STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
Carson City

View of the southern part of Monitor Valley.

GROUND-WATER RESOURCES – RECONNAISSANCE SERIES

REPORT 30

GROUND–WATER APPRAISAL OF MONITOR, ANTELOPE, AND KOBEH VALLEYS, NEVADA

By
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Geologist
and
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Chemist

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

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SUMMARY

Monitor, Antelope, and Kobeh Valleys, in central Nevada, are large, open valleys, draining to Diamond Valley. Precipitation within the drainage area is the source of virtually all the water. Most of the economically available ground water is stored in and transmitted through Tertiary and Quaternary alluvium. Storm and snowmelt runoff commonly cause flow in Slough Creek through Devils Gate to Diamond Valley, but there is no flow here most of the time.

Underflow of ground water occurs from Monitor Valley to Kobeh Valley. Recent faults cut the alluvium of northern Antelope Valley and impede ground-water flow northward to Kobeh Valley. Underflow to Diamond Valley through Devils Gate is considered very small. Leakage of ground water through bedrock from the report area has not been identified.

The estimates of the average annual recharge and discharge for the entire area are 37,000 and 30,000 acre-feet, respectively. The preliminary estimate of perennial yield is 34,000 acre-feet. However, because the area is elongate, irregular in shape, and of large extent and because the principal valleys are hydrologically interconnected, the approximate yields of individual valley units were estimated to provide information useful for the development of the area: Southern part of Monitor Valley 13,000 acre-feet, northern part of Monitor Valley 8,000 acre-feet, Kobeh Valley 16,000 acre-feet, Antelope Valley 4,000 acre-feet, and Stevens Basin 200 acre-feet.

The total amount of ground water in storage in the upper 100 feet of saturated alluvium is estimated to be about 6,000,000 acre-feet. About 1 million acre-feet is in Antelope Valley and in each of the two parts of Monitor Valley, about 2.7 million acre-feet is in Kobeh Valley, and about 50,000 acre-feet is in Stevens Basin.

All the well water sampled and some spring water was found suitable for irrigation. The water generally is a calcium bicarbonate type, and the best quality is near the areas of recharge.

Surface water is used partly for irrigation in Kobeh Valley. In 1963 ground-water pumpage was only about 1,700 acre-feet. Springs on the valley floor discharge about 5,200 acre-feet annually. Kobeh Valley has the greatest potential for irrigation development in the report area because it has the largest perennial yield and probably has the longest growing season. The areas adjacent to the phreatophyte areas are best suited hydrologically for the development of ground water for irrigation. Wells should have proper spacing to prevent local overdraft and to provide for maximum utilization of the ground-water potential of the valley.

INTRODUCTION

Purpose and Scope of the Study

One of the greatest deficiencies in water knowledge in Nevada is the lack of hydrologic data in about half of the valleys in the State. In an effort to overcome this deficiency, legislation was enacted in 1960 to provide for reconnaissance studies of ground-water basins in Nevada under the cooperative program between the U. S. Geological Survey and the Nevada Department of Conservation and Natural Resources. The purpose of these studies is to provide ground-water resources information to the public and to assist the State Engineer in the administration of the ground-water law by making preliminary estimates of the average annual recharge to, the discharge from, and the perennial yield of valleys and basins. The scope of the reports also 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.

This report is number 30 in the series of reconnaissance studies and the area covered is shown on figure 1. The field work was done in April and May 1964 and consisted of a 3-week study of the hydrologic conditions and the geologic environment of the area.

Location and General Features:

The report area is in central Nevada and includes the major valleys of Monitor, Antelope, and Kobeh, and one small valley, Stevens Basin, which is along the eastern side of the area. The area is enclosed by long 116°00' and 117°00' W., and lat 30°30' and 40°00' N., and is in southeastern Lander, southwestern Eureka, and northern Nye Counties (figs. 1 and 2). It is about 100 miles long in a north-south direction and 40 miles wide in the latitude of U.S. Highway 50. The total area is about 2,400 square miles, subdivided among the four valleys as follows: Monitor, 1,060; Antelope, 456; Kobeh, 875; and Stevens, 18 square miles.

U. S. Highway 50 extends eastward through Kobeh Valley and connects the nearby towns of Austin and Eureka. Tonopah is about 50 miles southwest of Monitor Valley (fig. 2).

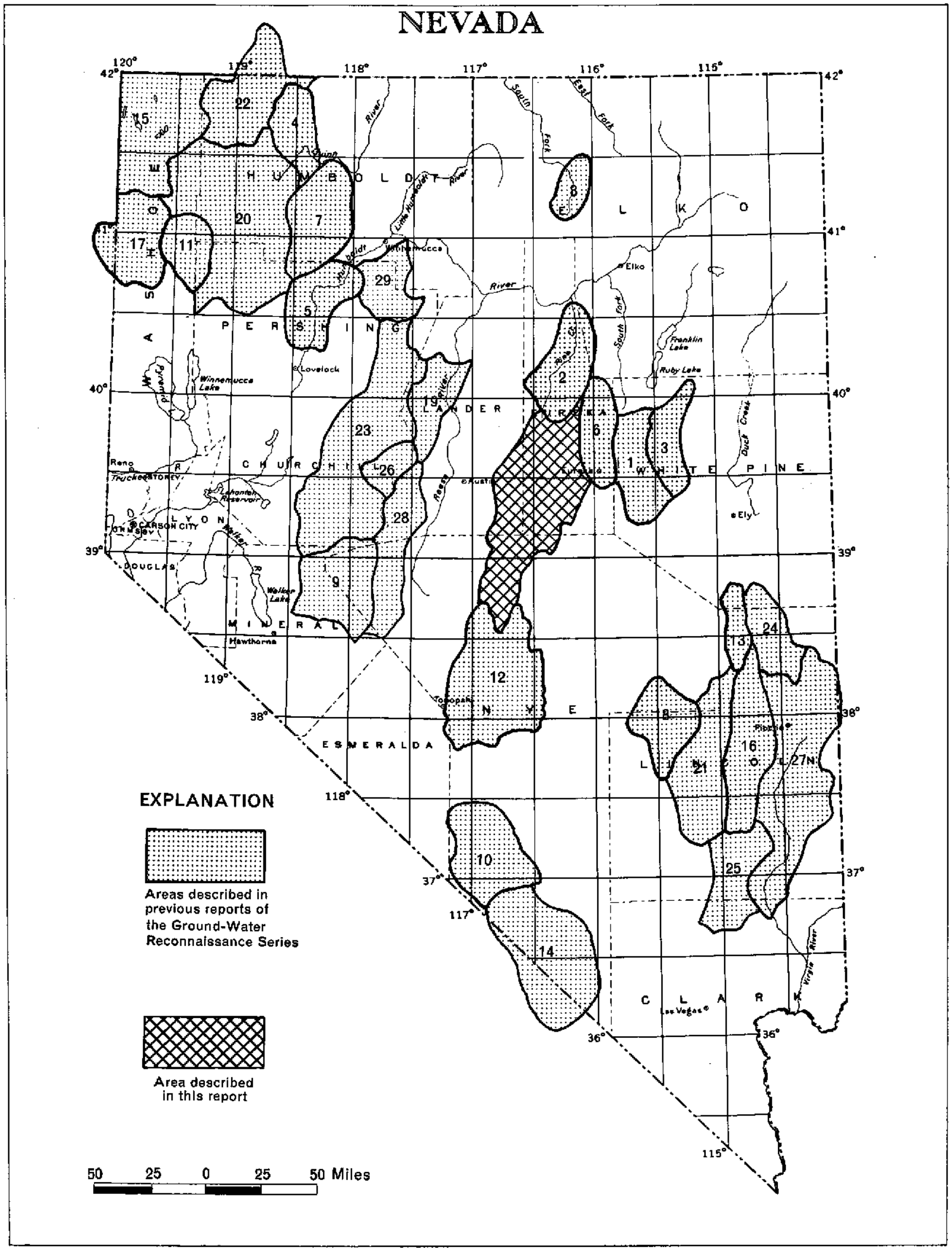

Figure 1.— **MAP OF NEVADA**
showing areas described in previous reports of the Ground-Water Reconnaissance Series and the area of this report.

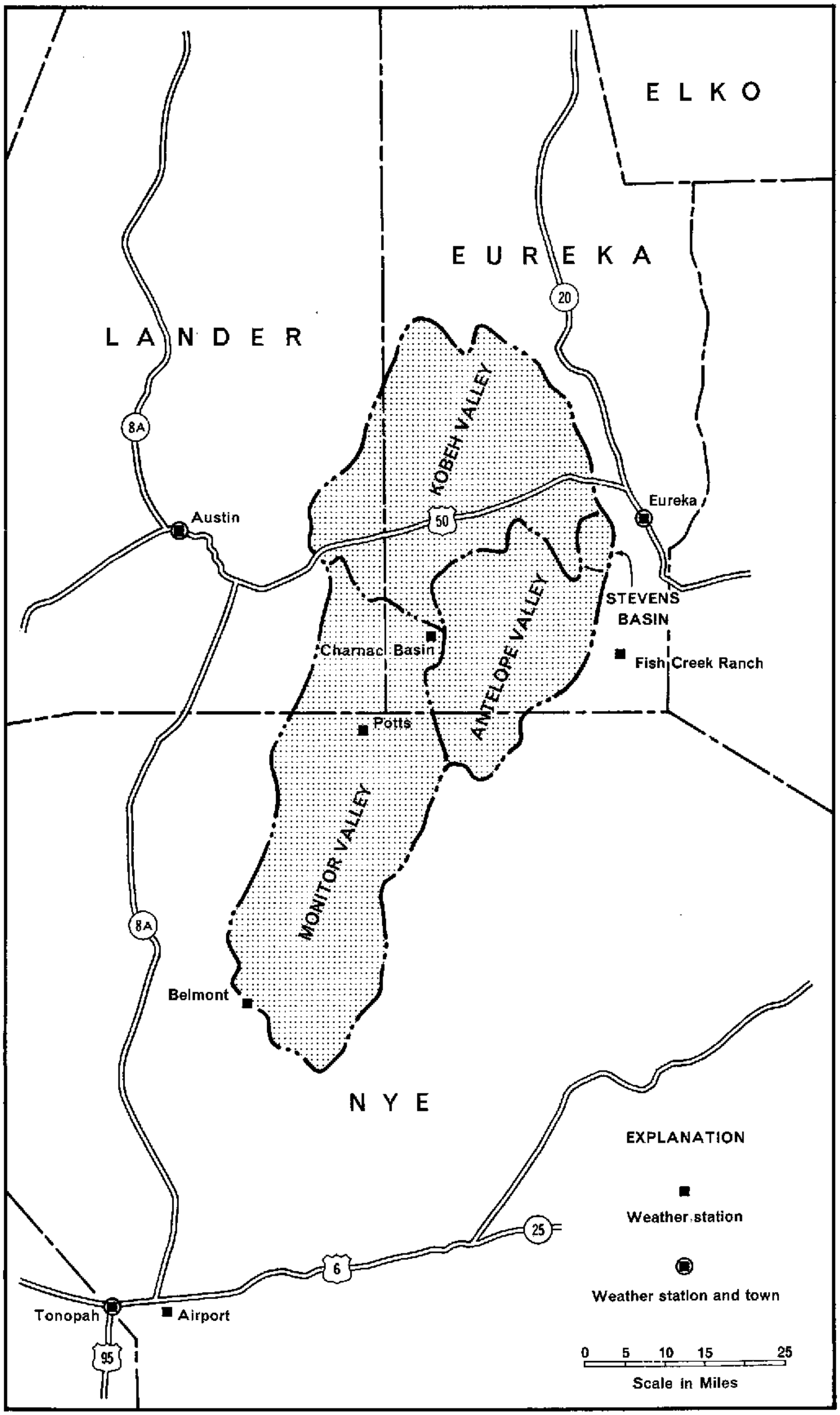

Figure 2.—Map of central Nevada showing the location of the valleys in the report area, the principal communities, and the weather stations.

Belmont, virtually a mining ghost town at the south end of Monitor Valley, had a population of 1,500 in 1873. During that era it was the Nye County seat. Belmont was abandoned when mining in the area became unprofitable, and the county seat was moved to Tonopah.

Physiography and Drainage

Monitor, Antelope, and Kobeh Valleys are in the central part of the Great Basin section of the Basin and Range physiographic province. The bordering mountains generally trend north-south. Monitor and Antelope Valleys are elongate in this same direction; Kobeh Valley is roughly equidimensional in form. The report area is bounded on the west by the Toquima Range and the Simpson Park Mountains, on the north by the Roberts Mountains, and on the south and east by the Monitor, Antelope, Fish Creek, and Sulphur Spring Ranges. In the report area the northern part of the Monitor Range separates Monitor and Antelope Valleys. An isolated peak, Lone Mountain, is in the eastern part of Kobeh Valley, just north of U. S. Highway 50 (pl. 1).

The highest peaks are along the east and west sides of Monitor Valley in the Toquima and Monitor Ranges. In the Toquima Range the highest peak is Mount Jefferson (11,949 feet). Other high peaks of that range are Toquima (10,916 feet) and Wildcat (10,507 feet) Peaks, Sawlog Ridge (10,478 feet), and White Rock Mountain (10,156 feet). In the Monitor Range the high peaks are Monitor (10,886 feet), Carl (10,538 feet), and Antelope (10,220 feet) Peaks, and Summit Mountain (10,461 feet). Ninemile Peak (10,104 feet) is in the Antelope Range, and Roberts Creek Mountain (10,133 feet) is in the Roberts Mountains.

The lowest point in the area is Devils Gate (5,990) feet) where U. S. Highway 50 passes from Kobeh Valley eastward into Diamond Valley. The altitudes of the valley floors range from about 6,000 feet in the lower part of Kobeh Valley to more than 7,000 feet at the south end of Monitor Valley. The mountains commonly rise as much as 4,000 feet above the adjacent valley floors, and attain a maximum relief where Mount Jefferson rises about 5,000 feet above Monitor Valley.

The surface drainage is generally from the mountains toward the adjacent valley floor. Drainage from Antelope and the northern part of Monitor Valleys extends northward to Kobeh Valley. Infrequent drainage probably occurs from the southern to the northern parts of Monitor Valley through the bedrock gap in Tps. 13 and 14 N., R. 47 E. In Kobeh Valley the surface drainage on the valley floor is eastward toward Devils Gate, where flow may pass into Diamond Valley. Stevens Basin has internal surface drainage.

Climate

The air masses that move generally eastward across Nevada are characteristically deficient in moisture. The precipitation pattern is related principally to the topography; the stations at the higher altitudes generally receive more precipitation than those at lower altitudes. As a result the valleys are semiarid, whereas the higher mountain areas are subhumid. The regional air masses supply most of the precipitation in the winter. Thunderstorms supply most of the precipitation during the summer, but are usually localized in extent.

Precipitation has been recorded at Belmont, Potts, and Charnac Basin in the report area and at five nearby stations at Austin, Eureka, Fish Creek Ranch, Tonopah, and Tonopah Airport. These stations are shown in figure 2; the precipitation data are given in table 1. The maximum average annual precipitation, 11.92 inches, was recorded at Austin. Charnac Basin with only a 7-year record, has a similar average of 11.61 inches annually. At Potts and Belmont, the averages are 6.33 inches and 8.53 inches, respectively. The smallest precipitation recorded was at Tonopah Airport, where the average is 3.78 inches a year.

Table 1.--Average monthly and annual precipitation at eight stations in central Nevada
(from published records of the U. S. Weather Bureau)

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Austin [1/]	1.14	1.19	1.50	1.50	1.27	0.82	0.57	0.44	0.44	1.07	0.90	1.08	11.92
Belmont [2/]	.85	1.01	.97	.68	.80	.40	.48	.84	.47	.65	.29	1.09	8.53
Charnac Basin [3/]	.92	1.46	1.12	1.24	2.02	.66	.41	.66	.63	.62	1.04	.83	11.61
Eureka [4/]	.88	.99	.97	1.34	1.22	.72	.60	.71	.61	.88	.63	.76	10.31
Fish Creek Ranch [5/]	.44	.32	.53	.51	.62	.34	.55	.48	.53	.33	.59	.50	5.74
Potts [6/]	.56	.66	.74	.72	.95	.36	.51	.44	.27	.33	.37	.42	6.33
Tonopah [7/]	.43	.42	.54	.59	.38	.21	.38	.44	.37	.49	.34	.39	4.98
Tonopah Airport [8/]	.25	.32	.16	.20	.70	.09	.54	.43	.43	.22	.28	.16	3.78

1. Altitude 6,549 feet. Location sec. 19, T. 19 N., R. 44 E. Period of record 30 years, 1933-1962.
2. Altitude 7,600 feet. Location sec. 26, T. 9 N., R. 45 E. Period of record 16 years, 1889-96, 1900-05, 1915-16.
3. Altitude 8,500 feet. Location sec. 20, T. 17 N., R. 49 E. Period of record 7 years, 1955-61 (storage gage).
4. Altitude 6,500 feet. Location sec. 13, T. 19 N., R. 53 E. Period of record 20 years, 1922-30, 1959-42, 1953-62.
5. Altitude 6,050 feet. Location sec. 10, T. 16 N., R. 53 E. Period of record 19 years, 1944-62.
6. Altitude 6,635 feet. Location sec. 35, T. 15 N., R. 47 E. Period of record 28 years, 1892-1919.
7. Altitude 6,093 feet. Location sec. 2, T. 2 N., R. 42 E. Period of record 47 years, 1907-53.
8. Altitude 5,426 feet. Location sec. 31, T. 3 N., R. 44 E. Period of record 9 years, 1954-62.

The records for the three stations in the report area provide the basis for several tentative conclusions on the precipitation pattern. First, the average annual precipitation at Potts, 6.33 inches, probably is typical of the amount that falls in the lowest parts of Antelope and northern Monitor Valleys, which are at altitudes below 7,000 feet. Precipitation at Belmont, about 8 1/2 inches, may be typical of the higher parts of the valley floors, such as southern Monitor Valley, which is at an altitude of about 7,000 feet and the lower parts of Kobeh Valley. The mountains receive still larger precipitation as indicated by the recorded average annual precipitation at Charnac Basin (altitude 8,500 feet) of 11.61 inches.

Temperature data have been recorded at Austin, Eureka, Fish Creek Ranch, and Tonopah. Since 1949 the Weather Bureau has been publishing freeze data, which are given for these stations in table 2. 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).

Fish Creek Ranch (6,050 feet) is the lowest of the four stations and yet has the shortest average growing season. This may be due to thermal inversions common to many of the valleys of Nevada, or to topographic position and exposure. A crop experiencing a killing frost at 28°F would have an average growing season there of only about 73 days. Austin and Eureka, though at higher altitudes, had longer growing seasons; 134 and 116 days, respectively. Tonopah, situated similar to Austin and Eureka, and also much lower and farther south, had the longest season; about 172 days. Probably no parts of Monitor, Antelope, or Kobeh Valleys have growing seasons as long as those at Tonopah.

Table 2. --Number of days between the last spring minimum and the first fall minimum for Austin, Eureka, Fish Creek Ranch, and Tonopah

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

Year	Austin			Eureka			Fish Creek Ranch			Tonopah		
	24°	28°	32°	24°	28°	32°	24°	28°	32°	24°	28°	32°
1948	139	129	125	--	--	--	125	56	29	173	139	129
1949	177	125	111	--	--	--	119	80	a40	190	188	160
1950	143	113	99	--	--	--	88	40	33	146	114	88
1951	174	141	125	--	--	--	94	81	9	207	160	144
1952	--	90	90	--	--	--	142	87	44	237	201	91
1953	163	147	126	129	128	111	89	69	3	173	149	147
1954	174	115	111	150	115	96	98	70	48	--	--	--
1955	164	154	115	143	117	108	88	82	b63	187	177	144
1956	192	162	128	133	109	109	135	58	c28	204	200	152
1957	--	--	--	96	96	95	121	35	28	196	179	161
1958	152	150	134	140	134	93	139	98	d73	178	178	159
1959	177	132	108	131	112	27	121	79	e44	228	197	156
1960	144	138	120	--	--	--	141	87	87	209	174	139
1961	156	149	124	--	--	--	110	91	65	170	158	149
1962	--	--	--	--	--	--	122	77	27	237	191	143
Average	163	134	117	132	116	91	115	73	41	195	172	140

a. The record shows frost on June 30 and July 1, but no frost during the succeeding 40 days to August 10th.

b. The record shows frost on June 30 and July 7, but no frost during the succeeding 63 days to September 9th.

c. The record shows frost on June 22 and July 6, but no frost during the succeeding 28 days to August 3rd.

d. The record shows frost on June 29 and July 1, but no frost during the succeeding 73 days to September 28th.

e. The record shows frost on June 30 and July 8, but no frost during the succeeding 44 days to August 21st.

As no temperature data are available for stations in the report area, only comparisons with the nearby stations can be made. The conditions on the valley floors of Antelope, Kobeh, and northern Monitor Valleys probably are similar to those at the Fish Creek Ranch station where an average growing season of 73 days occurs for a crop experiencing a killing frost at 28°F. In the southern part of Monitor Valley, the length of the growing season is difficult to estimate, but probably is shorter. The shortness of the growing season will be an important factor in the long-term success of farming in these valleys. As agricultural development continues in Diamond Valley to the east, the experiences of the farmers in regard to the length of growing season will be useful in evaluating potential success in the report area. The growing season here probably will be shorter than in Diamond Valley. Before any extensive farming is undertaken in these valleys, it would seem prudent to establish stations for obtaining temperature data as an aid in estimating the length of the growing season.

Typical annual temperature extremes in the valleys of central Nevada range from -10°F to 97°F.

Previous Work:

Very little hydrogeologic information has been published for Monitor, Antelope, and Kobeh Valleys and the surrounding mountains. Captain Simpson (1876) first visited and described the area in 1859 in an effort to find a shorter wagon route than the Emigrant Trail along the Humboldt River from Camp Floyd, Utah, to Genoa in Carson Valley, Nevada. Hague (1883 and 1892) and Nolan and others (1956) reported on the geology of the Eureka mining district to the east.

The first water-resources report of central Nevada was prepared by Meinzer (1917) on Big Smoky, Clayton, and Alkali Spring Valleys; Big Smoky Valley is the adjacent valley west of Monitor Valley (pl. 1, fig. 2). Ferguson (1933) described the geology of the Tybo mining district, which is about 20 miles southeast of the south end of Monitor Valley. The stratigraphy of the Toquima Range (Kay and Crawford, 1964) and the Roberts Mountains were described by Kay (1955), Merriam (1940), Merriam and Anderson (1942), and Clark and Ethington (1964). Roberts and others (1958) described the Paleozoic rocks of north-central Nevada. The Paleozoic rocks of Antelope Valley were recently described and mapped by Merriam (1963).

Reconnaissance studies of the ground-water resources have been made in many areas of the State, including the adjacent areas of Diamond Valley (Eakin, 1962a), Ralston and Stonecabin Valleys (Eakin, 1962b), and Smith Creek and Ione Valleys (Everett and Rush, 1964).

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 unit, separated from the first by the slant, is the range east of the meridian. The third unit is separated from the second by a dash and designates the section number. 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 18/51-30dl is the first well recorded in the southeast quarter of section 30, T. 18 N., R. 51 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 GEOLOGY AND HYDROLOGY

Geomorphic Features

The mountains of the report area are complexly folded and faulted blocks of igneous, metamorphic, and sedimentary rocks. The present topographic relief is largely the result of movement along many north-trending faults. Many small Recent faults cutting the alluvium are evident from aerial photos and field investigation and some are shown on plate 1.

Large alluvial fans were formed from debris washed from the Toquima Range into Monitor Valley. These fans are best developed at the mouths of Ikes, June, Willow, and Cave Canyons. The apex of the June Canyon fan is about 700 feet higher than its toe. In antelope Valley, along the eastern flank of the Monitor Range, large fans have developed at the mouths of Copenhagen Canyon and Allison Creek. They are generally not as large as those in Monitor Valley. In the Simpson Park Range, Ferguson Creek has transported a large amount of rock debris to form a large fan in the western part of Kobeh Valley (T. 21 N., R. 48 E.). Elsewhere along much of the mountain front, the alluvial apron is composed of many small fans, and in part forms an intermediate slope between the mountains and the valley floor. However, in some areas sloping planed-rock surfaces, called pediments, have been eroded at the foot of the mountains. These are well developed in the northern part of Kobeh Valley (Tps. 22 and 23 N., R. 49 E.), in east-central Monitor Valley (T. 14 N., R. 48 E.), and on the western side of Bellvue Peak (T. 17 N., R. 51 E.) in Antelope Valley.

Alluvial fans of two ages have been formed in the report area. The older fans are deeply dissected and are found along the relatively stable mountain fronts. The younger fans are not dissected and are along the mountain fronts where Recent faulting has occurred. The fans that have formed at the mouths of Willow and Cave Canyons are younger in age and are covered by a veneer of younger alluvium.

The valley floor in the central and eastern parts of Kobeh Valley is a broad, flat area which slopes upward to the alluvial apron and merges with it. In the western part of Kobeh Valley and in Monitor and Antelope Valleys, the valley floor is much narrower, averaging 2 to 3 miles in width.

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 vary widely with differences in their physical and chemical properties. The surface distribution of the units is shown in plate 1. The reconnaissance geologic mapping is based on aerial-photo interpretation supplemented by field observations at widely scattered points.

Most of the mountain areas of the western and northern parts of the report area are comprised chiefly of Tertiary and Cretaceous lava flows and volcanic tuff. However, the dominant rock types in the Fish Creek Range and that part of the Antelope Range bordering Antelope Valley are marine sedimentary rocks, principally dolomite and limestone. Quartzite, shale and sandstone are interbedded with the carbonate rocks in minor amounts. The eastern flank of the Monitor Range near Copenhagen Canyon is comprised predominantly of carbonate rocks (Merriam, 1963, pls. 1 and 2). The carbonate rocks range in age from Cambrian to Permian and are estimated by Merriam (1963, p. 6) to about 25,000 feet thick.

The older alluvium is late Tertiary to Quaternary in age. It characteristically consists of unconsolidated and poorly consolidated, dissected, and commonly faulted and folded, poorly sorted gravel, sand, and silt. Most of the alluvial apron is older alluvium derived from debris washed from the mountains.

The younger alluvium is late Pleistocene and Recent in age. Although not all are distinguished on the geologic map (pl. 1), four types were identified: (1) stream-channel and flood-plain deposits, commonly of sand and gravel, along the major streams; (2) fine-grained lake beds of Pleistocene age in Stevens Basin and perhaps of this age or older in Kobeh Valley; (3) fine-grained playa deposits in southern Monitor Valley and in Stevens Basin; and (4) thin alluvial-fan deposits formed downgradient from active mountain-front faults. For the most part all four types are uncolsolidated, relatively undissected, and relatively undisturbed. The first three types are shown on plate 1 as younger alluvium; the last type forms only a veneer and is not shown.

The younger alluvium is generally finer grained and better sorted than the coarse-grained older alluvium.

Most of the economically available water in the report area occurs in the coarse-grained units of the younger alluvium in the valley lowlands and older alluvium which comprise the ground-water reservoir. The older alluvium, composed of low to moderately permeable mixtures of silt, sand, and gravel, will characteristically yield water to wells at a low to moderate rate. Where saturated near the valley troughs, moderate to large water supplies can be developed from the better sorted younger alluvium.

Except for the carbonate rocks, the consolidated rocks have low permeability; hence, they are among the least economical sources of water in the area. Many springs flow from this type of rock, but most have a low rate of flow and many are dry in the summer or during periods of drought. The carbonate rocks contain solution channels and locally are moderately permeable. Because of their topographic position in the mountains and because of their great depth beneath the valley floors, they are not considered an economical source of water.

Kral (1951, p. 21) reports that at the Belmont mining districts, shafts encountering ground water at a depth of 50 feet were dewatered to a depth of about 400 feet by pumping at a rate of about 300 gpm (gallons per minute). This indicated low permeability of these fractured carbonate rocks. Similar conditions are reported by Ferguson (1933, p. 56) at Tybo southeast of the report area. However, the carbonate rocks may provide the means by which moderately large quantities of water could be discharged from this area to adjacent valleys having lower altitudes. This possibility is considered in a subsequent section of the report.

SURFACE-WATER FEATURES

Numerous streams have their sources in the mountains of the area, but they flow generally only in response to snowmelt and flash-flood producing storms. Peak periods of flow in the spring of 1964 were in May. At that time, as well as in April, observations were made of the flow in many creeks. The areal distribution of streamflow in selected streams is presented in table 3 and the sites are shown on plate 1.

Continuous surface flow during the period of field investigation extended from northern Kobeh Valley in Coils Creek and from the Monitor Range of western Antelope Valley in Dagget Creek to where they join Slough Creek and cause flow to Devils Gate. No other creeks at this time directly contributed to the flow through Devils Gate; rather, the flow of other creeks of the report area was absorbed locally on the alluvial apron or on the valley floor. During periods of large runoff caused by rapid snowmelt or intense storms, streams probably flow along the axis of the valleys in Stoneberger Creek and Antelope Wash and contribute flow to Slough Creek.

Residents of Kobeh Valley report that in the spring of most years the flow of Slough Creek commonly extends through Devils Gate to Diamond Valley, but in springs following especially dry winters the flow commonly is absorbed by the alluvium before it reaches Devils Gate. Coils Creek apparently is the principal tributary to Slough Creek and has its origin in the Simpson Park and Roberts Mountains at the north end of Kobeh Valley. On May 19, 1964, an estimated flow in Coils Creek of about 8 cfs (cubic feet per second) was observed at the bridge crossing in sec. 27, T. 22 N., R. 49 E. During the period of study, the creeks in Monitor and Antelope Valleys did not have a continuous flow to Slough Creek. By late spring of most years, the flow through Devils Gate decreases to zero and streamflow throughout the area decreases greatly.

The playa in southern Monitor Valley (T. 13 N., R. 47 E.) was dry in mid-April 1964; however, the subsequent storm and snowmelt of early May produced flooding of the playa.

A Pleistocene lake in Stevens Basin has been identified from aerial photographs. The maximum recognizable extent of the lake was about 1,200 acres. Its highest recognizable level was about 7,240 feet, and it apparently had a maximum depth of about 30 feet, as computed from the present playa surface. Lake terraces near the Hay Ranch in Kobeh Valley have been identified (George Hardman, oral communication, 1964); however, their age is unknown. It is presumed that they probably would predate the cutting of Devils Gate.

Table 3. --Miscellaneous streamflow estimates in Monitor, Antelope, and Kobeh Valleys in April and May 1964

Map No. 1/	Site	Location: Section	Location: Township	Location: Range	Date	Discharge in cfs
1	Meadow Creek	8	° N.	46 E.	4-15-64	.4
2	Meadow Creek	35	10 N.	46 E.	4-15-64	.02
3	Corcoran Canyon	28	10 N.	46 E.	4-15-64	.2
4	Barley Creek	16	9 N.	47 E.	4-15-64	2.
5	Pine Creek	16	11 N.	46 E.	5-21-64	2.
5a	Meadow Creek	6	11 N.	47 E.	5-21-64	0
6	South Fork Mesquito Creek	32	12 N.	47 E.	4-15-64	2.
7	Tributary to Stoneberger Creek	9	13 N.	47 E.	4-15-64	0
8	Tributary to Stoneberger Creek	22	14 N.	47 E.	4-15-64	2.
9	Tributary to Stoneberger Creek	2	14 N.	47 E.	4-15-64	2.
10	Stoneberger Creek	14	15 N.	47 E.	4-15-64	1.5
11	Tributary to Willow Creek	29	15 N.	48 E.	5-21-64	1.
12	Willow Creek	25	15 N.	47 E.	4-15-64	.5
13	White Sage Canyon	15	15 N.	48 E.	5-21-64	0
13a	Stoneberger Creek	35	16 N.	47 E.	4-13-64	0
14	Stoneberger Creek	3	16 N.	47 E.	4-13-64	0
15	Stoneberger Creek	3.5	19 N.	47 E.	4-13-64	0
16	Ackerman Canyon	25	20 N.	47 E.	5-19-64	.5
17	Willow Creek	20	19 N.	49 E.	5-18-64	1.
18	Snow Water Canyon	31	22 N.	49 E.	5-19-64	2.5
19	Ferguson Creek	11	21 N.	48 E.	5-19-64	4.
20	Tributary to Coils Creek	23	20 N.	49 E.	5-19-64	1.

Table 3.--Continued

Map No. 1/	Site	Location			Discharge	
		Section	Township	Range	Date	in cfs
21	Coils Creek	27	22 N.	49 E.	5-19-64	8.
22	Slough Creek	5	19 N.	51 E.	5-18-64	2.
23	Copenhagen Canyon	24	15 N.	49 E.	5-21-64	2.
24	Copenhagen Canyon	30	16 N.	50 E.	5-21-64	0
25	Antelope Wash	26	16 N.	50 E.	5-21-64	0
26	Nine Mile Creek	25	16 N.	50 E.	5-21-64	1.5
27	Antelope Wash	31	17 N.	51 E.	4-15-64	0
28	Allison Creek	30	17 N.	50 E.	4-15-64	1.
29	Allison Creek	29	17 N.	50 E.	4-15-64	0
30	Hot Spring Wash	28	18 N.	50 E.	4-15-64	1.
31	Antelope Wash	30	19 N.	51 E.	4-16-64	0
32	Dagget Creek	7	19 N.	51 E.	4-16-64	1.5
33	Browns Canyon	21	19 N.	51 E.	4-16-64	0
34	Slough Creek	22	20 N.	51 E.	5-19-64	1.5
35	Tributary to Slough Creek	11	20 N.	51 E.	5-19-64	0
36	Tributary to Slough Creek	26	21 N.	51 E.	5-19-64	0
37	Tributary to Slough Creek	12	20 N.	51 E.	5-19-64	0
38	Slough Creek at Devils Gate	26	20 N.	52 E.	5-19-64	2.5

1. Measuring site and number shown on plate 1.

GROUND WATER APPRAISAL

Monitor, Antelope, and Kobeh Valleys form a hydrologically interconnected but irregular area (pl. 1). A meaningful evaluation of the supply available for development is facilitated by subdividing the area into four valley units for which recharge, discharge, and the approximate yield are estimated. Moreover, ground-water inflow and outflow between adjacent units are estimated where applicable. The four units are: The southern part of Monitor Valley, extending from the south end of the valley to the bedrock narrows just south of Dianas Punch Bowl; the northern part of Monitor Valley, extending northward from the bedrock narrows south of Dianas Punch Bowl to the bedrock narrows at Grimes Hills; Kobeh Valley; and Antelope Valley. The hydrology of Stevens Basin, which is a minor valley discharging either to Antelope Valley or Diamond Valley, is also evaluated.

Occurrence and Movement of Ground Water

Ground water occurs under both confined (artesian) and unconfined (water-table) conditions. Hydrostatic heads in many wells and springs are above land surface. Such heads are found in Kitchen Meadows (T. 18 N., Rs. 50 and 51 E.) of Antelope Valley and Bean Flat (Tps. 19 and 20 N., R. 50 E.) of Kobeh Valley where both springs and wells flow from the younger alluvium. In the central part of Monitor Valley, hot springs, such as those near Dianas Punch Bowl (sec. 22, T. 14 N., R. 47 E.), flow in response to a pressure head.

The thickness of the ground-water reservoir is not known because wells near the centers of the valley do not penetrate the full thickness of the alluvium. Bedrock was reached in several wells in Antelope Valley and one in Kobeh Valley, where it was encountered at depths ranging from 16 to 328 feet (see tables 10 and 11 for well records and drillers' logs). However, all these wells were on the valley margins where the alluvial thickness commonly is less than on the valley floor. A deep well (18/51-30dl), drilled to a depth of 738 feet along the axis of Antelope Valley in Kitchen Meadows, apparently did not encounter bedrock, but bottomed in red clay, according to the driller's log. However, a nearby well (18/51-18cl), 670 feet deep, penetrated hard limestone at 645 feet. In Monitor Valley, a 350-foot well (15/48-30dl) was drilled, but no log is available to evaluate the materials encountered.

In general, the ground-water movement is in the direction of surface flow; that is, from the mountains toward the valley floors where much of it is discharged by evapotranspiration. In Monitor Valley the movement is northward to Kobeh Valley. In Antelope Valley, most of the ground water moves northward and is consumed locally in the Kitchen Meadow area. In Kobeh Valley, most of the ground water moves into and is discharged along the east-tranding trough in the central part of the valley. The alluvium is the principal aquifer, and most of the ground water moves through it.

Estimated Underflow

Where rock material is permeable and ground-water or pressure gradients exist, ground water flows through the rock material in response to the gradient, the volume of flow being proportional to the transmissibility, the gradient, and the cross-sectional width of flow. This movement of ground water is called underflow.

Conditions are favorable for ground-water underflow from the southern part to the northern part of Monitor Valley. The underflow is through older alluvium; however, additional amounts may be transmitted through the adjacent basaltic rocks in this part of the valley (pl. 1). Considering only the flow through the older alluvium, the estimated average annual underflow is on the order of 2,000 acre-feet. This estimate is based on an assumed coefficient of transmissibility of the older alluvium of 50,000 gpd/ft (gallons per day per foot), an approximate ground-water gradient of 20 feet per mile, and an effective width of flow in the alluvium of about 2 miles.

Similar conditions are found where Monitor Valley joins Kobeh Valley at Grimes Hills. Here the estimated average underflow from the northern part of Monitor Valley to Kobeh Valley is on the order of 6,000 acre-feet per year. The underflow is through younger and older alluvium, and to a lesser extent through basalt and rhyolite deposits of Grimes Hills (T. 18 N., R. 47 E.). The estimate is based on an assumed average coefficient of transmissibility of 100,000 gpd/ft, a ground-water gradient of about 10 feet per mile, and an effective width of flow of about 6 miles.

In the northern part of Antelope Valley, east-trending faults of Recent age (Tps. 18 and 19 N., Rs. 50 and 51 E.) cut the alluvium. These faults form barriers which impede the northward flow of ground water. The result is that south of the faulted area the water table is near or at land surface, causing discharge by evapotranspiration of ground water that otherwise would flow to Kobeh Valley. North of the faulted area and south of Slough Creek, no ground-water evapotranspiration takes place because of the lack of phreatophytes and a depth to water of at least 50 feet.

Underflow from Stevens Basin equals the recharge to the ground-water reservoir in the basin. No evapotranspiration of ground water occurs there because the ground-water level, as indicated by well 19/52-34dl (table 10), is generally in excess of 400 feet below land surface. The underflow probably is to Antelope Valley or Diamond Valley.

Underflow through the alluvium in Devils Gate from Antelope and Kobeh Valleys into Diamond Valley is estimated by Eakin (1962, p. 18) to be small. For the purposes of this report the same conclusion is made. Devils Gate at its narrowest place is only about 100 yards wide. At depth the width between the bedrock walls probably is less.

Leakage of ground water through bedrock from the report area to adjacent areas is possible. However, no evidence was found to suggest or identify any such leakage.

Estimated Average Annual Recharge

The precipitation in the drainage area is the ultimate source of the ground water in the area. The recharge to the ground-water reservoir is estimated by a method described by Eakin and others (1951, P. 79-81). The method assumes that the average annual recharge to the ground-water reservoir can be estimated as a percentage of the total precipitation within the drainage area. Hardman (1936) showed that in gross aspect the average annual precipitation in Nevada is related closely to the altitude of land surface and that it can be estimated with a reasonable degree of accuracy by assigning precipitation rates to various altitude zones.

The precipitation in the northern part of the report area is larger than in the southern part for the altitude zones. This conclusion is based in part on the precipitation data in table 1 and on the stream-flow and vegetative-cover conditions as observed in the field. The precipitation and percentage of recharge from precipitation in the northern part of the area (Kobeh Valley) appears to be similar to the general conditions as found in many areas covered to date by the Reconnaissance Series reports (fig. 1). For Kobeh Valley the distribution of estimated average annual precipitation is delineated as follows: 12 inches at 7,000 feet, 15 inches at 8,000 feet, and 20 inches at 9,000 feet. Four precipitation zones are selected using the above values. The area of Kobeh Valley underlain by alluvium is assumed to have no recharge to the ground-water reservoir, because this material has the capacity to absorb and hold the small amount of precipitation near the surface and to discharge it by subsequent evapotranspiration. Therefore, no recharge is assumed to occur below an altitude of 7,000 feet.

The southern part of the drainage area in Monitor and **Antelope** Valleys and Stevens Basin is drier than Kobeh Valley and the distribution of the estimated average annual precipitation is delineated as follows: 7 inches at 7,000 feet, 10 inches at 8,000 feet, 15 inches at 9,000 feet, and 18 inches at 10,000 feet. The percentages of recharge from the precipitation also are reduced proportionately for the altitude zones to match the reduction in precipitation. Five precipitation zones are selected for these valleys. Like Kobeh Valley, no ground-water recharge is assumed to occur below an altitude of 7,000 feet. The zones, the estimated precipitation, and the estimated recharge for the area are summarized in table 4.

The preliminary estimates of the average annual ground-water recharge from precipitation are: Monitor Valley, southern part, 15,000 acre-feet; Monitor Valley, northern part, 6,300 acre-feet; Antelope Valley 4,100 acre-feet; Kobeh Valley 11,000 acre-feet; and Stevens Basin 200 acre-feet--a total of about 37,000 acre-feet. The estimated recharge in the southern part of Monitor Valley is about 5 percent of the estimated precipitation, in the northern part of Monitor Valley about 3 percent, and in Antelope and Kobeh Valleys and Stevens Basin about 2 percent.

Table 4.--Estimated average annual precipitation and ground-water recharge in Monitor Antelope, and Kobeh Valleys and Stevens Basin, Nevada

Precipitation zone (feet)	Area (acres)	Estimated annual precipitation: Range (inches)	Average (feet)	Average (acre-feet)	Estimated recharge from precipitation: Percentage of Precipitation	(Acre-ft. per year)
			MONITOR VALLEY (southern part)			
Above 10,000	12,000	More than 18	1.7	20,000	22	4,500
9,000 to 10,000	27,400	15 to 18	1.4	38,000	12	4,600
8,000 to 9,000	80,400	10 to 15	1	80,000	5	4,000
7,000 to 8,000	136,000	7 to 10	.7	95,000	2	1,900
Below 7,000	86,200	Less than 7	.5	43,000	0	0
Subtotal (rounded)	342,000			280,000		15,000
			(northern part)			
Above 10,000	300	More than 18	1.7	510	22	110
9,000 to 10,000	11,000	15 to 18	1.4	15,000	12	1,800
8,000 to 9,000	52,300	10 to 15	1	52,000	5	2,600
7,000 to 8,000	131,000	7 to 10	.7	92,000	2	1,800
Below 7,000	140,000	Less than 7	.5	70,000	0	0
Subtotal (rounded)	335,000			230,000		6,300
			ANTELOPE VALLEY			
Above 10,000	200	More than 18	1.7	340	22	75
9,000 to 10,000	5,600	15 to 18	1.4	7,800	12	940
8,000 to 9,000	38,700	10 to 15	1	39,000	5	1,900
7,000 to 8,000	86,500	7 to 10	.7	61,000	2	1,200
Below 7,000	161,000	Less than 7	.5	80,000	0	0
Subtotal (rounded)	292,000			190,000		4,100

Table 4.--Continued

Precipitation zone (feet)	Area (acres)	Estimated annual precipitation: Range (inches)	Estimated annual precipitation: Average (feet)	Estimated annual precipitation: Average (acre-feet)	Estimated recharge from precipitation: Percentage of Precipitation	Estimated recharge from precipitation: (Acre-ft. per year)
KOBEH VALLEY						
Above 9,000	2,100	More than 20	1.75	3,700	25	920
8,000 to 9,000	22,200	15 to 20	1.46	32,000	15	4,800
7,000 to 8,000	65,900	12 to 15	1.12	74,000	7	5,200
Below 7,000	470,000	Less than 12	.75	350,000	0	0
Subtotal (rounded)	560,000			460,000		11,000
STEVENS BASIN						
8,000 to 9,000	800	10 to 15	1	800	5	40
7,000 to 8,000	11,000	7 to 10	.7	7,700	2	150
Subtotal (rounded)	11,800			8,500		200
TOTAL (rounded)	1,540,000			1,200,000		37,000

Table 5. --Estimated evapotranspiration by phreatophytes of ground water in Monitor, Antelope, and Kobeh Valleys and Stevens Basin in 1964

Area	Phreatophyte	Area (acres)	Areal density (percent)	Depth to water (feet)	Evapotranspiration: Acre-feet per acre	Evapotranspiration: Acre-feet (rounded)
Monitor Valley Southern part	Greasewood, rabbitbrush, and small areas of saltgrass and meadow	30,000	20 to 30	5 to 40	0.3	9,000
	Bare soil	2,500	--	less than 10	.1	250
	Cottonwood and willow	trace	--	1 to 5	2	trace
				Subtotal (rounded)		9,200
Northern part	Greasewood and rabbitbrush	5,100	20 to 25	15 to 40	.2	1,000
	Saltgrass and moderately wet meadow	800	--	less than 10	1.25	1,000
				Subtotal (rounded)		a 2,000
Antelope Valley	Greasewood and rabbitbrush	11,000	10 to 25	5 to 40	.2	2,200
	Saltgrass and moderately wet meadow	1,600	--	less than 5	1.25	2,000
	Cottonwood and willow	trace	--	1 to 5	2	trace
				Subtotal (rounded)		b 4,200
Kobeh Valley	Greasewood, rabbitbrush, and saltgrass	12,000	20 to 25	less than 20	.4	4,800
	Greasewood and rabbitbrush	10,000	20 to 25	20 to 40	.2	2,000

	Saltgrass and moderately wet meadow	6,500	--	less than 5	1.25	8,100
	Cottonwood and willow	trace	--	1 to 5	2	trace
				Subtotal (rounded)		c 15,000
Stevens Basin	Bare soil	400	--	460	0	0
Total (rounded)		80,000				30,000

a. Includes about 1,500 acre-feet of spring discharge at Dianas Punch Bowl and Pottx.

b. Includes about 1,000 acre-feet of spring discharge at Kitchen Meadow and Klobe Springs.

c. Includes about 2,500 acre-feet of spring discharge at Bean Flat, Bartine Ranch, and Hay Ranch.

Ground water is pumped by wells, but most wells are used for domestic or stock-watering purposes, and their total discharge does not exceed 100 acre-feet per year for each area exclusive of Stevens Basin where only one well is intermittently operated. Only two large-diameter irrigation wells were active in 1963. Well 19/49-30a1 discharged about 800 acre-feet of water which was used to irrigate about 240 acres of land. In 1964 the owner indicates that he plans to use about 1,200 acre-feet of water to irrigate about 400 acres. Well 15/48-30d1 pumped an estimated 250 acre-feet of ground water to irrigate about 80 acres of meadow grass. A third large-diameter irrigation well, 15/50-4d1, was drilled early in 1964; however, no information was obtained as to its proposed use during the following growing season. Flowing wells at the Bartine Ranch in Kobeh Valley discharge about 250 acre-feet per year but their discharge is used by phreatophytes or otherwise consumed by evapotranspiration.

Springs, both warm and cold, are found in all the valleys of the report area and discharge a large quantity of water. In the southern part of Monitor Valley, only small springs exist, and their estimated combined discharge is on the order of 200 acre-feet per year. In the northern part of Monitor Valley, two areas of large spring discharge are at Potts (Tps. 14 and 15 N., R. 47 E.) and at Dianas Punch Bowl (T. 14 N., R. 47 E.); the estimated total annual discharge is 1,500 acre-feet. Most of these springs are hot, having a water temperature of about 140°F. The high temperature probably indicates deep circulation of the water.

The estimated ground-water discharge of the springs in Antelope Valley, principally Klobe Springs (T. 18 N., R. 50 E.) and those at Kitchen Meadow (T. 18 N., R 51 E.), is about 1,000 acre-feet per year. The principal springs in Kobeh Valley are those at the Bean Flat (Tps. 19 and 20 N., R. 49 E.), the Bartine Ranch (T. 19 N., R. 50 E.), and the Hay Ranch (T. 20 N., R. 52 E.) areas. The estimated total spring discharge in Kobeh Valley is on the order of 2,500 acre-feet per year.

All the spring discharge, about 5,200 acre-feet per year, is assumed to be used by the phreatophytes and discharged by evapotranspiration. This discharge, therefore, is included in the estimated phreatophyte discharge in table 5.

Table 5 shows that the estimated natural ground-water discharge by phreatophytes is about 30,000 acre-feet per year. The estimated total ground-water discharge in 1963 by phreatophytes and all types of wells, but excluding underflow of ground water from one valley to another within the report area and outflow from the report area, is about 32,000 acre-feet, distributed among the valley units as follows: Monitor Valley, southern part, 9,300 acre-feet; Monitor Valley, northern part 2,400 acre-feet; Antelope Valley, 4,300 acre-feet; Kobeh Valley, 16,000 acre-feet; and Stevens Basin, 200 acre-feet. The underflow of ground water from valley to valley within the report area and the loss of ground water from the report area have been discussed in the section on estimated underflow.

Ground-Water Budget

Before the development of ground water by man, the ground-water system was in dynamic equilibrium; the long-term average annual recharge and discharge were equal. The estimated average annual recharge and natural discharge, as computed in previous sections of the report, are about 37,000 and 30,000 acre-feet, respectively (tables 4 and 5). The imbalance between the two values is the result of limited available data and unresolved hydrologic factors.

Table 6 shows the ground-water budget analysis for the northern and southern parts of Monitor Valley, Kobeh Valley, and Antelope Valley and Stevens Basin. For example, in the southern part of Monitor Valley, the average recharge of 15,000 acre-feet per year is not offset by an equal amount of discharge. The imbalance amounts to 3,800 acre-feet per year. The estimated 2,000 acre-feet per year of discharge by ground-water outflow through the alluvium from the southern part of Monitor Valley enters the northern part of the valley and becomes part of the estimated 8,300 acre-feet per year of recharge to the area. The recharge to the northern part of the valley is offset by a similar amount of natural discharge, of which an estimated 6,000 acre-feet per year is ground-water outflow to Kobeh Valley. In Kobeh Valley there is an imbalance between the 17,000 acre-feet of estimated annual recharge and the 15,000 acre-feet of estimated natural discharge. The imbalance may represent underflow from Kobeh Valley through carbonate bedrock to Diamond Valley; however, no evidence is available to support this hypothesis.

Antelope Valley appears to be semi-isolated from Kobeh Valley by fault barriers which apparently impede the northward flow of ground water, thereby causing the discharge of a volume of water essentially equal to the average annual recharge.

In Stevens Basin nearly all the recharge moves out of the valley by leakage from the area. The volume of water is small and therefore cannot be identified as recharge elsewhere.

Table 6. --Ground-water budget analysis, in acre-feet per year, for Monitor, Antelope, and Kobeh Valleys and Stevens Basin, Nevada

	Monitor Valley		Kobeh Valley	Antelope Valley	Stevens Basin	Total
	Southern part	Northern part				
Recharge						
Precipitation (table 4)	15,000	6,300	11,000	4,100	200	36,600
Ground-water inflow (p. 28-29)	0	2,000	6,000	trace	0	--
Total (1)	15,000	8,300	17,000	4,100	200	b 36,600
Discharge						
Evapotranspiration (table 5)	9,200	2,000	15,000	4,200	0	30,400
Ground-water outflow (p. 28-29)	2,000	6,000	trace	trace	a 200	--
Total (2)	11,200	8,000	15,000	4,200	200	b 30,400
Imbalance (1) - (2)	3,800	300	2,000	- 100	0	6,000

a. Not estimated, but equal to recharge.

b. Does not include interbasin flow.

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. Perennial yield can not exceed the natural recharge to an area indefinitely. Moreover, the perennial uield ultimately is limited to the amount of natural discharge that can be economically salvaged for beneficial use.

Table 6 shows that the imbalance between the estimates of recharge and discharge is about 6,000 acre-feet per year. Because the data used to compute recharge and discharge are no more accurate for one than the other, the perennial yield of the entire area is taken as the average of the two, or roughly 34,000 acre-feet.

Because the area. is elongate, irregular in shape, and covers a large area, development in one part of the area will not salvage all the discharge nor intercept all the recharge. For example, a large-scale pumping development in the central part of Kobeh Valley would possibly affect the supply in the northern part of Monitor Valley, but it never would have an appreciable effect on the southern part of Monitor Valley, some 50 miles to the south. Accordingly, the approximate yield is evaluated for each of the four principal valley units, recognizing of course that if substantial development should occur in one unit, it would reduce the yield of the downstream unit and might reduce the yield of the adjacent upstream unit. The extent to which the adjacent upstream unit would be affected is dependent on the magnitude of the development and on the effectiveness of the barriers in the northern part of Antelope Valley and near Dianas Punch Bowl (pl. 1).

The reduced yields of valley units adjacent to a heavily pumped unit would be caused by the interception of ground-water outflow to the downstream unit and by increased inflow from the adjacent upstream unit, subject of course to the limitations of movement imposed by any intervening barriers. As a result, water crossing a boundary between valley units theoretically can be developed in either valley. Therefore, including this water in the estimates of the perennial yield for each valley, the sum of the perennial yields of the valley units will numerically exceed the total perennial yield value for the combined report area. Table 7 shows the approximate magnitude of the yields for the valley units. The estimates of total recharge and discharge, including the estimates of ground-water inflow and outflow, are from table 6.

Table 7. --Approximate yields, in acre-feet per year, of Monitor, Antelope, and Kobeh Valleys and Stevens Basin, Nevada

	Monitor Valley		Kobeh Valley	Antelope Valley	Stevens Basin	Total
	Southern part	Northern part				
Total recharge	15,000	8,300	17,000	4,100	200	b 36,600
Total discharge	11,000	8,000	15,000	4,200	a 200	b 30,400
Approximate yield[1]	13,000	8,000	16,000	4,000	200	b 34,000

a. Not estimated, but equal to recharge.

b. Does not include interbasin flow.

1. Taken as the average of total recharge and total discharge, and rounded.

Storage

Under native conditions the amount of water in storage is nearly constant. This balance has been disturbed only slightly by the diversion of small amounts of surface and ground water. Water-level measurements have been made on three wells in the study area for a period of several years. The measurements in these wells, 18/51-7dl, 18/51-34dl, and 21/49-16cl (table 10), indicate that there is a very slow local decline in the amount of ground water in storage.

Recoverable ground water in storage is that part of the stored water that will drain by gravity from the ground-water reservoir. The specific yield of a rock or soil is the ratio of the volume of water which, after being saturated, it will yield by gravity to its own volume. This ratio is stated as a percentage. In the report area, 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 600,000 acres, or roughly 80 percent of the 750,000 acres mapped as alluvium. Therefore, the estimated volume of water stored in the upper 100 feet of saturated alluvium is about 6 million acre-feet. The computed ground water in storage for each valley is shown in table 8.

With regard to the water resources of the area, the estimated amount of stored water in the upper 100 feet of saturation is roughly 175 times the estimated perennial yield. This large reserve of stored water is more than ample to meet the future demand during any period of below-average recharge.

Table 8. --Estimated ground water in storage in the upper 100 feet of saturated alluvium in each valley unit of the report area

Valley unit	Area 1/ (acres)	Ground water in storage 2/ (acre-feet)
Monitor Valley		
Northern part	97,600	1,000,000
Southern part	105,000	1,000,000
Subtotal (rounded)	203,000	2,000,000
Antelope Valley	121,000	1,200,000
Kobeh Valley	270,000	2,700,000
Stevens Basin	4,600	50,000
Total (rounded)	600,000	6,000,000

1. Taken as 80 percent of the total area of alluvium.

2. Using an assumed specific-yield value of 10 percent, and rounded.

Chemical Quality

Ten water samples were analyzed as part of the present study to make a generalized appraisal of the suitability of the ground water for agricultural use and to help define potential water-quality problems. The analyses are listed in table 9.

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 concentration 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 mangesium as "alkali hazard".

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

Sampling sites were chosen in Monitor, Antelope, and Kobeh Valleys to achieve the widest possible areal coverage. All the wells sampled yield water which probably is suitable for irrigation. However, water from spring 13/47-29cl had a high alkali and salinity hazard and probably would be marginal if used for irrigation. Water from springs 18/50-28dl and 18/50-28d2 had an extremely high alkali hazard because it contains sodium but little or no hardness. Accordingly, this water probably is unsuitable for irrigation.

Table 9. --Chemical analyses, in parts per million, of water from selected wells and springs in Monitor, Antelope, and Kobeh Valleys, Nevada

(field analyses by the U. S. Geological Survey)

Location (well or spring No.)	Date of collection	Temperature (°F.)	Calcium (Ca)	Magnesium (Mg)	1/ Sodium (Na)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Chloride (Cl)	Sulfate (SO_4)	Hardness as CaCO: Calcium magnesium	Hardness as CaCO: Non Carbonate	SAR	RSC (epm)	Specific conductance (micromhos at 25°C)	pH
13/ 47-29cl	4-14-64	54	48	39	201	212	20	110	340	280	0	5.2	0	1,470	8.7
16/47-4dl	4-14-64	60	50	8.8	31	182	0	15	55	161	0	1.0	0	460	7.6
16/50-29al	4-16-64	67	53	19	22	212	14	9	48	212	0	.7	0	481	8.7
18/47-20al	4-14-64	71	62	12	36	160	0	43	88	204	0	1.1	0	579	7.8
18/50-28dl	5-21-64	72	0.0	0.0	72	92	29	7.3	22	0	0	(a)	2.48	319	9.1
18/50-28d2	5-21-64	158	0.0	0.0	71	94	26	7.1	22	0	0	(a)	2.41	315	9.0
18/51-30bl	4-16-64	72	24	7.8	36	135	12	7.0	28	92	0	1.6	.37	319	8.7
18/51-34dl	4-16-64	61	31	15	21	164	0	13	32	141	0	.8	0	355	8.2
22/48-36al	5-19-64	--	16	4.4	17	80	0	6.0	19	58	0	.9	.15	186	7.8
22/49-27dl	5-19-64	--	26	6.3	23	132	0	10	18	91	0	1.0	.34	280	8.2

1. Computed by difference.

a. extremely high

Water Quality and its Relation to the Ground-Water System

The quality of ground water in the project area varies from place to place. However, in general, the dissolved-solids content is low in the recharge areas in the mountains and increases as it moves toward the discharge areas in the valley lowlands. In Monitor Valley, water from wells 18/47-20al and 16/47-4dl is a calcium bicarbonate type and has specific conductance values of 579 and 460 micromhos per centimeter, respectively. The source of much of the water probably is recharge derived from precipitation on the Toquima Range, Monitor Range, and Simpson Park Mountains. Water from well 13/47-29cl has a specific conductance value of 1,470 micromhos. It is expected that this water would have a high dissolved-solids content, because the well is adjacent to the playa and is in a discharge area. The most abundant ions in the water from this well are sodium and sulfate. The well penetrates fine-grained lacustrine strata, and these ions presumably were derived largely from evaporites in the lacustrine deposits.

In Antelope Valley, water from wells 16/50-29al and 18/51-34dl is a calcium bicarbonate type having specific conductance values of 481 and 355 micromhos, respectively. The source of much of this water probably is recharge derived from precipitation on the Monitor and Fish Creek Ranges. Water from the two wells at Klobe Springs, 18/50-28dl and 18/50-28d2, is a sodium bicarbonate type having specific conductance values of 319 and 315 micromhos, respectively. Although the two wells are only a about 100 feet apart, the temperature of the water from 28dl is 72°F. and that from 28d2 is 158°F. The reason for the difference in temperature is not known. The high temperature of water from well 28d2 indicates that the water has moved to this discharge point through rocks having relatively high temperature. This commonly infers that the water has moved to considerable depth in the underlying aquifers. Some of the deep aquifers probably are volcanic rocks similar to the types found in the adjacent Monitor Range. These springs yield water having a hardness content of less than 0.5 ppm (parts per million), but it is not uncommon to find thermal spring water in Nevada with little or no hardness.

DEVELOPMENT

Present Development

Surface Water

Surface water, where available, is used to irrigate meadow grass and alfalfa. Maximum flow occurs during the late spring; by early summer the snowmelt-fed creeks are usually dry. The acreage of irrigated land expands when the amount of snowmelt is large; it is reduced when the supply is small. Most of this type of irrigation is done at the mouths of the several canyons near presently active ranches. The crop is usually cut for hay; the estimated average irrigated area is 1500 acres.

Two small reservoirs in Kobeh Valley store snowmelt runoff which is used for irrigation. They are at the Roberts Creek (T. 22 N., R. 51 E.) and Three Bar (T. 22 N., R. 49 E.) Ranches. These reservoirs reportedly were filled in 1952, 1953 and 1964, being only partially filled in the intervening years..

Ground Water

Ground water in the report area is virtually undeveloped, except for springs and small diameter flowing wells which are used for domestic, stock-water, and irrigation purposes. Salt grass and meadow grass are utilized as pasture where the water table is within the reach of their roots. The principal areas are at Potts, Bean Flat, Kitchen Meadow, and the area just west of Devils Gate along Slough Creek. The two active irrigation wells, one at Potts (15/48-30dl) and the other near Bean Flat (19/49-30al), had a combined discharge in 1963 of about 1,000 acre-feet.

Potential Development

Surface Water

In the spring, following winters when a large amount of snow accumulated in the mountains, the flow of several creeks is large. Commonly this flow extends from Kobeh Valley through Devils Gate to Diamond Valley and is lost for use in the report area. The stream that appears to have the largest potential for irrigation development is Coils Creek in Kobeh Valley. When observed in May 1964, its flow probably was larger than the combined flows of all the other creeks in Kobeh Valley. A small reservoir at Three Bar Ranch stores water from Coils Creek; however, if additional storage were developed, more land could be irrigated during years of large flow.

Ground Water

Large amounts of ground water are available for development but are now wasted by phreatophytes. Kobeh Valley has the greatest agricultural potential because it probably has a longer growing season than either Antelope or Monitor Valleys and a larger yield (table 7). From a ground-water management standpoint, the best areas for development in Kobeh Valley would be adjacent to the phreatophyte areas where ground water can be intercepted before it migrates to the discharge area. In this potential development area the ground water is within economic reach by wells, perhaps at depths of 50 to 100 feet, and is of good chemical

Table 10.--Records of selected wells in Monitor, Antelope, and Kobeh Valleys and Stevens Basin, Nevada

Altitude: estimated
Measuring point, description: TC, top of casing;
TF, top of floor
Water level: M, measured; R, reported

Use of water: D, domestic; I, irrigation;
O, observation; S, stock; U, unused
Remarks: Number is log number in files of State Engineer

Well number and location	Owner and/or name	Date drilled	Depth (feet)	Diameter of casing (inches)	Principal water-bearing zone (feet)	Altitude (feet)	Measuring point: Description	Measuring point: Above land surface (feet)	Water level: Below measuring point (feet)	Water level: M or R	Water level: Date	Temperature (°F)	Use	Remarks
10/46-12a1	Pine Creek Ranch	8-1947	13	12-8	74-92	6,895	TC	1.0	8.0	M	9-19-61	--	S	Windmill
10/46-13a1	John Wardlaw	8-1947	90	12	42-64	6,900	--	--	7.	R	8-1947	46	I	Log 133. Test pumped 600 gpm at 40 feet.
10/46-13a2	John Wardlaw	8-1947	94	12	74-92	6,900	--	--	7.	R	8-1947	52	I	Log 134. Test pumped 600 gpm at 32 feet.
11/46-11c1	Pine Creek Ranch	--	--	6	--	6,865	TC	0	8.5	M	4-15-64	--	S	Windmill
12/47-18a1	Pine Creek Ranch	--	--	24	--	6,820	TC	1.2	5.4	M	4-15-64	--	S	Windmill
13/47-29c1	Pine Creek Ranch	--	--	6	--	--	TC	0	3.4	M	4-15-64	54	S	Windmill
15/47-8a1	Monitor Ranch	--	210	--	--	6,720	--	--	170.	R	4-14-64	--	D	Located at ranch house.
15/48-30d1	Monitor Ranch	1959	350	12	--	6,692	--	--	10.	R	1959	cold	I	Log 4939. Test pumped 1000 gpm from 110.
15/50-4d1	Domingo Segura	2-1964	252	16	141-196	6,460	--	--	125.	R	2-1964	--	I	Log 7649. Test pumped 2550 gpm at 172 feet.
16/47-4d1	Potts well	--	--	6	--	6,450	TF	2.0	60.2	M	9-21-61	60	S	Windmill
16/47-26d1	Airport well	--	--	6	--	6,510	TC	.8	85.4	M	4-14-64	--	S	Windmill
16/50-29a1	--	--	--	6	--	6,540	TC	1.5	218.0	M	4-16-64	--	S	Windmill
16/51-7d1	Bartholomae Corp.	--	30	72	--	6,325	TF	0	25.4 25.5 25.4 24.9 25.0 25.0 25.4 25.8 27.1 27.2 27.3 28.0	M M M M M M M M M M M M	7-21-40 9-19-50 9-11-51 10-01-52 9-15-54 9-18-55 12-17-59 9-28-60 9-21-61 10-12-62 9-10-63 3-24-64	--	S,O	
16/51-7d2	Bartholomae Corp.	6-1963	105	6	28-54	6,325	TC	1.5	26	R	6-1963	54	S	Log 7237. Test pumped 18 gpm with 31 feet drawdown.
17/47-8a1	--	--	--	6	--	6,380	TC	.5	77.2	M	4-14-64	--	S	Windmill
17/50-25a1	Bartholomae Corp.	6-1951	60	8	18-40	6,270	--	--	16.	R	6-1951	--	S	Log 1684.
17/51-27c1	OK well	9-1942	272	6	240-262	6,410	TC	1.0	158. 161.7	R M	9-1942 7-20-49	--	S	Log 212.
17/51-31b1	Cerutti well	--	18	6	--	6,290	TC	1.0	15.9 15.4	M M	7-20-49 4-16-64	--	S	Twenty-foot windmill tower.
17/52-4c1	Mine well	8-1942	351	6-4	325-328	6,570	--	--	318.	R	8-26-42	58	S	Log 211. Old mine well.
17/52-17b1	Fish Creek well	--	26	14	--	6,800	--	0	23.8	M	7-21-49	--	O	Old mine well. 5.4 mi. ENE along trail from 17/51.
18 1/2-47-5c1	Damele well	--	115	6	--	6,290	TC	.5	82.0 81.3	M M	4-16-47 3-16-48	--	S	Windmill
18/47-8c1	--	--	--	6	--	6,317	--	--	--	-	--	71	S	Windmill
18/48-7b1	Grimes Ranch	--	--	6	--	6,370	TC	.5	154.1	M	4-14-64	--	S	Windmill. Located 100 yds. west of shack.
18/50-28d1	Hot Spring Ranch	--	35	12	2-40	6,340	TC	0	4.6 4.8	M M	7-20-49 4-16-64	72	U	Well drilled in Klobe Spring.
18/50-28d2	Hot Spring Ranch	10-1942	39.5	12	9-40	6,340	TC	2.0	(flowing)	M	7-20-49	158	S,O	Well drilled in Klobe Spring. Spring flowed 500 gpm (4-16-64).
18/51-10b1	--	--	--	6	--	6,230	TC	.5	177.2	M	4-16-64	--	S	Windmill
18/51-18c1	Bartholomae Corp.	8-1943	670	12-8	--	6,160	--	--	(flowing)	M	8-08-49	74	I	Log 216. Flowed 14 gpm (8-8-49). Test pumped 76 gpm from 10 feet.
18/51-22b1	Angelo Florio	6-1950	135	6	65-130	6,230	TC	.5	59.3	M	4-16-64	69	S	Log 1330. Windmill.
18/51-30b1	Bartholomae Corp.	11-1943	--	6	--	6,090	TC	--	(flowing)	M	8-02-49	72	--	Flowed 170 gpm (8-2-49) and an estimated 200 gpm (4-16-64).
18/51-30d1	Bartholomae Corp.	--	738	13-8	8-80 225-235	6,090	TC	--	(flowing)	M	8-18-49	64	I	Log 217. Casing to 260 feet. Flowed 3 gpm (8-18-49). Test pumped 100 gpm with 12 feet of drawdown.
18/51-34d1	Arduna well	--	134	6	--	6,330	TC	.6	94.7 94.6 94.7 94.6 94.6 94.7 94.8 95.9 94.9 94.9 95.0	M M M M M M M M M M M	7-20-49 9-19-50 9-11-51 10-01-52 9-14-53 9-18-55 12-17-59 9-21-61 3-25-62 3-25-63 3-24-64	61	S,O	Well inside building, 11.7 mi. S of Route 50.
19/47-9a1	Dry Creek Ranch	--	119	--	--	6,350	--	--	--	-	--	--	S	
19/47-36b1	Dry Creek Ranch	4-1958	102	8	102-113	6,260	--	--	56 47.6	R M	4-19-58 4-14-64	cold	O	Log 7140. Located 100 yds. north of U.S. 50.

Table 10.--continued

Well number and location	Owner and/or name	Date drilled	Depth (feet)	Diameter of casing (inches)	Principal water-bearing zone (feet)	Altitude (feet)	Measuring point: Des-cription	Measuring point: Above land surface (feet)	Water level: Below measuring point (feet)	Water level: M or R	Water level: Date	Temper-ature (°F)	Use	Remarks
19/48-12a1	Maurice Farr	8-1959	90	6	28-90	--	--	--	23	R	8-1959	52	S	Log 5515.
19/49-5c1	Peter Damele	10-1951	280	12-10	6-220	--	--	--	--	-	--	--	I	Log 1885. On Bean Flat.
19/49-30a1	Maurice Farr	8-1959	223	18	105-130	6,280	--	--	85 90	R R	8-1959 5-1964	cold	I	Log 4893. Paul Conlan was former owner.
19/50-16b1	Bartine Ranch	--	315	--	--	--	--	--	(flowing)	M	8-18-49	--	D,S,I	Nearby well, west of house flowed 155 gpm (8-18-49).
19/52-34d1	Dry Lake well	--	540	6	--	7,210	--	--	461.3	M	11-17-53	--	U	Well in Stevens Basin
20/49-9c1	Bartine Ranch	--	23	4	--	6,154	TC	.5	7.8	M	1-15-48	--	S	
20/49-9c2	Fred Etcheguary	9-1951	250	20-10	20-220	--	--	--	6	R	9-1951	--	I	Log 1887.
20/49-9d1	Bernard Damele	8-1953	85	12	--	--	--	--	15	R	8-1953	65	I	Log 2671.
20/52-17c1	Hay Ranch	--	25	6	--	--	TC	.7	7.0	M	11-18-53	--	S	In railroad tie shed, north of U.S. Highway 50, 2.5 mi. by trail.
20/52-17d1	Hay Ranch	--	90	10	--	--	TC	1.0	18.8	M	11-18-53	--	I	Pumping rate, 300 to 500 gpm (11-18-53). South side of trail, 1.6 mi. from Route 50.
20/52-20a1	Hay Ranch	5-1951	120	10	100-120	--	--	--	16	R	5-1951	68	I	Log 1676. Test pumped 600 gpm with 29 feet of drawdown.
21/48-10c1	Ferguson Ranch	10-1947	20	6	18-20	6,600	--	--	10	R	10-1947	--	D	Bedrock reported at 18 feet.
21/49-16c1	Santa Fe Ranch	1945	60	6	--	6,290	TC	2.5	43.4 43.3 45.4 45.4 42.6 45.7 46.2 47.1 47.1 47.9 47.9 49.1	M M M M M M M M M M M M	1-15-48 9-13-49 9-19-50 9-11-51 9-14-53 9-18-55 12-17-59 9-20-60 9-21-61 10-12-62 9-10-63 3-24-64	--	S,O	Windmill. West of trail 0.6 mi.
22/51-19c1	Roberts Creek Ranch	8-1958	350	12	142-152	--	--	--	142.	R	8-1958	cold	I	Log 4274. Test pumped 165 gpm at 255 feet.

quality. Upslope toward the mountains, the depth to water increases; in the phreatophyte areas the water is likely to be more highly mineralized.

For the best utilization of the ground-water resources, concentration of pumping in one or two small areas should be avoided. Preferably, development should be scattered around the margins of the phreatophyte area. In this way, the water levels in the phreatophyte area eventually would be lowered below the roots of the plants, and thereby the ground water that now is going to waste would be salvaged.

PROPOSALS FOR ADDITIONAL STUDIES

In accordance with the request of Hugh A. Shamberger, Director, Nevada Department of Conservation and Natural Resources, suggestions for future studies in Monitor, Antelope, and Kobeh Valleys are listed below.

1. Install gaging stations on Slough Creek at Devils Gate and on Coils Creek **south** of Three Bar Ranch. The data would be useful in evaluating the potential development of the surface water in Kobeh Valley and the relation of the stream to ground-water recharge in Kobeh and Diamond Valleys.

2. After substantial ground-water development has occurred and when more well date become available, it will be desirable to refine the estimates of intervalley flow between the southern and northern parts of Monitor Valley and between the northern part of Monitor Valley and Kobeh Valley. This information will be needed to reappraise the supply available in the several valley units.

Table 11. --Selected drillers' logs of wells in Monitor, Antelope, and Kobeh Valleys, Nevada

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
10/46-13a1 John Wardlaw			15/50-4d1 Domingo Segura		
Clay, blue	15	15	Topsoil	3	3
Gravel	10	25	Gravel, coarse and clay	10	13
Clay, blue	15	40	Gravel, pea-size	5	18
Gravel	25	65	Gravel and clay	24	42
Clay, yellow	9	74	Gravel, pea-size	12	54
Gravel	18	92	Gravel, pea-size and clay	6	60
Clay, white	2	94	Clay, sandy, soft	4	64
			Sand and pea-size gravel	18	82
			Sandstone	1	83
			Gravel, pea-size	8	91
			Sand and gravel	6	97
			Sandstone	2	99
			Clay, sandy	13	112
			Clay and gravel	10	122
			Sand and gravel	17	139
			Clay, sandy, soft	2	141
			Gravel and sand	17	158
			Sandstone	2	160
			Clay and gravel	24	184
			Gravel, pea-size	4	188

Table 11. --continued

Material	Thickness (feet)	Depth (feet)
Clay and gravel	36	224
Gravel, pea-sized	4	228
16/51-7d2 Bartholomae Corp.		
Soil	11	11
Soil, clay and small gravel	8	19
Gravel, sandy, fine	9	28
Gravel, water-bearing	26	54
Clay, tough, gray	42	96
Clay, gray; mixed with gravel	9	105
17/51-27c1 3C well		
Sand	102	102
Boulders	5	107
Sand, coarse, cemented	71	178
Sand, water-bearing	3	181
Caliche	68	249
Gravel, water-bearing	13	262
Bedrock, porphyry	10	272
18/50-28d1 Hot Spring Ranch		
Silt and sand	9	9
Clay	7	16
Bedrock, decomposed granite (?)	25	41
18/50-28d2 Hot Spring Ranch		
Silt and boulders	9	9
Granite, decomposed	16	25
Granite, solid (?)	20	45

Table 11/ --continued

Material	Thickness (feet)	Depth (feet)	Material	Thickness (feet)	Depth (feet)
17/52-7cl Mine well					
Silt	3	3			
Gravel, coarse and boulders	125	128			
Caliche and cemented gravel	197	325			
Cavity, water-filled	3	328			
Bedrock, limestone	23	351			
18/51-18cl Bartholomae Corp.			**18/51-30dl Bartholomae Corp.**		
Silt	30	30	Soil	8	8
Gravel, fine and sand; water-bearing	2	32	Sand, with water	47	55
Sand and clay	58	90	Clay	2	57
Sand and fine gravel; water-bearing	2	92	Sand, with water	23	80
Clay	58	150	Hardpan	43	123
Clay, sandy	139	289	Clay, sandy, red	47	170
Caliche, very hard	28	317	Clay, white	30	200
Clay, sandy	53	370	Clay, red	25	225
Clay, red	10	380	Clay, sandy, with water	10	235
Rock, red	50	430	Clay, white	15	250

Table 11. --continued

Material	Thickness (feet)	Depth (feet)
Caliche	20	450
Limestone, white	7	457
Caliche	18	475
Limestone, white	3	478
Caliche	7	485
Limestone, soft	5	490
Caliche	12	502
Limestone, soft	2	504
Caliche	16	520
Limestone, soft	125	645
Limestone, very hard	25	670

19/47-36b1 Dry Creek Ranch

Material	Thickness (feet)	Depth (feet)
Gravel	24	24
Clay	3	27
Sand and gravel	39	66
Clay, gray	3	69
Gravel and sand	23	92
Gravel and clay	10	102

Material	Thickness (feet)	Depth (feet)
Chalk, hard, white	50	300
Clay, white	80	380
Chalk, white	20	400
Clay, wet	10	410
Clay and sand, wet	10	420
Hardpan	20	440
Clay, white	20	460
Clay, sticky	10	470
Clay, hard, dry	10	480
Chalk, white	20	500
Limestone	190	690
Clay, red	20	710
Chalk	10	720
Clay, red	18	738

19/49-30a1 Maurice Farr

Material	Thickness (feet)	Depth (feet)
Sand and Gravel	14	14
Clay, hard and sandstone	16	30
Clay, sandy	4	34
Clay, brown	3	37
Clay, sandy	25	62
Gravel, fine	2	64

Table 11. --continued

Material	Thickness (feet)	Depth (feet)
Gravel, water-bearing	11	113

19/49-5c1 Peter Damele

Material	Thickness (feet)	Depth (feet)
Soil	3	3
Clay, white	3	6
Sand and gravel	68	74
Clay, yellow	16	90
Sand and gravel	130	220
Rock, red, hard	20	240
Sand and gravel	40	280

Material	Thickness (feet)	Depth (feet)
Clay, sandy	37	101
Gravel, large, dry	2	103
Granite, decomposed	2	105
Gravel	7	112
Sand, fine and gravel	8	120
Gravel, fine and large	10	130
Clay	3	133
Gravel, small	8	141
Sandstone	3	144
Gravel, small	2	146
Sandstone, bright yellow	4	150
Gravel, cemented	2	152
Granite, decomposed	22	174
Granite, fresh	20	194
Volcanic rock	10	204
Rock, very hard	19	223

20/49-9c2 Fred Etchegary

Material	Thickness (feet)	Depth (feet)
Soil	3	3
Sand and gravel	217	220
Clay, yellow	20	240
Sand	10	250

Table 11. --continued

Material	Thickness (feet)	Depth (feet)
20/52-20 al Hay Ranch		
Clay	5	5
Boulders	13	18
Sand, fine	12	30
Boulders	70	100
Sand, water-bearing	20	120
22/51-19cl Roberts Creek Ranch		
Gravel and clay, mixed	23	23
Gravel and boulders	8	31
Boulders, gravel, and clay	111	142
Gravel and sand	10	152
Gravel and clay	37	189
Gravel and sand	50	239
Clay, yellow	2	241
Boulders, gravel, and sand	109	350

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3.	Ground-Water Appraisal of Long Valley, White Pine and Elko Counties, Nevada. June 1961, by Thomas E. Eakin. (Supply Exhausted)
4.	Ground-Water Resources of Pine Forest Valley, Humboldt County, Nevada. Jan. 1962, by William C. Sinclair. (Supply Exhausted)
5.	Ground-Water Appraisal of the Imlay Area, Humboldt River Basin, Pershing County, Nevada. Feb. 1962, by Thomas E. Eakin. (Supply Exhausted)
6.	Ground-Water Resources of Diamond Valley, Eureka and Elko Counties, Nevada. Feb. 1962, by Thomas E. Eakin. (Supply Exhausted)
7.	Ground-Water Resources of Desert Valley, Humboldt County, Nevada. April 1962, by William C. Sinclair.
8.	Ground-Water Appraisal of Independence Valley, Western Elko County, Nevada. May 1962, by Thomas E. Eakin.
9.	Ground-Water Appraisal of Gabbs Valley, Mineral and Nye Counties, Nevada. June 1962, by Thomas E. Eakin.
10.	Ground-Water Appraisal of Sarcobatus Flat and Oasis Valley, Nye County, Nevada. Oct. 1962, by Glenn T. Malmberg and Thomas E. Eakin.
11.	Ground Water Resources of Hualapai Flat, Washoe, Pershing and Humboldt Counties, Nevada. Oct. 1962, by William C. Sinclair.
12.	Ground-Water Appraisal of Ralston and Stonecabin Valleys, Nye County, Nevada. Oct. 1962, by Thomas E. Eakin.
13.	Ground-Water Appraisal of Cave Valley in Lincoln and White Pine Counties, Nevada. Dec. 1962, by Thomas E. Eakin.
15.	Ground-Water Resources of Amargosa Desert, Nevada-California. March 1963, by George E. Walker and Thomas E. Eakin.

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Report No.

15. Ground-Water Appraisal of the Long Valley-Massacre Lake Region, Washoe County, Nevada, by William C. Sinclair; also including a section on The Soils of Long Valley by Richard L. Malchow, May 1963.

16. Ground-Water Appraisal of Dry Lake and Delamar Valleys, Lincoln County, Nevada. May 1963, by Thomas E. Eakin.

17. Ground-Water Appraisal of Duck Lake Valley, Washoe County, Nevada. June 1963, by William C. Sinclair.

18. Ground-Water Appraisal of Garden and Coal Valleys, Lincoln and Nye Counties, Nevada. July 1963, by Thomas E. Eakin.

19. Ground-Water Appraisal of Antelope and Middle Reese River Valleys, Lander County, Nevada. September 1963 by E. G. Crosthwaite.

20. Ground-Water Appraisal of the Black Rock Desert Area, Northwestern Nevada. October 1963, by William C. Sinclair.

21. Ground-Water Appraisal of Pahranagat and Pahroc Valleys, Lincoln and Nye Counties, Nevada. October 1963, by Thomas E. Eakin.

22. Ground-Water Appraisal of the Pueblo-Valley-Continental Lake Region, Humboldt County, Nevada. November 1963, by William C. Sinclair.

23. A Brief Appraisal of the Ground-Water Hydrology of the Dixie-Fairview Valley Area, Nevada. November 1963, by Philip Cohen and D. E. Everett.

24. Ground-Water Appraisal of Lake Valley in Lincoln and White Pine Counties, Nevada. December, 1963, by F. Eugene Rush and Thomas E. Eakin.

25. Ground-Water Appraisal of Coyote Spring and Kane Spring Valleys and Muddy River Springs area, Lincoln and Clark Counties, Nevada, February 1964, by Thomas E. Eakin.

26. Ground-Water Appraisal of Edwards Creek Valley, Churchill County, Nevada, April 1964, by D. E. Everett.

27. Ground-Water Appraisal of the Meadow Valley Area, Lincoln and Clark Counties, Nevada, July, 1964, by F. Eugene Rush.

28. Ground-Water Appraisal of Smith Creek and Ione Valleys, Lander and Nye Counties, Nevada, by D. E. Everett and F. Eugene Rush, July 1964.

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Report No.	
29.	A Brief Appraisal of the Ground-Water Resources of the Grass Valley area, Humboldt and Pershing Counties, Nevada, September 1964, by Philip Cohen.
30.	Ground-Water Appraisal of Monitor, Antelope, and Kobeh Valleys, Nevada. November 1964, by F. Eugene Rush and D. E. Everett.

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

THE STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

PLATE 1.—GENERALIZED HYDROGEOLOGIC MAP OF MONITOR, ANTELOPE, AND KOBEH VALLEYS, NEVADA