STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
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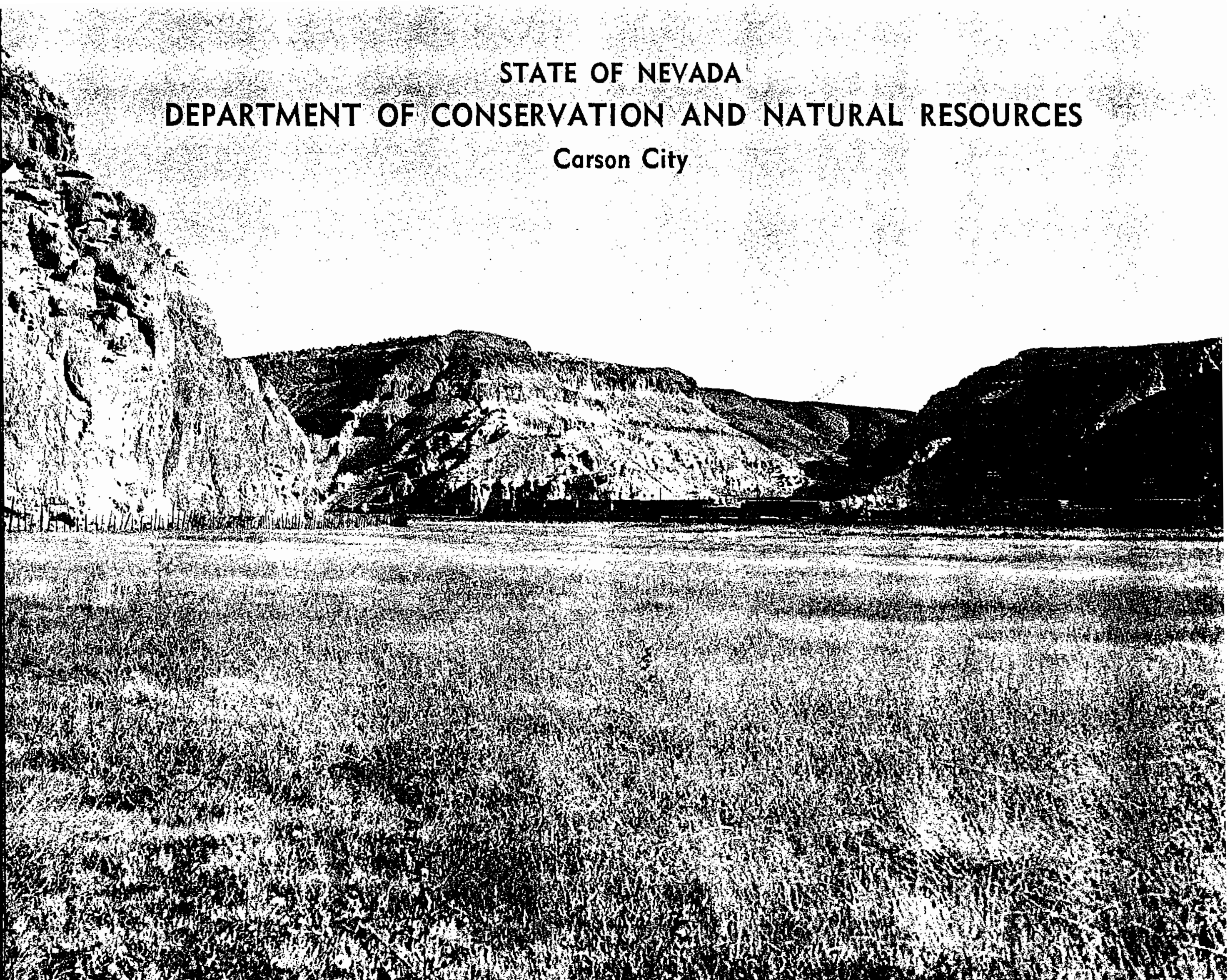


View of an irrigated field in lower Meadow Valley.

GROUND-WATER RESOURCES – RECONNAISSANCE SERIES

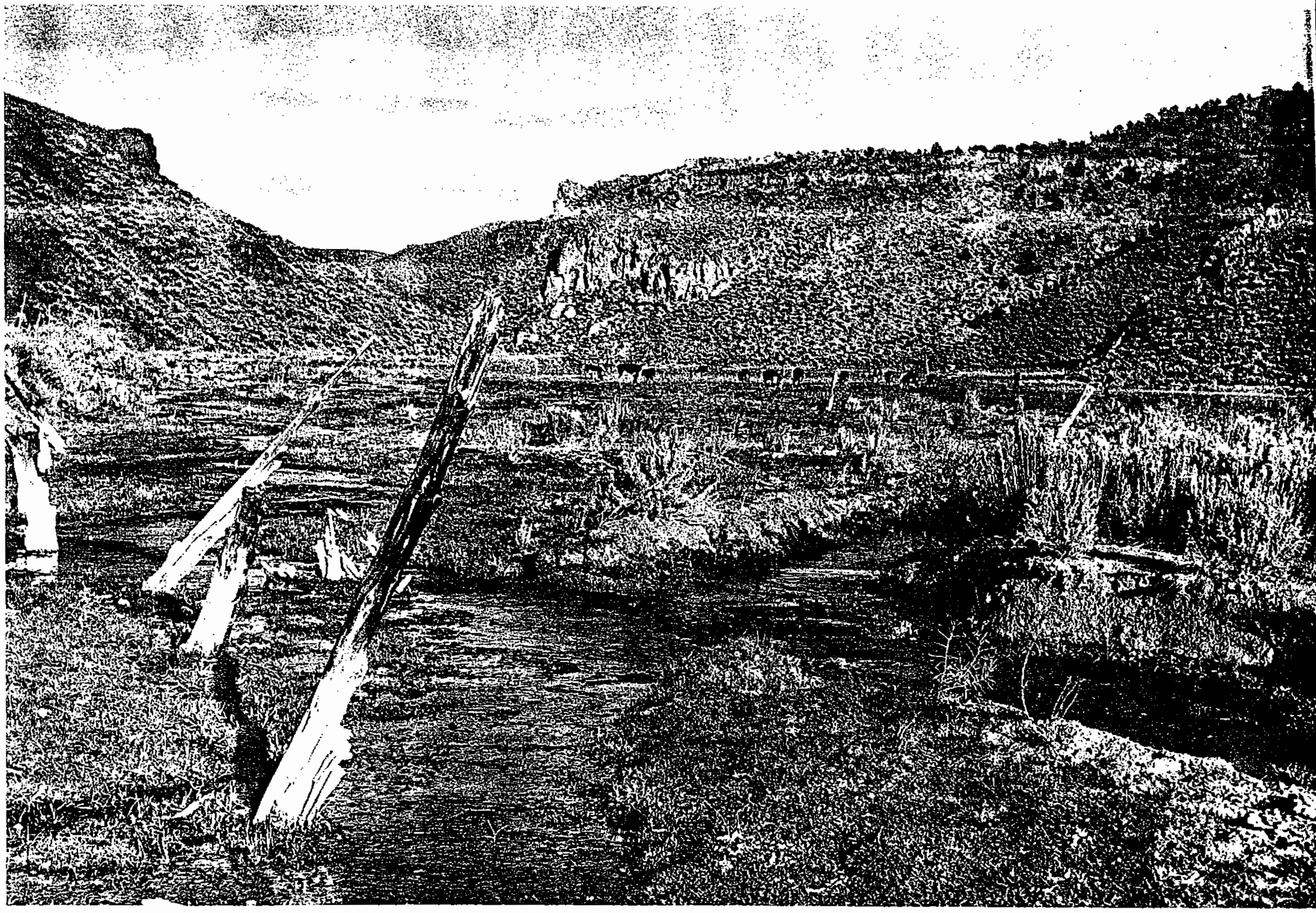
REPORT 27

GROUND-WATER APPRAISAL OF THE MEADOW VALLEY AREA, LINCOLN AND CLARK COUNTIES, NEVADA

By
F. EUGENE RUSH
Geologist

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

JULY 1964



View of southern part of Spring Valley showing the flow of water from springs about two miles north. The water rises from the alluvium of the valley and supports the meadows and pasture in Spring Valley. The flow that leaves the valley is used in Eagle and Rose Valleys to irrigate crops.

COVER PHOTOGRAPH

View of a field in lower Meadow Valley, about two miles south of Caliente, that is used for hay and pasture. The fields of the area are irrigated by diverting the flow in the wash (beyond railroad tracks) and by pumping irrigation wells. The main line of the Union Pacific Railroad passes through lower Meadow Valley.

GROUND-WATER RESOURCES---RECONNAISSANCE SERIES

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FOREWORD

This report, the 27th in the series of reconnaissance ground-water studies which were initiated following authorization by the 1960 Legislature, gives the results of a study of the Meadow Valley area. This area includes eight valleys in southeastern Nevada -- Patterson, Spring, Eagle, Dry, Rose, Panaca, Clover, and Lower Meadow Valley -- all part of the Colorado River drainage system.

This study was made and report prepared by F. Eugene Rush, Geologist for the U. S. Geological Survey.

These reconnaissance ground-water resources surveys make available pertinent information of great and immediate value to many State and Federal agencies. As development takes place in any area, demands for more detailed information will arise and studies to supply such information will be undertaken. In the meantime, these reconnaissance type studies are timely and adequately meet the immediate needs for information on the ground-water resources of the areas covered by the reports.

Hugh A. Shamberger, Director
Department of Conservation and
Natural Resources

CONTENTS

ILLUSTRATIONS

TABLES

GROUND-WATER APPRAISAL OF THE MEADOW VALLEY AREA,

LINCOLN AND CLARK COUNTIES, NEVADA

by
F. Eugene Rush

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SUMMARY

The Meadow Valley area includes eight valleys in southeastern Nevada: Patterson, Spring, Eagle, Dry, Rose, Panaca, Clover, and Lower Meadow Valleys. The area is a hydrologic unit forming part of the Colorado River drainage system.

Precipitation within the drainage area and underflow from Lake Valley are the source of virtually all the ground water. Most of the ground water is stored in and transmitted through the Tertiary and Quaternary alluvial valley fill. The Paleozoic carbonate rocks apparently transmit a large amount of ground water from Patterson Valley to Panaca Valley where much of it is discharged as warm water by Panaca Spring. Surface flow is perennial in some reaches of Meadow Valley wash. Storm and snowmelt runoff cause flow to the mouth of the wash during the winter and spring of some years.

The estimated average annual recharge to the area is 24,000 acre-feet from precipitation and 3,000 acre-feet by underflow from Lake Valley, for a total of 27,000 acre-feet. About two-thirds of the recharge occurs in Patterson and Spring Valleys where the bordering mountains are high.

The estimated discharge of water by phreatophytes, principally greasewood, rabbitbrush, and saltbush was 3,600 acre-feet in 1963. It is estimated that wells discharged about 19,000 acre-feet in 1963; the net draft on the ground-water reservoir was about 12,000 acre-feet. Panaca Spring has an estimated flow of 8,000 acre-feet a year, having a net draft of about 4,000 acre-feet. The discharge of ground water due to subsurface outflow from the Meadow Valley area to the lower Moapa Valley was not determined. The ground water in storage in the uppermost 100 feet of saturated alluvium in the area is estimated to be at least 8 million acre-feet.

The preliminary estimate of perennial yield of the area is 25,000 acre-feet. This value cannot be refined until data are available to determine the subsurface outflow from the area. Local overdraft may be occurring in Panaca Valley where net draft now exceeds the local recharge to the valley.

The chemical quality of the ground water is best near the sources of recharge and generally increases in dissolved-mineral content southward

toward Glendale. The salinity hazard of most of the water sampled was medium to high. Near Glendale, the ground-water quality seems to be deteriorating with time.

Part of the ground water now wasted by phreatophytes and lost for development due to underflow from the Meadow Valley area may be salvaged for use by lowering the water table below the phreatophyte root-system and by reducing the ground-water gradient toward the Muddy River area near Glendale. Flash runoff and unused spring discharge might be salvaged by inducing greater infiltration to the alluvium and consequent recharge to the ground-water reservoir.

The total amount of water available rather than the amount of available land suitable for irrigation, probably will be the limiting factor in agricultural development.

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 with the U. S. Geological Survey. 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 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 27 in the series of reconnaissance studies (fig. 1). The field work was a 3-week study of the hydrologic conditions and the geologic environment of the area. The field work was done in October and December 1963.

The author takes this opportunity to thank his colleagues, D. O. Moore and L. K. Nalder, who provided considerable assistance by making many of the surface-water flow and spring-discharge measurements.

Special acknowledgement is due Lester Mathews, Amy Mathews, and Ronald Mathews in helping the author locate many of the wells and in furnishing power-consumption data for these wells. In addition, help was received from Darrell Free, well driller, and many well owners.

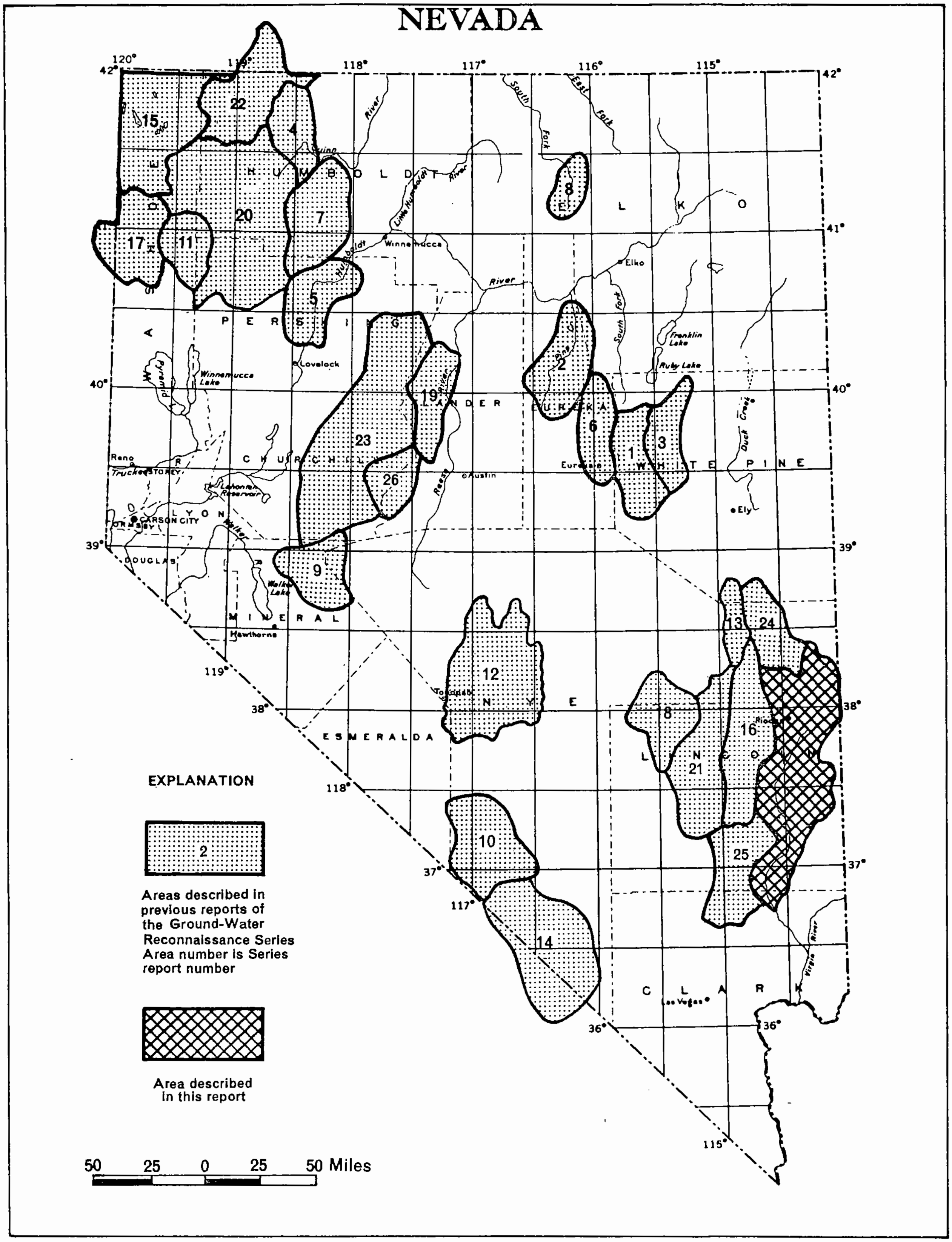

FIGURE 1. Map of Nevada showing areas described in previous reports of the Ground-Water Reconnaissance Series and the area described in this report

Location and General Features:

The Meadow Valley area is in the southeastern part of Nevada and is enclosed by longitude 114° 00' W. and 115° 00' W., and latitude 36° 30' N. and 38° 30' N. (fig. 1). The area is mostly in Lincoln County; however, the southern part of the area is in northeastern Clark County. The north end of the area is about 80 miles south of Ely, Nevada; the south end about 50 miles northeast of Las Vegas. The principal communities of the area are Pioche, Panaca, and Caliente.

The Meadow Valley area, as defined for this study, is a long, narrow series of valleys, having its maximum dimension, 110 miles, in a north-south direction. Its maximum width between topographic divides, measured near Caliente, is about 35 miles. It has an area of about 2,500 square miles.

The area is made up of many small valleys that locally have names. All the principal named valleys, except Clover Valley and the southern part of lower Meadow Valley, are shown in figure 2. These include Patterson, Spring, Eagle, Rose, Dry, Panaca, and lower Meadow Valleys.

Principal access to the area is by U.S. Highway 93 which extends northward through the northern half of the area; Nevada State Highway 25 and Utah Highway 56 which jointly extend eastward from Panaca to Cedar City, Utah; and U.S. Highway 91 which traverses the southern tip of the area at Glendale and connects Las Vegas with Salt Lake City. Paved roads extend from Pioche to Ursine and Caselton. Improved roads extend southeastward from State Highway 25 through Crestline; eastward from Caliente to Beaver Dam State Park, which is just east of the report area; and southward from Caliente through the small communities of Elgin and Carp to Glendale. Numerous roads and trails cross the area and connect the small valleys.

The main line of the Union Pacific railroad passes through the area from Glendale along Meadow Valley Wash to Caliente and then eastward through Clover Valley to Salt Lake City. A spur line extends from Caliente through Panaca Valley to the mining area west of Pioche.

The exact population of the area is not known; however, the Nevada Department of Economic Development estimates that in 1963 between 1,600 and 1,800 people lived in the area. The largest community is Caliente, having a population of about 800. Pioche is nearly as large with a population of about 600.

Physiography and Drainage:

The Meadow Valley area is a part of the Colorado River drainage and is in the eastern part of the Great Basin section of the Basin and Range physiographic province. This north-trending area is tributary to the Muddy River drainage near Glendale and, together with the Virgin River, these comprise the

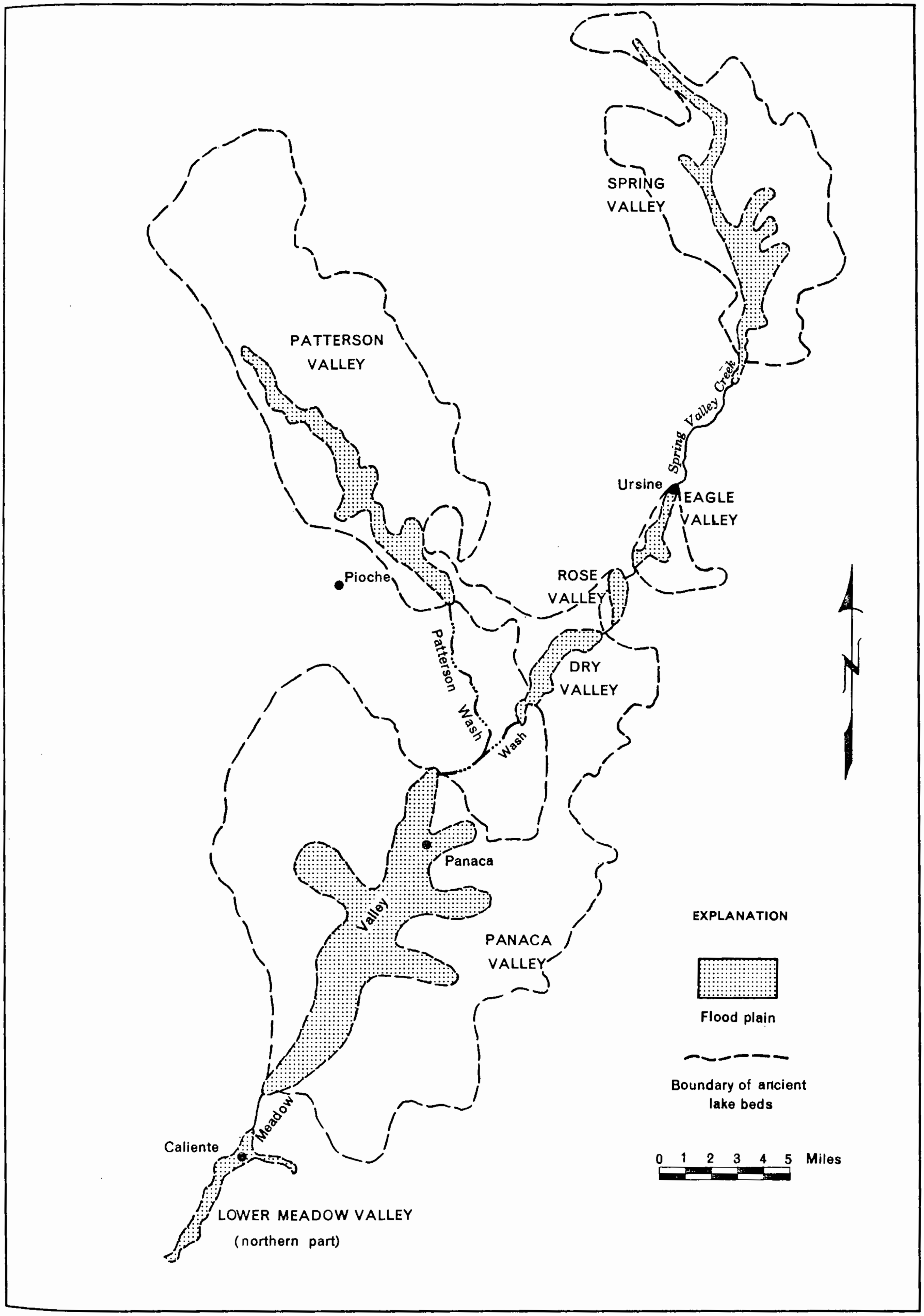

Figure 2.—Sketch map of part of the Meadow Valley area showing the flood plain and the area of ancient lake beds in each valley and the principal drainage

areas tributary to the Overton arm of Lake Mead. The north end of the area is separated from Lake Valley; in part by a low alluvial divide, and in part by the Wilson Creek Range. The report area is bounded on the east by the White Rock, Needle, and Mormon Mountains; and on the west by the Ely, Bristol, and Highland Ranges, and the Meadow Valley Mountains.

The highest peaks are along the boundaries of the northern part of the report area. The highest, Highland Peak a few miles west of Pioche, has an altitude of 9,500 feet. Two others, Mount Wilson (9,296 feet) and White Rock Peak (9,196 feet), are along the north boundary of the area. Parsnip Peak (8,942 feet) is in the Wilson Creek Range on the divide between Patterson Valley and Spring Valley. Another notable peak, Mormon Peak (7,411 feet), is 10 miles south of Carp along the east boundary of lower Meadow Valley. The lowest point in the report area is at Glendale where Meadow Valley Wash joins the Muddy River. The altitude here is about 1,500 feet. North of Caliente the valley floor is above an altitude of 4,400 feet and reaches an altitude of about 6,000 feet in Spring Valley. The mountains generally rise 2,000 to 3,000 feet above the adjacent valley floors; however, in some areas the highest peaks extend 5,000 feet above the valleys.

The many small valleys that comprise the Meadow Valley area are interconnected by a common drainage system. The main drainage way, Meadow Valley Wash, is formed by the junction of Patterson Wash and Spring Valley Creek at Condor Canyon (pl. 1).

Climate:

The air masses that move across the Meadow Valley area are characteristically deficient in moisture. The valley floors are semiarid to arid, whereas the higher mountain areas are semihumid. The precipitation pattern is related to the topography; the stations at the high altitudes generally receive a greater amount than those at the low altitudes. This relationship is shown by the graph in figure 3. Thunderstorms occur principally in the summer, and commonly result in flash floods.

Precipitation data have been recorded at nine stations in the report area and at Logandale and Overton, a few miles south of the area. These stations are shown in figure 4. For the period 1952-61 the maximum average annual precipitation, 15.92 inches, occurred at the Bunker Peak station. A great variation in the annual precipitation has occurred there during this period, ranging from about 24 inches to less than 7 inches per year. At the five other high altitude stations, all at altitudes of about 6,000 feet or more, the average precipitation equaled or exceeded 11 inches per year (tables 1 and 2). For the period 1940-62 the smallest average annual precipitation, 4.22 inches, occurred at Overton. As shown in table 2, the Carp and Logandale stations have recorded similar amounts. At the intermediate altitudes, the Caliente and Elgin stations have recorded an average of about 9 inches annually.

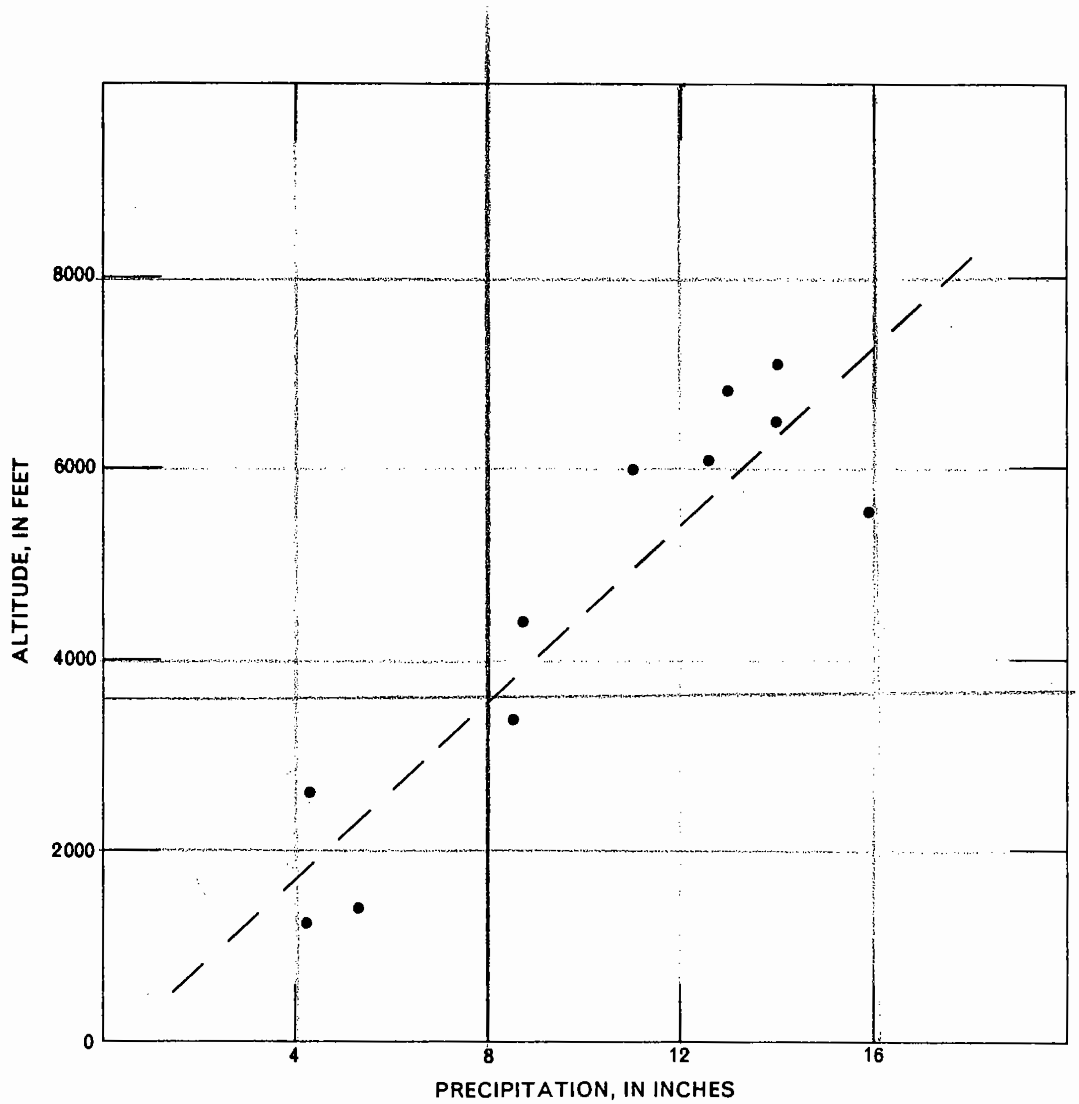

Figure 3.—Graph showing the relation of station altitude to the measured amount of average annual precipitation in the Meadow Valley area

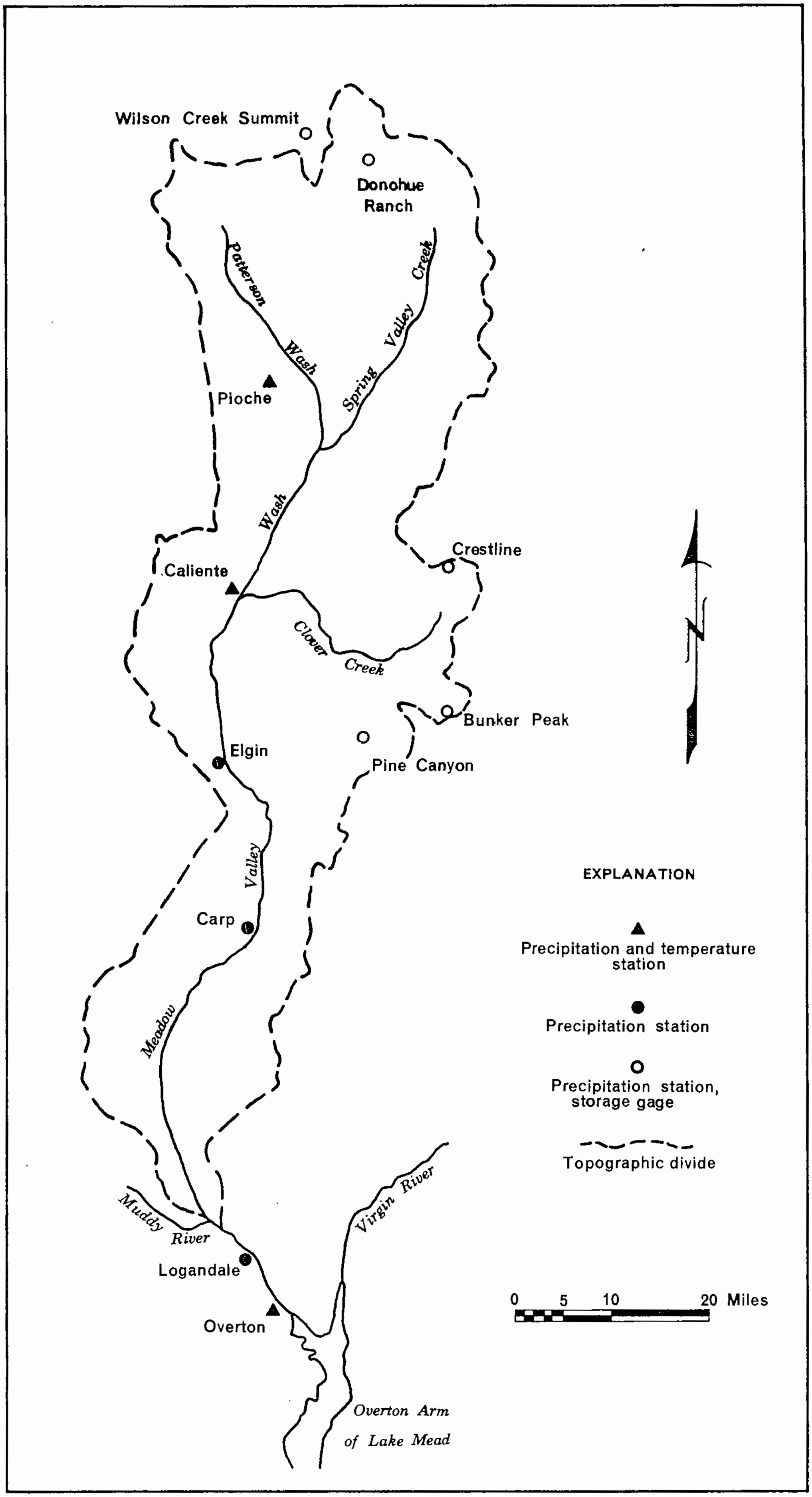

Figure 4.—Sketch map of the Meadow Valley Area showing the locations of weather stations.

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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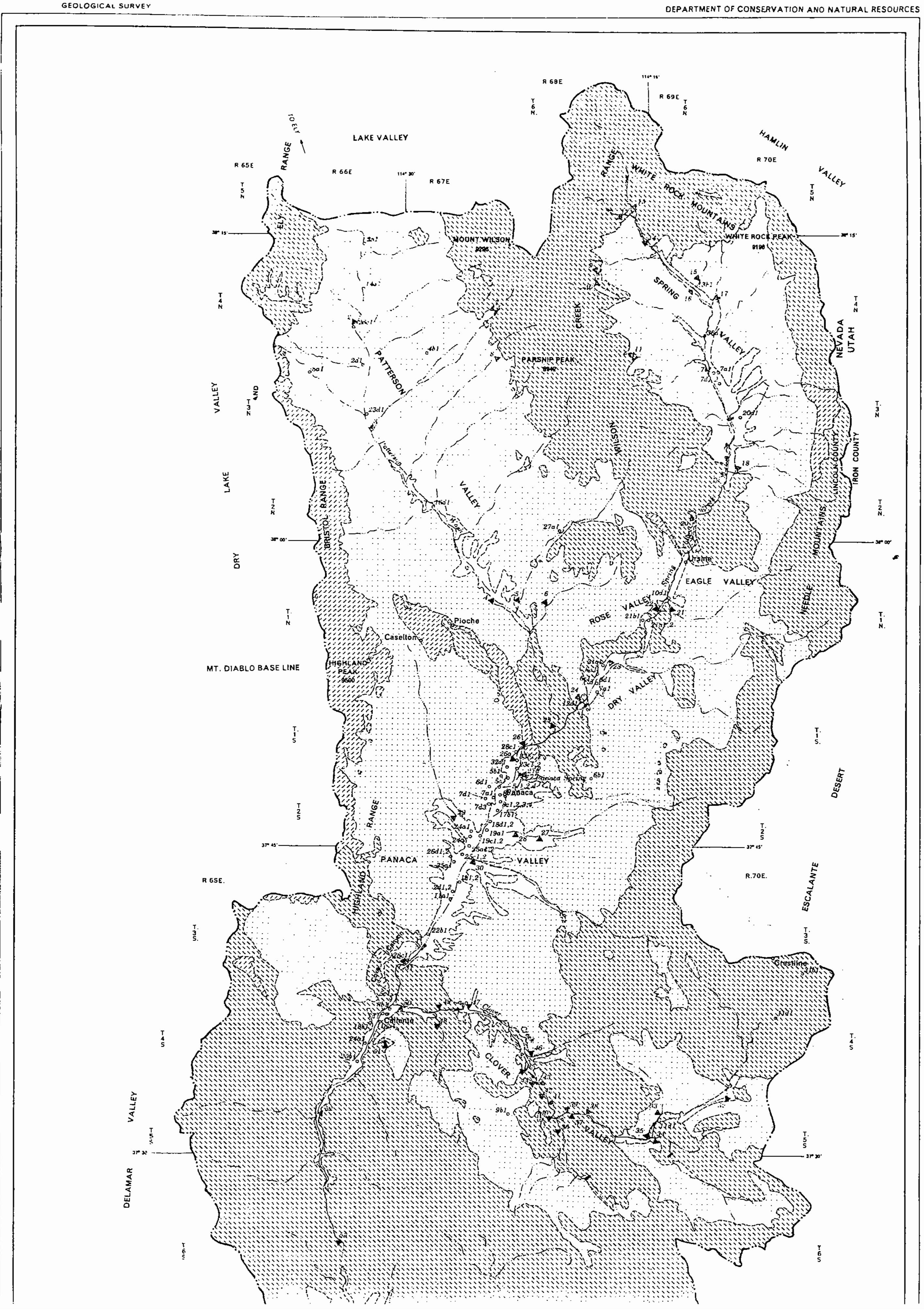


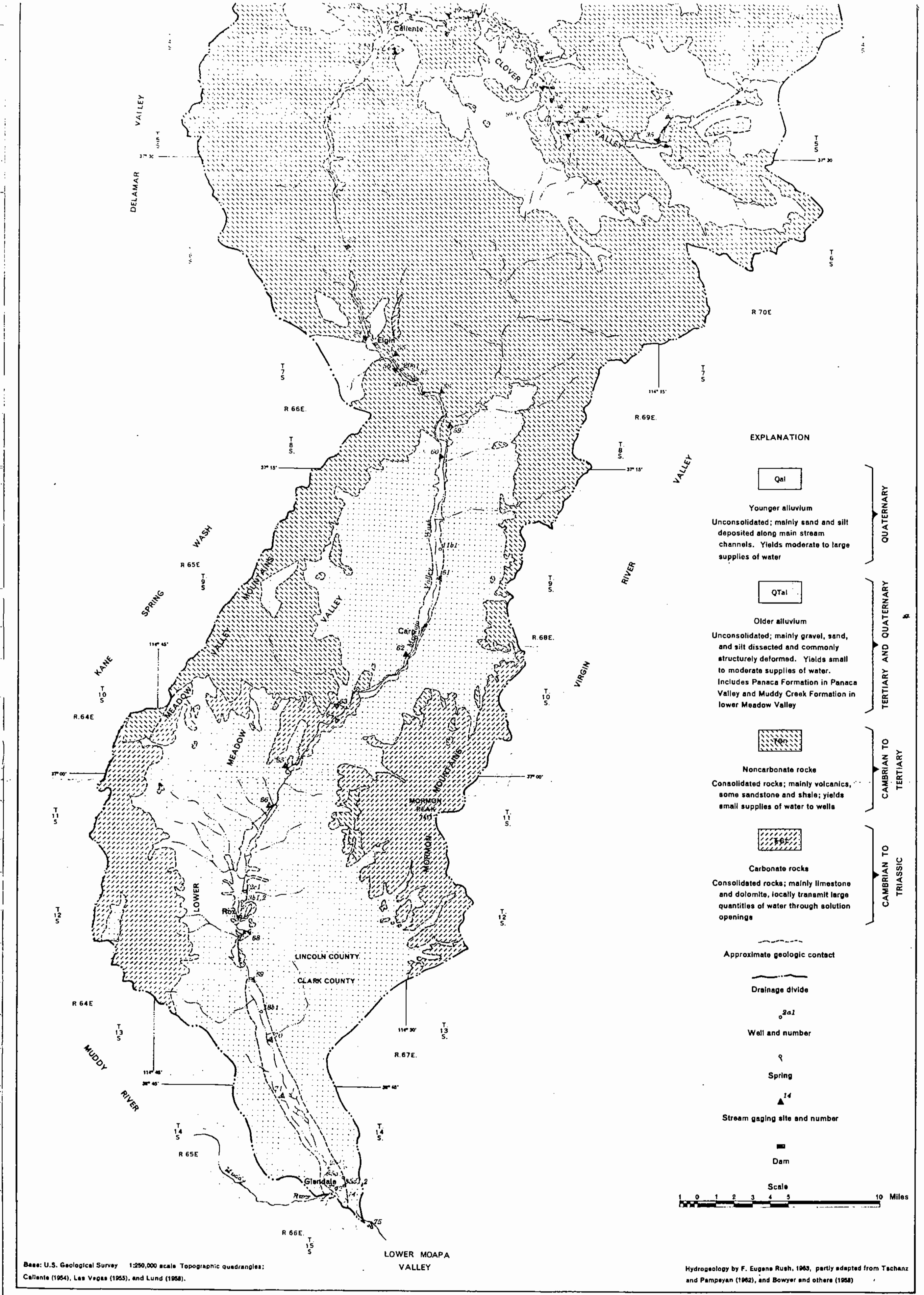


PLATE 1.—GENERALIZED HYDROGEOLOGIC MAP OF THE MEADOW VALLEY AREA, LINCOLN AND CLARK COUNTIES, NEVADA

Table 1.--Precipitation data at five storage-gage stations in the Meadow Valley area

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

Station	Location	Altitude (feet)	Period of record	Annual precipitation (inches)		
				Average	Maximum	Minimum
Bunker Peak	Sec. 12, T. 6 S., R. 70 E.	5,575	1952 to 1961	15.92	24.46	6.57
Crestline	Sec. 26, T. 3 S., R. 70 E.	5,982	8-27-57 to 9-13-63	11	--	--
Donohue Ranch	Sec. 29, T. 5 N., R. 69 E.	6,825	6-20-59 to 10-04-62	13	--	--
Pine Canyon	Sec. 28, T. 6 S., R. 69 E.	6,500	1952 to 1961	13.01	17.93	5.96
Wilson Creek Summit	Sec. 17, T. 5 N., R. 68 E.	7,100	1955 to 1962	14.03	19.29	5.73

Table 2.--Average monthly and annual precipitation at six stations in the Meadow Valley area

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

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
	Precipitation, in inches												
Caliente[1/]	.83	.80	.85	.67	.55	.37	.79	.93	.49	.88	.71	.85	8.72
Carp[2/]	.83	.37	.60	.26	.13	.04	.42	.28	.30	.40	.29	.62	4.24
Elgin[3/]	1.27	1.01	.61	.47	.49	.12	.79	.85	.60	.81	.94	.56	8.50
Logandale[4/]	.79	.67	.49	.29	.14	.14	.46	.58	.30	.48	.37	.58	5.29
Overton[5/]	.54	.48	.41	.24	.15	.05	.20	.38	.29	.47	.41	.60	4.22
Pioche[6/]	1.50	1.30	1.40	1.12	.82	.32	.89	1.10	.68	1.11	.92	1.30	12.46

1. Altitude 4,402 feet. Location sec. 8, T. 4 S., R. 67 E. Period of record, 32 years, 1931-62.
2. Altitude 2,600 feet. Location sec. 3, T. 10S., R. 67 E. Period of record, 8 years, 1950-57, 1962. Records used not complete.
3. Altitude 3,385 feet. Location sec. 7, T. 7 S., R. 67 E. Period of record, 10 years, 1953-62.
4. Altitude 1,400 feet. Location sec.22, T. 15S., R. 67 E. Period of record, 32 years, 1906-37.
5. Altitude 1,220 feet. Location sec.19, T. 16S., R. 68 E. Period of record, 13 years, 1940-62.
6. Altitude 6,110 feet. Location sec.22, T. 1 N., R. 67 E. Period of record, 24 years, 1939-62.

In summary, the precipitation pattern varies with the surface altitude. The least amount of precipitation, averaging perhaps 4 to 6 inches annually, can be expected in lower Meadow Valley between Elgin and Glendale. In the high mountain ranges of the northern half of the report area amounts ranging from 10 to 20 inches on the average fall annually, whereas the valleys in this northern area receive 6 to 12 inches.

Temperature data have been recorded at Caliente, Pioche, and Overton. For these stations, the Weather Bureau has been publishing freeze data since 1948. This information is given in table 3. 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 and the first fall minimum.

At Pioche and Caliente, the growing season contains about the same number of days. Here, crops experiencing a killing frost at 28°F would typically have a growing season of about 160 to 190 days. In the lower altitude area between Elgin and Glendale, the average growing season for such a crop is probably 200 to 220 days. In Spring Valley, owing to the high altitude of the valley floor, the growing season probably is very short for most crops. In Patterson Valley, the figure may be somewhat less than at Pioche, because of the probable thermal inversions at the lower altitudes.

The average temperature extremes are summarized for Caliente, Overton, and Pioche in table 4.

Table 3.--Number of days between the last spring minimum and the first fall minimum for Caliente, Overton, and Pioche

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

Year	32°F or below			28°F or below			24°F or below		
	Caliente	Overton	Pioche	Caliente	Overton	Pioche	Caliente	Overton	Pioche
1948	129	168	128	140	173	140	204	285	178
1949	180	230	141	198	298	191	204	299	203
1950	146	241	147	150	282	185	214	283	198
1951	157	243	173	178	278	175	207	309	223
1952	183	243	173	208	265	210	227	319	232
1953	122	221	146	144	221	162	191	267	173
1954	151	234	136	206	256	176	210	338	177
1955	137	198	143	178	227	170	186	227	197
1956	151	205	152	--	226	163	204	253	204
1957	138	238	134	162	247	190	227	298	227
1958	134	207	178	150	252	179	152	300	224
1959	135	243	131	150	243	178	200	291	209
1960	141	207	144	189	274	164	205	295	204
1961	136	208	148	179	260	165	183	301	188
1962	157	--	142	175	--	180	229	277	232
Ave.	146	220	148	165	250	175	191	289	205

Table 4.--Range of typical annual maximum and minimum temperatures recorded at Caliente, Overton, and Pioche

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

Station	Average annual maximum temperature (°F)	Average annual minimum temperature (°F)
Caliente	100 to 105	-10 to 0
Overton	115 to 120	15 to 25
Pioche	95 to 100	0 to 5

Previous Work:

The geology of Lincoln and Clark Counties, jointly including all the Meadow Valley area, has been mapped by Tschanz and Pampeyan (1961) and Bowyer and others (1958), respectively. A study of the ground-water resources of Panaca Valley and reconnaissance ground-water investigations of the remaining parts of the Meadow Valley area north of the vicinity of Caliente were made by Phoenix (1948). In addition, a geologic map and sections of the Pioche Hills were compiled by Parks and others (1958). A report describing the ground-water resources of southeastern Nevada was compiled by Carpenter (1915).

Reconnaissance studies of the ground-water resources has been made in many areas of the State, and in the adjacent areas of Dry Lake and Delamar Valleys (Eakin, 1963), Pahranagat and Pahroc Valleys (Eakin, 1963) and Lake Valley (Rush and Eakin, 1963) as shown in figure 1 and listed in a later section of this report.

GENERAL GEOLOGY AND HYDROLOGY

Geomorphic Features:

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

Debris washed from the mountains has formed large alluvial fans along the mountain fronts in the areas to the north of Caliente and to the south of Elgin. In much of these areas the fans are extensively dissected, but retain their original form along the east flank of the Bristol Range northwest of Pioche and along the western slope of the Mormon Mountains southwest of Mormon Peak.

In Patterson Valley the alluvial fans bordering the Ely and Bristol Ranges on the west and the Wilson Creek Range on the east nearly merge along the axis of the valley, resulting in the development of a very narrow flood plain (fig. 2). The maximum development of the flood plain in the valley is east of Pioche where it reaches a width of about a mile. The plain slopes southward 30 to 60 feet per mile.

In Spring, Eagle, Rose, and Dry Valleys a distinctive, very flat flood plain is developed; however, it is very narrow, rarely exceeding a mile in width.

The flood plain of Panaca Valley is the largest in the Meadow Valley area. The flood plain is broad, flat, and has a very gentle slope to the south of about 25 feet per mile. It extends laterally several miles from the axis of the main drainage channel up the principal tributary valleys.

The flood plain has been formed by the cutting and eroding away of Pliocene lake beds, locally called the Panaca Formation. This dissection has formed three distinct terraces in Panaca Valley. The lake beds were cut below the present land surface in the area where the younger alluvium is now present. Phoenix (1948, table 7) logged 15 feet of younger alluvium in well 1S/68-28cl near Condor Canyon, whereas at Cove Canyon, 166 feet of younger alluvium was logged in a U.S. Geological Survey test well (3S67-28c2)

Downstream from Caliente along Meadow Valley Wash, the flood plain is narrow and discontinuous. Where present, it seldom exceeds half a mile in width. Locally, such as south of the Lincoln County-Clark County line, it is more extensively developed.

The streams of Patterson Valley flow only in response to overland runoff of precipitation. No important springs feed them, and the channels are at all times above the water table. In the other valleys of the Meadow Valley area streamflow is present at least part of the year. Springs discharge into the main channel of Spring Valley and the resulting surface flow is continuous throughout the year. This flow probably reaches a maximum at the southern end of the valley. Peak flow occurs generally during the late winter and spring when melting snow adds overland runoff to the spring discharge. Downstream from Spring Valley the surface flow decreases but extends as far as Rose Valley in the summer and fall and to below Carp in the winter and spring. Flow in the wash at Glendale is generally small. Flash floods resulting from thunderstorms or rapid snowmelt periodically cause road and crop damage in Panaca Valley and in lower Meadow Valley.

Lithologic and Hydrologic Features of the Rocks:

The rocks of the report area are grouped into four principal lithologic units: carbonate rocks, the consolidated rocks other than the carbonates, older alluvium, and younger alluvium. This division is based on the hydrologic properties of the rock units. The surface exposures of these units are shown on plate 1. The geologic information shown is based on the work of Tschanz and Pampeyan (1961) in Lincoln County and Bowyer and others (1958) in Clark County, on field work done by the writer, and on aerial-photo interpretation.

Carbonate rocks, largely limestone and dolomite, are present in some of the mountain areas and may underlie some of the valleys at depth. Large exposures of this rock type are in the Bristol and Highland Ranges west and northwest of Pioche, the Mormon Mountains south of Carp, and the southern half of the Meadow Valley Mountains (pl. 1). Locally, small exposures of carbonate rocks crop out on the east side of Spring Valley in the northern part of the Needle Mountains, a few miles north of Ursine at the southern end of the Wilson Creek Range, and in a narrow band extending from Pioche to the north end of Panaca Valley. Farther south they are exposed north and west of Caliente and a few miles northeast of Elgin.

Most of the mountain area of the report area is underlain by noncarbonate consolidated rock, chiefly of Tertiary age. These rocks are principally volcanic rocks. However, sandstone and shale of Paleozoic and Tertiary age are included locally.

The older alluvium is characteristically unconsolidated or poorly consolidated, dissected, deformed, poorly sorted, and composed of gravel, sand, silt, and clay. It is late Tertiary and early Quaternary in age. The deposits consist of lake beds and terrace and fan gravels formed from debris derived from the mountains.

The younger alluvium by contrast to the older alluvium, generally is unconsolidated, undissected, and structurally undisturbed. It is composed of gravel, sand, silt, and clay deposited by streams during late Pleistocene and Recent Epochs. These deposits are better sorted and are more porous and permeable than the older alluvium because it is made up generally from reworked older alluvium that has been subjected to further erosion.

The lake beds of clay, sand, and silt are common throughout the Meadow Valley area. They are locally called the Panaca Formation in Panaca Valley and Muddy Creek Formation in lower Meadow Valley. Extensive outcrops are in Patterson Valley, Spring Valley, and the combined areas of Dry, Rose, and Panaca Valleys, as shown in figure 2. In these valleys about a third to a half of the area of the older alluvium is lake deposits. Additional areas of lake deposits are east of Barclay in Clover Valley.

The lake deposits occuring at the highest altitude are in Spring Valley where they have a maximum altitude of about 7,000 feet. Those in the southern part of the report area near the county line are at a maximum altitude of about 3,400 feet. The remaining lake deposits reach altitudes of between 5,800 feet in Panaca Valley and 6,200 feet in Eagle Valley. It is probable that Spring Valley was a topographically closed valley during late Tertiary time when these sediments were deposited. The remaining lake-deposit areas of the north half of the report area probably formed in another closed valley. By subsequent erosion, interconnecting channels were cut to form the present drainage system.

Most of the economically available water in the report area occurs in the younger and older alluviums, which comprise the ground-water reservoir. The older alluvium, composed of low to moderately permeable silt, sand, and gravel, characteristically will yield water to wells at low to moderate rates. Moderate to large water supplies can be developed in the younger alluvium. Sand and gravel beds are generally present at depth and yield water freely to wells.

The noncarbonate consolidated rocks are the least favorable for development of water by wells. A large number of springs flow from this type of rock, but most of them have a very low rate of flow and dry up in the summer or during periods of drought. The carbonate rocks, however, are more soluble to natural waters and therefore contain underground channelways through which ground water can move. For example, Panaca Spring flows from carbonate terrain just south of Condor Canyon. The outcrop pattern of the rocks indicates that recharge occurs in the Bristol and Highland Ranges, and in part migrates down-gradient to be discharged at Panaca Spring. This conclusion is substantiated in part by the absence of large amounts of natural discharge by other means, such as evapotranspiration in Patterson Valley. However, underflow through the carbonate rocks probably is the largest means of natural discharge from Patterson Valley.

SURFACE-WATER FEATURES

Most of the base flow in Meadow Valley Wash is from ground-water sources. Generally this surface flow is reabsorbed by the alluvium as it flows southward. However, during periods of spring snowmelt or flash floods caused by thunderstorms, water flows to the mouth of the wash and discharges into the Muddy River. This water, having never been ground water, is not included in the appraisal of annual ground-water recharge and discharge.

Streamflow data are available for several stations on Meadow Valley Wash. For the period 1951-60 a station was maintained 4 1/2 miles south of Caliente, and the streamflow averaged 8,620 acre-feet a year, as shown in table 5. The peak periods of flow were generally during February and March when snow melting occurred. The smallest flow was generally in September or October of each year and reflects the general absence of significant rainfall events for the period of record in these months. The ground-water contribution immediately upstream from the gaging station appears to sustain a minimum base flow of about 0.8 cfs (cubic feet per second) at the station.

For shorter periods of time streamflow data are available for Spring Valley Creek in the canyon between Spring and Eagle Valleys. A gage was installed and the measurements began in August 1962, so that data are available for only 13 months. For the period May through August 1963, the daily discharge averaged about 3 cfs, never exceeding 5.4 cfs nor dropping below 1.6 cfs. This flow is largely spring discharge of ground water. For the year beginning October 1, 1962, and ending September 30, 1963, the flow past the gage was 4,050 acre-feet. The momentary maximum rate recorded was 29 cfs on February 1, 1963. This high rate is due to melting snow in Spring Valley.

For the period 1945-49, a station was maintained on Spring Valley Creek in sec. 13, T. 1 S., R. 68 E. at the south end of Dry Valley, near the Delmue Ranch headquarters. The average discharge was 3,400 acre-feet a year as shown in table 6. Streamflow greater than a fraction of a cubic foot per second, issuing from local springs on the ranch, was recorded only during the winter and early spring. During the growing season, the streamflow from Spring Valley is diverted in both Eagle and Rose Valleys resulting in no flow through Dry Valley.

Floods of large magnitude have been reported in Meadow Valley Wash. In March 1906 and again in January 1910, devasting floods occurred, which forced the relocation of the then San Pedro, Los Angeles, and Salt Lake Railroad Company tracks along Clover Creek east of Caliente and along Meadow Valley Wash south of Caliente. The "highline" of the railroad, including 15 tunnels, was constructed between August 1910 and April 1912 to avoid future destruction. At that time it was concluded that the floods were related to the removal of the forest and woodland cover in Clover Valley. Other floods occurred in the years 1907, 1908, 1911, 1914, 1922, and 1938. The author can find no evidence of higher floods since 1938. The damage in 1938 prompted the approval by Congress in May 1955 of construction of two flood-control dams in Clover Valley. These were constructed at Pine Canyon (sec. 30, T. 5 S., R. 69 E.) and Mathews Canyon (sec. 24, T. 5 S., R. 69 E.) but have remained empty most of the time since their completion. The dams are designed to contain flash floods that occur in this otherwise moderate precipitation area.

Table 5.--Monthly and yearly runoff, in acre-feet, of Meadow Valley Wash, 4 1/2 miles southwest of Caliente
(from published records of the U.S. Geological Survey)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year	Momentary rate: Maximum: Discharge (cfs)	Maximum: Date	Minimum: Discharge (cfs)	Minimum: Date
1951	--	800	600	451	282	137	114	88	91	165	286	1,710	--	50	2-05-51	0.6	8-24-51
1952	1,270	1,720	11,580	5,570	592	307	338	208	206	211	478	1,220	23,700	1,000	3-27-52	2.0[a]	8-24-52 8-25-52
1953	1,200	777	581	319	265	254	148	506	98	169	445	464	5,230	110	8-02-53	1.1[a]	9-29-53 9-30-53
1954	1,360	1,200	878	284	228	247	209	542	436	136	276	571	6,370	825	9-04-54	.7[b]	--
1955	552	1,210	5,670	324	147	175	381	2730	193	202	526	1,530	13,640	785	8-03-55	1.9[a]	10-03-55
1956	1,520	1,060	644	175	109	686	855	247	101	147	208	335	6,090	1,500	6-30-56	.8	9-17-56
1957	844	1,570	880	255	497	169	140	124	116	186	758	1,020	6,560	117	2-11-57	1.6[c]	--
1958	954	1,430	2,430	2,560	198	158	121	125	137	106	315	594	9,130	249	3-22-58	.9	5-06-58
1959	1,010	1,440	702	143	235	137	98	99	119	95	209	515	4,800	75	2-19-59	1.2	5-20-59
1960	624	1,250	984	231	163	123	97	94	79	--	--	--	--	98	2-10-60	.8	9-21-60
Average 1951-60 (rounded)	1,040	1,[illegible]	2,490	1,030	272	239	250	476	158	157	389	884	8,620				

a. M[illegible]ly. b. July 11-14, 1954. c. Minimum daily, Aug. 25 to Sept. 1, 1957.

Table 6. --Yearly discharge of Meadow Valley Wash at the south end of Dry Valley

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

Year	Momentary rate				Runoff (ac. -ft.)
	Maximum		Minimum		
	Discharge (cfs)	Date	Discharge (cfs	Date	
1945	605	8-02-45	0.1	7-03-45 and 7-04-45	5,450
1946	946	8-05-46	.1	5-13-46, 8-10-46, and 9-23 to 30-46	4,240
1947	--	--	.2	on several days	1,820
1948	70	2-20-48	.2	on several days	2,610
1949	43	3-20-49	.2	8-20-49 and 8-21-49	2,681
	Average (rounded)				3,400

In February 1955, the U. S. Geological Survey, at the request of the Nevada State Engineer, studied the cause of streamflow loss in Meadow Valley Wash between the gaging stations near Caliente and near Glendale. Very little streamflow had entered Muddy River during the preceding several years. On February 17, stream-discharge measurements were made at the north and south ends of the flood plain just north of Carp. The plain is about 10 miles long and has an area of about 3,200 acres. (See pl. 1). The measurements showed a decrease in streamflow from 20 cfs to 1.5 cfs, or a loss of 18.5 cfs on that day. However, at Carp the springs in the alluvium increased the flow from 1.5 cfs to 7.5 cfs, but it again dwindled to 1.5 cfs in the middle of the next flood plain of 2,800 acres just north of Rox. Again springs near Rox increased the flow, but only to 2.5 cfs, which was absorbed on the third flood plain of 9,100 acres between Rox and Glendale. No flow was at the mouth of the wash.

It was concluded that the three flood plains had sufficient storage capacity to absorb a minimum of 20,000 acre-feet -- and perhaps much more-of streamflow resulting from any single storm. It was further concluded that over a period of months of no storm runoff, the absorbed water would be slowly re-discharged; mostly by evaporation, transpiration, and possibly by underflow to the Muddy River area so that storage capacity would be maintaine
During 1952 and 1955, however, streamflow was sufficient to overcome the absorption capacity of the flood plains and contribute significantly to flow of

the Muddy River, as shown by the following discussion.

There are two gaging stations on the Muddy River near the mouth of Meadow Valley Wash; one near Moapa 9 1/2 miles upstream from the mouth, the other near Glendale 2 1/2 miles downstream. For the 8-year period, 1952-59, the flow at the two Muddy River stations was very similar, except for the years 1952 and 1955 (table 7). For these years a flow of about 5,000 acre-feet more was recorded at the downstream gage than at the upper gage. A similarly larger-than-normal annual flow was measured in Meadow Valley Wash near Caliente. A further inspection of the discharge measurements at these three stations indicates that there were three periods of high discharge at the lower gage near Glendale in 1952 and four in 1955 that were not recorded upstream near Moapa. Because these stations are only 12 miles apart, the increase probably was caused by flow from Meadow Valley Wash rather than by localized storms or snowmelt occurring between stations. This is further supported by the fact that the data for the Caliente gaging station show sharp increases in streamflow about two days in advance of the events at the lower station near Glendale (table 8). It is concluded that during these two years of the 8-year period, seven important storms or snowmelts caused flow in Meadow Valley Wash from above Caliente to its mouth. These large flows, as recorded near Caliente, were reflected in the large difference in the total annual discharge at the two stations on the Muddy River.

Table 7. -- Annual discharge, in acre-feet of the Muddy River and Meadow Valley Wash

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

Calendar year	Muddy River near Moapa 1/	Muddy River near Glendale 2/	Change in discharge between Moapa and Glendale stations	Meadow Valley Wash 3/
1952	34,030	39,600	+5,570	23,700
1953	33,250	32,420	- 830	5,230
1954	33,190	32,140	-1,050	6,370
1955	33,960	39,130	+5,170	13,640
1956	33,160	31,500	-1,660	6,090
1957	35,800	36,900	+1,100	6,560
1958	34,950	33,450	-1,500	9,130
1959	36,030	32,760	-3,270	4,800
Average 1952-59 (rounded)	34,200	34,700		9,400

1. Gaging station 9 1/2 miles upstream from the mouth of Meadow Valley Wash.
2. Gaging station 2 1/2 miles downstream from the mouth of Meadow Valley Wash.
3. Gaging station 4 1/2 miles downstream from Caliente.

Table 8.--Daily discharge, in cubic feet per second, of the Muddy River and Meadow Valley Wash, for the dates given

(from publications of the U. S. Geological Survey)

Date	Meadow Valley Wash 1/	Muddy River near Moapa 2/	Muddy River near Glendale 3/	Date	Meadow Valley Wash 1/	Muddy River near Moapa 2/	Muddy River near Glendale 3/
12-29-51	20	50	56	3-05-55	333	50	103
12-30-51	258	50	57	3-06-55	147	49	194
12-31-51	311	49	57	3-07-55	129	47	143
1-01-52	54	49	109	3-08-55	225	47	104
1-02-52	22	50	63	3-09-55	297	47	131
2-28-52	37	48	48	3-10-55	179	47	223
2-29-52	124	48	47	3-11-55	184	48	159
3-01-52	777	48	48	7-24-55	2.2	43	39
3-02-52	454	49	169	7-25-55	57	43	39
3-03-52	131	49	241	7-26-55	8.5	42	72
3-24-52	30	51	55	7-27-55	4.4	42	45
3-25-52	216	51	52	8-02-55	5.6	42	37
3-26-52	622	50	86	8-03-55	30	42	37
3-27-52	797	49	347	8-04-55	5.5	42	80
3-28-52	416	48	528	8-05-55	194	42	100
3-02-55	81	50	57	8-06-55	43	42	119
3-03-55	172	50	57	8-07-55	11	43	54
3-04-55	305	50	66				

1. Gaging station 4 1/2 miles downstream from Caliente.

2. Gaging station 9 1/2 miles upstream from the mouth of Meadow Valley Wash

3. Gaging station 2 1/2 miles downstream from the mouth of Meadow Valley Wash.

GROUND-WATER APPRAISAL

Occurrence and Movement of Ground-Water:

Ground water in the Meadow Valley area is derived mostly from precipitation within the drainage area. However, ground-water underflow from Lake Valley moves through the alluvium underlying the low divide at the northern end of the area and adds recharge to Patterson Valley (Rush and Eakin, 1964, p. 12). In the low lying areas, where precipitation is small, little if any recharge to the ground water occurs. In the mountains most of the recharge occurs because of the greater precipitation.

The snow and rain of the mountains in part infiltrates the consolidated rocks and in part collects into small, short streams which generally are absorbed by the alluvium of the fans. Much of this water is evaporated before and after infiltration, some adds to the 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 it is held in the alluvium and is used by the plants or evaporated. The water that reaches the main stream channel by surface and subsurface runoff, as in Spring Valley, is generally absorbed by the alluvium as it flows through the several valleys to the south.

Ground water occurs under both confined (artesian) and unconfined (water table) conditions in the Meadow Valley area. Hydrostatic heads in several wells are above land surface in Panaca Valley. Two such wells are the Amy Mathews west well (2S/68-19c1) about 3 miles southwest of Panaca and the Chester Oxborrow well 2 (3S/67-28c1) at the north end of Cove Canyon. The Mathews well, whose principal water-bearing zone is from 85 to 125 feet below the land surface, was reported to flow 50 gpm (gallons per minute) in 1956 and now flows only during the winter and spring. The Oxborrow well, which taps sand from 45 to 98 feet below land surface, flowed at an estimated rate of 100 gpm in November 1962. At the time the author obtained a water sample from the well in December 1963, the estimated flow was about the same. In both wells the aquifers were overlain by clay or silt, which form the confining beds.

The thickness of the ground-water reservoir is not known because most wells do not exceed 150 feet in depth. The deepest known well drilled in the area was constructed near Panaca in 1940 (Phoenix, 1948, p. 104). It was drilled to a depth of 620 feet and bottomed in alluvium. However, below a depth of 400 feet, no productive sand or gravel beds were logged. The well yielded only 70 gpm with a drawdown of 150 feet.

In general, the ground-water movement is in the direction of surface flow; that is, from the mountain areas toward the centers of the valleys. This pattern is modified, however, by the general flow of ground water from the northern part of the area, where most of the recharge occurs, to the southern part of the area where much of the discharge occurs. The ground water is transmitted largely in the alluvium. In the canyons connecting the various valleys, the capacity of the water to be transmitted in the subsurface is reduced because of the reduction of the cross-sectional area of the alluvial fill. Where this occurs, such as at the canyon between Spring and Eagle Valleys, Condor and Cove Canyons, and the canyons just south of Carp and Rox, the ground water "overflows" to the land surface and flows in Meadow Valley Wash until it is discharged by evaporation or is re-absorbed into the alluvium.

Stream-discharge measurements were made at 75 sites during October 1963; the data are presented in table 9, and the sites are shown on plate 1. These data illustrate the general conditions of surface-water flow during the late part of the growing season. All of the measured streamflow was from ground-water sources.

The hydrologic conditions of Patterson Valley are different from those in the rest of the Meadow Valley area. No base flow is observed in the area, no significant areas of natural discharge due to phreatophytes are found, and no typical rise of water from the subsurface to the stream channel occurs in the bedrock canyon which drains the area (T. 1 S., R. 68 E.). Most of the recharge from precipitation and underflow from Lake Valley (Rush and Eakin, 1964, p. 12) discharges from the area through the consolidated rock. Carbonate rocks, which commonly transmit large quantities of water through enlarged joints and fractures in this part of Nevada (Eakin, 1963, p. 11), are exposed in the high mountains on the west side of the wash and at the south end of the area (pl. 1). The alluvium at the southern end of Patterson Wash and part of Panaca Valley probably is underlain by these rocks.

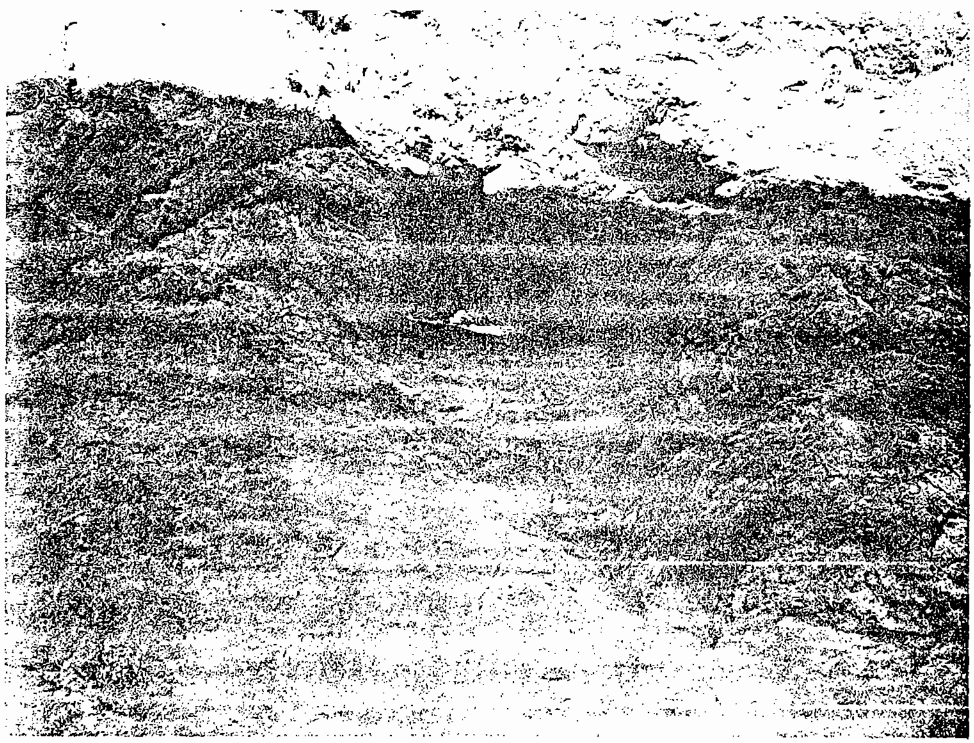
An inspection of the carbonate rocks was made in Condor Canyon near Panaca Spring (25/68-4b1) where large and numerous solution cavities were observed as shown in photographs 3 and 4. Much of the ground-water recharge in the mountains bordering Patterson Valley enters the carbonate-rock system and is transmitted to Panaca Valley, where most of the water is discharged by Panaca Spring. Panaca Spring undoubtedly issues from the carbonate rock, because it is on the western flank of a limestone hill and is near the southern extent of the outcrop of the carbonate system. The temperature of the water is warm, 85°F, indicating relatively deep percolation. Records indicate that the spring had a flow of about 14 cfs in 1946, or the equivalent of 10,000 acre-feet per year. This is very close to the estimated recharge from all sources, 9,000 acre-feet, for Patterson Valley. The flow of the spring in October 1963 was only 10.88 cfs, or about 8,000 acre-feet per year. Some irrigation wells also yield abnormally warm water, although well water is not as warm nor as nearly free of dissolved minerals as the spring water. It is concluded that the well water is a mixture of the water in the carbonate rocks and the colder, more highly mineralized water of the alluvium. This relationship is discussed further in the quality of water section of this report.

Table 9.--Miscellaneous streamflow measurements in the Meadow Valley area - October 1963

Map[1] No.	Site	Location Township	Range	Date	Discharge[2] (cfs)
1	Wildhorse Bill Spring	4 N.	66 E.	10-23-63	0
2	Patterson Wash	4 N.	66 E.	10-23-63	0
3	Patterson Wash	3 N.	66 E.	10-23-63	0
4	Patterson Wash	1 N.	66 E.	10-24-63 10-29-63	0 0
5	Tributary to Patterson Wash	1 N.	66 E.	10-29-63	0
6	Tributary to Patterson Wash	1 N.	66 E.	10-29-63	0
7	Tributary to Patterson Wash	4 N.	68 E.	10-24-63	(0.05)
8	Tributary to Patterson Wash	3 N.	67 E.	10-24-63	0
9	Steward and Kaiser - Upper Spring	4 N.	68 E.	10-25-63	(.01)
10	Steward and Kaiser - Lower Spring	4 N.	68 E.	10-25-63	(.02)
11	Parsnip Wash Spring	3 N.	69 E.	10-25-63	(.04)
12	Tributary to Spring Valley Creek	5 N.	69 E.	10-25-63	.33
13	Tributary to Spring Valley Creek	5 N.	69 E.	10-29-63	.27
14	Spring Valley Creek	5 N.	69 E.	10-25-63	.80
15	Tributary to Spring Valley Creek	4 N.	69 E.	10-25-63	0
16	Spring Valley Creek	4 N.	69 E.	10-25-63	0
17	Tributary to Spring Valley Creek	4 N.	69 E.	10-29-63	0
18	Tributary to Spring Valley Creek	2 N.	70 E.	10-29-63	0
19	Spring Valley Creek	2 N.	70 E.	10-25-63	3.72
20	Spring Valley Creek gaging station[3]	2 N.	70 E.	10-29-63	4.91
21	Tributary to Spring Valley Creek	1 N.	69 E.	10-29-63	0
22	Spring Valley Creek[4]	1 N.	69 E.	10-29-63	2.12
23	Spring Valley Creek[5]	1 N.	69 E.	10-25-63	0
24	Delmue Springs - at house[6]	1 S.	68 E.	10-26-63	(.50)
25	Patterson Wash[7]	1 S.	68 E.	10-29-63	0
26	Meadow Valley Wash[8]	1 S.	68 E.	10-28-63	.81
26	Meadow Valley Wash	1 S.	68 E.	10-28-63	0
27	Tributary to Meadow Valley Wash	2 S.	68 E.	10-28-63	0
27a	Panaca Spring[9]	2 S.	68 E.	10-28-63	10.88
28	Tributary to Meadow Valley Wash	2 S.	68 E.	10-28-63	0
29	Tributary to Meadow Valley Wash	2 S.	67 E.	10-28-63	0
30	Tributary to Meadow Valley Wash	2 S.	68 E.	10-28-63	0
31	Meadow Valley Wash	3 S.	67 E.	10-29-63	1.46
32	Clover Creek	5 S.	70 E.	10-28-63	0
33	Tributary to Clover Creek	5 S.	69 E.	10-28-63	0
34	Tributary to Clover Creek	5 S.	69 E.	10-28-63	0
35	Clover Creek	5 S.	69 E.	10-28-63	(.50)
36	Clover Creek	5 S.	69 E.	10-28-63	(.01)
37	Clover Creek	5 S.	68 E.	10-28-63	0
38	Tributary to Clover Creek	5 S.	69 E.	10-28-63	0
39	Clover Creek	5 S.	68 E.	10-28-63	(.30)
40	Clover Creek	5 S.	68 E.	10-28-63	1.89
41	Clover Creek	5 S.	68 E.	10-28-63	(.10)
42	Clover Creek	5 S.	68 E.	10-28-63	(.01)
43	Clover Creek	4 S.	68 E.	10-28-63	(.20)
44	Clover Creek	4 S.	68 E.	10-28-63	(.02)
45	Clover Creek	4 S.	68 E.	10-28-63	0
46	Tributary to Clover Creek	4 S.	68 E.	10-28-63	0
47	Clover Creek	4 S.	67 E.	10-28-63	0
48	Tributary to Clover Creek	4 S.	67 E.	10-28-63	0
49	Clover Creek	4 S.	67 E.	10-28-63	(.10)
50	Clover Creek[10]	4 S.	67 E.	10-28-63	0
51	Tributary to Meadow Valley Wash[11]	4 S.	67 E.	10-28-63	(.03)
52	Meadow Valley Wash	5 S.	66 E.	10-27-63	2.27
53	Meadow Valley Wash	6 S.	66 E.	10-27-63	2.04
54	Meadow Valley Wash	7 S.	67 E.	10-27-63	(1.50)
55	Meadow Valley Wash	7 S.	67 E.	10-27-63	(.60)
56	Meadow Valley Wash	7 S.	67 E.	10-27-63	(.10)
57	Meadow Valley Wash	7 S.	67 E.	10-27-63	(.30)
58	Meadow Valley Wash	7 S.	67 E.	10-27-63	2.82
59	Tributary to Meadow Valley Wash	8 S.	67 E.	10-27-63	0
60	Meadow Valley Wash	8 S.	67 E.	10-27-63	(.75)
61	Meadow Valley Wash	9 S.	67 E.	10-27-63	0
62	Meadow Valley Wash	10 S.	67 E.	10-27-63	2.94
63	Tributary to Meadow Valley Wash	10 S.	66 E.	10-27-63	0
64	Meadow Valley Wash	10 S.	66 E.	10-27-63	1.74
65	Meadow Valley Wash	11 S.	66 E.	10-27-63	.47
66	Meadow Valley Wash	11 S.	66 E.	10-27-63	(.10)
67	Meadow Valley Wash	12 S.	65 E.	10-27-63	(.02)
68	Meadow Valley Wash	12 S.	65 E.	10-27-63	(.30)
69	Meadow Valley Wash	13 S.	65 E.	10-27-63	.59
70	Meadow Valley Wash	13 S.	66 E.	10-27-63	0
71	Meadow Valley Wash	14 S.	66 E.	10-27-63	0
72	Meadow Valley Wash[12]	14 S.	66 E.	10-27-63	(.30)
73	Muddy River[13]	15 S.	66 E.	10-25-63	40.7
74	Muddy River[14]	15 S.	66 E.	10-26-63	40.1
75	Muddy River gaging station[15]	15 S.	67 E.	10-26-63	47.1

1. Site identification number shown on plate 1.
2. Figures in parentheses are estimated by personnel of the U.S. Geological Survey.
3. In canyon between Spring Valley and Eagle Valley.
4. In canyon between Eagle Valley and Rose Valley.
5. In canyon between Rose Valley and Dry Valley.
6. Flow of 0.45 cfs reported by Phoenix (1948, p. 49).
7. At point where Patterson Wash enters Meadow Valley Wash.
8. At southwest end of Condor Canyon.
9. Warm Spring, 2 miles north of Panaca.
10. At point where Clover Creek enters Meadow Valley Wash.
11. Flow of two springs in State Park.
12. Just upstream from where Meadow Valley Wash enters Muddy River.
13. Above Meadow Valley Wash.
14. Below Meadow Valley Wash.
15. Below Meadow Valley Wash and site 74.

Photograph 3



Photograph 4

Views of the limestone walls of Condor Canyon showing solution openings caused by ground water. Photograph 3 shows an enlarged joint along a bedding plane of the limestone. Photograph 4 shows an irregular solution opening, about five feet wide, having no recognizable orientation or relation to fractures.

Estimated Average Annual Recharge:

Precipitation in the drainage area and ground-water inflow from Lake Valley to Patterson Valley probably are the principal sources of the ground water in the area. A method described by Eakin and others (1951, p. 79-81) is used to estimate the recharge. This method assumes that a fixed percentage of the average annual precipitation recharges the ground-water reservoir. 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. Figure 4 shows this relationship for the precipitation stations in the Meadow Valley area.

The average annual precipitation distribution is delineated as follows: 8 inches at 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 are selected, using the above values. The zones, the estimated precipitation, and the estimated recharge are summarized in table 10. The estimated average annual precipitation over the entire area is about 1,000,000 acre-feet, and the estimated average annual recharge resulting from this precipitation is only 2.4 percent, or 24,000 acre-feet. The underflow from Lake Valley (Rush and Eakin, 1964, p. 13) adds an additional 3,000 acre-feet a year, making a total of 27,000 acre-feet a year of recharge from all sources. The highest rate of estimated recharge occurs in Spring Valley, where 5.6 percent of the estimated precipitation enters the ground-water system. In Patterson Valley the figure is 3.1 percent.

About two-thirds of the recharge from precipitation occurs in Patterson and Spring Valleys, which combined are only 40 percent of the Meadow Valley area. The highest mountains of the report area are in these two areas.

Estimated Average Annual Discharge:

Prior to development by man, all the ground water in the area was discharged by evaporation, transpiration, and subsurface and surface outflow to the Muddy River valley. With the advent of mining and agriculture, spring flow was diverted and wells were pumped to satisfy domestic, stock, and irrigation needs. The net result has been an increase in the draft on the ground-water reservoir.

Natural Discharge by Evapotranspiration: Much of the ground water discharged by evapotranspiration is consumed by native phreatophytes. These plants, prior to the development of agriculture, probably grew over most of the flood plains, except in Patterson Valley where the depth to water is generally more than 50 feet. Much of the flood plains in the several valleys have been cleared of these plants in recent years, and irrigated crops are grown in their place.

The principal phreatophytes are greasewood, rabbitbrush, meadow grass, and salt bush. Cottonwood, willow, and saltcedar are others, and occur

Table 10.--Estimated average annual precipitation and ground-water recharge in the Meadow Valley area

Precipitation zone (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)
SPRING VALLEY							
Above 9,000	0	more than 20	21	1.75	0	25	0
8,000 to 9,000	10,600	15 to 20	17.5	1.46	15,500	15	2,300
7,000 to 8,000	69,000	12 to 15	13.5	1.12	77,300	7	5,400
6,000 to 7,000	101,000	8 to 12	10	.83	83,800	3	2,500
below 6,000	3,500	less than 8	6	.50	1,750	0	0
Subtotal (rounded)	184,000				178,000		10,000
PATTERSON VALLEY							
Above 9,000	150	more than 20	21	1.75	260	25	70
8,000 to 9,000	5,400	15 to 20	17.5	1.46	7,900	15	1,200
7,000 to 8,000	23,800	12 to 15	13.5	1.12	26.700	7	1,900
6,000 to 7,000	123,000	8 to 12	10	.83	102,000	3	3,100
below 6,000	114,000	less than 8	6	.50	57,000	0	0
Subtotal (rounded)	266,000				194,000		6,000
REMAINDER OF THE MEADOW VALLEY AREA							
Above 9,000	350	more than 20	21	1.75	610	25	150
8,000 to 9,000	4,500	15 to 20	17.5	1.46	6,600	15	990
7,000 to 8,000	20,200	12 to 15	13.5	1.12	22,600	7	1,600
6,000 to 7,000	202,000	8 to 12	10	.83	168,000	3	5,000
below 6,000	942,000	less than 8	6	.50	472,000	0	0
Subtotal (rounded)	1,170,000				670,000		8,000
Total (rounded)	1,620,000				1,000,000		24,000
Estimated ground-water underflow from Lake Valley to Patterson Wash							3,000
Estimated average annual recharge from all sources to the Meadow Valley area							27,000

27,000 Recharge

along the banks of the wash in lower Meadow Valley.

Table 11 lists the estimated acreage of the phreatophytes for each valley in 1963 and summarizes the estimates of evapotranspiration. These estimates are based on rates of consumption of ground water by phreatophytes in other areas, and are derived largely from the work of Lee (1912), White (1932), Young and Blaney (1942), and Houston (1950). The estimated total evapotranspiration of ground water by phreatophytes in the Meadow Valley area is about 3,600 acre-feet per year.

During the nongrowing season, several areas become very wet and are partially covered by standing water. The principal areas of this kind are the wet and dry meadows of Spring Valley and fields northwest of Panaca in Panaca Valley. In early December 1963, standing water was observed in the latter area. The springs of the wet-meadow area of Spring Valley, Panaca Spring, and surface-water runoff are the principal sources of this water.

Evaporation from these wet areas during the nongrowing season possibly is large and may even be as large as the evapotranspiration of the phreatophytes. However, adequate data are not available on which to base an estimate.

Discharge of Wells and Springs: Most of the discharge of wells and springs is used to irrigate crops. Many wells are used for stock-watering and domestic supply, but their combined discharge in relation to that for irrigation purposes is very small; probably less than 100 acre-feet a year.

In 1963 there were 60 active irrigation wells and 5 public-supply wells in the report area. Forty of the irrigation wells were in Panaca Valley. The remaining wells were scattered throughout the several valleys (pl. 1). An inventory of pumpage was made for the area, based principally upon rates of electric-power or diesel-fuel consumption and the measured and estimated rates of discharge from the wells. A summary of the pumpage of the irrigation and public-supply wells is given in table 12, which shows that in 1963 the estimated total pumpage for the Meadow Valley area was 19,000 acre-feet. The single area of largest annual pumpage, about 7,500 acre-feet, was Panaca Valley. Lower Meadow Valley was next largest, having a pumpage of about 4,700 acre-feet.

It is estimated that about 40 percent of the irrigation water seeps back to the ground-water reservoir, the remaining amount being consumed by evapotranspiration. Therefore, in 1963 the estimated net draft on the ground-water reservoir resulting from the discharge of wells was on the order of 12,000 acre-feet.

There are several thermal springs in the area, the largest of which is Panaca Spring. Smaller thermal springs are at the Delmue Ranch in Dry Valley and at Caliente. The Delmue Springs (sec. 18, T. 1 S., R. 69 E.) flow only a fraction of a cubic foot per second; the spring at Caliente no longer flows. A nearby public-supply well pumps water that has a temperature of 104°F.

Table 11. --Estimated natural evapotranspiration by phreatophytes of ground water in the Meadow Valley area - 1963

Area	Phreatophyte	Area (acres)	Areal density (percent)	Depth to water (feet)	Evapotranspiration: Acre-feet per acre	Evapotranspiration: Acre-feet (rounded)
Patterson Valley	Greasewood and rabbitbrush	750	20 to 25	20 to 30	0.1	80
Spring Valley	Rabbitbrush	600	15 to 30	5 to 25	.1	60
	Very wet meadow	500	--	0 to 5	1.5	750
	Dry meadow	450	--	5 to 10	.5	220
Eagle Valley	Dry meadow	500	--	--	.5	250
	Rabbitbrush and big sage	140	15 to 25	10 to 15	.3	40
Rose Valley	Rabbitbrush and big sage	60	20 to 35	20 to 25	.1	10
Dry Valley	Rabbitbrush, some big sage	80	40 to 60	15 to 40	.1	10
Panaca Valley	Greasewood and rabbitbrush	3,300	20	10 to 20	.1	330
	Rabbitbrush	1,000	30 to 50	15 to 25	.2	200
Clover Valley	Dry meadow	300	--	5 to 10	.5	150
	Rabbitbrush	300	15 to 25	10 to 25	.2	60
Lower Meadow Valley	Saltbush	3,000	--	20 to 60	.1	300
	Greasewood and rabbitbrush	1,100	20	20 to 50	.1	110
	Greasewood and rabbitbrush mixed with creosote bush	800	10	--	.1	80
	Cottonwood, willow, and salt cedar	300	--	0 to 5	3.	900
Total (rounded)		13,000				3,600

revised to ~10,000 based on Nichols (2000)

Table 12.--Inventory of pumpage from large-capacity wells in the Meadow Valley area in 1963

Valley	Active wells	Estimated pumpage (acre-feet)
Spring Valley	0	0
Eagle Valley	1	220
Rose Valley	3	1,200
Dry Valley	5	3,600
Patterson Valley	1	85
Panaca Valley	41	7,500
Clover Valley	0	0
Lower Meadow Valley		
Caliente area	8	1,900
Elgin area	2	950
Carp area	2	2,400
Rox area	1	80
Glendale	1	1,300
Total (rounded)	65	19,000

The discharge from Panaca Spring is used during the growing season for irrigation. During the remainder of the year, a small part of the flow is used for stock watering. The remaining flow is discharged on the fields where it evaporates, adds to the soil moisture, recharges the ground-water reservoir, and drains from the area in Meadow Valley Wash. It is estimated that about half the flow ultimately recharges the ground-water reservoir; the remainder, about 4,000 acre-feet per year, is discharged by evapotranspiration.

Outflow: Ground-water outflow from the Meadow Valley area to the Muddy River valley occurs in two forms: underflow through the alluvium of lower Meadow Valley, and leakage through bedrock.

Although the outflow cannot be computed by direct methods with the data now available, the total probably is several thousand acre-feet per year (see below)

Total Annual Ground-Water Discharge: The total ground-water discharge is the sum of (1) the evapotranspiration by phreatophytes, (2) the evapotranspiration by irrigated crops of water obtained from wells and springs, (3) the evaporation from wet areas during the nongrowing season, and (4) the subsurface outflow near Glendale. Of these four types of discharge, only the first two have been estimated by direct methods--for 1963 they total about 20,000 acre-feet. Because most of the areas presently irrigated by pumping were at one time areas of evapotranspiration, there probably has been only a very slight net increase in the discharge by these two processes.

Over the long term the recharge should equal the natural discharge. Thus, a crude approximation of the discharge by evaporation from wet areas during the nongrowing season plus subsurface outflow near Glendale (processes 3 and 4 above)is about 7,000 acre-feet per year; computed by the difference between the estimated average annual recharge of 27,000 acre-feet (p.20). and the discharge by process 1 and 2 above of about 20,000 acre-feet.

Storage:

Under natural conditions, 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, and the amount of water in storage remained nearly constant. This balance has been disturbed by destroying many acres of phreatophytes which use ground water and by the diversion of surface and ground water. The first tended to reduce discharge, the latter to increase it. Figures 5 and 6 show the trends of water levels in observation wells for recent years. The general trend is one of very slow local decline of ground-water levels, which indicates that water is being taken from storage and that, locally, discharge exceeds recharge. It is evident that the increased discharge by pumpage has more than offset the decrease in discharge caused by the removal of phreatophytes. The amount of excess discharge over recharge is not known; however, the very slow reduction of ground water in storage indicates it is small.

Storage apparently is increasing locally in the flood plain just north of Rox. Water level in observation well 12S/65-13b2 shows a slight but general rise, as shown in figure 6.

Short-term fluctuations of water-levels within a period of a year indicate seasonal changes in ground-water recharge and discharge and the resulting short-term changes of ground water in storage. These fluctuations are illustrated in figures 5 and 6 during years in which several water-level measurements were made.

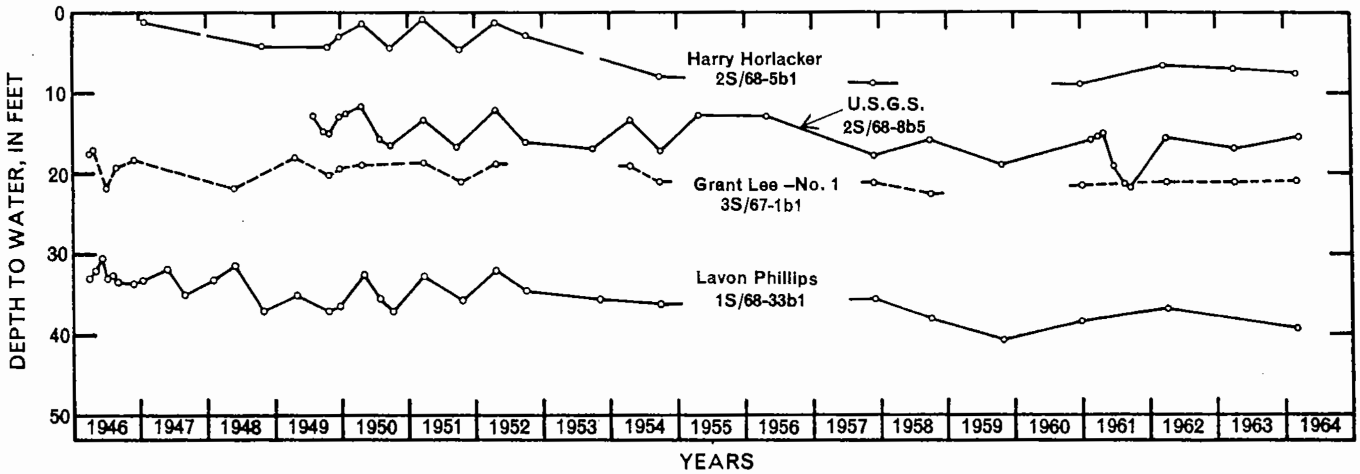


Figure 5.—Graph showing the slow decline of water levels in several wells of Panaca Valley

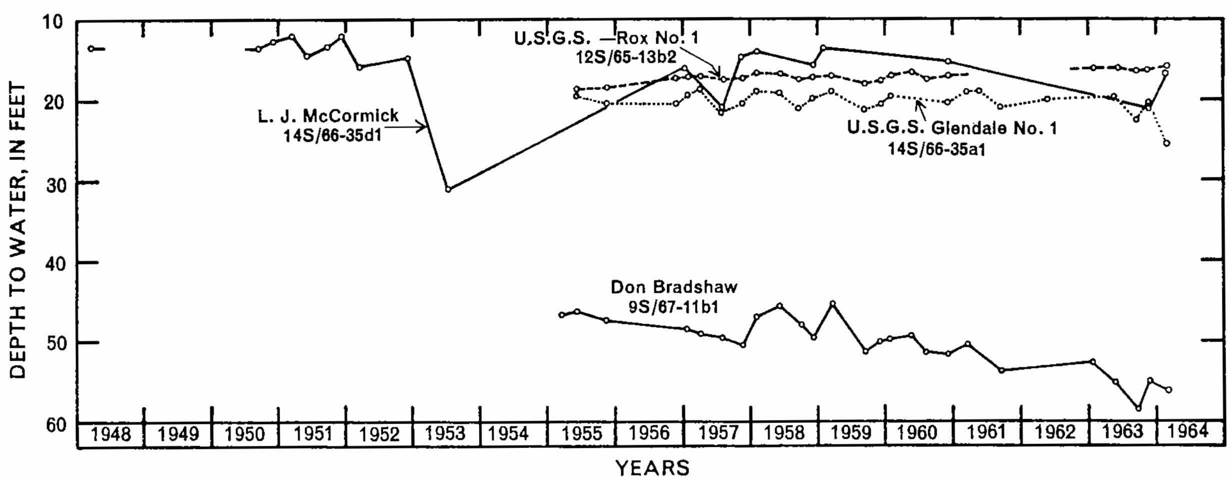


Figure 6.—Graph showing the fluctuation of water levels in several wells of Lower Meadow Valley

Recoverable ground water in storage is that part of the stored water that will drain by gravity from the ground-water reservoir. It is equal to the product of the specific yield of the deposits, their saturated thickness, and the area. The specific yield is the quantity of water that a unit volume of permeable rock or soil, after being saturated, will yield when drained by gravity. It may be expressed as a ratio or as a percentage by volume. In Meadow Valley area the average specific yield of the uppermost 100 feet of saturated alluvium probably is at least 10 percent. The alluvium underlies an area of about 800,000 acres. Therefore, the estimated volume of water stored in the upper 100 feet of saturated thickness of alluvium can be computed to be about 8 million acre-feet, or about 300 times the estimated average annual recharge.

The estimated amounts of ground water stored in the uppermost 100 feet of saturated alluvium in the several valleys in the area are:

Valley	Stored water (acre-feet)
Spring Valley	800,000
Eagle Valley	180,000
Rose Valley	80,000
Dry Valley	360,000
Patterson Valley	1,800,000
Panaca Valley	1,400,000
Clover Valley	650,000
Lower Meadow Valley	2,800,000
Total (rounded)	8,000,000

Perennial Yield:

Perennial yield of a ground-water reservoir is the maximum amount of water of usable chemical quality that can be withdrawn economically each year for an indefinite period of years. If the perennial yield is continually exceeded, water levels will decline until the ground-water reservoir is depleted of water of usable quality or the pumping lifts become uneconomical to maintain. Perennial yield cannot exceed the natural recharge to an area. On the other hand, the yield may be limited to the amount of natural discharge that can economically be salvaged for beneficial use.

The Meadow Valley area is comprised of several areas which, in downstream order, are hydrologically interrelated. Moreover, Lake Valley, which is north of this area, contributes about 3,000 acre-feet of water per year to Patterson Valley. Accordingly, development in one valley may intercept the supply that otherwise would reach the next valley downstream. As a consequence, the determination of the perennial yield of each small valley is not warranted. Consideration is given only to the perennial yield of the entire area, even though it is recognized that substantial development to the north would decrease the supply reaching Patterson Valley, and large withdrawals in the Meadow Valley area in turn could reduce the supply of lower Moapa Valley.

The estimated average annual recharge to the area is 27,000 acre-feet. The perennial yield could be this large if the subsurface inflow to Patterson Valley were not intercepted in Lake Valley, and if all the subsurface outflow near Glendale could be salvaged. On the other hand, the yield might be less than 20,000 acre-feet if theconverse conditions of subsurface flow should occur at sometime in the future. It is assumed that with substantial ground-water development in the area, most of the evapotranspiration loss could be salvaged. Because the inflow from Lake Valley and the outflow near Glendale are not likely to change appreciably in the near future, the preliminary perennial yield of the area is considered to be about 25,000 acre-feet.

Nearly all the estimated 12,000 acre-feet of net draft in 1963 (p. 21) was downstream from Spring and Patterson Valleys, where the estimated average recharge is only 8,000 acre-feet per year (table 10). Obviously, then, unless pumpage induces additional recharge from upstream valleys and (or) salvages substantial outflow to downstream areas, local overdraft will likely occur, particularly in Panaca Valley where gross pumpage in 1963 was about 7,500 acre-feet (table 12).

Chemical Quality:

Water plays a dominant part in the process of decomposition of rock and rock minerals. The salt beds and saline lakes, which occupy the lower parts of some of the closed valleys of Nevada, are the result of accumulation of the products of erosion by solution of the rocks of the surrounding areas. Deposition of minerals from circulating ground water has played a part in both the production of commercially valuable mineral deposits and in the deterioration of agricultural land.

Water acts as a solvent; its dissolving power is greatly increased by carbon dioxide, which is present in most natural waters. Rain water dissolves carbon dioxide from the air, and ground water receives even larger amounts from the decomposition of organic matter in the soil. The longer the percolation time and the greater the amount of rock material the water contacts, the more dissolved mineral matter the water is likely to contain. Therefore, in the mountain areas where most of the recharge occurs, the water generally has a low mineral content. As the water percolates through the rock material, the dissolved mineral content of the water increases. Thus, by the time the water reaches the central part of the valley, the dissolved-solid content may have a wide range.

The use of the water for irrigation tends to increase the mineral content. Irrigation water which percolates down to the water table and is again used in irrigation would have an increased dissolved mineral content.

Twenty-five water samples, taken from streams, wells, and springs in October and December 1963, were analyzed as part of this study so that a partial appraisal of the suitability of the ground water for agricultural purposes could be made. Sample sites were selected for all the valleys of the Meadow Valley area where there is significant ground-water development. The analyses are listed in table 13.

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

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

No data are available on the sodium content or the presence of toxic elements in the water; however, specific conductance was measured for each sample. About half the samples were classified C2 and about half C3. In good agricultural practice excess soluble mineral matter from water left in the soil from irrigation is generally removed by leaching; i. e., by applying more water than what the crop consumes, and allowing the resulting solution to percolate to the ground-water reservoir. In most of the Meadow Valley area, where the water level beneath the irrigated land is beyond the reach of the crop root system and the soil is permeable, the leaching process should be effective in maintaining permanent productivity.

The sample having the lowest specific conductance was from Parsnip Wash Spring (sec. 5, T. 3 N., R. 69 E.) in Spring Valley. The spring is in the Wilson Creek Range at an altitude of nearly 7,000 feet (pl. 1). This

Table 13.--Chemical analyses, in parts per million, of water from the Meadow Valley area

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

Location	Owner and/or name	Date collected	Calcium (Ca)	Magnesium (Mg)	Bicarbonate (HCO_3)	Chloride (Cl)	Total hardness	Specific conductance (micromhos at 25°C)	pH	Remarks[1]
Spring Valley										
Sec. 7, T. 3 N., R. 69 E.	Parsnip Wash Spring	10-25-63	18	5.1	98	13	66	211	7.8	Surface water sample.
Sec. 7, T. 2 N., R. 70 E.	Spring Valley Creek	10-25-63	51	10	268	39	168	575	7.8	Surface water sample taken at bridge over wash.
Sec. 25, T. 2 N., R. 69 E.	Spring Valley Creek	10-27-63	--	--	- -	--	---	528	--	Surface water sample taken at gage site in canyon between Spring and Eagle Valley.
Eagle Valley										
1N/69-10d1	Paul Bliss well	10-25-63	95	17	412	65	262	927	7.4	
Sec. 15, T. 1 N., R. 69 E.	Spring Valley Creek	10-25-63	--	--	- -	--	---	681	--	Surface water sample taken in canyon between Eagle and Rose Valleys.
Rose Valley										
Sec. 28, T. 1 N., R. 69 E.	Spring Valley Creek	10-26-63	72	15	342	48	242	711	8.1	Surface water sample taken in canyon between Rose and Dry Valleys.
1N/69-21a2	James Rosa well	10-25-63	73	9.8	294	43	222	672	7.5	
Dry Valley										
Sec. 28, T. 1 S., R. 68 E.	Meadow Valley Wash	10-27-63	33	4.7	137	41	113	442	8.7	Surface water sample taken at mouth of Condor Canyon. Also: Carbonate (CO_3), 10 ppm.
1S/69-6d1	Delmue Brothers - North well	10-26-63	83	12	480	55	257	774	7.5	
Patterson Valley										
3N/66-2d1	Twenty-one mile holding corral well	10-23-63	42	9.0	129	30	142	374	7.8	
Panaca Valley										
1S/68-33c1	C. Kenneth Lee - South well	12- 4-63	41	9.8	214	13	143	508	7.7	
2S/67-24d1	Roy Kurt - No. 1 well	10-27-63	82	25	268	117	307	1,120	7.5	
Sec. 4, T. 2 S., R. 68 E.	Panaca Spring	4-15-63	31	9.8	189	15	118	401	8.1	Warm Spring, 2 miles north of Panaca. Also: Silica (SiO_2), 51; Iron (Fe), 0; Sodium (Na), 38; Potassium (K), 6.8; Sulfate (SO_4), 29; Fluoride (F), 1.6; Nitrate (NO_3), 2.6; Boron (B), 0.1; Dissolved solids, 271.
2S/68-5b1	Harry H. Horlacker well	12- 4-63	61	31	354	89	280	1,050	7.6	
2S/68-7a1	Panaca LDS Church well	12- 4-63	65	21	239	125	250	810	7.8	
2S/68-8b5	U.S.G.S. - Observation well	12- 3-63 6-1949	56 22	31 24	619 1,130	107 282	266 154	1,700 3,390	7.6 - -	Half mile west of Panaca. Also: Silica (SiO_2), 85; Sodium (Na) + Potassium (K), 795; Sulfate (SO_4), 507; Fluoride (F), 12; Nitrate (NO_3), 0; Boron (B), 1.0; Dissolved Solids, 2,280.
2S/68-8c3	Delmue Brothers - North well	12- 4-63	61	31	308	63	282	1,020	7.8	
2S/68-8c4	Delmue Brothers - South well	12- 4-63	114	68	500	274	565	2,240	7.5	
2S/68-18d2	Don Wadsworth - No. 1 well	10-28-63	157	24	462	117	488	1,780	7.4	
2S/68-19a1	Don Wadsworth - No. 2 well	10-28-63	111	18	426	71	350	1,330	7.5	
3S/67-1b1	Grant Lee - No. 1 well	12- 4-63	73	31	328	55	310	1,010	7.7	
3S/67-28c1	Chester Oxborrow - No. 2 well	12- 4-63	24	7.5	183	31	91	480	9.2	
Lower Meadow Valley										
4S/66-24a1	Emory Conaway - Middle well	12- 5-63	70	15	340	37	236	793	7.7	Two miles south of Caliente.
4S/66-25b1	Emory Conaway - Lower well	12- 5-63	53	11	272	26	176	592	7.8	Three miles south of Caliente.
4S/67-18b1	Emory Conaway - Upper well	12- 5-63	54	16	260	21	174	522	7.7	Half mile west of Caliente.
7S/67-21c1	James W. Bradshaw well	12- 5-63	43	14	340	43	165	812	8.0	Three miles south of Elgin.
12S/65-13b1	Mildred Breedlove well	12- 5-63	109	67	264	95	546	1,540	7.9	Near Rox, Nevada.
14S/66-35d1	L. J. McCormick well	10-10-49	132	80	250	32	658	1,450	- -	At Glendale. Also: Silica (SiO_2), 27; Sodium (Na) + Potassium (K), 62; Sulfate (SO_4), 516; Nitrate (NO_3), 8.8; Dissolved solids, 981.

1. Water temperature shown in table 15.

was the only water sampled that had a salinity-hazard classification of C1. However, it is likely that water from other high-altitude springs of Spring Valley would have a similar classification.

Samples from Meadow Valley Wash above Condor Canyon showed a gradual increase in specific-conductance values downstream. The increase was from 575 micromhos in Spring Valley to 711 micromhos in the canyon between Dry and Rose Valleys. The samples from wells in the same area generally had slightly higher values, reflecting the concentration of salts as water was evapotranspired.

Surface water in Condor Canyon is less mineralized than water farther upstream, and had a specific conductance of 442 micromhos, indicating that the flow probably is derived in large part from a source other than the alluvium. In this case, the surface flow is largely from the thermal springs at Delmue Ranch just upstream from the canyon in Dry Valley. In Patterson Valley the single stock well sampled had a specific conductance of 374 micromhos.

Specific conductance of water from 11 wells in Panaca Valley ranged from 480 to 2,240 micromhos. The sample from 1S/68-33c1, which is within a mile of Panaca Spring, had a specific conductance of 508 micromhos. The dissolved-solid content of the well water is very similar to that of Panaca Spring, as shown in table 13. This suggests a probable common source. The remaining samples from the valley had higher specific-conductance values; except for the sample from flowing artesian well 3S/67-28c1 at the south end of the valley, which had a specific conductance of 480 micromhos. The source of this low specific-conductance water is not known; however, it probably is from bedrock by way of the alluvium near the well. A test well drilled in the same area penetrated noncarbonate bedrock at a depth of 166 feet (Phoenix, 1948, p. 106).

A large variation in ground-water temperature was measured in Panaca Valley. (See table 15) Normally, in the absence of warm-water sources, the ground water at shallow depths has a temperature near the average annual air temperature, which at Pioche is 51°F, at Caliente is 53°F, and at Overton is 66°F. However, the temperatures of 13 ground-water samples ranged from 56°F to 78°F. It is apparent that warm water from deep circulation is mixing with the water otherwise normally in the alluvium, thus causing the higher ground-water temperatures. Panaca Spring water, having a temperature of 85°F, is assumed to be undiluted deep-circulation warm water. The coldest water sampled, 56°F at well 2S/68-18d2 just south of Panaca, probably most nearly represents the water normally in the alluvium.

The mixing should also affect the chemical quality of the water. Figure 7 is a graph showing the relation of the specific conductance to the temperature of these mixed waters. The graph suggests that two distinct sources of water are present; a warm, low mineral-content water probably transmitted to Panaca Valley in the carbonate-rock system and a cold,

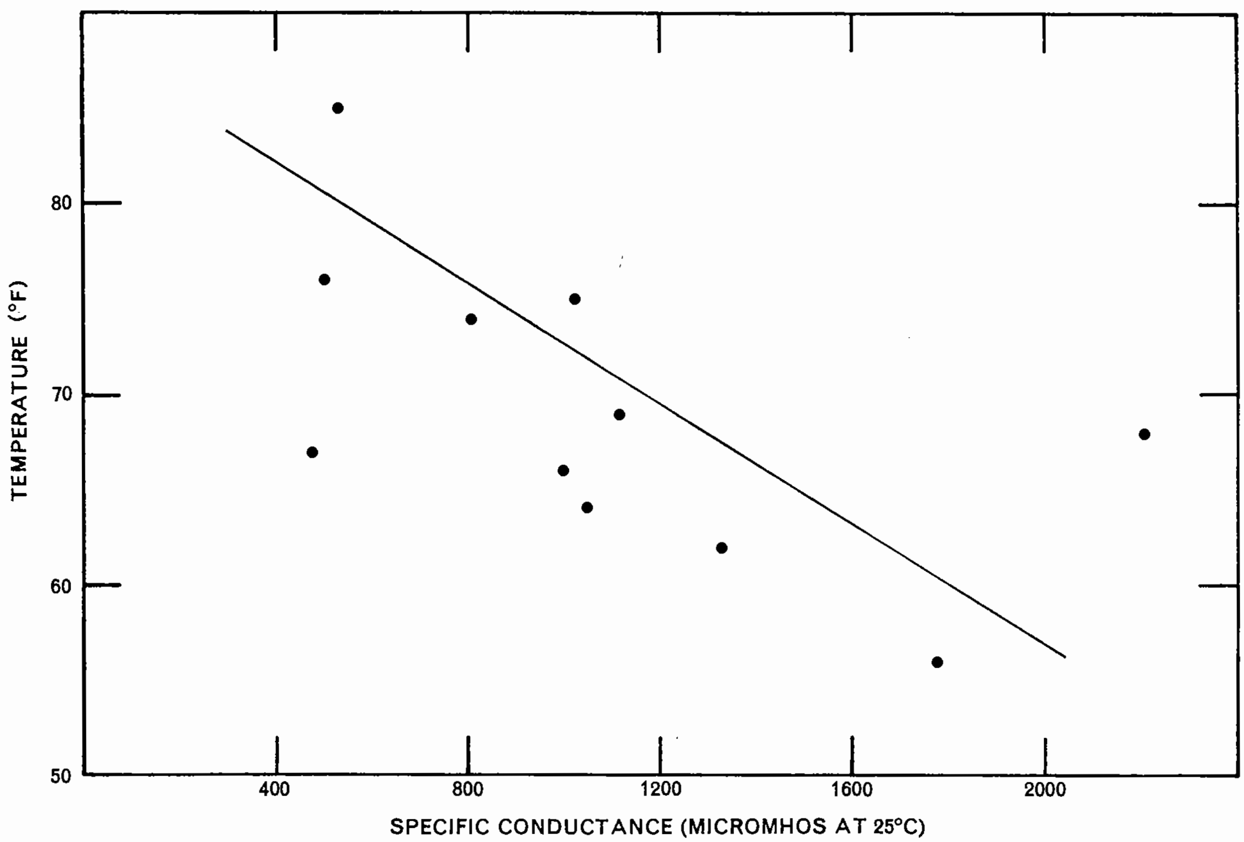


Figure 7.—Graph showing the relation of temperature to specific conductance of ground water in Panaca Valley

somewhat more mineralized water normal to the valley alluvium. These two waters mix in varying amounts in Panaca Valley, producing variations in temperature and mineral content.

In lower Meadow Valley, six ground-water samples were taken. Dissolved-solid concentrations increase southward along the wash. The values of the specific conductance of water from three wells on the Conaway Ranch near Caliente were 522, 592, and 793, respectively. The first two are classified as C2 and the latter as C3. The samples taken from wells on the three alluvial plains near Carp, Rox, and Glendale, as shown on plate 1, had high values and are classified C3.

Water from well 4S/66-24a1 had a much higher specific conductance than wells 4S/67-18b1 and 4S/66-25b1 a few miles distant. The well is where the depth to water is small and where use of water by phreatophytes is large.

In the southern part of lower Meadow Valley, mineral content of the ground water is high for several possible reasons: (1) the length of percolation time and the amount of rock material the water has contacted in its migration downgradient are large, (2) some of the water has been recycled several times through the soil by irrigation and natural flow, and (3) a large amount of evapotranspiration takes place locally in the area, causing increased mineral concentration.

Near Glendale, the water quality seems to be deteriorating with time. Bourns (1963) reports that the specific conductance of water samples from well 14S/66-35d1 has increased from 1,450 micromhos in October 1949 to 3,800 micromhos in May 1962 and 4,400 micromhos in December 1962. If this reported trend continues and the samples are representative of the ground water in the area, its use may become unsatisfactory for general irrigation purposes.

DEVELOPMENT

Present Development:

Agriculture started in the area nearly 100 years ago when settlers came to Panaca Valley from Utah. Early irrigation was limited principally to the use of Panaca Spring and flow in Meadow Valley wash. Not until 1940 was the first irrigation well drilled and used. Since then many irrigation wells have been drilled throughout the Meadow Valley area.

Surface Water: Surface water is utilized where there is flow during the growing season. The areas where such flow is used are Spring, Eagle, and Rose Valleys, along Clover Creek, and in lower Meadow Valley a few miles southwest of Caliente.

In Spring Valley, about 1,000 acres of native meadow is irrigated from the flow of local springs in the alluvial plain. The meadow area is protected by the Hollinger debris dam, located in sec. 20, T. 3 N., R. 70 E. An excess of water is available, resulting in outflow to Eagle Valley where generally all of the surface flow is diverted by ditches to irrigate about 500 acres of pasture and meadow. When needed, an irrigation well supplements the surface flow. At the south end of the valley ground water discharges into the wash where it flows through a bedrock canyon to Rose Valley. Here again the stream is diverted by ditches to irrigate about 300 acres of alfalfa and pasture. Three irrigation wells supplement the supply. Normally, flow in the wash extends into Dry Valley, only in the winter and early spring.

The flow in the wash at the canyons below each valley in late October 1963 was: Spring Valley, 4.9 cfs (cubic feet per second), Eagle Valley, 2.1 cfs; and Rose Valley, none. These data and additional streamflow measurements are summarized in table 7 and the measurement sites shown on plate 1.

The springs at the Delmue Ranch in Dry Valley are used to irrigate hay and pasture at the south end of the valley; any excess water flows through Condor Canyon and is diverted for irrigation at the north end of Panaca Valley. During the summer and fall the flow normally is small, and in late October 1963 was measured as 0.8 cfs.

Along Clover Creek, 10 to 20 miles southeast of Caliente, springs cause continuous flow in the creek. This flow is diverted to irrigate about 300 acres of crop land. A few miles south of Caliente in lower Meadow Valley, perennial streamflow is also used to irrigate hay and pasture.

Ground-Water: Ground-water development initially consisted of the utilization of water from springs. Panaca Spring still is an important source of ground water (table 9). In 1940 the first successful irrigation well in the area was drilled (well 3S/67-1b1, table 15) south of Panaca. It is still used by the owner, Grant Lee. In 1948, eight irrigation wells pumped an estimated 743 acre-feet of water (Phoenix, 1948, p. 71). By 1950, 16 wells pumped an estimated 2,600 acre-feet annually. In 1951 pumpage had increased to about 3,500 acre-feet. The number of wells and the amount of water pumped has continued to increase, and in 1963, 40 irrigation wells pumped an estimated 7,000 acre-feet to irrigate about 2,000 acres of land in Panaca Valley.

Wells are used to irrigate crops in all the valleys, except Patterson, Spring, and Clover Valleys. In 1963, 19,000 acre-feet of water was pumped from 60 irrigation wells and 5 public-supply wells. Most of the water was used for hay and pasture. Near Rox, well 12S/65-13b1 was used to irrigate fruits and vegetables. The pumpage for this purpose was only 77 acre-feet in 1963. In 1964 the owner plans to use an additional well (12S/65-12c1).

Table 14 shows that the estimated total acreage under irrigation from both surface-water and ground-water sources in 1963 was 6,100 acres.

Potential Development:

Surface Water: Surface runoff that reaches the mouth of Meadow Valley wash and is discharged into the Muddy River is lost for development in the Meadow Valley area. Normally the flow in the wash is too small to extend to its mouth. Generally it is diverted and used for irrigation or in part percolates into the alluvium and adds to the ground water in storage. Therefore, additional surface-water development in the area might best be directed toward preventing the loss to the Muddy River of surface water from spring snowmelt and flash floods. Because this water is in contact with the rock and soil only while it is draining off the land, the water probably is of low mineral content.

The storm and snowmelt runoff that causes flow to the mouth of the wash is not usable for systematic irrigation of crops, because the flow is intermittent and is unpredictable in frequency and duration. From a water-management standpoint, this water might be saved and stored by ponding it on permeable alluvium to achieve maximum infiltration to ground-water storage. Maximum infiltration could be obtained by damming the water on flood plains, where the water would be spread over a large alluvial area. The water could be recovered principally by wells for use in the area down-gradient from the reservoir. During periods when water was in the reservoir, direct diversion could be utilized.

Ground Water: The local decline of ground-water levels in Panaca and lower Meadow Valleys, as shown in figures 5 and 6, indicates that the amount of ground water in storage is decreasing because the total discharge is slightly larger than the total recharge in this part of the area. Therefore, in order to salvage additional quantities for beneficial purposes within the limits of perennial yield, it would be necessary to reduce the nonbeneficial consumption or underflow from the area.

The evapotranspiration by most phreatophytes, an estimated 3,600 acre-feet a year, is generally considered to be a waste of water. Continued development of agriculture in these areas probably will have two affects: the clearing of phreatophytes for crops and the lowering of the water table beyond the reach of their roots by increased pumping for irrigation. In both cases, the effect will be the salvage of some water that is now wasting.

In Panaca Valley the growing season averages about 170 days a year. During the remainder of the year, about 200 days, Panaca Spring discharges about 4,400 acre-feet of water. It would be worthwhile to investigate the possibility of salvaging a large part of the winter discharge for use in Panaca Valley during the growing season.

Ground-water outflow to the Muddy River area could be reduced if the present gradient of about 28 feet per mile could be reduced by lowering of the water level at Rox in relation to the levels at Glendale in the Muddy River valley. The present outflow probably is several thousand acre-feet per year.

The Nevada Power Company is developing a plan to build a power-generating plant near Glendale and has proposed the exchange of water from wells drilled by the power company in the Meadow Valley drainage area for water from the Muddy River in Moapa Valley (Bourns, 1963). The feasibility of the plan would depend in part on the long-term adequacy of the supply of satisfactory-quality water from the power company wells. At this writing, the limited data available does not permit specultation as to the future quality characteristics of the ground water in the vicinity of the potential well field near Glendale.

Table 14 summarizes the present and potential agricultural land use and the irrigation water needs for the Meadow Valley area. The data presented are modified from information in publications prepared by the Cooperative Extension Service, Max C. Fleischmann College of Agriculture, University of Nevada and the Lincoln County Rural Areas Development Committee (1963) and Shamberger (1954). With full development of all the land that can be irrigated profitably, an estimated 41,000 acre-feet a year of water would be consumed on about 11,000 acres. In 1963 the estimated irrigated land was 6,100 acres. At full development the limiting factor would be the amount of water available rather than the amount of land suitable for irrigation.

Additional water would be made available for irrigation in Lower Meadow Valley if the recommendations of the U. S. Bureau of Reclamation (1962) for an exchange of water between this area and Lower Moapa Valley are fulfilled. The proposed Moapa Valley pumping project would provide water for the presently irrigated lands in Lower Moapa Valley by pumping the required quantity of water from Lake Mead. An equivalent quantity of Muddy River water would be made available for transfer to Lower Meadow Valley for the irrigation of an estimated 3,000 acres of land in this area.

The valley of largest potential development is lower Meadow Valley, where it is estimated that 3,000 acres of additional land can be used for irrigation. Most of this land is between Rox and Glendale. The southern part of Panaca Valley still supports about 4,000 acres of greasewood and rabbitbrush, most of which could be cleared for production. Here the estimated potential irrigated land is about 1,000 acres. It is yet to be determined whether enough good quality water will be available for the full development in these two valleys and the remaining valleys of the Meadow Valley area. Further studies are proposed in a later section of this report that would help to expand the needed knowledge of the water resources of the Meadow Valley area.

Table 14.--Estimates of present and potential agricultural land use and irrigation-water needs in the Meadow Valley area 1/

Valley	Irrigated land in 1963 (acres)	Potential irrigated land (acres)	Land suitable for irrigation (acres)	Potential annual diversion requirements		Potential annual beneficial consumption	
				Rate (acre-feet per acre)	Total (acre-feet)	Rate (acre-feet per acre)	Total (acre-feet)
Patterson	0	(unkown)	--	--	--	--	--
Spring	1,000	0	1,000	4.0	4,000	2.5	2,500
Eagle	500	100	600	5.0	3,000	3.0	1,800
Rose	350	175	525	5.0	2,625	3.0	1,575
Dry	650	450	1,100	5.0	5,500	3.0	3,300
Panaca	2,000	1,000	3,000	5.0	15,000	3.0	9,000
Clover	300	250	550	5.0	2,750	3.0	1,650
Lower Meadow	1,300	3,000	4,300	7.0	30,100	5.0	21,500
TOTAL (rounded)	6,100	5,000	11,100		63,000		41,000

1/ Data modified from Cooperative Extension Service, Max C. Fleischmann College of Agriculture, University of Nevada and the Lincoln County Rural Areas Development Committee (1963) and Shamberger (1954).

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 the Meadow Valley area are listed below.

1. The reinstallation of the gaging station 4 1/2 miles south of Caliente on Meadow Valley wash is suggested. The station would provide the needed data on the amount and distribution of stream discharge, and its relationship to flow from ground-water sources and to storm and snowmelt runoff with continued increase of agricultural development in the area upstream from the gage. The data would also be useful in evaluating and managing the water resources of lower Meadow Valley.

2. To utilize fully and manage the total water resources of the Meadow Valley area, it is necessary to know the magnitude of ground- and surface-water outflow and water-quality changes near Glendale. The ground-water outflow evaluation would require test-well drilling, instrumentation, and data collection for a period of a few years. The surface-water outflow evaluation would probably require the maintenance of a gage near Caliente (as mentioned in proposal 1, above) and the installation of a gage between Rox and Glendale. Data would have to be collected for a period of several years before a satisfactory evaluation could be made. Water samples should be collected and analysed at least annually.

3. An evaluation of the two types of ground water in Panaca Valley could provide a better understanding of their sources and development potentials. This information could be used to utilize selectively the best quality of water in the area.

4. Water-level measurements should be continued in selected observation wells to provide information on changes of ground water in storage. This information will be needed in future evaluations of the water resources and of water development.

DESIGNATION OF WELLS

In this report the number assigned to a well is both an identification number and location number. It is referenced to the Mount Diablo base line and meridian.

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

Table 15.--Records of selected wells in the Meadow Valley area

Owner and/or name: BLM, Bureau of Land Management

Use of water: PS, public supply; D, domestic; I, irrigation; O, observation; S, stock; Ind, industrial

Water level: M, measured; R, reported

Altitude: estimated from topographic maps

Measuring point: TC, top of casing; HC, hole in casing; HPB, hole in pump base; PC; plug in casing

Remarks: Number is log number in files of the Nevada 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
4N/66-2a1	BLM, Dodge well	9-1937	301	6	--	5900	TC	2.5	197.5	M	7-18-63	--	S	Log 303
4N/66-14d1	BLM, Seeding well	7-1958	303	6	230-235	5846	TC	.5	165 166.7	R M	7-1958 8-28-63	--	S	Log 4189
4N/66-26c1	Twenty-one Mile well	--	144	4	--	5775	TC	0	122.7	M	7-18-63	--	S	Chemical analysis, table 13
4N/69-13b1	BLM, Spring Valley Holding Corral well	1941	206	6	--	6280	TC	1.8	182.1 177.1	R M	7-31-46 10-25-63	--	S	
4N/69-36a1	Unknown	1963	106	6	--	6200	TC	1.8	71.6	M	10-25-63	--	S	
3N/66-2d1	BLM, Twenty-one Mile Holding Corral well	12-1947	140	6	--	5726	TC	0	See remarks 92.4	R M	4-12-46 10-23-63	61	S	Log 305. Water level 92.4 feet measured in replaced well.
3N/66-8a1	BLM, Bristol Wash well	1954	220	8	--	5900	TC	1.5	dry	M	10-23-63	--	S	
3N/66-23d1	Fifteen-mile well	11-1937	87	6	--	5650	TC	.4	42.1 42.8 42.4 42.3	R M M M	7-26-46 12-07-60 2-21-63 10-23-63	--	S	
3N/67-4b1	BLM	1-1958	382	6	340-345	6040	--	--	340	R	1-1958	--	S	Log 4001
3N/70-7a1	E. Lytle	--	30	6	--	6080	TC	0	8.	R	1946	58	S	See Water Resources Bull. 7, p. 88 for chemical analysis.
3N/70-7b1	Unknown	--	--	24	--	6070	TC	1.0	8.1	M	10-25-63	--	S	
3N/70-7d1	Roy E. Lytle	9-1948	96	12	35-93	--	--		47	R	9-1948	--	I	Log 676. See water.
3N/70-7d2	BLM, White Rock well	1953	--	8	--	6050	TC	1.5	23.7	M	10-25-63	--	S	In Spring Valley.
3N/70-20d1	BLM	--	77	6	--	6080	TC	.8	51.8	M	10-25-63	--	S	
2N/67-16d1	Eight-mile well	--	48	6	--	5580	TC	0	22.2	M	10-24-63	--	S	
2N/68-27a1	BLM	12-1937	40	8	--	5980	--	--	16	R	12-1937	--	S	Log 306.
1N/67-15a1	Pioche Mines Co.	1-1938	563	10	365-563	5720	TC	--	368.	R	3-1963	--	-	Test pumped 350 gpm at 500 feet.
1N/69-10d1	Paul Bliss	7-1958	107	12	97-107	5590	TC	0	8.2 8.0	R M	7-1958 10-25-63	--	I	Log 4187. In Eagle Valley. Chemical analysis, table 13.
1N/69-21a1	McCrosky Bros. - Orchard well	7-1961	119	14	34-115	5550	--	--	17.3 21.1	R M	7-1961 10-25-63	--	I	Log 6041. Replacement well.
1N/69-21a2	James Ross	7-1963	110	14,10	60-88	5550	--	--	24	R	7-1963	48	I	Log 7320. Chem. anal., table 13. Replacement well. Test pumped 630 gpm at 50 feet.
1N/69-21b1	McCrosky Bros., - East well	1941	88	10	--	--	--	--	--	-	--	--	I	
1N/69-31c1	Chester Oxborrow - No. 1	2-1956	120	14,10	82-118	5190	-- PC	-- 1.3	46.5 52.4	R M	2-1956 10-26-63	--	I	Log 3341. Test pumped 900 gpm, at 87 feet.
1N/69-31c2	Chester Oxborrow - No. 2	8-1959	120	16,10	67-98	5200	--	--	38	R	8-1959	--	I	Log 4785. Test pumped 850 gpm at 100 feet.
1S/68-12d1	Civilian Conservation Corps	--	76	8	--	5250	TC	0	29.5 29.2	R M	3-23-46 10-26-63	59.5	O	See Water Resources Bull. 7, p. 88 for chemical analysis. In Dry Valley.
1S/68-28c1	C. Kenneth Lee - North well	12-1951	154	12,10	115-120	4900	HC	.5	45.3 48.8 44.9 47.9 46.4 45.8 49.8 49.7 49.3 47.1 45.8 44.6 47.6 43.6 45.6 50.6 48.9 49.0 49.4	R M M M M M M M M M M M R M M M M M M	3-01-46 6-11-46 4-17-47 9-25-47 12-30-47 4-25-48 9-27-48 3-21-49 9-19-49 12-14-49 3-20-50 3-14-51 12-1951 3-25-52 10-23-57 12-07-60 2-24-62 2-21-63 12-04-63	--	I	Log 1818. Test pumped 150 gpm at 90 feet. Replaced well drilled in 1942.
1S/68-32d1	Kenneth D. Lee - South well	12-1954	75	12,10	44-68	4810	--	--	35 39.4	R M	12-1954 12-04-63	Warm	I	Log 2818. Replacement well. Test pumped 800 gpm at 45 feet.
1S/68-33b2	Kenneth D. Lee - North well	12-1954	112	12	77-104	4860	--	--	38 42.0	R M	12-1954 12-04-63	--	I	Log 2819. Test pumped 800 gpm at 75 feet.

Table 15.--(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: 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
1S68-33b1	Lavon Phillips	--	120	10	--	4850	HPB	.3	32.8	R	3-01-46	--	-	See Water Resources Bull. 7, p. 102 for log.
									33.5	M	7-28-46			
									33.7	M	11-02-46			
									32.0	M	4-17-47			
									35.2	M	9-25-47			
									31.7	M	4-25-48			
									37.0	M	9-27-48			
									33.4	M	3-21-49			
									37.2	M	9-21-49			
									32.4	M	3-20-50			
									37.2	M	9-12-50			
									32.1	M	3-14-51			
									35.6	M	9-11-51			
									31.8	M	3-25-52			
									34.4	M	9-11-52			
									35.8	M	9-16-53			
									36.2	M	9-09-54			
									37.1	M	10-23-57			
									38.3	M	9-07-58			
									40.8	M	9-19-59			
									38.2	M	12-07-60			
									36.4	M	2-21-62			
1S/68-33c1	C. Kenneth Lee - South well	6-1952	106	12	6-40	4800	--	--	6.2	R	6-1952	76	I	Log 1948. Replacement well. Test pumped 1400 gpm.
									14.1	M	12-04-63			
1S/68-33c2	Rufus Hurst	3-1959	128	12	100-122	4820	--	--	26	R	3-1959	--	I	Log 4471.
1S/69-6a1	Chester Oxborrow - No. 3	10-1962	124	14	40-89	5180	--	--	27	R	10-1962	--	I	Log 6811. Test pumped 900 gpm at 80 feet.
1S/69-6c1	Delmue Brothers - West well	1963	--	14	--	5190	TC	.5	21.6	M	10-26-63	--	I	In Dry Valley.
1S/69-6d1	Delmue Brothers - North well	10-1952	100	12	42-92	5190	--	--	17	R	10-1952	49	I	Log 2083. Chem. anal., table 13. Test pumped 800 gpm at 60 feet.
1S/69-7a1	Delmue Brothers - South well	8-1954	100	12	63-89	5170	--	--	12	R	8-1954	--	I	Log 2691. Test pumped 900 gpm at 60 feet.
									14.8	M	12-1963			
2S/67-24a1	Roy Kurt - No. 2	--	--	14	--	4700	HC	.8	9.1	M	10-27-63	--	I	
2S/67-24d1	Roy Kurt - No. 1	--	--	--	--	--	--	--	--	-	--	69	S,I	Chemical analysis, table 13.
2S/67-25a1	Thomas Glay - No. 2	10-1960	183	--	141-180	4660	--	--	28	R	10-1960	--	I	Log 5471.
2S/67-25a2	Farrell Andhers	3-1961	150	12,6	122-132	4670	--	--	28.5	R	3-1961	--	I	Log 5808.
2S/67-25c1	Thomas Clay - No. 6	2-1961	135	14	77-90	4650	--	--	27.5	R	2-1961	--	I	Log 5626. Test pumped 900 gpm at 70 feet.
2S/67-25c2	Thomas Clay - No. 7	2-1961	187	14	145-185	4650	--	--	26.7	R	2-1961	--	I	Log 5708. Test pumped 700 gpm at 70 feet.
							HPB	0	28.8	M	10-25-63			
2S/67-26d1	Thomas Clay - No. 5	12-1960	115	14	75-101	4650	--	--	29	R	12-1960	--	I	Log 5625. Test pumped 350 gpm at 70 feet.
2S/67-26d2	Thomas Clay - No. 8	4-1963	65	10	28-47	4650	--	--	28.5	R	4-1963	--	D,I	Log 7145. Test pumped 120 gpm at 50 feet.
2S/67-35a1	Thomas Clay - No. 4	--	193	14	--	--	--	--	--	-	--	--	I	
2S/68-5a1	Lester Mathews - Pasture well	7-1959	160	14	60-75	4790	--	--	3.9	R	7-1959	--	I	Log 4765. Test pumped 325 gpm at 36 feet.
2S/68-5b1	Harry H. Horlacker	1948	--	--	--	4800	--	--	1.6	M	12-30-47	64	I	Test pumped 400 gpm. Previous owner was D. L. Gemmill.
									4.3	M	9-27-48			
									4.2	M	9-19-49			
									3.2	M	12-14-49			
									1.6	M	3-20-50			
									4.5	M	9-12-50			
									1.1	M	3-14-51			
									4.6	M	9-12-51			
									1.4	M	3-25-52			
									3.1	M	9-11-52			
									8.1	M	9-09-54			
									8.7	M	10-23-57			
									8.8	M	12-07-60			
									6.6	M	2-24-62			
									7.4	M	2-21-63			
2S/68-5c4	Lester Mathews - Dairy barn irrigation well	6-1949	158	14,10	--	4765	HPB	1.4	18	R	6-1949	78	I	Log 955
									19.0	M	9-19-49			
									18.9	M	12-14-49			
									17.4	M	3-20-50			
									19.9	M	9-12-50			
									18.0	M	3-14-51			
									21.6	M	9-13-51			
									17.1	M	3-25-52			
									18.0	M	3-18-54			
									21.0	M	9-08-54			
									17.1	M	3-23-55			
									20.2	M	10-23-57			
									22.0	M	9-07-58			
									23.3	M	9-19-59			
									21.8	M	12-07-60			
									21.5	M	2-24-62			
									22.4	M	2-21-63			
									22.8	M	12-04-63			
2S/68-5c1	Panaca Formstead Water Company	1-1953	170	12	120-170	4760	--	--	12.2	R	1-1953	--	PS	Log 2148. Test pumped 1800 gpm at 70 feet.
2S/68-5c2	Lester Mathews - Reservoir well	4-1957	117	12	62-78	4780	--	--	26.8	R	4-1957	--	I	Log 3713.
2S/68-6d1	Lester Mathews - West well	5-1962	100	14	56-83	4790	--	--	48	R	5-1962	--	I	Log 6552.
									3.3	R	5-1962			
2S/68-7	Thomas Clay	10-1961	90	6	72-90	--	--	--	62	R	10-1961	--	S	Log 6168.

Table 15.--(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: 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
2S/68-7a1	Panaca LDS Church	5-1960	135	14	60-98	4730	HC	0.5	18	R	5-1960	--	I	Log 5177 Test pumped 900 gpm at 60 feet.
									21.1	M	12-05-63	74		
2S/68-7d3	Murray Lee	5-1948	105	8	13-105	4730	TC	1.0	15.8	M	10-06-48	--	I	Log 513. Test pumped 300 gpm with 17 feet drawdown.
									13.2	M	3-21-49			
									15.6	M	9-19-49			
									13.1	M	3-20-50			
									15.7	M	6-22-50			
									16.3	M	9-12-50			
									13.5	M	3-14-51			
									16.6	M	9-13-51			
									13.0	M	3-25-52			
									16.0	M	9-11-52			
									16.8	M	9-16-53			
									18.0	M	3-18-54			
									17.2	M	9-09-54			
									13.9	M	3-23-55			
									16.5	M	9-15-55			
									12.6	M	3-16-56			
									17.8	M	10-23-57			
									17.1	M	9-07-58			
									17.8	M	12-07-60			
									17.8	M	2-21-63			
2S68-8b1	Pioche LDS Church	--	--	10	--	--	--	--	--	-	--	72	1	
2S/68-8b5	U.S. Geological Survey	6-1949	110	8	105-110	4720	TC	1.0	13.6	M	6-28-49	--	0	Log 954. Chem. anal., table 13.
									14.7	M	9-19-49			
									11.7	M	3-20-50			
									15.7	M	6-22-50			
									16.1	M	9-12-50			
									12.8	M	3-14-51			
									16.4	M	9-13-51			
									12.2	M	3-25-52			
									16.0	M	9-11-52			
									17.0	M	9-16-53			
									13.44	M	3-18-54			
									17.4	M	9-08-54			
									12.4	M	3-23-55			
									12.8	M	4-08-56			
									16.8	M	10-23-57			
									16.8	M	9-07-58			
									19.0	M	9-19-59			
									15.8	M	2-06-61			
									15.1	M	3-17-61			
									19.3	M	5-31-61			
									21.6	M	7-23-61			
									21.8	M	8-30-61			
									15.7	M	2-24-62			
									17.1	M	2-21-63			
									18.3	M	12-05-63			
2S/68-8c1	Urban Cole	--	--	--	--	4715	HPB	1.0	11.0	M	9-19-49	--	1	Previously owned by D. J Ronnow.
									7.6	M	3-20-50			
									10.8	M	6-22-50			
									11.7	M	9-12-50			
									7.5	M	3-14-51			
									11.9	M	9-13-51			
									11.0	M	9-11-52			
									11.9	M	9-16-53			
									12.2	M	9-08-54			
									12.6	M	10-23-57			
									12.5	M	9-05-58			
									14.2	M	9-19-59			
									11.9	M	12-07-60			
									9.34	M	2-21-63			
2S/68-8c2	Grant Lee - North well	--	--	8	--	--	--	--	--	-	--	--	I	
2S/68-8c3	Delmue Brothers - North well	12-1959	120	14	74-90	4720	--	--	11	R	12-1959	75	1	Log 4994. Chem. anal., table 13.
2S/68-8c4	Delmue Brothers - South well	11-1960	180	14	117-147	4710	--	--	8.3	R	11-1960	68	1	Log 5620. Test pumped 700 gpm at 70 feet.
									11.8	M	12-05-63			
2S/68-17b1	John Wadsworth	11-1955	152	12	130-152	4710	--	--	2.2	R	11-1955	--	1	Log 3241.
2S/68-18d1	Don Andhers	1-1952	170	12	130-160	4700	--	--	4.4	R	1-1952	--	I	Log 1844. Test pumped 2100 gpm with 44 feet drawdown.
2S/68-18d2	Don Wadsworth - No. 1	4-1957	184	14	148-184	4705	--	--	7.3	R	4-1957	56	I	Log 3754. Chem. anal., table 13.
2S/68-19a1	Don Wadsworth - No. 2	6-1961	165	14	75-105	4695	--	--	8	R	6-1961	62	I	Log 5934. Chem. anal., table 13.
2S/68-19c1	Amy Mathews - West well	1-1956	125	12	85-125	4685	--	--	See remarks	R	1-1956	--	I	Log 3301. Flowed 50 gpm in 1956.
2S/68-19c2	Amy Mathews - East well	1-1960	178	12	137-158	4675	--	--	4.9	R	1-1960	61	I	Log 5014.
2S/69-6b1	BLM - Demon well	--	300	6	--	5450	TC	.3	See remarks	M	12-03-63	--	S	Depth to water greater than 200 feet.

Table 15.--(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: 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
3S/67-1b1	Grant Lee - No. 1	1940	225	10	--	4630	--	--	17.2	M	3-01-46	66	I	Chem. anal., table 13.
									21.8	M	6-13-46			
									18.5	M	11-02-46			
									21.8	M	4-27-48			
									17.9	M	3-21-49			
									20.1	M	9-19-49			
									19.1	M	12-14-49			
									18.5	M	3-20-50			
									18.5	M	3-14-51			
									21.0	M	9-12-51			
									18.5	M	3-25-52			
									19.2	M	3-18-54			
									20.8	M	9-08-54			
									21.3	M	10-23-57			
									22.4	M	9-07-58			
									21.5	M	12-07-60			
									20.9	M	2-24-62			
									21.2	M	2-21-63			
									21.7	M	12-05-63			
3S/67-1b2	Grant Lee - No. 2	10-1955	145	12	94-138	4620	--	--	22.9	R	10-1955	cold	I	Log 3224. Replacement well. Test pumped 250 gpm at 105 feet.
3S/67-2d1	Grant Lee	4-1958	158	12	132-158	--	--	--	24.3	R	4-1958	--	I	Log 4067.
3S67-2d2	William M. Pierce - No. 1	4-1963	163	10	137-148	4610	--	--	21	R	4-1963	--	I	Log 7143. Test pumped 480 gpm at 90 feet.
3S/67-11a1	William M. Pierce - No. 2	4-1963	204	14	130-182	4600	--	--	18	R	4-1963	--	I	Log 7144.
3S/67-22b1	Chester Oxborrow - No. 1	4-1962	175	14	138-155	--	--	--	--	-	--	--	I	Log 6551. Test pumped 600 gpm at 70 feet.
3S/67-28c1	Chester Oxborrow - No. 2	11-1962	118	14	45-98	4460	--	--	See remarks	R	11-1962	67	I	Log 6767. Flows 100 gpm. Test pumped 1,000 gpm at 40 feet.
3S/71-31b1	BLM	3-1963	265	6	225-265	6100	--	--	214	R	3-1963	--	S	Log 7087.
4S/66-24a1	Emory Conaway - Middle well	4-1952	95	12	30-95	4300	--	--	4	R	4-1952	59	I	Log 1905. Chem. anal., table 13
4S/66-25b1	Emory Conaway - Lower well	6-1949	108	10	20-108	4270	--	--	15	R	6-1949	62	I	Log 946. Chem. anal., table 13.
4S/67-5c1	Caliente Public Utility - No. 4	1945	130	12	--	4410	--	--	10.3	M	4-1946	104	I	At Ryan Street and U.S. 93. Used for irrigation by Cyril Bastian See Water Resources Bull. 7, p. 88 for chemical analysis.
4S/67-7d1	Caliente Public Utility - No. 7	12-1953	190	12	135-190	4380	--	--	14.2	R	12-1953	--	PS	Log 2636. Test pumped 1,025 gpm with 100 feet drawdown. Located at A and Second Streets.
4S/67-8b1	Caliente Public Utility - No. 6	11-1952	185	12,10,7	145-165	4390	--	--	8	R	11-1952	--	PS	Log 2104.
4S/67-8c1	Caliente Public Utility - No. 3	1963	181	--	--	--	--	--	--	-	--	--	PS	
4S/67-18a1	Charles W. Culverwell	3-1949	90	10	32-90	4385	--	--	23.5	R	3-1949	--	I	Log 853. Test pumped 700 gpm.
4S/67-18b1	Emory Conaway - Upper well	11-1959	165	14	129-165	4360	--	--	26	R	11-1959	--	I	Log 4943. Pumping level 80 feet. Chem. anal., table 13.
							HC	1.0	24.2	M	12-05-63			
4S/70-11d1	Headwater Cattle Co.	5-1951	197	8	175-197	5880	--	--	175	R	5-1951	--	S	Log 1728.
5S/68-9b1	BLM	1-1963	200	6	160-200	5600	--	--	155	R	1-1963	--	S	Log 7046.
5S/69-11d1	Robert C. Poremaster	10-1962	127	8	85-127	5300	--	--	82	R	10-1962	--	D	Log 6802. Test pumped 30 gpm.
7S/67-20a1	Oliver Schlarman	11-1961	120	14	96-120	3240	--	--	21	R	11-1961	--	I	Log 6296.
7S/67-21c1	James W. Bradshaw	8-1962	115	14	70-115	3200	HC	1.0	20	R	8-1962	63	I	Log 6717. Pumping level 65 feet. Chem anal., table 13.
									20.6	M	12-05-63			
9S/67-11b1	Don Bradshaw	11-1961	150	14	70-150	2720	PC	1.5	51	R	11-1961	--	I	Log 6269. Pumped 2200 gpm, 5-26-63. Measurements prior to 1961 were made pre-existing 4-inch diameter well.
									46.3	M	3-1955			
									46.3	M	6-1955			
									47.6	M	11-1955			
									48.3	M	2-1957			
									48.8	M	4-1957			
									49.6	M	8-1957			
									50.1	M	11-1957			
									47.0	M	2-1958			
									45.6	M	6-1958			
									48.1	M	9-1958			
									49.3	M	12-1958			
									45.6	M	3-1959			
									51.7	M	9-1959			
									50.1	M	12-1959			
									49.9	M	2-1960			
									49.6	M	5-1960			
									51.6	M	8-1960			
									51.9	M	12-1960			
									50.2	M	3-1961			
									53.8	M	9-1961			
									52.6	M	2-1963			
									55.3	M	5-1963			
									58.4	M	9-1963			
									55.4	M	11-1963			

Table 15.--(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: 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
9S/67-34b1	Charles Brundy	--	90	12	--	2550	--	--	15	R	2-1964	--	I	
12S/65-12c1	C. P. Breedlove	--	105	10	--	1950	--	--	22	R	12-1963	68	I	Test pumped 2,000 gpm.
12S/65-13b1	Mildred Breedlove	11-1962	115	12	85-105	1930	--	--	11	R	11-1962	70	I	Log 6900. Test pumped 1,100 gpm. Chem. anal., table 13.
							TC	-3.0	5.3	M	12-05-63			
12S/65-13b2	U.S.G.S. - Rox No. 1	1955	18	1	--	1930	TC	4.2	18.7	M	6-16-55	--	O	
									18.3	M	11-1955			
									17.3	M	11-1956			
									16.9	M	2-1957			
									17.0	M	4-1957			
									17.7	M	8-1957			
									17.3	M	11-1957			
									16.6	M	2-1958			
									16.8	M	6-1958			
									17.7	M	9-1958			
									17.3	M	12-1958			
									16.9	M	3-1959			
									17.9	M	9-1959			
									17.5	M	12-1959			
									16.8	M	2-1960			
									16.7	M	5-1960			
									17.5	M	8-1960			
									16.8	M	12-1960			
									16.0	M	2-23-63			
									16.0	M	6-27-63			
									16.6	M	9-21-63			
									16.4	M	11-18-63			
13S/66-18b1	Wayne Cole	4-1963	88	15,12	60-88	1770	--	--	58	R	4-1963	--	I	Log 7141. Test pumped 500 gpm at 75 feet.
14S/66-25d1	Nevada Power Company	10-1962	480	16,14	95-195	1500	--	--	17	R	10-1962	--	Ind	Log 6806. Test pumped 1,900 gpm at 70 feet.
14S/66-35a1	U.S.G.S. - Glendale No. 1	1955	28	3/8	--	1495	TC	1.4	19.3	M	6-18-55	--	O	
									20.1	M	11-1955			
									20.3	M	11-1956			
									19.4	M	2-1957			
									18.8	M	4-1957			
									21.0	M	8-1957			
									20.1	M	11-1957			
									18.9	M	2-1958			
									19.4	M	6-1958			
									20.9	M	9-1958			
									19.9	M	12-1958			
									18.7	M	3-1959			
									21.3	M	9-1959			
									20.3	M	12-1959			
									19.3	M	2-1960			
									20.2	M	12-1960			
									18.9	M	3-1961			
									18.9	M	5-1961			
									21.3	M	9-09-61			
									20.0	M	5-27-62			
									19.5	M	5-26-63			
									22.5	M	9-21-63			
									20.5	M	11-18-63			
14S/66-35d1	L. J. McCormick	10-1947	118	16	62-88	1490	HC	.8	15	R	10-1947	--	I	Log 243. Test pumped 1,400 gpm with 60 feet drawdown.
									13.5	M	3-12-48			
									13.6	M	9-12-50			
									12.4	M	12-12-50			
									12.0	M	3-28-51			
									14.4	M	6-06-51			
									13.4	M	9-13-51			
									12.0	M	12-18-51			
									15.8	M	3-30-52			
									14.5	M	12-10-52			
									30.96	M	7-18-53			
									16.0	M	1-1957			
									20.8	M	8-1957			
									14.5	M	11-1957			
									14.0	M	2-1958			
									15.7	M	12-1958			
									13.6	M	2-1959			
									14.9	M	12-1960			
									20.7	M	11-18-63			
14S/66-35d2	Nevada Power Company	3-1963	212	16	105-190	1495	--	--	18	R	2-1963	--	Ind	Log 7163. Test pumped 1,500 gpm at 75 feet.
							TC	1.0	20.6	M	12-1963			

and southeast quarter of the section.

Wells on plate 1 are identified only by the section number, quarter-section letter, and serial number. The township in which the well is located can be determined by the township and range numbers shown on the margin of plate 1. For example, well 4N/66-2a1 is shown on plate 1 as 2a1 and is within the rectangle designated as T. 4 N., R. 66 E.

Table 16.--Selected drillers' logs of wells in the Meadow Valley area

	Thickness (feet)	Depth (feet)
4N/66-14d1 BLM, Seeding well		
Soil	2	2
Gravel, cemented	228	230
Sand and gravel	5	235
Gravel, cemented	15	250
Sand and gravel	4	254
Gravel, cemented	46	300
Sand and gravel	3	303
3N/67-4b1 BLM		
Soil	5	5
Gravel, cemented	335	340
Sand and gravel	5	345
Gravel, cemented	23	368
Clay	12	380
Sand and gravel	2	382
3N/70-7d1 Roy E. Lytle		
Clay, gray	20	20
Clay, blue	10	30
Clay, sandy	5	35
Gravel	5	40
Gravel, some coarse	20	60
Clay	10	70
Gravel, coarse	20	90
Hardpan and cemented gravel	3	93
Clay	3	96

	Thickness (feet)	Depth (feet)
2N/68-27a1 BLM		
Soil	8	8
Sand, gray, cemented	8	16
Sand, red; gravel	14	30
Rock, red	10	40
1N/67-15a1 Pioche Mines Co.		
Deposits, surface	80	80
Alluvium, quartzite and limestone boulders	360	440
Limestone, fractured	47	487
Limestone, black	76	563
1N/69-10d1 Paul Bliss		
Clay, black	37	37
Sand	5	42
Clay	1	43
Gravel	31	74
Boulders in clay	22	96
Clay, red	1	97
Sand, coarse red	10	107

Table 16.--(continued)

	Thickness (feet)	Depth (feet)
1N/69-21a2 James Rosa		
Sand	27	27
Clay	25	52
Gravel	5	57
Clay	3	60
Gravel	28	88
Ledges	20	108
Bedrock	2	110
1N/69-31c2 Chester Oxborrow - No. 2		
Clay	6	6
Gravel	2	8
Clay	30	38
Gravel and sand	27	65
Sand	2	67
Gravel	31	98
Clay	14	112
Gravel	6	118
"Panaca bed"	2	120
1S/68-33b2 Kenneth D. Lee - North Well		
Silt, sandy	3	3
Gravel, coarse	12	15
Silt, sandy	35	50
Gravel	7	57
Sand	8	65
Gravel	7	72
Sand	5	77
Gravel	27	104
Clay and gravel, mixed	8	112
1S/69-7a1 Delmue Brothers-South Well		
Clay	35	35
Sand	8	43
Clay, sandy	5	48
Gravel	8	56
Sand	7	63
Gravel	26	89
Clay	11	100
2S/67-25c3 Thomas Clay - No. 7		
Clay, sandy	92	92
Gravel	4	96
Sand	12	108
Gravel	4	112
Clay	4	116
Gravel	22	138
Sand	7	145
Gravel	40	185
Gravel, cemented	2	187
2S/68-5c4 Lester Mathews - Dairy barn irrigation well		
Clay, orange, sandy	18	18
Clay	17	35
Sand, gray; stratified with clay	90	125
Sand and gravel	33	158
2S/68-8b5 U.S. Geological Survey		
Silt, orange, sandy	34	34
Clay, gray	29	63
Sand and clay	12	75
Gravel	3	78
Clay, gray	7	85
Gravel	3	88
Clay	3	91
Gravel	4	95
Clay	10	105
Gravel	5	110
2S/68-8c3 Delmue Brothers - North well		
Gravel	12	12
Clay	4	16
Gravel	14	30
Clay, sandy	6	36
Gravel	16	52
Clay	18	70
Gravel	3	73

(continued next page)

Table 16.--continued

	Thickness (feet)	Depth (feet)
2S/68-8c3 (continued)		
Clay	1	74
Gravel	16	90
Clay, orange, sandy	16	106
Clay, orange; gravel	11	117
Clay	3	120
2S/68-18d2 Don Wadsworth - No. 1		
Silt, sandy	25	25
Clay, blue	7	32
Sand, fine	26	58
Sand	3	61
Sand, fine and clay, stratified	17	78
Sand	11	89
Gravel	23	112
Clay	36	148
Gravel	36	184
2S/68-19c2 Amy Mathews - East well		
Clay, gravely	22	22
Clay, blue	26	48
Gravel	8	56
Clay, sandy	14	70
Silt, sandy	52	122
Sand	15	137
Gravel	21	158
Clay	20	178
3S/67-2d2 William M. Pierce - No. 1		
Clay, orange	45	45
Clay, gray	80	125
Clay and gravel, mixed	12	137
Sand and gravel	11	148
Gravel and sand	7	155
3S/67-28c1 Chester Oxborrow-No. 2		
Clay, blue	45	45
Gravel	53	98
Gravel, cemented	6	104
Sand and gravel	14	118
4S/66-25b1 Emory Conaway - Lower Well		
Silt, sandy and large boulders	20	20
Sand, fine	8	28
Sand and gravel	12	40
Sand and Clay, stratified	40	80
Sand and gravel	5	85
Sand and clay, stratified	20	105
Gravel	3	108
4S/67-7d1 Caliente Public Utility - No. 7		
Clay	15	15
Sand and clay	60	75
Sand	5	80
Sand and clay	35	115
Sand	20	135
Gravel	7	142
Clay	5	147
Gravel	20	167
Clay	4	171
Gravel, coarse	19	190

Table 16.--(Continued)

	Thickness (feet)	Depth (feet)
4S/67-18bl Emory Conaway - Upper well		
Silt, sandy	37	37
Sand, fine	3	40
Clay, sandy	20	60
Clay	10	70
Gravel	6	76
Clay	4	80
Gravel and boulders	6	86
Clay	12	98
Sand and clay	24	122
Gravel	5	127
Clay	2	129
Gravel	33	162
Bedrock	3	165
4S/70-11dl Headwater Cattle Co.		
Silt, sandy	35	35
Sand; some gravel	50	85
Gravel, cemented	50	135
Sand and clay	62	197
5S/68-9bl BLM		
Loam, sandy	3	3
Sand and gravel	5	8
Clay, orange, sandy	22	30
Sand	80	110
Tuff, gray	50	160
Tuff, brown	15	175
Tuff, light gray	3	178
Tuff, brown	22	200
5S/69-11dl Robert C. Formaster		
Sand and gravel	28	28
Gravel, cemented	57	85
Sand and gravel, cemented	42	127
7S/67-21cl James Bradshaw		
Sand and gravel	35	35
Sand, fine; some gravel	25	60
Gravel	3	63
Clay	2	65
Sand	5	70
Gravel; large boulders	35	105
9S/67-11bl Don Bradshaw		
Silt, sandy	70	70
Gravel	80	150
12S/65-13bl Mildred Breedlove		
Silt	22	22
Sand and gravel	2	24
Clay	3	27
Sand and gravel	15	42
Gravel	18	60
Sand, fine	12	72
Sand and gravel	8	80
Clay	5	85
Gravel	20	105
13S/66-18bl Wayne Cole		
Silt	60	60
Sand, fine	5	65
Sand and gravel	9	74
Gravel, cemented	4	78
Sand, gravel, and boulders	10	88
Clay, red	--	at 88

Table 16. --(continued)

14S/66-25d1 Nevada Power Co.

	Thickness (feet)	Depth (feet)
Clay, brown, sandy	30	30
Sand, gray	60	90
Clay, gray	5	95
Sand and gravel	85	180
Sand, brown	15	195
Clay, brown	10	205
Sand and gravel	12	217
Clay, brown	5	222
Gravel, cemented	48	270
Clay, brown	3	273
Clay, brown	3	283
Gravel, cemented	7	290
Clay, brown	3	293
Gravel, cemented	22	315
Clay, brown	3	318
Gravel, cemented	47	365
Lime, red	63	428
Clay, brown	20	448
Gravel, cemented	22	470
Clay, brown	10	480

14S/66-35d1 L. J. McCormick

	Thickness (feet)	Depth (feet)
Clay	18	18
Sand	10	28
Sand and gravel	2	30
Sand	17	47
Gravel	5	52
Sand	10	62
Gravel	26	88
Clay, sandy	6	94
Clay	24	118

14S/66-35d2 Nevada Power Co.

	Thickness (feet)	Depth (feet)
Soil, sandy	5	5
Sand and clay	25	30
Sand	5	35
Clay, sandy	15	50
Sand, gray	10	60
Clay, red with sand streaks	20	80
Sand, gray	10	90
Clay, red	15	105
Gravel, large	85	190
Limestone, pink	22	212

REFERENCES CITED

Bourns, Charles T., 1963, Feasibility of exchange of waters from the Muddy River and wells of the Nevada Power Company at Glendale, Nevada: University of Nevada, Rept. Series No. 5, 11 p.

Bowyer, Ben, Pampeyan, E. H., and Longwell, C. R., 1958, Geologic map of Clark County, Nevada: U.S. Geol. Survey Mineral Inv. Field Studies Map MF-138.

Carpenter, Everett, 1915, Ground water in southeastern Nevada: U.S. Geol. Survey Water-Supply Paper 365, 86 p.

Cooperative Extension Service, Max C. Fleischmann College of Agriculture, University of Nevada and Lincoln County Rural Areas Development Committee, 1963, Economic development plan for Lincoln County, Nev: Nevada Univ. Ext. Circ. 183 (revised), 41 p.

Eakin, Thomas E., 1963, Ground-water appraisal of Dry Lake and Delamar Valleys, Lincoln County, Nevada: Nevada Dept. Conserv. Nat. Resources, Ground-Water Resources - Reconnaissance Ser. Rept. 16, 26 p.

Eakin, Thomas E., 1963, Ground-water appraisal of Pahranagat and Pahroc Valleys, Lincoln and Nye Counties, Nevada: Nevada Dept. Conserv. Nat. Resources, Ground-Water Resources - Reconnaissance Ser. Rept. 21, 36 p.

Eakin. T. E., and others, 1951, Contributions to the hydrology of eastern Nevada: Nevada State Engineer, Water Resources Bull. 12, 171 p.

Hardman, George, 1936, Nevada precipitation and acreages of land by rainfall zones: Nevada Univ. Agr. Exp. Sta. Mimeo. Rept. and Map, 10 p.

Houston, C. E., 1950, Consumptive use of irrigation water by crops in Nevada: Nevada Univ. Bull. 185, 27 p.

Lee, C. H., 1912, An intensive study of the water resources of part of Owens Valley, California: U.S. Geol. Survey Water-Supply Paper 294, 135 p.

Parks, C. F., Gemmill, Paul, and Tschanz, C. M., 1958, Geologic map and sections of the Pioche Hills, Lincoln County, Nevada: U.S. Geological Survey Mineral Inv. Field Studies Map MF-136.

Phoenix, David, 1948, Geology and ground water in the Meadow Valley Wash drainage area, Nevada, above the vicinity of Caliente: Nevada Water Resources Bull. No. 7, 117 p.

Rush, F. Eugene and Eakin, Thomas E., 1963, Ground-water appraisal of Lake Valley in Lincoln and White Pine Counties, Nevada: Nevada Dept. Conserv. Nat. Resources, Ground-Water Resources - Reconnaissance Ser. Rept. 24, 29 p.

Shamberger, Hugh A., 1954, Present and potential use of the waters of the Colorado River and tributaries within Nevada together with related matters: Carson City, Nevada, State Printing Office, 140 p.

Tschanz, C. M., and Pampeyan, E. H., 1961, Preliminary geologic map of Lincoln County, Nevada: U.S. Geol. Survey Mineral Inv. Field Studies Map MF-206.

U.S. Bureau of Reclamation, 1962, Moapa Valley pumping project, Nevada: Bureau of Reclamation Reconnaissance Report, Boulder City, Nevada, 84 p.

U.S. Department of Agriculture, 1954, Diagnosis and improvement of saline and alkaline soils: Agricultural Handbook No. 60, 160 p.

White, W. N., 1932, A method of estimating ground-water supplies based on discharge by plants and evaporation from soil: U.S. Geol. Survey Water-Supply Paper 659-A, 165 p.

Young, A. A., and Blaney, H. F., 1942, Use of water by native vegetation: California Dept. Pub. Works Bull. 50, 154 p.

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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.

5. Ground-Water Appraisal of the Imlay Area, Humboldt River Basin, Pershing County, Nevada. Feb. 1962, by Thomas E. Eakin.

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.

14. Ground-Water Resources of Amargosa Desert, Nevada-California. March 1963, by George E. Walker and Thomas E. Eakin.