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DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
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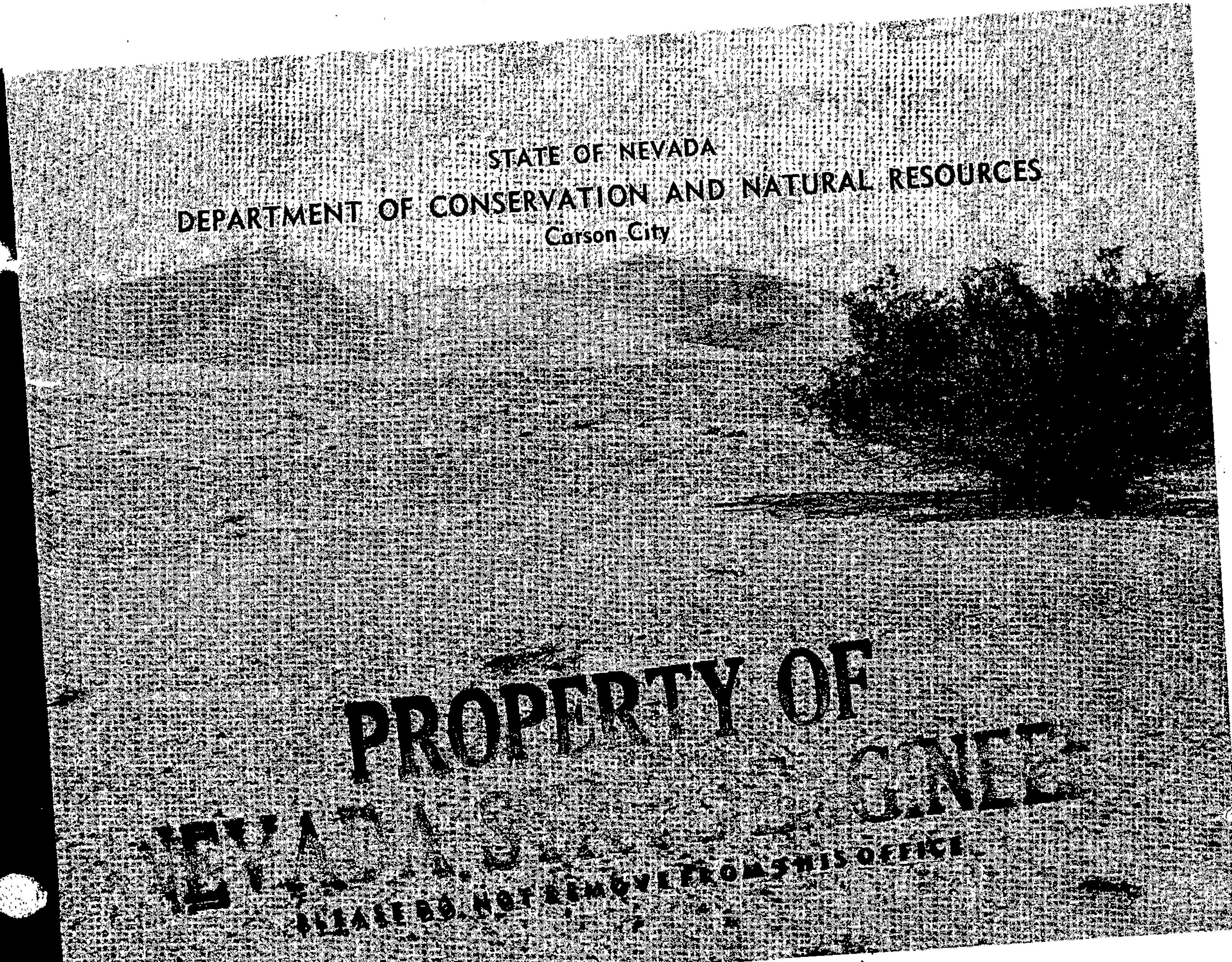


Big Dune, Amargosa Desert

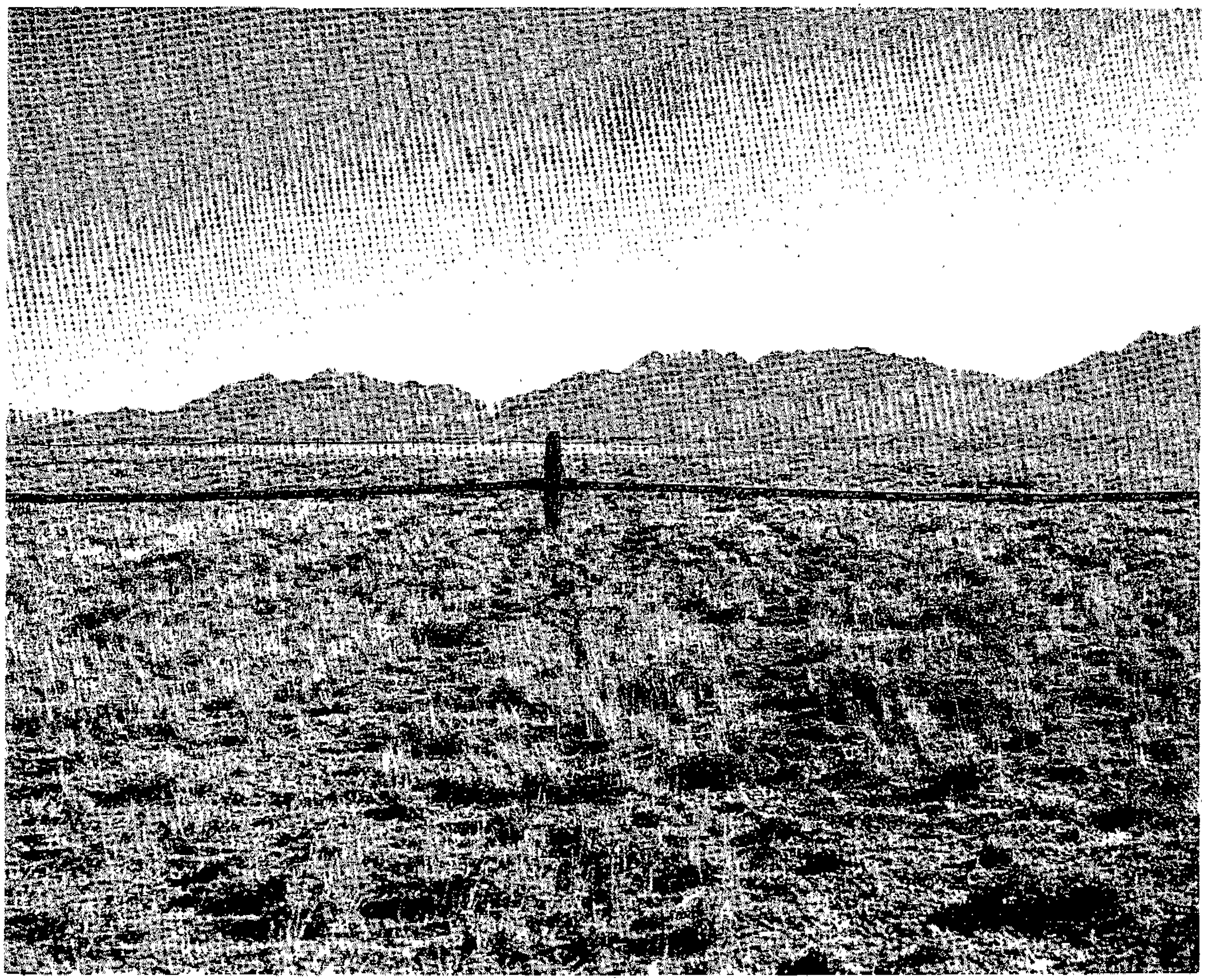
GROUND-WATER RESOURCES – RECONNAISSANCE SERIES
REPORT 14

GEOLOGY AND GROUND WATER OF AMARGOSA DESERT, NEVADA–CALIFORNIA

By
GEORGE E. WALKER
and
THOMAS E. EAKIN
Geologists

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

MARCH 1963



View south of part of irrigated alfalfa field in the NE¼, sec. 23, T. 15 S., R. 48 E. Light colored vegetation is dry remnants of 1962 growth. New growth is developing from recent irrigation. March 1963. Photograph by T. E. Eakin.

COVER PHOTOGRAPH

View of northwest side of Big Dune in April 1962. Main mass of dune migrates within a 3- to 4-square mile area in response to wind patterns. Note sand accumulation trailing downward from scattered bushes in foreground. Photograph by T. E. Eakin.

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FOREWORD

This report is the 14th in the reconnaissance ground-water series. It covers the ground-water resources of the Amargosa Desert in Nevada and California and considers the problem of the movement of water from areas beyond the surficial boundaries of the area. The authors, George E. Walker and Thomas E. Eakin, conclude that only a small part of the ground-water of Amargosa Desert, which is defined to include Ash Meadows, derives from the precipitation which falls on the land surface within the geographical boundaries of the area. The authors suggest that much of the ground water of the area is a contribution from other areas and arrives by movement through underlying Paleozoic carbonate rocks.

This report indicates that the average annual recharge to the underground waters of Amargosa Desert and Ash Meadows is on the order of 24,000 acre-feet. Of this amount, 17,000 acre-feet are discharged by the springs in Ash Meadows and 7,000 acre-feet is potentially available for pumping from the underground water in Amargosa Desert.

The report also points out that there is a very large quantity of ground water in storage in the Amargosa Desert area. While the report does not discuss the agricultural land resources of Amargosa Desert, available information indicates that the acreage of good agricultural land is limited. There seems a reasonable possibility that if all of the estimated 7,000 acre-feet of the annual increment was made available, only a modest annual withdrawal of the stored water would be necessary to permit development of the total area of desirable agricultural land. The situation strongly suggests that a planned withdrawal of ground-water in excess of the estimated annual recharge may be reasonable and desirable.

As suggested in this report and in previous publications, the subject of the inter-basin movement of ground water should be investigated. A knowledge of such inter-basin movements of ground water is necessary to an understanding of the ground water resources of any area in a region in which such ground water movements occur and to the full utilization of these resources.

Hugh A. Shamberger
Director
Department of Conservation and
Natural Resources

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GEOLOGY AND GROUND WATER OF AMARGOSA DESERT,
NEVADA-CALIFORNIA

by

George E. Walker and Thomas E. Eakin

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SUMMARY

The Amargosa Desert is a north-northwest trending intermontane valley in the south-central part of the Basin and Range physiographic province. The climate is arid, and precipitation in the area averages less than 5 inches annually.

The valley is surrounded by mountain ranges composed of rocks of Precambrian (?), Paleozoic, and Tertiary age, consisting principally of tuff and lava, dolomite, limestone, shale, siltstone, quartzite, and slate in varying proportions. These mountains were uplifted by faulting and tilting during the late Tertiary and early Quaternary time. Erosion products of the surrounding mountains have filled the basin of the valley with several hundred feet of alluvium, including lake and stream deposits.

The amount of water that may be available annually is estimated to be about 17,000 acre-feet from the springs issuing from Paleozoic carbonate rocks in Ash Meadows, and about 7,000 acre-feet from wells developed in the valley fill to the northwest and northeast of the springs in the Amargosa Desert. The estimated perennial yield of Amargosa Desert is the sum of the two, or 24,000 acre-feet, and is based on the estimate of average annual ground-water discharge.

Ground-water pumpage by wells during the summer of 1962 is roughly estimated to be 3,000 acre-feet. Of the 162 wells listed in this report, of which more than 100 are for irrigation, only 18 were reported to have been pumped during the summer of 1962.

Analyses of 28 samples of water from wells and springs in the area indicate that the water commonly can be used for irrigation but generally is classed as medium-salinity water or poorer and may require leaching of the soil. Medium- to high-sodium water occurs locally with the poorer quality water and generally is found in the southern part of the area.

Of 19 analyses for boron, 9 had concentrations less than 0.33 ppm, 9 had concentrations between 0.36 and 1.4 ppm, and 1 had a concentration of 2.8 ppm. The median value of 0.36 ppm for the 19 analyses suggests that the boron concentration may offer a problem in the growing of some crops.

For public supplies the ground water generally is suitable, except that the fluoride concentration may locally be greater than twice the optimum recommended limits (about 1.4 ppm) of the U.S. Public Health Service. Of 28 analyses for fluoride, 26 have concentrations greater than 0.7 ppm, the optimum control limit recommended by U.S. Public Health Service. Of these, 14 have concentrations of more than 1.4 ppm and 10 have concentrations of 2.8 ppm or more.

About 1.4 million acre-feet of ground water is estimated to be stored in the upper 100 feet of saturated alluvial deposits beneath a four-township area roughly enclosing the area of principal concentration of wells. Although not permissible under the present Nevada ground-water law, some consideration has been given to the effects of planned over-development; that is, regulated withdrawal in excess of the perennial yield. A simplified illustration of the effect of overdevelopment on ground-water levels suggests that pumping at the rate of 60,000 acre-feet a year would lower water levels in this four township area an average of 100 feet in about 25 years and would intercept most of the recharge now moving through the valley toward the area of natural discharge.

INTRODUCTION

In recent years there has been a large increase in the development of ground water in Nevada. The increase is partly due to the interest and efforts to bring new land under cultivation. This has created the need for more information on the ground-water resources throughout the State.

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

A special report series to expedite publication of the results of these reconnaissance studies has been established by the Department of Conservation and Natural Resources. The present report is the fourteenth in this series. It describes the physical conditions of the Amargosa Desert in Nye County, Nevada, and Inyo County, California, and includes observations and evaluations of the interrelation of climate, geology, and hydrology as they affect the ground-water resources. It also includes an evaluation of the chemical quality of the ground water and its suitability for irrigation and domestic use.

Figure 1 shows the areas discussed in previous reports of the reconnaissance series and in this report.

Purpose and Scope of Investigation

The present reconnaissance investigation was undertaken to appraise and evaluate ground-water conditions in the Amargosa Desert prior to additional extensive irrigation development. The short time available limited the scope of the investigation. However, much useful data were collected during this investigation and are described in tables 3 to 5, 8, and 9 of this report.

The senior author did the field work during the summer of 1962, including an inventory of all irrigation wells, domestic wells, and springs; collection of water samples for chemical analysis; and a geologic reconnaissance of the valley fill. He also prepared the major part of the report. The junior author prepared the sections on storage, chemical quality, recharge, discharge, perennial yield, and development. The authors profited by consultation with their colleagues, especially I. J. Winograd and R. A. Young on several aspects of ground water in the area. Mr. Young further gave valuable assistance in the field and in report preparation. The investigation was made under the general direction of G. F. Worts, Jr., district chief in charge of water-resources studies in Nevada.

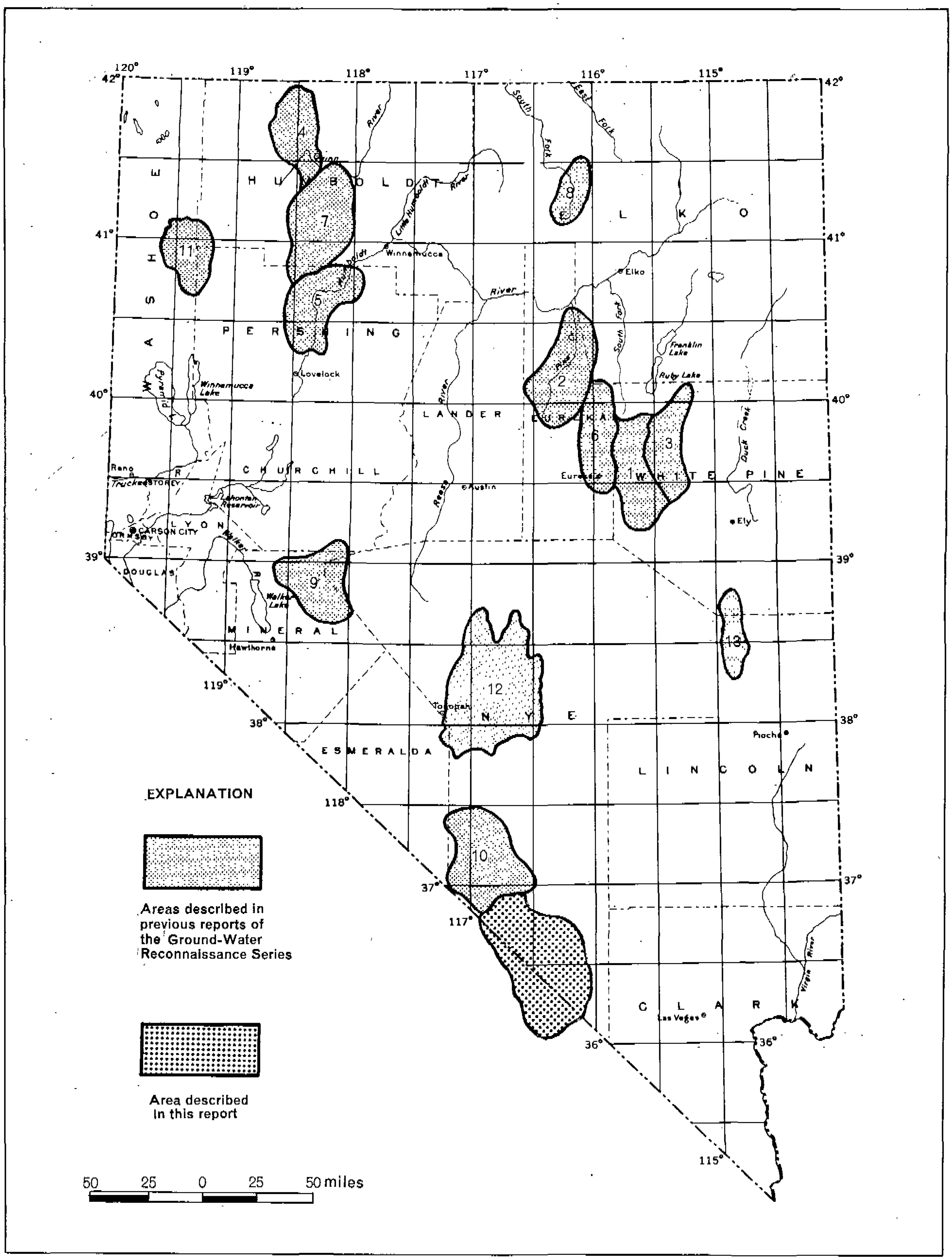

Figure 1. Map of Nevada showing areas described in previous reports of the ground-water reconnaissance series and the area described in this report

Some data were obtained from unpublished manuscripts and published reports. Much of the geologic conditions within and surrounding the area are described in reports by Ball (1907), Denny and Drewes (written communication, 1962), Jennings (1958), Cornwall and Kleinhampl (1961), and Burchfiel (written communication, 1960 and 1961).

Location and Extent of Area

The Amargosa Desert lies south of Beatty, Nevada, and extends south-southeastward to Eagle Mountain, California, a distance of some 50 miles. It is about 30 miles across at its widest point. The total surficial drainage area of Amargosa Desert, including its tributaries Oasis Valley, Crater Flat, Fortymile Canyon, Jackass Flats, and Rock Valley, is about 2,600 square miles (Pl. 1). However, most of the available data are concentrated in the southern two-thirds of the valley, between Lathrop Wells and Death Valley Junction, which is the principal area discussed in this report. More specifically, the principal area includes that part of Amargosa Desert between Big Dune and the Spring Mountains southward to Eagle Mountain. This restricted area is about 600 square miles and is shown on plates 2, 3, and 4.

Acknowledgements

Acknowledgment is made to all the individuals who have given information on their wells and especially to those who have permitted repeated access to their properties. Mr. H. V. Weimer and Mr. L. C. Cook, well drillers within the area, supplied a number of well logs (table 4) and other data. Most of the well logs shown in table 4 were supplied by the State Engineer's office.

Special thanks are due to C. S. Denny and H. Drewes of the Geological Survey for permission to draw upon the draft of their report on the geology of the Ash Meadows quadrangle, Nevada-California.

Numbering System for Wells and Springs

The well-numbering system used in the Amargosa Desert indicated the location of wells and springs within the official rectangular subdivision of the public lands, with reference to the Mount Diablo base line and meridian in Nevada and the San Bernardino base line and meridian in California. The first segment of a number designates the township. The "S" for wells in Nevada indicates that the township is south of the Mount Diablo base line; the "N" for wells in California indicates that the township is north of the San Bernardino base line. The second segment, separated from the first by a slant, denotes the range east of the respective meridians. The third segment, separated from the second by a dash, identifies the section number, followed by a letter which designates the quarter section in which the well or spring is located. The letters a, b, c, and d designate, respectively, the northeast, northwest, southwest, and southeast quarters of the section. The number following the letter designates the order in which the well was recorded in the quarter section. Thus, well number 17S/51-1a1 indicates that this well was the first well recorded in the NE 1/4 sec. 1, T. 17 S., R. 51 E.

Owing to limited space, wells and springs on plates 3 to 5 are identified only by the quarter section and serial number. The township in which the well is located can be ascertained by the township and range numbers shown at the margin of the map. The section in which the well is located is numbered for most of the area of the map. Where the section is not numbered, as on plate 1, the section number is added to the quarter section and serial number for the specific well.

Most of the wells listed in table 3 are shown on plate 3. Those outside of the area of plate 3 are shown on plate 1.

PHYSICAL ENVIRONMENT

Surface Features

The Amargosa Desert is in the south-central part of the Basin and Range physiographic province. It is north-northwest trending intermountain valley. The Amargosa Desert differs from the typical basin and range intermountain valley in that it is not topographically closed and the playas within it are presently eroding. The Amargosa River and its tributaries are shown on plate 1, which delineates the surficial drainage area north of Eagle Mountain.

Bare and Yucca Mountains and Pahute Mesa are prominent to the north, the Specter Range, northwest end of the Spring Mountains, and Resting Springs Range are prominent to the northeast, east, and southeast, respectively. The Greenwater Range and the Funeral Mountains are dominant topographically to the southwest and west. Pyramid Peak, altitude 6,703 feet, in the Funeral Mountains is the highest peak adjoining the valley. The average relief between the valley floor and the mountain crests is approximately 2,100 feet. The surrounding mountains consist of clastic, carbonate, metamorphic, and pyroclastic rocks ranging in age from Precambrian(?) to Tertiary. The mountains are principal areas of erosion and generally are characterized by relatively steep, barren slopes.

Coalescing alluvial fans and washes form piedmont slopes between the mountains and the lowlands. The alluvial-fan deposits intertongue with lake and playa deposits. The alluvial-fan and wash deposits underlie the intermediate slopes between the mountains and the lower parts of Amargosa Desert. The surfaces of the fan deposits are not smooth but are cut by numerous washes. These washes and the Amargosa River and its tributaries in the lowlands contain alluvium of Recent age.

The gradient of the main axis of the valley is generally south-southeastward and the slope ranges from more than 17 feet per mile in the vicinity of Big Dune to about 5 feet per mile southeast of Death Valley Junction.

The channel of the Amargosa River heads in Oasis Valley; it continues southeastward through Amargosa Desert past the west side of Eagle Mountain and extends another 40 miles southward; it then turns northwestward, finally terminating in Death Valley. The channel lies between a series of low bedrock outcrops on the western side of Amargosa Desert south of Big Dune and appears to be structurally controlled. The channel carries flood water following cloudbursts or high-intensity storms. Generally, however, the Amargosa River is intermittent, except for short sections of the channel which contain water from springs and areas where the ground water is at the land surface. For example, numerous springs occur along the Amargosa River in Oasis Valley between Springdale and Beatty (Malmberg and Eakin, 1962, p. 7-8), in Ash Meadows northeast of Death Valley Junction, and near Shoshone about 25 miles south of Eagle Mountain. Ground-water discharge in these spring areas provides low flow to these segments of the Amargosa River during the winter when evapotranspiration is at a minimum. During the summer, the discharge of the springs is almost entirely lost by evapotranspiration, leaving little if any flow in the Amargosa River. During part of the year, ground-water discharges into the channel of Amargosa River near Eagle Mountain. In April 1962, a flow of about one-half a cubic foot per second was observed on the south side of Eagle Mountain.

The chief tributary of the Amargosa River in the Amargosa Desert is Carson Slough. It is along the eastern side of the valley and flows south-southwest where it joins the Amargosa River near Alkali Flat, just north of Eagle Mountain. The chief source of water in Carson Slough is from springs in Ash Meadows. During the summer months, Carson Slough dries up as all of the spring flow is consumed by evapotranspiration.

Climate

The climate of the Amargosa Desert is arid. The precipitation and humidity are low and summer temperatures and evaporation rates are high. Both daily and seasonally, temperature ranges are large. The U. S. Weather Bureau has only two weather stations within the Amargosa Desert, one at the extreme northwestern end of the area at Beatty, Nevada, and the other at Lathrop Wells, Nevada. The monthly and annual precipitation records at Beatty and Lathrop Wells for the 10-year period 1952-61 are given in table 1.

The average monthly and annual temperatures at Beatty and Lathrop Wells for the 10-year period 1952-61 are shown in table 2. The recorded extremes of temperature at Beatty range from 115°F, to 1°F., and at Lathrop Wells, range from 115°F. to 5°F.

The U.S. Weather Bureau does not maintain an evaporation station within the Amargosa Desert. However, the stations most representative of the Amargosa Desert may be Caliente, or possibly Boulder City, Nevada (Richardson, 1962, written communication).

Table 1. Average monthly and annual precipitation for Beatty and Lathrop Wells, Nev. 1952-61 (from published records of the U. S. Weather Bureau)

	Beatty											Lathrop Wells										
Month	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	Average	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	Average 1/
Jan.	1.98	.04	1.30	.99	.02	.67	.15	.46	.70	1.16	.75	--	--	1.31	.75	.05	.69	.35	--	--	.36	.63
Feb.	.02	.00	.68	.12	T	.61	1.12	.96	.47	.00	.40	--	--	.36	.32	.00	.20	.46	--	--	--	.26
Mar.	2.36	.15	.70	.00	.00	.29	.59	.00	.11	.50	.47	--	--	.70	.00	.00	.59	.40	--	--	--	.33
Apr.	1.48	.02	.34	.14	1.25	.39	1.52	T	.13	.00	.53	.95	--	T	.28	.91	.54	.75	--	.04	--	.49
May	.00	.05	.00	1.04	.03	1.29	.45	T	.00	.00	.29	--	--	.00	.33	.00	.83	.46	--	.00	--	.32
June	.03	.00	.01	.00	.00	.17	.00	.07	.45	.03	.08	--	--	T	.00	.00	.28	.00	--	.00	--	.05
July	.76	.12	.86	.04	.37	T	.00	.12	.09	.11	.25	--	--	.55	.24	.24	T	.00	--	.00	--	.20
Aug.	.00	.11	T	1.40	.00	.00	.39	.10	.00	.23	.22	--	--	.00	.75	.00	.00	.77	--	.00	--	.30
Sept.	.08	.00	.45	.00	.00	.06	.05	.69	.50	.00	.18	--	--	.00	.00	T	.00	.05	--	--	--	.01
Oct.	.00	.12	.00	.00	T	.74	.51	.00	.38	.00	.18	--	--	T	.00	.00	.85	.64	--	--	--	.29
Nov.	.58	.18	1.66	.26	.00	.75	.40	.00	2.29	.92	.70	--	--	1.30	.00	.00	1.68	.62	--	1.38	--	.72
Dec.	1.07	.00	.89	.32	.00	.94	.00	.99	.00	.34	.46	--	--	.35	.00	.00	.46	.00	--	.01	--	.16
Annual	8.36	.79	6.89	4.31	1.67	5.91	5.18	3.39	5.12	3.29	4.51	--	--	4.57	2.67	1.20	6.12	4.50	--	--	--	3.76

1/ Average for 5-year period, 1954-58

Table 2.--Average monthly and annual temperatures for Beatty and Lathrop Wells, Nev. 1952-61.

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

Beatty											
Month	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	Average
Jan.	37.5	46.9	42.0	34.0	44.6	37.3	43.6	45.6	--	45.4	37.7
Feb.	44.1	46.0	51.9	40.3	40.4	49.6	47.6	42.8	43.4	47.9	45.4
March	45.1	50.7	47.7	49.4	51.0	51.8	45.4	53.4	54.7	51.7	50.1
Apr.	58.9	57.6	63.6	54.2	57.0	56.9	54.6	62.5	61.5	60.3	58.7
May	68.9	58.6	71.6	63.7	67.1	62.9	68.7	64.7	66.4	64.8	65.7
June	71.9	73.2	75.1	--	77.4	78.5	72.5	78.4	79.5	78.7	75.8
July	82.3	84.5	84.2	79.8	80.1	81.1	--	84.6	83.9	85.0	82.8
Aug.	81.8	78.1	78.0	82.7	77.3	78.5	--	78.3	80.5	80.7	79.5
Sept.	74.9	75.6	--	74.0	75.1	72.5	--	71.0	76.2	68.9	73.5
Oct.	67.5	60.4	62.8	64.8	59.1	57.4	--	64.3	61.7	61.1	62.1
Nov.	46.7	50.9	53.5	49.4	50.8	46.0	52.0	52.2	50.2	47.3	49.9
Dec.	40.9	42.4	40.1	42.5	45.0	44.2	50.3	45.6	45.1	41.9	43.8
Annual	60.0	60.4	60.9	57.7	60.4	59.7	54.3	61.9	63.9	61.1	60.0

Lathrop Wells											
Month	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	Average 1/
Jan.	--	--	--	40.1	48.2	41.9	47.6	--	--	47.4	--
Feb.	--	--	--	43.9	43.8	54.7	52.6	--	--	--	--
March	--	--	--	53.2	54.9	56.3	50.8	--	60.5	--	--
Apr.	--	--	--	58.0	60.1	60.0	62.3	--	63.6	--	--
May	--	--	--	68.0	69.9	67.0	75.9	--	70.4	--	--
June	--	--	--	76.7	80.6	82.5	79.4	--	83.6	--	--
July	--	--	89.0	83.7	83.6	82.8	83.2	--	88.3	--	--
Aug.	--	--	82.5	86.9	80.5	--	86.4	--	83.2	--	--
Sept.	--	--	78.2	78.5	80.9	--	77.8	--	--	--	--
Oct.	--	--	67.8	69.5	64.2	--	--	--	--	--	--
Nov.	--	--	58.5	--	53.9	48.6	--	--	52.2	--	--
Dec.	--	--	44.8	--	48.3	47.1	--	--	45.7	--	--
Annual	--	--	--	--	64.1	--	--	--	--	--	--

1/ Average not indicated due to incomplete record.

The following evaporation figures, in inches, are from the Weather Bureau's 1961 Annual Climatological Summary for Nevada

BOULDER CITY, NEVADA

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
3.47	4.97	7.07	11.26	14.16	16.90	16.00	12.82	11.29	8.18	4.62	2.26	113.00

CALIENTE, NEVADA

--	--	--	7.19	9.40	12.07	11.06	7.90	6.68	4.07	--	--	--

The Amargosa Desert lies within the Las Vegas and Pahranagat growing season zones as defined by Hardman and Mason (1949, p. 12). These growing seasons are based in terms of crop adaptability rather than in terms of frost-free periods. In the Las Vegas zone, according to Hardman and Mason (1949, p. 14), practically all temperate zone plants having a dormant period can be grown. The winter temperatures are too low for commercial production of winter vegetables. Five cuttings of alfalfa may be obtained. In the Pahranagat zone, including the northern part of Amargosa Desert, occasional winter temperatures are too low for many of the tender plants grown in the Las Vegas zone. Three to four cuttings of alfalfa can be expected, and late maturing varieties of corn can be grown.

According to Houston (1950, p. 19), the average growing season for the Beatty area is 184 days (April 26 to October 27). The actual growing season would vary in different parts of the Amargosa Desert, but would tend to be longer toward the southern part of the area.

GEOLOGY

The Amargosa Desert in large part is surrounded and probably underlain at depth by rocks ranging in age from Cambrian to Devonian. Most are carbonate rocks interbedded with lesser amounts of quartzite and argillite. Rocks of possible Precambrian age crop out in parts of and adjacent to the Funeral Mountains southwest of Big Dune and are mainly quartzite and argillite. The rocks in the area west of Fortymile Canyon to Bare Mountain are mostly tuff and lava flows of Tertiary age. Valley fill of Tertiary and Quaternary age underlies most of the central part of the desert. Valley fill includes alluvial-fan deposits and fresh-water or brackish-water playa deposits. Deposits of Quaternary age, including stream deposits, playa deposits, and dune sand, occur locally. Plate 1 shows the general distribution of the valley fill and the older bedrock in the Amargosa Desert and its tributary areas; plate 2 shows a more detailed distribution of rock types within the restricted area of this report.

Rocks of Precambrian(?) and Paleozoic Age

Rocks of Precambrian(?) age were mapped in the eastern half of the Funeral Range by Noble and Wright (1958). Where examined, these rocks were mostly quartzite and argillite. Similar rocks north of the Nevada-California State line and west of Big Dune are included with Paleozoic clastic rocks (pl. 2). The largest of these outcrops, west of Big Dune, is mostly quartzite and the smaller ones are composed, about evenly, of sandstone, quartzite, and argillite.

The rocks of Paleozoic age surrounding the Amargosa Desert have been mapped as the Johnnie(?) Formation, Stirling(?) Quartzite, Carrara, Bonanza King, and Nopah Formations of Cambrian age; the Pogonip Group, Eureka Quartzite, and Ely Springs Dolomite of Ordovician age; undifferentiated dolomite of Silurian age, and the Nevada Formation and Devils Gate Limestone of Devonian age (Ball, 1907; Nolan, 1929, Hazard, 1937; Palmer and Hazzard, 1956; Johnson and Hibbard, 1957; Cornwall and Kleinhampl, 1961; Burchfiel, written communication, 1961). For the purpose of this report the Paleozoic rocks shown on plate 2 are grouped into carbonate and quartzite or argillite units without regard to formation designation. Cornwall and Kleinhampl (1961) described 11 Paleozoic formations in the Bare Mountain area having a combined thickness of more than 21,000 feet. The dominant rock types are limestone and dolomite. The limestone and dolomite are the principal aquifers and transmit ground water in contrast to the relatively impermeable quartzite and argillite.

Volcanic Rocks of Tertiary and Quaternary Age

Rhyolitic and dacitic tuff, including ashfalls, welded tuff, and some flows, constitute most of the rocks of Tertiary age. They crop out in the Yucca Mountain area between Fortymile Canyon and Bare Mountain southeast of Beatty. Cornwall and Kleinhampl (1961) described about 6,000 feet of Tertiary and Quaternary volcanic rocks in the Bare Mountain area.

Undifferentiated Tertiary rocks in the southern part of the area probably are also volcanic in origin, although some of them have been deposited in water.

The younger volcanic rocks consist of several volcanic cones adjacent to Yucca Mountain, and are reported to range from Pliocene to Recent age by Cornwall and Kleinhampl (1961). Most of the cones are small and are composed of explosive debris. One, southeast of Yucca Mountain, produced a small flow of scoriaceous basalt.

Valley Fill of Tertiary and Quarternary Age

Fresh- or brackish-water deposits occur throughout the basin of the Amargosa Desert but are most prominent south of Lathrop Wells. These deposits consist of several hundred feet of clay, silt, sand, gravel, and freshwater limestone. Individual layers are of limited extent both vertically and horizontally. They also include a number of ash beds deposited in water. Basaltic debris waspenetrated between 600 and 630 feet below land surface in well 17S/49-4a1. The total thickness is unknown. Inspection of the cuttings indicate that the basaltic material was transported by ephermeral surface flow similar to that which occurs today.

Layers of caliche were reported in the well above the basalt and relatively thin beds of limestone(?) have been reported in a number of other well logs. The caliche and limestone(?) layers probably represent ancient soil zones.

Generally, marginal to the lake bed deposits discussed above and adjacent to the mountain areas are deposits of boulders, gravel, sand, and silt. Commonly these are alluvial-fan or wash deposits and in general are coarser grained than the lake-bed deposits. At depth, however, present data do not permit separation of these two units. They were deposited more or less contemporaneously and locally interfinger. However, in general, the areas shown as alluvial-fan deposits probably are underlain by a substantially higher proportion of sand and gravel than the areas shown as lake-bed deposits.

Alluvium of Quaternary Age

The areas mapped as Recent alluvium along the stream courses are, in general, thin bodies of unconsolidated sand and gravel from which the fines have been washed by the occasional storm runoff. The large area mapped as alluvium near Death Valley Junction is in the lower part of the basin and generally is finer grained than elsewhere; it grades laterally into the playa deposits. Recent playa deposits occur just north of Eagle Mountain and in the vicinity of the northwest quarter of T. 17 S., R. 51 E.

Windblown sand forms numerous dunes throughout the desert and is deposited against many of the Paleozoic and Tertiary outcrops, especially around the northern rim of the basin. Big Dune, covering about 4 square miles, is especially prominent in the northwestern part of the area. The proximity of Big Dune to a number of Precambrian(?) or Paleozoic outcrops leads to the hypothesis that the dune overlies a bedrock high. The principal mass of Big Dune reportedly migrates seasonally to some extent. The limited migration may well be controlled by orographic effects and seasonal shifts of wind direction.

Structure

The substantial structural deformation, including several episodes of thrust and high-angle faulting in the region, have involved the Paleozoic rocks and to a lesser extent the Tertiary volcanic rocks. Strong deformation is evident in most outcrops of Paleozoic rocks. Deformation and erosion of Paleozoic rocks make it difficult to project the Paleozoic rock surface beneath the valley fill. Preliminary gravity data (Healey, written communication, 1962) in the Amargosa Desert suggest that the area may be divided into three more or less distinct topographic lows in the Paleozoic surface.

A continuous line of limestone outcrops, extending from Devils Hole (pl. 1) to the Paleozoic outcrops in Skeleton Hills along a gravity high, separates the playa area in T. 17 S., R. 51 E. from the area west of R. 51 E. Another line of outcrops, extending northward from the Funeral Mountains into the desert west of Big Dune, is alined with Paleozoic outcrops extending southward from Bare Mountain. This alinement coincides with a gravity high across the Amargosa Desert in this area. Major gravity lows occur beneath the playa in T. 17 S., R. 51 E., the Fortymile Canyon, and along the Amargosa River northwest of T. 14 S., R. 48 E.

The actual thickness of the valley fill in these three major subbasins is unknown, as the density of the volcanic tuff is similar to that of the valley fill. The gravity lows and highs roughly afford gravity differentiation between the valley fill and the Tertiary tuffs and the Paleozoic rocks. Thus, gravity data provide an approximate expression of the buried surface of the Paleozoic rocks. According to Healey (written communication, 1962), the depth to the Paleozoic rock surface may be on the order of 2,500 feet below land surface in the deeper part of the area southwest of Lathrop Wells.

Geologic History

The geologic history of the area is at present poorly understood; therefore, the following outline of events is highly generalized and approximate only.

1. During most of the Paleozoic time the area was a part of the Cordilleran geosyncline, and substantial thicknesses of limestone, dolomite, shale, and sandstone were deposited. In the Specter Range during the Early Cambrian time, more than 10,000 feet of clastic sediments and thin beds of limestone were deposited in fluctuating marine and nonmarine environments. During the early Middle Cambrian, there was transition from older coarse clastic rocks to younger thick carbonate formations. More than 12,000 feet of carbonate rocks were deposited in the Specter Range from near the middle part of the Middle Cambrian through Late Devonian. Unconformities in the Paleozoic rocks indicate periods of emergence and erosion.

2. Near the end of the Paleozoic Era a period of emergence and extensive erosion occurred. This was followed by a period of oscillation between marine and continental conditions which culminated in complete emergence. Orogeny and erosion probably continued into Tertiary time. The dominant deformation was thrust and associated faulting which probably was preceded and accompanied by extensive block faulting.

3. Vast quantities of volcanic rocks, predominantly tuff, were deposited during the Tertiary and early Quaternary time. Basin and range

normal faults developed in late Tertiary and Quaternary time. The present topographic relief of the Amargosa Desert probably was formed largely during this interval.

4. Since the late Tertiary time erosion of the surrounding mountains and deposition in the valleys has taken place. Deposition has been principally in a combination of subaerial and lacustrine environments. Deposits range from clay to very coarse gravel and locally include spring and probably some evaporite deposits. Alluvial fans spread out from the highlands to an extensive playa that occupied about the southern half of the Amargosa Desert. Dissection of the playa probably began in the late Pleistocene.

Since the late Pleistocene, aeolian sand, alluvial detritus, and playa deposits have been deposited in topographically favorable areas in the Amargosa Desert.

Water-Bearing Properties of the Rocks

Rocks of Precambrian(?), Paleozoic, and Tertiary age are exposed in the mountains surrounding the Amargosa Desert. They include clastic, carbonate, and volcanic rocks which have been folded, faulted, and metamorphosed in varying degrees. As such, they are not good aquifers. However, locally developed secondary openings, due to faulting, folding, and weathering, have resulted in the development of a secondary permeability for these rocks. Fractures in the carbonate rocks may have been enlarged by solutions and locally increased the secondary permeability.

Secondary permeability in the carbonate rocks is the principal source of ground-water supply in the adjoining area to the northeast at the Nevada Test Site (Schoff, Sl. and Winograd, I. S. 1962, p. 111-113). Most of the discharge from the springs in Ash Meadows probably involves ground water moving through secondary openings in the Paleozoic rocks, especially the carbonate units. Water in Devils Hole fills solution developed caves. A sketch profile (P. M. Neely, written communication, January 9, 1955) prepared from information obtained by a group of divers from the National Speleological Society indicates that caverns and connecting conduits extend more than 130 feet below water level in Devils Hole and laterally for more than 300 feet. Further, a passage which is partly above the water-level altitude of Devils Hole contains air. It is likely also that several existing wells in the Amargosa Desert obtain at least parts of their water supply from carbonate rocks that locally have secondary permeability.

Fractures or solutions openings locally may transmit substantial quantities of water, partial examples of which may be several of the springs in Ash Meadows. Further, although the total volume of water moving through the bedrock may be relatively large, the proportion of fractures to total volume of the carbonate rocks is relatively small. Therefore, the success of a well penetrating the bedrock is dependent upon the well bore tapping enough of the secondary water-bearing zones to yield adequate amounts of water. At present, data are insufficient to determine the chances of intercepting a sufficient number of water-bearing zones in the bedrock underlying the valley fill.

The Tertiary and Quaternary volcanic rocks underlying the valley fill are composed primarily of ash-fall tuffs which is generally capable of transmitting only small amounts of water through fractures. The specific capacity of wells developed in the tuff generally is less than a few gallons per minute per foot of drawdown (Winograd and West, written communication, 1962) and therefore, generally the yield would be inadequate for an irrigation water supply. However, investigations at the Nevada Test Site indicate that a specific capacity of as much as 30 gallons a minute per foot of drawdown was obtained in one well developed in fractured welded tuff.

The valley fill principally includes Pleistocene lake deposits and alluvial-fan debris which have been eroded from the surrounding mountains. Overlying them are relatively thin surficial deposits of stream alluvium and aeolian sand. The alluvial-fan deposits of unknown thickness are unconsolidated or weakly indurated, water-lain rock debris ranging in size from boulders to clay. Saturated zones of well-sorted sand or gravel in the alluvial-fan deposits yield moderate to large amounts of water to wells. Of six wells in T. 16 S., R. 48 E., for which reported information is available, specific capacities ranged from 20 to 250 gallons a minute per foot of drawdown; for four of these wells specific capacities ranged from 40 to 110. The coarse deposits in the valley fill are the principal source of ground water in the valley.

The lake and playa deposits consist largely of silt and clay and some lenses of sand and fine pebble gravel. The lake deposits locally contain deposits of water-lain volcanic ash and fresh-water limestone. The sand and gravel strata are the best water-yielding zones in the lake and playa deposits.

The alluvium of Recent age along the courses of some intermittent streams is permeable but thin and generally above the water table, except locally in the southern part of the area. Aeolian sand deposits are found over much of the area. They are above the water table, but their relatively high permeability permits ready absorption of precipitation on their surfaces. The Recent playa deposits are fine-grained and saturated to within a few feet of land surface, but are of low permeability and yield water slowly to wells.

WATER RESOURCES

Surface Water

Surface water flows from Oasis Valley into the northern part of Amargosa Desert through the Amargosa Narrows near Beatty only following periods of heavy precipitation. According to Malmberg and Eakin (1962, p. 26) some ground water moves through the Amargosa Narrows as underflow in stream deposits. Part of the underflow is diverted by a ditch intercepting the ground-water table 6 to 10 feet below land surface.

Stream flow occurs at the southern end of Amargosa Desert, near Eagle Mountain, during part of the year. It is supplied largely from spring discharge in the Ash Meadows area and ground water in the vicinity of the playa during the winter when evapotranspiration is at a minimum. In April 1962 flow in the channel just south of Eagle Mountain was estimated to be about one-half a cubic foot per second. Flow may occur in any dry channels within the area for short periods after high-intensity precipitation.

Four small perennial ponds are within the Amargosa Desert. The three largest ponds are about 1 mile east of Ash Tree Spring and about 4 miles west of Crystal Spring (pl. 3). These three ponds are locally known as the "Clay Pits". All are the result of open pit clay mining in the early 1900's. The ponds are supplied principally by ground-water inflow. Water is discharged from the ponds by evapotranspiration. The balance between recharge to and discharge from the ponds is sufficiently close so that the ponds are maintained throughout the year.

The temperature of the water in the northernmost of the three ponds was 76°F. when measured on August 22, 1962, and the specific conductance was 1,200 micromhos; the southernmost pit had a water temperature of 70°F. when measured on June 16, 1962, and the specific conductance was 1,590 micromhos. The relatively high conductivity of the water probably results from a high evaporation rate causing an increase in concentration of salts. The differences in the water temperature probably are due to the difference in time of year when the two measurements were made.

The fourth pond, the smallest of the four, is in the northwest quarter of sec. 21, T. 17 S., R. 51 E. The pond is in a pit which is approximately 10 feet wide, 30 feet long, and 10 feet deep. The majority of the ponds contained water when observed in February (Winograd, written communication, 1962); however, by July all but one pond were completely dry. From February until mid-August the water level in this pond declined less than 1 foot.

Ground Water

Occurrence and Movement: Within the principal area of this report ground water occurs in the valley fill and the underlying volcanic and Paleozoic carbonate rocks. Recharge to the ground-water system is supplied to some extent by precipitation within the surficial drainage area, including the tributaries of Oasis Valley, Crater Flat, Fortymile Canyon, Jackass Flats, Rock Valley, and the northern and western flanks of the Spring Mountains. Within the drainage area of Amargosa Desert, which covers about 2,600 square miles, recharge to the ground-water reservoir probably is derived largely from precipitation in the higher mountains. In addition to the limited amount of recharge from precipitation within the surficial drainage area, recharge to Amargosa Desert apparently is supplied by underflow through Paleozoic and possibly Tertiary rocks outside the surface drainage area. The principal source of this underflow may be from the higher parts of the Spring Mountains and to a lesser extent from the area to the northeast.

Although the ground water in Amargosa Desert is part of a single large system, elements of that system are partially separated locally. This separation may be identified by variations of head or artesian pressure between some deep and shallow wells and between some wells and springs tapping alluvium and carbonate rocks.

The water-level contours shown on plate 3 indicate that ground water in the valley fill is moving southeastward along the axis of the Amargosa Desert from north of Big Dune toward Death Valley Junction. The tributary valleys, of which Fortymile Canyon is the principal one, supply some water. Movement from the east is shown in the vicinity of T. 17 S., R. 51 E., and from the springs issuing from the carbonate rocks along the east side of Ash Meadows. The artesian head in the carbonate rocks is higher than that to the west and north in the valley fill.

The springs and subsurface discharge from the carbonate rocks supplies water to the valley fill. The relatively steep water-level slope west of the springs in Ash Meadows closely parallels the general westward slope of the land surface. The closely spaced contours near the northwest corner of T. 18 S., R. 50 E., may reflect upward leakage which discharges from Ash Tree Spring and partial return flow to ground water in the valley fill.

The relatively high water levels in the eastern part of T. 16 S., R. 49 E., probably indicate upward leakage from the underlying carbonate rocks into the water-bearing zones supplying some of the deeper wells in that area.

The area around the southeast quarter of T. 16 S., R. 48 E. shows some irregularity of contours. Part of the irregularity is caused by differences of head in deep and shallow wells in the area, and part is caused by withdrawal of water for irrigation.

In summary, the water-level contours show the generalized features of the water surface of the ground-water reservoir. In detail, conditions are most complex, because of the merging of ground waters in two partially separated systems -- one in the valley fill and the other in the carbonate rocks. Each enters the area under a different head. The ground-water in the carbonate rocks generally is under higher head -- some discharges from springs and moves into the valley fill; some moves upward into the ground-water system in the valley fill where permeability of the deposits permits.

The slope of the water-level surface generally conforms to the slope of the land surface. However, the gradient of the water surface commonly is somewhat less than that of the land surface. In the southern part of the area north of Death Valley Junction the water-level gradient is about 12 feet per mile compared to the land-surface gradient of about 13 feet per mile -- a ratio of 12 to 13 (1 to 1.1); in the vicinity of Big Dune the ratio of gradients is about

1 to 1.25 and north of Lathrop Wells the ratio of gradients is about 1 to 7.5. The net effect of this general relationship is that the depth to water in wells increases northward. For example, at Death Valley Junction, the depth to water in well 25N/5-14c1 is about 2 feet; in the southwest corner of T. 16 S., R. 49 E., the depth to water is 40 to 50 feet; in the northern part of T. 16 S., R. 48 E., the depth to water is 125 to 135 feet; and near Lathrop Wells, the depth to water is on the order of 360 feet. Local variations occur and depend in part on the head in the water-bearing zone developed by a particular well.

Water-Level Fluctuations: Water-level fluctuations in general reflect changes in the amount of ground water in storage. An annual rise and fall of water-levels correspond to an annual cycle of changes in the relative quantities of recharge and discharge. The fluctuations are small in areas remote from areas of recharge or discharge, and the largest changes commonly are caused by pumping of ground water.

Water-level measurements made by the U.S. Geological Survey in the Amargosa Desert consist of random yearly measurements in the period 1952-62 (table 5). The longest record, that for well 16S/49-31b1, includes only 10 measurements. Water levels were measured principally in the eastern part of T. 16 S., R. 48 E., and the western tier of sections in T. 16 S., R. 49 E. Thus, the measurements are not representative of the entire area. Because the wells were measured only once a year in most cases, the seasonal effect of pumping and evapotranspiration is evident only in a general way.

Hydrographs for eight wells are shown in figure 2. The hydrographs are based on measurements made by personnel of the State Engineer's office.

Water levels taken between 1952 and 1957 generally show a relatively constant level; those recorded after 1957 commonly show a decline. In the area where periodic measurements were made only 12 out of about 42 wells were drilled prior to 1957. The water-level decline in the wells measured between 1957 and 1962 ranges from 0.1 foot to 6.1 feet over the 5-year period, and averages about 0.7 foot per year. Most of the decline may be due to pumping, but some may be due to deficient recharge.

Estimated Average Annual Recharge: Recharge to Amargosa Desert is derived in part from precipitation within the surficial drainage area shown on plate 1 and in part from ground-water underflow through bedrock from the east and northeast beyond the drainage area.

That part of the recharge occurring within the drainage area can be estimated as a percentage of the average annual precipitation. The average annual precipitation can be estimated from a generalized map showing the distribution of precipitation in Nevada (Hardman and Mason, 1949, p. 10). This map is divided into zones of precipitation, based largely upon records of precipitation, altitude, and types of vegetation. In general, precipitation increases

Table 5.--Records of water-level measurements in selected wells in the Amargosa Desert, Nevada-California.

Altitudes given are in feet above mean sea level for the land-surface datum at the well. Altitudes given in whole feet are interpolated from topographic maps. Altitudes given in feet and tenths were determined by plane table.
Measurements. All measurements were made by the U.S. Geological Survey. All measurements have been adjusted to depth below land surface.
Well number. See page 4 for description of well numbering system.

Well number	Altitude (feet)	Date	Depth to water (feet)
13S/47-35a1	2,788	7-15-61	282.5
		7-12-62	282.3
14S/48-16c1	2,608	5-24-56	252.8
		7-12-62	253.1
15S/50-18c5	2,656.1	5- 8-52	346.7
		6-22-53	339.4
16S/48-15a1	2,375.5	2-14-55	95.1
		5-23-56	96.6
16S/48-15b1	2,373.3	2-14-55	95.7
		5-23-56	95.6
		7-14-62	97.2
16S/48-24	2,367	2-12-55	94.7
		2-14-55	94.7
		5-24-56	94.4
16S/48-24d1	2,357.1	2-14-55	88.8
		2-14-56	88.6
16S/48-25a1	2,343.4	5- 7-52	79.2
		10- 9-52	79.3
		8-28-57	79.6
		9- 3-58	80.3
		9-15-59	81.0
		3- 7-61	82.4
		7- 9-62	84.5

Well number	Altitude (feet)	Date	Depth to water (feet)
16S/48-25c1	2,326.6	5- 7-52	64.2
		10- 9-52	64.3
		8-25-53	63.8
		8-28-57	65.7
		9- 3-58	64.8
		9-15-59	64.8
		3- 7-61	63.9
		7- 9-62	67.1
16S/48-26a1	2,336	5- 7-52	71.2
		10- 9-52	71.3
		8-25-53	71.3
		8-25-57	71.5
		9- 3-58	71.9
		9-15-59	72.1
		3- 7-61	73.7
		7- 4-62	75.7
16S/48-36a1	2,323.7	5- 7-52	62.9
		3-14-54	63.2
		2-12-55	63.1
		8-28-57	67.4
		9- 3-58	66.5
		9-15-59	67.1
		3- 7-61	68.0
		7- 5-62	67.5

Well number	Altitude (feet)	Date	Depth to water (feet)
16S/48-36d2	2,304	5- 7-52	49.6
		8-25-53	49.9
		3-15-54	49.8
		2-12-55	49.9
		8-28-57	49.9
		9- 3-58	50.3
		9-15-59	50.3
		3- 7-61	52.6
		7- 5-62	54.1
16S/49-18d2	2,375.1	8-27-53	104.0
		2-12-55	103.1
		5-24-56	103.1
		8-28-57	103.2
		2-15-58	103.4
		9- 4-58	103.7
		9-15-59	104.7
		3- 7-61	104.4
		6-28-62	108.5
16S/49-19a1	2,373.6	2-12-55	103.7
		5-24-56	103.7
		8-28-57	103.8
		9- 3-58	104.8
		9-15-59	105.6
		3- 7-61	Plugged
16S/49-19b1	2,370.8	2-12-55	104.7
		12- 6-55	101.7
		5-24-56	99.7
		8-28-57	99.9
		9- 3-58	100.5
		3- 7-61	102.0
		7- 9-62	106.0

Well number	Altitude (feet)	Date	Depth to water (feet)
16S/49-19d1	2,362.8	2-14-55	94.4
		5-24-56	94.7
		8-28-57	94.8
		9- 3-58	95.3
		9-15-59	95.9
		3- 7-61	101.2
		7- 9-62	99.0
16S/49-30b1	2,348.2	5- 7-52	83.6
		10- 9-52	83.7
		3-16-54	83.7
		2-12-55	83.8
		8-28-57	84.6
		9- 3-58	84.5
		9-15-59	Plugged
16S/49-31b1	2,326.3	5- 7-52	66.1
		10- 9-52	66.3
		8-25-53	66.5
		3-16-54	66.3
		2-12-55	66.4
		8-28-57	66.4
		9- 3-58	66.5
		9-15-59	67.1
		3- 7-61	68.0
		6-26-62	69.4

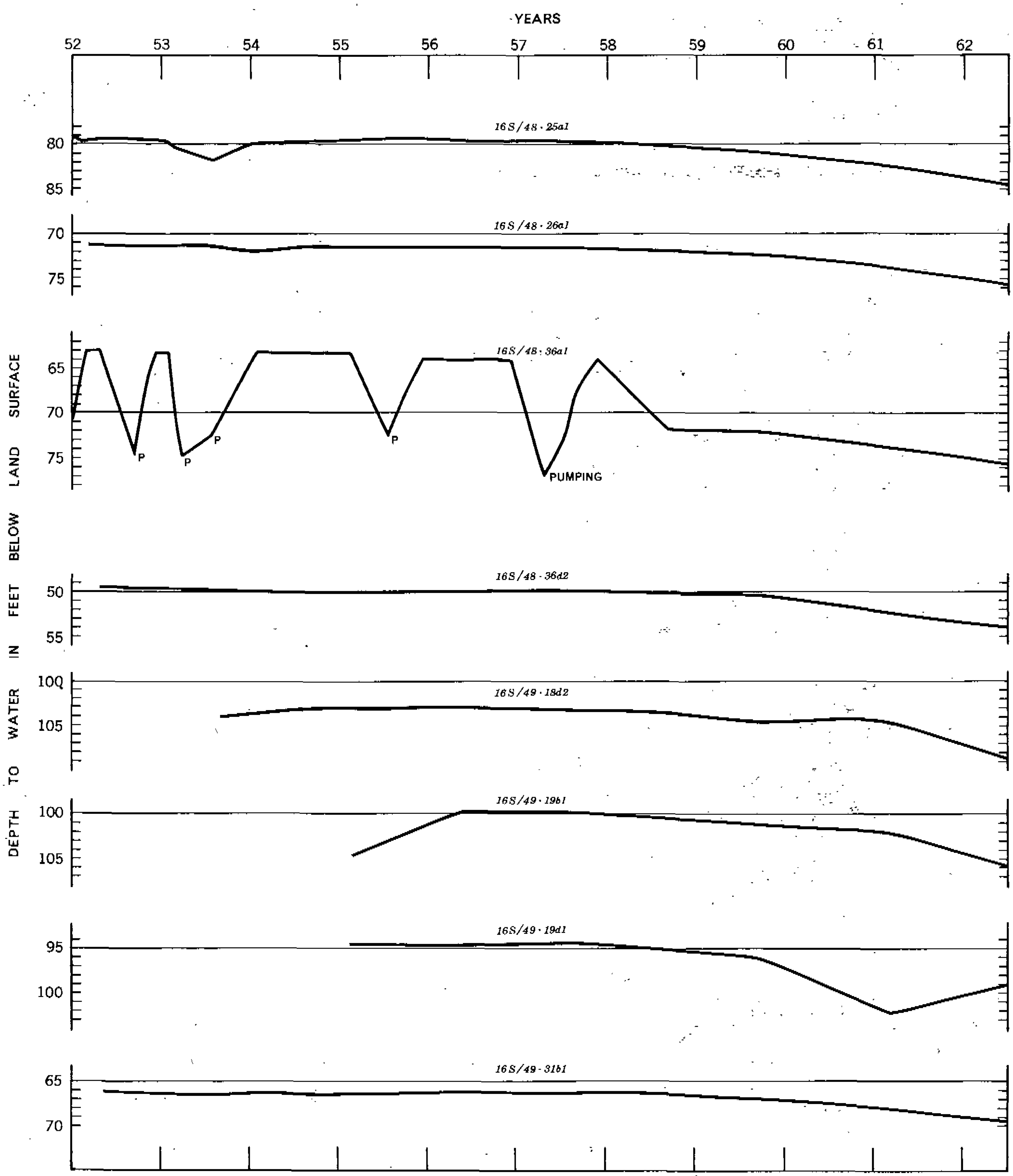

Figure 2. Hydrographs for 8 wells in Amargosa Desert

with altitude, the greater amount commonly occurring on the highest mountains. A comparison of the precipitation map with more recent topographic maps (scale 1: 250,000) indicates that the precipitation zones suggested by Hardman and Mason roughly coincide with altitude contours, although on a state-wide basis the precipitation zones rise somewhat in altitude in the southern one-third of the State. The map suggests that in the area lying below 5,000 feet the average annual precipitation is less than 8 inches, at altitudes between 5,000 and 6,000 feet, it ranges from 8 to 12 inches; and from 6,000 to 7,000 feet, it ranges from 12 to 15 inches.

The total average annual precipitation on each zone is computed by multiplying the average precipitation for each zone by the area of that zone. Based on these computations, the average annual precipitation within the surficial drainage area totals 875,000 acre-feet.

A very small percentage of precipitation that falls on the area recharges the ground-water reservoir. A method for crudely estimating the probable average annual recharge from precipitation has been developed by Eakin and others (1951, p. 79-81). Based on this method, the recharge is estimated as a percentage for each precipitation zone in the drainage area as follows: zone of less than 8 inches of precipitation, none; 8- to 12-inch zone, 1 percent; 12- to 15-inch zone, 7 percent; and 15- to 20-inch zone, 15 percent. The reliability of the estimates so obtained, of course, is related to the degree to which the assigned values approximate the actual precipitation, and the degree to which the assumed percentages represent the equivalent amount of the actual recharge. Neither of these factors is known precisely enough to assume a high degree of reliability for any one valley. However, experience suggests that the resulting estimates commonly are a reasonable approximation of average recharge.

Table 6 summarizes the computation of estimated recharge from precipitation within the surficial drainage area of Amargosa Desert, as shown on plate 1. The approximate recharge (column 5) for each zone is obtained by multiplying the figures in columns 2, 3, and 4. For example, for the 12- to 15-inch zone, the estimated recharge is: 9,000 acres x 1.12 feet x .07 (7 percent) = 700 acre-feet. The total average annual recharge from precipitation so estimated is 1,500 acre-feet, most of which is derived from precipitation in the Oasis Valley and Fortymile Canyon, which are tributary to Amargosa Desert.

Table 6.--Estimated average annual ground-water recharge from precipitation in Amargosa Desert and tributary areas

Precipitation zone (inches) (1)	Approximate area of zone (acres) (2)	Average annual precipitation (feet) (3)	Percent recharged (4)	Estimated recharge (feet) (2x3x4 ÷ 100) (5)
12-15	9,000	1.12	7	700
8-12	96,000	.83	1	800
< 8	1,570,000	.5	-	---
		Recharge from precipitation		1,500

For Oasis Valley, Malmberg and Eakin (1962, p. 24) estimated that the average recharge from precipitation is about 250 acre-feet a year. Thus the estimated average recharge to Amargosa Desert below the Amargosa Narrows would be about 250 acre-feet a year less than the 1,500 acre-feet shown in table 6 for the entire drainage area, or roughly 1,200 acre-feet a year.

In considering the magnitude of recharge by underflow through bedrock from areas to the east and northeast beyond the surficial drainage divide, the validity of the method of estimating ground-water recharge from precipitation is handicapped by the uncertainity of the effective tributary area. There is a strong suggestion that a large part of the water discharged from the springs in Ash Meadows ultimately is derived from precipitation in the Spring Mountains (Loeltz, 1960, p. 1917-1918).

Using the same method discussed above, the average annual recharge to ground water from precipitation on the northern and western slopes of the Spring Mountains, an area which may contribute recharge to Amargosa Desert, is estimated to be about 3,500 acre-feet. If all of this recharge reaches the ground-water reservoir in Amargosa Desert, then the combined average recharge from precipitation within the surficial tributary drainage area and the northern and western slopes of Spring Mountains would be nearly 5,000 acre-feet.

There is a definite possibility that this estimate is low because the high proportion of permeable Paleozoic carbonate rocks in the Spring Mountains may result in an above-average percentage of precipitation being recharge. At present, however, no data are available on which to assign different values for percentage recharge for the several precipitation zones. The estimate also may be low because recharge to Amargosa Desert from the Spring Mountains may be derived from a much larger area than that assumed for this computation. For example, Maxey (1948, p. 117) estimated that recharge from the southwestern slopes of Spring Mountains to Pahrump Valley is on the order of 23,000 acre-feet a year. Little water is consumed by phreatophytes in Pahrump Valley, except that supplied by water discharged from the springs. If these estimates are correct, about 13,000 acre-feet might be available from the Spring Mountains as underflow to the Ash Meadows spring system, which discharged about 17,000 acre-feet a year (p. 40).

If an average of 13,000 acre-feet a year actually were supplied to the Ash Meadow spring system from the Spring Mountains, then the remaining 4,000 acre-feet discharged from the springs may be derived by underflow through carbonate rocks from the northeast. Additionally, some water is discharged from the carbonate rock system by upward leakage into the valley fill, as suggested by the water-level contours on plate 3, about 7 miles south of Lathrop Wells. Thus, based on these assumptions the total estimated recharge to Amargosa Desert from precipitation within the surficial drainage area plus recharge to Paleozoic carbonate rocks from beyond the drainage area would be roughly 20,000 acre-feet a year.

The general known and inferred conditions relating to the direction of ground-water movement in Paleozoic carbonate rocks in the area north and northeast of Amargosa Desert and the favorable recharge conditions in the Spring Mountains seem to support the hypothesis that recharge from the Spring Mountains probably contributes most of the water discharged by the springs in Ash Meadows. Assuming this to be correct, the underflow in Paleozoic carbonate rocks from the area north and northeast of Amargosa Desert may be on the order of only a few thousand acre-feet a year. The difficulty of obtaining a satisfactory estimate of ground-water recharge for Amargosa Desert, as illustrated here, demonstrates the need for special investigations that would lead to improved methods and techniques of estimating recharge for use in Nevada. Such investigations have been suggested in previous reports of the Ground-Water Reconnaissance Series (Eakin, T. E., December 1960, p. 20; Eakin, T. E., January 1961, p. 29, 30).

Estimated Average Annual Discharge:

Natural Discharge:--Ground water is discharged from Amargosa Desert by the natural processes of transpiration of vegetation, evaporation from the soil and free-water surfaces, and to a lesser extent by stream flow and underflow from the Alkali Flat southeast of Death Valley Junction. If the total discharge by these processes could be determined precisely, a highly reliable estimate of ground-water discharge could be made. However, in the absence of precise data, annual rates of evapotranspiration by native vegetation using ground water can only be approximated from work done in other areas. 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, Robinson (1958) 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 crude estimates of discharge by transpiration, evaporation, and underflow are summarized in table 7.

The principal area of phreatophytes is in T. 17 S., R. 50 E., and T. 18 S., R. 51 E., along the southeastern margin of the valley. Phreatophytes in this area obtain their water primarily from spring discharge and from some shallow ground water derived mainly from spring discharge. Other small areas of phreatophytes occur along the Amargosa River channel and in the unnamed playa in the northeastern part of the valley. These plants obtain their water supply from shallow ground water.

There are two main areas of evaporation within the valley. The largest extends from about 2 miles southwest of Ash Tree Spring to Eagle Mountain. The other smaller area is in the playa in the northwestern part of T. 17 S., R. 51 E.

Data are not available to make a direct estimate of the amount of ground-water discharged by underflow and surface flow through the gap at Eagle Mountain from Amargosa Desert. However, the general hydrogeologic conditions suggest that the magnitude of the outflow is on the order of 500 acre-feet a year.

The total natural discharge from Amargosa Desert is estimated to be about 24,000 acre-feet per year (table 7).

Table 7.--Estimated average annual ground-water discharge by natural processes from the Amargosa Desert, Nevada-California

Process of Ground-water discharge	Area (acres)	Approximate discharge (acre-ft. per year)
Native vegetation:		
Principally mesquite, saltgrass, rabbit-brush in varying proportions; density moderate to low but locally moderate to heavy; depth to water ranges from a few to about 20 feet, averaging about 10 feet below land surface. Average annual use about 0.5 foot	2,000	1,000
Principally meadow grass, mesquite, willow, salt grass, salt cedar in varying proportions; depth to water 0 to 5 feet; largely watered by discharge from springs and shallow ground water. Includes about 1,200 acres with an estimated average annual ground-water use of about 1.25 feet; and about 2,800 acres of marsh grasses and 200 acres of pasture grass and milo which normally is flooded by spring discharge. Average annual use about 3 feet	4,200	10,500
Evaporation:		
Rate could approach potential evaporation rate from free-water system but is limited by amount supplied from ground-water reservoir through capillary openings; annual rate estimated at 1 foot	12,000	12,000
Outflow:		
Ground-water and surface-water outflow from the valley at Eagle Mountain (estimate based on general hydrogeologic conditions at the narrows by Eagle Mountain).		500
Estimated average annual discharge		24,000

Ground-water discharge from Amargosa Desert may be estimated in another way, which affords a partial check on the discharge by evapotranspiration. The several springs in the Ash Meadows area are supplied largely by ground water moving through Paleozoic carbonate rocks as discussed previously. Much of the spring discharge flows overland and is consumed by transpiration of vegetation and is evaporated, but part returns to the ground-water reservoir and is then discharged by evapotranspiration, surface flow, or underflow from the Amargosa Desert. In either case the water issuing from the springs is finally discharged from the area. Thus, as estimate of the spring discharge provides a partial check on the total ground-water discharged from Amargosa Desert by natural processes.

Table 8 lists miscellaneous measurements for 24 springs in the Ash Meadows area. All were measured during the summer of 1962. The combined discharge of these springs in the summer of 1962 was about 10,300 gpm, or 23 cfs. Measurements made in the winter of 1953 on 17 of the larger of these springs indicated a total discharge of about 10,900 gpm, or somewhat more than 24 cfs. The measurements made during the winter of 1953 are roughly 5 percent larger than those made in the summer of 1962. The limited data suggest relatively uniform discharge from the springs as a group, although some seasonal variations are to be expected because of the effect of high rates of evapotranspiration during the summer months. Assuming that flow from the springs is relatively uniform, discharge of about 17,000 acre-feet a year is indicated.

Table 8. -- Records of Springs in the Amargosa Desert, Nevada-California

(See page 4 for description of numbering system.
Waterbearing unit: Lb, Lake bed; Tr. travertine.
m: Measured by U. S. Geological Survey; all others reported.)

No. for this report	Name of Spring	Water bearing unit	Yield (gpm)	Temp. (°F.)	Conductivity	Date of Observations
17S/49-35dl.	Ash Tree	Lb	10m	74	---	5-8-52
			9m	--	350	7-31-62
17S/50-9al.	Fairbanks	Lb	2357	--	--	1910
			2043	-	--	7-14-23
			1756	-	--	8-16-46
			1661m	82	--	2-1-53
			1702	-	--	6-?-61
			1715m	81	650	7-23-62
17S/50-10cl.	Bell; Soda	Lb(?)	85m	72	--	2-1-53
			87	-	--	6-?-61
			79m	73	725	7-31-62
17S/50-15al.	Rogers	Lb	674	-	--	12-24-23
			717m	84	--	2-1-53
			664	-	--	6-?-61
			736m	82	650	7-29-62
17S/50-22al.	Longstreet	Lb	1257	-	--	3-27-21
			1239m	80	--	2-3-53
			1271	-	--	6-?-61
			1042m	82	640	7-29-62
17S-50-23bl	---	Lb	115m	94	--	2-3-53
			193m	94	650	7-23-62
17S/50-35al.	---	Lb	88m	91	--	2-3-53
			140m	92	640	7-24-62
17S/50-35bl.	---	Lb	17m	83	620	7-23-62
17S/50-35dl.	---	Lb	25m	90	---	1-31-53
			6m	94.5	620	7-24-62

Table 8.--Records of Springs in the Amargosa Desert, Nevada-California. (continued)

No. for this report	Name of Spring	Water-bearing unit	Yield (gpm)	Temp. (°F)	Conductivity	Date of Observations
18S/50-3a1.	Crystal Pool	Lb	4266	-	--	6-?-61
			3071	-	--	4-1-50
			2815m	89	--	1-31-53
			2981	-	--	6-?-61
			2824m	91	650	7-29-62
18S/50-11d1.	Davis Ranch	Lb	718m	74	--	2-2-53
			397m	77	750	7-25-62
18S/50-11d2.	Davis Ranch	Lb	174m	74	--	2-2-53
			5m	-	--	7-25-62
18S/50-11d3.	Davis Ranch	Lb	38m	70	--	2-2-53
			30m	72	775	7-25-62
18S/50-12c1.	--	Lb	52m	73	--	2-2-53
			11m	80	725	7-25-62
18S/51-7d1.	King; Point of Rock	Tr	2128	-	--	7-17-43
			1247m	89.5	--	1-31-53
			685	-	--	6-?-61
			1078m	90	675	7-25-62
18S/51-7d2.	Indian Rock	Tr	134	-	--	3-31-50
			69m	90	--	1-31-53
			119	-	--	6-?-61
			22m	92	640	7-25-62
18S/51-7d3.	Indian Rock	Lb	343m	90	--	1-31-53
			300	-	--	6-?-61
			379m	91.5	645	7-26-62
18S/51-7d4.	---	Lb	19m	93	650	7-26-62
18S/51-7d5.	---	Lb	2m	93	650	7-26-62
18S/51-18b1.	Jack-rabbit; Roger's	Lb	498m	82	--	2-1-53
			638	-	--	6-?-61
			587m	-	675	7-27-62

Table 8.--Records of Springs in the Amargosa Desert, Nevada-California. (continued)

No. for this report	Name of Spring	Water-bearing unit	Yield (gpm)	Temp. (°F.)	Conductivity	Date of Observations
18S/51-19a1.	Big; Deep; Ash Meadows	Lb	1122	-	--	1916
			1055^{m}	82.5	--	2-2-53
			1078	-	--	6-?-61
			1036^{m}	-	--	7-19-62
			1036^{m}	-	--	7-26-62
			-	83	700	8-22-62
18S/51-29b1.	---	Lb	1^{m}	72	790	7-28-62
18S/51-30a1.	---	Lb	12^{m}	72	--	7-27-62
18S/51-30d1.	Last Chance	Lb	1^{m}	68	575	7-28-62

Water-level data used in preparation of the water-level contour map (pl. 3) further suggest that ground water from the Paleozoic carbonate rocks in part leaks upward into the ground-water reservoir in the valley fill. This is indicated, for example, by the closely spaced contours in the southeastern part of T. 16 S., R. 49 E., and by the high water levels in some of the wells immediately north in the same township. The amount of this upward leakage cannot be directly estimated, but may be several thousand acre-feet a year. Collectively then, ground-water discharge from the carbonate rocks is more than 17,000 acre-feet and may exceed 20,000, if upward leakage in the ground-water reservoir is included. This discharge accounts for most of the 24,000 acre-feet estimated as ground-water discharge by natural processes.

Because the Paleozoic carbonate rocks transmit ground water into Amargosa Desert from beyond the surficial drainage area, it may be assumed also that some ground water may leave Amargosa Desert by similar processes. Hunt and Robinson (1960, p. 273) hypothesized underflow from Amargosa Desert along a transverse fault in the Funeral Mountains to supply water to springs on the east side of Death Valley. If this is correct, and assuming that the total discharge of the springs on the east side of Death Valley, near Furnace Creek, were derived from Amargosa Desert, the quantity probably would be less than 3,000 acre-feet a year. However, the water-level contours (pl. 3) do not indicate westward movement to the west of California Highway 127.

Discharge from wells.--Ground-water discharge from wells is largely used for irrigation. Most of the water applied is used by crops or evaporated in the process of irrigation. Undoubtedly, however, some infiltrates to the ground-water reservoir.

Irrigation from wells has been carried on for many years, but the amount of water pumped was very small prior to about 1955. Since that time there has been an increasing amount pumped, although most of the wells drilled for irrigation are not yet in use. Eighteen wells were pumped, at least to a limited extent, for irrigation during the summer of 1962. However, no measurements were made of the seasonal pumpage. As an approximation, a rough computation may be made from the irrigation requirements of the crops grown and the acreages planted. An estimated 800 acres of alfalfa and milo maize and 600 acres of wheat and barley were irrigated during 1962.

Irrigation requirements, interpolated from Houston (1950, p. 21, 23, 24), would be about 3.4 feet for alfalfa, 1.8 feet for milo maize (assumed approxiximately equivalent to corn), and 1.4 feet for small grains. As the acreage of alfalfa and milo maize is not separated in the available information, it is further assumed that about 2.5 feet of water was the average requirement for the total acreage of alfalfa and milo maize. Based on these assumptions, the irrigation requirements in 1962 would have been about 3,000 acre-feet.

Pumpage for domestic or public supply by comparison was very small and probably did not exceed 100 acre-feet.

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 plus that which might become available by artificial recharge and water returned to the ground-water system by infiltration of irrigation or waste water.

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 available supply or at the other exteme 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 natural area of discharge or underflow from the basin.

Ground-water underflow 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 physical conditions in Amargosa Desert suggest that the estimate of discharge is the better basis on which to estimate perennial yield in the light of present information. Thus, the tentative perennial yield may be about 24,000 acre-feet a year. Of this, about 17,000 acre-feet can be obtained by full development of the springs in Ash Meadows. The remaining amount would be available for development by wells largely in the area northwest and northeast of the springs. Unused discharge from the springs that is returned to the ground-water reservoir downgradient from the springs toward Death Valley Junction could be withdrawn for use. However, the chemical quality generally becomes progressively poorer by this recycling and the suitability for the intended use should be evaluated carefully.

Storage: A large quantity of ground water is in transient storage in the valley fill in Amargosa Desert. The total volume in storage is many times the average annual recharge to the system and probably represents an accumulation over a period of several hundreds or thousands of years.

The total volume of valley fill that forms the principal ground-water reservoir is unknown because of the variation in the thickness of the valley fill. Accordingly the total volume of water that is stored in the main ground-water reservoir in Amargosa Desert cannot be computed from available information.

Some concept of the total amount of recoverable ground water in storage may be obtained, however, for the purpose of illustration, by estimating the amount of water that may be drained from the upper 100 feet of saturated deposits in a selected area and without regard to the effect on the surrounding area. A block of four townships, comprising about 92,000 acres and occupying the area in and adjacent to the principal concentration of wells, that is Tps. 15 and 16 S., and Rs. 48 and 49 E., is used for the example. If the drainable pore space in the upper part of the saturated valley fill is assumed to be about 15 percent, the volume of water that will drain from a given volume of saturated deposits by gravity is equal to approximately 0.15 of the volume of the dewatered material; that is, for each hundred cubic feet of saturated deposits approximately 15 cubic feet of water will be released by gravity drainage. Based on these values, approximately 1.4 million acre-feet of water would drain from storage with the lowering of the water table an average of 100 feet beneath the 92,000 acre area referred to above. This represents more than 50 times the estimated average annual ground-water discharge from Amargosa Desert.

The reliability of this estimate is contingent on the degree to which the assumed specific yield represents the average field specific yield. The determination of the specific yield of any large volume of unconsolidated or partly-consolidated sediments is a complex problem. Assuming that the specific yield of samples of each grain-size group, representing definite sedimentary units, can be determined precisely, there still remains the problem of determining the actual volume of these sedimentary units as they occur in the area of consideration. Many laboratory studies of specific yield for different sediment sizes have been made, and a wide range of values have been obtained for samples, particularly in the silt and clay sizes. The range in values tends to decrease with the larger sand and gravel sizes. Cohen (1961, p. 44) summarizes the specific yield of 209 sediment samples from the Humboldt River valley near Winnemucca, Nevada, as follows:

	Range of median diameters (millimeters)								All samples
	0.004-0.0625	0.0625-0.125	0.125-0.25	0.25-0.5	0.5-1	1-2	2-4	4-8	
Number of samples	121	15	17	23	6	19	7	1	209
Mean specific yield percent	19.1	21.4	25.9	25.9	22.2	20.8	17.4	17.4	20.7
Range of specific yield percent	1.0-34.1	2.5-36.5	7.0-35.4	7.2-39.5	10.7-35.3	4.6-36.2	4.9-27.4	-- --	1.0-39.5

Piper and other (1939, p. 121) list a range of 0.5 to 12.2 percent for the specific yield of materials composed of very fine sand, silt, and clay. They also obtained values of 34.1 and 34.9 percent for two samples of gravel and coarse sand.

In estimating the ground-water storage capacity in the San Joaquin Valley, California, Davis and others (1959), table 5, p. 209) assigned specific-yield values to groups of material as follows:

Gravel; sand and gravel; and related coarse gravelly deposits	25 percent
Sand, medium- to coarse-grained, loose, well-sorted	25
Fine sand; tight sand; tight gravel; and related deposits	10
Silt; gravelly clay, sandy clay; sandstone; conglomerate; and related deposits . . .	5
Clay and related very fine-grained deposits	3

The groups listed above were based on an analysis by Davis and others (1959, p. 202-206) of nearly 6,000 drillers' logs, core records of 64 test holes, and more than 1,000 electric logs of water wells and oil wells. Because of variation in usage and many individual expressions used by drillers, some 300 drillers' terms were grouped as expressing the equivalent of the groups of material listed above. The assignment of specific yield values to the groups was based on the results of previous studies in California, adapted to conditions in San Joaquin Valley (Davis and others, 1959, p. 206-211).

In the present study of Amargosa Desert, available time and data do not permit a similar analysis to the extent of that made for San Joaquin Valley. However, a simplified example may be used for illustration. This requires an assumption that the local drillers' terms for groups of material can be related to specific-yield values, although actually core samples and electric logs are not available to demonstrate an actual relationship. With this limitation, a reconnaissance examination of 57 drillers' logs for wells in Tps. 15 and 16 S., Rs. 48 and 49 E. suggests about 57 percent of material falls in the gravel or sand and gravel range, 15 percent in the sand and fine sand groups, and about 28 percent in the clay and silt groups, for the 100-foot interval below water level in the respective wells. Specific-yield values may be assumed as 25 percent for the gravel and sand and gravel, 15 percent for the sand group, on the basis of drillers' descriptions apparently indicating a specific yield characteristic closer to the fine sand group than sand group in the above listing, and 3 percent for the clay group. Multiplying these as follows,

$$
\begin{aligned}
57 \times .25 &= 14.25 \\
15 \times .15 &= 2.25 \\
28 \times .03 &= \underline{.84} \\
& 17.34 \text{ percent}
\end{aligned}
$$

Thus the average specific yield, for the upper 100 feet of saturated deposits, as represented by the 57 wells, is about 17 percent.

Even if the value of 17 percent actually represents the average specific yield of the upper 100 feet of saturated deposits penetrated by the 57 wells, the question still remains as to whether the value represents the average specific yield for the upper 100 feet of saturated deposits throughout the 4-township area in which the wells are located. In any case, the physical conditions of the area suggest that the average specific yield probably is not greater than 20 percent nor less than 10 percent. The amount of stored water in the 92,000-acre area in the upper 100 feet of saturated deposits for the three assumed specific-yield values is:

20 percent	1.8	million acre-feet
15	1.4	do
10	.9	do

It seems prudent, for the purposes of this reconnaissance report, to use the intermediate value of 15 percent for average specific yield and a value of 1.4 million acre-feet for the ground water in storage in the upper 100 feet of saturated deposits in the 4-township area as a reasonable illustration of the magnitude of that storage. When mcre data are available an improved estimate can be made subsequently.

This illustration of the magnitude of ground water in storage in a small part of Amargosa Desert indicates that a substantial reserve exists for maintaining a uniform annual supply through periods of deficient recharge. Moreover, even if a moderate depletion of stored water should occur during extended periods of drought, the basin can still be operated within the concept of the State ground-water law.

Chemical Quality: The chemical quality of the water in most ground-water systems in Nevada varies from place to place. In areas of recharge the dissolved-solids content 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 different solubility. The extent to which water dissolves chemical constituents from the rock materials is governed largely by the solubility, volume, and distribution of the rock materials, the time the water is in contact with the rocks, and the temperature and pressure in the ground-water system.

For the present study, samples of water from 28 wells and springs in Amargosa Desert were collected and analyzed by the Geological Survey. The analyses are listed in table 9. The chemical character of the water as determined by the several analyses is shown diagramatically on plate 4.

The chemical analyses identify the more important dissolved constituents and their concentrations in the water. On the basis of the chemical character indicated by the analyses, water can be classified as to its suitability for a variety of uses. For irrigation water some substances, such as calcium, magnesium, potassium, sulfate, and nitrate, are beneficial to plant growth, whereas others, such as sodium and chloride may be detrimental to both soil and vegetation. Minor constituents such as boron also may affect plant growth.

A method of classifying water for irrigation used by the U.S. Salinity Laboratory (1954) is based on the electrical conductivity, or specific conductance, of the water and the sodium-adsorption ratio (SAR). The specific conductance is an approximate measure of the concentration of the ionized constituents in the water, and the sodium-adsorption ratio is a measure of the adsorption of sodium by soil. Water of low conductivity and SAR value is more suitable for irrigation than water of high conductivity and SAR value.

By plotting the calculated value of the specific conductance at 25°C, and the sodium-adsorption ratio on a diagram shown in figure 3, water can be classed as to its suitability for irrigation. The Salinity Laboratory of the U.S. Department of Agriculture (1954, p. 79) gives the following classification of irrigation water with respect to the salinity and sodium hazards.

Table 9.--Chemical analyses, in parts per million, of water from selected wells and springs in the Amargosa Desert, Nevada-California

(Analyses by Denver and Salt Lake City Laboratories, Quality of Water Branch, U.S. Geological Survey)

Location	Date of collection	Depth of well (feet)	Temperature (°F)	Silica (SiO_2)	Aluminum (Al)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Strontium (Sr)	Sodium (Na)	Potassium (K)	Lithium (Li)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Boron (B)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Noncarbonate	Percent Na	SAR	RSC	Irrigation class	Specific conductance (micromhos at 25°C)	pH	Color
13S/51-30d1	9-18-57	1,327	92	67	0.1	0.26	85.0	14.0	0.0	157	16.0	--	102	0	484	20.0	0.9	7.4	0.0	--	893	270	186	54	4.4	0.0	C3-S1	1,210	7.8	3
14S/50- 6a1	4-25-58	887	78	26	.2	.52	9.6	1.9	--	46	5.2	--	121	0	24	7.0	1.8	.0	.0	--	169	32	0	72	4.1	1.45	C2-S1	266	8.2	1
15S/49-14a1	4-24-58	570	82	52	.1	.09	25	2.4	--	41	5.2	--	145	0	33	8.0	1.4	3.5	.0	--	233	72	0	53	2.25	.93	C2-S1	336	8.0	0
15S/50-18c1	5- 8-52	395	--	36	--	1.50	16	2.4	--	119	4.2	--	166	0	124	25	1.9	6.5	--	.29	417	50	0	82	7.47	1.72	C2-S2	629	7.9	-
15S/50-18c5	6-26-59	360	75	45	.0	.67	21	2.9	<.2	103	6.0	--	162	0	122	18	1.4	6.9	.0	--	408	64	0	76	5.78	1.37	C3-S1	863	7.9	0
16S/48-15a1	5-24-56	150	--	76	--	.22	12	3.2	--	65	3.2	0	166	0	30	8.0	3.0	4.1	--	.09	--	43	0	--	4.43	1.86	C2-S1	381	7.7	5
16S/48-17a1	8-18-62	280	75	75	.0	.00	60	7.8	.6	157	12	.20	302	0	179	69	1.2	1.2	.0	.57	800	182	0	--	5.06	1.32	C3-S1	1,074	7.4	-
16S/48-23b1	8-19-62	330	75	74	.57	1.1	9.4	1.0	1.8	66	6.8	.06	156	0	27	8.8	2.0	3.1	.0	.15	294	30	0	--	5.32	1.93	C2-S1	346	7.3	-
16S/48-36a1	2-21-56	165	74	82	.2	.14	70	3.9	--	62	9.0	--	142	0	107	61	1.4	17	.0	--	489	190	74	40	2.13	.0	C2-S1	700	7.9	0
16S/48-36d1	8-18-62	407	--	74	.22	.03	40	8.6	.7	98	11	.10	278	0	43	29	2.8	7.8	.0	.28	506	137	0	--	3.14	1.83	C2-S1	670	7.6	-
16S/49- 9c1	8-19-62	300	75	56	.30	.00	28	3.4	.9	46	7.6	.06	142	0	53	10	.7	3.3	.0	.16	310	85	0	--	2.17	.63	C2-S1	381	7.2	-
16S/49-35b1	8-18-62	325	76	34	.60	.03	50	17	1.0	106	12	.18	286	0	145	29	4.4	.5	.0	.42	545	196	0	--	3.38	.79	C3-S1	796	7.3	-
16S/50- 7c1	8-18-62	200	--	31	.29	.88	51	18	1.2	103	13	.14	288	0	143	30	4.0	.7	.0	.36	581	203	0	--	3.13	.70	C3-S1	821	7.7	-
16S/53- 4b1	7-10-62	1,953	92	21	.03	.03	47	21	.40	37	5.2	0	256	0	53	16	.9	1.2	.16	--	330	204	0	--	1.2	.12	C2-S1	544	7.1	-
17S/49-35d1 Ash tree Spring	5- 8-52	--	74	80	--	.08	16	4.8	--	55	7.9	--	160	0	37	7.2	2.8	3.9	--	.29	293	60	0	63	3.35	1.43	C2-S1	370	7.9	-
17S/50-15a1	8-18-62	464.6	67	23	.12	.16	50	20	.8	67	9.2	.10	305	0	79	23	1.2	.9	.0	.28	447	209	0	--	2.02	.75	C2-S1	665	7.6	-
17S/50-29d1	8-18-62	470.7	67	67	.00	.10	2.8	2.9	7.7	250	15	.14	494	0	105	26	3.2	.0	.0	1.4	733	28	0	--	27.6	7.72	C3-S4	1,067	7.6	-
17S/50-36d1 Devils Hole	1-22-53	--	92	23	--	.04	51	21	--	66	7.2	--	311	0	79	22	1.6	.5	--	.38	425	214	0	39	2.08	.83	C2-S1	686	7.4	-
17S/51- 1a1	1-10-61	135	73	18	.2	.00	39	20	--	69	10	--	350	0	53	6.0	.6	.0	.32	--	372	180	0	--	2.43	1.79	C2-S1	607	7.2	1
17S/52- 8c1	4-27-58	--	82	18	.2	.00	34	22	--	61	7.2	--	274	0	63	21	1.1	.0	.0	--	342	176	0	42	2.14	.98	C2-S1	595	8.0	0
18S/50- 5d1 Carson Slough	1-27-59	--	50	28	.2	.21	40	26	1.8	125	16	--	362	10	122	40	2	.0	.07	.68	566	207	0	54	4.05	2.12	C3-S1	937	8.5	0
18S/51- 7c1 King Spring	2-28-49	--	89	23	--	.02	49	21	--	69	7.7	--	310	0	80	21	1.4	.4	--	.1	425	209	0	--	2.21	.91	C2-S1	680	7.2	-
18S/51-19a Big Spring	1-27-59	--	83	32	.0	.11	45	18	1.8	98	8.8	--	314	0	110	25	1.4	.3	.08	.51	468	186	0	52	3.5	1.88	C3-S1	780	7.7	0
18S/51-30a Bole Spring	7-27-62	--	72	33	.11	.03	38	19	.60	106	9.2	.17	306	0	113	27	1.0	1.0	.0	--	500	173	0	--	3.7	1.56	C3-S1	776	7.1	-
25N/5-14c1	8-29-52	146	--	31	--	.06	1.9	1.9	--	325	12	--	556	43	149	49	7.9	.2	--	1.3	874	12	0	96	37.9	9.57	C3-S4+	1,380	8.6	-
25N/6-18a1	8-18-62	27.5	67	64	.12	.10	4.8	3.3	.5	370	16	.30	542	0	256	102	3.2	.5	.0	2.8	1,119	26	0	--	31.6	8.37	C4-S4+	3,241	7.9	-
25N/6-20c1	8-18-62	8.1	68	28	.43	.03	1.2	1.4	4.2	1,060	88	.10	712	64	297	1,050	7.0	.2	.32	.2	2,891	223	0	--	123	13.6	C4-S4+	4,730	8.6	-
27N/4-27b2	8-18-62	300	72	72	.14	.10	58	19	.6	134	19	.14	438	0	107	32	3.6	--	.0	.4	640	--	0	--	3.90	2.73	C3-S1	943	7.8	-

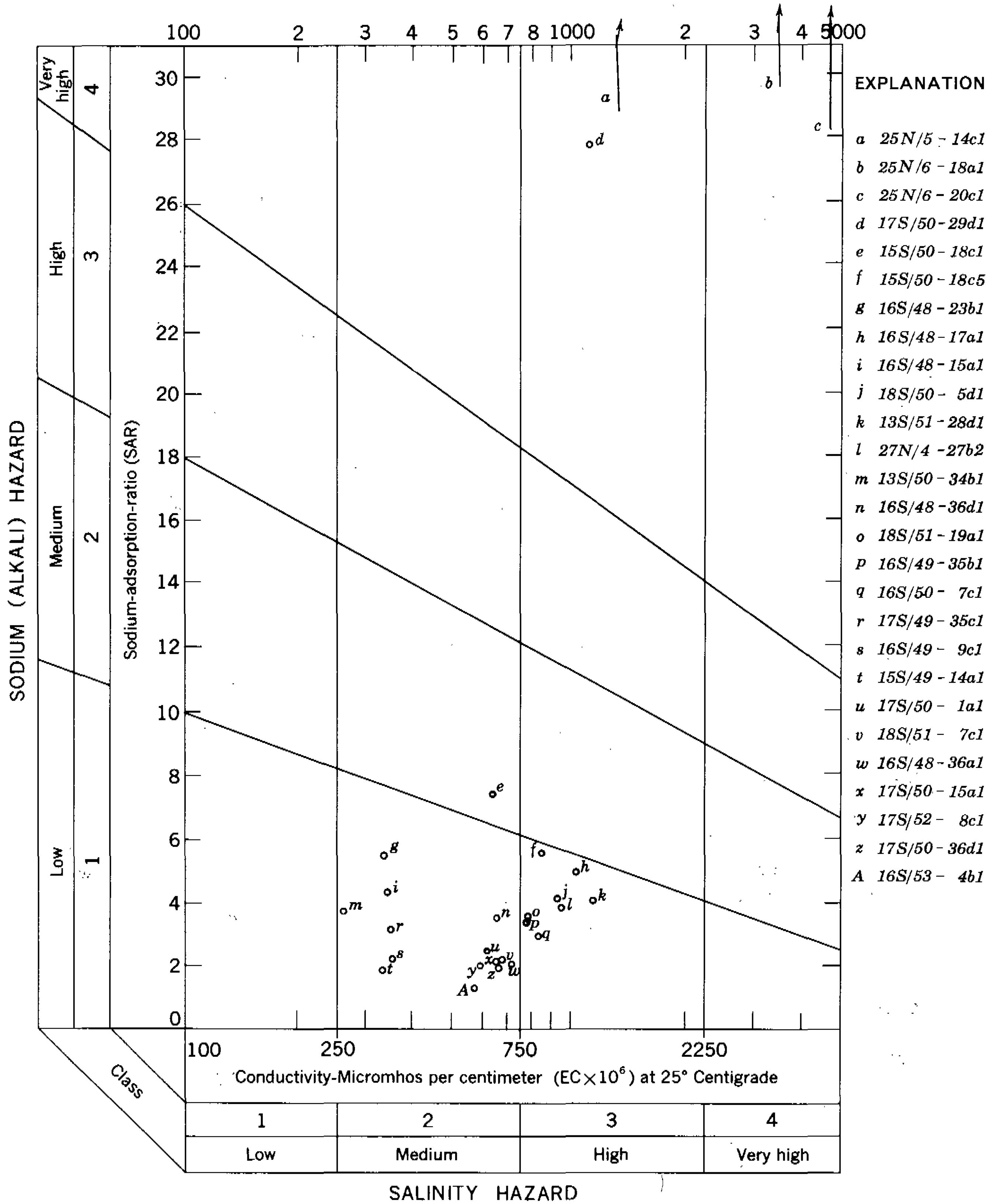

Figure 3. Diagram for the classification of irrigation waters. (after Wilcox, L. V., 1948).

Salinity hazard:

1. Low-salinity water (C1) can be used for irrigation with most crops on most soils with little likelihood that soil salinity will develop. Some leaching is required, but this occurs under normal irrigation practices, except in soils of extremely low permeability.

2. Medium-salinity water (C2) can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control.

3. High-salinity water (C3) cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.

4. Very high salinity water (C4) is not suitable for irrigation under ordinary conditions but may be used occasionally under very special circumstances.

Sodium hazard:

1. Low-sodium water (S1) can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. However, sodium-sensitive crops, such as stonefruit trees and avocados, may accumulate injurious concentrations of sodium.

2. Medium-sodium water (S2) will present an appreciable sodium hazard in fine-textured soils having high cation-exchange capacity, especially under low-leaching conditions; unless gypsum is present in the soil. This water may be used on coarse-textured or organic soils with good permeability.

3. High-sodium water (S3) may produce harmful levels of exchangeable sodium in most soils and will require special soil management--good drainage, high leaching, and organic matter additions.

4. Very high-sodium water (S4) is generally unsatisfactory for irrigation purposes, except under special circumstances.

Of the 28 analyses shown in table 9, 14 are classed as C2-S1; 9 as C3-S1; 1 as C3-S4; 1 as C3-S4+; 2 as C4-S4+; and 1 as C2-S2. Figure 3 shows the classification of the several samples. Although there is considerable local variation in the chemical quality, the poorest quality generally occurs in the water sampled in T. 25 N., Rs. 5 and 6 E., near the playa in the vicinity of Death Valley Junction. Water of relatively high salinity was also found in some samples between Lathrop Wells and Death Valley Junction.

Residual sodium carbonate is a measure of the hazard that may be involved in the use of high bicarbonate water. Using Eaton's (1950) concept of "residual sodium carbonate" (RSC) values (as described in U. S. Department of Agriculture handbook, no. 60, 1954) for the analyses of water from the 28 samples, the range is from zero for the sample from well 13S/51-28d1 to 13.6 for the sample from well 25N/6-20c1. The median value for all analyses was 1.44. According to Eaton's method of evaluation, values greater than 2.5 are not suitable for irrigation purposes. Waters having values of 1.25 to 2.5 are marginal and those containing less than 1.25 millequivalents per liter probably are safe. On this basis, 5 of the analyses indicate water unsuitable for irrigation; 12 of the analyses indicate water thay may be of marginal quality; and 11 of the analyses indicate water that probably is safe for irrigation. RSC values for the individual analyses are listed in table 9.

The quantity of boron in solution is an additional factor that must be considered in classifying water for irrigation. In small quantities boron is necessary for proper plant nutrition, but in quantities of slightly more than optimum, boron is extremely toxic. Scofield (1936) proposed permissible limits of boron concentration for several classes of irrigation water according to the following tabulation.

Boron class	Sensitive crops (ppm)	Semi-tolerant crops (ppm)	Tolerant crops (ppm)
1	$<$ 0.33	$<$ 0.67	$<$ 1.00
2	0.33 to 0.67	0.67 to 1.33	1.00 to 2.00
3	.67 to 1.00	1.33 to 2.00	2.00 to 3.00
4	1.00 to 1.25	2.00 to 2.50	3.00 to 3.75
5	$>$ 1.25	$>$ 2.50	$>$ 3.75

Of nineteen analyses for boron, nine were less than 0.33 ppm, which is the lower limit for adverse affect on sensitive crops. The highest concentration of boron was 2.8 ppm in water from well 25N/6-18a1, in the southern part of Amargosa Desert at Death Valley Junction. The remaining nine analyses show boron concentrations ranging from 0.36 to 1.4 ppm. The median value for the nineteen analyses is 0.36 ppm of boron.

The foregoing discussion indicates that, although the chemical quality of ground water may be suitable generally for irrigation, water of median salinity is common and water of high salinity occurs locally. Boron commonly is found in relatively small concentration. However, the wide range in concentration in the available analyses suggests that concentration at harmful levels may be encountered locally within the area. This further suggests that the quality of water from individual wells should be checked for suitability with due regard to soil and drainage conditions on land on which that water is to be used and also to the tolerance of the proposed crops.

The communities at Lathrop Wells and Death Valley Junction together with possible increase in population in the area because of the development of irrigation and industry warrant consideration of the ground water in Amargosa Desert as to its suitability for domestic and public supply.

The presence of excessive concentrations of major constituents, such as magnesium, sodium, sulfate, and chloride, may make the water unsuitable for domestic use. Also small quantities of some substances, such as fluoride, nitrate, arsenic, iron, and manganese, in drinking water may have adverse physiological effects on humans or otherwise impart a quality unsuitable for domestic use. Therefore, it is essential to know the concentrations of the various constituents in solution in the water.

The range in concentration of several constituents, obtained from the analyses of water in Amargosa Desert and which are shown in table 9, are tabulated as follows:

Constituent	Range (in parts per million) Low	High	Public Health Standards (should not exceed)
Calcium (Ca)	1.9	85	
Magnesium (Mg)	1.0	26	125
Sodium (Na)	41	1,060	
Potassium (K)	3.2	88	
Bicarbonate plus carbonate ($HCO_3 + CO_3$)	102	778	
Sulfate (SO_4)	24	484	250
Chloride (Cl)	6.0	1,050	250
Fluoride (F)	.6	7.9	a/
Nitrate (NO_3)	.0	17	45

a/ 0.8 ppm for annual average of maximum daily air temperature 79.3 to 90.5°F, according to Federal Register, Mar. 6, 1962--Title 42, para. 72.205.

The permissible concentration of fluoride varies according to the average annual maximum daily air temperatures, according to recent information of the U. S. Public Health Service. Presumably this inverse relation reflects the fact that with higher temperature, more water will be consumed as will the total intake of fluoride of a given concentration. Thus, the Public Health Service decreases the permissible fluoride concentration in areas of higher annual average maximum daily air temperature. At Lathrop Wells the average Maximum temperature is 79.5°F, according to the U.S. Weather Bureau. For this temperature average, the U. S. Public Health Service shows a recommended upper control limit of 0.8 ppm of fluoride. They indicate that, when fluoride is naturally present in drinking water, the concentration should not average more than the recommended upper control limit.

The Public Health Service further recommends that average fluoride concentration more than twice the recommended optimum control limit, (in this case 0.7); that is, more than 1.4 ppm would be grounds for rejection of the water supply. Of the 28 analyses for fluoride, 26 have concentrations greater than 0.7 ppm, 14 have concentrations of more than 1.4 ppm, and 10 have concentrations of 2.8 ppm or more. The concentration of fluoride for the individual analyses is listed in table 9. Plate 4 shows fluoride concentrations diagramatically.

Too much fluoride in water used for drinking purposes commonly results in dental fluorosis and discoloration in the teeth of children. A recent dental examination of school children in Beatty by officers of the Nevada

Department of Health showed that 19 out of 20 children who lived in Beatty since birth were affected with dental fluorosis (W. White, Director, Nevada Bur. Environmental Health, oral communication, 1962). The fluoride content of the municipal water supply for Beatty apparently averages about 4 ppm. This probably is an extreme example to apply to much of the area of Amargosa Desert where fluroide concentration generally is less than 2 ppm. Even so, problems of dental fluorosis would be expected to some extent. It is obvious then that fluoride concentration should be checked where ground water is to be used regularly for public supply.

For the other constituents, the concentration of sulfate exceeds Public Health Service recommended limits in water from wells 13S/51-30d1, 25N/6-18a1, 25N/6-20c1, and of chloride in well 25N/6-20c1. Throughout the main area of well development the analyses indicate that the constituents, other than fluoride, are below the limit recommended by Public Health Service.

Development:

Historical: Ground water in Amargosa Desert was used by the Indians to some extent before the white man came into the region. The big springs issuing from the Ash Meadows area undoubtedly attracted their attention because of the vegetative growth maintained by the water flowing from the springs. Subsequently prospectors and travelers passing through the Amargosa Desert also relied on these springs for water supply.

Mendenhall (1909, p. 36, 37) states that the Franklin well (26N/5-5b1) was dug by Mr. Franklin in 1852 to supply water for parties surveying the boundary line between California and Nevada. Later other wells were dug or drilled along main travel routes between mining towns and along the alinements of the Tonopah and Tidewater and the Las Vegas and Tonopah railroads now abandoned. The T and T ranch in sec. 25, T. 16 S., R. 48 E., was developed in about 1917 to produce crops, irrigated by wells, apparently for the market created by mining in Bullfrog, Rhyolite, and Beatty. The drilling of well 16S/48-36a1 and application to appropriate ground water for irrigation by the Tonopah and Tidewater Railroad Company in 1917 probably marks the beginning of irrigation from wells in the Amargosa Desert.

Present: Irrigation from wells remained at a very modest scale until recent years. Of the wells for which the year of completion is shown in table 3, 4 were drilled prior to 1950, another 4 during the period of 1951-54, 39 during the period 1955-58, and 66 during the period 1959 to September 1962. Although this represents only 113 wells out of the 162 listed in table 3, it does indicate the rapid expansion of drilling in recent years. Of the total of 162 wells listed in table 3, 90 are reported to be for irrigation use, 49 are unused or dry, 8 are test or observation wells, 8 are used for public supply, 5 for domestic use, 1 for stock use, and 1 for industry.

During the summer of 1962, 18 wells were pumped for irrigation. Most of the remaining wells intended for irrigation are not yet in operation. Installation of pumping equipment may have been delayed in anticipation that electric power will soon be available. Several wells provide water for public supply, principally at Lathrop Wells and Death Valley Junction. The springs in Ash Meadows are used principally to supply water to native pasture.

Potential: The potential for development of ground water in Amargosa Desert is limited by quantity and chemical quality. Under the concept of perennial yield, development would be limited to a quantity that is about equivalent to the estimated average natural discharge of 24,000 acre-feet a year from the ground-water system.

The present area of well development (Tps. 16 and 17 S., Rs. 48 and 49 E.) is several miles northwest of the area of spring discharge in Ash Meadows, where 17,000 of the 24,000 acre-feet of natural discharge occurs each year. Whether pumping in the present area of well development from the valley would ever materially affect, or intercept, the spring discharge from the carbonate rocks cannot be evaluated at this time. Thus, pumping from the valley fill might be limited to somewhat less than the 7,000 acre-feet supplied by underflow from the northwestern part of the Amargosa Desert, from Fortymile Canyon area and by upward leakage from the carbonate rocks south of Lathrop Wells.

The present discharge of the springs in Ash Meadows largely supports pasture or native vegetation during the growing season, but wastes during the remainder of the year. Thus, only a small part of the average annual discharge of these springs is being utilized. Moreover, it is evident that there is a potential for a higher beneficial use of the water; that is, changes of use probably could be achieved to result in greater economic return on a year-around basis. For example, collection works and distribution systems could be installed to permit fuller control of the water for high-valued crops either in the area west and southwest of the springs or in areas where soil and drinage conditions may be better.

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 or discharge--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 importation of needed water supplies, where such exist, when the cost of obtaining ground water from the local area becomes too great. However, if no sources are available for importation, the over-development of ground water implicitly indicates that at some time in the future it will no longer be economically feasible to obtain water. One principal problem is the difficulty of predicting the economical cost limit of withdrawing ground water. The time may be extended, if under actual conditions of with-drawal, more water is available than can be estimated, if greater efficiency of water use is achieved with time, or if changes in use result in greater economic benefit. The time may be shortened by the reverse of the above conditions, or by a severe recession of the economy for any of several reasons. It should be reemphasized that in Nevada, present ground-water laws are based on the concept that development should not exceed the perennial yield.

Planned overdevelopment has been used in Utah and New Mexico to achieve some of the additional economic benefits possible 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 in obtaining a fuller understanding of the results in the Amargosa Desert. It is intended neither to support nor negate the possible use of such methods.

The physical process of planned overdevelopment of ground water involves withdrawal at a rate greater than can be supplied by natural recharge for a specified period of time. If the area of development is properly located in the ground-water system, the lowering of water levels will result in a diversion of most of the recharge into the area of development and permit at least a one-time beneficial use of the stored water to a reasonable depth before it can be discharged by natural processes. It further permits beneficial use of a limited amount of the stored water within the area influenced by ground-water withdrawals. For the purpose of illustration, we may refer to the four-township area of present development, previously discussed in the section on storage, where water levels in 1962 were 50 to 100 feet below land surface (table 3). After a several-year period of large withdrawals water levels would be lowered sufficiently to intercept most of the inflow moving in the valley fill from the north and northwest and upward from the underlying Paleozoic carbonate rocks.

The magnitude of the annual pumpage required to lower water levels 100 feet beneath this 92,000-acre area alone can be computed by the equations:

$$\text{Pumpage} = \frac{\text{Stored water}}{\text{years}} + \text{annual recharge}$$

or

$$\text{Pumpage} = \frac{\text{1.4 million acre-feet}}{\text{years}} + < \text{7,000 acre-feet}$$

For example, if the period of planned overdevelopment were 25 years, pumpage could be at least 60,000 acre-feet per year. Of course if the lateral storage depletion were included, as it would be under actual conditions, annual pumpage could be somewhat larger.

It is evident that with a known volume of water in storage within a definable area the time a given rate of withdrawal could be maintained with a given lowering of water levels could be reasonably forecast. The accuracy of such forecasting is dependent on having reliable geologic and hydrologic data in the area of concern. It is evident too that the problems of administration would be many and difficult. Sound administration of a planned overdevelopment requires full and reliable data of the physical environment in addition to the necessary legal authority and the proper understanding and full support of the individuals and groups directly involved.

CONCLUSIONS

Ground-water development in the Lathrop Wells-Death Valley Junction area of Amargosa Desert is expanding rapidly. More than 100 wells now have been drilled for irrigation. The principal concentration of wells is in T. 16 S., Rs. 48 and 49 E., and T. 17 S., R. 49 E., for which records of 106 wells were obtained in this investigation. However, during the summer of 1962 only 18 wells were reported to have been pumped for irrigation. Principal development by wells has come from sand and gravel zones in the valley fill.

Ground water in Amargosa Desert is recharged in part by infiltration of precipitation within the tributary drainage area of about 2,600 square miles, but most is supplied by underflow from beyond the tributary through Paleozoic carbonate rocks. Thus, most of the 17,000 acre-foot discharge from springs in Ash Meadows is considered to be supplied largely from ground-water recharge in the Spring Mountains. A much smaller quantity, perhaps on the order of a few thousand acre-feet a year, is supplied to the ground-water reservoir in Amargosa Desert by underflow through Paleozoic carbonate rocks from north and northeast beyond the surficial tributary drainage area.

The average annual ground-water discharge from Amargosa Desert by evapotranspiration and outflow is estimated to be on the order of 24,000 acre-feet. Of this amount, about 17,000 acre-feet is available on a perennial basis from the springs in Ash Meadows. Most of the remainder is available to wells in the valley fill northwest and northeast of the springs.

As an illustration of the magnitude of ground water in storage in Amargosa Desert, about 1.4 million acre-feet was estimated to be in storage in the upper 100 feet of saturated valley fill in a 92,000 acre area, roughly four townships, around the principal area of development. A simplified example of planned overdevelopment of ground water suggests that pumpage at the rate of 60,000 acre-feet a year probably would result in a lowering of water levels an average of 100 feet in this four-township area in about 25 years. Under the present State ground-water law, however, ground-water withdrawals are limited to the perennial yield of the ground-water basin.

PROPOSALS FOR ADDITIONAL GROUND-WATER STUDIES

In compliance with the request of Hugh A. Shamberger, Director, Department of Conservation and Natural Resources, State of Nevada, suggestions for special studies are listed below to obtain needed basic data and a better understanding of the factors that influence or control ground water in Amargosa Desert and similar areas in Nevada. These proposed studies are separate from the usual areal investigations, which commonly are needed after the development of ground water in a given area become substantial.

1. Investigation of the interrelation of the ground water in the Paleozoic carbonate rocks and in the valley fill in the area around the springs in Ash Meadows. The investigation should seek to define the distribution of the difference in head between ground water in the valley fill and the carbonate rocks, the area or areas in which subsurface leakage occurs from the carbonate rocks to the valley fill, and the magnitude of subsurface leakage. The investigation requires additional study of available data and of wells that may be drilled in the future. Further, several test holes will be needed to obtain detailed subsurface data. Additional detailed gravity data also will be needed to supplement available data for better control and definition of the Paleozoic bedrock surface in selected areas.

2. An investigation of physical parameters to develop improved estimates of ground water in storage. This will involve analysis and correlation of drillers' logs and terms with electric or gamma logs, samples or cores, and further study of the geology and hydrology with respect to the distribution and range of storage and transmissibility coefficients in the area. The study should include the application of techniques for analyzing the effects of development on the ground-water system. For this purpose the possible use of an electric analog model warrants serious consideration. Potentially the electric analog model will be of much value in demonstrating the character of various ground-water systems and should be a valuable tool to aid in the management of ground-water resources in Nevada.

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Table 3.--Record of selected wells in the Amargosa Desert, Nevada-California

Well number and location: See page 4 for description of numbering system.
Depth of well: m, measured by U.S.G.S.; other depths are reported.
Altitude: Land surface above mean sea level. Altitudes given in whole feet are interpolated from topographic maps. Altitudes given in feet and tenths were determined by plane table.
Measuring point: Above land surface: L, land surface; Tc, top of casing; Ep, entry point; Dp, discharge pipe.

Water level: In feet and tenths if measured by U.S.G.S.; in feet only if reported.
Yield: m, measured by U.S.G.S.; other yields are reported.
Drawdown: m, measured by U.S.G.S.; other drawdowns are reported.
Status or use: Ir, irrigation; Dr, dry; P, public supply; Obs, observation; D, domestic; E, exploration; U, unused; S, stock; Ind, industry.
Remarks: A, chemical analysis; Ar, radiochemical analysis; Dl, drillers log, Sp. cond., specific conductance in micromhos/centimeter at 25°C.

Well number and location	Owner	Year completed	Depth (feet)	Casing: Diameter (inches)	Casing: Depth (feet)	Casing: Perforated zone (feet)	Altitude (feet)	Meas. point: Description	Meas. point: Height (feet)	Water level: Above(+) or below land surface (feet)	Water level: Date	Yield (gpm)	Drawdown (feet)	Temperature (°F)	Status or use	Remarks
13S/47-35a1	Nuclear Engineering Co.	1961	575	8	573	453 to 493; 513 to 573	2788	Tc	.5	282.3	7-12-62	^{m}100	43	84	E	Dl
13S/51-30d1	--	1957	1329	12 3/4	1327	1077 to 1097; 1244 to 1300	3443	Tc	3.0	1046	9-13-57	105	48	96	Ind	A
14S/47-24d1	W. Dale	--	^{m}484.1	14	--	--	2608	L	--	253.1	7-12-62	^{m}180	--	--	U	--
14S/48-32a1	Rose's Station	--	^{m}177.8	42x42	10	--	2542	L	--	--	--	--	--	--	Dr	Depth to water rept. 208' in U.S.G.S. Bull. 308.
14S/50- 6a1	--	1957	887	12 3/4	887	793 to 868	3128	Tc	3.0	734	10-31-57	200	--	78	P	A
15S/49-11c1	R. Washburn	1958	^{m}243.4	12	--	--	2679	Tc	0	--	--	--	--	--	Dr, U	Dl; original depth 986'
15S/49-14a1	R. Washburn	1953	^{m} 77.7	--	--	--	--	--	--	--	--	--	--	--	Dr, U	Dl; A, original depth 90'
15S/49-22a1	J. Shaw	1953	570	14	380	70 to 188	2612.2	Tc	4.0	290.9	12- 7-53	300	--	80	Ir	Dl; Sp. cond. 276
15S/49-22d1	R. Washburn	1958	^{m}486.8	14-10 3/4	500	0 to 500	2572	Tc	.4	255.8	7-12-62	800	10	--	Ir	Dl
15S/49-27d1	R. Washburn	1958	442	12 3/4	433	300 to 420	2540	Tc	--	229	10-18-58	--	--	--	Ir	Dl
15S/50-18c1	L. Pereirda	1952	395	8-6	395	335 to 395	2664	--	--	--	--	--	--	--	U	Dl, A
15S/50-18c2	L. Pereirda	1950	^{m}353	8	373	--	2665	Tc	.9	351.3	6-12-62	--	--	--	U	--
15S/50-18c3	L. Pereirda	1955	507	10	507	380 to 507	2665	Tc	.8	358.8	6-12-62	--	--	--	P	Dl
15S/50-18c4	B. Bossingham	1961	471	12	471	103.6-122.4 167.7-271.0 293.2-314.0 451.3-471.0	2664	--	--	333	5-20-61	--	--	--	U	Dl
15S/50-18c5	Nevada Highway Department	--	360	--	--	--	2656.1	Tc	.3	339.1	6-22-53	--	--	--	P	A, Ar
15S/50-18c6	B. Whellock	1955	505	10	505	360 to 505	2655	Tc	1.8	365.6	6-12-62	--	--	--	P	Dl
16S/48- 2b1	--	1962	^{m}332	12	--	--	2423	Tc	1.8	135.9	7- 2-62	--	--	--	Ir	--
16S/48- 2d1	D. Heath	1961	^{m}409.6	14	422	212 to 422	2409.7	Tc	1.3	124.3	7- 2-62	--	--	74	Ir	Dl
16S/48- 3a1	F. Keefe	1960	^{m}234.6	12 3/4	250	120 to 250	2412.3	Tc	0	127.4	7- 2-62	650-900	30	72	Ir	Dl
16S/48- 4d1	E. Mankinen	1961	308	12 3/4	308	203 to 298	--	Ep	.4	108.6	7- 2-62	1,900	20	--	Ir	Dl
16S/48- 5b1	F. Wooldridge	1960	250	12 3/4	250	130 to 250	2405.5	Tc	1.3	127.6	7- 2-62	--	--	68	Ir	Dl
16S/48- 5d1	T. & T. Railroad	--	^{m} 51.0	14	--	--	--	--	--	--	--	--	--	--	Dr	Original depth 179'
16S/48- 8a1	E. Schultz	1962	^{m}272.6	12 3/4	315	189 to 315	2382	Tc	.8	109.2	7- 2-62	--	--	--	Ir	Dl
16S/48- 8b1	C. DeFir, Sr.	1959	250	12	250	100 to 250	2384	Tc	.6	111.9	7- 2-62	1,400	8-10	--	Ir	Dl
16S/48- 9b1	C. DeFir, Jr.	1959	^{m}242.0	12	250	100 to 250	--	Tc	.8	105.2	7- 3-62	--	--	--	Ir	Dl
16S/48- 9c1	C. Caldwell	1958	350	14	347	105 to 347	2373.1	Tc	.4	100.4	7- 3-62	1,150	--	--	Ir	Dl
16S/48- 9d1	D. Fadenrecht	1959	410	12	410	144 to 410	2385.3	Ep	.6	108.0	7- 3-62	1,550	6	--	Ir	Dl
16S/48-10a1	A. Mankinen	1961	320	12 3/4	320	150 to 320	--	Ep	.6	107.8	7- 2-62	3,000	27	--	Ir	Dl
16S/48-10b1	W. Monroe	1958	300	12 3/4	300	200 to 300	2397.8	Ep	.2	116.6	7- 3-62	--	--	65	Ir	Dl
16S/48-11c1	J. Pierce	1960	^{m}288.4	12 3/4	302	130 to 302	--	Tc	.4	112.3	7- 4-62	--	--	72	Ir	Dl
16S/48-13a1	P. Parker	1958	250	14	--	--	2386.1	Ep	.8	116.8	7- 4-62	--	--	--	Ir	Dl
16S/48-14b1	T. Gallagher	1955	^{m}315.2	12 3/4	349	146 to 158; 170 to 195 240 to 295	2381	Tc	2.0	102.7	7- 4-62	--	--	--	Ir	Dl
16S/48-14d1	P. Perry	1958	240	12	240	100 to 240	--	--	--	92	11-26-58	--	--	--	Ir	Dl
16S/48-15a1	E. Mankinen	1954	156	14	150	--	2375.5	Tc	1.0	96.6	5-23-56	800	40	--	Ir	Dl, A
16S/48-15b1	L. Densby	1954	149	14	149	--	2373.3	Tc	1.0	97.2	7- 4-62	700-800	--	--	Ir	Dl
16S/48-16a1	E. Selbach	1958	250	12	250	--	2375	--	--	90	8-15-58	1100-1200	--	--	Ir	Dl
16S/48-17a1	J. Overhalser	1959	280	12	280	120 to 280	2370.3	Ep	.2	100.6	8-18-62	1200-1500	--	75	Ir	Dl, A, Ar
16S/48-18b1	J. Bell	1961	^{m}361.1	16	380	140 to 218; 258 to 380	2363	Ep	.6	90.0	7- 3-62	--	--	72	Ir	Dl
16S/48-20d1	J. Downey	1961	366	16	264	119 to 255	2340.7	Dp	3.2	65.6	7- 4-62	1500	38	72	Ir	Dl
16S/48-23a1	H. Gillespie	1960	330	14	330	80 to 330	2358	--	--	84	4- -60	1400	--	--	Ir	Dl, Sp. cond., 350
16S/48-23b1	H. Gillespie	1960	330	12	330	100 to 330	--	--	--	94	3-23-60	--	--	75	Ir	Dl, A, Ar
16S/48-23c1	H. Gillespie	1961	510	14	485	170 to 485	2341.2	Tc	.6	75.7	7- 7-62	--	--	74	Ir	Dl
16S/48-23d1	V. Gillespie	1961	^{m}474.0	14	503	270 to 503	--	Tc	1.2	79.1	7- 7-62	--	--	74	U	Dl
16S/48-24a1	M. Records	1956	480	14	--	--	2367	--	--	94.4	5-24-56	1600	--	80.5	Ir	Dl, Sp. cond., 345
16S/48-24c1	R. Records	1960	^{m}289.3	12 3/4	306	110 to 306	2346.9	Tc	.2	84.1	7- 9-62	--	--	74	Ir	Dl
16S/48-24d1	R. Records	--	421	14	421	--	2357.1	Tc	.3	88.6	5-24-56	1100	--	81.5	Ir	Dl, Sp. cond., 325
16S/48-25a1	G. Bettles	1921	^{m}164.6	16	164	60 to 150	2343.4	Tc	0	84.6	7- 9-62	--	--	--	Obs	Dl

Table 3.--(continued.)

Well number and location	Owner	Year completed	Depth (feet)	Casing: Diameter (inches)	Casing: Depth (feet)	Casing: Perforated zone (feet)	Altitude (feet)	Meas. point: Description	Meas. point: Height (feet)	Water level: Above (+) or below land surface (feet)	Water level: Date	Yield (gpm)	Drawdown (feet)	Temperature (°F)	Status or use	Remarks
16S/48-25c1	G. Bettles	--	--	12	--	--	2326.6	L	--	67.1	7- 9-62	500	18	--	Obs	--
16S/48-26a1	G. Bettles	--	^{m}137.6	16	--	--	2336	Tc	0	75.7	7- 4-62	--	--	--	Obs	--
16S/48-27c1	M. Barr	1960	236	12	236	106 to 236	2321.6	Tc	.4	57.0	7- 4-62	--	--	74	Ir	Dl
16S/48-27c2	C. Barr	1960	^{m} 11.43	10½	--	--	--	--	--	--	--	--	--	--	Dr, U	Dl, original depth 236'
16S/48-27d1	M. Dolph	1956	^{m}188.4	12	200	65 to 200	2324.6	Ep	.4	58.8	7- 4-62	--	--	--	Ir	Dl
16S/48-36a1	G. Bettles	1917	165	--	--	--	2323.7	Tc	0	67.5	7- 5-62	1,000	--	76	D, Ir	A, Ar, Sp. cond., 620
16S/48-36d1	H. Watson	1959	407	14	407	165 to 407	2303.3	--	--	42	6-25-59	^{m}940	--	70	Ir	Dl, A, Ar, Sp. cond., 675
16S/48-36d2	G. Bettles	--	62	16	--	--	2304	Tc	.6	54.1	7- 5-62	--	--	--	Obs	--
16S/49- 6a1	--	1962	350	14	--	160 to 350	2441	L	--	148.78	10-12-62	--	--	--	U	--
16S/49- 8a1	M. Meese	1962	^{m}290.5	14	300	170 to 300	--	Tc	.3	148.4	6-29-62	--	--	63	Ir	Dl
16S/49- 9c1	T. Solbach	1958	300	12	300	--	2434	--	--	150	7-15-58	^{m}274	--	75	Ir	Dl, A, Ar
16S/49- 9d1	Nye County Land Development Co., Inc.	1962	^{m}189.8	6¼	--	--	--	Tc	.9	160.8	6-29-62	--	--	--	D	--
16S/49-10c1	Miller Well #1	--	68	60	--	--	2444.2	--	--	--	--	--	--	--	Dr, U	Originally described in U.S.G.S. Bull. 308 as 186' deep and having a water level of 183'
16S/49-12c1	--	--	^{m}448.0	12	--	--	--	Tc	0	173.9	6-29-62	--	--	--	U	--
16S/49-14a1	W. Johns	1959	300	12	290	51 to 290	2450	Tc	.4	158.7	6-29-62	400	--	--	Ir	Dl
16S/49-14b1	W. Johns	1960	^{m}370.8	12 3/4	390	150 to 390	--	Tc	.4	157.3	6-29-62	--	--	73	Ir	Dl
16S/49-15a1	W. Johns	1960	^{m}390.2	12 3/4	420	150 to 420	--	Ep	.1	168.8	6-29-62	--	--	75	Ir	Dl
16S/49-18a1	W. Hanks	1960	420	12 3/4	420	140 to 420	--	Tc	.2	116.2	6-28-62	--	--	73	Ir	Dl
16S/49-18d1	--	--	--	--	--	--	2383	Ep	.5	116.3	6-28-62	--	--	--	Ir	--
16S/49-18d2	U.S.B.L.M.	--	^{m}348.1	12	--	--	2375.1	Tc	0	108.5	6-28-62	--	--	--	Obs	--
16S/49-19a1	L. Meeter	1955	^{m}104.5	14	480	130 to 480	2373.6	Tc	3.0	104.6	9-15-59	--	--	--	Dr	Dl. Used by U.S.G.S. as obs. well from 1955-59. Well caved in 1960
16S/49-19b1	L. Meeter	1955	725	14-8	725	100 to 725	2370.8	Ep	1.0	106.0	7- 9-62	2,400	--	--	Ir	Dl, 14" csg. from 0' to 526', 8" csg. from 526 to 725'
16S/49-19c1	R. Records	1960	300	12 3/4	300	100 to 300	2357.9	Tc	.4	98.0	7- 9-62	1,200	--	74	Ir	Dl
16S/49-19d1	L. Meeter	1954	307	14	307	120 to 307	2362.8	Dp	.5	99.0	7- 9-62	--	--	--	Ir	Dl
16S/49-20a1	M. Travis, J. Earl, P. Clement	1959	^{m}204.1	14	300	110 to 150 170 to 190 220 to 240 280 to 300	2384	Tc	1.0	118.4	6-28-62	--	--	60	Ir	Dl
16S/49-20d1	E. Easterbrook	1959	410	12	410	156 to 410	2366	--	--	--	--	--	--	--	Ir	Dl
16S/49-22b1	--	--	^{m}346.9	12	--	--	2395	Tc	1.1	131.1	6-28-62	--	--	--	Ir	--
16S/49-22d1	--	--	^{m}340.8	16	--	--	--	Ep	.4	112.1	6-28-62	--	--	--	Ir	--
16S/49-23a1	R. Dalton	1961	^{m}381.7	12	500	120 to 500	2403	Tc	1.3	105.9	6-28-62	--	--	--	Ir	Dl
16S/49-26d1	D. Bilsborough	1960	^{m}278.2	14	300	--	2351	Tc	.5	82.7	6-26-62	--	--	--	Ir	Dl
16S/49-26d2	M. Records	1961	300	10 3/4	300	140 to 300	2352	Ep	.4	106.8	6-26-62	--	--	--	Ir	Dl
16S/49-26d3	H. Weimer	1962	200	10 3/4	200	--	--	--	--	112	6-20-62	--	--	--	D	--
16S/49-28a1	M. Wickner	1959	300	16	300	120 to 300	2367	--	--	106	3-15-59	--	--	75	Ir	Dl, Sp. cond. 440
16S/49-28c1	E. Mason	1959	^{m}185.2	16	200	107 to 200	2349	Ep	.8	92.0	6-26-62	--	--	65	Ir	Dl
16S/49-28d1	M. Wickner	1959	^{m}256.0	16	300	117 to 300	2354	Ep	.1	97.0	6-26-62	--	--	65	Ir	Dl
16S/49-29c1	L. Gamell	1956	^{m} 82.4	--	--	--	2338	L	0	80.9	6-26-62	--	--	--	U	Dl, no csg, hole diameter 14"
16S/49-30b1	G. Bettles	--	^{m} 84.6	16	--	--	2348.2	Tc	.4	84.9	9- 3-58	--	--	--	Dr; U	Original depth rept. 180'
16S/49-31b1	G. Bettles	--	^{m}152.9	16½	--	--	2326.3	Tc	0	69.4	6-26-62	--	--	--	Obs	Meas. by U.S.G.S. yearly
16S/49-32b1	J. Housell	1956	^{m} 74.0	--	--	--	2328	--	--	--	--	--	--	--	Dr	Dl, no csg.
16S/49-32c1	J. Housell	1956	^{m} 66.2	--	--	--	2317	L	0	63.6	6-26-62	--	--	--	U	Dl, no csg.
16S/49-32d1	M. Stephens	1959	^{m}232.8	12 3/4	253	94 to 248	2324	Tc	.9	69.2	6-26-62	--	--	70	Ir	Dl
16S/49-33b1	M. Hodges	1960	^{m}217.1	14	300	100 to 300	2336	Tc	1.2	81.6	6-26-62	--	--	--	Ir	Dl
16S/49-33d1	P. Honig	1962	^{m}321.0	14	--	--	--	Ep	.7	84.5	6-20-62	--	--	--	Ir	--
16S/49-34c1	--	1962	--	--	--	--	--	L	--	88.17	10-24-62	450	--	--	Ir	--
16S/49-35a1	N. Berry	1957	^{m}170.6	16	200	110 to 200	2323	Ep	.2	99.3	6-27-62	750	--	--	Ir	Dl
16S/49-35b1	E. McCoy	1959	325	14	223	100 to 223	2341	--	--	85	3-15-59	--	--	76	Ir	Dl, A, Ar
16S/49-36a1	Bradley	--	--	12	--	--	--	--	--	--	--	--	--	--	Ir	--
16S/50- 7c1	L. Cook	1961	200	6	200	120 to 200	2480	--	--	140	7-31-62	--	--	--	D	Dl, A, Ar
16S/50- 7c2	L. Cook	1962	335	12	--	--	2478	Tc	.9	112.8	8-18-62	--	--	--	Ir	--

Table 3.--(continued.)

Well number and location	Owner	Year completed	Depth (feet)	Casing: Diameter (inches)	Casing: Depth (feet)	Casing: Perforated zone (feet)	Altitude (feet)	Meas. point: Description	Meas. point: Height (feet)	Water level: Above(+) or below land surface (feet)	Water level: Date	Yield (gpm)	Drawdown (feet)	Temperature (°F)	Status or use	Remarks
16S/51-28d1	Miller Well #2	--	^{m}29	6	--	--	2370.6	--	--	70	1907	--	--	--	Dr; U	Water level rept. 70' in U.S.G.S. Bull. 308, 1907
16S/51-36a1	--	1962	--	8	--	--	2444.4	L	0	99.5	8-30-62	--	--	--	Ir	--
16S/52- 8c1	Las Vegas and Tonopah R.R.	--	^{m}0	2 3/4	--	--	2777	--	--	--	--	--	--	--	Dr; U	T.D. in 1952 was 149.5; well was dry; well now destroyed
16S/53- 4b1	--	1962	1946	13 3/4 to 6 1/8	1360	800 to 1050	3154	Ep	--	786	7- -62	438	130	89	P	A
17S/48- 1a1	D. Hallowell	1957	135	16	135	73 to 131	2303	Tc	.2	51.6	7- 5-62	750	15	--	Ir	Dl
17S/48- 1c1	W. Hoyle	1955	214	14	214	92 to 205	2295.7	Tc	.5	45.2	7- 5-62	--	--	--	Ir	Dl
17S/48- 1d1	A. Bettles	1959	203	12	203	60 to 202	--	Dp	.8	43.8	7- 5-62	--	--	--	Ir	Dl
17S/48- 1d2	A. Bettles	1960	^{m}101.9	14	105	43 to 105	--	Tc	.2	45.6	7- 5-62	--	--	--	Ir	Dl
17S/48- 1d3	A. Bettles	1960	^{m}188.4	14	197	30 to 197	2292.6	Tc	.5	43.7	7- 5-62	--	--	70	Ir	Dl
17S/48-12a1	A. Bettles	1955	85	14	--	--	--	--	--	42	12- 6-55	--	--	--	Ir	Dl
17S/48-12a2	A. Bettles	1955	^{m}85.4	12	--	--	2284.4	Ep	.8	55.0	6-25-62	--	--	--	Ir	--
17S/48-12d1	--	1962	205	14	205	60 to 205	--	L	--	51.03	10-31-62	--	--	--	U	--
17S/49- 2b1	--	--	^{m}174.3	16	--	--	2301	Tc	.1	81.6	6-26-62	--	--	--	Ir	--
17S/49- 2b2	H. Berry	1957	^{m}82.2	--	--	--	2305	--	--	60	5- 7-57	850	60	--	Dr; U	Dl, well uncased
17S/49- 2c1	--	--	^{m}191.2	12	--	--	2292	Tc	.9	71.8	6-26-62	--	--	--	Ir	--
17S/49- 4a1	Nye County Land Development Co., Inc.	1962	630	14	588	--	--	L	--	80.68	10-30-62	650	125	83	Ir	--
17S/49- 4d1	Nye County Land Development Co., Inc.	1962	554	16	554	--	2290	L	--	69.38	9-14-62	--	--	--	E	--
17S/49- 5a1	W. Moore, Jr.	1956	^{m}91.2	--	--	--	2317	L	0	84.3	6-26-62	--	--	--	U	Dl
17S/49- 5a2	W. Moore, Jr.	1956	^{m}49.5	--	--	--	2302	--	--	68	1-20-56	--	--	--	Dr; U	Dl, hole diam. 16"
17S/49- 5b1	P. Moore	1956	^{m}51.6	--	--	--	2300	--	--	52	1-16-56	--	--	--	Dr; U	Dl, hole diam. 16"
17S/49- 5b2	--	--	^{m}16.8	--	--	--	2299	--	--	--	--	--	--	--	Dr; U	Hole diam. 16"
17S/49- 6a1	E. Cleveland	1955	^{m}56.4	--	--	--	2310	--	--	59	12-22-55	--	--	--	Dr; U	Dl
17S/49- 6a2	E. Cleveland	1956	^{m}68.6	--	--	--	2298	L	0	66.4	6-26-62	--	--	--	U	Dl, hole diam. 16"
17S/49- 6b1	J. Tynan	1955	^{m}119.6	12 3/4	155	66 to 155	2305	Tc	1.0	50.1	6-26-62	--	--	--	Ir	Dl
17S/49- 7a1	T. Davis	1960	^{m}209.3	14	210	55 to 210	--	Tc	1.8	56.7	6-25-62	--	--	74	Ir	Dl
17S/49- 7b1	H. Davis	1960	500	16	390	56 to 385	--	Ep	0.0	40.8	6-25-62	--	--	--	Ir	Dl
17S/49- 7c1	H. Davis	1955	61	--	--	--	--	--	--	44	12- 3-55	--	--	--	U	Dl, well destroyed
17S/49- 7d1	T. Davis	1960	400	16	361	54 to 360	--	Tc	.2	57.5	6-25-62	--	--	74	Ir	Dl
17S/49- 8a1	A. Cleveland	1956	^{m}59.4	--	--	--	2284.7	Ep	.4	57.7	5-11-56	--	--	--	Dr; U	Dl
17S/49- 8c1	F. Cleveland	1956	^{m}61.1	--	--	--	--	Ep	.4	49.3	6-25-62	--	--	--	U	Dl, hole diam. 16"
17S/49- 8d1	A. Cleveland	1956	^{m}50.3	--	--	--	--	Ep	.5	48.1	6-25-62	--	--	--	U	Dl, hole diam. 16"
17S/49- 9b1	S. Wall, R. Geers	1959	500	16-12	480	150 to 352 330 to 480	2285.5	Ep	1.5	157.1	6-20-62	800-900	^{m}154.7	65	Ir	Dl, 16" csg. 0-352; 12" csg. 330-480; Sp. cond., 350
17S/49-11b1	G. Bettles	1955	^{m}145.4	10	160	45 to 160	2274.8	Tc	.6	61.6	6-20-62	--	--	--	Ir	Dl, Sp. cond., 960
17S/49-11b2	L. Siegel	1962	^{m}274.5	14	300	80 to 300	--	Ep	.4	59.4	6-20-62	--	--	70	Ir	Dl
17S/49-15b1	J. Steelman	1959	200	10	201	55 to 200	2264.8	Dp	5.0	52.0	6-19-62	--	--	--	Ir	Dl
17S/50-15a1	Nye County Land Development Co., Inc.	1962	^{m}464.6	16-14	480	100 to 475	2289.8	Tc	1.4	0.0	6-14-62	--	--	67	Ir	Dl, A, 16" csg. 0-186; 14" csg. 175-480; measured flow 2.5 gpm on 6-14-62; Sp. cond., 700
17S/50-29d1	Nye County Land Development Co., Inc.	1962	^{m}470.6	16	514	150 to 500	2170.9	--	--	0.0	6-16-62	2000	30	67	Ir	Dl, A, Ar; measured flow 5.4 gpm on 6-16-62; Sp. cond., 950
17S/51- 1a1	W. White	1959	135	8	135	48 to 135	2402.6	Tc	0.0	59.8	6- 9-62	^{m}191.1	^{m}11.0	73	Ir	Dl, A
17S/51- 1a2	W. White	1959	103	8	103	--	2403	Tc	0.0	60.0	6- 9-62	--	--	--	D	--
17S/51-23b1	--	--	^{m}22.8	6	--	--	2328.3	Tc	0.0	0.0	6- 9-62	--	--	68	S	Measured flow 1/6 gpm on 6-9-62; Sp. cond., 600
17S/51-24b1	--	--	^{m}22.2	--	--	--	--	L	0.0	15.9	6- 9-62	--	--	--	U	Dug well 5' x 5'
17S/52- 8c1	J. Daniels	1961	400	16	--	39 to 139	2393.4	--	--	33	10-30-61	--	--	--	Ir	Dl
17S/52- 8c2	J. Daniels	--	^{m}84.7	16	--	--	2397.3	Tc	0	36.8	6- 9-62	--	--	--	P	Supplies water to 8 families
18S/49- 1a1	--	--	^{m}21.3	--	--	--	--	Ep	.8	15.1	6-16-62	--	--	--	U	Dug well, diam. 4' x 4'
18S/49- 2c1	B. Embry	1962	402	12 3/4	402	303 to 402	2183.1	Tc	.1	71.6	7-31-62	--	--	--	D	Dl

Table 3.--(continued.)

Well number and location	Owner	Year completed	Depth (feet)	Diameter (inches)	Casing: Depth (feet)	Casing: Perforated zone (feet)	Altitude (feet)	Meas. point: Description	Meas. point: Height (feet)	Water level: Above (+) or below land surface (feet)	Water level: Date	Yield (gpm)	Drawdown (feet)	Temperature (°F)	Status or use	Remarks
California																
25N/5-14c1	E. Lee	1935	[m]139.2	12	--	65 to 70	2036.7	Ep	2.3	2.4	6-19-62	200	35	74.5	P	A, Sp. cond., 1,350
25N/5-14c2	E. Lee	--	[m]68.6	12	--	125 to 128	--	Tc	0.0	.9	6-18-62	--	--	73	U	Sp. cond., 1,800
25N/5-15a1	California Div. of Highways	--	160	8	160	--	2049	Tc	.9	5.2	7-31-62	--	--	--	P	--
25N/6-18a1	do	--	[m]27.5	12	--	--	2033	Tc	.6	+ 1.1	8-24-62	--	--	67	U	A, Ar, measured flow 2 gpm on 6-21-62; Sp. cond., 1,600
25N/6-18b1	do	--	[m]7.2	30x30	--	--	--	Tc	.3	4.6	6-19-62	--	--	70	U	Sp. cond., 720
25N/6-19a1	do	--	--	8	--	--	--	--	--	--	--	--	--	66	U	Sp. cond., 1,400
25N/6-19a2	do	--	[m]6.9	6	--	--	--	Tc	2.2	1.6	6-21-62	--	--	--	U	--
25N/6-19d1	do	--	[m]3.4	9	--	--	2013.7	Tc	-.1	0.0	6-21-62	--	--	68	U	Est. flow less than 1 gpm on 6-21-62; Sp. cond., 2,600
25N/6-20c1	do	--	[m]8.1	12	--	--	2015	Tc	.4	+ 4.1	8-24-62	--	--	68	U	A, Ar; meas. flow 2.2 gpm on 6-21-62; Sp. cond., 5,000
25N/6-30a1	do	--	[m]8.6	12	--	--	2011.7	Tc	1.0	+ .5	8-24-62	--	--	70	U	Estimated flow less than .1 gpm on 6-21-62; Sp. cond., 5,000
25N/6-31d1	do	--	[m]3.9	6	--	--	--	--	--	--	--	--	--	--	Dr; U	--
26N/5- 5b1	do	--	[m]10.4	--	--	--	2181.7	L	0.0	9.2	6-18-62	--	--	--	U	Franklin's well on topographic map
26N/5- 9d1	do	--	[m]3.0	--	--	--	--	--	--	--	--	--	--	--	Dr; U	Dug diam. 5' x 5'
26N/5-34c1	do	--	[m]19.3	--	--	--	--	--	--	--	--	--	--	--	Dr; U	Dug diam. 4' x 4'; Kelleys well on topographic map
27N/4-25b1	do	--	[m]22.8	60x60	--	--	2231	Tc	2.0	20.7	6-18-62	--	--	--	U	Scranton well on topographic map
27N/4-26b1	Morris & Van Der Lendon	--	[m]393.4	14	--	--	2237.2	Tc	.2	25.2	6-19-62	--	--	--	U	--
27N/4-26c1	Morris & Van Der Lendon	--	300	14	--	--	2234.6	Ep	0.0	32.0	6-19-62	--	--	--	Ir	--
27N/4-27a1	Morris & Van Der Lendon	1960	300	14	--	--	2241.9	--	--	--	--	[m]912.7	--	72	Ir	Sp. cond., 1,100
27N/4-27b1	Morris & Van Der Lendon	--	[m]124.0	14	--	--	2243.8	Tc	0.0	42.6	6-19-62	--	--	--	U	--
27N/4-27b2	Morris & Van Der Lendon	1962	300	14	--	--	2247.4	--	--	45	6-19-62	[m]1275	--	72	Ir	A, Ar; meas. yield 8-18-62; Sp. cond., 970
27N/4-27c1	Morris & Van Der Lendon	1961	[m]284.4	14	--	--	2244.8	Ep	.9	40.6	6-19-62	--	--	--	Ir	--

Table 4.--Drillers' logs of selected wells in the Amargosa Desert, Nevada-California

(The well logs contained herein were obtained from the office of the Nevada State Engineer, Carson City, Nevada. The terminology of the logs has been slightly modified for uniformity and clarity.)

13S/47-35a1. Nuclear Engineering Co., Inc.

Material	Thickness (feet)	Depth (feet)
Loam, sandy	2	2
Boulders, sand, and large gravel	31	33
Gravel, small, and sand	12	45
Boulders, large gravel, and brown, sandy clay	89	134
Boulders	13	147
Clay, brown	1	148
Boulders and large gravel	8	156
Clay, brown, and shale	5	161
Boulders and streaks of red and orange, sandy clay; cored from 181' to 206½'	74	235
Boulders, and large gravel	30	265
Clay, brown; cored from 275' to 280'	37	302
Clay, white	6	308
Clay, brown	14	322
Boulders, multicolored, and yellow clay	32	354
Clay, white	3	357
Clay, brown, and small gravel	21	378
Clay, greenish-brown	6	384
Clay, white, and boulders	22	406
Clay, brown	19	425
Quartzite	11	436
Clay, reddish, and some boulders	9	445
Boulders, hard (quartz, granite, dolomite)	22	467
Clay, red	5	472
Boulders, large and small; water	16	488
Clay, reddish-brown, shale, and boulders	41	529
Clay, brown	9	538
Boulders	15	553
Gravel, small; water	8	561
Gravel, small, and streaks of yellow clay	5	566
Sand, hard, compacted	9	575
Total depth		575

15S/49-11c1. R. Washburn

Material	Thickness (feet)	Depth (feet)
Sand, gravel, and boulders	140	140
Sand, compacted, and gravel	144	284
Sand and gravel	199	483
Clay and sand	30	513
Boulders and clay	39	552
Sand, hard	27	579
Sand, hard, gravel, and conglomerate	214	793
Sand and gravel	11	804
Boulders (hard, rough drilling)	6	810
Sand, fine; water	5	815
Sand, gravel, and boulders	75	890
Boulders (rough drilling)	5	895
Sand and small gravel	73	968
Total depth		968

15S/49-14a1. R. Washburn

Material	Thickness (feet)	Depth (feet)
Sand and gravel	15	15
Boulders	25	40
Boulders, brown and white	50	90
Total depth		90

15S/49-22a1. J. Shaw

Material	Thickness (feet)	Depth (feet)
Sand, gravel, and rock	570	570
Total depth		570

15S/49-22d1. R. Washburn

Material	Thickness (feet)	Depth (feet)
Sand and boulders	22	22
Gravel	26	48
Sand, fine, gravel, and boulders	133	181
Sand, fine	14	195
Gravel, sand; water	25	220
Sand, gravel, and boulders	55	275
Gravel; water	59	334
Clay and boulders	15	349
Clay, boulders, and gravel layers	151	500
Total depth		500

15S/49-27d1. R. Washburn

Material	Thickness (feet)	Depth (feet)
Gypsum, sandy, and gravel	4	4
Gypsum	3	7
Sand, gravel, and rocks	222	229
Sand, gravel; water	25	254
Sand, gravel, and rocks; water	92	346
Clay, red, sandy, and gravel; water	72	418
Clay, red	8	426
Clay, red, and gravel	16	442
Total depth		442

15S/50-18c1. L. Pereirda

Material	Thickness (feet)	Depth (feet)
Gravel	395	395
Total depth		395

15S/50-18c3. L. Pereirda

Material	Thickness (feet)	Depth (feet)
Surface	2	2
Sand and gravel	126	128
Sand, clay, and boulders	76	204
Sand and gravel	5	209
Clay, hard	45	254
Sand, gravel, and boulders	16	270
Clay, hard	91	361
Sand and gravel; water	4	365
Clay, hard, and boulders	11	376
Sand and gravel	6	382
Clay, hard, and boulders	24	406
Sand and gravel	27	433
Clay	14	447
Sand and gravel	22	469
Clay	7	476
Sand and gravel	10	486
Clay	10	496
Clay	11	507
Total depth		507

15S/50-18c4. B. Bossingham

Material	Thickness (feet)	Depth (feet)
Loam, sandy	3	3
Gravel, coarse, and boulders	62	65
Sand, hard, compacted, and small gravel	239	304
Clay, brown, sandy	30	334
Sand, coarse, gravel, and boulders	19	353
Clay, gray, sandy	7	360
Snad, coarse, gravel, and boulders	33	393
Sand, hard	27	420
Clay	51	471
Total depth		471

15S/50-18c6. B. Whellock

Material	Thickness (feet)	Depth (feet)
Surface	5	5
Sand and gravel	6	11
Gravel, sand, and boulders	17	28
Sand	7	35
Clay, sandy	10	45
Gravel and boulders	31	76
Boulders and clay	13	89
Gravel, boulders, and sand	57	146
Boulders and clay	11	157
Boulders, gravel, and sand	51	208
Boulders and clay	26	234
Clay, hard	131	365
Sand, gravel, and boulders	4	369
Clay, hard	7	376
Sand, gravel, and boulders	6	382
Clay, hard	12	394
Sand, gravel, and boulders	5	399
Clay, hard	12	411
Sand, gravel, and boulders	8	419
Clay, hard	12	431
Sand and gravel	14	445
Clay, sandy	31	476
Sand and gravel	5	481
Clay, hard	24	505
Total depth		505

16S/48-2d1. D. Heath

Material	Thickness (feet)	Depth (feet)
Topsoil	12	12
Soil, sandy	46	58
Sand, fine, and gravel	38	96
Sand and clay	40	136
Sand, coarse, and gravel	148	284
Clay with streaks of white lime	78	362
Sand and gravel	57	419
Clay, red	3	422
Total depth		422

16S/48-3a1. F. Keefe

Material	Thickness (feet)	Depth (feet)
Surface sand and gravel	40	40
Gravel, coarse, and sand	95	135
Gravel, coarse, and limey shale	85	220
Shale, limey, and clay	20	240
Clay	10	250
Total depth		250

Table 4.--(continued)

16S/48-4d1. E. Mankinen

Material	Thickness (feet)	Depth (feet)
Topsoil	9	9
Clay, sandy	7	16
Sand and gravel	11	27
Clay, sandy	25	52
Gravel, cemented	4	56
Clay and gravel	24	80
Clay, sandy	21	101
Sand, gray, fine	14	115
Sand, fine, and gravel; water	15	130
Sand, red	7	137
Sand and gravel	15	152
Clay, blue, hard	11	163
Gravel, large; water	6	169
Clay, blue	4	173
Sand and gravel	7	180
Clay	6	186
Sand and gravel	29	215
Sand, fine, and small gravel	9	224
Sand and gravel	11	235
Gravel, very coarse	13	248
Gravel, small	18	266
Gravel, coarse	36	302
Clay and gravel	6	308
Total depth		308

16S/48-5b1. F. Wooldridge

Material	Thickness (feet)	Depth (feet)
Sand and small rock	16	16
Rock, red	2	18
Gravel	8	26
Clay, gray	9	35
Sand and gravel	16	51
Sandstone	8	59
Sand and gravel	6	65
Sandstone	16	81
Rock, red	21	102
Sand	9	111
Sandstone	5	116
Sand	5	121
Sandstone	10	131
Sand	7	138
Gravel	6	144
Sandstone	4	148
Sand and gravel	7	155
Sandstone	16	171
Sand and gravel	38	209
Sand and clay	10	219
Sand and gravel	18	237
Clay, red	13	250
Total depth		250

16S/48-8a1. E. Schultz

Material	Thickness (feet)	Depth (feet)
Sand, gravel, and boulders	25	25
Clay, brown, sandy, and gravel	45	70
Sand, medium	8	78
Sand and gravel	34	112
Sand, large	10	122
Clay, brown, sandy, and gravel	48	170
Sand and small gravel	10	180
Clay, brown, sandy	95	275
Sand, large	5	280
Clay, sandy, and gravel	35	315
Total depth		315

16S/48-8b1. C. DeFir, Sr.

Material	Thickness (feet)	Depth (feet)
Topsoil	2	2
Sand and gravel	16	18
Clay	14	32
Sand and rock	19	51
Clay	44	95
Sand and gravel	103	198
Clay, sandy	12	210
Sand and gravel	40	250
Total depth		250

16S/48-9b1. C. DeFir, Jr.

Material	Thickness (feet)	Depth (feet)
Topsoil	6	6
Sand and gravel	14	20
Clay, sandy	14	34
Sand and rock	20	54
Clay	37	91
Sand and gravel	94	185
Clay, sandy	20	205
Sand and gravel	45	250
Total depth		250

16S/48-9c1. C. Caldwell

Material	Thickness (feet)	Depth (feet)
Sand and clay	100	100
Gravel and sand	10	110
Clay and gravel	70	180
Sand and gravel	65	245
Sand	75	320
Sand and gravel	27	347
Rock, hard	3	350
Total depth		350

16S/48-9d1. D. Fadenrecht

Material	Thickness (feet)	Depth (feet)
Topsoil and sand	30	30
Clay, sandy	20	50
Sand and gravel	22	72
Clay, sandy	24	96
Sand and gravel	24	120
Sand, hard, and gravel	22	142
Clay, sandy	28	170
Sand, fine	25	195
Sand, hard, and rock	15	210
Clay, sandy	20	230
Sand and gravel	20	250
Clay and rock	28	278
Sand, hard, and rock	16	294
Sand	26	320
Clay	16	336
Sand and gravel	26	362
Clay	12	374
Sand and gravel	20	394
Clay	16	410
Total depth		410

16S/48-10a1. Mrs. A. Mankinen

Material	Thickness (feet)	Depth (feet)
Sand and topsoil	11	11
Clay, sandy	29	40
Clay	5	45
Gravel, cemented, coarse	5	50
Clay, sandy	40	90
Clay, hard	5	95
Gravel, loose	9	104
Sand, fine, and gravel; water	16	120
Gravel, coarse	12	132
Clay, hard	4	136
Gravel, coarse	10	146
Clay, sandy	4	150
Sand, fine	8	158
Clay	2	160
Sand	4	164
Gravel	7	171
Sand and gravel	25	196
Sand, coarse	2	198
Gravel	2	200
Sand	10	210
Pea gravel, large	14	224
Pea gravel, mixed	22	246
Pea gravel, large	3	249
Boulders	13	262
Pea gravel	5	267
Sand	11	278
Pea gravel	9	287
Clay	5	292
Pea gravel	13	305
Sand	3	308
Gravel	12	320
Total depth		320

16S/48-10b1. W. Monroe

Material	Thickness (feet)	Depth (feet)
Sand	20	20
Sand and gravel	106	126
Gravel, coarse	12	138
Gravel and sand	162	300
Total depth		300

16S/48-11c1. J. Pierce

Material	Thickness (feet)	Depth (feet)
Surface sand and gravel	35	35
Sand, coarse, and small gravel	165	200
Gravel, coarse	50	250
Gravel, coarse, streaked with clay	52	302
Total depth		302

16S/48-13a1. P. Parker

Material	Thickness (feet)	Depth (feet)
Topsoil	2	2
Sand and gravel	26	28
Clay, sandy	8	36
Sand and gravel	42	78
Clay, sandy	20	98
Clay, hard	12	110
Sand and gravel	12	122
Sand, fine	9	131
Clay, hard	17	148
Clay, sandy	24	172
Sand, fine	8	180
Clay, sandy	16	196
Sand, hard, and rock	17	213
Clay, sandy	14	227
Sand, coarse	8	235
Clay, sandy	7	242
Sand and rock	4	246
Clay, hard	4	250
Total depth		250

Table 4.--(continued.)

16S/48-14b1. T. Gallagher

Material	Thickness (feet)	Depth (feet)
Topsoil	2	2
Sand and gravel	93	95
Clay	9	104
Sand and gravel; water	32	136
Sand and fine gravel	10	146
Gravel, large	12	158
Sand and fine gravel	12	170
Gravel, medium	11	181
Pea gravel	14	195
Sand, fine, and small gravel	8	203
Sand, fine, and light red clay	37	240
Pea gravel and boulders	6	246
Pea gravel and sand	17	263
Sand and small gravel	32	295
Clay	6	301
Clay, fine, sandy	48	349
Total depth		349

16S/48-14d1. P. Perry

Material	Thickness (feet)	Depth (feet)
Rock, sandy	90	90
Clay	5	95
Sand and gravel	15	110
Sand, hardpack	18	128
Clay	18	146
Sand, fine	18	164
Clay	16	180
Sand and gravel	30	210
Clay	18	228
Sand and gravel	12	240
Total depth		240

16S/48-15a1. E. Mankinen

Material	Thickness (feet)	Depth (feet)
Topsoil	4	4
Clay	9	13
Sand, red, and gravel	31	44
Sand	45	89
Clay, red	8	97
Sand and gravel; water	53	150
Total depth		150

16S/48-15b1. L. Dansby

Material	Thickness (feet)	Depth (feet)
Topsoil	4	4
Clay	17	21
Clay	9	30
Sand and clay	15	45
Sand, hard, brown	22	67
Sand, hard	8	75
Gravel, red	5	80
Clay, brown, and sand	7	87
Clay, brown, and sand	6	93
Sand; water	9	102
Sand and gravel	20	122
Gravel; water	7	129
Gravel	8	137
Gravel; water	8	145
Clay and gravel	4	149
Total depth		149

16S/48-16a1. E. Selbach

Material	Thickness (feet)	Depth (feet)
Soil, sandy	12	12
Sand and rock	93	105
Clay, sandy	13	118
Sand and rock	46	164
Clay, sandy	6	170
Sand and gravel	38	208
Clay	4	212
Sand, coarse	16	228
Clay	6	234
Sand, fine	8	242
Clay	8	250
Total depth		250

16S/48-17a1. J. Overhalser

Material	Thickness (feet)	Depth (feet)
Topsoil	4	4
Gravel, cemented	128	132
Sand, fine	2	134
Gravel, cemented	146	280
Total depth		280

16S/48-18b1. J. Bell

Material	Thickness (feet)	Depth (feet)
Topsoil	5	5
Sand	10	15
Sand, coarse	23	38
Sand and gravel	202	240
Sand	52	292
Rock, broken	6	298
Sand, red	82	380
Total depth		380

16S/48-20d1. J. Downey

Material	Thickness (feet)	Depth (feet)
Topsoil	8	8
Sand	22	30
Rock	4	34
Sand, brown	151	185
Limestone	2	187
Sand, brown	68	255
Limestone, broken	6	261
Limestone	14	275
Limestone, broken	11	286
Limestone, broken	50	336
Sand, hard	30	366
Total depth		366

16S/48-23a1. H. Gillespie

Material	Thickness (feet)	Depth (feet)
Sand and gravel	25	25
Pea gravel	70	95
Sand	80	175
Gravel	155	330
Clay		330
Total depth		330

16S/48-23b1. H. Gillespie

Material	Thickness (feet)	Depth (feet)
Gravel, coarse	84	84
Gravel	230	314
Gravel and clay	10	324
Clay	6	330
Total depth		330

16S/48-23c1. H. Gillespie

Material	Thickness (feet)	Depth (feet)
Topsoil	10	10
Soil, sandy, tight	57	67
Sand, fine, and gravel	18	85
Clay, light, sandy	77	162
Clay, red, with streaks of gravel	33	195
Clay, red, sandy, with steaks of white lime	128	323
Sand and fine gravel	120	443
Clay, sticky	37	480
Sand, coarse, and gravel	21	501
Clay, hard, sticky	9	510
Total depth		510

16S/48-23d1. V. Gillespie

Material	Thickness (feet)	Depth (feet)
Topsoil	8	8
Soil, sandy, tight	54	62
Sand, fine, and gravel	19	81
Clay, light, sandy	77	158
Clay, red, with streaks of gravel	32	190
Clay, red, sandy, with streaks of white lime	130	320
Sand and fine gravel	125	445
Clay with streaks of white lime	35	480
Pea gravel	21	501
Clay, sticky	2	503
Total depth		503

16S/48-24a1. M. Records

Material	Thickness (feet)	Depth (feet)
Surface soil	2	2
Gravel and sand	9	11
Clay	10	21
Sand and gravel	10	31
Clay	15	46
Sand and gravel	8	54
Clay	12	66
Gravel and sand	13	79
Clay	12	91
Sand, gravel, and boulders	18	109
Clay	5	114
Gravel and boulders	15	129
Clay	19	148
Sand and gravel	8	156
Clay	18	174
Sand and gravel	23	197
Clay	21	218
Boulders and gravel	13	231
Clay and boulders	23	254
Sand and gravel	8	262
Clay	14	276
Sand, gravel, and boulders	8	284
Clay	13	297
Sand, gravel, and boulders	19	316
Clay	11	327
Sand and gravel	12	339
Clay	23	362
Boulders and clay	7	369
Clay	18	387
Boulders and clay	5	392
Clay	22	414
Boulders	7	421
Clay, hard	48	469
Boulders	3	472
Rock	8	480
Total depth		480

Table 4.--(continued.)

16S/48-24c1. R. Records

Material	Thickness (feet)	Depth (feet)
Surface soil, sand, and gravel	35	35
Gravel, medium	60	95
Clay	40	135
Lime shale	70	205
Clay	25	230
Lime shale and gravel	76	306
Total depth		306

16S/48-24d1. R. Records

Material	Thickness (feet)	Depth (feet)
Surface soil	2	2
Sand and gravel	6	8
Clay	6	14
Sand and gravel	14	28
Clay	9	37
Sand and gravel	6	43
Clay	11	54
Sand and gravel	15	69
Clay and gravel	24	93
Sand and gravel	4	97
Clay	6	103
Sand and gravel	15	118
Clay	11	129
Boulder and gravel	8	137
Clay, hard	6	143
Gravel and sand	19	162
Clay, hard	10	172
Clay, sandy	12	184
Gravel, sandy	12	196
Clay	17	213
Sand, boulders, and gravel	14	227
Clay	12	239
Sand and gravel	16	255
Clay	12	207
Clay	16	283
Sand, boulders, and gravel	16	299
Clay	13	312
Boulders and gravel	21	333
Clay	1	334
Gravel and sand	5	339
Clay	22	361
Boulders and gravel	17	378
Clay	4	382
Gravel and boulders	6	388
Clay	3	391
Gravel and sand	20	411
Clay	10	421
Total depth		421

16S/48-25a1. G. Bettles

Material	Thickness (feet)	Depth (feet)
Pit	25	25
Gravel, coarse, and sand	6	31
Gravel, hard, fine, and sand	12	43
Sand, hard, fine, with streaks of clay	7	50
Gravel, cemented, and limestone	3	53
Gravel, hard, and limestone	6	59
Gravel, hard, and sand	6	65
Gravel, fine, and sand	9	74
Limestone, hard(?)	6	80
Gravel, cemented	9	89
Gravel, loose	4	93
Sand, fine	8	101
Gravel, coarse	3	104
Gravel, fine	21	125
Gravel, hard, coarse, clay, and limestone	3	128
Clay, sandy	6	134
Clay, hard, sandy, gravel, and limestone	12	146
Gravel, with streaks of clay	9	155
Gravel, hard, and limestone	5	160
Gravel, cemented, and limestone	5	165
Limestone	10	175
Gravel, cemented	8	183
Limestone, hard	3	186
Gravel, cemented	4	190
Gravel and some clay	5	195
Limestone, sandy, very hard	3	198
Total depth		198

16S/48-27c1. M. Barr

Material	Thickness (feet)	Depth (feet)
Sand and limestone	53	53
Sand and gravel	20	73
Gravel	10	83
Rock and gravel	10	93
Gravel, coarse	19	112
Gravel	30	142
Sand and gravel	10	152
Sand	10	162
Sand and gravel	10	172
Gravel	20	192
Sand, fine	10	202
Gravel	5	207
Gravel, coarse	10	217
Sand, clay, and gravel	10	227
Sand, fine, and clay	9	236
Total depth		236

16S/48-27d1. M. Delph

Material	Thickness (feet)	Depth (feet)
Top soil	25	25
Limestone, very hard	4	29
Soil, sandy	20	49
Sandstone, crumbly	26	75
Clay, light and sand	50	125
Clay, pink and sand	15	140
Sandstone, light brown	45	185
Clay, red, and little sand	15	200
Total depth		200

16S/48-36d1. Mrs. H. Watson

Material	Thickness (feet)	Depth (feet)
Surface soil	32	32
Limestone, cemented, and gravel	13	45
Clay, reddish, cemented, and gravel	15	60
Clay, light colored, and sand	35	95
Sandstone, gray	10	105
Limestone, hard	5	110
Clay, red, and little sand	41	151
Clay, red, sticky	14	165
Clay, red, and sand	25	190
Clay, red, and gravel	10	200
Clay, brown	43	243
Limestone, hard	9	252
Clay, white (talc)?	43	295
Clay, gray, with occasional boulder	55	350
Limestone, gray (medium)	12	362
Clay, gray	33	395
Limestone, gray (medium)	12	407
Total depth		407

16S/49-8a1. M. Meese

Material	Thickness (feet)	Depth (feet)
Surface soil	8	8
Loose rock and gravel	82	90
Dry gravel	6	96
Conglomerate	54	150
Sand, yellow	20	170
Sand, light colored	20	190
Gravel, large; water	5	195
Clay, red; with lens of gravel and sand a few inches thick every 4 or 5 feet	105	300
Total depth		300

16S/49-9c1. T. Selbach

Material	Thickness (feet)	Depth (feet)
Sand and rock	11	11
Sand, hard pack, and rock	3	14
Clay and rock	18	32
Sand and rock	37	69
Clay, sandy	41	110
Sand and rock	3	113
Clay, sandy	7	120
Sand	8	128
Sand and clay	14	142
Sand and rock	8	150
Clay and rock	30	180
Clay	18	198
Sand and gravel	12	210
Clay	25	235
Sand, hard	7	242
Clay	18	260
Sand and rock	8	268
Clay	22	290
Sand and rock	8	298
Clay	2	300
Total depth		300

16S/49-14a1. W. Johns

Material	Thickness (feet)	Depth (feet)
Loam, brown, sandy	2	2
Sand and gravel	5	7
Boulders	16	23
Gravel, large	32	55
Gravel, hard, compacted, and sand	55	110
Clay and boulders	14	124
Clay, light gray	5	129
Clay, brown	36	165
Clay and large gravel	10	175
Limestone, hard	2	177
Clay, brown	31	208
Sand, hard compacted	2	210
Conglomerate composed of clay and gravel	90	300
Total depth		300

16S/49-14b1. W. Johns

Material	Thickness (feet)	Depth (feet)
Surface soil, sand, and gravel	140	140
Sand and gravel	150	290
Gravel	100	390
Clay	-	390
Total depth		390

Table 4.--(continued.)

16S/49-15a1. W. Johns

Material	Thickness (feet)	Depth (feet)
Sand	23	23
Sand and gravel	35	58
Gravel	28	86
Sand and gravel	114	200
Clay, brown	109	309
Clay, gray	33	342
Clay, brown	28	370
Sand	50	420
Total depth		420

16S/49-18a1. W. Hanks

Material	Thickness (feet)	Depth (feet)
Surface soil, sand, and gravel	80	80
Sand and pea gravel	280	360
Sand, hard	25	385
Gravel	15	400
Sand, hard	20	420
Clay	-	420
Total depth		420

16S/49-19a1. L. Meeter

Material	Thickness (feet)	Depth (feet)
Surface soil	2	2
Gravel and sand	9	11
Clay	10	21
Sand and gravel	10	31
Clay	15	46
Sand and gravel	8	54
Clay	12	66
Sand and gravel	13	79
Clay	12	91
Sand, gravel, and boulders	18	109
Clay	5	114
Sand, boulders, and gravel	15	129
Clay	19	148
Sand and gravel	8	156
Clay	18	174
Sand and gravel	23	197
Clay	21	218
Sand, boulders, and gravel	13	231
Clay and boulders	23	254
Sand and gravel	9	263
Clay	13	276
Sand, gravel, and boulders	8	284
Clay	13	297
Sand, gravel, and boulders	19	316
Clay	11	327
Sand and gravel	12	339
Clay	23	362
Boulders and clay	7	369
Clay	18	387
Boulders and clay	5	392
Clay	22	414
Boulders	7	421
Clay, hard	48	469
Boulders	3	472
Rock	8	480
Total depth		480

16S/49-19b1. L. Meeter

Material	Thickness (feet)	Depth (feet)
Surface soil	3	3
Hardpan	2	5
Sand	6	11
Clay	12	23
Sand and gravel	18	41
Clay	8	49
Sand and gravel	27	76
Clay	31	107
Sand	22	129
Clay	19	148
Sand and gravel	16	164
Clay	13	177
Sand, gravel, and boulders	22	199
Clay	22	221
Sand, gravel, and boulders	20	241
Clay	21	262
Sand and gravel	16	278
Clay	16	294
Sand and gravel	26	320
Clay	17	337
Sand and gravel	11	348
Clay	24	372
Boulders and gravel	15	387
Clay	16	403
Sand and gravel	23	426
Clay	13	439
Sand, gravel, and boulders	13	452
Clay	17	469
Sand	13	482
Clay, hard	6	488
Sand, gravel, and boulders	14	502
Clay	19	521
Sand, gravel, and boulders	44	565
Clay	39	604
Sand, gravel, and boulders	22	626
Clay	17	643
Sand, gravel, and boulders	18	661
Clay	18	679
Sand, gravel, and boulders	22	701
Clay	10	711
Sand and gravel	7	718
Clay	7	725
Total depth		725

16S/49-19c1. R. Records

Material	Thickness (feet)	Depth (feet)
Sand and gravel	24	24
Sand and coarse gravel	30	54
Gravel, coarse	100	154
Clay	20	174
Clay and gravel	10	184
Gravel	10	194
Clay and gravel	60	254
Sand and clay	20	274
Clay and gravel	10	284
Clay and small amount of gravel	10	294
Clay	6	300
Total depth		300

16S/49-19d1. L. Meeter

Material	Thickness (feet)	Depth (feet)
Surface soil	2	2
Sand and gravel	1	3
Hardpan	6	9
Sand and gravel	13	22
Clay	3	25
Boulders and clay	2	27
Clay	6	33
Sand and gravel	14	47
Clay and sand	17	64
Sand and gravel	9	73
Clay and sand	12	85
Gravel and boulders	22	107
Clay and sand	8	115
Gravel and sand	4	119
Clay and sand	15	134
Gravel and sand	12	146
Clay and gravel	12	158
Sand and gravel	15	173
Clay and sand	8	181
Boulders	18	199
Clay and gravel	17	216
Boulders and gravel	10	226
Sand and gravel	13	239
Clay	7	246
Gravel	20	266
Clay and gravel	7	273
Gravel and sand	12	285
Clay, hard	5	290
Sand, boulders, and gravel	7	297
Clay	6	303
Sand and gravel	4	307
Total depth		307

16S/49-20a1. M. Travis, J. Earl, and P. Clement

Material	Thickness (feet)	Depth (feet)
Sand and ash	80	80
Gravel, coarse	10	90
Sand, fine	20	110
Sand and gravel	58	168
Gravel	15	183
Sand, coarse	24	207
Sand, fine, and gravel in layers	57	264
Sand, coarse	36	300
Total depth		300

16S/49-20d1. E. Easterbrook

Material	Thickness (feet)	Depth (feet)
Topsoil	2	2
Sand and rock	22	24
Sand, hard, and rock	18	42
Clay, white	8	50
Clay, and rock	60	110
Sand, hard, and rock	25	135
Clay	17	152
Sand, hard, and rock	58	210
Clay	25	235
Sand and gravel	22	257
Clay	19	276
Sand and gravel	34	310
Sand, hard, and gravel	34	344
Clay, red	26	370
Sand and rock	40	410
Total depth		410

16S/49-23a1. Mrs. R. Dalton

Material	Thickness (feet)	Depth (feet)
Clay	10	10
Sand and clay	30	40
Boulders	10	50
Sand and gravel	53	103
Sand	14	117
Clay, brown	3	120
Gravel with streaks of clay	35	155
Clay, brown	10	165
Gravel	2	167
Clay, brown	43	210
Gravel	45	255
Clay, brown	50	305
Gravel	27	332
Clay, brown, sandy	27	359
Gravel	3	362
Clay, brown, sandy	38	400
Gravel	2	402
Clay, brown, sandy	31	433
Sand, hard	37	470
Clay, brown	15	485
Sand, hard	5	490
Clay, brown	10	500
Total depth		500

Table 4.--(continued.)

16S/49-26d1. D. Bilsborough

Material	Thickness (feet)	Depth (feet)
Surface soil	2	2
Sand, gravel, and boulders	98	100
Sand	7	107
Gravel and boulders	11	118
Sand	6	124
Sand and gravel	56	180
Boulders, loose	22	202
Sand and gravel	28	230
Clay	2	232
Sand and gravel	68	300
Total depth		300

16S/49-26d2. M. Records

Material	Thickness (feet)	Depth (feet)
Topsoil	6	6
Tight soil	9	15
Limestone, hard	7	22
Clay, light colored	18	40
Clay, brown or reddish	50	90
Clay, light, with an occasional hard streak every 2 or 3 feet	50	140
Clay, light colored, with lens of sand and gravel	140	280
Clay, sticky	20	300
Total depth		300

16S/49-28a1. M. Wickner

Material	Thickness (feet)	Depth (feet)
Topsoil	8	8
Conglomerate with few boulders	30	38
Limestone, hard	2	40
Conglomerate with larger boulders	75	115
Sand, light colored	35	150
Gravel, cemented	100	250
Gravel; water	3	253
Gravel, cemented, with red clay lens	47	300
Total depth		300

16S/49-28c1. E. Mason

Material	Thickness (feet)	Depth (feet)
Topsoil	7	7
Conglomerate with large boulders	33	40
Limestone	8	48
Conglomerate	67	115
Sand, light colored	40	155
Gravel, cemented	15	170
Sand and gravel	14	184
Gravel, cemented	16	200
Total depth		200

16S/49-28d1. M. Wickner

Material	Thickness (feet)	Depth (feet)
Topsoil	8	8
Conglomerate with few boulders	27	35
Limestone	7	42
Conglomerate	78	120
Sand, light colored	40	160
Gravel, cemented	120	280
Gravel; water	5	285
Clay, reddish, with little gravel	15	300
Total depth		300

16S/49-29c1. L. Gamell

Material	Thickness (feet)	Depth (feet)
Surface soil	15	15
Soil, sandy	17	32
Soil and rocks	13	45
Sand, light colored	25	70
Sand and gravel	27	97
Total depth		97

16S/49-32b1. J. Housell

Material	Thickness (feet)	Depth (feet)
Surface soil	15	15
Soil, sandy	17	32
Gravel, small, cemented	33	65
Gravel, large, cemented	23	88
Total depth		88

16S/49-32c1. J. Housell

Material	Thickness (feet)	Depth (feet)
Surface soil	5	5
Rocks and soil	27	32
Gravel and reddish clay	28	60
Gravel, fine, and sand	20	80
Total depth		80

16S/49-32d1. M. Stephen

Material	Thickness (feet)	Depth (feet)
Clay and sand	70	70
Sand and gravel; water	48	118
Clay and limestone	135	253
Total depth		253

16S/49-33b1. M. Hodges

Material	Thickness (feet)	Depth (feet)
Surface soil	9	9
Sand and gravel	18	27
Clay, sandy	5	32
Sand and gravel	40	72
Clay	7	79
Sand	26	105
Gravel and boulders	37	142
Clay, hard	20	162
Sand and gravel	51	213
Clay, sandy	25	238
Sand and gravel	11	249
Clay, sandy	51	300
Total depth		300

16S/49-35a1 N. Berry

Material	Thickness (feet)	Depth (feet)
Soil	4	4
Clay and gravel	21	25
Boulders, large, and clay	15	40
Clay	50	90
Boulders and clay	20	110
Sand	4	114
Clay	46	160
Clay and boulders	20	180
Clay	20	200
Total depth		200

16S/49-35b1. E. McCoy

Material	Thickness (feet)	Depth (feet)
Topsoil	12	12
Clay, yellow	112	124
Boulders, large	11	135
Clay, yellow	85	220
Boulders and gravel	18	238
Clay, white	87	325
Total depth		325

16S/50-7c1. L. Cook

Material	Thickness (feet)	Depth (feet)
Sand	23	23
Boulders	66	89
Gravel, fine	15	104
Clay	40	144
Gravel, fine, and boulders	46	190
Boulders	4	194
Clay	6	200
Total depth		

17S/48-1a1. D. Hallowell

Material	Thickness (feet)	Depth (feet)
Sand	35	35
Limestone, white, soft, (?) or tufa	30	65
Gravel and sand; water	10	75
Gravel	60	135
Total depth		135

17S/48-1c1. W. Hoyle

Material	Thickness (feet)	Depth (feet)
Surface soil	3	3
Sand	5	8
Clay	5	13
Sand and gravel	6	19
Clay	2	21
Boulders and gravel	2	23
Limestone	7	30
Clay with gravel	3	33
Clay	21	54
Sand and gravel	4	58
Boulders and gravel	6	64
Clay and boulders	3	67
Limestone	18	85
Clay	7	92
Sand and gravel	9	101
Clay and gravel	10	111
Clay	5	116
Sand and gravel	12	128
Clay	9	137
Clay and gravel	14	151
Limestone broken up with gravel	63	214
Total depth		214

17S/48-1d1. A. Bettles

Material	Thickness (feet)	Depth (feet)
Topsoil	6	6
Clay, yellow	18	24
Gravel and boulders	5	29
Clay, yellow	13	42
Boulders	18	60
Limestone	38	98
Clay, yellow	6	104
Sand and gravel	16	120
Limestone	8	128
Limestone, hard	2	130
Clay, yellow	10	140
Clay, white	11	151
Limestone	6	157
Clay, white	23	180
Gravel and sand	2	182
Clay, brown	20	202
Boulder	1	203
Total depth		203

Table 4.--(continued.)

17S/49-8c1. F. Cleveland

Material	Thickness (feet)	Depth (feet)
Surface soil	12	12
Soil with gravel	20	32
Limestone, white	5	37
Clay, pink colored, and gravel	28	65
Total depth		65

17S/49-8d1. A. Cleveland

Material	Thickness (feet)	Depth (feet)
Surface soil	20	20
Soil, sandy	12	32
Sand, cemented, and gravel	28	60
Total depth		60

17S/49-9b1. S. Wall

Material	Thickness (feet)	Depth (feet)
Topsoil	8	8
Sand, hard, and rock	26	34
Clay, sandy	46	80
Sand and gravel	28	108
Sand, hard, and rock	44	152
Sand and rock	36	188
Clay, sandy	22	210
Sand and rock	30	240
Clay and rock	32	272
Sand and rock	78	350
Limestone, hard	6	356
Sand, gray	64	420
Clay, gray	40	460
Clay, light colored	40	500
Total depth		500

17S/49-11b1. G. Battles

Material	Thickness (feet)	Depth (feet)
Surface soil	26	26
Clay	18	44
Gravel and sand	4	48
Clay and boulders	14	62
Sand and gravel	7	69
Boulders and clay	9	78
Sand and gravel	7	85
Boulders and clay	6	91
Sand and gravel	50	141
Boulders and clay	3	144
Sand and gravel	41	185
Total depth		185

17S/49-11b2. Mrs. L. Siegel

Material	Thickness (feet)	Depth (feet)
Topsoil	4	4
Loose rocks and soil	13	17
Limestone, hard, light colored	53	70
Sand, reddish	30	100
Sand and gravel	158	258
Sand and clay	20	278
Clay, white	7	285
Clay, red	15	300
Total depth		300

17S/49-15b1. J. Steelman

Material	Thickness (feet)	Depth (feet)
Topsoil	4	4
Gravel	7	11
Caliche	27	38
Gravel, cemented	17	55
Sand and gravel; water	2	57
Gravel, cemented	9	66
Gravel; water	8	74
Clay	5	79
Clay with gravel lens 3 to 6 feet thick; water	64	143
Conglomerate	3	146
Gravel; water	18	164
Limestone, very porous; water	13	177
Sand and gravel; water	23	200
Total depth		200

17S/50-15a1. Nye County Land and Development Co., In.

Material	Thickness (feet)	Depth (feet)
Limestone; small amount water	40	40
Limestone, broken, and yellow clay	85	125
Sand and gravel; small amount water	5	130
Limestone, gravel, and clay	112	242
Limestone, gravel, sand, and clay	103	345
Gravel, cemented	55	400
Gravel, sand; small amount water	5	405
Gravel, cemented	92	497
Total depth		497

17S/50-29d1. Nye County Land and Development Co., Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	3	3
Limestone, hard	19	22
Limestone, fractured; water	10	32
Clay, brown, sand, and limestone	11	43
Limestone	27	70
Limestone and sand; water	5	75
Limestone, hard	65	140
Limestone, fractured	60	200
Clay, gray	10	210
Limestone, fractured	17	227
Clay, gray and clay	18	245
Sand; water	5	250
Sand, clay, and gravel	30	280
Sand and gravel	40	320
Gravel, cemented	18	338
Sand, gravel, and quartz	4	342
Gravel, cemented	73	415
Sand; water	75	490
Clay, red, and lava	35	525
Clay, red	5	530
Total depth		530

17S/51-1a1. W. White

Material	Thickness (feet)	Depth (feet)
Sand and clay	30	30
Rocks	5	35
Sand, coarse, and clay	20	55
Mud, sticky, gray	9	64
Clay	16	80
Clay, slipping, and boulders	22	102
Clay, white	20	122
Clay and gravel	13	135
Total depth		135

17S/52-8c1. J. Daniels

Material	Thickness (feet)	Depth (feet)
Clay	33	33
Boulders	12	45
Gravel, large	7	52
Boulders	268	320
Limestone, black	80	400
Total depth		400

18S/49-2c1. B. Embry

Material	Thickness (feet)	Depth (feet)
Sand and gravel	10	10
Clay, sandy	12	22
Conglomerate, hard	7	29
Clay, gray	11	40
Gravel, large	2	42
Clay, gray	83	125
"Opalite"	2	127
Clay, brown	13	140
"Opalite"	10	150
Clay, brown	50	200
Clay, brown, sandy	46	246
Clay, blue	45	291
Clay, brown	13	304
Boulders and large gravel	16	320
Clay, brown, sandy	82	402
Total depth		402

Table 4.--(continued.)

17S/48-1d2. A. Bettles

Material	Thickness (feet)	Depth (feet)
Surface material	43	43
Limestone, hard	15	58
Limestone, porous, altered	47	105
Total depth		105

17S/48-1d3. A. Bettles

Material	Thickness (feet)	Depth (feet)
Unrecorded	24	24
Sand and rock; water	30	54
Sand, gravel, and limestone	30	84
Limestone and sand	30	114
Sand and clay	29	143
Clay and gravel	31	174
Gravel; water	41	215
Total depth		215

17S/48-12a1. A. Bettles

Material	Thickness (feet)	Depth (feet)
Surface soil	30	30
Limestone, cemented, and gravel	35	65
Sandstone, reddish, porous, with gravel	20	85
Total depth		85

17S/49-2b2. H. Berry

Material	Thickness (feet)	Depth (feet)
Sand and gravel	40	40
Clay and sand	10	50
Hardpan	10	60
Sand, and some granite	20	80
Sand, gravel, and rock	40	120
Sand and coarse gravel	30	150
Sand, coarse gravel, and some clay	50	200
Total depth		200

17S/49-4a1. Nye County Land and Development Col, Inc.

Material	Thickness (feet)	Depth (feet)
Sand and pebble gravel Pink and yellow, rounded to angular and clear, rounded to euhedral, very fine to very coarse quartz. Rounded to angular, sand and pebble gravel (to a maximum of 10 mm) fragments of white to red, brown, and gray welded tuff. Caliche with very fine to very coarse quartz and magnetite. Some black obsidian either angular or rounded with calcareous deposit on outside, chert, and magnetite. Sand and gravel varies in percentage, throughout with either reaching a maximum of 80 to 85 percent. Tan to light brown, silty, calcareous clay between 240 and 250 feet	340	340
Clay, tan to light brown, silty, calcareous. Some very fine to very coarse quartz and magnetite, as above. Some white, calcareous material between 360 and 390 feet	100	440
Sand and granule gravel. Pink and yellow, rounded to angular, and clear, rounded to euhedral, very fine to very coarse, silty quartz. Rounded to angular, sand and granule gravel fragments of white to red, brown, and gray welded tuff. Caliche with very fine to very coarse quartz and magnetite. Some black obsidian either angular or rounded with calcareous deposit on outside, chert and magnetite. Clay cuttings present throughout, probably cavings	70	510
Clay, tan to light brown, silty, calcareous. Some very fine sand as above. White calcareous material between 550 and 600 feet Sandy with very fine to coarse quartz, welded tuff, caliche, obsidian, magnetite, and some very fine to very coarse fragments of basalt with calcite in basal 10 feet	90	600
Basalt, gray to black, subrounded to angular fragments, dense, vesicular, and calcitic. Some yellow material(?) both loose and with basalt	30	630
Total depth		630

17S/49-5a1. W. Moore, Jr.

Material	Thickness (feet)	Depth (feet)
Topsoil	4	4
Soil and rocks	16	20
Soil, sandy	25	45
Gravel, reddish, cemented	49	94
Total depth		94

17S/49-5a2. W. Moore, Jr.

Material	Thickness (feet)	Depth (feet)
Surface soil	7	7
Soil and rocks	23	30
Soil, sandy	10	40
Gravel, reddish, cemented	43	83
Total depth		83

17S/49-5b1. P. Moore

Material	Thickness (feet)	Depth (feet)
Surface soil	18	18
Sand and gravel cemented with clay	42	60
Gravel, large (caving)	3	63
Total depth		63

17S/49-6a1. E. Cleveland

Material	Thickness (feet)	Depth (feet)
Topsoil	10	10
Soil, sandy	25	35
Sand and gravel	33	68
Total depth		68

17S/49-6a2. E. Cleveland

Material	Thickness (feet)	Depth (feet)
Topsoil	15	15
Soil, sandy	20	35
Sand and gravel	35	70
Sand, hard, cemented, and gravel	10	80
Total depth		80

17S/49-6b1. J. Tynan

Material	Thickness (feet)	Depth (feet)
Topsoil	4	4
Soil, tight	16	20
Soil, sandy	2	22
Clay and gravel	48	70
Sand, light colored	2	72
Clay, reddish, and gravel in layers	80	152
Clay, red, with little sand	3	155
Total depth		155

17S/49-7a1. T. Davis

Material	Thickness (feet)	Depth (feet)
Surface material	40	40
Limestone, hard	15	55
Limestone, porous	155	210
Total depth		210

17S/49-7b1. H. Davis

Material	Thickness (feet)	Depth (feet)
Topsoil	10	10
Soil, tight	28	38
Gravel, cemented, interbedded with hard limestone	97	135
Clay, reddish, sand and gravel, interbedded	55	190
Clay, light colored, and sand	60	250
Clay, light colored	35	285
Limestone, white, chalky	13	298
Clay, reddish, interbedded white limestone and gray, porous limestone	42	340
Gravel, coarse, and sand	3	343
Clay, red, interbedded with white limestone	42	385
Sand and gravel	5	390
Clay, mostly green	17	407
Clay, red, interbedded with white limestone	28	435
Clay, red, interbedded with gray porous limestone	45	4[illegible]0
Sand, dark	5	485
Clay, light colored	15	500
Total depth		500

17S/49-7c1. H. Davis

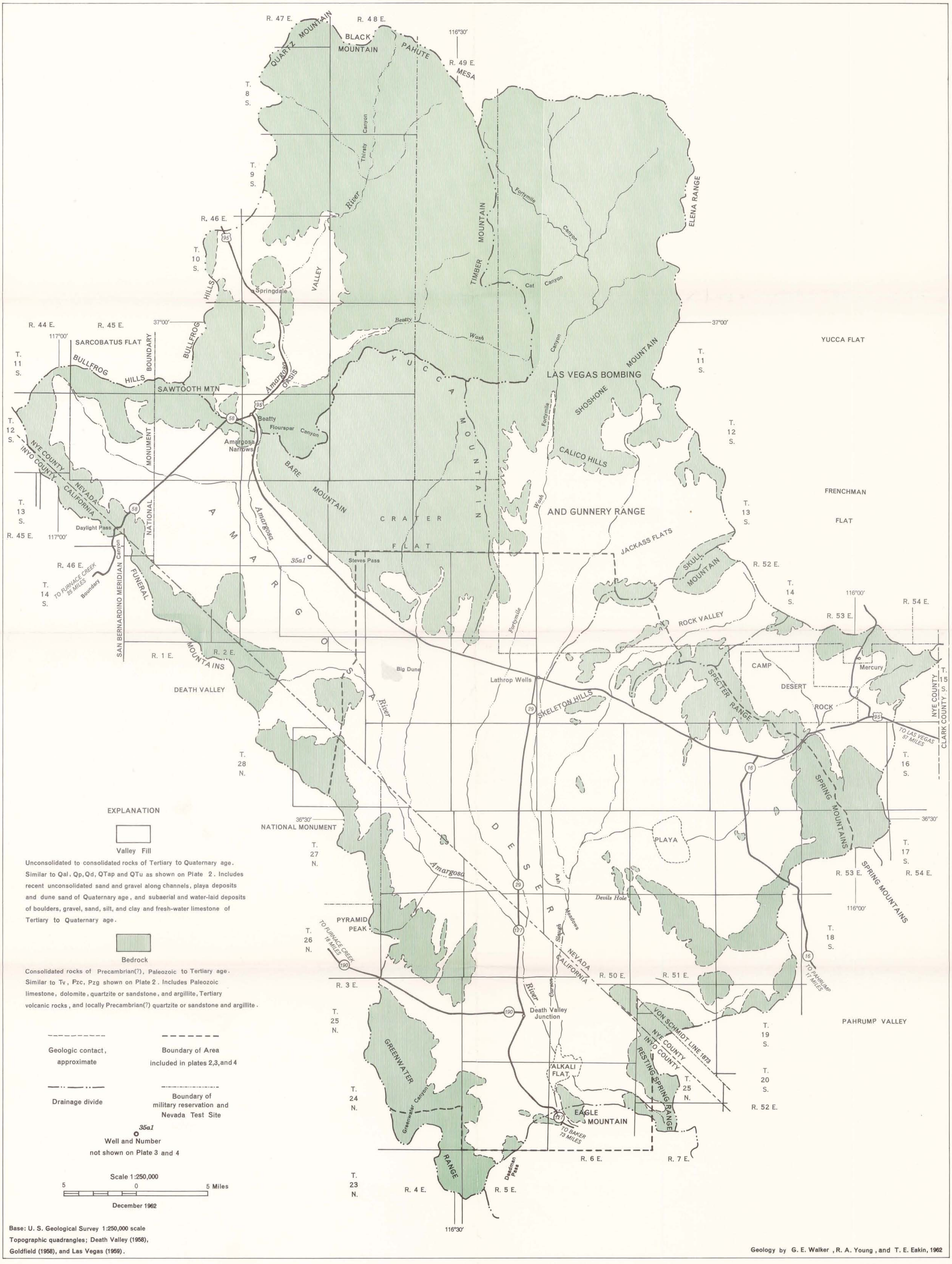
Material	Thickness (feet)	Depth (feet)
Surface soil	32	32
Limestone, cemented, and gravel	29	61
Total depth		61

17S/49-7d1. T. Davis

Material	Thickness (feet)	Depth (feet)
Topsoil	10	10
Soil, tight, with gravel and rocks	27	37
Clay, light colored, with fine sand	33	70
Clay, white	30	100
Clay, pink, with streaks of sand	50	150
Clay, light colored	12	162
Clay, red, with streaks of gravel	13	175
Clay, red, with thin layers of white limestone	25	200
Limestone(?) Did not bail any mud through this formation. Bailer only brought up very small amounts of limestone cuttings	80	280
Clay, red, with an occasional layer of white limestone	20	300
Limestone, white, with few layers of sticky clay	30	330
Limestone, white, with different changes of hardness	70	400
Total depth		400

17S/49-8a1. A. Cleveland

Material	Thickness (feet)	Depth (feet)
Surface soil	25	25
Soil, sandy	15	40
Soil, sandy, and gravel	38	78
Total depth		78



EXPLANATION

Valley Fill

Unconsolidated to consolidated rocks of Tertiary to Quaternary age. Similar to Qal, Qp, Qd, QTap and QTu as shown on Plate 2. Includes recent unconsolidated sand and gravel along channels, playa deposits and dune sand of Quaternary age, and subaerial and water-laid deposits of boulders, gravel, sand, silt, and clay and fresh-water limestone of Tertiary to Quaternary age.

Bedrock

Consolidated rocks of Precambrian(?), Paleozoic to Tertiary age. Similar to Tv, Pzc, Pzg shown on Plate 2. Includes Paleozoic limestone, dolomite, quartzite or sandstone, and argillite, Tertiary volcanic rocks, and locally Precambrian(?) quartzite or sandstone and argillite.

Geologic contact, approximate

Boundary of Area included in plates 2,3, and 4

Drainage divide

Boundary of military reservation and Nevada Test Site

35a1
Well and Number not shown on Plate 3 and 4

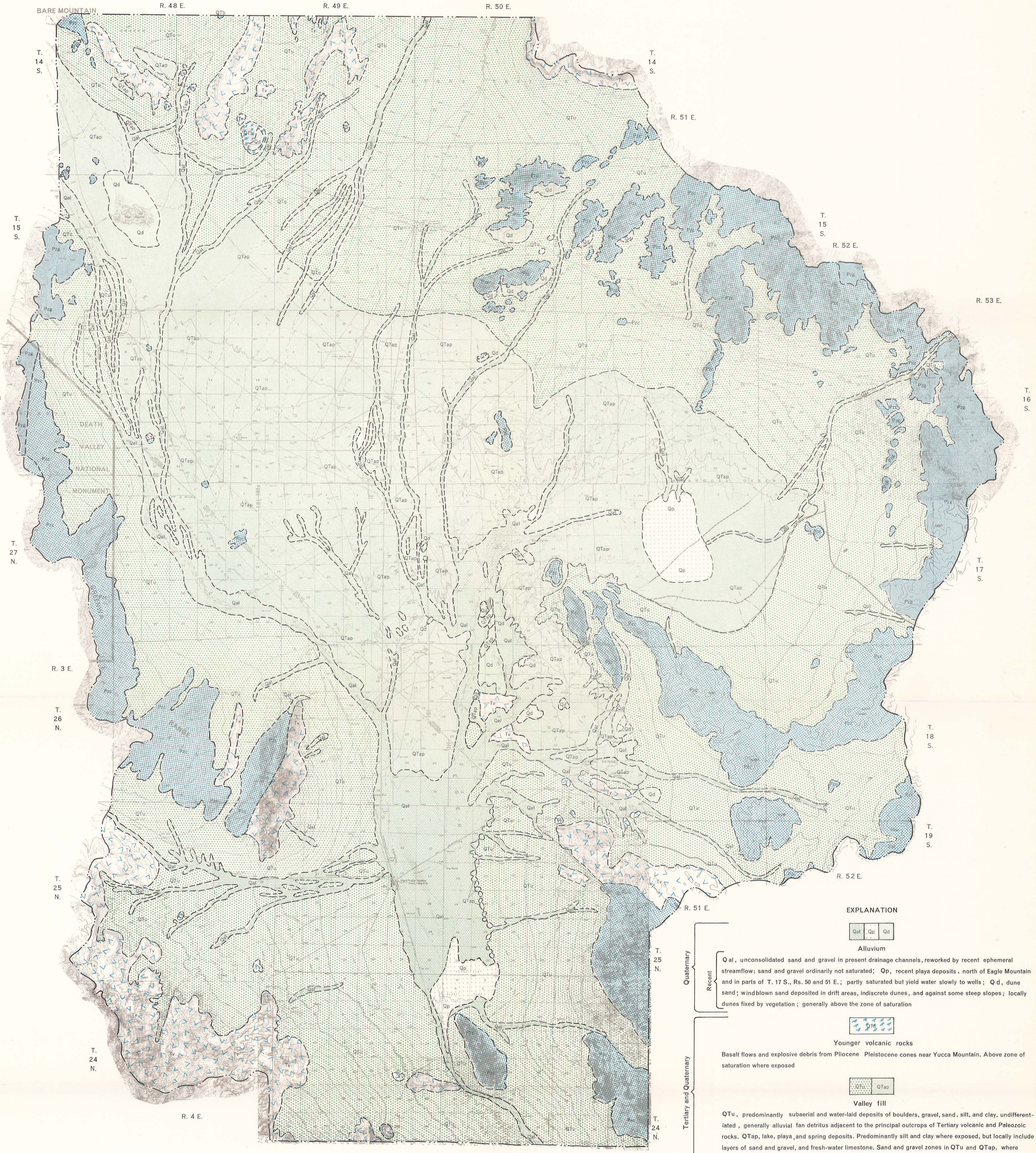
Scale 1:250,000

5 0 5 Miles

December 1962

Base: U. S. Geological Survey 1:250,000 scale Topographic quadrangles; Death Valley (1958), Goldfield (1958), and Las Vegas (1959).

Geology by G. E. Walker, R. A. Young, and T. E. Eakin, 1962



EXPLANATION

Quaternary — Recent

Qal | Qp | Qd

Alluvium

Q al, unconsolidated sand and gravel in present drainage channels, reworked by recent ephemeral streamflow; sand and gravel ordinarily not saturated; Qp, recent playa deposits, north of Eagle Mountain and in parts of T. 17 S., Rs. 50 and 51 E.; partly saturated but yield water slowly to wells; Q d, dune sand; windblown sand deposited in drift areas, indiscrete dunes, and against some steep slopes; locally dunes fixed by vegetation; generally above the zone of saturation

Tertiary and Quaternary

QTb

Younger volcanic rocks

Basalt flows and explosive debris from Pliocene Pleistocene cones near Yucca Mountain. Above zone of saturation where exposed

QTu | QTap

Valley fill

QTu, predominantly subaerial and water-laid deposits of boulders, gravel, sand, silt, and clay, undifferentiated, generally alluvial fan detritus adjacent to the principal outcrops of Tertiary volcanic and Paleozoic rocks. QTap, lake, playa, and spring deposits. Predominantly silt and clay where exposed, but locally include layers of sand and gravel, and fresh-water limestone. Sand and gravel zones in QTu and QTap, where saturated, comprise principal supply to large-yield wells

Tertiary

Tv

Volcanic rocks

Largely volcanic tuff and ash fall material, locally welded; includes some flows. Yields to wells small unless developed throughout thick section of saturated tuff or in highly fractured welded tuff

Paleozoic

Pzc | Pzg

Sedimentary rocks

Pzc, Limestone and dolomite of Paleozoic age; transmits water freely where highly fractured or where solution openings occur; Pzg, quartzite or sandstone and argillite of Paleozoic age or, southwest of Big Dune, of Precambrian (?) age

Geologic contact, approximate

Boundary of Death Valley National Monument

Boundary of plate, in part drainage divide

Boundary of military reservation

Scale 1:125,000

5 0 5 Miles

1962

Base: U. S. Geological Survey 1:62,500 scale Topographic quadrangles; Ash Meadows (1952), Big Dune (1952), Eagle Mountain (1951), Ryan (1952), and Specter Range (1952); and Lathrop Wells (unpublished); and 1:250,000 scale Topographic quadrangle, Death Valley (1958)

Geology by G. E. Walker, 1962

PLATE 2. GENERALIZED GEOLOGY MAP OF THE AMARGOSA DESERT IN THE VICINITY OF LATHROP WELLS, NEVADA, AND DEATH VALLEY JUNCTION, CALIFORNIA

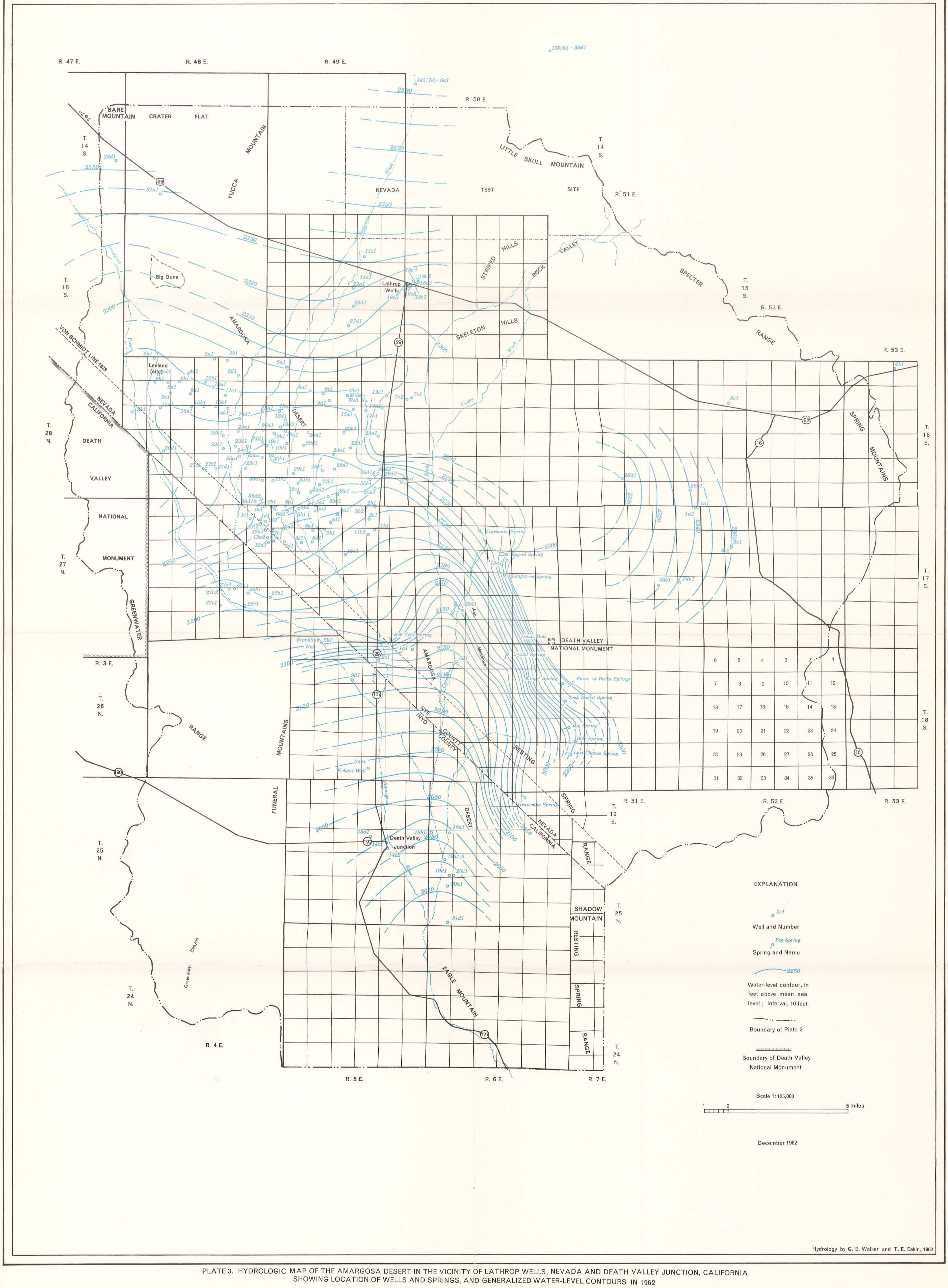


PLATE 3. HYDROLOGIC MAP OF THE AMARGOSA DESERT IN THE VICINITY OF LATHROP WELLS, NEVADA AND DEATH VALLEY JUNCTION, CALIFORNIA SHOWING LOCATION OF WELLS AND SPRINGS, AND GENERALIZED WATER-LEVEL CONTOURS IN 1962

United States Department of Interior
Geological Survey

State of Nevada
Department of Conservation and Natural Resources

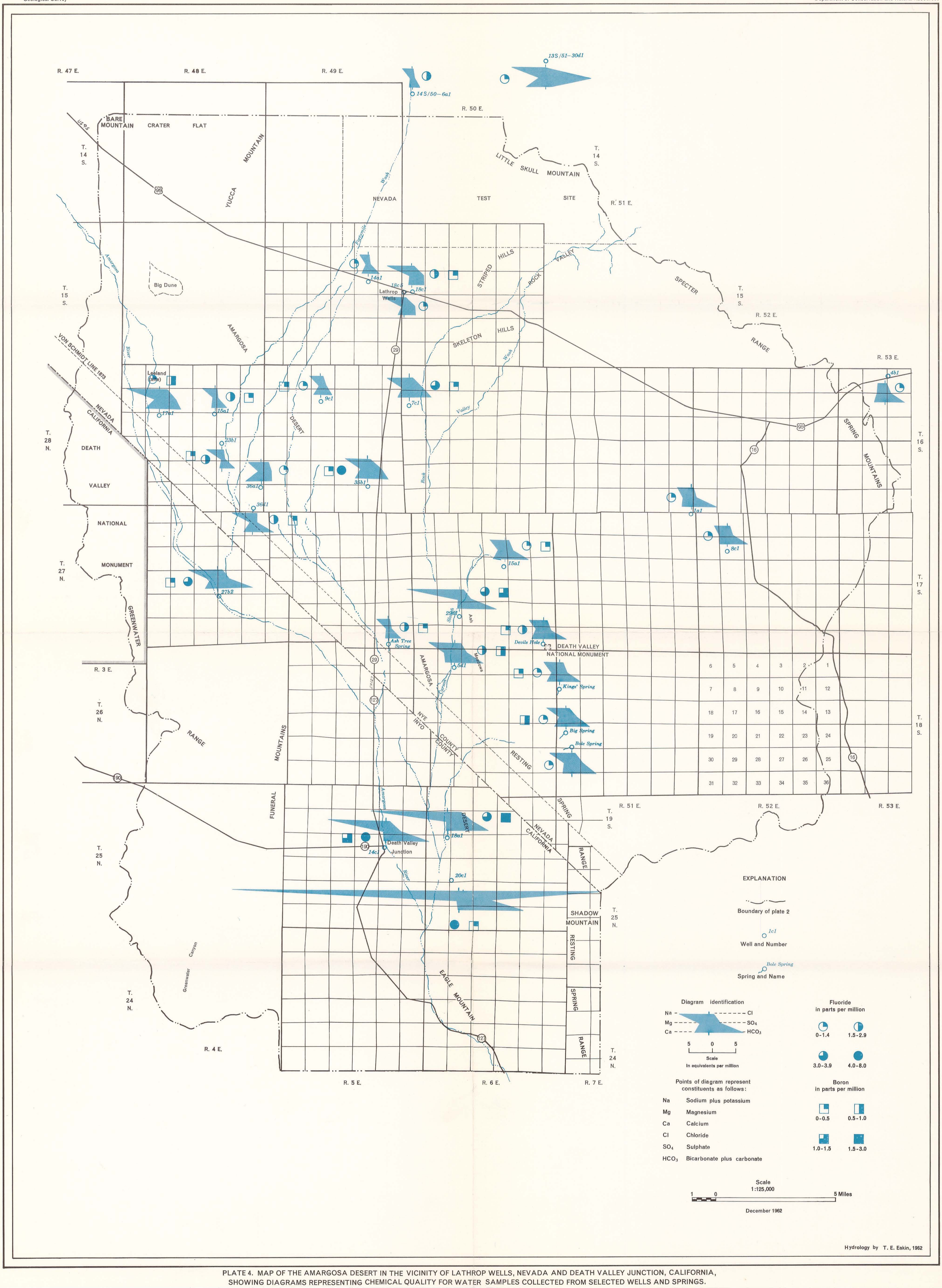


PLATE 4. MAP OF THE AMARGOSA DESERT IN THE VICINITY OF LATHROP WELLS, NEVADA AND DEATH VALLEY JUNCTION, CALIFORNIA, SHOWING DIAGRAMS REPRESENTING CHEMICAL QUALITY FOR WATER SAMPLES COLLECTED FROM SELECTED WELLS AND SPRINGS.