STATE OF NEVADA
OFFICE OF THE STATE ENGINEER

WATER RESOURCES BULLETIN No. 6

GROUND WATER IN LAS VEGAS, PAHRUMP, AND INDIAN SPRING VALLEYS, NEVADA

(A SUMMARY)

By
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Prepared in cooperation with the
UNITED STATES DEPARTMENT OF THE INTERIOR
Geological Survey
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FOREWORD

This report, the sixth in the series of Nevada Water Resources Bulletins, summarizes the results of the ground-water studies in Las Vegas, Pahrump, and Indian Spring Valleys, Nevada. It was prepared by the U. S. Department of the Interior, Geological Survey, in cooperation with the State Engineer.

A cooperative arrangement for a study of the ground-water resources in Las Vegas Valley was begun in July 1944 as the result of an agreement between the Director of the Geological Survey and the State Engineer of Nevada. The program for the State is under the supervision of Hugh A. Shamberger, Assistant State Engineer, and for the Geological Survey, under the direction of Thomas W. Robinson, District Engineer in Nevada for the Ground Water Division.

Prior to the present cooperative arrangement, a cooperative study was made of the underground leakage from artesian wells in the vicinity of Las Vegas. The findings of this investigation by Penn Livingston of the Ground Water Division, Geological Survey, are set forth in U. S. Geological Survey, Water Supply Paper 849–D. As the result of the present cooperative arrangement four reports on the ground water of the area have been prepared and a fifth is in preparation. The first, entitled "Progress Report on the Ground-Water Resources of the Las Vegas Artesian Basin, Nevada," was published in 1945. This was followed by "Water Levels and Artesian Pressure in Wells in Las Vegas Valley and in Other Valleys in Nevada, 1913–1945." Water Resources Bulletin No. 3 (in Press 1947); "Well Data in Las Vegas and Indian Spring Valleys, Nevada," Water Resources Bulletin No. 4, 1946, and the present report. A comprehensive and detailed report of the geology and hydrology in the three valleys is in final preparation at the present time.

ALFRED MERRITT SMITH,
State Engineer.

February 18, 1947

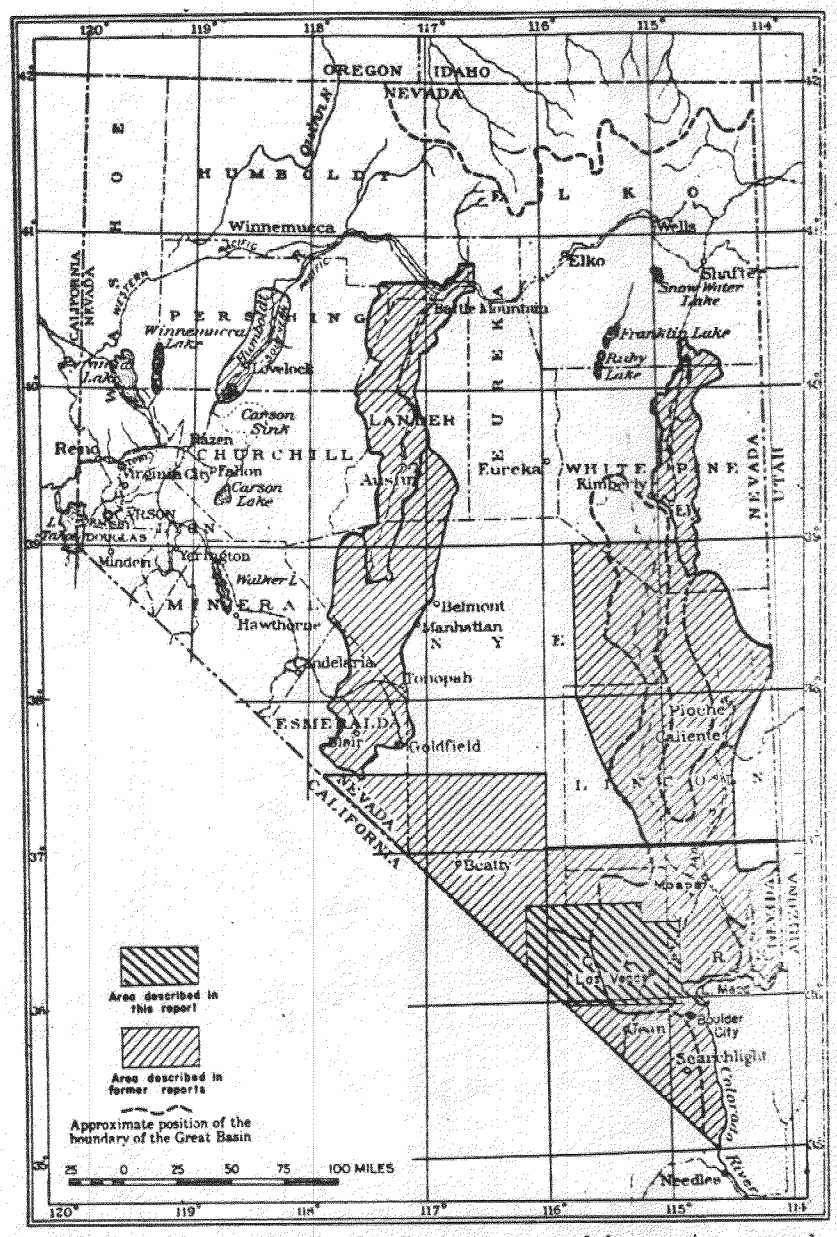

FIGURE 1—Map of Nevada showing areas covered by previous ground-water reports in Nevada and by the present report.

GROUND WATER IN LAS VEGAS, PAHRUMP, AND INDIAN SPRING VALLEYS, NEVADA

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INTRODUCTION

Efficient development, conservation, and use of ground water in Las Vegas, Pahrump, and Indian Spring Valleys has long been of paramount importance to the residents of those areas, and to the general welfare of southern Nevada. Ground water was the only source of supply in these areas until 1942, when a pipeline and pumping system were constructed to supply the Basic Magnesium Project, in Las Vegas Valley, with water from Lake Mead. The huge plant and the towns of Henderson, Victory Village, and Carver Park used nearly 30,000 acre-feet of water between April 1942 and December 1944. Since January 1945 about 6,000 acre-feet of water a year has been pumped to the project. None of this water was used off the project and most of the waste water from the plant and the towns has flowed back into Lake Mead without entering the ground-water reservoir. A small part of this waste water undoubtedly percolates into the gravels of the alluvial fan and locally recharges the ground-water reservoir in the vicinity of the project and Pittman. Thus, ground water is the only source of water supply in most of Las Vegas Valley and in Pahrump and Indian Spring Valleys, and many residents of the three valleys, and State and Federal officials as well, have long been actively interested in the ground-water problems. Several studies have been made by the Office of the State Engineer, the Nevada State Agricultural Experiment Station, and the U. S. Geological Survey, primarily for the purpose of developing water for irrigation. Considerable information had been gathered and numerous suggestions for better utilization and conservation of ground water had been made prior to 1944. However, no detailed investigation of the ground-water resources had been carried to completion and little was known concerning the character, extent, and safe yield of the ground-water reservoirs in the three valleys.

Following the construction of Boulder Dam (1929–1936) the

State Engineer's office became actively interested in the ground-water resources of the State, and in 1939 that office was instrumental in the enaction of a law by the State Legislature[1] providing for regulation of the appropriation and use of ground water. Under the provisions of this law, regulation of the appropriation, conservation, and use of ground water, and designation of artesian basins subject to regulation were vested in the State Engineer. As a result, in 1941 the Las Vegas and Pahrump Artesian Basins were designated as such and an Artesian Well Supervisor for the two basins was appointed.

Fragmentary records show that during the years 1907 to 1924 the individual yields of springs and flowing wells diminished and water levels declined in Las Vegas Valley. More complete records beginning in 1924 show that this trend continued into 1946. The population of the valley increased tremendously in the years 1940 to 1945. During this same period there was a rapid increase in the annual withdrawal of ground water and in the rate of the water-level decline. Early in 1944 the State Engineer realized that a critical water shortage might develop if the safe yield of the ground-water reservoir in Las Vegas Valley were exceeded. He also recognized that legal regulation of the appropriation of ground water required, among other things, knowledge of the safe yield of the ground-water reservoirs in the three valleys. Determination of the safe yield required a detailed hydrologic investigation, beyond the scope of the State Engineer's office. Therefore, in 1944 the U. S. Geological Survey was asked to make a special study in cooperation with the Las Vegas Artesian Basin and the State of Nevada, and the study was started in July of that year.

A comprehensive report containing the results of the investigation from July 1944 to December 31, 1946, is now in preparation and will be published in 1947. The present report has been prepared to make available to the public a summary of the results of the detailed investigation.

Since the investigation was begun, an inventory of more than 600 wells has been made, including all of the known artesian and water-table wells in the valleys. A study of the quality of the waters has been made and many samples of water have been collected and analyzed. The temperature of the water from most of the wells has been obtained, and the use to which the water is

[1]For a description of laws relating to ground water in Nevada, see "An Act relating to Underground Water," approved March 25, 1939, by the Nevada State Legislature. (Available from Office of the State Engineer, Carson City, Nevada.)

put has been determined. Well logs have been compiled and studied. All of the data collected up to April 30, 1946, has been published by the State Engineer's office[2]. Since 1939 water levels have been measured periodically in about 100 wells in the three valleys. These measurements and all other recorded significant measurements made between 1924 and December 31, 1945, have been published[3]. Several test wells have been drilled and numerous pumping tests and other studies of the characteristics of the ground-water reservoirs have been conducted. Information on the geology of the area has been compiled from former work and from reconnaissance and detailed work during the present investigation. The relation of the geology to the ground-water conditions has been studied. Precipitation stations have been installed in the mountainous areas and all existing climatological data and their relation to ground-water conditions in the area have been studied. A suitable base map of the area has been compiled and much geologic and hydrologic information has been plotted on it. All available well records have been studied and the amount of water withdrawn from wells and springs during the last 40 years has been determined or estimated. A progress report briefly describing general geologic and ground-water conditions in Las Vegas Valley was published in March 1945[4].

LOCATION AND GENERAL PHYSICAL FEATURES

The area described in this report (see fig. 1) is the west-central part of Clark County and the southern part of Nye County, in southern Nevada. It lies approximately between 35°55′ and 36°40′ north latitude, and 114°55′ and 116°05′ west longitude (see pl. 1). The lofty Spring Mountains occupy almost a third of the area and trend northwesterly across it from the center of the southern boundary to the northwest corner. Pahrump Valley, a desert basin with interior drainage, lies on the west side and Las Vegas Valley on the east side of the Spring Mountains. The northern extremity of these mountains forms the south side of Indian Spring Valley, a crescent-shaped basin with interior drainage. Las Vegas Valley is bordered on the northeast by the southern

[2]Maxey, G. B., and Jameson, C. H., Well Data in Las Vegas and Indian Spring Valleys, Nevada: State of Nevada, Office of the State Engineer, Water Resources Bulletin No. 4, 1946.

[3]Maxey, G. B., and Jameson, C. H., Water levels and artesian pressure in wells in Las Vegas Valley and in other valleys in Nevada, 1913–1945: State of Nevada, Office of the State Engineer, Water Resources Bulletin No. 3 (in press) 1947.

[4]Maxey, G. B., and Jameson, C. H., Progress report on the ground-water resources of the Las Vegas Artesian Basin, Nevada: Mimeographed report, Nevada State Engineer's office, 1945.

parts of the north-south trending Pintwater, Desert, Sheep, and Las Vegas Ranges; on the east by Frenchman Mountain (also known as Sunrise Mountain); and on the south by the River Mountains and the northern extremity of the McCullough Range. The northernmost part of Las Vegas Valley drains into a playa lake about eight miles east of the settlement of Indian Springs. The rest of the valley drains southward through Las Vegas Wash into the Colorado River. Pahrump Valley is bounded on the west by a group of low-lying unnamed ridges and hills that extends southerly about one-third the length of the valley, and by the Nopah and Kingston Ranges (not shown on pl. 1). Indian Spring Valley is bordered on the north and west sides by the Spotted Range and on the east side by the Pintwater Range.

No perennial streams occur in the area and the intermittent streams have no regular seasonal flow. Surface water runs in the washes only during and for short periods following the infrequent and torrential storms. Springs fed by water from artesian aquifers occur near the toes of the large alluvial fans in all three valleys. Also, numerous gravity springs occur in the mountains and in some parts of the valleys.

PRECIPITATION

Long-period records of precipitation obtained by the Weather Bureau at Las Vegas, and fragmentary records from other precipitation stations in Las Vegas, Pahrump, and Indian Spring Valleys, are available. They show that the average annual precipitation at low elevations (1,870 to 3,150 feet) is less than six inches. The average annual precipitation, according to the 42-year record at Las Vegas, is 4.62 inches. The average annual precipitation at four other stations whose period of record is less than 10 years is as follows: Las Vegas Airport, 4.26 inches; Desert Game Range, 4.99 inches; Indian Springs, 5.77 inches; and Pahrump, 5.02 inches.

Precipitation increases with elevation in the mountain area. At Kyle Canyon Ranger Station, on the east slope of the Spring Mountains at an elevation of 7,165 feet, the average annual precipitation during a 7-year period was 19.79 inches. More than half of this falls in the form of snow. Other stations with short-term records show more precipitation at higher elevations. The snow falls largely during the period November to May and remains on the ground as late as July. Most of the precipitation occurs during the period December to February; however, thunderstorms during July and August result in considerable rainfall.

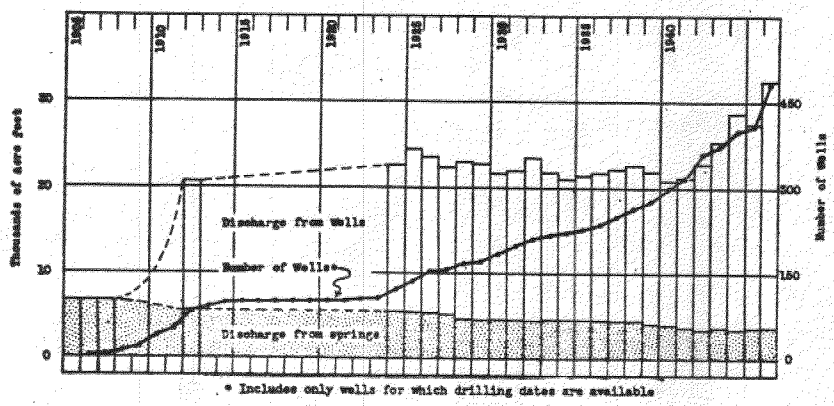

FIGURE 2—Total discharge from wells and springs and number of wells drilled in Las Vegas Valley, 1905–1946.

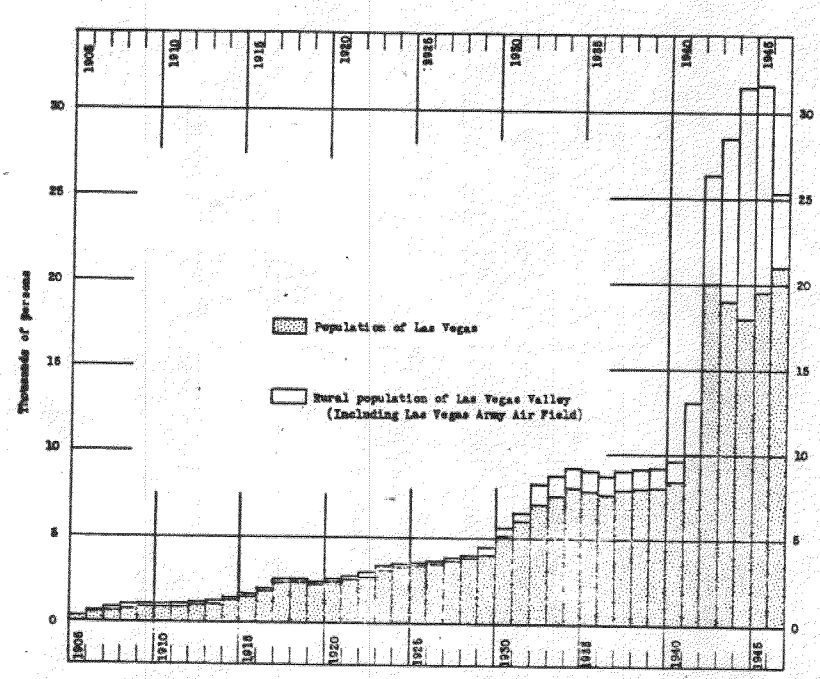

FIGURE 3—Population of Las Vegas Valley (Henderson, and Basic Magnesium project excluded).

The path of the major storms in the area is from southwest to northeast. The greatest intensity and frequency of storms occur in the vicinity of Charleston Peak in the Spring Mountains. Available records and observations indicate that precipitation is greatest at the crest and on the east slope of the Spring Mountains. The Sheep Range, the only other mountains of high elevation in the area, lie in the storm shadow of the Spring Mountains and receive less precipitation at corresponding elevations.

HISTORY OF GROUND-WATER DEVELOPMENT

Large springs furnished the principal water supply in Las Vegas Valley until the influx of population during the twenties. The first well was drilled in 1906, and by 1907 numerous wells had been drilled, principally in search of water for agricultural use. In 1912, according to Carpenter[5], there were more than 100 deep wells in the valley and more than 20,000 acre-feet of water was being discharged annually by wells and springs. By 1924 the number of wells had increased to approximately 125, and between 1924 and 1935 the number increased to more than 275. The annual yield of wells and springs during the period 1912–1935 probably averaged about 21,000 acre-feet, of which less than half was put to beneficial use. From 1936 through 1946 the number of wells increased to more than 600. The largest recorded single-year increase occurred in 1946 when more than 70 wells were drilled (see fig. 2). As the result of conservation measures and greater use by the increased population (see fig. 3) the proportion of ground water beneficially used increased to about 85 percent.

In Pahrump Valley, springs also furnished most of the water used until 1940. Well drilling started in the valley about 1910, but at first only a few wells were drilled and only small quantities of water, used principally for domestic purposes, were obtained. It was not until 1937 that wells of large yield were drilled. During the period 1937 to 1946, 13 wells were completed, and the total amount of water discharged from wells and springs increased from 7,100 acre-feet in 1937 to about 14,000 acre-feet in 1946.

Indian Spring is still the principal source of water in Indian Spring Valley; however, small quantities of water are obtained from a few shallow wells and two deep nonflowing artesian wells, drilled by the U. S. Army in 1942. These two wells yielded about

[5]Carpenter, E., Ground water in southeastern Nevada: U. S. Geol. Survey Water-Supply Paper 365, p. 40, 1915.

70 acre-feet of water annually during the years 1943 to 1945, inclusive. Indian Spring and the rest of the wells and springs in the valley discharge about 800 acre-feet of water annually.

GENERAL GEOLOGY

The three valleys are bordered and completely enclosed by mountains composed of Paleozoic, Mesozoic, and Tertiary rocks. These rocks are complexly folded and faulted and are well consolidated. They include rocks of sedimentary and igneous origin. They are mostly impermeable and act as a barrier to movement of water into and out of the valleys. The area enclosed by the drainage boundaries of each valley may be considered a separate ground-water basin, although on the surface a small part of the boundary of each valley is composed of alluvial materials. The areas of outcrop of these rocks and the drainage boundaries of each basin are shown on plate 1.

The alluvial deposits of gravel, sand, silt, and clay that make up the valley fill contain the most productive aquifers and yield most of the water discharged from wells and springs in the area. The contact where the older consolidated, impermeable rocks that form the mountains disappear beneath the alluvial deposits is at an average elevation of about 4,500 feet. The maximum elevation of this contact is about 9,000 feet in the vicinity of Charleston Peak, near the heads of Kyle, Lee, and Clark Canyons. Thus the bulk of these deposits is confined to the valley and canyon areas and, by analogy, they form a "sea" in which the numerous high "islands" of older rock occur. The alluvial deposits range from a featheredge to an unknown thickness. Near the mountains, in the upper part of the alluvial aprons, they consist largely of massive beds of coarse, well-rounded to angular, poorly assorted materials, all of local derivation and of high permeability, which dip away from the mountains at angles of 12° to 18°. Lower down on the alluvial aprons the beds become more sandy and silty and dip at lower angles. On the lower parts of the alluvial aprons the beds of coarser materials thin and interfinger with thick lenses of silt and clay. The character and position of these sediments is of great significance in the occurrence of ground water in the area. Nearly all the heavy precipitation in the mountainous area falls on the outcrop area of the gravels or on areas tributary to them. That fraction which is not lost by evaporation or transpiration seldom runs off as streams; instead, it percolates down into the gravel beds and thus recharges the ground-water reservoirs.

In the southern part of Las Vegas Valley and in the central part of Pahrump Valley numerous logs of the alluvial material have been recorded. They show that clay, sandy and silty clay, and caliche make up by far the largest part of the valley deposits near the lower ends of the alluvial fans. Layers of sand and gravel ranging from 1 to 20 feet in thickness occur infrequently. Also, the logs show that these layers of sand and gravel are lenticular and thin rapidly toward the central parts of the valleys. Probably most of the sand and gravel lenses are limited in horizontal extent and are more or less imperfectly interconnected.

A few wells have been drilled to depths of more than 1,000 feet in Las Vegas Valley. The logs of these wells show that the upper part of the valley fill, from the surface to about 700 feet, contain much coarse material; and that locally at depths below approximately 700 feet, the valley fill consists of fine materials with only a few thin lenses of permeable sand and fine gravel. These lower beds closely resemble the beds of clay, silt, and sand, largely of lacustrine origin, that are widespread over southern Nevada and are known as the Muddy Creek formation. This formation was probably deposited in Tertiary Pliocene (?) time, long before deposition of the bulk of the alluvial fan and valley fill material. The alluvial fan materials are overlain by late Pleistocene lake beds in the lower parts of the main valleys, and locally they are overlain by thick layers of recently deposited playa lake clay, silty sand, and silt. Locally dune sand also has been deposited on parts of the alluvial apron and the valley floor.

The alluvial fan material lies at its initial dip almost everywhere in the area and apparently only in one locality, in the south part of Las Vegas Valley, has it been disturbed by structural movements. These displacements appear to be small faults that occurred as a result of differential compaction of the sediments within the valley fill. The faults are probably the principal cause of the scarps in the vicinity of Las Vegas and west of Whitney (see pl. 1), although the scarps undoubtedly have been accentuated by erosion.

OCCURRENCE OF GROUND WATER

As stated in the foregoing paragraphs, most of the ground water used in the area is obtained from wells and springs that draw their water from the sand and gravel lenses of the valley

fill. Although it is difficult to recognize definite beds of marked horizontal extent, a dense, sticky, gray blue to dark blue clay ranging from 10 feet to 60 feet in thickness is penetrated at a depth of approximately 450 feet by wells in the vicinity of Las Vegas. This bed is relatively widespread in the south part of the Las Vegas Valley.

More than three-fourths of the wells in Las Vegas Valley draw water from three sand and gravel lenses above the blue clay. These aquifers occur at approximate depths of 250 feet, 300 feet, and 350 to 400 feet below the land surface and are referred to as the Shallow Zone of aquifers.

Another zone of aquifers underlies the blue clay horizon and occurs at depths from 500 to about 700 feet. This group is designated the Middle Zone of aquifers. Several wells of large yield draw water from aquifers in this zone.

A few wells drilled to depths of more than 700 feet have encountered thin water-bearing beds of sand and fine gravel as deep as 1,255 feet. All the water-bearing beds below 700 feet are included in, and referred to as, the Deep Zone of aquifers.

Ground water also occurs in Las Vegas Valley at shallow depths. In parts of the valley this water is under slight artesian pressure, in other parts of the valley it occurs under water-table conditions. This water is referred to in this report as the "near-surface" water. Local residents in the valleys call it the "surface water."

Ground-water occurrence is similar in Pahrump and Indian Spring Valleys. In the former, confined water is encountered in wells at depths ranging from 165 feet to more than 900 feet. In Indian Spring Valley confined water has been encountered at depths ranging from 400 to 600 feet. "Near-surface" water is also present and has been encountered at depths ranging from a few feet to more than 100 feet in both valleys.

SOURCE OF THE GROUND WATER

As have been previously mentioned, the areas enclosed by the drainage boundaries of each of the valleys can be considered separate ground-water basins. Thus the ultimate source of the ground water must necessarily be the precipitation within these drainage boundaries. However, only a small part of the water that falls as rain and snow on the watersheds reaches the ground-water reservoirs in the valleys. Undoubtedly large quantities are lost by transpiration and evaporation before the water has

deeply penetrated the soil and rocks that make up the surface of the watersheds. An appreciable fraction of the measured precipitation probably never reaches the soil but falls on trees and plants and evaporates following the storms. Studies of this problem have been made in other areas, the physical characteristic of which resemble, more or less, those of the three valleys covered by the present study. From the results of these investigations it can be safely assumed that in very dry areas of low precipitation only negligible quantities of water reach the underground reservoirs, and most of the precipitation is dissipated by evaporation and transpiration. It appears probable that most of the watershed beneath the 6,000-foot contour on the east slope of the Spring Mountains, where the average annual rainfall is less than 10 inches, contributes only a negligible amount of water to the ground-water reservoir of Las Vegas Valley.

On the west and north slopes of the Spring Mountains, tributary to Pahrump and Indian Spring Valleys, respectively, fragmentary records and field observations indicate that the annual precipitation is less than at corresponding elevations on the east slope of the Spring Mountains. Similar conditions also exist on the west slope of the Sheep Range, tributary to Las Vegas Valley. In the absence of reliable precipitation records and other data, it is believed that the precipitation is less than 10 inches as high or possibly higher than 6,500 feet. The portion of this precipitation that reaches the ground-water reservoirs is probably negligible.

Sufficient data are available to estimate the average quantity of water that falls annually as precipitation on the east slope of the Spring Mountains, tributary to Las Vegas Valley. It is estimated that between elevations of 6,000 and 8,000 feet, an area of 61,000 acres, the quantity is 81,500 acre-feet; between 8,000 and 10,000 feet, an area of 18,000 acres, the quantity is 33,000 acre-feet; and above 10,000 feet, an area of 5,000 acres, the quantity is 10,500 acre-feet.

Only a fraction of the total water from precipitation percolates deeply enough to recharge the ground-water reservoir. At present estimates of this fraction must be based upon limited knowledge of the process. Determination of the quantity of water that actually infiltrates to depth and thus recharges the ground-water reservoirs is a complex problem involving many fundamental factors, some of which have never been studied. It requires lengthy, detailed studies far beyond the scope of this

investigation. Possibly 20 percent of the total precipitation between elevations of 6,000 to 8,000 feet and 25 percent of the precipitation above 8,000 feet recharges the ground-water reservoirs. These estimates are based on the best available data, largely from similar but less arid areas.

On this basis, the average quantity of water available for recharge to the ground-water reservoir in Las Vegas Valley from the east slope of the Spring Mountain Range is in the order of magnitude of 27,000 acre-feet a year.

The Las Vegas Valley watershed on the east side of the Spring Mountains is naturally divided by La Madre Mountain, a long bedrock spur. The rocks forming this spur form a highly impermeable barrier around which ground water from the watershed north of La Madre Mountain must pass in order to reach the southern part of Las Vegas Valley. On the same basis as above, it is estimated that about 24,000 acre-feet of ground water a year originates north of the La Madre Mountain spur. Data based on the hydrologic properties of the aquifer are available for estimating the flow of ground water past La Madre Mountain into the southern part of Las Vegas Valley.

The logs of wells in the vicinity of the Gilcrease and Tule Springs Ranches, about six miles east of the La Madre Mountain spur, show that the materials making up the valley fill here are tight and transmit only inappreciable quantities of water. Two test wells drilled between the Gilcrease Ranch and the eastern extremity of the La Madre Mountain penetrated a considerable thickness of permeable water-bearing beds, capable of transmitting large quantities of water. Thus, the ground water originating north of La Madre Mountain must pass through these permeable materials to reach the south part of Las Vegas Valley. From information obtained from the test wells and their logs and from the slope of the piezometric surface, the quantity of water passing through the permeable materials between the Gilcrease Ranch and La Madre Mountain is estimated to be about 25,000 acre-feet annually. This estimate is of the same order of magnitude as the estimate of recharge based upon precipitation north of La Madre Mountain.

In the area south of La Madre Mountain it is estimated from precipitation data that the recharge to the ground-water reservoir is about 3,000 acre-feet of water annually. The data are insufficient to estimate the recharge from the Sheep Mountains, but it is believed to be much less than that from the Spring

Mountains. The quantity of water from the Sheep Mountain drainage that reaches the southern part of Las Vegas Valley is probably less than that contributed by the area south of La Madre Mountains. Thus, it is estimated the total recharge to the southern part of Las Vegas Valley is in the order of magnitude of 30,000 acre-feet annually.

On the same basis, and allowing for the lower precipitation at corresponding elevations, it is estimated that the average recharge to Pahrump Valley from the west slope of the Spring Mountains is of the order of magnitude of 25,000 acre-feet.

It is believed, at the present time, that there are insufficient data to estimate the recharge to the ground water in Indian Springs Valley.

Recharge to the "near-surface" water is largely supplied from the artesian aquifers as a result of upward leakage through the confining beds. The "near-surface" water is also recharged by water leaking from poorly constructed wells and water from irrigation.

GROUND-WATER DISCHARGE AND UTILIZATION

Las Vegas Valley

As a part of the inventory of wells, a record was obtained of most of the discharge of water from wells and springs for the years 1905 to 1907, 1912, and 1924 to 1946. The estimated annual discharge is presented in graphical form in figure 2 and is given in acre-feet in the following table for the years 1924 to 1946:

Year	Amount	Year	Amount
1924	22,400	1936	21,500
1925	24,300	1937	21,900
1926	23,400	1938	22,300
1927	22,100	1939	21,700
1928	22,800	1940	20,600
1929	22,600	1941	22,100
1930	21,500	1942	22,600
1931	21,700	1943	25,400
1932	23,300	1944	28,300
1933	21,600	1945	27,000
1934	20,800	1946	31,700
1935	21,200		

In addition to the quantities of discharge shown in the table and in figure 2, ground water has been discharged naturally throughout the period of record by means of evaporation and transpiration from areas where the "near-surface" water level

is within a few feet of the land surface. No detailed studies of the loss through transpiration and evaporation were made. The natural vegetation is largely salt grass and mesquite with some cottonwood. In a total area of about 5,000 acres the "near-surface" water stands 10 feet or less below the land surface. On the basis of studies in other areas it is estimated the natural loss may range from 5,000 to 8,000 acre-feet a year. Therefore, in 1946, the total discharge of ground water in Las Vegas Valley was between 37,000 and 40,000 acre-feet. This figure includes all the water discharged from Las Vegas Valley, for there is no appreciable underflow out of the valley.

Most of the ground water withdrawn between 1905 and 1946 has been used for domestic purposes, cooling, and limited irrigation. The amount of land irrigated has remained about the same since 1912, but from 1912 to 1940 the population increased about sevenfold. Thus, during the period 1912 to 1940 a considerable amount of water was not beneficially used. The tremendous increase in population in the valley between 1941 and 1945 (fig. 3), and better conservation of water since 1939 have resulted in more complete utilization of the present discharge of water from wells and springs. Only about 15 percent of the total discharge ran to waste in 1946.

The maximum use of water occurs during August, and the minimum use of water occurs during December and January. In the period 1938–1946 an average of about 34 acre-feet a day was withdrawn during the month of highest use. It is estimated that nearly three-fourths of the total amount of water used in the valley is withdrawn from wells and springs in the vicinity of the city of Las Vegas, in an area of little less than 22 square miles.

Pahrump Valley

Records of the discharge of wells and springs in Pahrump Valley are fragmentary and only a few measurements of the discharge have been made. Estimates of the discharge based on these incomplete records are summarized in the following table:

Period	Amount of water (acre-feet a year)
1916 to 1937	9,600
1937 to 1940	7,000
1940 to 1946	14,000

The valley is a completely enclosed, isolated ground-water basin and there is no loss of water by underflow from it. However, considerable quantities of water are discharged as a result

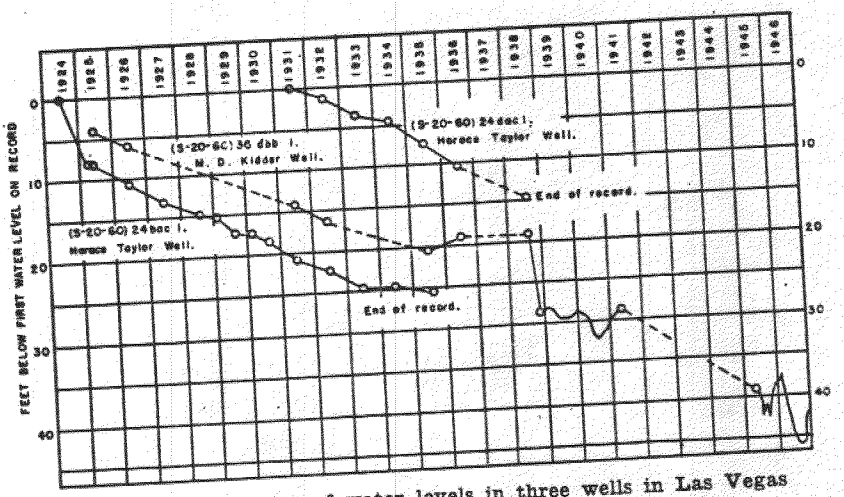

FIGURE 4—Decline of water levels in three wells in Las Vegas Valley, 1905–1946

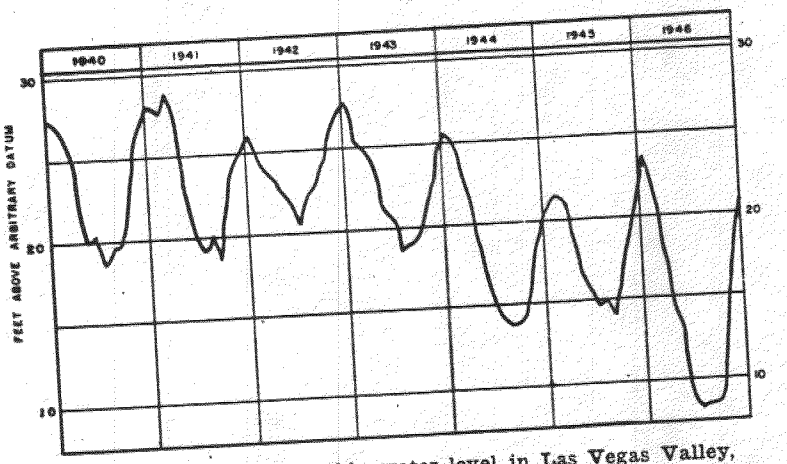

FIGURE 5—Mean monthly water level in Las Vegas Valley, based on monthly measurements of water level in 15 selected wells.

of evaporation and transpiration from areas where the "near-surface" water level is near the surface. Adequate study to determine the amount of water thus lost has not been made and, therefore, an estimate of the total discharge of ground water from Pahrump Valley is not available.

All the water derived from wells and springs in Pahrump Valley that does not run to waste is used for domestic, irrigation, and stock-watering purposes. Maximum use of water occurs during the summer months.

Indian Spring Valley

It is estimated that an average of approximately 800 acre-feet of water a year was discharged from the ground-water reservoir during the years 1905 to 1942, inclusive, and in 1946. Most of this water was supplied by Indian Springs and was used for irrigation and domestic purposes. During the period 1943–1945 the annual discharge increased to more than 1,450 acre-feet as a result of increased pumping of wells at the U. S. Army Air Field at Indian Springs.

BY WELLS & SPRINGS ONLY.

WATER-LEVEL FLUCTUATIONS

Las Vegas Valley

Dependable records of occasional water-level measurements in wells in Las Vegas Valley are available for the years 1925 to 1939. Records of periodic measurements made in numerous wells throughout the valley are available for the years 1939 to 1946. From these records it is possible to determine both long-term and minor fluctuations of the water levels.

Figure 4 shows the hydrographs of water levels in the Kidder well, (S–20–60) 36 dbb 1, and the Horace Taylor wells, (S–20–60) 24 bac 1, and (S–20–60) 24 dac 1, which are approximately three miles west and four miles northwest of the city of Las Vegas, respectively. They are between the recharge area and the main discharge area in Las Vegas Valley. These hydrographs indicate a continuous decline in water level from 1925 to 1946. Other fragmentary records of water levels in the valley also show this decline. Some wells that flowed prior to and during the early part of the period of record have now ceased to flow.

Figure 5 is a graph showing the mean monthly water level in several selected wells in Las Vegas Valley. It illustrates the principal fluctuations of water levels caused by large withdrawals from the aquifers in the summer months, and by recovery of the water levels during the winter months when ground-water

draft is much less. The graph also shows the year-to-year decline of water levels discussed in the foregoing paragraph. During 1945 the general water level did not decline below levels reached in the corresponding seasons of 1944, and in many wells the water levels were higher at the end of 1945 than they were in December 1944. In 1946 the average water level declined to the lowest stage on record. It is believed that the 1945 rise in water level was the result of decreased withdrawals and more efficient conservation of water. The 1946 decline was largely the result of unprecedented heavy withdrawals during that year.

The decline in water level as shown by the Kidder and Horace Taylor wells may be the result, in small part, of interference from near-by wells. However, the greater part is believed to be due to the development of a cone of depression caused by large withdrawals from closely spaced wells in the vicinity of Las Vegas. Apparently this cone of depression has grown outward from the center of pumpage in the vicinity of Las Vegas, resulting in a decline of water levels and reduction in the area of flowing wells. The shrinkage in the area of flowing wells between 1912 and 1946 is shown on plate 1. It also is reflected in the diminishing flow of the springs, as shown by figure 2.

In several places heavily pumped wells are closely spaced, and the heavy withdrawals from such small areas produced excessive interference, resulting in an abnormally large decline in water levels.

Pahrump Valley

Records showing water-level fluctuations in Pahrump Valley are available only for the period since October 1944. According to these records, fluctuation of the water levels is closely related to changes in the amount of water used in the valley. Thus, the highest water levels occur in January and the lowest levels occur in September and October. In one observation well the water level declined one foot during 1945, and approximately an additional foot during 1946. Similar declines in water level occurred in other observation wells during the same period. This decline probably is largely a result of interference among closely spaced, recently drilled wells.

Indian Spring Valley

No long period records of water-level fluctuations are available for Indian Spring Valley. Reports by residents and well owners and occasional water-level measurements indicate that there has been little change in water levels in the valley in the last 20 years.

SUMMARY OF GROUND-WATER CONDITIONS

From the foregoing discussion the following conclusions may be drawn: The only source of ground water for the three valleys is precipitation on the higher areas of the Spring and Sheep Mountains. However, only a small part of this precipitation recharges the alluvial fan and valley fill materials that compose the ground-water reservoirs. Estimates based on the available precipitation data show that the annual recharge to the ground-water reservoir in Las Vegas Valley is approximately 30,000 acre-feet, and it is approximately 25,000 acre-feet to the ground-water reservoir in Pahrump Valley.

The discharge from wells and springs in Las Vegas Valley was less than 30,000 acre-feet through 1945 and that figure was exceeded for the first time in 1946. Discharge from wells and springs in Pahrump Valley has never exceeded 14,000 acre-feet. In the vicinity of Las Vegas there are areas of local overdevelopment, as a result of close spacing and heavy pumping of wells. Water levels have been declining and are continuing to decline in Las Vegas Valley. In Pahrump Valley water levels have also declined during the short period of record. In both valleys, the ground-water levels may be expected to continue to decline until the cones of depression in the piezometric or pressure indicating surface caused by the withdrawal of water from wells and springs have grown sufficiently to intercept the recharge necessary to balance the total withdrawals of ground water. In Las Vegas Valley, where the withdrawal from wells approaches the total annual recharge, this may be expected to take longer than in Pahrump Valley. The available data indicate that continued withdrawal of substantially more than 30,000 acre-feet of ground water annually will result in overdevelopment of the ground-water supply in Las Vegas Valley. Some ground water appears to be available for additional development in Pahrump Valley. Sufficient data are not available to show whether a substantial additional supply is available in Indian Spring Valley.

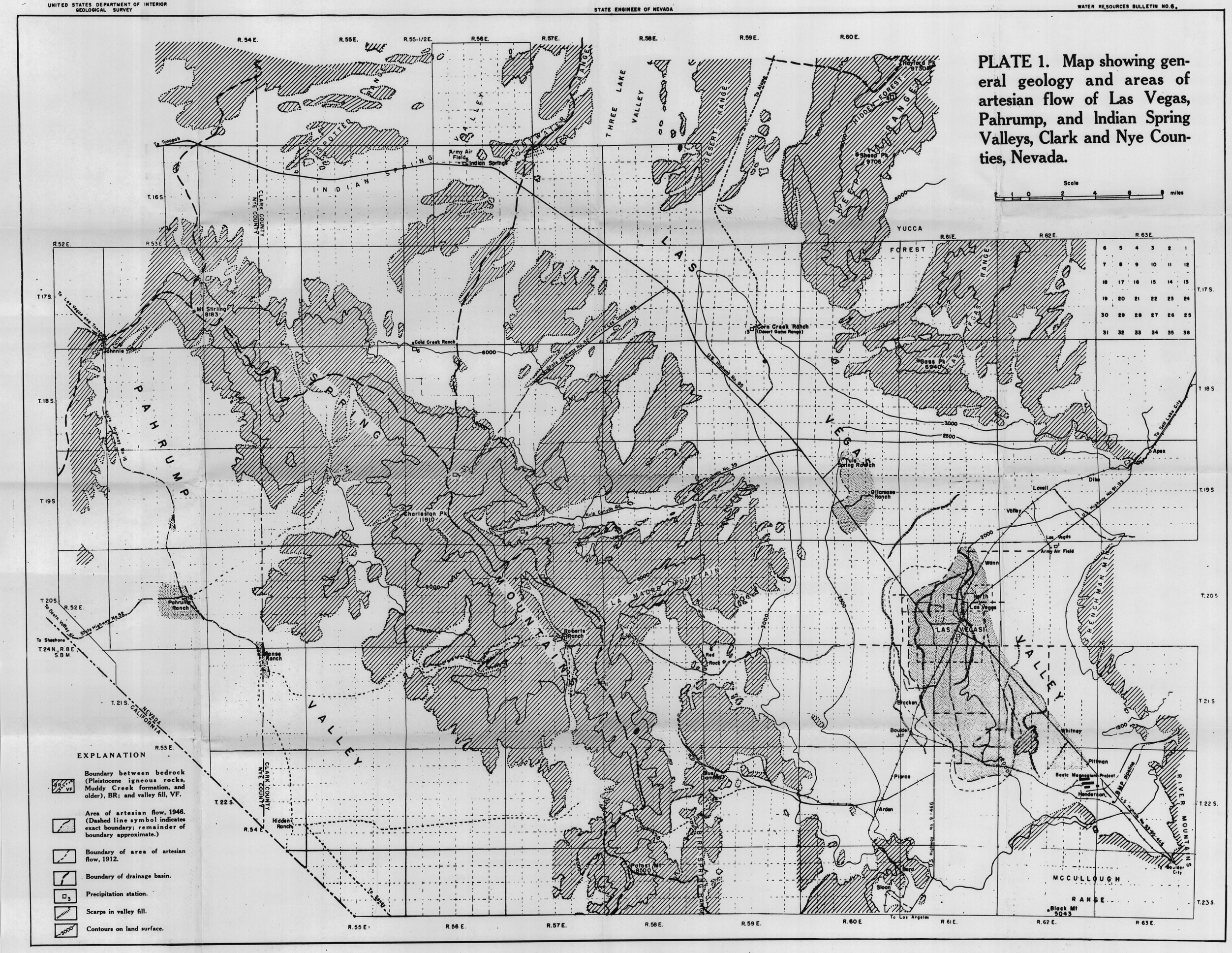

PLATE 1. Map showing general geology and areas of artesian flow of Las Vegas, Pahrump, and Indian Spring Valleys, Clark and Nye Counties, Nevada.