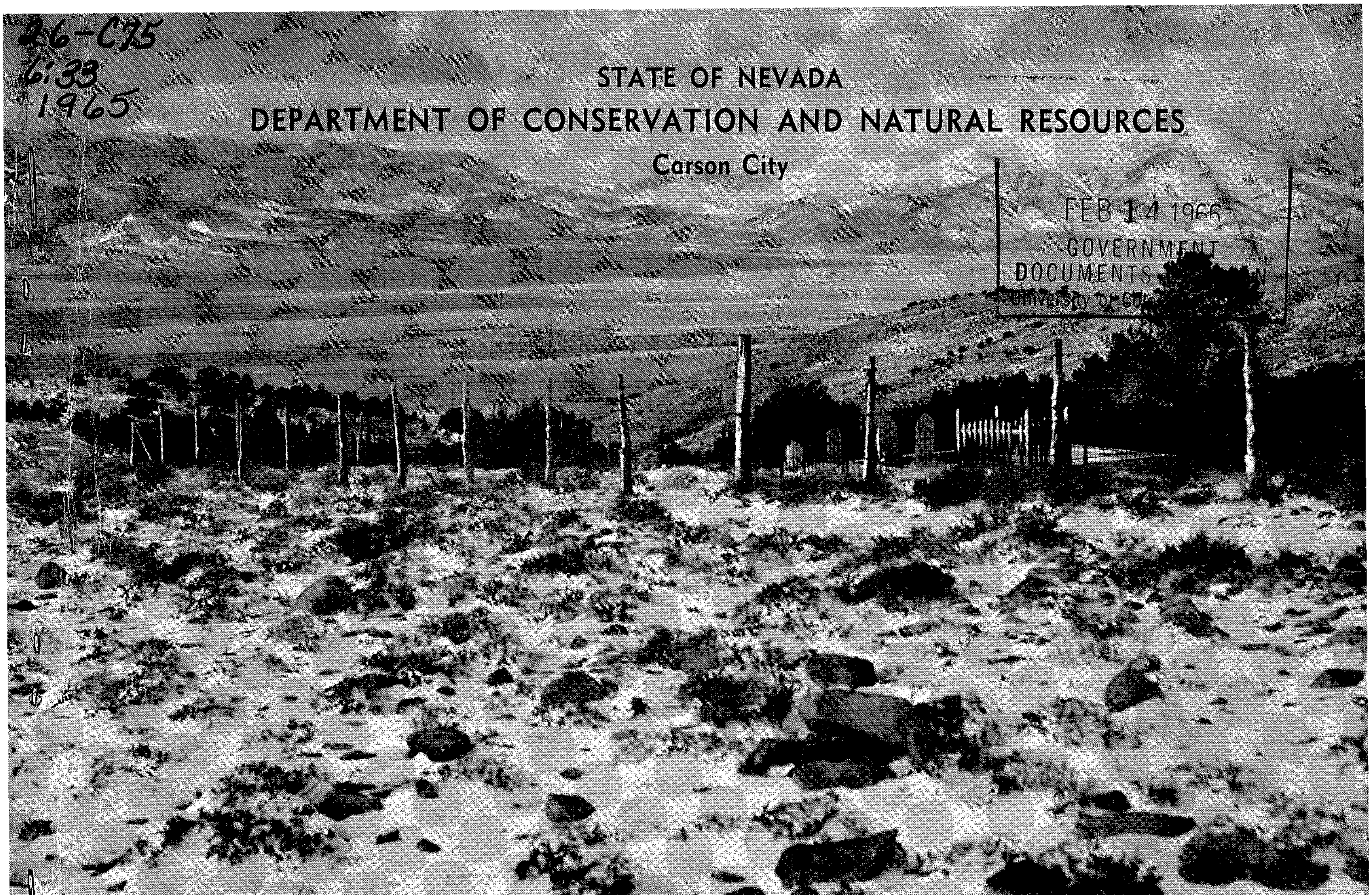

View of Spring Valley looking northwest from the town site of Osceola

WATER RESOURCES-RECONNAISSANCE SERIES
REPORT 33

WATER RESOURCES APPRAISAL OF SPRING VALLEY, WHITE PINE AND LINCOLN COUNTIES, NEVADA

By

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Geologist

and

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Geologist

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

JULY 1965

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WATER RESOURCES APPRAISAL OF SPRING VALLEY, WHITE PINE AND LINCOLN COUNTIES, NEVADA

By

F. Eugene Rush and S. A. T. Kazmi

SUMMARY

Spring Valley is in eastern Nevada in White Pine and Lincoln Counties, and has an area of about 1,700 square miles. The valley floor is arid to semiarid, and most of the precipitation that contributes to streamflow and to ground-water recharge falls on the mountains in the winter in the form of snow.

The younger and older alluvium, mostly gravel, sand, and clay, compose the principal ground-water reservoir. Ancient-lake deposits of low permeability blanket much of the valley floor to a maximum depth of 300 feet, and wells would have to penetrate to underlying aquifers to obtain high yields. The consolidated rocks in the mountains are a poor source of water; however, locally the carbonate rocks of the Snake Range may transmit large quantities through solution channels.

Cleve Creek, the largest creek in the valley, has an average flow of 6,060 acre-feet per year. About 13 creeks flow all year; in July 1964 they had a combined flow of about 50 cfs. The estimated total average annual runoff from all streams in the valley is 90,000 acre-feet. The central part of the Schell Creek Range, though constituting only 18 percent of the runoff area, yields about 62 percent of the valley runoff. More than 8,000 acre-feet per year of streamflow is diverted for the irrigation of about 5,200 acres. Of the remaining runoff, part recharges the ground-water reservoir and the rest wastes to the two playas.

The estimated average annual ground-water recharge is 75,000 acre-feet, which is derived from an estimated average annual precipitation of 960,000 acre-feet. Of the total recharge, about 65,000 acre-feet is derived from precipitation on the mountains, the remaining 10,000 acre-feet from precipitation on the alluvial aprons.

The estimated average annual ground-water discharge is 74,000 acre-feet. About 70,000 acre-feet is consumed by phreatophytes and evaporation in an area of about 186,000 acres, and about 4,000 acre-feet is discharged from the southern part of the valley by ground-water outflow to Hamlin Valley. In 1964 pumpage for stock, domestic, and irrigation use probably was less than 1,000 acre-feet.

The estimated minimum yield of Spring Valley is 70,000 acre-feet per year. If a substantial part of the runoff now wasting to the playas could be salvaged by a well-designed, intensive ground-water development, the perennial yield might be on the order of 100,000 acre-feet per year.

Cleve Creek and the other mountain streams have the lowest mineral content. Ground water between the mountain front and the phreatophyte area is intermediate in mineral content and generally acceptable for irrigation. The shallow ground water in the phreatophyte area generally is highly mineralized and is of poor quality for irrigation. At greater depth the quality may be better.

INTRODUCTION

Purpose and Scope of the Study

Prior to 1960, one of the greatest deficiencies in water knowledge in Nevada was the lack of quantitative hydrologic data for more than half the valleys in the State. In an effort to overcome this deficiency, legislation was enacted in 1960 to provide for reconnaissance studies of drainage basins in Nevada under the cooperative program between the Nevada Department of Conservation and Natural Resources and the U.S. Geological Survey. The purpose of these studies is to provide water-resource information to the public and to assist the State Engineer in the administration of the water law by making preliminary estimates of the average annual recharge to, the discharge from, and the perennial yield of the ground water in the valleys and basins. In addition to these estimates, the scope of the reports includes appraisals and information on (1) climate, (2) geologic environment, (3) extent of the hydrologic systems, (4) ground water in storage, (5) streamflow and runoff, (6) water quality, (7) areas of potential development, (8) existing and potential problems, and (9) needs for additional study.

This report is the 33rd in the series of reconnaissance studies (fig. 1). The field work was limited to a brief study of the hydrologic conditions and the geologic environment of the area, and was done in July and August 1964.

S. A. T. Kazmi, a coauthor of this report, is a Senior Geologist of the West Pakistan Water and Development Authority. He participated in the field work and prepared parts of the report. He was assigned to the Nevada district to become familiar with the technique used in the reconnaissance studies. This assignment was carried out under the U.S. Geological Survey's foreign-participant training program sponsored by the United States Government.

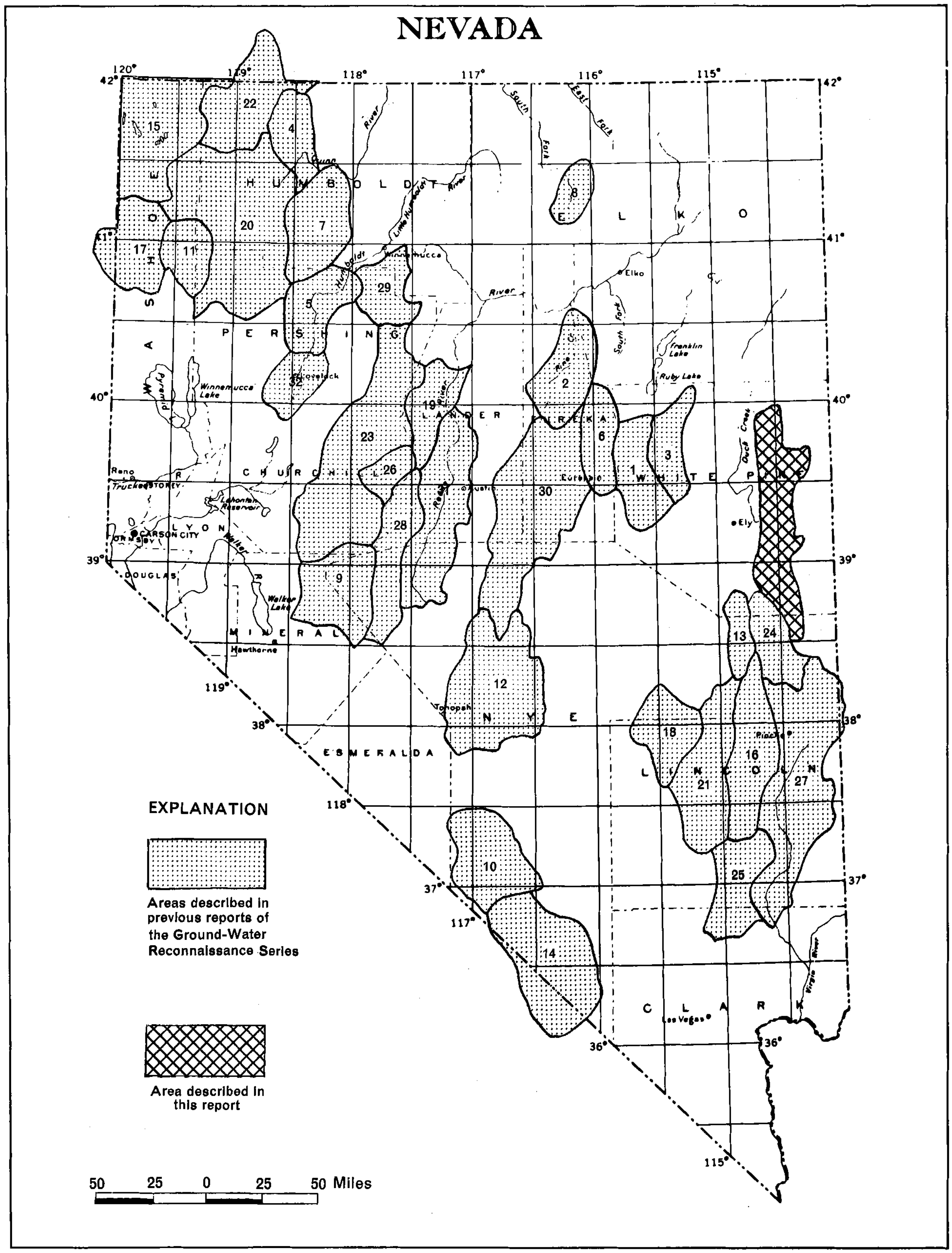


Figure 1.— **MAP OF NEVADA**

showing areas described in previous reports of the Water Resources Reconnaissance Series and the area described in this report

Location and General Features

Spring Valley is a topographically closed valley in eastern Nevada within longitudes 114°00' W. and 114°45' W. and latitudes 38°15' N. and 40°15' N. (fig. 1). It is in eastern White Pine and northeastern Lincoln Counties, about 120 miles long in a north-south direction and about 15 miles wide. The valley has an area of about 1,700 square miles.

Principal access to the valley is by U.S. Highways 6 and 50, which extend east-west through the valley, and by U.S. Highway 93, which extends southward from Highways 6 and 50 through Pioche, Lincoln County (fig. 2). Paved roads extend northward from Highways 6 and 50 and southeastward from Highway 93, and provide access to the west-central and south-central parts of the valley. Numerous graded and unimproved roads extend to all parts of the valley and to adjacent valleys.

The population of the area is unknown; however, there are about 15 ranches and perhaps a total population of between 75 and 150.

Previous Work

Spring Valley was first visited and described by Simpson (1876) in 1858 and 1859. Spurr (1903, p. 44-47), Misch (1960), and Drewes (1960; 1964) have described briefly some large geologic structures of part of the Schell Creek Range. Papers by Young (1960), Langenheim (1960), and several other writers that deal with various geologic features of eastern Nevada are published in the Guidebook to the geology of east-central Nevada. Geologic maps of the Wheeler Peak quadrangle and Lincoln County, which include the southern part of Spring Valley, have been prepared by Tschanz and Pampeyan (1961) and Whitebread and others (1962), respectively. Bissell (1962, 1964), Misch and Hazzard (1962), and Coogan (1964) have reported on the stratigraphy of the bedrock of the area.

One of the first ground-water studies in east-central Nevada was made by Clark and Riddell (1920) in Steptoe Valley, which adjoins Spring Valley to the west. Maxey and Eakin (1949) made a ground-water study of White River valley, southwest of Spring Valley. The ground-water resources of 10 valleys in eastern Nevada were reported on by Eakin and others (1951). As part of the Ground-Water Resources - Reconnaissance Series, reports covering the nearby Long Valley (Eakin 1961) and Lake Valley (Rush and Eakin 1963), and the Meadow Valley area (Rush 1964) have been published. The relation of ancestral lakes in Spring Valley to past and present climates is discussed in a paper by Snyder and Langbein (1962). Snyder (1963, p. 427-428) has tabulated data on stock-watering facilities in the valley.

Climate

The airmasses that move across eastern Nevada are characteristically deficient in moisture. The valleys are semiarid, whereas the higher mountain areas are subhumid, receiving somewhat more precipitation, especially in the winter. Thunderstorms provide most of the precipitation during the summer.

Precipitation has been recorded at nine stations in the area adjacent to Spring Valley (fig. 2), where the average annual amount ranges from about 6 to 14 inches. A further discussion of precipitation is included in the hydrology section of this report.

Temperature data have been recorded at Ely Airport, Geyser Ranch, Ibapah (Utah), Lehman Caves, and McGill. Since 1949, the U.S. Weather Bureau has been publishing freeze data; this information is given in table 1. Because killing frosts vary with the type of crop, temperatures of 32°F, 28°F, and 24°F are used to determine the number of days between the last spring minimum (prior to July 1) and the first fall minimum (after July 1).

The length of the growing season is controlled in large part by the elevation of the station in relation to the adjacent valley floor. The topography of the area favors the flow of heavy cold air toward the lower parts of the valley during periods of little or no wind movement, causing thermal inversions. The growing season at McGill in Steptoe Valley and at Lehman Caves in Snake Valley is relatively long. These two stations are on alluvial aprons well above the valley floor. A crop experiencing a killing frost at 28°F would have an average growing season of about 150 days at McGill and Lehman Caves. Geyser Ranch in Lake Valley, having an elevation of only about 50 feet above the adjacent floor, has an average growing season of about 114 days. At Ely Airport and Ibapah, both on valley floors, the average growing season is near 100 days.

Because no temperature data are available for stations in Spring Valley, only comparisons with the nearby stations can be made. The conditions on the valley floor of Spring Valley probably are similar to those at Ibapah, Ely Airport, and Geyser Ranch. On most parts of the valley floor, a crop experiencing a killing frost at 28°F probably would have an average growing season of about 100 days. At higher elevations on the alluvial apron of the valley, the growing season probably would be on the order of 130 to 150 days. The annual low and high temperatures for Spring Valley can be expected to range from about -15°F in the winter to about 97°F in the summer.

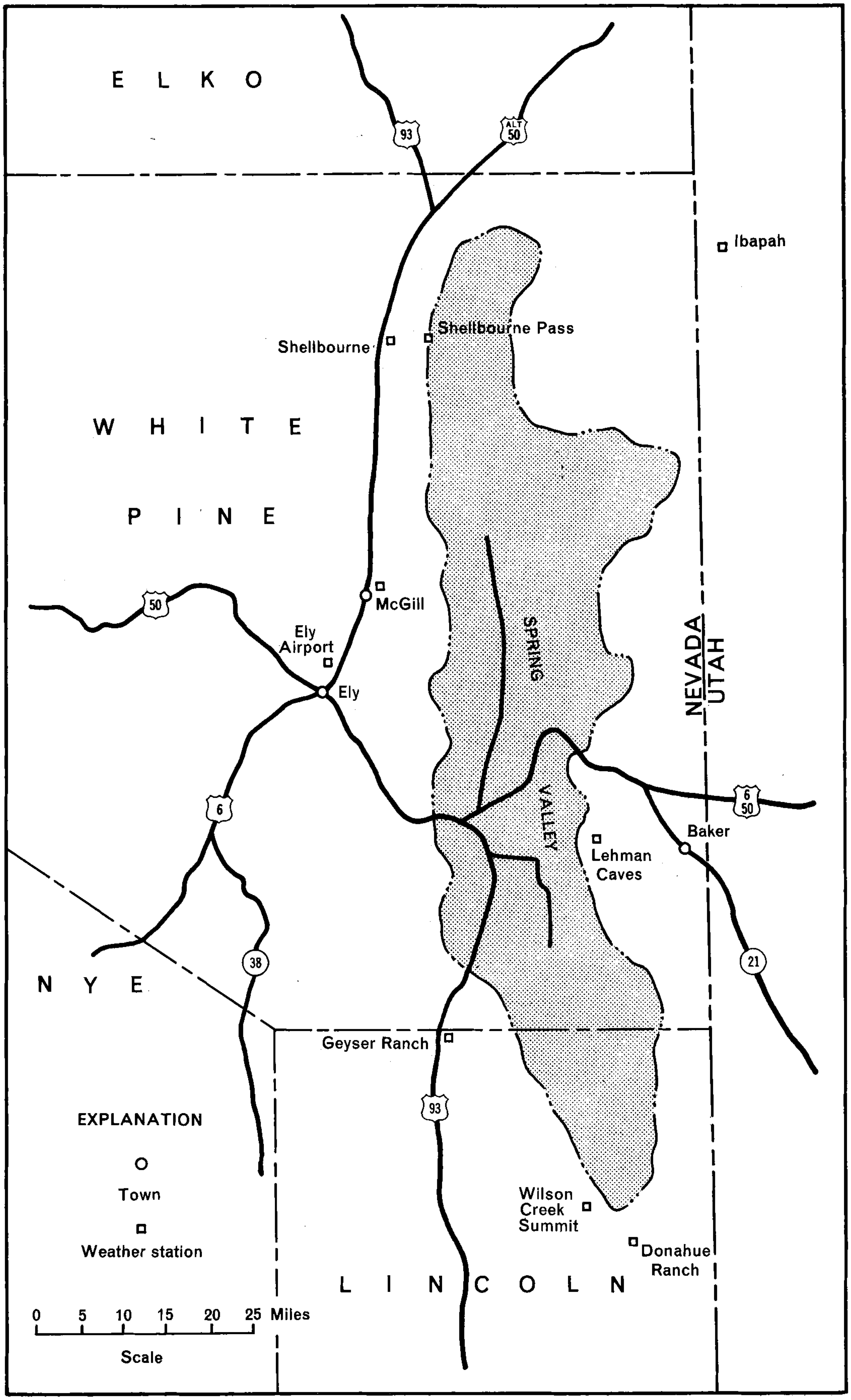


Figure 2.— Map of eastern Nevada showing the locations of Spring Valley, paved roads, and weather stations.

Table 1. --Number of days between the last spring minimum and the first fall minimum temperatures at several stations in the Spring Valley area

(From published records of the U. S. Weather Bureau)

Year	Ely Airport 32°F	Ely Airport 28°F	Ely Airport 24°F	Geyser Ranch 32°F	Geyser Ranch 28°F	Geyser Ranch 24°F	Ibapah 32°F	Ibapah 28°F	Ibapah 24°F	Lehman Caves 32°F	Lehman Caves 28°F	Lehman Caves 24°F	McGill 32°F	McGill 28°F	McGill 24°F
1950	42	86	114	84	95	113	34	81	95	35	177	185	113	114	150
1951	91	94	124	94	102	112	91	100	121	140	155	192	123	144	192
1952	88	88	88	75	77	78	66	80	173	151	202	207	150	204	216
1953	70	90	128	81	118	118	45	72	100	123	127	[illegible]	117	--	191
1954	97	97	124	--	--	--	41	95	101	110	112	176	114	174	178
1955	7	114	143	--	--	--	115	130	108	116	143	143	116	141	183
1956	86	130	153	--	--	--	9	66	109	152	153	164	137	164	194
1957	75	96	139	--	--	--	--	--	--	96	128	179	121	136	151
1958	91	112	172	--	--	--	97	109	173	139	151	177	120	151	180
1959	53	113	130	--	--	--	81	82	131	129	131	162	120	126	130
1960	63	63	96	--	--	--	62	63	150	138	167	187	90	93	143
1961	92	118	141	109	142	143	93	119	140	134	135	170	113	139	141
1962	84	94	168	79	105	167	76	84	117	141	148	201	94	146	188
1963	125	153	182	123	157	175	71	154	176	172	172	192	125	172	191
Average	76	103	136	92	114	130	68	95	130	127	150	179	118	146	174

Physiography and Drainage

Spring Valley is a topographically closed valley in the eastern part of the Great Basin section of the Basin and Range physiographic province. The bordering mountains generally trend northward. The valley is bounded on the west by the Fortification and Schell Creek Ranges, on the south by the Wilson Creek Range, and on the east by the Snake and Antelope Ranges, the Red Hills, and the Kern Mountains. At the north end of the valley, a low divide separates Spring Valley from Steptoe Valley.

High peaks in the Snake and Schell Creek Ranges are along both the east and west sides of the valley. In the Snake Range the highest is Wheeler Peak (13,063 feet). Six other peaks exceeding an altitude of 11,500 feet are in the range. In the Schell Creek Range the highest peak is North Schell Peak (11,883 feet). Seven other peaks exceed an altitude of 10,000 feet.

The lowest point (altitude 5,536 feet) is on the small playa east of South Schell Peak along the axis of the valley. The highest altitudes of the valley floor (about 6,500 feet) are at the north and south ends of the valley. The mountains commonly rise to as much as 4,000 feet above the adjacent valley floor, and reach a maximum relief where Wheeler Peak rises more than 7,000 feet above the adjacent valley floor. The valley has internal surface drainage from the mountains toward the valley floor and subsequently toward the small playas in the northern and southern parts of the valley.

The floor of Spring Valley is generally lower than the corresponding areas in Steptoe Valley to the west and Lake Valley to the south. However, the valley floor in Snake Valley to the east ranges from the same elevation as the floor of Spring Valley to about 700 feet lower at its northern end.

Numbering System for Wells and Springs

The numbering system for wells and springs in this report is based on the rectangular subdivisions of the public lands, referenced to the Mount Diablo base line and meridian. It consists of three units: the first is the township north of the base line; the second, separated from the first by a slant, is the range east of the meridian; the third, separated from the second by a dash, designates the section. The section number is followed by a letter that indicates the quarter section, the letters a, b, c, and d designating the northeast, northwest, southwest, and southeast quarters, respectively. Following the letter, a number indicates the order in which the well or spring was recorded within the 160-acre tract. For example, well 8/68-14a1 in table 9 is the first well recorded in the NE1/4 sec. 14, T. 8 N., R. 68 E., Mount Diablo base line and meridian.

Because of the limitation of space, wells and springs are identified on plate 1 only by the section number, quarter section letter, and number indicating the order in which they were located. Township and range numbers are shown along the margins of the area on plate 1.

GENERAL HYDROGEOLOGIC FEATURES

Geomorphic Features

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

The large alluvial fans in Spring Valley have developed from debris derived from the Schell Creek and Snake Ranges. Major fans have developed at the mouths of Lincoln and Cooper Canyons, at the mouth of Cleve Creek, and of the unnamed canyon at Rodgers Ranch. The apexes of the Cooper Canyon and Cleve Creek fans stands about 700 feet higher than their toes. The apex of the Lincoln Canyon fan is about 100 feet higher but is smaller in areal extent. Elsewhere along much of the mountain fronts the alluvial aprons, composed of many smaller fans, have formed an intermediate slope between the mountains and the valley floor. However, in some areas sloping, planed rock surfaces have been eroded at the foot of the mountains. They are well developed at the northern end of the valley in T. 24 N., R. 66 E., and along the Schell Creek Range in Tps. 11 to 13 N.

Alluvial fans of two ages have formed in the valley. The older fans are deeply dissected and are along the relatively stable mountain fronts, whereas the younger fans are only locally dissected and usually occur along the mountain fronts where recent faulting has occurred. Good examples of the younger alluvial fans are at the mouths of Cleve Creek and the unnamed creek at Rodgers Ranch. Older alluvial fans are exemplified at the mouths of Lincoln and Cooper Canyons.

The valley floor of Spring Valley is relatively flat; around the margins the floor slopes upward to the alluvial apron and merges with it. The valley floor has its most extensive development at Baking Powder Flat and in the Area extending northward from U.S. Highways 6 and 50 for about 35 miles. The flatness of the valley floor is interrupted both at the north and the south margins of Baking Powder Flat by crescent-shaped gravel bars that extend across the valley. Other smaller lake-shore features are present.

Lithologic and Hydrologic Features of the Rocks

The rocks of the report area are divided into three lithologic units: consolidated rocks, older alluvium, and younger alluvium. This division is based largely on their hydrologic properties; however, the hydrologic properties of the consolidated rocks may very widely with differences in their physical and chemical properties. The surface exposures of the units are shown on plate 1. The geologic mapping is based principally on the field work done by the writers, on aerial-photo interpretation, and on the geologic maps of Wheeler Peak quadrangle (Whitebread and others, 1962) and Lincoln County (Tschanz and Pampeyan, 1961), which were useful in identifying the lithology of the consolidated rocks in those areas.

Most of the Snake Range is composed of carbonate rocks, chiefly Paleozoic in age. Most of the Fortification and Wilson Creek Ranges are composed of lava flows and volcanic tuff of Cretaceous and Tertiary age. The Schell Creek Range probably is composed mostly of sedimentary and metamorphic rocks, chiefly Paleozoic in age.

Except for the carbonate rocks, the consolidated rocks of the report area have low permeability; hence, they are among the least economic sources of water in the area. The carbonate rocks commonly contain solution channels, such as Lehman Caves east of the area, and locally are moderately permeable. Because of their topographic position in the mountains and their unknown depth and distribution beneath the valley floor, they presently are not considered an economic source of water, except where springs from these rocks discharge to streams that can be utilized for irrigation on the alluvial apron or on the valley floor.

The older alluvium is late Tertiary to Quaternary in age and is composed mostly of gravel and sand formed from debris derived from the adjacent mountains. These deposits underlie the older fans and are characteristically unconsolidated or poorly consolidated, dissected, poorly sorted, and commonly deformed.

The younger alluvium, in contrast to the older alluvium, generally is unconsolidated, undissected, and relatively undisturbed. Two principal types are recognized. The first type is the reworked sand, silt, and clay deposited by the principal streams on the valley floor, and the lake deposits formed in lakes principally during Pleistocene time. The younger alluvium is better sorted than the older alluvium and probably is more porous, and except for the lake deposits, is generally more permeable. Lakes of Pleistocene age occupied an area of about 310 square miles of the valley floor and the lower parts of the alluvial apron. The maximum recognized altitude of the lake surface is 5,780 feet; the maximum recognized area of the lake and the lake deposits are shown on plate 1. Local well drillers report that these deposits locally may be as much as 300 feet thick. Many of the well logs in table 10 indicate a preponderance of clay and silt in the uppermost 200 to 300 feet of alluvium. Below these beds, apparently good aquifers of sand and gravel are present, such as below a depth of 220 feet in well 18/68-31a2.

The second type of younger alluvium is the veneer of gravel and sand deposited on the downstream sides of active faults. This type of younger alluvium is similar to the older alluvium in texture and composition. Some of these faults are range-front faults, others cut older alluvium, causing the rejuvenation of the streams and resulting in the erosion and redeposition of the material as younger alluvium on the downthrown, valley side of the faults. The distribution of the surface exposures of the three generalized lithologic units and the location of identifiable faults of Recent age are shown on plate 1. Where the fan material is thin and mantles the older alluvium, it is not shown, because it is hydrologically insignificant to the water supply of the area.

Most of the economically available ground water in the report area is stored in the younger and older alluvium which form the principal ground-water reservoir. The older alluvium characteristically yields water to wells at low to moderate rates. Moderate to large water supplies probably can be developed in the alluvium beneath the lake deposits on the valley floor. The younger alluvium that forms a veneer on the fans along recently active faults generally is above the water table. The lake deposits, composed of clay and silt, yield very little water to wells.

HYDROLOGY

Precipitation

As stated previously, precipitation has been recorded at nine stations in the Spring Valley area. One of the stations, Schellbourne Pass, is on the drainage divide of Spring Valley in the Schell Creek Range; the other stations are near the valley. (See fig. 2.)

Long-term variations in the precipitation pattern are illustrated by the record at McGill. McGill was selected because it has the longest and most nearly continuous record of all the stations near the study area.

A cumulative departure curve for McGill, shown in figure 3, indicates that two drought periods occurred during the period of record, one in 1926-35 and the other in 1948-62. Above-normal precipitation occurred during the two remaining periods, 1916-25 and 1936-47. The year 1963 and the first part of 1964 had above-average precipitation. It would be premature to conclude that the drought, which began in 1947, has ended.

The average monthly and seasonal precipitation during the year varies greatly. Data for a high-altitude station, Schellbourne Pass (8,100 feet), and a low-altitude station, Geyser Ranch (6,020 feet), are shown in figure 4 to illustrate the seasonal variations and station differences. The average precipitation measured at both stations during the summer and fall was similar in total amount and distribution. Larger amounts, however, were measured at Schellbourne Pass than at Geyser Ranch during the winter and spring. This is the period of regional storms. Both stations show the effects of midsummer thunderstorm activity common to the area by an increase in precipitation during that time.

The precipitation pattern in Nevada is related principally to the topography; the stations at the higher altitudes generally receive more precipitation than those at lower altitudes. However, this relation may be considerably modified by local conditions. For example, Ibapah (elevation 5,280 feet), the lowest station in the area, receives nearly twice as much precipitation as Schellbourne, which is about 1,400 feet higher. Schellbourne Pass, though at 8,100 feet, receives on the average less precipitation than the lower stations at Wilson Creek Summit (7,100 feet) and Lehman Caves (6,825 feet). The stations other than Ibapah, Schellbourne, and Schellbourne Pass, listed in table 2, conform reasonably well to the anticipated precipitation for stations at their altitudes.

Because no precipitation stations have been maintained within Spring Valley, the precipitation pattern in the valley can be estimated only from the records of nearby stations. In comparison, the valley floor probably receives an average of about 4 to 8 inches of precipitation per year. The alluvial apron on Spring Valley, ranging in altitude from about 6,000 to 7,000 feet, probably receives an average annual precipitation of 8 to 12 inches. The higher mountain areas may have an average annual precipitation of 20 inches or more.

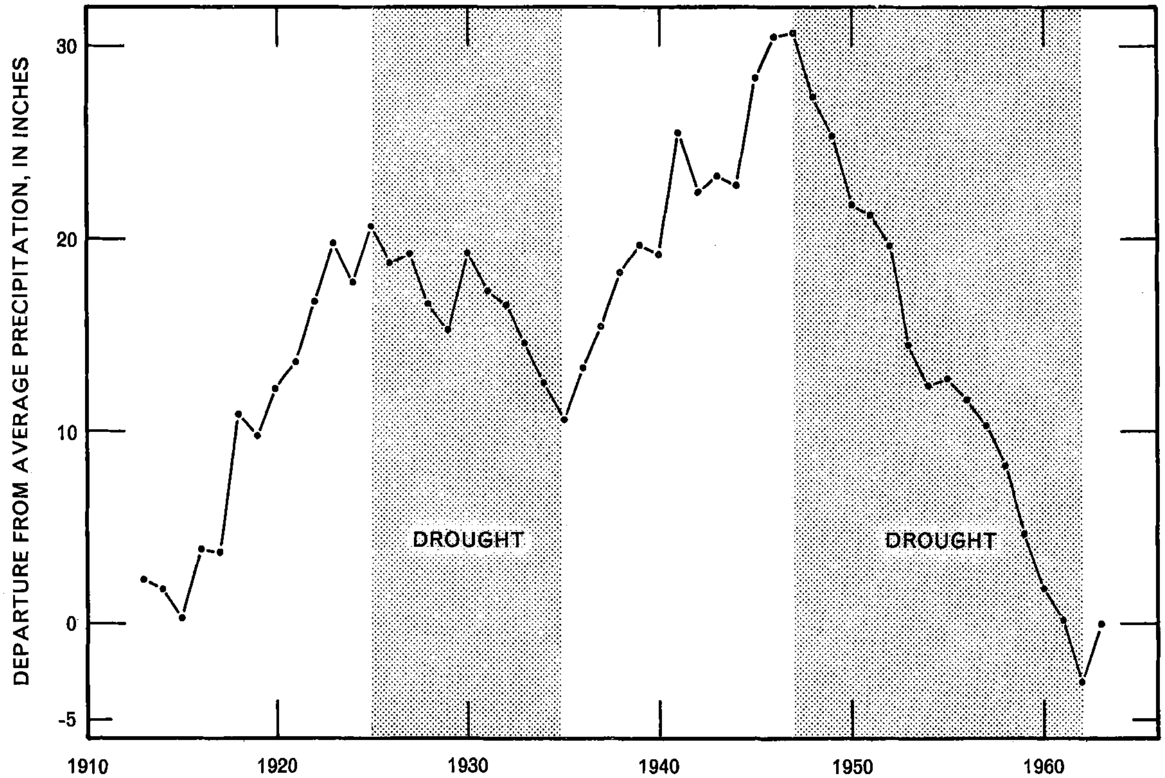


Figure 3.— Graph of cumulative departure from average annual precipitation at McGill for the period 1913-63

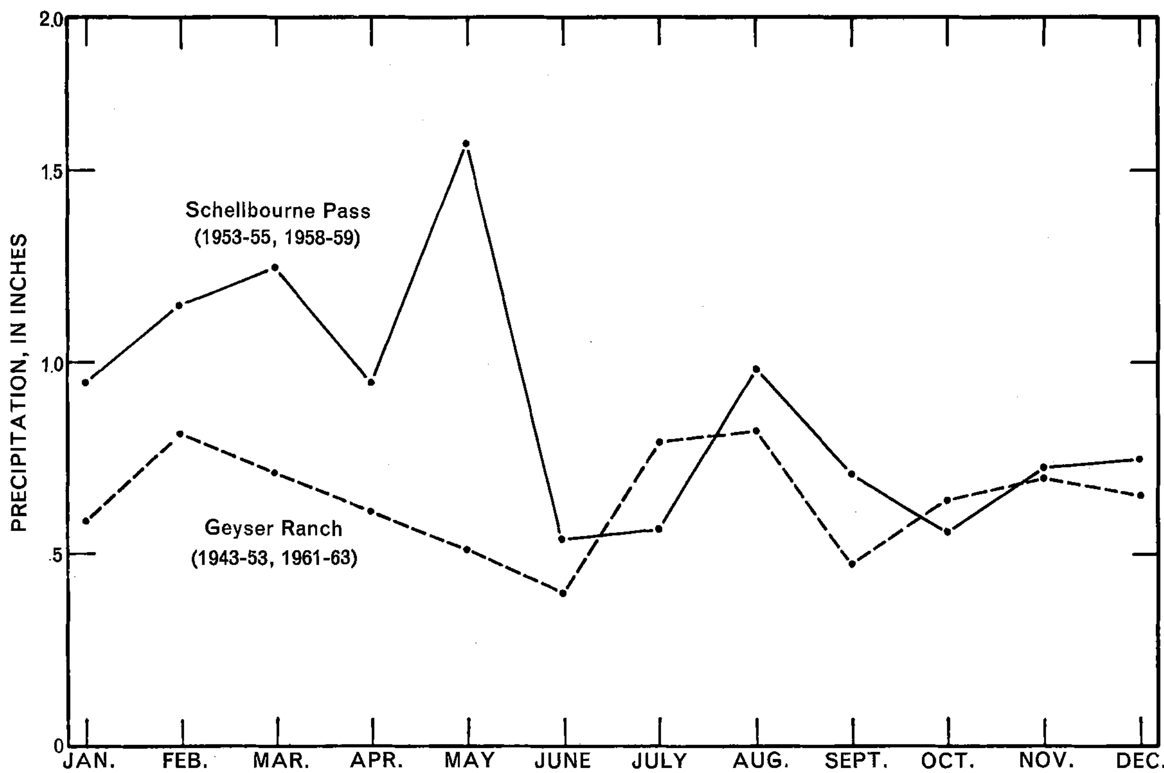


Figure 4.— Graph of average monthly precipitation at Shellbourne Pass and Geyser Ranch

Table 2. --Average monthly and annual precipitation at nine stations near Spring Valley

(From published records of the U. S. Weather Bureau)

Station		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Donahue Ranch	1/	--	--	--	--	--	--	--	--	--	--	--	--	12.78
Ely Airport	2/	0.64	0.66	0.92	0.70	0.92	0.61	0.56	0.44	0.59	0.43	0.52	0.57	7.56
Geyser Ranch	3/	.59	.82	.72	.61	.51	.40	.79	.83	.47	.64	.71	.66	7.75
Ibapah	4/	.70	.97	1.07	1.24	1.59	.94	.80	1.01	.61	.98	.65	.67	11.23
Lehman Caves	5/	.95	1.21	1.57	1.25	1.15	.70	.62	1.03	.70	1.32	1.22	.92	12.64
McGill	6/	.71	.70	.77	.97	1.05	.76	.68	.84	.57	.76	.56	.60	8.97
Schellbourne	7/	.32	.46	.34	.38	.68	.46	.50	1.06	.50	.16	.16	.65	5.67
Schellbourne Pass	8/	.94	1.21	1.31	1.24	1.58	.53	.52	.93	.78	.56	.73	.69	11.02
Wilson Creek Summit	9/	1.62	1.68	1.34	1.09	1.25	.64	.84	1.24	.78	1.03	1.68	.92	14.11

	Altitude (feet)	Location Section	Location Township	Location Range	Period of record (years)	Period of record (years)	Remarks
1.	6,825	29	5N	69 E.	5	1959-64	Storage gage
2.	6,257	35	17N	63 E.	16	1948-63	
3.	6,020	13	9N	65 E.	14	1943-53, 1961-63	
4.	5,280	15	25N	71 E.	58	1903-42, 1946-63	
5.	6,825	15	13N	69 E.	23	1938-48, 1952-63	
6.	6,340	28	18N	64 E.	51	1913-63	
7.	6,720	11	22N	64 E.	5	1953-55, 1958-59	
8.	8,150	8	22N	65 E.	9	1955-63	Storage gage
9.	7,100	26	6N	67 E.	10	1954-63	Storage gage

Surface Water

By Donald O. Moore

General Conditions

Surface water in Spring Valley is derived from precipitation within the drainage area. On the valley floor, where precipitation is light, little streamflow occurs, except that which is fed by mountain streams. Most of the streamflow occurs in the mountains and on the alluvial apron because of the greater average precipitation, and its accumulation as snow during the winter months.

The snow and rain in the mountains in part infiltrates the rock material, becoming ground water, and in part collects into small, short streams. These streams collect to feed the major mountain streams that flow onto the alluvial apron, where much of the streamflow is absorbed by the alluvium. Under native conditions, only the major mountain streams flowed to the two playa areas in Tps. 12 and 17 N., R. 67 E., and then probably only during periods of high runoff. Most of the larger mountain streams have been diverted and utilized for irrigation, thus minimizing flow to the lower parts of the valley floor.

The largest stream in the area is Cleve Creek, which has its source high in the Schell Creek Range near South Schell Peak (T. 17 N., R. 66 E.). A gaging station on Cleve Creek near Ely has been maintained by the U.S. Geological Survey for several years. The gage is near the bedrock-alluvium contact at an altitude of about 6,220 feet. In areas similar to Spring Valley, streams commonly have their maximum rate of flow near the bedrock-alluvium contact. The monthly and yearly runoff and the minimum and maximum momentary rates of discharge for Cleve Creek for each water year of record are listed in table 3.

For the period of record, the average annual runoff was 6,270 acre-feet. April through June was the period having the highest rate of runoff, which averaged about 900 acre-feet per month. The total for the 3-month period was about 45 percent of the yearly total. During the remainder of the water year, the average monthly runoff was about 390 acre-feet, or 6.5 cfs (cubic feet per second).

The maximum momentary discharge rates for Cleve Creek, averaging 38 cfs, probably are caused by rapid melting of accumulated snow. The minimum momentary discharge rates, occurring during the winter months and averaging 3.5 cfs, represent the base flow from ground-water sources. In fact, the average flow of 6.5 cfs during the period July through March is also largely base flow from ground-water sources within the mountains.

The other major streams of the valley probably have similar runoff

Table 3. --Monthly and yearly runoff, in acre-feet, of Cleve Creek in Spring Valley

(From published records of the U. S. Geological Survey)

Water year ending Sept. 30	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Year	Momentary rate: Maximum: Discharge (cfs)	Momentary rate: Maximum: Date (month and day)	Momentary rate: Minimum: Discharge (cfs)	Momentary rate: Minimum: Date
1914	--	--	--	--	--	--	--	--	1750	873	609	529	--	44	6 -3	--	--
1915	539	534	446	497	447	510	791	1200	1230	621	442	363	7620	30	6-8, 10	--	--
1916	442	436	396	297	358	910	1110	1490	1020	504	419	374	7760	32	5 -9	--	--
1917	507	494	359	--	--	--	--	--	--	--	--	--	--	--	--	4.1	12-18
1960	287	283	289	249	254	324	377	528	372	305	245	233	3740	13	5 -5	2.3	2-27
1961	281	304	263	251	253	286	389	631	510	318	297	257	4040	56	8-24	3.0	2- 4
1962	290	269	284	274	313	367	1450	1110	885	505	362	315	6420	39	4-15	3.5	1-23, 24
1963	356	360	328	316	428	358	374	895	1620	610	426	403	6470	56	6-13	3.5	1-12
1964	392	388	414	408	386	399	461	1320	877	498	439	384	6370	38	5-20	4.5	11-12
Average (rounded)	387	384	347	326	348	451	707	1020	1010	529	405	356	6270	38		3.5	

characteristics; however, gages have not been maintained on them. During July and August 1964, when the field work was being done for this report, miscellaneous observations of the streamflow were made by Lane Nalder, U.S. Geological Survey, and the authors. These data are listed in table 4, and the observation sites are shown on plate 1. In mid-July 1964 the 13 major creeks had a combined flow of about 50 cfs.

Estimated average annual runoff

A method of estimating runoff in Nevada has recently been devised by the author of this section and is applicable to areas of Nevada where little or no streamflow data are available (Eakin and others, 1965). The method is a reconnaissance technique, still in the development stage, and is useful in showing the magnitude and distribution of runoff in the valley. The runoff is estimated at the bedrock-alluvium contact, which in Spring Valley ranges in altitude from about 6,000 to about 7,200 feet (pl. 1) and averages nearly 7,000 feet.

Briefly, the method for estimating the average annual runoff is based on the general condition that the higher altitudes receive more precipitation than the lower altitudes. (See preceding discussion of precipitation.) It is therefore assumed that the higher altitudes also produce more runoff than the lower areas. Because the relations of precipitation, altitude, and runoff are different in the various parts of the State (and even in the various parts of Spring Valley), different correlation factors are used to adjust the altitude-runoff relationship for the several mountain areas. This adjustment is based on streamflow measurements, differences in vegetation, amounts of precipitation, and geology.

The estimated average annual runoff in Spring Valley, summarized in table 5, is 90,000 acre-feet per year, or about 20 percent of the estimated average annual precipitation at altitudes above 7,000 feet. (see table 6.)

Runoff is not evenly distributed throughout the mountains. It is estimated that about 81 percent occurs in the mountains on the western side of the valley and the remainder on the eastern side. Of the western mountains, the central part of the Schell Creek Range (T. 17 N. to T. 22 N.), though comprising only 18 percent of all the mountain area, yields 62 percent of the runoff. Of the 13 creeks that were found to be flowing in midsummer 1964 (listed in table 4), 7 were in this segment of the Schell Creek Range. These seven creeks have a projected flow of about 23,000 acre-feet per year.

The high mountains of the southern part of Snake Range (the Wheeler Peak area) would generally be expected to produce more runoff than is computed in the table. Several factors may cause the reduction from the anticipated amounts, two of the factors being less than expected precipitation and unfavorable geologic structure. Whitebread and others

(1962) show on their geologic map of the Wheeler Peak quadrangle many eastward-dipping fault zones. These zones may be highly permeable and may absorb and transmit large quantities of water to the eastern side of the range, where it is discharged as spring-fed mountain streams. This fault pattern appears to be complemented by generally southeastward dipping bedrock toward the southern end of the Snake Range.

Table 4. -- Miscellaneous streamflow measurements in Spring Valley

Map 1/ No.	Site	Location Township	Range	Date	Discharge 2/ (cfs)
1.	Dry canyon and Williams Canyon Creeks	12 N.	68 E	7-14-64	(3.)
2.	Pine and Ridge Creeks	13 N.	67 E	7-14-64	(3.)
3.	Willard Creek	13 N	68 E	7-12-64	.35
4.	Cleve Creek	16 N	66 E	7-14-64	8.3
				8-15-64	7.1
5.	(Unnamed)	16 N	68 E	7-14-64	3.03
6.	Taft Creek	17 N	66 E	7-14-64	(3.)
				9-18-64	(2.)
7.	McCoy Creek	17 N	66 E	7-14-64	9.52
				8-15-64	5.95
8.	(Unnamed)	18 N	68 E	7-14-64	.07
9.	Bassett Creek	18 N	66 E	7-16-64	(5.)
				8-15-64	3.13
10.	Kalamazoo	20 N	66 E	7-14-64	6.87
				8-15-64	4.56
11.	Muncy Creek	20 N	66 E	7-14-64	4.23
				8-15-64	1.98
12.	North Creek	21 N	65 E	7-14-64	2.23
13.	Seigel Creek	22 N	66 E	7-16-64	(2.)
	Total (rounded)				50

1. Map number corresponds to the measuring site number shown on Plate 1.

2. Numbers in parentheses are estimated.

Table 5. --Distribution of the estimated average annual runoff in Spring Valley.

(Runoff computed at the bed-rock alluvium contact)

Mountain segment	Location	Area (Acres)	Area (Percent of runoff area)	Estimated runoff (Acre-feet per year)	Estimated runoff (Percent of total runoff)
		WESTERN MOUNTAINS			
Schell Creek Range					
Northern part	T.23N., T24 N.	24,000	7	2,000	2
Central part	T.17N., toT22 N.	64,000	18	56,000	62
Southern part	T.11N.to T16 N.	83,000	24.	13,000	14
Wilson Creek and Fortification Ranges	T.6 N. to T.10 N.	16,000	5	3,000	3
Subtotal		187,000	54	74,000	81
		EASTERN MOUNTAINS			
Antelope Range, Red Hills, and Kern Mountains	T.20N., to T.25 N.	50,000	14	4,000	5
Snake Range					
Northern Part	T.18N., T.19 N.	26,000	7	5,000	6
Central Part	T.15N., T17 N.	32,000	9	4,000	5
Southern part	T. 9N., T14 N.	55,000	16	3,000	3
Subtotal		163,000	46	16,000	19
Total (Rounded)		350,000	100	90,000	100

Development

At Osceola, on the western slope of the Snake Range near Wheeler Peak, gold-placer deposits were discovered in 1877. The gold rush to Osceola began in the same year, and from 1880 until the turn of the century creeks were diverted for hydraulic mining of gold, silver, and lead. One of the largest projects undertaken at Osceola was the construction of about 35 miles of ditch, 18 miles of which was on the Snake Valley side of the range and 17 miles on the Spring Valley side. This ditch collected and carried water from the streams draining the slopes of the Snake Range for the hydraulic mining. These activities at their height supported a population at Osceola of about 2,000.

At present all the large creeks of the valley are diverted and used for irrigation and stock watering. About 8,700 acres is now being irrigated with water from all sources, according to Lester McKenzie of the Soil Conservation Service (written communication, 1965). About 60 percent, or 5,200 acres, is irrigated by streamflow; the remainder by springs and wells.

The largest irrigation project in the northern part of the valley is on the Cleveland Ranch, where in 1964 about 2,500 acres of grass and alfalfa was irrigated with water from Cleve and Stephens Creeks and springs. At the Robinson Ranch (T. 19 N., R. 66 E.) about 500 acres, mostly of alfalfa, was irrigated with flow from Meadow and Piedmont Creeks. The operator of Bastian Creek Ranch reports that 300 acres of grass and alfalfa was irrigated in 1964 from Bastian Creek (T. 15 N., R. 66 E.). On the Doutre Ranch (T. 21 N., R. 66 E.) about 40 acres of alfalfa and 50 acres of barley and oats were grown in 1963 and 1964. The eight previous years were reported to be dry, during which time less acreage was utilized. The source of water is Seigel Creek.

Other sources of streamflow used for irrigation are: Muncy and Kalamazoo Creeks (Eldridge Ranch), Garden and Bassett Creeks (Bassett Ranch), Odgers and Nigger Creeks (Robinson Ranch, T. 18 N., R. 66 E), McCoy Creek (Heckethorne Ranch), Taft Creek (Yelland Ranch). Pipelines have been constructed to carry water from Taft, Odgers, and Nigger Creeks to the point of utilization on the nearby ranches. An estimated 3,400 acres is irrigated by streamflow in Spring Valley north of U.S. Highways 6 and 50.

In the southern part of the valley, about 1,500 acres is irrigated by streamflow; much of the acreage is subirrigated. Pipelines carry water from Williams Canyon and Shingle Creek to nearby ranches. The other major sources of streamflow in this part of the valley, Swallow and Dry Canyons and Ridge and Pine Creeks, are diverted to fields by ditches.

Using a consumptive-use factor of 1.5 acre-feet for the irrigation of alfalfa, pasture, and small grain, about 8,000 acre-feet of surface water is needed for the estimated 5,200 acres of land irrigated from creeks. However, an amount considerably in excess of this amount of water is supplied to the fields.

During the nongrowing season, over 200 days per year, much of the streamflow of the valley runs to waste. Some of the water flows to the playas and is evaporated, but a large part seeps into the ground and recharges the ground-water reservoir. Because this recharge is potentially available for ground-water development, the amount of seepage is not generally considered wasted. However, from a surface-water utilization standpoint, some of the winter flow could be stored in reservoirs for irrigation. The economics of water use in the valley may require that such storage be left undeveloped in favor of supplemental development of ground water by the use of irrigation wells.

Ground Water

Occurrence and Movement

Ground water occurs under both confined (artesian) and unconfined (water-table) conditions. Hydrostatic heads in a few wells and all springs are at or above land surface, and occur principally along the east side of Baking Powder Flat (Tps. 11, 12, and 13 N., R. 67 E.) and on the west side of the northern part of the valley (Tps. 16 and 17 N., R. 67 E., and T. 18 N., R. 66 E.), as shown on plate 1. Wells 23/66-31a1 and 23/66-31b2, one of which is 600 feet deep, are at the north end of the valley and yield small flows of water of above-normal temperature (table 9). The five flowing wells in sec. 2, T. 12 N., R. 67 E., at Baking Powder Flat, yield water of a similar temperature. Two were drilled to depths of 407 and 750 feet.

The thickness of the ground-water reservoir is not known, because no wells penetrate the entire thickness of the alluvium. Bedrock was reached in two wells in the valley at depths of 20 feet and 300 feet; however, both these wells were on the valley margins where the alluvial thickness is considerably less than beneath the valley floor. A deep flowing well (23/66-31b2) was reportedly drilled to a depth of 1,040 feet along the axis of the north end of the valley. No log is available for the well, and therefore it is not known whether bedrock was penetrated during its construction.

In all parts of the valley, except south of Baking Powder Flat, ground-water movement is in the direction of surface flow; that is, from the mountain areas toward the valley floor, where much of it is discharged by evapotranspiration. Subsurface flow occurs principally in the alluvium, the water passing through the intergranular spaces. South of Baking Powder Flat, ground-water movement is generally from the mountains toward the axis of the valley, but rather than flowing northwestward along the valley axis toward the flat it flows southeastward, as indicated by figure 5. The water levels in wells 10/67-16a1 and 11/68-31c1 are at altitudes of about 5,815 feet and 5,795 feet, respectively, as indicated in table 9. Along the axis of the valley between the two wells the water level probably is no lower than 5,790 feet. Fifteen miles southeastward, well 8/68-14a1 has a water-level altitude of 5,760 feet, or 30 feet lower. These data indicate a minimum hydraulic gradient of about 2 feet per mile to the southeast and a flow of ground water in that general direction.

Across the topographic divide to the east, well 8/69-15b1 in Hamlin Valley has a ground-water altitude of about 5,674 feet, or 86 feet lower than well 8/68-14a1. Two wells 4 miles farther to the northeast and southeast in Hamlin Valley have still lower water levels. These data indicate subsurface outflow of ground water from Spring Valley to Hamlin Valley.

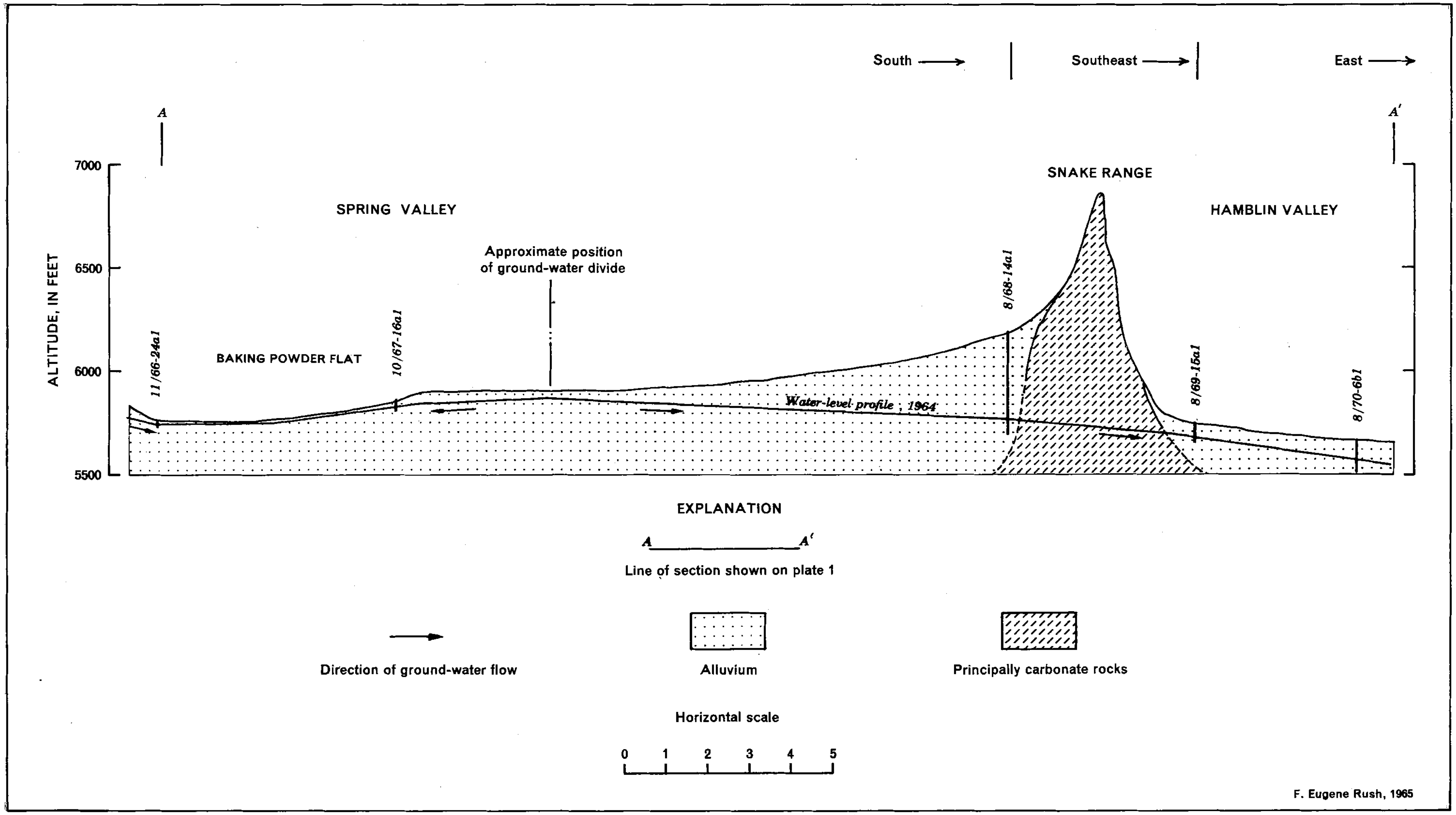


Figure 5.— Cross section of southeastern Spring Valley showing the general topography, water table, and direction of ground-water flow

Recharge

Ground water in Spring Valley, like the surface water, is derived from precipitation within the drainage basin. On the valley floor, where precipitation is slight, little if any infiltrates to the ground-water reservoir. Greater precipitation in the mountains and on the alluvial apron provides most of the recharge.

Part of the snow and rain in the mountains infiltrates the rock material and part collects into small, short streams, which generally are absorbed on the alluvial fans. Much of this water is evaporated before and after infiltration, some adds to soil moisture, and some percolates to the water table and recharges the ground-water reservoir.

Little of the precipitation occurring in the low-lying areas reaches the water table; rather, the moisture is held in the alluvium and is used by the plants or is evaporated. The water that reaches the main stream channels by surface and subsurface flow generally is absorbed by the alluvium as it flows toward the lowest parts of the valley floor.

Although precipitation within the drainage basin is the principal source of recharge to the ground-water reservoir in Spring Valley, only a small percentage reaches the ground-water reservoir. A method described by Eakin and others (1951, p. 79-81) is used in this report to estimate recharge. The method assumes that a fixed percentage of the average annual precipitation recharges the ground-water body. Hardman (1936) showed that in gross aspect the average annual precipitation in Nevada is related closely to altitude and that it can be estimated with a reasonable degree of accuracy by assigning precipitation rates to various altitude zones.

The amount of precipitation and percentage of recharge from precipitation in Spring Valley seem to be similar to the general conditions found in many areas covered by the Reconnaissance Series reports. The distribution of the average annual precipitation is delineated as follows: 8 inches at an altitude of 6,000 feet, 12 inches at 7,000 feet, 15 inches at 8,000 feet, and 20 inches at 9,000 feet. Five precipitation zones have been selected according to the above values. The zones, the estimated precipitation, and the estimated recharge for the area are summarized in table 6.

The preliminary estimate of the average annual precipitation in Spring Valley is 960,000 acre-feet. The estimated ground-water recharge is about 75,000 acre-feet per year, or about 8 percent of the estimated precipitation.

Ground water in that part of Spring Valley southeast of a line connecting the southwest corner of T. 10 N., R. 67 E., and the northeast corner of T 10 N., R. 68 E., is discharged by subsurface outflow principally through the carbonate rocks of the Snake Range to Hamlin Valley (pl. 1 and fig. 5). The annual recharge in this 120,000-acre drainage area is estimated to be about 3,500 acre-feet.

Table 6. --Estimated average annual precipitation and ground-water recharge in Spring Valley

Precipitation zone (altitude-feet)	Area (acres)	Estimated annual precipitation: Range (inches)	Average (inches)	Average (feet)	Average (acre-feet)	Estimated recharge from precipitation: Percentage of Precipitation	Acre-feet per year
Above 9,000	59,100	more than 20	21	1.75	103,000	25	26,000) a
8,000 to 9,000	107,300	15 to 20	17.5	1.46	156,000	15	23,000) a
7,000 to 8,000	183,500	12 to 15	13.5	1.12	206,000	7	14,000) a
6,000 to 7,000	393,000	8 to 12	10	.83	326,000	3	10,000) b
Below 6,000	342,000	less than 8	6	.50	171,000	0	0) b
Total (rounded)	1,085,000				960,000		75,000

a. Recharge from streams in the mountains and on the alluvial apron and underflow from the mountains to the alluvium.

b. Recharge from precipitation on the alluvial apron.

Discharge

Prior to development by man, all the ground water in Spring Valley was discharged by evaporation, transpiration, and subsurface outflow to Hamlin Valley. With the advent of mining and agriculture, springs and streamflows were diverted and wells were pumped to satisfy industrial, domestic, stock, and irrigation needs. The net result has been a small increase in the draft on the ground-water reservoir. The estimated total natural discharge is nearly 75,000 acre-feet per year; pumpage and flow from wells in 1964 totaled only about 1,000 acre-feet.

Evapotranspiration.--Most of the ground water is discharged by transpiration of phreatophytes and evaporation from bare soil. The plants grow over much of the valley floor and include greasewood, rabbitbrush, meadow grass, and salt grass. Cottonwood, willow, and wild rose grow along the banks of the creeks in many of the canyons. "Swamp cedar," its unusual presence on the valley floor first noted by Simpson (1876, p. 120), is in Tps. 12, 15, and 16 N., R. 67 E. (pl. 1). The areas where these "cedars" grow are generally wet, because of a shallow water table. Generally in the Great Basin, similar types of trees are restricted to the mountains and the upper slopes of the alluvial apron.

Table 7 lists the acreage of the phreatophytes and bare soil in the valley and summarizes the estimates of evapotranspiration, which are based on rates of consumption of ground water in other areas as described by Lee (1912), White (1932), Young and Blaney (1942), and Houston (1950). The area of ground-water discharge consists of about 186,000 acres of the valley floor. Most of the area is covered by phreatophytes; the dominant types are greaswood and rabbitbrush, which cover about 75 percent of the discharge area. The two playas account for about 11,600 acres. The preliminary estimate of the average annual discharge of phreatophyte areas and bare soil is 70,000 acre-feet.

Springs.--A large number of springs are along the margin of the valley floor and within the surrounding mountains. Most of the larger springs are shown on plate 1. Two notable areas of spring discharge are along the west side of the valley north of U.S. Highways 6 and 50, and on the east side of the valley south of the highways. These two areas are adjacent to the two mountain blocks that have the highest rates of precipitation and recharge.

Many of the springs along the margin of the valley are in the form of seeps; however, in some areas, notably near Shoshone (T. 11 N., R. 67 E.) and at the Cleveland Ranch (T. 16 N., R. 67 E.), the localized flow is considerable. The discharge from the springs supports extensive areas of grass. The total discharge of ground water by springs has not been estimated because of their large number and the limited scope of this investigation. However, because they support phreatophyte growth, their discharge is included in estimated average annual discharge by phreatophytes in table 7 as discussed previously in this section of the report.

Table 7. --Estimated average annual discharge by phreatophytes in Spring Valley

Means of ground-water discharge	Depth to water (feet)	Area (acres)	Average areal density (percent)	Probable average rate of use of water (acre-feet per acre per year)	Approximate discharge (acre-feet)
Wet meadow & salt grass	0- 5	14,600	50	1.5	22,000
Saltgrass, rabbitbrush, and moderately wet meadow	0-10	13,200	30	1.0	13,000
Greasewood, saltgrass, meadow grass, and "swamp cedar" in varing proportions	5-15	7,100	30	.5	3,600
Greasewood and rabbitbrush	10-50	139,000	15	.2	28,000
Base soil & sparce vegetation	5-15	11,600	--	.1	1,200
Cottonwood, willow and wild rose	0- 5	Trace	50	2.0	Trace
Total (rounded)		186,000			70,000

Subsurface outflow.--Subsurface, or ground-water, outflow occurs from the southeastern part of Spring Valley principally through the carbonate rocks of the Snake Range to Hamlin Valley. (See discussions of occurrence, movement, and recharge.) Based on an average water-level gradient in the alluvium east of well 8/68-14a1 of about 20 feet per mile (fig. 5), an approximate flow width of 4 miles, and an assumed coefficient of transmissibility of the alluvium of 50,000 gpd per foot, the estimated outflow is roughly 4,000 acre-feet per year. This quantity agrees reasonably well with the estimated recharge of 3,500 acre-feet per year for the area south of the ground-water divide in Spring Valley (pl. 1 and fig. 5).

Eastward movement of ground water from other parts of Spring Valley has not been identified, although carbonate rocks, which are moderately permeable, occur throughout most of the Snake Range.

Discharge from wells.--A few wells are pumped in Spring Valley but only a small amount of the available ground water is utilized. Though stock and domestic wells are numerous, their combined discharge is small, probably not exceeding 200 acre-feet per year. About 10 irrigation wells are used in the valley; their use is limited to years when streamflow is insufficient to satisfy the needs for irrigation. In 1963 and 1964 the wells generally were not used because of adequate snowmelt feeding the creeks. At the time the field work for this report was being done, in July and August 1964, only one irrigation well (13/67-31a1) was being pumped to irrigate about 130 acres of grain. The pumpage estimate for the season was 300 acre-feet. The irrigation of this acreage is entirely dependent on the well because no surface-water supply is available. In 1963, well 12/67-12d3 at the Kirkeby Ranch reportedly pumped about 180 acre-feet of water. The two irrigation wells on the Robison Ranch (T. 18 N., R. 66 E.) have not been used since 1962. No pumpage data are available for irrigation wells in the valley prior to 1962.

Flowing wells discharge an estimated 700 acre-feet of ground water per year. Some of this discharge is used for domestic and stock-watering purposes; however, most of it supports meadow grass and rabbitbrush or percolates back to the water table. The discharge of these wells, like that of the springs, is included in the estimated average annual discharge by the phreatophytes and bare soil.

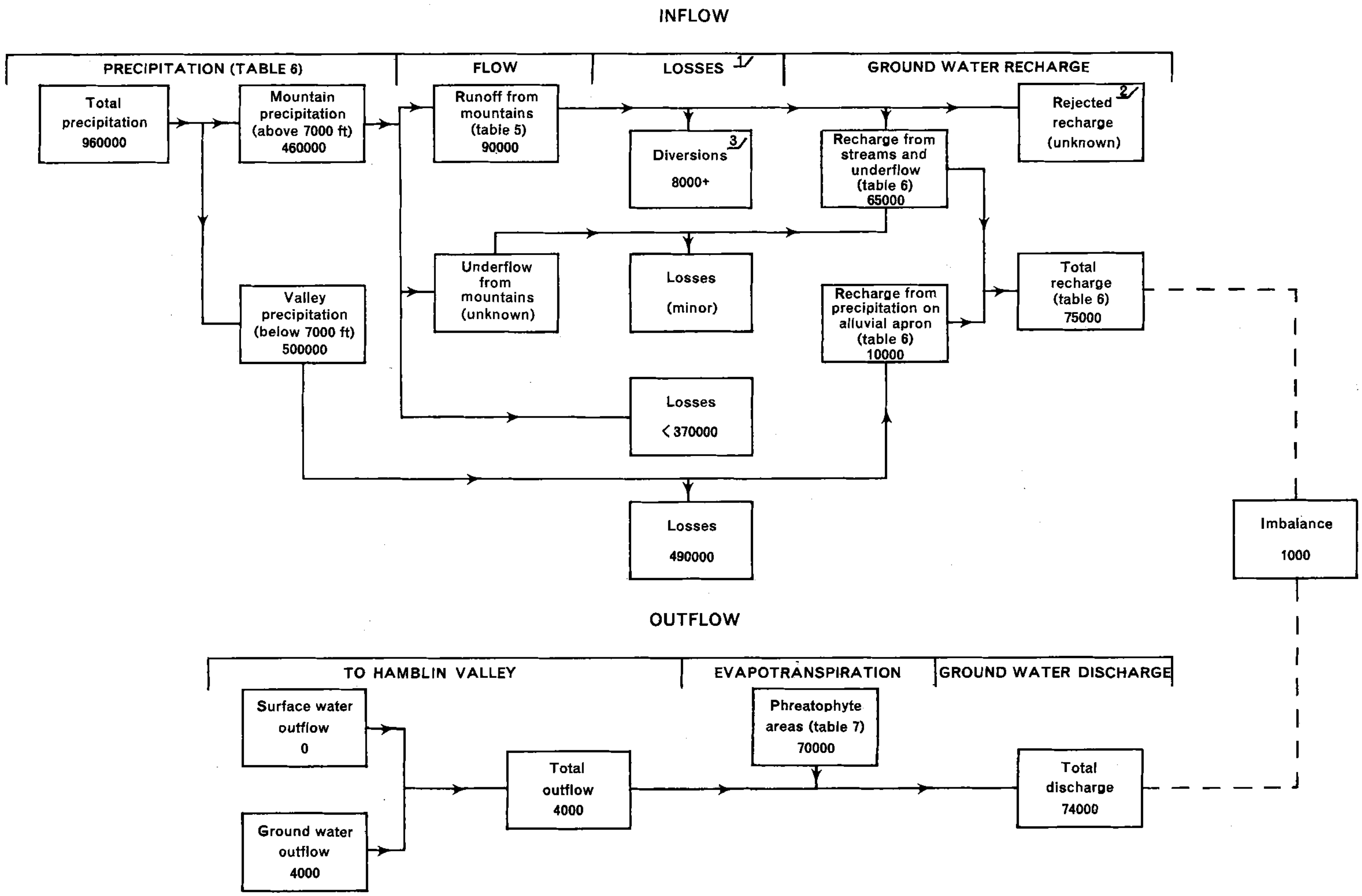
Water Budget

The surface-water and ground-water flow systems in Spring Valley have been modified only to a minor extent by the activities of man. The principal change has been the diversion of somewhat more than 8,000 acre-feet of streamflow for irrigation. In effect, this diversion has modified the system only to the extent of putting to beneficial use this amount of water that formerly was consumed by native vegetation and evaporation on the valley floor.

A water budget showing the gross hydrologic components of the flow system is presented in figure 6. The estimate of ground-water recharge (table 6) includes (1) recharge by seepage loss from streams both in the mountains and on the alluvial apron and subsurface inflow from the mountains to the alluvium (65,000 acre-feet); and (2) deep infiltration of precipitation on the higher parts of the alluvial apron (10,000 acre-feet). The estimated runoff from the mountains, or at the bedrock-alluvium contact (table 5), represents the surface-water inflow to the valley (90,000 acre-feet). As mentioned above, part seeps into the alluvium and part is diverted for irrigation. The remainder, termed rejected recharge in figure 6, flows onto the playas and is lost by evaporation.

No data are available to estimate the seepage loss, the subsurface inflow from the mountains, or the amount of streamflow reaching the playas. Thus, several critical elements of the water budget in figure 6 cannot be estimated at this time.

Because pumpage has been small, the natural regimen has been only slightly disturbed. This is suggested by the close agreement between the estimates of recharge and natural discharge, each about 75,000 acre-feet per year. That these independently derived estimates are nearly equal (an imbalance of only 1,000 acre-feet per year, as shown in figure 6) should not be construed to indicate a high order of accuracy for either value; rather, both are based on limited data and are considered to be preliminary and subject to refinement.



1. The losses from precipitation are from soil moisture and use by native vegetation
2. Rejected recharge is principally the runoff reaching the playas, where it is lost by evaporation
3. Includes subirrigated meadow and cropland

Figure 6.—Generalized water budget, in acre-feet per year, for Spring Valley, Nevada

Perennial Yield

The perennial yield of a ground-water reservoir is the maximum amount of water of usable chemical quality that can be withdrawn and consumed economically each year for an indefinite period of time. If the perennial yield is continually exceeded, water levels will decline until the ground-water reservoir is depleted of water of usable quality or until the pumping lifts become uneconomical to maintain. Perannial yield cannot exceed the natural recharge to an area indefinitely, and ultimately it is limited to the amount of natural discharge that can be salvaged for beneficial use.

Figure 6 shows that the total average annual natural discharge consists of an estimated 70,000 acre-feet of evapotranspiration, 4,000 acre-feet of ground-water outflow to Hamlin Valley, and an unknown amount of rejected recharge, or surface-water flow to the playas. If the total discharge and the amount of losses that could be salvaged were known, the perennial yield would be known. A minimum yield can be based on the assumptions that virtually all the ground-water evapotranspiration loss of 70,000 acre-feet per year could be salvaged but that very little of the ground-water outflow to Hamlin Valley could be salvaged. Using these assumptions, the estimated minimum yield would be about 70,000 acre-feet per year.

Of the estimated average annual runoff of 90,000 acre-feet at the mountain front, somewhat more than 8,000 acre-feet is diverted for irrigation, leaving the remainder for ground-water recharge and waste to the playas (fig. 6). Even if water levels were drawn down substantially beneath the alluvial aprons, the opportunity for additional recharge by seepage loss from streams is limited by the short distance between the mountain front and the playas. Moreover, it is recognized that even with depressed water levels and without surface-storage reservoirs, much of the storm runoff would reach the playas.

The amount of rejected recharge that could be salvaged by extensive and well-distributed pumping might be on the order of one-third of the estimated runoff at the mountain front. If this assumption is a reasonable measure of the salvage, then the preliminary estimate of perennial yield of Spring Valley would be on the order of 100,000 acre-feet. Obviously, the magnitude of the yield will be governed by the controlling hydrologic factors set forth in the preceding paragraphs.

Storage

Recoverable ground water in storage is that part of the stored water that will drain by gravity from the ground-water reservoir. Under native conditions the amount of stored ground water remains nearly constant. The balance of recharge to discharge, which controls the changes of ground water in storage, has been disturbed only slightly by the diversion of small amounts of surface and ground water. Water-level measurements have been made in seven wells in Spring Valley for a period of several years. These data, listed in table 9, show that the water levels in the ground-water reservoir have been declining locally at a very slow rate, indicating a small decrease in the quantity of stored ground water. The decrease could be attributed to the local increased draft on the stored water due to pumping or to the decrease in ground-water recharge associated with the recent drought (fig. 3). Probably both factors have contributed to the decrease in storage.

Specific yield of a rock or soil is the ratio of (1) the volume of water which, after being saturated, it will yield by gravity to (2) its own volume. This ratio is stated as a percentage. In Spring Valley, the average specific yield of the younger and older alluvium (the ground-water reservoir) probably is at least 10 percent. The estimated area underlain by 100 feet or more of saturated alluvium is at least 420,000 acres, or roughly 80 percent of the 548,000 acres mapped as alluvium. Therefore, the estimated volume of recoverable water stored in this block of ground-water reservoir is at least 4.2 million acre-feet. This large reserve of stored water is more than ample to meet foreseeable future demands during periods of below-average precipitation and recharge or short periods of overdraft.

Chemical Quality of the Water

Ten water samples were collected and analyzed as part of the present study to make a generalized appraisal of the suitability of the ground and surface water for agricultural use and to help define potential water-quality problems. These analyses and five more are listed in table 8.

Suitability for agricultural use.--According to the Salinity Laboratory Staff, U.S. Department of Agriculture (1954, p. 69), the most significant factors with regard to the chemical suitability of water for irrigation are dissolved-solids content, the relative proportion of sodium to calcium and magnesium, and the concentrations of elements and compounds that are toxic to plants. Dissolved-solids content commonly is expressed as "salinity hazard," and the relative proportion of sodium to calcium and magnesium as "alkali hazard."

The Salinity Laboratory Staff suggests that salinity and alkalinity hazards should be given first consideration when appraising the quality of irrigation water, then boron or other toxic elements, and bicarbonate, any one of which may change the quality rating.

All samples analyzed had a low or medium rating for salinity and alkali hazards, except the three from stock wells 13/76-33dl, 16/67-27dl, and 18/67-lcl, which had high salinity hazard ratings. Water from these wells and any nearby wells tapping the same shallow aquifer probably would be unsuitable for irrigation. The sample from well 16/67-27dl had a high residual sodium carbonate (RSC) value, and is classified as not suitable on this additional basis.

Table 8.--Chemical analyses, in parts per million, of water from selected sites and sources in Spring Valley

[Field analyses of U.S. Geological Survey. SAR, Sodium adsorption ratio; RSC, Residual sodium carbonate]

Location (well or spring no.)	Date of collection	Source type	Temperature (°F)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) Potassium (K) (computed by difference)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH	SAR	RSC	Salinity hazard	Alkalinity hazard
9/67-27a1	7-15-64	Spring	70	24	6.8	18.	122	0	11	11	88	0	236	7.9	0.8	0.24	Low	Low
11/67-1c1	--	Domestic well	54	58	12.	8.2	220	0	14	7	194	14	374	--	.3	.0	Medium	Low
12/67-2a1	7-16-64	Flowing well	75	23	.9	13.	92	0	6.4	5.2	61	0	161	7.7	.7	.29	Low	Low
13/67-15d1	6-21-50	Domestic well	64	17	3.3	14.	84	0	7.0	7	56	0	161	--	.8	.26	Low	Low
13/67-18d1	7-14-64	Stock well	54	39	22.	12.	204	0	34	8	189	0	395	8.2	1.2	.0	Medium	Low
13/67-33d1	7-14-64	Stock well	57	61	14.	82.	239	16	52	80	211	0	750	8.5	7.8	.23	High	Medium
13/67-35d1	5-26-49	--	73	18	1.0	16.	88	0	5.8	3.5	49	0	158	--	1.0	.46	Low	Low
14/66-24a1	7-15-64	Stock well	53	48	26.	22.	220	0	63	19	226	0	499	7.8	2.0	.0	Medium	Low
15/68-8b1	7-15-64	Stock well	54	65	33.	21.	346	0	26	23	298	0	626	8.0	1.6	.0	Medium	Low
16/66-13a1	7-16-64	Spring	55	38	7.8	15.	172	0	12	4.7	127	0	287	7.8	3.6	.28	Medium	Low
Sec. 28, T. 16 N., R. 66 E.	7-16-64	Cleve Creek	65	5.0	1.1	4.1	22	0	6.4	1.0	17	0	42	7.3	4.4	.02	Low	Low
16/67-27d1	7-15-64	Stock well	60	58	30.	105.	521	0	36	23	270	0	911	8.0	8.8	3.15	High	Medium
18/66-25a1	6-21-50	Domestic well	54	10	3.6	12.	63	0	3.9	5	40	0	112	--	.8	.24	Low	Low
18/67-1c1	7-16-64	Stock well	54	47	26.	122.	264	0	148	85	225	0	975	8.1	11.2	0	High	Medium
23/66-31a1	6-22-50	Domestic well	89	24	7.4	34.	141	0	22	16	90	0	309	--	1.6	.50	Medium	Low

Water quality and its relation to the ground-water system.--The water of best quality has had a minimum contact with the rocks and soil. In hydrogeologic environments such as occur in Spring Valley, the surface water flowing in the mountain streams and down across the alluvial fans can be expected to be of low mineral content. This is apparent from the analysis of Cleve Creek water (table 8), which has a specific conductance of only 42 micromhos at 25°C--an indication of very low dissolved solids. The other creeks that flow from the Schell Creek and Snake Ranges probably have similarly low dissolved solids. The surface water that wastes to the playas and ponds there can be expected in time to become poor in quality through the processes of concentration by evaporation and solution of the concentrated salts from the soil on the playas.

The ground water in the valley generally has a much higher dissolved-solids content than the mountain streams, as can be seen in table 8. As previously mentioned, this is caused by the length of time that the ground water has been in contact with the rock and soil and the distance the water has passed through them. The dissolved-solids content is least near the areas of recharge; it is greatest usually in the discharge areas farthest from the areas of recharge. In Spring Valley, the ground water of lowest dissolved-solids content probably will be found on the western side of the valley north of U.S. Highways 6 and 50. In the discharge area, the phreatophytes use the ground water and much is lost by evaporation, leaving a concentration of salts in the soil. As a result, the shallow ground water in the central part of the discharge area can be expected to be of poor quality, as was found in well 13/67-33dl.

At depth the water may be of better quality; however, data are not available to demonstrate this in Spring Valley. The margins of the phreatophyte areas generally can be expected to yield ground water of intermediate quality, except on the sides of the valley where recharge is slight and where the dissolved-solids content generally is high at shallow depth. Such areas are on the east side of the valley north of U. S. Highways 6 and 50 (for example, wells 18/67-1cl and 16/67-27dl) and on the west side of the valley south of Highways 6 and 50.

Springs flowing from bedrock or from the toes of alluvial fans generally have an intermediate dissolved-solids content as compared to the lower content in the mountain creeks and in the alluvium beneath the valley floor.

The water in the valley is commonly a calcium-magnesium bicarbonate type, probably reflecting the abundance of limestone and calcium-rich rocks in the surrounding mountains.

Generally the ground water in the alluvium has a temperature near the average annual air temperature of the area. In Spring Valley this temperature is approximately 50° to 55°F. Water temperatures appreciably higher than this indicate high thermal gradients or relatively deep water circulation, or both. Ground water under such conditions may reach the boiling point; however, in Spring Valley the highest temperature of the water sampled, 89°F, was obtained from well 23/66-31al.

Development

Spring discharge in Spring Valley in part has been developed and utilized for irrigation and stock watering. Spring flow on the valley floor in the Cleveland Ranch area (T. 16 N., R. 67 E.) and near Shoshone (T. 11 N., R. 67 E.) supports meadow grass, which is utilized for pasture and hay. The spring flow at the Cleveland Ranch is estimated to be about 5 cfs. The total acreage under irrigation, mostly from springs, is about 3,500 acres. The consumption of water by these crops is included in the discharge estimates (table 7). Irrigation wells, about 10 in number, are pumped principally to supplement creek flow during dry years. As an example, the Robison Ranch has two irrigation wells but neither was utilized in 1963 or 1964. One irrigation well (13/67-31al) is known to be the sole source of water for crop irrigation. In 1964 this well was pumped to irrigate with sprinklers about 130 acres of grain. Many stock-watering and domestic wells are used in the valley, but their combined draft on the ground-water reservoir is very small.

At the Kirkeby Ranch, well 12/67-12d3 had not been used in 1964 up to the time of the field work for this report. The following is an estimate of the pumpage in previous years:

Year	Pumpage (acre-feet)
1959	180
1960	260
1961	260
1962	0
1963	180

The well is used to supplement the flow from Williams and Dry Canyons for irrigation of about 120 acres of alfalfa and oats.

Development in the southern part of the valley might reduce somewhat the estimated ground-water outflow to Hamlin Valley of 4,000 acre-feet per year. However, the magnitude and location of the pumping would control the amount of water that would be salvaged.

At present only a very small part of the ground-water resources of the valley are developed. It is estimated that at least 60,000 acre-feet is discharged by low-value plants, such as greasewood, rabbitbrush, and salt grass. This water could be used for more beneficial purposes.

To determine the best areas for ground-water development in the valley, many factors, such as soil type, topography, drainage, water quality, and pumping lift, must be considered. The scope of this report is limited to a brief consideration of water quality and pumping lift. As pointed out in the chemical quality section, some areas, such as the central parts of the phreatophyte area on the valley floor, are not suitable for ground-water development. The most suitable areas probably are upstream from the margins of the phreatophyte area, because the water quality in general is good and the pumping lifts are moderate. Along the alluvial aprons, the areas opposite the highest mountains, which produce the highest rate of recharge, probably will have the lowest average lift and water containing the lowest amounts of dissolved solids. However, this evaluation is highly generalized and some areas will deviate from these anticipated conditions. A part of the final evaluation of an area for development should be based on drilling to test for yield and quality of the water.

Table 10. --Selected driller's logs of wells in Spring Valley

Material	Thickness (feet)	Depth (feet)
11/66-35d1 Dee Heckethorne		
Clay	220	220
Sand	1	221
Clay	17	238
Sand	2	240
11/68-29b1 Combined Metals Reduction Co.		
Gravel	268	268
Gravel, water-bearing	1	269
Gravel, cemented, alternating with sand and gravel	84	353
12/67-2a2 Fish & Game Commission		
Clay	12	12
Gravel	2	14
Clay, sandy, and boulders	35	49
Sand & Clay, hard	2	51
Clay, sandy	4	55
Sand, coarse and gravel	1	56
Clay, sandy	21	77
Hardpan	2	79
Clay, sandy	3	82
Hardpan	3	85
Clay, sandy	60	145
Sand and clay	13	158
12/67-2a2 (continued)		
Sand & gravel	1	159
Clay, sandy	7	166
Sand, water-bearing	3	169
Clay, sticky	12	181
Sand & gravel, water-bearing	4	185
Clay, sticky	2	187
Sand, water-bearing	4	191
Clay, sandy	3	194
12/67-13b1 Kirkeby Ranch		
Soil, sandy	7	7
Sand & gravel	13	20
Sand & boulders	30	50
Sand, fine	18	68
Gravel	8	76
Sand, fine, & clay streaks	70	146
Clay, sandy	54	200
Sand & gravel	20	220
12/67-24c1 Fred A. Farnsworth		
Topsoil	30	30
Gravel & sand	220	250
Clay, yellow lime	50	300

Material	Thickness (feet)	Depth (feet)
13/66-5a1 Buzz Pierce		
Boulders & gravel	20	20
Limestone, hard	25	45
13/66-25a1 Bureau of Land Management		
Sand & gravel, cemented	60	60
Gravel, water bearing	2	62
Clay, sandy	18	80
Gravel, water bearing	3	83
Clay, sandy	37	120
13/67-15d1 Melbourne Robison		
Soil & gravel	75	75
Clay	.3	78
Sand & gravel, water bearing	17	95
Clay	20	115
Sand & gravel, water bearing	10	125
Clay	18	143
Hardpan	10	153
Gravel, water-bearing	2	155
Gravel, dirty	4	159
Gravel, water bearing	3	162
Clay	88	250
13/67-15d1 (continued)		
Sand	1	251
Clay	9	260
Sand	1	261
Clay	29	290
16/67-3a2 Rodgers Brothers		
Clay, sandy	3	3
Hardpan	1	4
Clay	14	18
Sand, & gravel, water-bearing	3	21
Clay, sandy	26	47
Clay, white	21	68
Hardpan	4	72
Clay, sandy	6	78
Hardpan	1	79
Sand, water-bearing	1	80
Gravel	25	105
Clay, sandy	40	145
Hardpan	4	149
Clay, white	24	173
Hardpan	5	178
Clay, sandy	45	223
Hardpan	3	226
Sand & gravel	1	227
Clay, sandy	81	308
Hardpan	4	312
Clay, sandy	5	317

Material	Thickness (feet)	Depth (feet)
18/66-1b1 Richard Bate		
Boulders	23	23
Clay, sandy	12	35
Sand & gravel, water bearing	2	37
Clay, sandy	27	64
Sand & gravel water bearing	2	66
Clay, sandy	2	68
18/66-25a2 Bert Robison		
Boulders	28	28
Sand & gravel, cemented	12	40
Sand & gravel, water bearing	2	42
Clay, Sandy	9	51
Clay, sandy, cemented	6	57
Clay, sandy	6	63
Sand & gravel, water bearing	2	65
Sand & gravel, cemented	9	74
Clay, sandy	17	91
Gravel	12	103
Clay, sandy	5	108
Gravel	63	171
Sand, water bearing	1	172
Gravel & boulders	18	190

Material	Thickness (feet)	Depth (feet)
18/68-31a1 Delbert Eldridge		
Clay & boulders	63	63
Gravel, Water bearing	10	73
Clay & boulders	147	220
Gravel, boulders & coarse sand	245	465
23/66-31c1 Lawrence Henroid		
Gravel & clay	31	31
Sand & gravel	1	32
Clay, sandy	1	33
Boulders, gravel and sand, water bearing	15	48
Clay, sandy	1	49
Sand & gravel, water bearing	3	52
Clay, sandy, cemented	3	55
Sand & gravel, water bearing	3	58
Clay, sandy, cemented	12	70
Sand & gravel, water bearing	5	75
Clay, sandy	9	84
Sand & gravel	3	87
Clay, sandy	8	95
Hardpan	9	104

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