View of barley field

#232

GROUND-WATER RESOURCES – RECONNAISSANCE SERIES

REPORT 24

GROUND-WATER APPRAISAL OF LAKE VALLEY IN LINCOLN AND WHITE PINE COUNTIES, NEVADA

By

F. EUGENE RUSH

and

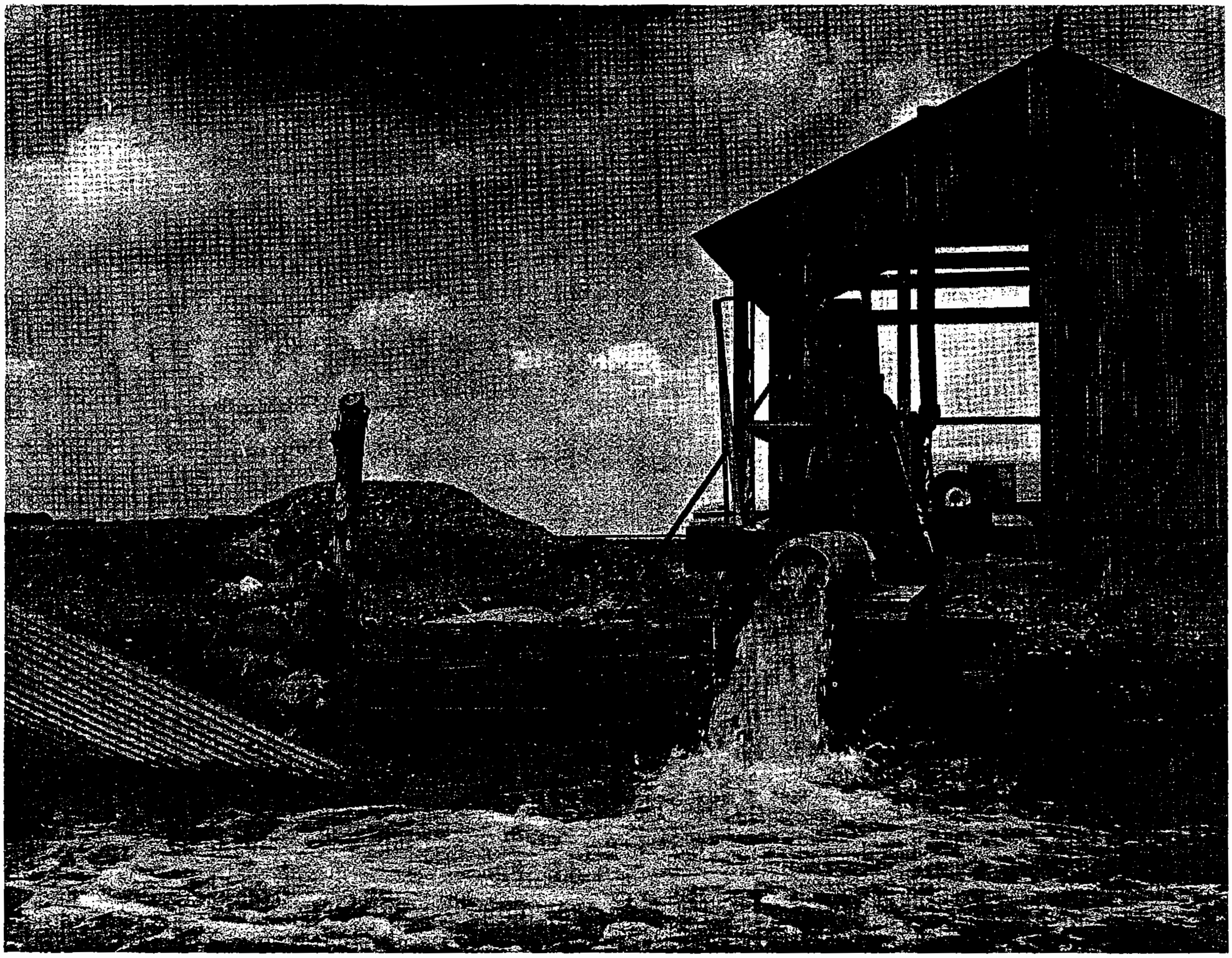
THOMAS E. EAKIN

Geologists

Price $1.00

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

DECEMBER 1963



View of the Archie Garwood irrigation well used to irrigate about 300 acres of barley during the 1963 growing season. This diesel-powered installation is pumping about 2,300 gallons per minute.

Photograph by F. EUGENE RUSH

COVER PHOTO

View of barley field, near wells 6/66–22b 1, 2, looking northeast toward the Fortification Range. This field is irrigated by one of the two irrigation wells in Lake Valley. The photo was taken in early December, 1963, at harvest time.

Photograph by F. EUGENE RUSH

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FOREWORD

This report, the 24th in the series of reconnaissance ground-water studies which were initiated following authorization by the 1960 Legislature, gives the results of a study of Lake Valley. This valley lies largely in Lincoln County but the northern end extends into Nye County. The study was made by Thomas E. Eakin and F. Eugene Rush, geologists with 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

December 1963

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GROUND-WATER APPRAISAL OF LAKE VALLEY

IN LINCOLN AND WHITE PINE COUNTIES, NEVADA

by
F. Eugene Rush and Thomas E. Eakin

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SUMMARY

Lake Valley is a north trending intermontane valley in the eastern part of Nevada. The climate is semiarid, and precipitation averages less than 10 inches a year.

The valley is surrounded by ranges composed of Paleozoic and Tertiary rocks, consisting principally of quartzite, limestone, shale, tuff, and other volcanic rocks. These mountains were uplifted by faulting and tilting. Erosion products of the surrounding mountains have filled the valley with at least several hundred feet of alluvium, including lake and stream deposits.

The tentative estimated perennial yield of Lake Valley is about 12,000 acre-feet, and is based on the estimate of average annual ground-water recharge and discharge. The amount of water that may be available from the principle springs in the northwestern part of the valley is 4,500 acre-feet a year. The remaining amount, 7,500 acre-feet, is available to wells in the valley fill, south and southeast of the spring areas. Additionally, the spring discharge returned to the ground-water reservoir by seepage may be withdrawn by wells.

The estimated pumpage from all wells in 1963 was about 2,000 acre-feet. Most of this water was pumped from two irrigation wells in the southern part of the valley. Although water-quality data for the valley is generally lacking, water from the two previously mentioned wells has been suitable for stock watering and for irrigating barley.

INTRODUCTION

The development of ground water in Nevada has shown a substantial increase in recent years. Part of this increase is due to the effort to bring new land into cultivation. The increasing interest in ground-water development has created a substantial demand for information on the ground-water resources throughout the State.

Recognizing this need, the State Legislature enacted special legislation (Chapt. 181, Stats. 1960) for beginning a series of reconnaissance studies of the ground-water resources of Nevada. As provided in the legislation, these studies are being made by the U.S. Geological Survey in cooperation with the Nevada Department of Conservation and Natural Resources.

Interest in ground-water resources currently includes many areas and is extending to additional areas almost continuously. Thus, the emphasis of the reconnaissance studies is to provide as quickly as possible a general appraisal of the ground-water resources in particular valleys or areas where information is urgently needed. For this reason each study is severely limited in time, field work for each area generally averaging about two weeks.

Additionally, the Department of Conservation and Natural Resources has established a special report series to expedite publication of the results of the reconnaissance studies. Figure 1 shows the areas for which reports have been published in this series. A list of the titles of previous reports published in the series is given at the end of this report. The present report is the twenty-fourth in the reconnaissance series. It describes the physical conditions of Lake Valley and includes observations of the interrelation of climate, geology, and hydrology as they affect the ground-water resources. It includes also a preliminary estimate of the average annual recharge to and discharge from the ground-water reservoir.

The authors take this opportun to express their appreciation for the assistance and contribution to the investigation of D. O. Moore relating especially to measurements of springs and to Howard O. Ness for field assistance.

Location and General Features:

Lake Valley, in eastern Nevada, lies within an area enclosed by lat 38°14' and 38°15' N. and long 114°18' and 114°46' W. The north end of the valley is about 30 miles south of Ely, Nevada. The south end of the valley is about 25 miles north of Pioche. North-trending Lake Valley is about 41 miles long and has a maximum width, between drainage divides, of about 21 miles near the southern end of the valley (pl. 1). The valley is bounded by the Fortification Range on the northeast and east, by the Wilson Creek Range on the southeast; by the Ely Range on the southwest, and by the Schell Creek Range on the west and northwest. Lakeview Summit is part of a low bedrock divide which closes the north end of the valley and which connects with the Schell Creek and Fortification Ranges. A low alluvial divide provides topographic closure at the south end of the valley. The valley as defined has an area of about 550 square miles.

Principal access to the valley is U.S. Highway 93 which connects Las Vegas and Ely and which traverses the west side of Lake Valley. Improved roads or unimproved trails through Patterson Pass from the west and through several other passes from the southwest, south, and east also provide access

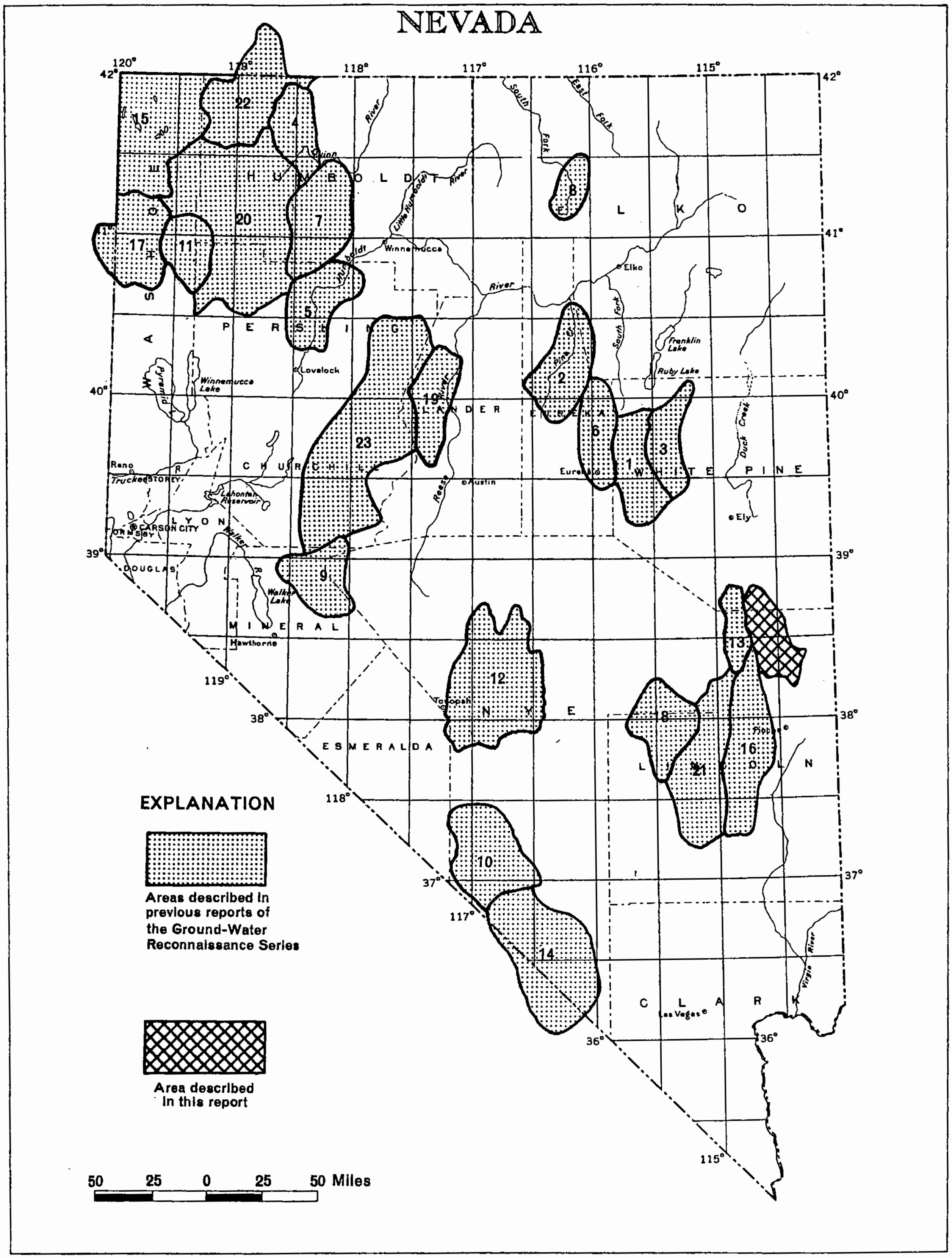

Figure 1.— **MAP OF NEVADA**

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

to the valley. Within the valley a gravel road crosses eastward from Poney Springs and other trails provide access to most parts of the valley in good weather.

Climate:

The climate of eastern Nevada is semiarid in the valleys and subhumid to humid in the higher mountains. In the valleys precipitation and humidity are generally low, and summer temperatures and evaporation rates are high. Precipitation is irregularly distributed but generally is least on the valley floor and greatest in the mountains. Winter precipitation occurs largely as snow; summer precipitation commonly occurs as localized thundershowers. The daily and seasonal range in temperature is large, and the growing season is relatively short.

Precipitation has been recorded intermittently at Geyser Ranch since 1897. Partial records were obtained during the periods 1897-1914 and 1941-1953. The average monthly and annual precipitation for the period of record at Geyser Ranch, according to records of the U.S. Weather Bureau, is given in table 1. More complete data have been obtained from the Weather Bureau precipitation records for Ely airport and Kimberly, about 30 miles north of Lake Valley (See table 1.)

A storage precipitation station has been maintained at Wilson Creek Summit, sec. 17, T. 5 N., R. 68 E., at an elevation of 7,100 feet, by the Weather Bureau. At this location the prorated annual precipitation ranged from 5.73 to 19.29 inches and averaged 14.04 inches for the period 1955-61.

During the period 1941-52, the maximum recorded annual precipitation at Geyser Ranch was 11.27 inches; the minimum was 6.23 inches.

Table 1.--Average monthly and annual precipitation at Geyser Ranch, Ely Airport and Kimberly for period of record.
(from published records of the U.S. Weather Bureau)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Geyser Ranch 1/	.80	.70	1.10	.73	.72	.35	.56	.94	.40	.64	.72	.74	8.40
1897-1914	.91	.73	1.21	.82	.81	.33	.32	.93	.42	.56	.69	.77	8.50
1941-53	.68	.66	.85	.63	.59	.39	.91	.96	.37	.72	.76	.70	8.22
Ely Airport 2/	.68	.67	.93	.60	.96	.41	.58	.45	.49	.43	.51	.60	7.32
Kimberly 3/	1.55	1.49	1.55	1.32	1.07	.66	.90	.83	.68	.89	.84	1.51	13.29

1. Altitude 5,984 feet. Location Sec. 24, T. 9 N., R. 65 E. Period of record, 31 years, 1897-1914, 1941-53.

2. Altitude 6,257 feet. Location Sec. 35, T. 17 N., R. 63 E. Period of record, 15 years, 1948-1962. (continuing).

3. Altitude 7,230 feet. Location Sec. 8, T. 16 N., R. 62 E. Period of record, 28 years, 1931-58.

The average growing season in Lake Valley has not been determined, but a crude approximation may be obtained by reference to a nearby area. Houston (1950, p. 6) states that the average growing season at McGill, about 60 miles north of Lake Valley is about 119 days (May 26 to September 22). Killing-frost conditions vary with the type of crop. Weather Bureau records beginning in 1948 list freeze data rather than killing frosts. The dates are listed for the occurrence of the last spring minimum and the first fall minimum for the following temperature groups; 32°F or below, 28°F or below, 24°F or below, 20°F or below, and 16°F or below. From these data, the number of days between the last spring minimum and first fall minimum occurrence for the respective temperature groups are given. Table 2 lists the number of days between the last spring minimum and first fall minimum for the first three of these groups at Ely airport and McGill during the 10-year period ending 1961, and for Geyser Ranch for the years 1961 and 1962.

Table 2.--Number of days between the last spring minimum and the first fall minimum for Geyser Ranch, Ely Airport, and McGill

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

	32°F or below			28°F or below			24°F or below		
	Geyser Ranch	Ely Airport	McGill	Geyser Ranch	Ely Airport	McGill	Geyser Ranch	Ely Airport	McGill
1953	--	70	117	--	90	--	--	128	191
1954	--	97	114	--	97	174	--	124	178
1955	--	a/7	116	--	114	141	--	143	183
1956	--	86	137	--	130	164	--	153	194
1957	--	75	121	--	96	136	--	139	151
1958	--	91	120	--	112	151	--	172	180
1959	--	53	120	--	113	126	--	130	130
1960	--	63	90	--	63	93	--	96	143
1961	109	92	113	142	118	139	143	141	141
1962	78	83	93	104	93	141	166	173	187

a. The record shows frost on June 30 and July 7, but no frost during the succeeding 72 days to September 17th.

The topography of Lake Valley favors the flow of heavy cold air toward the lower parts of the valley during periods of little or no wind movement. Therefore, the length of the growing season, although relatively short because of the latitude and because of the rather high altitude of the valley floor, undoubtedly varies considerably from one locality to another depending upon the pattern of flow of cold air currents. This may be illustrated, in part, by a comparison of the records of temperature at the climatological stations at Ely and McGill. The station at McGill is on the alluvial apron along the east side of Steptoe Valley. It is 250 to 300 feet above the axis of the valley. The station at the Ely Airport, although only about 80 feet lower than that at McGill, is near the topographic low of the valley in that latitude.

The 10-year average number of days between temperatures of 32°F or below, is 114 days at McGill and 72 days at Ely Airport; 28°F or below, 141 days at McGill and 103 days at Ely Airport; and for 24°F or below, about 166 days at McGill and 140 days at Ely Airport. Thus, the average growing season at McGill apparently averages 26 to 42 days more than at Ely Airport. Similar local variations may be expected in Lake Valley.

On the basis of altitude and topographic environment it would appear that the conditions controlling minimum temperature in the lower parts of Lake Valley are more nearly comparable with those at Ely Airport than with those at McGill; however the data from the Geyser Ranch weather station are too few to demonstrate this.

Physiography and Drainage:

Lake Valley is a topographically closed valley in the central part of the Great Basin section of the Basin and Range physiographic province. It is a north-trending valley bounded on the west by the Ely and Schell Creek Ranges and on the east by the Fortification and Wilson Creek Ranges. The Wilson Creek Range trends south and southwest from the Fortification Range. A low alluvial divide closes the south end of the valley. The Fortification and Ely Ranges terminate locally. A low bedrock divide, Lake Valley Summit, connects the north end of the Schell Creek and Fortification Ranges and separates the north end of Lake Valley from Spring Valley.

The lowest part of Lake Valley is near its center; altitude slightly above 5,900 feet. The highest point in the adjacent mountains is Mount Grafton, altitude 10,993 feet, in the Schell Creek Range. Accordingly, the maximum relief in the area is about 5,000 feet.

North of Patterson Pass for a distance of about 8 miles, the crest of the Schell Creek Range (inside cover photograph), is above an altitude of 9,000 feet. The crest of the Fortification Range (cover photograph) in this latitude generally is lower, the peaks reaching an altitude of about 8,000 feet.

The principal surface drainage in the valley is toward its center, but generally it is limited to the valley margins. Most channels contain streamflow only during the spring runoff or for short periods after high intensity storms. The only permanent streams in the valley are spring-fed Geyser Creek (Sheep Creek) and North Creek, which drain part of the Schell Creek Range, and Wilson Creek which flows from the northwest side of the Wilson Creek Range.

The longest drainage ways are in the southeastern part of the valley. There the drainage extends westward and northwestward on the alluvial apron and into the basin from the Wilson Creek Range for at least 15 miles. In the mountains erosion has produced steep-sided canyons, and stream-channel gradients commonly are more than 300 feet per mile.

In late Pleistocene time a lake occupied the lower part of Lake Valley. Beaches, bars, and spits locally are prominent. Several shore lines were noted at an altitude of about 6,000 feet. An inspection of aerial photographs and topographic maps indicates that the maximum altitude of the lake was not more than about 6,000 feet; therefore, it is possible that the lake overflowed intermittently into Patterson Wash to the south.

GENERAL GEOLOGY

A reconnaissance geologic map of Lincoln County (Tschanz and Pampeyan, 1961), which includes most of Lake Valley, is available as a result of the cooperative program between the U. S. Geological Survey and the Nevada Bureau of Mines. Other geologic reports are available for areas adjacent to Lake Valley. Most of these stem from interest in oil and mineral exploration or development in eastern Nevada. Among those of particular pertinence to Lake Valley are reports by Kellog (1960 and 1963), Tschanz (1960), and Woodward (1963). Additionally, several other papers published in the "Guidebook to the Geology of East-Central Nevada" (1960) provide useful information.

The rocks of Lake Valley have been divided into two general groups: bedrock in the mountains and valley fill in the lowlands, and further into four major units. The distribution of the four units is shown on plate 1.

The bedrock includes Paleozoic quartzite, carbonate, and clastic rocks and Tertiary volcanic rocks. These crop out in the mountains and underlie the valley fill.

The valley fill includes deposits ranging in age from Tertiary to Quaternary and consists of younger unconsolidated clay, silt, sand, and gravel, and older partly consolidated pyroclastic deposits of welded tuff and sedimentary deposits. The subsurface lithology and water-bearing properties of the rocks are not known. However, it is inferred that the Quaternary deposits were laid down under subaerial and lacustrine environments. The rocks of Tertiary age underlying the Quaternary deposits are believed to be similar in character to the Tertiary rocks exposed in the mountains.

Bedrock in the Mountains:

Paleozoic quartzite and shale are the principal rocks exposed in the Schell Creek Range adjacent to Lake Valley. However, minor amounts of Paleozoic and Tertiary volcanic rocks also crop out. Paleozoic carbonate rocks and shale and Tertiary volcanics are the dominant rock types in the Ely Range. Tuff and other volcanic rocks are the most abundant rocks of the Wilson Creek and Fortification Ranges. Carbonate rocks are also common in the northern part of the Fortification Range.

The Paleozoic and Tertiary rocks that crop out in the mountains have been deformed substantially by faulting. Because of differences in their hydrologic properties, the bedrock shown on plate 1 is divided into two units, those in which Paleozoic carbonate rocks predominate and those in which clastic or volcanic rocks predominate.

Valley Fill:

The valley fill shown on plate 1 is divided into two units: older unconsolidated to partly consolidated sedimentary deposits of late Tertiary and Quaternary age, and unconsolidated clay, silt, sand, and gravel of late Quaternary age. The valley fill was deposited partly under subaerial and partly under lacustrine conditions. Selected logs of wells drilled in the valley fill, given in table 8, illustrate the general character of these deposits. The logs suggest that deposition occurred in more or less alternating layers of clay, sand and gravel, or mixtures thereof. The mode of deposition for subaerial deposits suggests considerable lateral variation as well as vertical variation. However, deposition in lakes suggests that beds of fine-grained material might have fairly extensive lateral continuity.

Water-Bearing Properties of the Rocks:

The rocks of Paleozoic age generally have had their primary permeability substantially reduced, if not wholly eliminated, by changes subsequent to their deposition. However, because they have been substantially fractured, some of these rocks locally may contain secondary openings through which water may be transmitted to some degree. Further, fractures in carbonate rock may be enlarged from solution by water moving through them.

The occurrence and movement of ground water in carbonate rock are indicated by the many springs issuing from or adjacent to this rock in eastern Nevada. As many of these springs, such as Hot Creek and Lund in nearby White River valley (Maxey and Eakin, 1949, p. 35-39), discharge relatively large quantities of water, it is further indicated that carbonate rock locally may transmit a substantial quantity of ground water. Geyser Spring (9/65-4c1) undoubtedly is supplied largely by water transmitted in carbonate rock. The spring complex along the lower part of the alluvial slope at the Geyser Ranch probably has its origin in Paleozoic dolomite that crops out in a north-trending exposure about one mile to the west.

The Tertiary volcanic rock and older Tertiary sedimentary deposits exposed in the mountains are moderately consolidated. Although there may be some interstitial permeability, much of the limited amount of water transmitted probably is through fractures. In general, the capability of Tertiary rocks to transmit water is relatively low.

The unconsolidated sand and gravel deposits of Quaternary age are capable of transmitting ground water freely. However, the finer sand, silt, and clay have low permeability and transmit water slowly. These deposits occupy a large volume and have a relatively high porosity. Thus, where saturated, the Quaternary deposits contain a large volume of water in storage.

GROUND-WATER APPRAISAL

General Conditions:

Ground water in Lake Valley is derived from precipitation within the drainage area of the valley. Some of the precipitation in the mountains infiltrates into the bedrock and much of it moves laterally into the valley fill. In addition, some precipitation in the mountains collects and runs off onto the alluvial apron; part of the runoff infiltrates into the ground-water reservoir in the valley fill. Also some precipitation that falls on the alluvial apron may infiltrate directly to the ground-water reservoir or in part may infiltrate to the ground-water reservoir after it has collected as runoff. Most of the recharge to ground water occurs in or adjacent to the principal areas of precipitation. The principal areas of precipitation are the Schell Creek and Wilson Creek Ranges. Thus, the principal areas of recharge are in or adjacent to these ranges.

From the areas of recharge, ground water moves toward the ground-water reservoir in the valley fill. The total amount of ground water stored within Lake Valley may be hundreds of times the average annual natural recharge and discharge.

Natural ground-water movement in the reservoir is slow, ranging from a few feet to perhaps a few tens of feet a year. However slow, the movement generally is toward the area or areas of natural discharge.

Most of the natural discharge from Lake Valley is accomplished by evaporation from soil or free-water surfaces or by transpiration of phreatophytes, such as meadow grasses, salt grass, rabbitbrush, and greasewood. The discharge of the springs supplying the area of the Geyser Ranch also is consumed largely by evapotranspiration processes. Plate 1 shows the area of evapotranspiration. The rate of evapotranspiration is greatest where the water table is at or near land surface and the rate decreases as the depth to water increases. In Lake Valley the rate of evapotranspiration is greatest adjacent to the springs which bring ground water to the land surface. Elsewhere evapotranspiration is minimal because the depth to ground water is moderate to substantial. For example, the depth to water ranges from about

25 to 50 feet in the eastern one-third of Tps. 7 and 8 N., R. 65 E., and the western one-half of Tps. 7, 8, and 9 N., R. 66 E. The shallowest measured depth to water was 24 feet in well 8/65-12dl. Away from the phreatophyte area the depth to water increases. The maximum measured depth to water was 292 feet in well 8/65-33dl.

In hydrologically closed valleys all of the natural discharge occurs by evapotranspiration. This is not the case for Lake Valley. Inspection of the water-level contours on plate 1 shows a southward gradient about along the topographic trough of the valley. That is, some ground water discharges by underflow from Lake Valley southward into Patterson Wash. Figure 2 illustrates the gradient of the water surface along line A-A' shown on plate 1. Figure 2 also shows a hydraulic divide between Lake Valley and Spring Valley to the north in the vicinity of the topographic divide at Lake View Summit. Similar hydraulic divides are believed to occur more or less alined with the topographic divides in the mountains along the east and west sides of the valley. Thus, ground water is discharged naturally from Lake Valley by evapotranspiration within the valley and by underflow southward in the direction of lower hydraulic head.

Estimated Average Annual Recharge:

The average annual recharge to the ground-water reservoir may be estimated as a percentage of the average annual precipitation within the valley (Eakin and others, 1951, p. 79-81). A brief description of the method follows: Zones in which the average precipitation ranges between specified limits are delineated on a map, and a percentage of the precipitation is assigned to each zone which represents the assumed average recharge from the average annual precipitation on that zone. The degree of reliability of the estimate so obtained, of course, is related to the degree to which the values approximate the actual precipitation and the degree to which the assumed percentages represent the actual percentage of recharge. Neither of these factors is known precisely enough to assure a high degree of reliability for any one valley. However, the method has proved useful for reconnaissance estimates, and experience suggests that in many areas the estimates probably are relatively close to the actual long-time average annual recharge.

The precipitation map of Nevada (Hardman and Mason, 1949, p. 10) has been modified by Hardman (oral communication, 1962) in part to adjust to recent topographic base maps for the region. This is the same base used for plate 1 of this report. Five precipitation zones were selected: the boundary between the zones of less than 8 inches and 8 to 12 inches was delineated at the 6,000-foot contour; between 8 to 12 inches and 12 to 15 inches at the 7,000-foot contour; between 12 to 15 inches and 15 to 20 inches at the 8,000-foot contour; between 15 to 20 inches and more than 20 inches at the 9,000-foot contour.

The average precipitation used for the respective zones, beginning with the zone of 8 to 12 inches of precipitation, is 10 inches (0.83 feet), 13.5 inches (1.12 feet), 17.5 inches (1.46 feet), and 21 inches (1.75 feet).

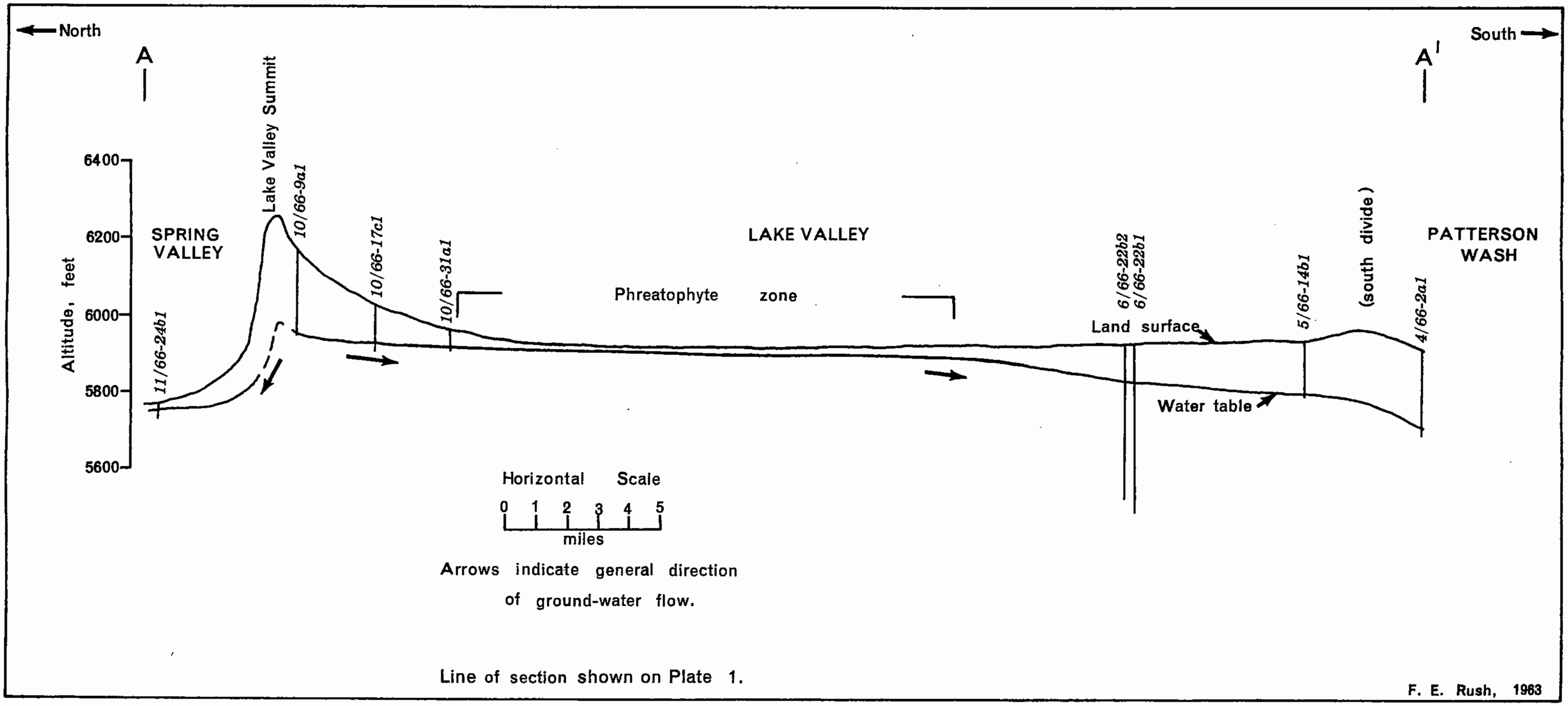

Figure 2.— Cross-section of Lake Valley, as seen looking east from U. S. Highway 93, showing the general topography and water table.

The recharge estimates as a percentage of the average precipitation for each zone are: less than 8 inches, 0; 8 to 12 inches, 3 percent; 12 to 15 inches, 7 percent; 15 to 20 inches, 15 percent; and more than 20 inches, 25 percent.

Table 3 summarizes the computation of recharge. The approximate recharge (column 5) for each zone is obtained by multiplying the figures in columns 2, 3, and 4. Thus, for the zone receiving more than 20 inches of precipitation, the computed recharge is 4,000 acres x 1.75 feet x 0.25 (25 percent) = about 1,800 acre-feet. The estimated average annual recharge to the ground-water reservoir in Lake Valley is about 13,000 acre-feet.

Table 3.--Estimated average annual ground-water recharge from precipitation in Lake Valley

(1) Precipitation zone (inches)	(2) Approximate area of zone (acres)	(3) Average annual precipitation (feet)	(4) Percent Recharged	(5) Estimated recharge (acre-feet) (2 x 3 x 4 ÷ 100)
20+	4,000	1.75	25	1,800
15 to 20	13,000	1.46	15	2,800
12 to 15	53,000	1.12	7	4,300
8 to 12	173,000	.83	3	4,300
8-	111,000	.58	--	--
	354,000	Estimated average annual recharge (rounded)		13,000

Estimated Average Annual Discharge:

Natural Discharge by Evapotranspiration and Underflow: Ground water is discharged from Lake Valley by the natural processes of transpiration of vegetation, evaporation from the soil surface, and to a lesser extent by subsurface outflow from the valley at the low, alluvial divide which separates Lake Valley from Patterson Wash to the south. In the absence of precise data, annual discharge rates can only be approximated. For this report, rates of use are adapted from studies of evapotranspiration of certain phreatophytes made by Lee (1912) and White (1932) in the Great Basin in the western United States, and by Young and Blaney (1942) in southern California. Rates of use were assigned on the basis of vegetative types, density, and depth to water table. The estimates of discharge by transpiration, evaporation, and outflow are summarized in table 4.

The principal area of phreatophytes is in Tps 7, 8, and 9 N., Rs. 65 and 66 E. as shown on plate 1. In addition, a minor amount of evapotranspiration occurs in small areas along spring-fed streams in the upper part of the alluvial fans. The average discharge of ground water attributed to phreatophytes is about 8,500 acre-feet per year.

A rough estimate of the subsurface outflow from Lake Valley to Patterson Wash can be made, based on the limited available data, by use of the following equation:

$$Q = 0.00112TIW \quad (1)$$

in which T is the coefficient of transmissibility, in gallons per day per foot, I is the hydraulic gradient in feet per mile, W is the width of the underflow section in miles, and 0.00112 is a factor for converting gallons per day to acre-feet per year.

Table 4.--Estimated average annual ground-water discharge by natural processes from Lake Valley

Process of ground-water discharge	Depth to water (feet)	Area (acres)	Approximate discharge (acre-feet per year)
Native vegetation:			
Saltgrass and very wet meadow area, average rate of use about 1.5 feet a year	less than 5	640	1,000
Saltgrass and moderately wet meadow area, average rate of use about 1.25 feet a year	less than 5	280	400
Saltgrass and dry meadow area, average rate of use about 0.5 foot a year	5-20	4,200	2,100
Principally by greasewood, average rate of use about 0.25 foot a year	20-25	5,800	1,400
Principally by greasewood and rabbitbrush mixed with big sage, average rate of use, about 0.1 foot a year	25-50	35,600	3,600
Estimated average annual discharge by phreatophytes			8,500
Subsurface outflow:			
Ground-water outflow to Patterson Wash			3,000
Estimated average annual natural discharge, (rounded)			12,000

The coefficient of transmissibility can be approximated by multiplying the specific capacity (gallons per minute per foot of drawdown) by an empirical factor. The specific capacity of wells 6/66-22b1 and 22b2 is about 80 gallons per minute per foot of drawdown. The empirical factor may be 1,500 to 2,000. Thus the transmissibility may be on the order of 120,000 to 160,000 gallons per day per foot.

The hydraulic gradient at the south end of the valley is about 20 feet per mile (pl. 1). The effective width of ground-water flow is about 1 mile (pl. 1). Substituting these values in equation 1, the estimated subsurface outflow is computed to be 3,000 acre-feet per year.

Discharge of Springs: Several small springs occur in the mountains surrounding Lake Valley. Most of these probably are supplied from perched or semi-perched ground-water bodies. As such, though important for stock supplies, they are of only local significance in the overall hydrologic system of the valley.

The largest springs are those which provide the supply for the Geyser Ranch area. Measurements were made at several localities and show the magnitude of the discharge of the several springs or spring areas. However, they do not indicate the total discharge of the springs because some discharge occurs by seepage which is not collected into channels when a direct measurement could be made.

The flow of spring-fed North Creek was 1.71 cfs (cubic feet per second) on August 4, 1963, at a point about 9,000 feet upstream from the intake of the pipe line. On the same day the flow at the pipe line intake was only 0.70 cfs. The discharge of Geyser Spring (9/65-4c1) is carried in an unlined ditch to the reservoir half a mile west of Geyser Ranch headquarters. Geyser Spring is characterized by a cyclic variation in discharge. The cycling pattern is shown by the sequence of measurements made in 1950 and graphed in figure 3. The 1950 measurements were made just west of U. S. Highway 93. Inspection of the graph suggests that the flow here may average about 200 to 225 gpm, or about 0.5 cfs.

During the present investigations a series of measurements were made on August 4, 1963, about 50 yards downstream from the outlet of Geyser Spring. As shown also on figure 3, the discharge ranged from about 0.13 to 2.57 cfs, and the apparent average discharge was about 1.2 cfs.

In the spring complex (9/65-1 to 9/65-12) along the lower part of the alluvial apron at Geyser Ranch, water is collected in two ditches to conduct the water northward and southward for irrigation. The flow in these ditches was measured at 0.96 and 2.17 cfs, respectively, on August 4, 1963. These measurements, of course, are indicative of spring flow at that time. During the spring, the combined flow probably is greater; during the fall, probably less. The total flow of these several springs at the time of measurement was

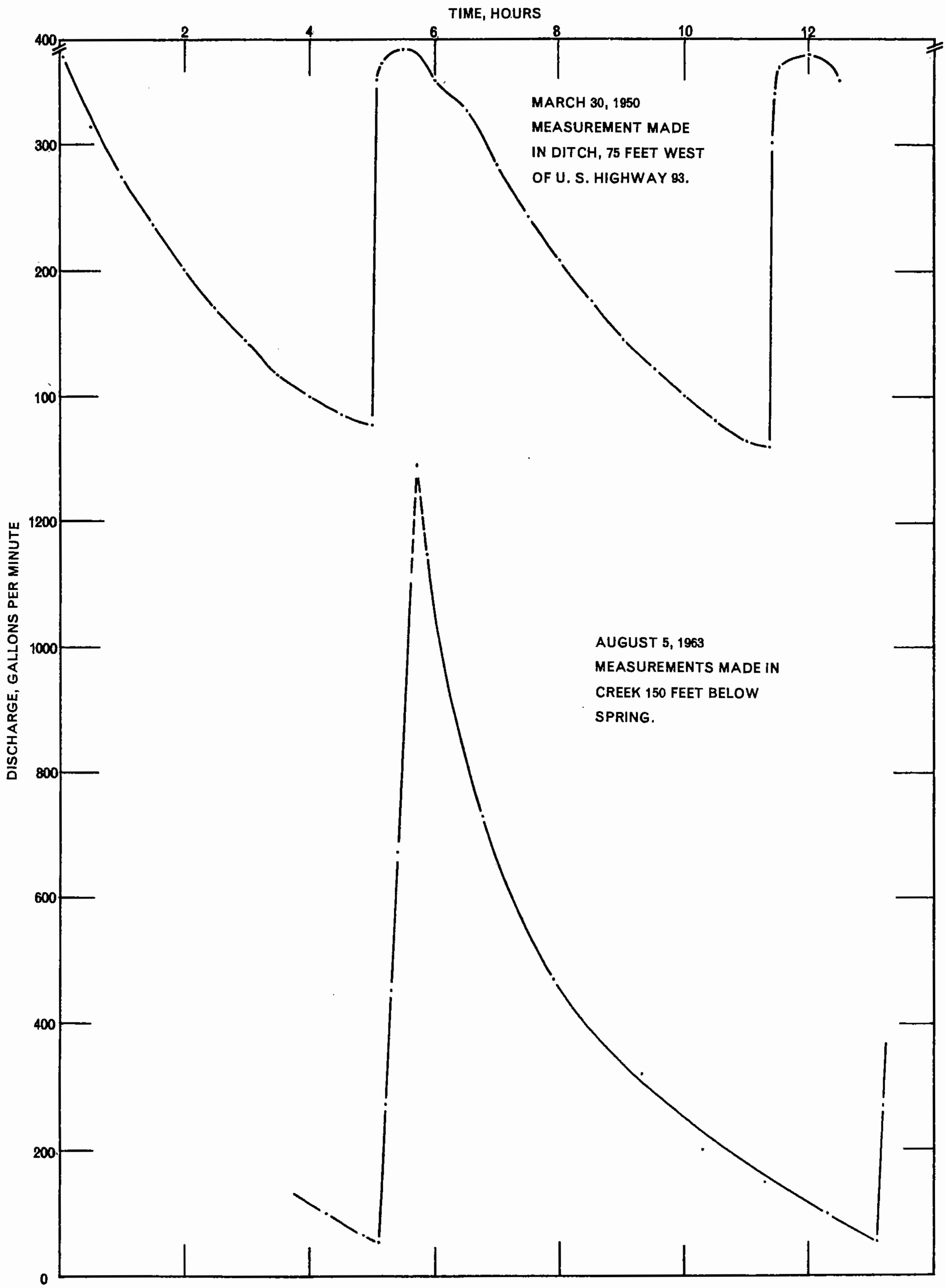

FIGURE 3.—GRAPH SHOWING CYCLIC VARIATION IN THE RATE OF DISCHARGE OF GEYSER SPRING.

roughly 6 cfs, or a rate of about 4,500 acre-feet a year. In considering the annual flow of the springs the average flow probably will be about equal to or somewhat greater than the measurements made on August 4, 1963.

The discharge of these springs to a large extent is finally discharged from the valley by evapotranspiration. Some, however, may return to the ground-water reservoir and be discharged by underflow at the south end of the valley. In either case, the estimates of ground-water discharge from the valley listed in table 4 and by subsurface outflow includes the spring discharge. It may be noted, however, that to the extent to which spring flow is returned to the ground-water reservoir it may be re-used in the valley, if intercepted prior to discharge by evapotranspiration or underflow from the valley.

Discharge from Wells: Pumpage from stock wells probably does not exceed 100 acre-feet a year. However, about 1,900 acre-feet of ground water was pumped to irrigate about 600 acres of barley during the 1963 crop season. This water was obtained from wells 6/66-22b1 and 22b2, drilled to depths of 410 and 450 feet and each yielding approximately 2,400 gpm with a drawdown of 30 feet. (see table 5.) During the 90-day period of irrigation, a total of about 3 feet of water was put on the fields by use of ditches flowing by gravity. The reported yield of grain from the first year of operation in 1963 ranged from 10 to 40 bushels per acre, and may have averaged about 30 bushels per acre.

It is not known to what extent the irrigation water may have penetrated the zone of aeration and returned to the underlying zone of saturation at the water table.

Perennial Yield:

The perennial yield is the maximum amount of water that can be withdrawn from the ground-water system for an indefinite period of time without causing a permanent depletion of the stored water or causing a deterioration in the quality of the water. It is ultimately limited by the amount of water annually recharged to or discharged from the ground-water system through natural process.

In an estimate of perennial yield, consideration should be given to the effects that ground-water development may have on the natural circulation in the ground-water system. The location of the development in the ground-water system may permit optimum utilization of the available supply or at the other extreme may be ineffective in the utilization of the water supply. The location of the wells may favor improving the initial quality with time or may result in deterioration of quality under continued withdrawals. Development by wells may or may not induce recharge in addition to that received under natural conditions. Part of the water discharged by wells may re-enter the ground-water reservoir by infiltration of excess irrigation or waste water and thus be available for re-use. Ground water discharged by wells eventually reduces the natural discharge. In practice, decreasing natural discharge by pumping is difficult, except when the wells are located where the water table can be lowered to a level that eliminates evapotranspiration in the area of natural discharge or outflow from the basin.

Ground-water outflow from a basin further complicates the final determination of perennial yield. The numerous pertinent factors are so complex that in effect specific determination of the perennial yield of a valley requires a very extensive investigation, based in part on data that can be obtained best only after there has been substantial development for a number of years.

The estimate of recharge and discharge for Lake Valley are nearly equal, 13,000 acre-feet a year and 12,000 acre-feet a year, respectively. The perennial yield tentatively is estimated to be about 12,000 acre-feet.

Storage:

A considerable amount of ground water is stored in the valley fill in Lake Valley. It is many times the volume of the average annual recharge to the ground-water reservoir. The magnitude of this stored ground water may be estimated by the following calculation:. The surface area of the valley fill below the 6,000-foot contour is about 111,000 acres. If it is assumed that this area overlies a reasonably thick section of valley fill that is saturated and if a value of 10 percent is assumed as the specific yield (drainable pore space) of the saturated deposits, then about 11,000 acre-feet of water is in storage for each foot of saturated valley fill. Thus, the amount of water in storage in the upper 100 feet of saturated valley fill would be at least a million acre-feet or 85 times the estimated average annual recharge to the ground-water reservoir.

The principal point to be recognized is that the volume of ground water in storage provides a reserve for maintaining an adequate supply for pumping during protracted periods of drought or for temporary periods of high demand under emergency conditions. This reserve, in effect, increases the reliability of ground water as a dependable source of supply and is an important asset in semiarid regions where suface-water supplies vary widely from year to year.

Chemical Quality:

The chemical quality of the water in most ground-water systems in Nevada varies considerably from place to place. In the areas of recharge the dissolved-solid content of the water normally is low. However, as the ground water moves through the system to the areas of discharge it is in contact with rock materials which have varying solubilities. The extent to which the water dissolves chemical constituents from the rock material is governed in large part by the solubility, volume, and distribution of the rock material, by the time the water is in contact with the rocks, and by the temperature and pressure in the ground-water system. On the basis of the general chemical character of water associated with the rock types present in Lake Valley, the ground water in Lake Valley, at least in the marginal parts of the valley fill adjacent to the areas of recharge, probably is slightly to moderately mineralized and probably is a calcium bicarbonate type where associated with the Paleozoic carbonate rock. A chemical analysis obtained from the owner of one of the two irrigation wells in the southern part of the valley and two analyses by the U.S. Geological Survey indicate that the water at the places of collection is of this type.

Two water samples were collected by the authors for analysis. Geyser Spring (9/65-4cl) and an unnamed stock-watering well (10/66-31al) were sampled. The result of the analyses indicate that the spring water is moderately hard and of good quality for irrigation. The well water was hard but of fairly good quality for irrigation. These two analyses are given in table 5.

Table 5.--Chemical analyses, in parts per million, of water from Lake Valley

(Analyses by U. S. Geological Survey)

Source	Geyser Spring	Stock-watering well
Location	9/65-4cl	10/66-31al
Date collected	8-7-63	8-7-63
Water temperature	68°F	59°F
Silica (SiO_2)	13	27
Calcium (Ca)	30	54
Magnesium (mg)	3.4	5.7
Sodium (Na)	3.0	7.4
Potassium (K)	1.0	1.9
Bicarbonate (HCO_3)	103	189
Carbonate (CO_3)	0	0
Sulfate (SO_4)	5.0	6.4
Chloride (Cl)	3.0	9.6
Fluoride (F)	0	0
Nitrate (NO_3)	.6	1.2
Boron (B)	0	0
Dissolved solids	115	203
Hardness	89	158
Noncarbonate hardness	5	3
Specific conductance	181	322
pH	8.0	7.8
Sodium-adsorption ratio (SAR)	.1	.3
Residual sodium carbonate (RSC)	0	0
Sodium (Alkali) hazard	Low (S1)	Low (S1)
Salinity hazard	Low (C1)	Medium (C2)

Specific conductance of water was measured for several wells. The specific conductance provides a simple measure of the mineral content of the water. The value of the specific conductance multiplied by a factor ranging from 0.5 to 1.0 will approximate the dissolved-solids content of the water in parts per million. A factor of 0.7 is commonly used. The specific conductance of water ranges from 31 micromhos at North Creek Spring near Mount Grafton in the northwestern part of the valley to 2,470 micromhos at a stock-watering well near the center of the valley. Most of the values were in the range from 350 to 650 micromhos. The individual values are listed in tables 6 and 7.

Development:

Present development.--Ground water presently is used for irrigation of native pasture and stock-feed, stock watering, and domestic supply, and in 1963 for irrigation of small grain.

For many years ground-water use was centered around the spring complex at the Geyser Ranch and was directed largely to the raising of cattle. Development of the spring area largely involved the construction of ditches to collect spring discharge for better control of the water. Later, a pipe line was laid to conduct part of the flow of North Creek Springs to a reservoir near the ranch. This reduced seepage loss in the segment of the alluvial apron over which the pipe line was laid. Subsequently four shallow irrigation wells were drilled in the lower area at the Geyser Ranch. However, total pumpage from these wells has been small and apparently the wells have not been pumped for several years. The water from the springs in the vicinity of Geyser Ranch is only partly used and most of it is discharged to the meadow and saltgrass areas during the winter months.

It is estimated that the average discharge of the Geyser, North Creek Springs and the spring complex at Geyser Ranch probably is in the order of 4,500 acre-feet a year--only a small part of which is used at the present time.

During 1963 two irrigation wells (6/66-22b1 and b2) were used to irrigate about 600 acres of newly reclaimed land in the southern part of the valley. The estimated discharge from these wells was about 1,900 acre-feet; the total discharge from all wells in the valley was about 2,000 acre-feet in 1963.

Potential Development:--The potential development of ground water in Lake Valley is limited by the quantity and possibly to some extent by the quality of the water. Under the strict concept of the State law, the development would be limited to the perennial yield of the valley, which tentatively is estimated to be about 12,000 acre-feet. Of this amount roughly 4,500 acre-feet could be obtained by full development of the springs presently supplying the Geyser Ranch area in the northwestern part of the valley. Assuming that the discharge of the springs supplying the Geyser Ranch is or will be developed fully, about 7,500 acre-feet of the tentative perennial yield would be available for development by wells. This would include the 1,900 acre-feet per year discharged by the two irrigation wells in sec. 22, T. 6 N., R. 66 E.

In a hydrologic sense, but not necessarily in an economic sense, wells should be located so that ground water would be intercepted prior to its discharge from the valley by evapotranspiration or subsurface outflow to Patterson Wash. This would suggest placing wells in or peripheral to the phreatophyte area to intercept ground water moving from recharge areas to the phreatophyte area and across the southern part of the valley to intercept the underflow moving south to Patterson Wash. Obviously this would result in wells being widely distributed in the valley.

Several non-hydrologic reasons support the idea that wells should be grouped for optimum operation. However, such development normally leads to the problem of local overdevelopment. That is, for many ground-water systems, development in a small area of the system cannot change the routing of recharge to the area of development under the general limitations of pumping cost. To illustrate, if a small area were developed in Lake Valley, it might ultimately require a local lowering of water levels of as much as 1,000 feet to divert all recharge to the wells. However, under present economic conditions of agricultural production, pumping would have to be curtailed long before this, perhaps when water levels were lowered to 200 to 300 feet.

The selection of areas of intensive ground-water development probably would be based principally on non-hydrologic factors. One area might be used to illustrate some of the hydrologic aspects of the problem. Note that the discussion refers to quantity of water, but variations of chemical quality of the water in part may impose restrictions in the actual operation of the development.

Assume a group of wells are located favorably to intercept the underflow from Lake Valley; that is, located within T. 6 N., R. 66 E., and the western part of T. 6 N., R. 67 E. Further assume that the annual pumping averages about 7,500 acre-feet--an amount equal to the estimated tentative perennial yield minus the discharge of the springs in the vicinity of the Geyser Ranch. In time water levels probably would be lowered 100 feet or more--sufficient to intercept most of the underflow from the valley. The amount of time required to reduce underflow from the valley to a minimum probably would be several tens of years. Partly, this is due to the fact that a substantial amount of stored ground water in the vicinity of the wells would have to be removed to provide the necessary lowering of water levels in the pumped areas. This would curtail most of the underflow from the valley that would be derived from a volume of stored ground water in the areas south of the pumped area. The amount of underflow would gradually decrease as this stored water was depleted.

To the north of the pumped area water levels would slowly decline--the amount of the decline decreasing with distance. If the average water level were lowered 100 feet in the area of pumping, lowering of water level 10 miles to the north probably would not be more than several feet after 10 years of pumping. The northward expansion of the area of lowering of water levels would continue until the inflow to this area balanced the discharge by pumping. As water levels gradually were lowered beneath the area of phreatophytes, the discharge of ground water by the phreatophytes would be reduced. The amount of water salvaged would then be diverted to the pumping area. However, because of the distance of the pumping area, used in this illustration, from the area of phreatophytes, appreciable salvage of phreatophyte discharge would not be achieved for many years. Further, appreciable salvage of ground-water discharge by pumping in the area eventually would require pumping lifts too great for present economic feasibility.

Thus, in the example given annual pumping at the rate of about 7,500 acre-feet--the estimated perennial yield minus the estimated spring discharge--probably could be maintained for many years, and might be limited finally to the permissible costs of lifting ground water to the surface. It may be noted that in the example given effects on the ground-water system were based on a one-time use of the water such as would be the case if the pumped water were exported from the valley. If the water were used for irrigation, some proportion of that water very likely would return to the ground-water reservoir to be used again. In effect this returned water would delay the rate of water-level decline due to pumping.

Planned overdevelopment has been used in Utah and New Mexico to achieve some additional economic benefits for limited periods of time. Planned overdevelopment is discussed herein only with respect to some of the physical problems relating to the occurrence, movement, and quality of ground water to aid the reader in obtaining a fuller understanding of the potential results of ground-water development in Lake Valley. It is intended neither to support nor negate the possible use of such methods.

In many ground-water basins outside Nevada, where large quantities of ground water in storage are known to exist, the "mining" of ground water--that is, withdrawing water for many years at a rate much in excess of the average annual natural recharge--has been considered or actually has been done. Uncontrolled pumping of ground water often has resulted in overdevelopment with the consequent continued lowering of water levels and depletion of stored water. In some areas lowering of water levels has amounted to several hundred feet over a period of time. Overdevelopment commonly has resulted in much economic benefit and may, under the right conditions, permit raising the economic level of an area to a point where it can support the cost of importing needed water when the cost of obtaining ground water locally becomes too great. However, if no water is available for importation, the overdevelopment of ground water implies that at some time in the future economic decline will result. One principal problem is the difficulty of predicting the economic cost limit of withdrawing ground water. The length of time that pumping may be continued may be extended, if under actual conditions of withdrawal, more water is available than originally estimated, if greater efficiency of water use is achieved with time, or if changes in use result in greater economic benefit. The length of time that pumping may be continued may be shortened by the reverse of the above conditions, or by a severe economic recession. It should be re-emphasized that in Nevada present ground-water laws are based on the concept that development should not exceed the perennial yield.

The physical process of planned overdevelopment of a ground-water reservoir involves withdrawal at a rate greater than can be supplied by natural recharge for a specified period of time.

For the purpose of illustration, we may refer to a 50-square-mile area in Tps. 6 and 7 N., R. 66 E., and the west half of T. 6 N., R. 67 E.--more or less the same general area discussed previously. In 1963, depth to water in this area ranged from 50 to 150 feet below land surface. We may assume then that planned overdevelopment will limit the average lowering of water levels in this 50-square-mile area to 100 feet. At this level, essentially all of the available inflow from the west, north, and east would be intercepted and underflow southward from the valley from the area of pumping would be reduced to a minimum.

The magnitude of the annual pumpage required to lower water levels an average of 100 feet beneath the 50-square-mile area can be computed by the equation:

$$\text{Annual pumpage} = \frac{\text{Stored water (acre-feet)}}{\text{years}} + \text{Average annual recharge (acre-feet)}$$

The amount of water stored in the upper 100 feet of saturated materials beneath the 50-square-mile, or 32,000-acre, area may be estimated as follows:

The specific yield may range from 10 to 20 percent--that is, 10 to 20 percent of the volume of the saturated materials would represent the amount of water that would drain by gravity from these deposits. The volume of deposits in a 100-foot thick section beneath this 32,000-acre area is 3.2 million acre-feet. The volume of water available from storage in the saturated 100-foot section would range from 0.32 million to 0.64 million acre-feet for the respective specific-yield values of 10 and 20 percent.

The average annual recharge initially would be equivalent to the estimated 3,000 acre-feet of subsurface outflow to Patterson Wash. Eventually after the ground-water system was stabilized under the new regimen resulting from the pumping, the average annual recharge might approach 7,500 acre-feet, which is the tentative perennial yield minus the spring discharge. For the purposes of illustration, an intermediate value of 5,000 acre-feet is used to represent average annual recharge to the pumped area. Thus, if overdevelopment were planned for a 25-year period, average annual pumpage would be computed as:

For specific yield of 10 percent:

$$\text{Annual pumpage} = \frac{320,000 \text{ acre-feet}}{25} + 5,000 \text{ acre-feet}$$

$$= 12,800 + 5,000$$

$$= \text{about } 18,000 \text{ acre-feet}$$

or, for a specific yield of 20 percent:

$$\text{Annual pumpage} = \frac{640,000 \text{ acre-feet}}{25} + 5,000 \text{ acre-feet}$$

$$= 25,600 + 5,000$$

$$= \text{about } 31,000 \text{ acre-feet.}$$

Similarily, if the period of planned overdevelopment were 50 years, the average annual pumpage would be on the order of 11,000 and 18,000 acre-feet for the respective specific-yield values of 10 and 20 percent.

The effect of removal of ground-water in storage for the area peripheral to the 50-square-mile area is not included in the computation, for simplicity. If it were, annual pumpage for the quantities given above would extend the time it would take to produce an average lowering of 100 feet in the 50 square-mile area; or, the quantities of pumpage might be increased somewhat for the given time interval.

As mentioned previously, the required lowering of water levels would average 100 feet in the 50-square-mile area. It should be noted, however, that to accomplish this would require a substantially greater lowering of water levels in and adjacent to the pumped wells. The accuracy of such forecasting is dependent on having reliable geologic and hydrologic data in the area of concern. These data, of course, are not available at present.

Table 6.--Records of selected wells in Lake Valley, Lincoln and White Pine Counties, Nev.

Use of water: D, domestic; I, irrigation; O, observation; S, stock
Water level: M, measured; R, reported
Altitude: estimated
Remarks: Number is log number in files of State Engineer

Well number and location	Owner and/or name	Date drilled	Depth (feet)	Casing: Diameter (inches)	Casing: Perforated 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
5/66-14b1	BLM, Spot Lite Well	4-1955	146	6	190-210	5,940	top of casing	1.5	140.0 145	M R	7-18-63 4- 55	-	S	Reported cased to 210 feet; Log 2907
5/68-6c1	Victor Cottino	- -	35	-	- -	6,580	top of casing	-2.0	32	R	9- 6-63	-	D	- -
6/66-8b1	BLM, Grassy Well	1945	95	6	- -	5,930	top of casing	0.6	52.7 55.2	M R	8- 6-63 10- 7-49	-	S	- -
6/66-19b1	BLM, (unknown)	- -	233	8	- -	5,990	top of casing	.7	97.1	M	8- 6-63	-	S	- -
6/66-22b1	Archie Garwood	6-1962	450	14	120-450	5,930	- -	-	103	R	6- -62	-	I	Log 6622
6/66-22b2	E. M. Sundgren	6-1942	410	24	120-410	5,930	- -	-	101	R	6- -62	-	I	Sp. Cond., 400; Log 6623
6/66-35c1	BLM, Poney Well	- -	161	8	- -	5,950	top of casing	-	130.4 130.0 130.3	M R R	7-17-63 9- 9-49 7-26-46	-	S	Log
6/67-18c1	BLM, Valley Well	12-1954	275	6	235-287	6,030	top of casing	1.0	209.4 224	M R	7-18-63 12- -54	-	S	Log 2832
7/65-17d1	BLM, Mule Shoe Summit	- -	229	6	- -	6,380	top of casing	.8	212.9	M	8- 6-63	54	S	Specific conductance 600
7/65-23d1	BLM, Dutch John Well	- -	30	6	- -	5,950	top of casing	1.5	27.3 27.7	M R	8- 6-63 10- 5-49	57	S	Specific conductance 602
7/66-6c1	BLM, South Well No. 3	1942	71.4	6	- -	5,930	top of casing	1.8	30.2 30.6	M R	8- 5-63 10- 5-49	60	S	Specific conductance 2,470
7/66-36c1	BLM, Mustang Well	- -	126	6	- -	5,940	top of casing	1.0	109.8 108	M R	7-18-63 12-20-46	-	S	Specific conductance 524
7/67-6b1	F & M Land Development Co	- -	872	-	- -	6,100	- -	-	16	R	2- 55	-	S	Plugged & abandoned, Log 4480
7/67-20c1	(unknown)	- -	180	6	- -	6,010	top of casing	2.8	171.2	M	7-17-63	-	S	- -
7/67-21a1	BLM, Fortification Well	- -	307	6	- -	6,175	top of casing	.5	292.5 274	M R	7-18-63 12-20-46	-	S	- -
8/65-2d1	(unknown)	- -	130.4	10	- -	5,975	top of casing	1.0	36.2	M	7-18-63	-	-	Unused
8/65-12d1	BLM, Lake Valley Well No. 1	- -	45	4	- -	5,940	top of casing	-	23.6 19.1	M R	7-18-63 10- 5-49	-	S	Specific conductance 620
8/65-33d1	BLM, Milk Ranch Well	1945	325	6	- -	6,280	top of casing	.5	297.8	M	8- 6-63	-	S	- -
8/66-27d1	BLM, Lake Valley Well No. 2	- -	56	8	- -	5,930	top of casing	.5	45.1 45.4	M R	7-18-63 10- 5-49	-	S	Specific conductance 2,100
9/65-1a1	Geyser Ranch	- -	165	10	- -	5,980	top of casing	-	38.4 38.0 37.9 36.1 36.6	M R R R R	7-18-63 12- 7-60 9-17-53 3-20-50 4-16-48	-	I	Well caved in at 40 ft.
9/65-1a2	Geyser Ranch	- -	128	6	- -	5,980	top of casing	-	37.8	M	7-17-63	-	D	Unused; Sp. Cond., 340
9/65-13b1	Nevada Highway Dept. Geyser Maintenance	1962	57.2	6	- -	5,960	top of casing	1.2	17.1	M	7-18-63	-	D	- -
9/66-4a1	BLM, North Well No. 3	- -	53	6	- -	5,980	top of casing	1.1	37.9	M	7-17-63	-	S	- -
9/66-34a1	BLM, Lake Valley No. 3	- -	103.4	6	- -	5,990	top of casing	1.0	89.4 105	M R	7-18-63 12-20-46	-	S	- -
10/65-36d1	Geyser Ranch	- -	165	10	- -	5,980	top of casing	.8	26.72 25.32 25.14	M R R	7-17-63 3- 2-50 4-16-47	-	I	Well caved in at 28 ft.
10/66-9a1	BLM, Heckethorn	- -	228	6	- -	6,120	top of casing	1.4	179.8	M	7-16-63	-	S	Unused
10/66-17a1	BLM, Twisselman	- -	125	6	- -	6,020	top of casing	1.0	100.2 102.3	M R	7-16-63 10- 6-49	-	S	- -
10/66-31a1	(unknown)	- -	45.8	6	- -	5,965	top of casing	-	33.4 31.0	M R	7-17-63 10- 6-49	-	S	Specific conductance 363

DESIGNATION OF WELLS AND SPRINGS

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 established by the General Land Office.

A typical number consists of three units. The first unit is the township north 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, and southeast quarters 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 5/66-14b1 is shown on plate 1 as 14b1 and is within the rectangle designated as T. 5 N., R. 66 E.

Table 7.--Records of discharge of springs in Lake Valley, Lincoln and White Pine Counties, Nevada.

Discharge: M, Measured; E, Estimated;
Use: D, Domestic; S, Stock; I, Irrigation; U, Unused.
(Measurements by D. O. Moore)

Spring location	Name	Probable Source	Discharge: Flow (gpm)	Discharge: M or E	Discharge: Date	Specific conductance at 25°C (micromhos)	Temperature (°F)	Use	Remarks
5/66- 6dl	Poney Sp.	Volcanic rock (Tertiary)	10	E	8-27-63	-	-	S	Water piped to stock tank, east of U.S. Hwy. 93.
5/68-17al	Cottino Rnch. Spring	Volcanic rock	100	E	8- 5-63	383	60	S	Discharge estimated 1 mi. below source.
6/65-23bl	Burnt Corral Spring	Pennsylvanian limestone	1	E	8- 7-63	-	-	S	--
6/68-11cl	Cole Rnch. Sp.	Volcanic rock	25	E	8- 7-63	-	-	D, S	--
9/65-1 to 9/65-12	Geyser Ranch sp. complex	Laketown Dolomite	1,400	M	8- 6-63	-	-	I	Discharge; to the south 970 gpm, to the north 430 gpm.
9/65- 4cl	Geyser Sp.	Pole Canyon Limestone	(see remarks	M	8- 5-63	233	68	I	(see Fig. 3)
9/65-30dl	Patterson Sp.	Pioche Shale	10	E	8- 7-63	-	-	U	--
10/65-19dl	North Creek Spring	Prospect Mountain Quartzite	770	M	8- 4-63	-	-	-	Discharge measured 1 mi. below source. Discharge measured at head of pipeline
			310	M	8- 4-63	-	-	-	
10/65-29cl	Little North Cr. Sp.	do	40	M	8- 4-63	31	56	U	--

Table 8.--Selected drillers' logs of wells in Lake Valley, Lincoln and White Pine Counties, Nevada.

	Thickness (feet)	Depth (feet)
5/66-14b1		
Soil	3	3
Gravel, cemented, and clay	172	175
Sand	5	180
Gravel, cemented, and clay	15	195
Sand	5	200
Gravel, cemented, and clay	20	220
Sand and gravel	5	225
Total		225
6/66-22b2		
Soil	10	10
Gravel	9	19
Clay	6	25
Gravel and sand	12	37
Clay and gravel	14	51
Gravel and sand	8	59
Clay and gravel	10	69
Clay and boulders	15	84
Gravel and sand	21	105
Boulders and clay	8	113
Clay and gravel	11	124
Gravel and sand	9	133
Clay and gravel	3	136
Gravel and sand	18	154
Clay and boulders	6	160
Gravel and clay	26	186
Sand and gravel	19	205
Sand and clay	20	225
Sand and gravel	15	240
Boulders and clay	13	253
Gravel and sand	25	278
Gravel and clay	12	290
Gravel and sand	16	306
6/66-22b2 (continued)		
Gravel and clay	16	322
Sand, gravel, and boulders	13	335
Boulders and clay	14	349
Boulders and gravel	20	369
Boulders and clay	20	389
Boulders and gravel	21	410
Total		410
6/66-35c1		
Silt, cemented gravel at 20 feet	20	20
Sand, black	142	162
Total		162
6/67-18c1		
Soil	3	3
Gravel, cemented	227	230
Sand	5	235
Gravel, cemented	55	290
Gravel	2	292
Total		292

Table 8. (continued)

	Thick-ness (feet)	Depth (feet)
7/67-6b1 (?)		
Top soil (sandy loam)	16	16
Clay	16	32
Sand, heavy, and gravel; water-bearing	53	85
Shale, blue	18	103
Sand and pea gravel; water-bearing	162	265
Clay, sandy	46	311
"Water" sand, fine	107	418
Shale, red sandy	15	433
Sand, fine, and pea gravel	332	765
Lime shelf	12	777
Shale, sandy	44	821
Sand and gravel, increase of water	51	872
Total		872

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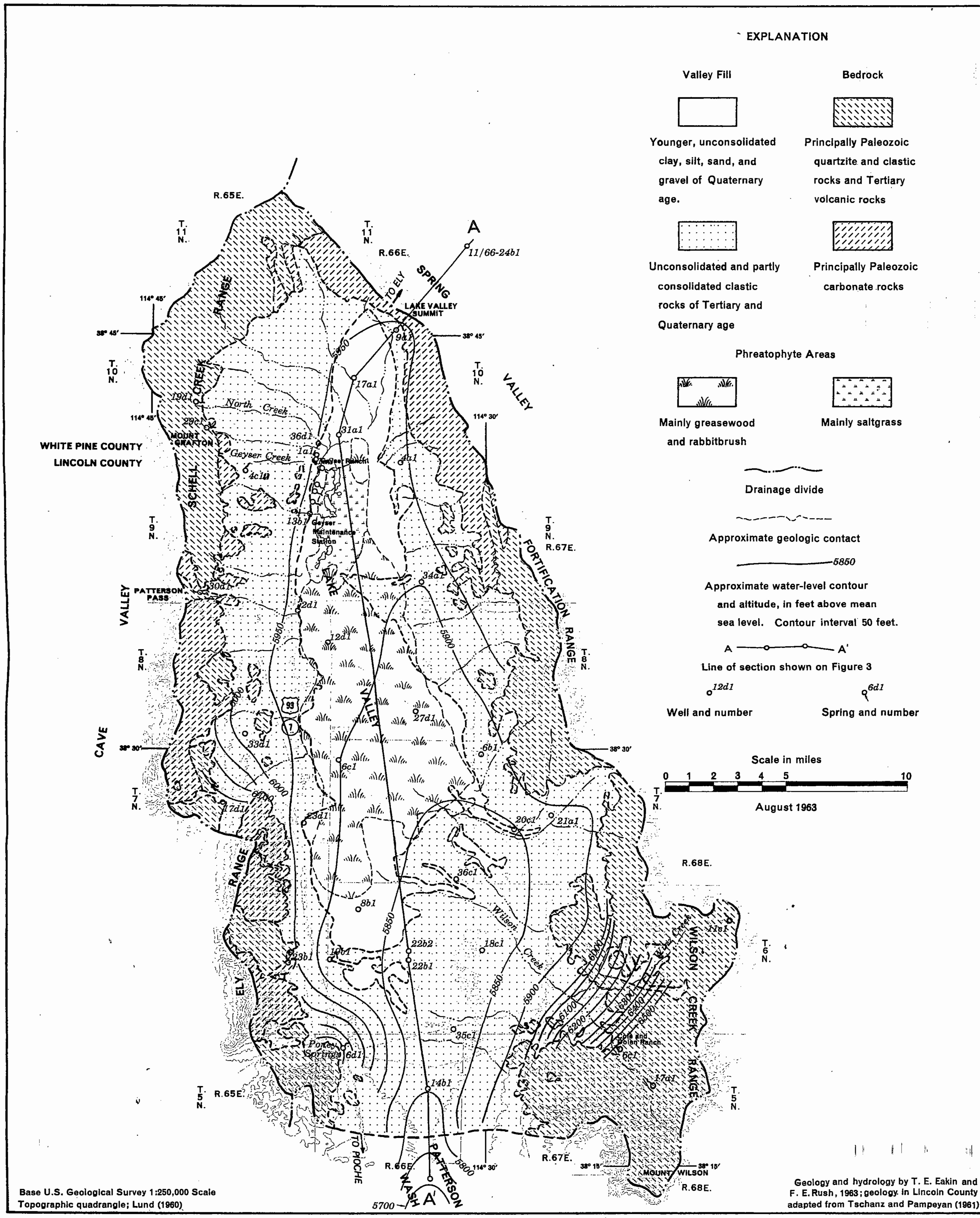

PLATE 1. MAP OF LAKE VALLEY, LINCOLN AND WHITE PINE COUNTIES, NEVADA
SHOWING AREAS OF BEDROCK, VALLEY FILL, PHREATOPHYTES, AND LOCATIONS OF WELLS AND SPRINGS.