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STATE OF NEVADA
OFFICE OF THE STATE ENGINEER

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WATER RESOURCES BULLETIN No. 7

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Geology and Ground Water In the Meadow Valley Wash Drainage Area, Nevada, Above the Vicinity of Caliente

By DAVID A. PHOENIX

With statements on

Classification of Irrigable Lands in the Panaca Area of Meadow Valley

By GEORGE HARDMAN and HENRY G. FOX

and

Quality of Spring and Well Waters of the Meadow Valley Wash Drainage Area Above the Vicinity of Caliente

By GEORGE HARDMAN and M. R. MILLER

Prepared in cooperation with the
UNITED STATES DEPARTMENT OF THE INTERIOR
Geological Survey
1948

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FOREWORD

This report is the seventh in the series of Nevada Water Resources Bulletins prepared by the U. S. Department of the Interior, Geological Survey, in cooperation with the State Engineer.

It describes the general geologic and hydrologic conditions with reference to ground water in the Meadow Valley Wash drainage area, Lincoln County, above the vicinity of Caliente. The ground-water resources of Meadow Valley, in which the greatest development has taken place, is discussed quantitatively, and that of the other valleys in the area qualitatively. A soil survey of Meadow Valley by the U. S. Department of Agriculture, Soil Conservation Service is discussed and the results of the classification of irrigable lands in the Panaca area of Meadow Valley summarized. The quality of the ground water and its suitability for domestic and irrigation use is discussed briefly.

A cooperative arrangement for the study of the ground-water resources in Nevada has been in effect since July 1944 as the result of an agreement between the Director of the Geological Survey and the State Engineer of Nevada. From July 1944, to June 30, 1945, this was limited to Las Vegas Valley in Clark County. Expansion of this arrangement, beginning July 1, 1945, to include the entire State, was made possible by the actions of the Forty-second Session of the Legislature in appropriating $35,000 for the biennium, to be matched by an equal amount by the Geological Survey. The Forty-third Session of the Legislature continued the study by an appropriation of $40,000 for the biennium, to be similarly matched.

The program for the State is under the supervision of Hugh A. Shamberger, Assistant State Engineer. The program of the Geological Survey is under the direction of Thomas W. Robinson, District Engineer in Nevada for the Ground-Water Division, Geological Survey.

ALFRED MERRITT SMITH,
State Engineer.

January 13, 1948.

ABSTRACT

The area described in this report lies within the Great Basin section of the Basin and Range province and covers about 2,000 square miles in the northern half of Lincoln County, Nevada. It is bounded on the north by the First Standard parallel north of the Mount Diablo base meridian and on the south by the First Standard parallel south of the Mount Diablo base meridian. On the east it is bounded by the Nevada-Utah State line which follows the Mormon Range and its northern continuation the White Rock Range, and on the west its boundary is the northerly trending interconnected Meadow Valley, Highland, Bristol, Fairview, and Shell Creek Ranges. The Wilson Creek Range lies within the northern half of the area and transects it from north to south. The area contains the headwaters of Meadow Valley Wash, a tributary to the Colorado River.

Three towns lie within the area. They are Pioche, the county seat of Lincoln County, Caliente, and Panaca. They are all served by the Union Pacific Railroad and U. S. Highway No. 91. The chief occupations of the inhabitants are mining and farming, the latter becoming more important as the successful development of under-ground water for irrigation use progresses.

Four valleys lie within the area, three of which lie along the southerly flowing Meadow Valley Wash, and a fourth that is tributary to this stream. Spring Valley is the headwater of Meadow Valley Wash. Downstream is Ursine Valley consisting of three small interconnected valleys, Eagle, Rose, and Dry Valleys. From Dry Valley, the lowermost of the three, Meadow Valley Wash flows through the narrow gorge of Condor Canyon and thence into Meadow Valley. Lake Valley lying to the west of, and separated from Spring Valley by the Wilson Creek Range drains into Meadow Valley Wash through Hamlight Canyon, tributary to Condor Canyon. Stream flow out of Lake Valley occurs only during and after periods of heavy precipitation. Land forms in the area indicate that Meadow Valley Wash and its tributaries were probably an active stream system throughout the Pleistocene period. Three and possibly four abandoned stream terraces in Meadow Valley are probably contemporaneous with the Pleistocene glacial lake stages of Lake Lahontan in western Nevada.

Climatic conditions in most of the valleys are favorable for

the growing of crops. However, the rainfall is insufficient for the production of crops and hence irrigation is necessary for successful agricultural development.

The rocks exposed in the area range in age from Pre-Cambrian to Recent. The older rocks form the surrounding ranges whereas the basins contain unconsolidated to semiconsolidated sediments derived from them. Paleozoic sediments ranging in age from Pre-Cambrian to Carboniferous comprise the ranges which form the western border of the area. They reach a total thickness of between 17,000 and 18,000 feet, and their prevailing dip is to the east. Tertiary volcanic rocks, tentatively assigned to the Miocene, border the area to the south, east, and north, and exceed in exposure area all the other consolidated rocks combined. A section more than 6,000 feet thick, with an average dip of 25° E., is exposed in the walls of Condor Canyon. They also make up the Wilson Creek, White Rock, and Mormon Ranges and are exposed along the canyon of Meadow Valley Wash below Caliente. These volcanic rocks are gently folded and cut by faults, however, their average dip is less than that of the Paleozoic sediments. The intervening valleys contain wind and lake deposits, called the Panaca formation, overlain by outwash from the mountains. Stream waters in Meadow Valley Wash and its tributaries have cut through the later alluvial cover and exposed several hundred feet of this underlying formation. The Panaca formation is Pliocene in age. It is best exposed in Meadow Valley, where it is composed of terra-cotta to light brown silts and fine sands and locally some diatomite and volcanic ash. These beds dip gently from both sides of Meadow Valley and are locally cut by faults of small displacement. The outwash covering the Panaca formation has been designated as the earlier Quaternary and later Quaternary alluvium, or simply earlier and later alluvium. The earlier alluvium caps the stream terraces in Lake, Spring, and Meadow Valleys. It consists of reworked alluvial fan sediments derived from the base of the adjacent mountains. These sediments consist of locally cemented gravels and sands whose thickness rarely exceeds 10 feet. The later alluvium is deposited as alluvial cones at the mouths of the canyons, at the base of the mountains, and as a filling beneath the channels of Meadow Valley Wash and its tributaries. These sediments are known to have thicknesses up to 160 feet. Their character is variable and depends upon their source. In the valleys through which Meadow Valley Wash flows, they have been prospected by wells. Here they consist of interbedded silts, sands, and gravels.

The upstream portions of the valleys generally contain the coarser and more permeable sediments; in the downstream portions of the valleys the sediments are generally more fine grained.

The development of ground water for irrigation, with two possible exceptions, is limited to the alluvial sediments on the floors of the valleys. The physical character and water-bearing properties of these sediments are favorable in most places for the development of wells with sufficient capacity for irrigation. The two possible exceptions are the Panaca formation and the "basement" rocks composed of the Paleozoic sediments and the Miocene (?) volcanics. However, past exploration of these formations are discouraging in that no wells of a large yield suitable for irrigation have been developed. It appears that failure rather than success might be the general expectation for wells drilled for irrigation water to the Panaca formation or "basement" rocks. It is not possible to point out with certainty places where water in sufficient quantity for irrigation is likely to be obtained from these formations.

All the valleys have land suitable for irrigation, and in general the quality of the ground water is also suitable for irrigation. The extent to which irrigation from wells can be practiced differs from valley to valley and is greatest in Meadow Valley. There has been little or no development of irrigation wells in Lake, Spring, and Ursine Valleys. Little is known concerning the probable yield of wells in these valleys. By the end of 1946 eight successful irrigation wells had been developed in Meadow Valley and additional development is feasible. Two successful irrigation wells have been developed in Meadow Valley Wash below Meadow Valley, and it is believed that, if properly located and constructed, additional wells suitable for irrigation can be developed.

It is estimated that in Spring Valley approximately 3,000 acre-feet of water is discharged annually by evaporation and transpiration. Recovery of much of this water by pumping appears to be feasible. In Meadow Valley it is estimated that under ideal conditions between 6,000 and 7,000 acre-feet of water could be salvaged annually by pumping from wells. However, under actual practice it is estimated this amount will be 5,000 acre-feet or less. This is in addition to the 743 acre-feet pumped during 1946. On the basis of the weighted average duty of water (3.14 acre-feet per acre) sufficient water to irrigate about 1,600 acres of land could be obtained.

According to Soil Conservation Service the gross area of land suitable for rotation cropland is about 7,400 acres, that suitable for occasional cultivation is about 200 acres, and that suitable for grazing is about 1,400 acres. All these areas must be reduced between 20 and 30 percent to allow for waste and unusable land.

In 1946 the gross amount of uncultivated land suitable for rotation cropland, that is, classes I, II, and III, that was unirrigated was estimated to be about 5,000 acres. As this must be reduced between 20 and 30 percent to allow for waste and unusable lands, the net area is estimated to be 3,500 to 4,000 acres.

On the basis of these data the estimated amount of ground water that can be recovered by pumping is sufficient to irrigate somewhat less than half of the present uncultivated croplands in Meadow Valley if the duty of water is maintained at 3.14 acre-feet per acre.

To irrigate additional rotation cropland suitable for cultivation it will probably be necessary to resort to artificial recharge by water spreading. The period of artificial recharge would of necessity be limited to the nongrowing season. Its success would depend upon the quantity of water available during that period and on the infiltration capacity of the sediments in the recharge area. Prior to attempting artificial recharge these factors should be carefully examined.

GEOLOGY AND GROUND WATER IN THE MEADOW VALLEY WASH DRAINAGE AREA, NEVADA, ABOVE THE VICINITY OF CALIENTE

By DAVID A. PHOENIX

INTRODUCTION

LOCATION AND EXTENT OF THE AREA

The area covered by this report (see Fig. 1 and Pl. 1) lies in Lincoln County, in southeastern Nevada. It is bounded on the north by the First Standard parallel north of the Mount Diablo base meridian, and to the south by the First Standard parallel south of the Mount Diablo base meridian, east by the Nevada-Utah State boundary, and on the west by a north-south trending interconnected chain of mountains. These mountains are the south end of the Shell Creek Range and the Fairview, Bristol, Highland Ranges and the north end of the Meadow Valley Range (Chief Mountain). The area covers approximately 2,000 square miles. Intensive and detailed work was confined largely to the Panaca area of Meadow Valley. Meadow Valley occupies the south central part of the drainage area of Meadow Valley Wash covered in this report. The agricultural town of Panaca, with an estimated population of 500, lies at its northern end. Meadow Valley has been earlier defined by Carpenter[1] as "a small basin lying along Meadow Valley Wash between Caliente and Delmue's ranch. It is about 25 miles long from north to south and extends from the Highland and Meadow Valley ranges on the west to the Mormon Range on the east."

The Panaca area is made up of the flood plain of Meadow Valley Wash lying within Meadow Valley, and the mouths of tributaries which arise in the ranges surrounding Meadow Valley. It is about 16 miles long from north to south, extending from the mouth of Condor Canyon on the north to the entrance of Cove Canyon on the south. (See Pl. 1 and 2.)

The largest towns of the area covered by the report are Pioche and Caliente. Pioche, the county seat of Lincoln County and the business center for the Pioche mining district, lies 15 miles to the north of Panaca, in the Ely Range. Caliente, a railroad center for the transcontinental Union Pacific Railroad, lies 14

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[1] Carpenter, Everett, Ground water in southeastern Nevada: U. S. Geol. Survey Water-Supply Paper 365, p. 49, 1915.

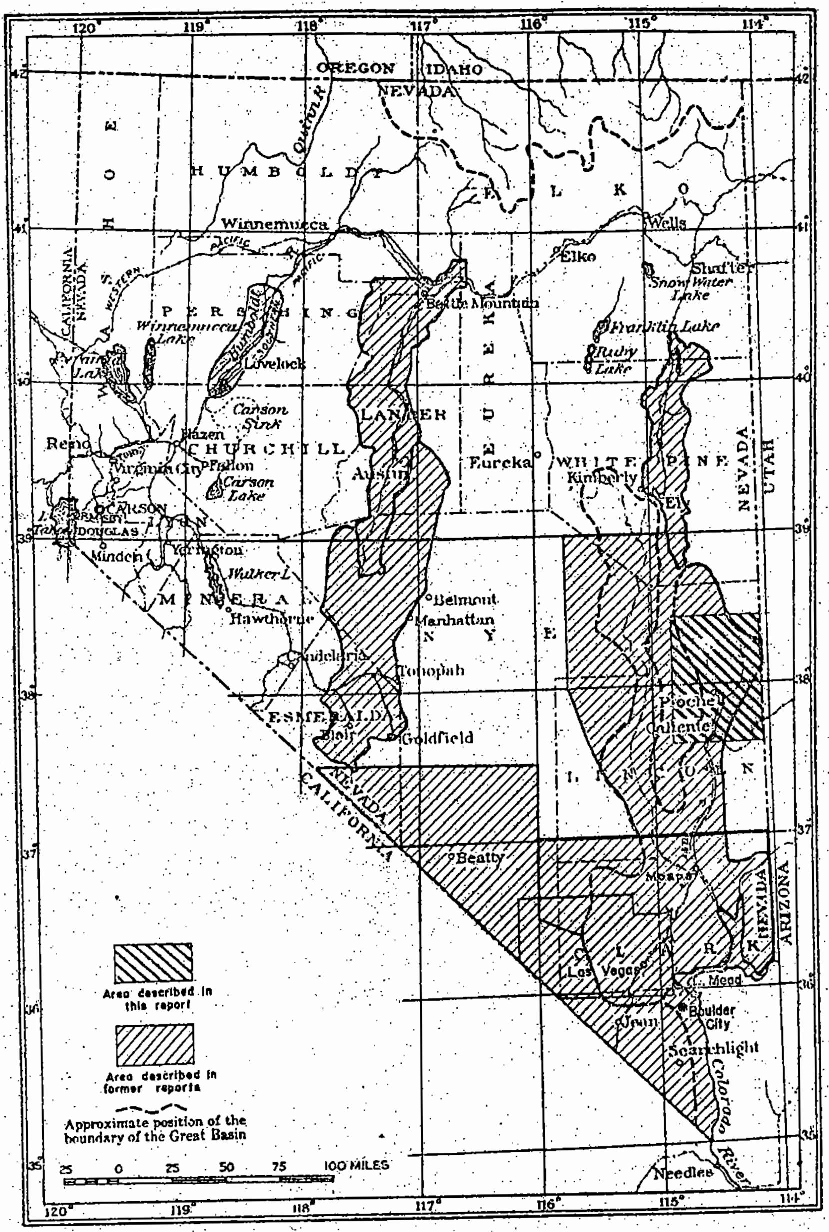

FIGURE 1—Map of Nevada showing areas covered by previous ground-water reports in Nevada and by the present report.

miles to the south. A branch line of the Union Pacific Railroad from Caliente to Pioche and U. S. Highway 93 serve as adequate means of transportation between the three towns, and give easy access to the surrounding territory and to the industrial centers of Salt Lake City, Utah, and Los Angeles, California.

PURPOSE AND SCOPE OF THE INVESTIGATION

This report describes the results of a geologic and hydrologic investigation of the Meadow Valley drainage area in relation to the occurrence and development of ground water. The successful development of ground water for irrigation near Panaca, beginning about 1938, has stimulated the use of ground water for agricultural purposes. Detailed studies were confined largely to the Panaca area of Meadow Valley (Pl. 2) while reconnaissance investigations were extended to the northern tributaries, Lake, Ursine, and Spring Valleys, and along the lower reaches of Meadow Valley Wash as far south as Elgin, a siding on the Union Pacific Railroad.

The field work was done by David A. Phoenix, who began intensive studies on March 1, 1946. The investigation was under the supervision of T. W. Robinson, District Engineer for the Geological Survey, Ground Water Division, for Nevada.

AGRICULTURAL AND MINING DEVELOPMENT

The chief source of income in Meadow Valley and Ursine Valley has been cattle raising, and with the beginning of good breeding practices and range management more and more good-quality beef has been sent to both local and outside markets.

Nearly all the inhabitants of these valleys are also engaged in farming. The chief crops have been native hay, alfalfa, potatoes, and some fruit. These crops have been raised in sufficient quantity to supply the local needs and to permit a limited amount of export for outside sale. Since 1935, however, when cheap power was made available from Hoover Dam, the office of the Nevada State Engineer and the Department of Agriculture, Soil Conservation Service, have encouraged efforts to augment the limited supply of irrigation water from runoff and springs with ground water from irrigation wells. The weighted average annual use of water in Meadow Valley, according to the Caliente office of the Soil Conservation Service is 3.14 acre-feet per acre. Estimates based on the classification of soils by the Soil Conservation Service indicate that in Meadow Valley the undeveloped land suitable for rotation cropland amounts to about 5,000 acres.

(See Pl. 3.) This is gross acreage which includes roads, stream channels, and other waste areas. The net usable land is estimated to be 20 to 30 percent less. No attempt was made to estimate the land suitable for occasional cultivation or for grazing. Since 1938 there has been a marked trend in the development of ground water for irrigation. Thus, with careful and continued development of this source of water supply, the yearly income derived from farming in Meadow and Ursine Valleys should be materially increased.

The Pioche silver-lead-zinc mines have long been the principal supply of mineral resources in Lincoln County. These mines were discovered in 1863. The first recorded production was in 1869, and from that time until 1940 this district is credited with $40,000,000 in silver, lead, gold, copper, zinc, and manganese—about two-thirds of the county's total mineral production.[2] The total income from the mining districts contained within the area covered by this report approximates $45,000,000. Undoubtedly much of the money resulting from the mining and expended in salaries has indirectly benefited the farmers in this part of Lincoln County.

HISTORY

The discovery of rich silver mines at Pioche closely parallels the first settlement of the small towns and communities in the outlying agricultural areas in Ursine and Meadow Valleys. According to Scott[3] "Several acres were planted in grain in Meadow Valley, probably near the present site of Panaca, in 1858. In 1863, Meadow, Eagle, and Spring Valleys were used as herding grounds by the St. George Mormons."

Westgate[4] reviews the history of Pioche as follows: "The first year for which there is a record of production from the Pioche district is 1869 * * *. Six years before, in 1863, Indians had shown silver ore, which they called 'panacare,' to William Hamblin, a Mormon missionary. Hamblin visited the place the same year and located the 'Panacker' claim. He revisited the region the next spring with others, and on March 18 they organized the Meadow Valley mining district. In May of this year the first settlement of Panaca was made. Indian hostilities in 1865 put a temporary stop to prospecting. * * * Water was lacking near Pioche, and the mills, to get water, were built in Meadow Valley. The first mill was * * * set up by Raymond and Ely at Bullionville, near Panaca, 10 miles south of Pioche. The ore was first hauled by wagon from Pioche to Bullionville at a cost of $5 a ton. To cut this cost a narrow-gage railway, 18 miles long, was built from Pioche to Bullionville by way of Condor Canyon and completed in 1873." Railway connections with the outside became possible in 1905 when the San Pedro, Los Angeles, and Salt Lake Railway (predecessor of the present Union Pacific Railroad) was built from Salt Lake City southwest, and ore was hauled as far as Juab, Utah, on this line. An early attempt to connect Pioche with the main line at Caliente was interrupted by the panic of 1893, and it was not until 1907 that the present branch line, 33 miles in length, was built.

The first settlement was made at Ursine in Eagle Valley in the late 1850's by Mormon cattlemen from Utah. The town of Caliente was laid out in 1901 as a construction camp for the San Pedro, Los Angeles, and Salt Lake Railway. The name Caliente, meaning "hot" or "warm" in Spanish, was probably derived from the presence of now nonflowing hot springs just north of town. Caliente has been for many years a division point of the Union Pacific Railroad, and is now the chief shipping center for practically all of the northern half of Lincoln County.

PREVIOUS INVESTIGATIONS

The earliest geologic and hydrologic investigations in Meadow Valley Wash was by Everett Carpenter[5] in 1915. Harry E. Wheeler[6] in 1941 was employed by the Department of Agriculture, Soil Conservation Service, to recommend drilling sites in or near Panaca for a proposed city water supply.

Geologic and mining investigations were started at an earlier date, as the result of the early mining activities at Pioche and other nearby mining camps. G. K. Gilbert[7] described briefly the ore deposit at Pioche, and his work was enlarged upon by many other engineers and geologists.[8]

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[2] Couch, B. F., Carpenter, J. A., Nevada's metal and mineral production (1859–1940, inclusive): Nevada Univ. Bull., vol. 37, No. 4; Geol. and Mining Ser. No. 38, p. 81, Nov. 1, 1943.

[3] Scott, A. L., Lincoln County, in Davis, S. P., The history of Nevada, Elms Pub. Co., Inc., Reno, Nev., and Los Angeles, Calif., p. 927, 1913.

[4] Westgate, L. G., and Knopf, A., Geology and ore deposits of the Pioche district, Nevada: U. S. Geol. Survey Prof. Paper 171, pp. 4–5, 1932.

[5] Op. cit.

[6] Wheeler, H. E., Ground water possibilities near Panaca, Lincoln County, Nevada: State of Nevada, Bienn. Rept. of State Engineer for period July 1, 1940, to June 30, 1942, pp. 73–79.

[7] Gilbert, G. K., Report on the geology of a portion of Nevada, Utah, California, and Arizona examined in the years 1871 and 1872: U. S. Geog. and Geol. Survey W. 100th Mer. Rept., vol. 3, Geology, pp. 257–261, Washington, 1875.

[8] Gianella, V. P., Bibliography of geologic literature of Nevada: Nevada Univ. Bull., vol. 30, No. 6; Geol. and Min. Ser. No. 43, pt. 1, Dec. 1945.

Stratigraphic and paleontologic studies in the Fairview, Bristol, Ely, and Highland Ranges have been carried on by Westgate and Knopf,[9] Wheeler and Lemmon,[10] and Wheeler,[11] and detailed descriptive sections of the Paleozoic rocks lying within this area have been prepared. The Tertiary valley fill in Meadow Valley has been described in some detail by Westgate and a collection of mammalian fossils from those beds has been described by Stock.[12] Callaghan[13] describes an occurrence of volcanic ash at the head of Cathedral Gorge, and a bed of diatomite a mile east of Panaca, both within the Panaca formation.

ACKNOWLEDGMENTS

During the course of the investigation many persons contributed valuable data and information. To the residents of the area the writer is grateful. Their many courtesies, wholehearted cooperation, and interest have served materially to make this investigation as complete as possible. Particularly the writer would like to acknowledge the many services rendered by D. Free, well driller, and Frank Walker, water rights surveyor, and by K. Lee, P. Edwards, Evan Edwards, Jobe Hall, residents and land owners, and many others too numerous to mention. The staff of the Soil Conservation Service office at Caliente loaned equipment, assisted in the field, and gave the writer free access to their files of hydrologic data. The Union Pacific Railroad Company furnished valuable data on the construction and performance of their wells at Caliente. The writer also gratefully acknowledges the data on stock wells furnished by the office of the Bureau of Land Management at Ely, Nevada. Material assistance was furnished by personnel of the State Engineer's Office, through records and files in their office and their intimate knowledge of the area. The writer is grateful to T. W. Robinson, C. L. McGuinness, and H. G. Ferguson of the Geological Survey who critically reviewed the manuscript and added much through their knowledge of geology and the field of ground-water hydrology.

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[9] Westgate, L. G., and Knopf, A., Geology and ore deposits of the Pioche district, Nevada: U. S. Geol. Survey Prof. Paper 171, 1932.

[10] Wheeler, H. E., and Lemmon, D. M., Cambrian formations of the Eureka and Pioche districts, Nevada: Nevada Univ. Bull., vol. 33, No. 3; Geol. and Min. Ser. No. 31, 1939.

[11] Wheeler, H. E., Revisions in the Cambrian stratigraphy of the Pioche district, Nevada: Nevada Univ. Bull., vol. 34, No. 8; Geol. and Min. Ser. No. 34, 1940; Lower and Middle Cambrian stratigraphy in the Great Basin area: Nevada Univ. Bull., vol. 38, No. 3; Geol. and Min. Ser. No. 39, 1944.

[12] Stock, Chester, Late Cenozoic mammalian remains from the Meadow Valley region, southeastern Nevada: Geol. Soc. America Bull., vol. 32, 1921.

[13] Callaghan, Eugene, Mineral resources of the region around Boulder Dam: U. S. Geol. Survey Bull. 871, p. 178 (volcanic ash), p. 180 (diatomite), 1936.

PHYSIOGRAPHY AND DRAINAGE

The area described in this report lies in the Great Basin section of the Basin and Range Province, a semiarid region of northerly trending mountain ranges and intermontane plains floored with detrital and outwash material from the adjacent mountains. Most of the ranges have well-defined north-south trends. The drainage in this area, unlike most of that found throughout the State, is not interior but finds its way down Meadow Valley Wash to the Colorado River, and from there to the Gulf of California.

On the west, Meadow Valley and its tributary, Lake Valley, are bordered by the southern end of the Shell Creek Range and the Fairview, Bristol, and Highland Ranges and the north end of the Meadow Valley Range (Chief Mountain). (See Pl. 1.) Between the southern end of the Shell Creek Range and Chief Mountain, west of Caliente, this series of closely connected ranges forms a northerly trending chain of mountains about 50 miles long, broken only by low intervening passes. These connected ranges attain altitudes of from 8,000 to a little over 9,000 feet, and rise from 3,000 to 5,000 feet above the valley floor.

To the east, Meadow Valley and its tributaries, Ursine and Spring Valleys, ascend to the Wilson Creek Range, the White Rock Mountains, and the low-lying range east of Panaca, referred to by Carpenter as the Mormon Range. These latter two ranges parallel the Nevada-Utah border and have summit elevations up to 9,500 feet.

At the north end of the area, bounded on the east and south by Spring and Ursine Valleys and to the west by Lake Valley, lies the Wilson Creek Range, with its southern termination at Ursine and its northern end some 35 miles to the north. Here it merges into the Fortification Range, swings to the east, and joins by means of a low pass with the arcuate White Rock Range. Mount Wilson and Parsnip Peak are the highest peaks in the White Rock Range, and it is believed that their altitudes approximate 9,000 feet.

Lake Valley, about 60 miles long and 10 to 12 miles wide, is bounded on the west by the south end of the Shell Creek Range and the Fairview, Ely, and Bristol Ranges, and on the east by the Fortification and Wilson Creek Ranges. A nearly imperceptible divide, originating near Poney Spring, separates Lake Valley into two distinct basins. The northern basin is described by Carpenter[14] as follows: "The northern part of Duck Valley

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[14] Op. cit., p. 44.

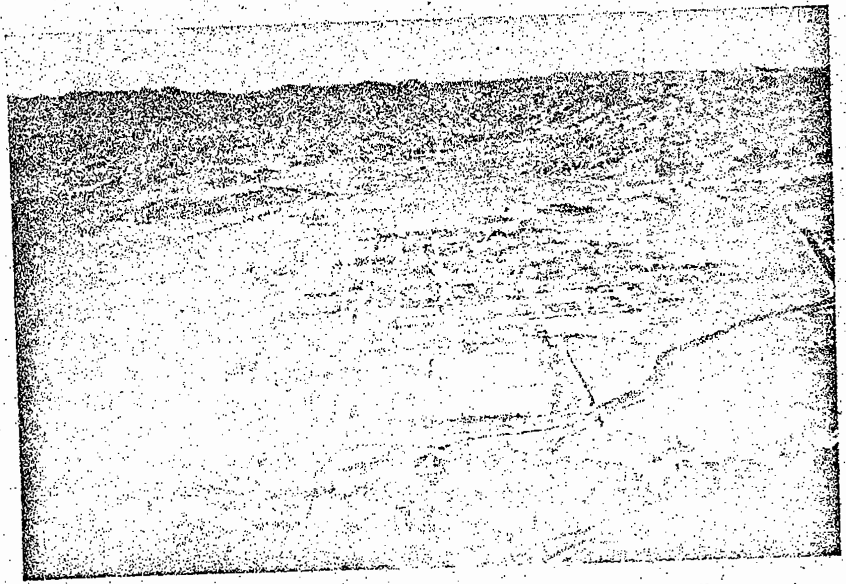
(now called Lake Valley) is a typical debris-filled basin whose smooth alluvial slopes are almost untouched by erosion. This part of the valley was once the site of a fresh-water lake that extended from about the latitude of Poney Spring to a point north of Geyser post office. This lake was about 20 miles long and 15 miles wide, its position being marked by well-preserved shore features. A few small ponds in the vicinity of Wambolt's ranch are all that remain of the ancient lake." The southern portion of Lake Valley, about 35 miles long from north to south, contains the central valley drainage channel, Patterson Wash, and its many lateral tributaries. From the drainage divide near Poney Spring, the drainage is north into a closed basin and south along Patterson Wash, a headwater portion of the seaward-flowing Meadow Valley drainage system. Patterson Wash drains through Hamlight Canyon, a steep-walled canyon carved in resistant volcanic rocks, into Condor Canyon and finally emerges onto the flood plain of Meadow Valley Wash in Meadow Valley.

Ursine Valley and its upper reaches, known as Spring Valley, extend north from Delumes about 40 miles, where it heads in the Wilson Creek and White Rock Ranges. These valleys are bordered on the east by the north end of the Mormon Range and the White Rock Range, and on the west by the Wilson Creek Range.

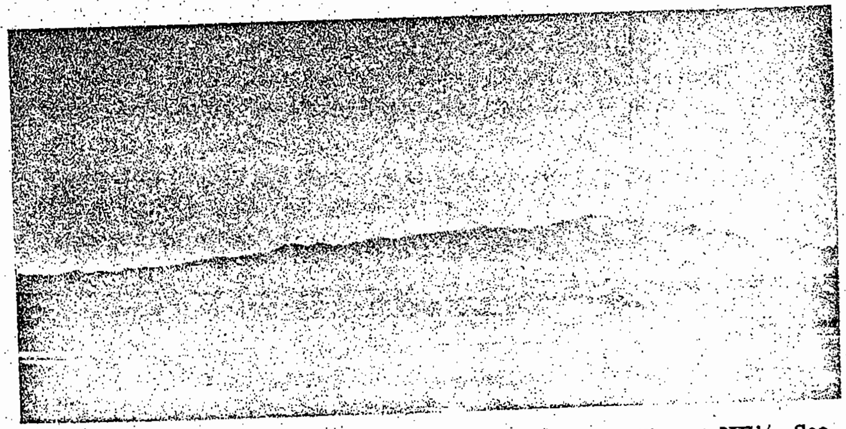
Spring Valley as defined in this report is that basin which starts about six miles north of Ursine and heads in the highlands of the Wilson Creek and White Rock Ranges, about 30 miles to the north. Camp Valley Wash, the intermittent and headwater portion of Meadow Valley Wash, is entrenched to depths of 50 to 100 feet in the nonresistant sediments filling the Spring Valley basin, and is frequently the site of heavy summer floods which originate as thunder showers in the bordering ranges. The name Spring Valley comes from the many springs which arise at its lower end and form the perennial headwaters of Meadow Valley Wash.

Eagle, Rose, and Dry Valleys, a single structural and physiographic unit consisting of three closely linked valleys, are given the common name of Ursine Valley, after the small Mormon community of that name in the upper end of Eagle Valley. Resistant beds of volcanic rocks which strike normal to the trend of the present drainage, and into which Meadow Valley Wash has been deeply entrenched, are responsible for the narrow constrictions that separate these small basins one from another. All these basins drain through Condor Canyon onto the central flood plain of Meadow Valley Wash in Meadow Valley.

PLATE 4 WATER RESOURCES BULL. NO. 7



A. Aerial view showing Panaca townsite and north end of the Panaca area. (1) Mouth of Condor Canyon; (2) Warm Spring; (3) Bullionville Spring; (4) Viewpoint for Pl. 4B. Photo courtesy Soil Conservation Service.



B. Terraces in Meadow Valley. View northwest from hilltop. NE¼, Sec. 16, T. 2 S., R. 68 E.

Meadow Valley is bounded on the north by the Ely Range, on the east by the Mormon Range, and on the west by the Highland Range and the Meadow Valley Range whose north end is defined by Chief Mountain.

Meadow Valley Wash enters Meadow Valley through Condor Canyon on the north and leaves the valley through Cove Canyon to the south. This wash in its passage through Meadow Valley has eroded into the valley floor forming an inner valley which now contains the flood plain of Meadow Valley Wash. This flood plain together with the outwash from tributary drainages forms what is called the Panaca area in this report. (See Pl. 2.) The flood plain has an elevation of 4,470 feet at the entrance to Cove Canyon and rises gently to an elevation of 4,830 feet at the mouth of Condor Canyon, 16 miles upstream. (See Pl. 4A.)

Condor Canyon is a deeply incised canyon extending from three miles north of the town of Panaca for a distance of six miles to Delmues. Cove Canyon is a similarly incised canyon extending from the south end of the Panaca area for a distance of two miles to Caliente.

Meadow Valley Wash, having as its perennial source the springs in Spring Valley, flows, except when diverted for irrigation purposes, through Ursine and Meadow Valley, and has been locally entrenched from 20 to 30 feet in easily eroded late Pleistocene and Recent alluvium.

Physiographic evidence indicates that the Meadow Valley Wash drainage pattern possibly dates well back into the Pleistocene. Such features as the stream entrenchment in resistant rocks to be found at the lower end of Spring Valley; between Eagle, Rose, and Dry Valleys; at the proposed dam site at Delmues; in Hamlight, Condor, and Cove Canyons; and in the reaches of Meadow Valley Wash below Caliente indicate that an ancient meandering stream of low gradient began to degrade and cut its way through easily eroded materials once overlying and masking older crystalline rocks. Finally the stream pattern was superimposed upon buried ridges and hills of crystalline rocks where, because it was already too deeply incised to choose a new course, it slowly carved out the present steep-walled canyons to be found in the area. The now-entrenched meanders of the ancient Meadow Valley Wash are particularly noticeable along the portion of Meadow Valley Wash extending south of Caliente.

Terraces formed by the meandering stream of the ancient Meadow Valley Wash as it flowed over the old plain in Meadow

Valley are additional prominent physiographic features formed by erosion during the Pleistocene epoch. These terraces, three of which may be seen west of Panaca, shown in (Pl. 4B), have been dissected by marginal drainage from the adjacent highlands, and are now generally seen only as isolated segments. In the upper reaches of the Meadow Valley Wash drainage system, formed by Patterson Wash and Camp Valley Wash, the three terraces seen near Panaca are nonexistent. Here, inner valleys ranging from 100 feet to a quarter of a mile wide and attaining depths as great as 100 feet, slope upward and grade into a single terrace. Side gullies have been deepened to keep pace with the downward cutting of the main drainage, and as a result a rolling and benchland topography has been developed. As the headwaters area of the drainage system is reached, the valleys become more plainlike and are little dissected.

CLIMATE

The climate of Meadow Valley is semiarid and there is seldom sufficient year-round rainfall to support agriculture without irrigation. The normal precipitation supports only native brush and short hardy grasses. The greater part of the moisture falls as snow in the mountains during the winter months from December to March. During the summer months of July and August, severe thunderstorms, sometimes of cloudburst proportions, may be expected, which fill Meadow Valley Wash and its tributaries with water, flood the lowlands, and finally pass down Meadow Valley Wash to the Colorado River. These cloudbursts are generally too local and too short in duration to augment materially the supply of irrigation water. The humidity is low, and the daily and seasonal range in temperature is fairly high. Evaporation during the year is high and the percentage of sunshine is also high. The prevailing winds are from the south and southwest, and rarely do they reach damaging velocities. The average dates and length of growing season for Caliente, Pioche, and Geyser are as follows:

Location	*Average date, last killing frost (spring)*	*Average date, first killing frost (autumn)*	*Average length growing season (days)*
Caliente	April 25	October 2	160
Pioche	May 26	September 24	121
Geyser	June 30	August 29	60

The available climatological data for the Meadow Valley Wash drainage area are summarized in the following tables:

TABLE 1

Average Monthly and Annual Precipitation, in Inches, at Five Climatological Stations in Meadow Valley Wash Drainage Area Above Caliente, Nevada

elevation ~ 5600'

Location	Years of record	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Panaca,[a] 5½ miles east of	11	0.63	0.92	1.16	1.18	0.38	0.17	0.95	1.59	0.84	1.29	0.58	0.91	10.60
Panaca,[a] 10 miles east of	11	.79	.83	1.00	.97	.57	.22	.93	1.44	.60	1.57	.54	.92	10.38
Pioche[b] (altitude 6,110 ft.)	30	1.47	1.27	1.37	.90	.98	.30	.78	1.47	.71	.55	.54	1.51	11.85
Caliente[b] (altitude 4,407 ft.)	29	1.03	1.16	.65	.41	.41	.25	.64	.49	.28	.26	.33	.46	6.37
Geyser[b] (altitude 5,984 ft.)	22	.84	.83	1.16	.81	.71	.30	.28	.90	.48	.68	.68	.72	8.39

[a] From files of the U. S. Department of Agriculture, Soil Conservation Service, Caliente, Nevada. Averages based on incomplete record from 1936 to 1946, inclusive. Altitude not determined.

[b] U. S. Department of Commerce, Weather Bureau.

TABLE 2

Average Monthly and Annual Temperature, in Degrees Fahrenheit, for Two Climatological Stations in Meadow Valley Wash Drainage Area Above Caliente, Nevada

(Data from U. S. Department of Commerce, Weather Bureau; Period from Establishment of Station to 1945, Inclusive)

Location	Years of record	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Caliente	22	31.8	36.7	46.1	51.8	60.0	67.9	75.0	73.9	64.9	52.4	41.7	34.0	53.0
Pioche	17	29.8	33.6	39.1	47.5	55.5	65.0	73.0	71.0	62.8	51.3	40.4	32.9	50.2

GENERAL GEOLOGY

SEQUENCE AND GENERAL FEATURES OF THE ROCKS

Paleozoic sedimentary rocks reaching a total thickness between 17,000 and 18,000 feet, unconformably overlain by volcanic rocks ranging in age from early Tertiary, or possibly late Mesozoic, to Miocene(?) time; wind- and water-laid arkosic sand and silt of Tertiary (Pliocene) age, known as the Panaca formation; and Quaternary sands, silts, and gravels of the alluvial aprons and valley fill, are exposed in the area. The Paleozoic rocks are intruded by stocks and dikes which have locally metamorphosed those sediments. Small dikes, probably related to the Tertiary volcanic rocks, may also be found in the area.

Of the consolidated sedimentary beds, those of Cambrian age have the greatest area of exposure. They can be traced from the north end of the Meadow Valley Range (Chief Mountain) northward through the Highland and Bristol Ranges, a distance of about 70 miles. They may also be found in the Ely Range, wherein lie the larger mines of the Pioche mining district. Elsewhere, except for local exposures, they are masked by the Miocene (?) volcanic rocks, Pliocene Panaca formation, and Quaternary alluvium.

The Tertiary volcanic rocks, tentatively assigned to the Miocene, border the area to the south, east, and north, and exceed in exposure area all the other consolidated rocks combined. The Wilson Creek, White Rock, and Fairview Ranges and the north end of the Mormon Range are almost completely composed of these Tertiary volcanic rocks.

The unconsolidated Tertiary deposits which comprise the Panaca formation of Pliocene age, fill the basins and overlie the crystalline older rocks. They are found in Lake, Meadow, and Spring Valleys and are overlain by less consolidated Quaternary alluvial outwash derived from the older rocks.

Thus, it is seen that the western border area draining into Meadow Valley Wash is composed of consolidated sedimentary rocks of Paleozoic age, whereas the eastern and northern border areas consist almost wholly of consolidated volcanic rocks; the intervening valley areas are filled with wind deposits and lake beds overlain by ill-sorted, unconsolidated valley fill.

GEOLOGIC HISTORY

The geologic history of the area has been briefly summarized by Westgate and Knopf.[15]

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[15] Westgate, L. G., and Knopf, A., Geology and ore deposits of the Pioche district, Nevada: U. S. Geol. Survey Prof. Paper 171, p. VII, abstract, 1932.

This summary has been slightly modified by the writer and is given below:

1. Deposition during Paleozoic time, from Cambrian to Pennsylvanian, of about 18,000 feet of sediments in what is now termed the Cordilleran geosyncline.
2. Uplift, slight warping, and erosion of these sediments.
3. Volcanism in perhaps late Mesozoic or early Tertiary time, producing lavas and tuffs. This period of volcanism may have lasted a long time and spanned one or more epochs of faulting. It is believed, however, to have reached its culmination by late Miocene time.
4. Tilting and normal faulting.
5. Thrust faulting.
6. Quartz monzonite intrusion at Blind Mountain of the Bristol Range.
7. Normal block faulting of the Basin Range type.
8. Erosion of the faulted blocks to maturity and essentially to the topography of today.
9. Deposition during Pliocene time of more than 1,400 feet of fine-grained detrital materials in the basins.
10. Cyclic periods of erosion and deposition in Pleistocene time in Meadow, Spring, and Lake Valleys, forming gravel-coated terraces and a badland topography on the soft Pliocene sediments. Entrenched stream channels have been formed where Meadow Valley Wash crosses the Paleozoic sedimentary strata and Tertiary igneous rocks.
11. Deposition during late Pleistocene and Recent time of alluvial fans, and flood plain deposits in Lake, Spring, Ursine, and Meadow Valleys. This last period of deposition is the last in the the periods of cyclic erosion and deposition believed to have been begun in early Pleistocene time.

PALEOZOIC ROCKS

The rocks of Paleozoic age were first described by Gilbert,[16] Walcott,[17] and Spurr.[18] They were later mapped in detail by Westgate and Knopf,[19] Wheeler and Lemmon,[20] and Wheeler,[21] and for the description of these rocks the writer has freely resorted to the work done by these men. For the following description of the Cambrian stratigraphy in the Pioche district, the writer has consulted the work done by Wheeler and Lemmon. For the description and stratigraphy of the later Paleozoic rocks the results of the work done by Westgate and Knopf has been used.

Cambrian System

The deposits of Cambrian age, which have been divided into the Lower, Middle, and Upper Cambrian, consist of a thickness of more than 9,500 feet of limestone, dolomite, quartzite, and shale. They are best exposed in the Highland and Ely Ranges, and in the hills just north of the town of Panaca.

The Lower Cambrian, where it is best exposed in the Ely Range, has no clear formational boundaries, but includes the upper part of the Prospect Mountain quartzite and the lower part of the Pioche shale. The Prospect Mountain quartzite consists of red to buff and white generally massive, partly cross-bedded quartzite, with some intercalated strata of conglomerate and some shale. In the Pioche district this formation is about 2,000 feet thick. The Pioche shale contains yellow, drab to greenish, and brown micaceous, arenaceous shale, and sandstone, with numerous intercalated limestone beds of differing thickness. In the Pioche district this formation is about 970 feet thick.

The Middle Cambrian rocks include the Lyndon limestone, the Chisholm shale, and the Highland Peak limestone. Wheeler[22] has proposed two new formation names for the lower part of the Highland Peak limestone: The Peasley limestone just above the Chisholm shale, and the Burrows dolomite above. Thus restricting the Highland Peak and the upper part of this formation as originally defined. He considers the upper part of the Highland Peak to be Upper Cambrian. This usage has not been adopted by the U. S. Geological Survey. The Lyndon limestone contains at the base 170 feet of dark-gray to fine- to medium-grained thick-bedded limestone, overlain by 141 feet of light-gray fine-grained to dense, massively bedded limestone, and the upper 34 feet consists of dark-gray to black fine- to medium-grained, thin-bedded limestone. The Chisholm shale, overlying the Lyndon limestone, and separated from it on fossil evidence, consists of yellowish-buff to brown fine-grained micaceous shale, with a few intercalated beds of olive-drab limestone. This formation is 137 feet thick. Above the Chisholm is the Highland Peak limestone, consisting of more than 3,500 feet of limestone and dolomite and a

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[16] Gilbert, G. K., op. cit., pp. 242–248.

[17] Walcott, C. D., Second contribution to the studies of the Cambrian faunas of North America: U. S. Geol. Survey Bull. 30, pp. 33–38, 1903.

[18] Spurr, J. E., Descriptive geology of Nevada south of the fortieth parallel and adjacent portions of California: U. S. Geol. Survey Bull. 208, pp. 38–47, 1903.

[19] Westgate, L. G., and Knopf, A., op. cit.

[20] Wheeler, H. E., and Lemmon, D. M., op. cit.

[21] Wheeler, H. E., Revisions in the Cambrian Stratigraphy of the Pioche district, Nevada: Nevada Uni. Bull., vol. 34, No. 8, Geol. and Min. Ser. No. 34, 1940; Lower and Middle Cambrian Stratigraphy in the Great Basin area: Nevada Univ. Bull., vol. 38, No. 3; Geol. and Min. Ser. No. 39, 1944.

[22] Wheeler, H. E., op. cit.

little interbedded shale and sandstone. At its base is the Peasley limestone of Wheeler, consisting of approximately 120 feet of mostly dark-gray medium-grained thick-bedded and massive limestone cut by numerous calcite stringers. Locally near the top is some thin-bedded limestone. Above is the Burrows dolomite of Wheeler, consisting of 100 to 400 feet of mostly white and light- to dark-gray coarse-grained thick- to massively-bedded dolomite. The basal 30 feet is intercalated medium and dark gray thin-bedded limestone. Above the Burrows dolomite is the Highland Peak limestone as restricted by Wheeler. The limestone, consisting of 3,325 feet of limestone and dolomite with a very minor amount of interbedded shale and sandstone layers, is overlain by the Mendha limestone.

The Upper Cambrian Mendha limestone is composed of nearly 2,125 feet of interbedded limestone and dolomite with a few thin beds of intercalated shale. The thickness of the formation may be somewhat greater, as the contact with the overlying Ordovician wherever mapped is faulted.

Ordovician System

The rocks of Ordovician age for the most part lie outside the drainage area considered in this report; they are of little importance to the problems of ground-water geology in the Meadow Valley Wash drainage area. The most complete section of these rocks and largest exposure area is in the Ely Springs Range, lying to the west of the Highland Range; elsewhere, these rocks crop out on the south side of Bristol Pass, a low pass separating the Bristol and Fairview Ranges, and a mile and a half northwest of Monument Canyon, on the northwest slope of Chief Mountain. These rocks have been described in some detail by Westgate and Knopf.[23]

The Ordovician section contains approximately 2,000 feet of gray conglomeratic thin- to thick-bedded dolomite or dolomitic limestone, quartzite, and quartzitic sandstone. These rocks have been divided into four formations, which in ascending order are the Yellow Hill limestone, Tank Hill limestone, Eureka quartzite, and the Ely Springs dolomite.

The Yellow Hill limestone, separated by faults from the underlying Upper Cambrian rocks, consists of 670 feet of medium-bedded locally conglomeratic limestone which near the top passes into fine-grained limestone in beds from two inches to a foot in thickness. The Tank Hill limestone, 450 feet thick, consists of gray fine-grained thin- to thick-bedded limestone. The upper 50 feet of the formation consists of shaly limestone and sandy shale. Above this is the Eureka quartzite, a white and pale-red vitreous quartzite and quartzitic sandstone averaging 200 feet in thickness. The uppermost formation in the Ordovician of this area is the Ely Springs dolomite, a dark-gray locally laminated and cherty dolomite whose beds rarely exceed five feet in thickness.

Silurian System

Conformably overlying the Ordovician rocks is about 75 feet of gray and brown dolomite. Fossils collected by Westgate and Knopf indicate that these beds are of Silurian age. The exposure area of these rocks, so far as is known, is like that of Ordovician rocks; they cover a relatively small outcrop area that is outside the region treated in detail in this report.

Devonian System

Both Middle and Upper Devonian rocks are to be found in the area. They crop out in the West Range, lying just to the west of the Bristol Range, at the west side of the Bristol Range, and on both sides of Bristol Pass. They are for the most part outside the Meadow Valley Wash drainage area and have little influence on the ground-water geology of the area. The Devonian rocks have been divided into two formations, the Silver Horn dolomite of Middle Devonian age and the West Range limestone of Upper Devonian age.

The Middle Devonian Silver Horn dolomite, whose contact with the underlying rocks is everywhere formed by a fault, consists predominantly of dolomite and sandy dolomite with some limestone. In the upper part, however, there are some quartzitic sandstone beds, and the formation is capped by a bed of quartzite 20 to 100 feet thick. The sandy dolomite is commonly laminated and locally it may pass into a porous open-textured sandstone. The whole formation reaches a thickness of not less than 3,000 feet.

The rocks of Upper Devonian age, the West Range limestone, consist for the most part of blue-gray fine-grained, locally nodular limestone which weathers to a characteristic yellow soil.

Carboniferous System

The Carboniferous rocks have been divided into four formations: the Bristol Pass limestone, Peers Spring formation, Scotty Wash quartzite, and the Bailey Spring limestone. The upper part of the Bailey Spring limestone has been defined as

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[23] Westgate, L. G., an Knopf, A., op. cit. pp. 14-16.

Pennsylvanian in age, whereas its lower portion and the three underlying formations have been determined to be of Mississippian age. These rocks crop out in a rather small area in the south end of the Fairview Range. Although, for the most part, they are overlain by Tertiary volcanic rocks in the Fairview Range, they possibly reappear again in the southern portion of the Shell Creek Range. Rocks of Mississippian age—the lower portion of the Bailey Spring limestone, the Scotty Wash quartzite, the Peers Spring formation, and the Bristol Pass limestone—attain an aggregate thickness of 1,500 feet. The Bristol Pass limestone is believed to lie conformably above the Upper Devonian West Range limestone. The Bristol Pass limestone is composed of more than 300 feet of gray finely crystalline limestone with a few cherty beds. The Peers Spring formation is quite variable in character. In some places it is a thin-bedded black, dense, fine-grained limestone; elsewhere it is a brown calcareous shale. Near the base the individual limestone beds become more prominent until gradually the limestone becomes more massive and assumes the appearance of the underlying Bristol Pass limestone. The Scotty Wash quartzite is a well-bedded quartzitic sandstone which apparently overlies the Peers Spring formation conformably. The quartzite attains a measured thickness of about 700 feet. It conformably underlies the Bailey Spring limestone.

CENOZOIC ROCKS

Tertiary System

Miocene (?) Volcanic Rocks. Several thousand feet of interbedded lavas, tuffs, and breccias ranging in composition from rhyolite to basalt make up by far the greatest outcrop area of consolidated rocks to be found in the region. They make up almost entirely the Fairview, Wilson Creek, and White Rock Ranges and underlie the area east and north of Caliente to the Nevada-Utah State line and a considerable portion of the area south and west of Caliente. Perhaps more than a third of the area shown on Plate 1 is underlain by exposed or thinly mantled volcanic rock. Westgate and Knopf[24] have measured these rocks in Condor Canyon and found that they exceed 6,000 feet in thickness; it is believed that if their succession could be worked out in detail this figure would probably be larger. Their widespread occurrence, however, is not due primarily to their thickness but is a function of the relatively flat-lying attitude of the beds.

Little is known about the regional structure of the volcanic rocks, but wherever exposed their dips seldom exceed 25° or 30°. In the Wilson Creek Range the prevailing dip is apparently to the east and northeast, although in the north end of this range the beds are almost flat and shallow dips not exceeding 10° to 15° to the north and south were observed; here a bench-land topography is locally well developed. In the north end of the White Rock Range, bordering the east side of Spring Valley, the flows dip slightly to the east and southeast. Southward along this range toward the eastern border of Meadow Valley the dips become more persistent to the east. Along the eastern border of Meadow Valley, and approaching the Union Pacific Railroad route to Salt Lake City from Caliente, the dips become flatter and the topography is that of gently undulating and rolling hills and high mesas. A prominent isolated hill about 12 miles east of Meadow Valley is believed to be the remnant of a related intrusive mass, perhaps the source of a part of these widespread flows.

At Condor Canyon an excellent section of the Miocene (?) lavas is exposed and has been described in detail by Westgate. Here the lavas are observed to rest unconformably upon Cambrian limestone and dip about 25° to the east. Although the rocks are probably cut by faults, the direction of dip remains persistent to the eastern edge of the area, a distance of about 14 miles. To the north and northeast of Ursine the attitude of these rocks becomes less constant, and locally they may be almost flat, with variable dips in all directions.

To the west, south, and east of Caliente all the hills are composed of volcanic flows with interbedded tuff and related breccia. They compose the hills as far east as the Nevada-Utah State line and as far south as 20 miles below Caliente, and they flank the east side of the Meadow Valley Range paralleling the west side of Meadow Valley Wash below Caliente. Meadow Valley Wash, below Meadow Valley, is now incised as much as 1,500 feet in what must have been during early Pleistocene time a broad north-south valley underlain by volcanic rock and separating the Meadow Valley Range on the west from the Mormon Range and other mountains on the east.[25]

Faults in these rocks have been observed in many places. In the Fairview Range, in the northwest corner of the area, a thick succession of light red biotite dacite and andesite, described by Westgate, is broken in many places by faults. In the Wilson

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[24] Westgate, L. G., and Knopf, A., op. cit. p. 27.

[25] Spurr, J. E., Descriptive geology of Nevada south of the fortieth parallel and adjacent portions of California: U. S. Geol. Survey Bull. 208, p. 139, [illegible].

See also, U. S. Geol. Survey reconnaissance map, Pioche quadrangle.

Creek Range, near the headwaters of Wilson Creek, drag folding along a northerly trending fault, possibly of considerable magnitude, was observed. The rocks are also cut by many smaller faults. Erosion along the northeasterly trending fault of considerable magnitude is believed to form the low divide between Parsnip Peak and Mount Wilson (see Pl. 1). This fault probably continues into the north end of the White Rock Range. In the low range directly to the east of Meadow Valley there are undoubtedly many faults that were not observed because of the mantle of detritus covering the hills. Meadow Valley Wash south of Caliente affords an excellent opportunity to observe the structure of these rocks. Here they are gently folded, with prevailing dips to the south, and are cut by numerous faults, the displacement in some exceeding 100 feet.

Pliocene Sediments (*Panaca Formation*). The late Tertiary valley fill throughout the State of Nevada is generally masked by Quaternary alluvial outwash from the mountains. However, as the southerly trending Meadow Valley Wash drainage system is one of the few systems in Nevada having outside drainage to the sea, erosion has exposed the older fill at the surface. In many places in Lake, Spring, and Meadow Valley are exposures of sediments of Pliocene age, named the Panaca formation by Stock.[26] The formation consists mostly of lake sediments and wind deposits.

R. A. Stirton[27] indicates the following age for the formation: "Cannon bone fragments in the Meadow Valley *Pliohippus*, display well developed distal keels more like those seen in middle Pliocene species. The beds cannot be older than late Clarendonian (lower Pliocene) nor are they as recent as Blancan (upper Pliocene)." In addition, Stirton[28] in discussing the use of the Nevada mammalian faunas as faunal units, further indicates the age of the fauna from these beds to be lower or middle Pliocene in age.

In the lower ends of Lake and Spring Valleys these beds are exposed along the terrace scarps of a simple bench-land topography developed by Patterson and Camp Valley Washes. In Meadow Valley, to the south, deeper erosion has exposed them along the fronts of at least three terraces (Pl. 4B) and along the slopes of the short streams cutting these terraces. It is in Meadow Valley that Westgate, Callaghan,[29] and Stock have studied the beds in greatest detail. Here the Panaca formation is best exposed in Cathedral Gorge, two miles northwest of Panaca, within the town of Panaca and its immediate vicinity, and in White Wash, two miles due south of Panaca. No connecting basins filled with these Tertiary beds are found south of Meadow Valley. Moapa Valley, 150 miles to the south and separated from Meadow Valley by a broad, highly dissected plateau elongated in a north-south direction and underlain by volcanic rocks, is the nearest basin wherein lie sediments of known late Tertiary age. No direct correlation has been made between the Tertiary deposits in Moapa Valley, called the Muddy Creek formation, and the Panaca formation. It is believed, however, that in time sufficient evidence may be collected to show that the two formations are in part of the same age.

The lithology and character of the Panaca formation are essentially uniform throughout its extent, although slight differences in grain size and composition exist, depending upon the local conditions of deposition and source of the materials. The sediments are predominately flat lying and thin-bedded, individual beds seldom exceeding six inches in thickness. The most prominent colors are tan and brown, though the sediments may be white to olive green. The sediments are composed generally of incoherent, friable rhyolitic sands and silts. Thin coherent porcelain-like beds ranging from half an inch to two inches in thickness are included within the sands and silts in many places, and they are responsible in part for the sharp V-crested ridges and etched appearance of the weathered surfaces. Locally some cross-bedding was observed. Exposures near two wells, the Thorley well (1S/67-32C1) at the outer margin of Meadow Valley and the Panaca town well (2S/68-9B1) in the north-central portion of the valley, and the driller's logs from these wells show that the sediments of the Panaca formation are finer-grained toward the center of the basin than around its outer margin six miles west of Panaca, and that in part at least they were derived from the bordering mountain masses. The Panaca formation in the vicinity of the Thorley well is mainly a medium- to coarse-grained quartzitic sand with beds of silt; the well log shows that these materials are present to a depth of about 450 feet below the land surface. The Panaca formation in the vicinity of the Panaca town well contains silts and diatomites with interbedded lenses of angular limestone

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[26] Stock, Chester, Late Cenozoic mammalian remains from the Meadow Valley region, southeastern Nevada: Geol. Soc. America Bull., vol. 32, p. 147, 1921.

[27] Stirton, R. A., personal communication.

[28] Stirton, R. A., Nevada mammalian faunas as faunal units: Sixth Pac. Sci. Cong., vol. 2, pp. 627-670, 1940.

[29] Callaghan, Eugene, Mineral resources of the region around Boulder Dam: U. S. Geol. Survey Bull. 871, pp. 178, 180, 1936.

gravel, and locally a bed three feet thick of compressed organic material resembling peat. Similar sediments are penetrated by the 620-foot Panaca town well. Microscopic examination of the cuttings from this well shows them to contain angular fragments of plagioclase, quartz, hornblende, and biotite, abundant fragments of carbonates of calcium, and locally abundant diatom tests. In both localities the formation contains abundant materials derived from the adjacent Cambrian limestone and quartzite and Tertiary volcanic rocks. Exposures in Lake Valley duplicate in part the lithology described in Meadow Valley, the only difference there appearing to lie in the greater abundance of clay and fine silt. A 520-foot well (1N/67–12D3), drilled by the Pioche Rodeo Association east of Pioche, on the west side of Patterson Wash, indicate silt from 35 to about 370 feet below the land surface. Below that the well penetrates fine to coarse quartzitic and rhyolitic sand to a depth of about 500 feet. Microscopic examination of the cuttings shows the fine material to be similar to that penetrated by the Panaca town well, except that the diatom tests are not present. In Spring Valley the Panaca formation consists almost entirely of fine volcanic detritus interbedded with layers of opaline material six inches to one foot thick.

A conglomerate, believed to be a basal conglomerate of the Panaca formation, is exposed at the contact with the underlying crystalline rocks. Where the conglomerate is exposed, the angular fragments of rock range from one to six inches in diameter and the coarse materials finger laterally into finer materials for distances of as much as 50 to 150 feet from the contact. This feature is exposed one mile northeast of Panaca and again in the south end of Meadow Valley. It is possible that the coarser material may extend as much as a mile out into the Panaca formation, as lenses of angular limestone and quartzite fragments, presumably derived from the Ely Range, were observed near the head of Cathedral Gorge.

The full thickness of the Panaca formation is not known. In Meadow Valley, where the formation is best exposed and most deeply dissected, it is estimated to be at least 1,400 feet thick. By projecting the dip of the uppermost beds, and assuming that this dip represents the original slope of the deposits in the lake floor, it is estimated that in the center of the valley between 800 and 900 feet of sediments have been removed. By adding to this figure the depth of the town well at Panaca, 620 feet, it can be seen that at least 1,400 feet of sediments was laid down in the

basin. As the town well at Panaca did not reach the underlying bedrock, an undetermined thickness yet remains to be measured.

The structure of the Panaca formation is simple. In only one locality, near Bennett Springs on the west side of Meadow Valley, do dips exceed 4°. Generally, wherever exposed, beds in the Panaca formation are flat lying and have suffered no deformation since the time they were deposited. Locally, dips of 2° to 3° were observed on the east and west margins of Meadow Valley. It is possible that they are the result of differential compaction in the central part of the basin, or represent the initial slopes of deposition, or both.

Minor faulting in the Panaca formation was observed. Near the head of Cathedral Gorge a normal fault with a displacement of 20 feet was noted. On the west edge of White Wash, two miles south of the town of Panaca, two northerly trending faults with displacements of two to six feet were observed. It is possible that these faults reflect movement along faults in the underlying basement rocks, as known faults in the adjacent Ely Range coincide with their projection. However, it is also possible that these faults represent readjustments due to differential compaction of the lake beds. Because little or no deformation exists in the Panaca formation and the Quaternary sediments overlying the Panaca formation are not cut by range-front faults, it must be assumed that the mountain ranges were in essentially their present position at the time of the deposition of the Panaca formation.

The sediments in the Panaca formation were deposited both by the wind and in shallow, perhaps ephemeral, lakes during a period of moderate climate in the basins of Lake, Spring, and Meadow Valleys. The composition of these sediments indicates that they contain materials derived in larger part by erosion of the adjacent land masses. The presence of volcanic ash in a bed about nine feet thick, exposed for about 1,500 feet in the banks of a wash west of Cathedral Gorge, indicates that at least some of the sediments were carried by wind and deposited on a lake floor during a period of local volcanism. Callaghan[30] describes the ash as follows:

"The ash is light gray to white, fine grained (largely between 0.1 and 0.3 millimeter), angular and friable but stands in vertical walls. It is composed of clear volcanic glass with mostly less than ten percent of quartz and feldspar fragments. A fine carbonate

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[30] Callaghan, Eugene, Mineral resources of the region around Boulder Dam: U. S. Geol. Survey Bull. 871, p. 179, 1936.

dust occurs even in the most friable material, and some, especially in the northern deposit * * *, is partly cemented by carbonate." Further evidence for deposition both by the wind and in shallow ephemeral lakes lies in the occurrence of both regular bedding and cross-bedding and locally of animal and plant remains, including tests of diatoms and peat-like material found at least within the exposed portion of the formation. Furthermore, the uniformly well-bedded and fine-grained nature of the sediments indicate that they were deposited in relatively quiet water; the sediments are not channeled and gravel beds are sparse, only two to three feet thick, and lenticular in character. Because the dip of the bedding in the Panaca formation is very slight near the bordering mountains and the coarsest sediments are seldom larger than a medium to coarse sand, at least near the Ely, Highland, and Wilson Creek Ranges, it appears that little or no rainfall of the cloudburst type occurred during their deposition.

QUATERNARY SYSTEM

Pleistocene and Recent Alluvium

Introduction—In the Meadow Valley Wash drainage area Quaternary deposits floor the present valleys and rise against the lower slope of the mountain. The material is derived from the crystalline Paleozoic and Tertiary rocks in the highlands and from the poorly consolidated Panaca formation. During cycles of erosion and deposition since early Quaternary time, three prominent terraces have been carved into the easily eroded Panaca formation, the terraces and the flood plains in the valleys have been covered with sediments, and alluvial fans have been built immediately adjacent to the mountains. The widespread terrace gravels are believed to be older than the flood plain deposits and alluvial-fan debris, and are designated the early Pleistocene alluvium, or simply the earlier alluvium, whereas the sediments composing the flood plains and immediately adjacent to the mountains are designated as the late Pleistocene and Recent valley fill and fan debris, or simply the later alluvium.

The early Pleistocene alluvium was derived from gravels deposited at the mouths of the highland canyons. Here, as the result of torrential rains of short duration, poorly stratified cobbles, boulders, sand, and gravel accumulated in beds with a high angle of repose. This material is believed to have accumulated as fans only during periods of aridity. Following a period of aridity and fan formation, and during a succeeding period of sustained rainfall and streamflow, the unstable slopes of the fans were

quickly attacked and the accumulated sediments were transported from the canyon mouths and spread as a blanket over terraces cut by the ancient Meadow Valley Wash and its tributaries. During the cycles of arid and humid climate, the accumulated materials were distributed over successively abandoned terraces until, as seen today, this blanket, 5 to 20 feet thick and composed of gravel and sand, caps the terraces and in many places overlaps their fronts. This material is best exposed along the bluffs bordering the central valley drainage channels of Patterson and Camp Valley Washes, and the terrace bluffs bordering the flood plain of Meadow Valley Wash in Meadow Valley.

The late Pleistocene alluvium and Recent valley fill floor the bottoms of the present central valley drainage channels, namely, Patterson, Camp Valley, and Meadow Valley Washes, and consists essentially of reworked early Pleistocene terrace gravels, and silts and sands derived from the Pliocene Panaca formation. This material is not more than 160 feet thick in Meadow Valley and is probably considerably thinner in the upstream Ursine Valley, Patterson Wash, and Camp Valley Wash. It is believed that the fill in the central valleys represents the last period of aridity in the cyclic climatic conditions which have produced the Quaternary physiographic features most pronounced in the Meadow Valley Wash drainage area.

Lake Valley—In Lake Valley the early Pleistocene outwash nearly everywhere overlies the Panaca formation, and it is believed to consist almost wholly of highly permeable sands and gravels derived from the adjacent highlands. These sediments have been undisturbed except in Patterson Wash and its tributary washes; reworked and redeposited Quaternary sediments floor the channels. Only in the south end of Patterson Wash is this material mingled with detritus from the exposed Panaca formation. As shown by well logs, the undisturbed Pleistocene alluvium and fan debris at the foot of the mountains reaches a thickness of about 400 feet and consists of permeable sands and gravels interbedded with local strata of clay. The composition of the sand and gravel depends upon its location with reference to the highlands. The outwash east of Patterson Wash and bordering the foot of the Wilson Creek Range consists of volcanic debris, whereas the outwash west of Patterson Wash, bordering the Ely and Highland Ranges, is composed of debris from Paleozoic limestones and quartzites. Northward along the west side of Patterson Wash the volcanic rocks in the Fairview Range have contributed great amounts of debris to the Pleistocene alluvium.

In the Patterson Wash, the central drainage channel of Lake Valley, wells have penetrated the late Tertiary and Quaternary valley fill at intervals of several miles from Pioche north to Poney Springs, a distance of about 30 miles. Logs are available for some of the wells. However, wells used by the early travelers going from Pioche to Ely, and named for their distances from Pioche, were dug by the local inhabitants and no record of the materials penetrated was kept. These wells, the Sixmile (2N/67–27D1), Eightmile (2N/67–16C1, and Fifteenmile (3N/66–23D1) wells, are believed to have penetrated typical montane outwash derived from the erosion of the adjacent highlands. These sediments are locally interstratified with layers of caliche. In later years deeper wells, the Poney (6N/66–36C1), Craw Creek (4N/66–2C1), Twentyonemile Holding Corral (3N/66–2D1), and other wells, were sunk along Patterson Wash by the Bureau of Land Management, Department of Interior. The Poney well, at the extreme north end of Patterson Wash, is 178 feet deep. According to the driller's log, the entire well is in black volcanic sand, undoubtedly Pleistocene valley fill derived by erosion of older rocks in the adjacent Wilson Creek and Fairview Ranges. The Craw Creek well, eight miles south of the Poney well, is 234 feet deep and penetrates gray to black clay and sandy clay. No visual examination of the material was made by the writer, but it is believed to be Pleistocene montane outwash.

At the Twentyonemile Holding Corral well the Pleistocene outwash is believed to be thinner. Here, only 25 feet of dark red sandy clay was penetrated before a red soft sandy clay, believed to be the Panaca formation, was encountered. Rather vague descriptions of the materials penetrated were available for two bench-land wells in the Lake Valley, the Airport (2N/66–25D1) and the Benchland (3N/67–23C1) wells. Both wells are north of Pioche and lie midway between Patterson Wash and the adjacent highlands. The Airport well is west of Patterson Wash, and the Benchland well lies east of it. The Benchland well is 400 feet deep and, according to the driller's log, the material encountered was "porphyry" and "clay"; this is interpreted to mean that the materials were volcanic gravels interbedded with some fine silts. The Airport well was drilled to a depth of 400 feet, and here again the driller's log is vague—"378 feet cement lime, 22 feet rock in bottom." From the geologic evidence this is interpreted to mean that the well penetrates 378 feet of caliche-cemented conglomerate followed by 22 feet of limestone bedrock.

Spring Valley—In Spring Valley the basin floor is dissected by the central drainage channel, Camp Valley Wash, and its tributaries. Along the bluffs bordering these dissecting channels are exposures of the Panaca formation capped by montane gravels derived from the adjacent highlands; flooring the streams are materials eroded from these exposed Tertiary and early Pleistocene sediments and from the adjacent ranges. Wells penetrate the later alluvium only locally. In the lower end of Camp Valley Wash three shallow dug wells penetrate these sediments to depths of about 20 feet. In the upper end of the wash the Bureau of Land Management drilled the Spring Valley Holding Corral Well (4N/69–13B1) to a depth of 206 feet, of which the first 10 feet was the later alluvium. Below this depth the well is believed to penetrate the Panaca formation. The material penetrated by the dug wells consists of permeable reworked sand and silt of the Panaca formation, interbedded with gravel derived from the volcanic rocks of the adjacent White Rock and Wilson Ranges. The material exposed in the banks of the dry washes dissecting the later alluvium consists of arkosic sand and silt interbedded with some clay.

The thickness of the later alluvium in Camp Valley Wash south of the Spring Valley Holding Corral well may range up to 100 feet. Along the bluffs bordering Camp Valley Wash the early Pleistocene gravel and sand deposits range up to 30 feet in thickness.

Ursine Valley—Ursine Valley consists of a chain of three small valleys, Eagle, Rose, and Dry Valleys, connected with Spring Valley on the north and Meadow Valley on the south. The headwaters of Meadow Valley Wash rise at the south end of Spring Valley and flow southward through Ursine and Meadow Valleys.

The three valleys of the chain lying along Meadow Valley Wash in Ursine Valley all contain later alluvium derived from the rocks bordering them and from the headwater Spring Valley. The deposits consist of axial stream-laid sands and gravels which, at the margins of the basins, interfinger with reworked Pleistocene terrace and alluvial fan debris. The gradient of Meadow Valley Wash is greater in the constrictions between these small valleys than in the middle parts of the valley floors, and the axial deposits are coarser in texture near the upper ends of the valleys. The texture of the interfingering outwash and alluvial-fan material at the margins depends upon the character of the hills surrounding these valleys. Where the surrounding hills are composed of the Panaca formation the alluvial-fan material is fine-textured, and where the adjacent hills are composed of volcanic rocks the fan material is generally conglomeratic.

All the known wells in Eagle Valley are in the town of Ursine, at the north end of Eagle Valley and at the mouth of a large side canyon. These wells have been sunk in both the axial and the marginal deposits. Those in axial deposits penetrate fine to coarse sands and gravels, whereas those in the marginal deposits penetrate interbedded coarse sand, gravel, and cobbles. The thickness of the valley fill in Eagle Valley is not known; the deepest well (2N/69–35D1), sunk to a depth of 108 feet, ended in later alluvium.

In Rose Valley, again, the wells are all at the upstream end of the valley. The deepest well (1N/69–21A1), 88 feet deep, penetrates sands and gravels and is believed to bottom on bedrock.

In Dry Valley, the southernmost of the three valleys making up Ursine Valley, the conditions contrast with those of Spring and Eagle Valleys. Dry Valley begins and ends in deep gorges cutting Miocene(?) volcanic rocks, as do Spring and Eagle Valleys, but Dry Valley is bounded on two sides by the Panaca formation. Spring and Eagle Valleys are surrounded by volcanic rocks. The axial part of Dry Valley contains late Pleistocene and Recent sediments which grade from coarse sands and gravels at the upstream end to fine silts and clay at the downstream end. Because the marginal deposits consist of fine silt and sand derived from the Panaca formation, they are uniformily finer in texture than those in Spring and Eagle Valleys. Dry Valley has been explored by wells in its lower end. There a well drilled for irrigation, and other wells drilled by the Soil Conservation Service to determine the depth to bedrock, penetrated mostly clay and fine sand. The depth to bedrock in the narrow gorge at the south end of Dry Valley, which probably represents the maximum thickness of the later alluvium in this valley, is between 70 and 80 feet.

Meadow Valley—Meadow Valley, locally known as Panaca Valley, is the southernmost basin covered in this report. It is separated from Ursine Valley by a deep gorge known as Condor Canyon, and from Lake Valley by Hamlight Canyon, a tributary to Condor Canyon. At its south end it ends in a narrow, constricted gorge to which the name Cove Canyon is applied in this report.

From Ursine Valley, Meadow Valley Wash flows through Condor Canyon and out onto the plain of the Panaca area of Meadow Valley where, after following a slightly meandering course for about 16 miles, it enters Cove Canyon.

The present central floor represents the flood plain of a through watercourse which during Quaternary time gradually cut its way into the Panaca formation of the Meadow Valley basin and elsewhere, and left as an expression of its existence the three pronounced terraces that rise above the valley floor on the west side of Meadow Valley and possibly a fourth which is believed to be buried beneath the late Pleistocene and Recent alluvium in the Panaca area (see Pl. 4B and cross section Pl. 2). The deposition of the later alluvium was probably a result of a prolonged period of aridity and also of a change in the type of rainfall from gentle to seasonal and torrential. As the annual flow of the stream was reduced, it lost its ability to cut deeper into the soft Panaca formation. As a result, seasonal floods brought heavy loads of sediments into the valley where, because of the dispersal of these flood waters and consequent loss in velocity and carrying power, the stream load was deposited and eventually built up the present flood plain.

The late Pleistocene and Recent sediments underlying the flood plain in Meadow Valley were derived from two sources, (1) material from the highlands adjacent to Meadow Valley, the Pliocene Panaca formation, and the early Pleistocene montane gravels, and (2) materials from the headwater portions of the Meadow Valley Wash drainage area, carried through Lake and Ursine Valleys and thence on to the flood plain of Meadow Valley. Locally this process of highland erosion and subsequent deposition in areas of low gradient is still continuing.

The character of these sediments depends upon their source and the place of deposition along the flood plain of Meadow Valley Wash in Meadow Valley. The deposits along the axis of the flood plain generally grade from sands and interbedded gravels at the mouth of Condor Canyon to medium and fine sands with some interbedded silts along the center of the flood plain. The percentage of silt increases toward the south. (See cross section, Pl. 2). Lateral drainage, however, somewhat modified the axial distribution of these sediments. It is believed that the finer sediments generally found along the axial portion of the flood plain grade laterally into more heterogeneous, coarser detritus opposite the mouth of the larger side washes. In addition, it is possible that buried stream channels containing gravel and sand and a lower gravel horizon may be present in the flood plain deposits in Meadow Valley.

PHYSICAL CHARACTERISTICS AND WATER-BEARING PROPERTIES OF THE ROCKS

PALEOZOIC ROCKS

The Paleozoic sediments bordering Meadow Valley Wash are generally poor water-bearing rocks. The rocks are well-consolidated and tightly cemented and have a low permeability. All these rocks, however, are fractured and jointed, and water is transmitted through these openings. Fault breccias where cemented, shale beds, and intrusive bodies furnish barriers to the movement of the water, and where conditions are favorable, small springs and seeps are formed where these impermeable rocks force the water to the surface. Floral Springs, which furnishes a part of the water supply for the town of Pioche, Connor Spring, Lime Spring, and Highland Spring, all in the Highland Range, are good examples of springs formed under these conditions. Water in the Caselton mines was encountered in greater quantities along uncemented fault breccia in the underground workings than elsewhere. Warm Spring, about one mile north of Panaca, is believed to rise along a buried fault cutting the Paleozoic sediments. This fault is exposed at the mouth of Condor Canyon about a mile north of the Spring. Here the breccia formed along it is seen to be highly permeable.

CENOZOIC ROCKS

Miocene(?) Volcanic Rocks

The volcanic flows in the Meadow Valley Wash drainage area are probably much better aquifers than the older Paleozoic rocks. However, their dips and their position in relation to the agricultural areas make it unfeasable to prospect them for ground water for irrigation purposes. Also, as their sequence is not known, predictions of places where water-bearing strata might be encountered cannot be made with much accuracy on the basis of the data available at present.

The physical characteristics favorable for the accumulation of water in these rocks are the jointed and, therefore, relatively permeable nature of the flows, which are interbedded in some places with poorly jointed and, therefore, relatively impermeable tuff and agglomerate. The low dips of the beds afford large areas of outcrop of the more favorable water-bearing strata, and because they are exposed in areas of relatively high precipitation in the White Rock, Wilson Creek, and Mormon Ranges they are favorably situated for recharge.

Numerous springs and seeps rise from the volcanic rocks, the greater number being along fault zones. Many of the springs in the Wilson Creek, White Rock, and Mormon Ranges rise along such zones. Perhaps the best example of this type of spring can be found at the head of Wilson Creek, where springs that rise along faults in the volcanic rocks flow the year around and serve to irrigate valley land along the lower reaches of Wilson Creek. Elsewhere smaller springs and seeps of this type are utilized as stock-watering places. Some fairly large springs occur under favorable conditions where fractured and jointed flows overlie beds of tuff and agglomerate. The springs at the Delmue and Flatnose ranches owe their origin to this condition. The springs at each of these two locations flow at the rate of approximately one cubic foot per second.

Pliocene Sediments (Panaca Formation)

The Pliocene Panaca formation contains ground water. The water-bearing materials are sands and lenticular beds of fine angular gravels, many of which occur throughout the formation, and are most prevalent around the outer margins of the basin. They are not uniform in distribution but rather are lenticular in character and are frequently separated by almost impervious beds of fine silt. Gradation in size and composition of the sediments is characteristic. Materials near the borders of the mountains are generally coarse to fine sand largely derived from the adjacent highlands. The materials near the centers of the basins are for the most part fine rhyolite sand, silt-cemented limestone, and quartzite gravels, and silt, separated by thin strata of hard calcareous material; locally these sediments are interstratified with lenticular beds of angular gravel and sand. It is probable that uniform beds of sand and gravel do not occur as single horizons across the width of the Panaca formation, but rather they interfinger gradually with the finer materials deposited near the centers of the basins.

The permeability of the water-bearing sediments in the Panaca formation is not known. It can be assumed only by observing outcrops and studying samples taken from the existing wells. In the silts it is probably very low, as the sediments, though highly porous, do not yield their water readily. As a rule sands yield water readily, although if they have a matrix of silt, a characteristic frequently difficult to determine from studying well logs, they probably will not yield much water. The angular gravel, in many places cemented with silt, will yield only small quantities of water. Gradation from silt to sand, coupled with lenticular bedding and interfingering of the sediments, prevents the free movement of water essential for large producing wells such as irrigation wells. The basal conglomerate of the Panaca formation occurring at the contact with the "basement" rocks, where observed, is tightly cemented with limy clay. It is possible that where the conglomerate is derived from quartzite or volcanic rocks it may not be cemented.

Pleistocene and Recent Alluvium

The physical characteristics and water-bearing properties of the Pleistocene and Recent alluvium differ with the type of deposit and kind of material.

The earlier alluvium, composed largely of poorly stratified sands and locally cemented gravels, in general is highly permeable. Water coming in contact with these deposits in the form of rainfall or stream flow is readily absorbed and percolates through them to the water table. In places these materials are drained by dissection of the deposits as the result of down-cutting of tributaries to the central drainage channel. The late Pleistocene and Recent alluvium consists of unconsolidated well-sorted silts, sands, and gravels and has variable water-bearing properties. Its physical character and water-bearing properties depend upon the nearness of the channels to the surrounding mountain ranges, or to the source of the material of which it is composed. In the north end of Lake Valley, where the later alluvial deposits consist of reworked earlier alluvium, the sediments locally are fairly coarse and permeable. In the south end of the valley, however, the central drainage channel has dissected the clay and silt of the Panaca formation. There the porosity of the sediments may be high but the permeability is low. In Spring Valley the water-bearing properties of the sediments are comparable to those found in Lake Valley.

The chain of valleys from Ursine to Panaca may be regarded as connected settling basins for the detrital materials swept into the ancestral drainage channels of Meadow Valley Wash by torrential rains. As a result, the coarsest materials appear to have been captured by the headwater basin, Eagle Valley, and the finest by the downstream basin, Meadow Valley. In addition, the physical character and water-bearing properties of the sediments in each valley are further modified, depending upon the character of the rocks which enclose the valley. In Eagle and Rose Valleys erosion and dissection of the surrounding Tertiary volcanic rocks by the tributary streams have contributed permeable sands and gravels to the valley fill. Dry Valley and the central drainage channel in Meadow Valley are surrounded by exposures of the Panaca formation, which upon erosion have contributed fine sand and silt of relatively low permeability to the valley fill. Here, however, permeable sand and gravel from the earlier alluvium are interbedded with the sediments. A gradation of material may be expected in each of these step-like basins; the coarser sediments occurring in the upstream end and the finer sediments in the downstream end. In addition, it appears probable that there are buried stream channels of permeable sand and gravel in the later alluvium of the valleys.

GROUND WATER

Most of the rocks in the area contain ground water. However, as their physical characteristics and water-bearing properties differ widely (see pp. 44–46) they have been divided into the three following hydrologic units. They are (1) rocks that in general are well-consolidated and cemented, and for the most part have low permeabilities; or are unfavorably situated for development of large supplies for use in the valleys; included in this group are the Paleozoic sediments and the Miocene (?) volcanic rocks; (2) rocks that are poorly consolidated and not cemented but contain considerable quantities of fine-grained material such as silt; included in this group is the Panaca formation; and (3) rocks that are unconsolidated, uncemented, and largely permeable; included in this group is the Quaternary alluvium.

WATER IN THE PALEOZOIC ROCKS AND MIOCENE (?) VOLCANIC ROCKS

The Paleozoic sediments and Miocene (?) volcanic rocks which comprise the "basement" rocks of the Meadow Valley drainage area yield water to numerous springs, both thermal and nonthermal. The Cole Ranch well (5N/67–1A1) is the only one known to penetrate and draw water from these rocks. The prospects of developing satisfactory wells in the Paleozoic sedimentary rocks are not promising except locally along fault and brecciated zones. In the Miocene (?) volcanic rocks the prospects are somewhat better, but until more is known of their sequence, favorable localities for wells cannot be predicted with certainty.

The nonthermal springs are generally small but numerous and are within the mountain ranges where seasonal rain and snowfall affords replenishment to the reservoirs which supply them. They issue from both the igneous and the sedimentary rocks and generally owe their origin to barriers formed by impervious gouge or clay formed along faults or intrusive contacts. Other small nonthermal springs are to be found at the base of the high volcanic cliffs enclosing Meadow Valley Wash below Caliente.

The thermal springs visited during the course of this study include Bennett Springs, Warm Spring (Panaca Spring), Delmue's Springs, Flatnose Spring, and Caliente Hot Spring. Hammond Spring, reported by Carpenter,[31] was not visited. All are believed to rise from the Paleozoic limestones and Miocene(?) volcanic rocks, although the rocks at Bennett Springs and the Caliente Hot Spring are masked with a mantle of unconsolidated Quaternary sediments. It is believed that all these springs except Delmue's Springs are associated with faults. At Delmue's Springs there are no surface indications of faulting; instead, the water rises from jointed lava rock overlying an impervious bed of tuff and breccia.

The moderate temperatures encountered at the Bennett, Delmue's, and Flatnose Springs suggest a meteoric source for the water arising from them. However, a uniform geothermal gradient is not indicated for the area as a whole, as the water from Warm Springs at Panaca is warmer than the others, whereas the temperature of water pumped from wells in the hot spring area at Caliente is about 112° F. The presence of siliceous sinter in the area of the Caliente Hot Spring further indicates that the temperature in this spring was considerably greater than the present temperature, and at present there is no deposit formed in the well or pipes. It is possible that heat generated by faulting and the heat retained within the widespread Miocene(?) flows and associated intrusive rocks may account for the differences in temperature between the springs rising from the Paleozoic sediments and those from the Miocene(?) volcanic rocks.

The location, flow, temperature, elevation, and remarks pertaining to the geology of the thermal springs visited are listed on opposite page.

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[31] Carpenter, Everett, Ground water in southeastern Nevada, U. S. Geol. Survey Water-Supply Paper 365, p. 49, 1915.

Name	Number	Flow (gallons a minute)	Temperature (degrees Fahrenheit)	Elevation (feet above sea-level datum)	Remarks
Bennett Springs	2S/67-7C1	10	70	5,266±	Quaternary gravel, near Tertiary lava, buried fault.
Caliente Hot Springs	4S/67-5C1	0	112±	4,420±	Tertiary lavas, buried faults. Sinter locally. Analysis*. Formerly flowed. Water 12 feet below land surface in 1946.
Delmue Springs	1S/69-7C6	200±	70	5,118±	Tertiary lava. Contact between jointed lava and unjointed tuff and breccia.
Flatnose Spring	1N/69-34D1	400±	77	5,500±	Tertiary lava, buried fault. Analysis.*
Warm Spring (Panaca Spring)	2S/68-4B1	3,600±	87	4,763±	Paleozoic limestone, buried fault. Analysis.*

*For Mineral Analyses see Table 5.

That water occurs in the vicinity of fault and brecciated zones in appreciable quantities is shown by some of the mines in the Pioche mining district. Mines in the vicinity of Pioche have penetrated the Paleozoic rocks to considerable depths and have locally encountered considerable quantities of water along faults. In some other places the mine workings have penetrated impervious fault gouge and shale beds, tapping perched water. According to S. Arentz,[32] Superintendent of the Combined Metals Reduction Company at Caselton, the underground workings of the Caselton mine encountered more water above the fault barriers dipping into the Ely Range than above those dipping towards Meadow Valley. During the period from 1936 to 1938, a reported average of 4,200 gallons a minute was pumped from the Caselton shaft; from 1938 to 1941 it was about 3,200 gallons a minute, and from 1941 to 1947 it was about 2,100 gallons a minute. The mineral content of these waters is reported to vary with the source, depending upon the relationship of the water to the sulfide ore bodies.

A part of the water contained within the Paleozoic sediments and Miocene(?) volcanic rocks is believed to contribute to the ground water in the Panaca formation and the Quaternary alluvium. The greatest contribution of water probably occurs in the vicinity of faults and brecciated zones where these zones are immediately overlain by the younger sediments. Although some of the spring discharge in the highlands is lost by transpiration and evaporation, most of it sinks into the valley fill and contributes to the water supply of those sediments. In a like manner the water from larger thermal springs, particularly Delmue's (1S/69–7C6), Flatnose (1N/69–34D1), and Warm (2S/68–4B1) Springs, contribute to the underground reservoir in the late valley fill, or to the stream flow in Meadow Valley Wash.

Caliente Hot Spring is reported by E. C. D. Marriage,[33] a former resident of Caliente, to have flowed from an orifice on the east side of Meadow Valley Wash prior to 1910. In 1910 erosion by flood waters lowered the bed of the adjacent wash about 15 feet. Discharge of the spring by percolation underground into the channel of the wash, may account for the spring ceasing to flow at the surface. Residents of Caliente report that in periods of low flow, the water in Meadow Valley Wash, opposite the spring is warmer than the water upstream. Attempts to confirm this difference in temperature were unsuccessful because of the large stream flow in the wash. It is also possible the water in the spring has been lowered as the result of pumping in Caliente.

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[32] Personal communication.

[33] Personal communication.

WATER IN THE PLIOCENE SEDIMENTS (PANACA FORMATION)

In the Panaca formation ground water occurs within the interstices of the sediments. The sand and gravel deposits of the formation are the most favorable materials for the development of ground water. The fine sediments which comprise the bulk of the formation do not yield water readily to wells.

The water in the Panaca formation is derived from runoff resulting from precipitation in the mountain ranges, infiltration from stream flow where conditions are favorable, possible upward percolation from buried faults, and direct precipitation on favorable exposures.

Runoff resulting from precipitation in the mountains is perhaps the chief source of supply of water to the Panaca sediments. This water is believed to enter the formation along the margins of the basins where the sediments are coarsest. Recharge to the formation is facilitated by a protective cover of late Pleistocene and Recent gravels in the form of alluvial fans having a high capacity to absorb the perennial spring runoff and the seasonal surface runoff. A part of this water percolates downward through the alluvial fans into the relatively coarse marginal sediments of the Panaca formation into its basal conglomerate, then laterally out into the permeable beds towards the centers of the basins. Direct precipitation on the exposures of the Panaca formation probably contributes very little water to the formation.

The stream of Meadow Valley Wash flows over the basal conglomerate of the Panaca formation at the mouth of Condor Canyon. It is possible that at this point some water finds its way into the Panaca formation through the basal conglomerate.

Upward percolation from buried faults may be an additional source of water in the Panaca formation. It is known that some faults in the older sediments afford either barriers or conduits for the movement of ground water, and that, where these faults are exposed at the surface, springs are frequently formed along them. Geologic mapping in the ranges has disclosed many faults which trend basinward and finally are buried by the Panaca formation. It is possible that along these faults the hydrostatic head is sufficient for percolation of water into the Panaca formation. In this connection it is significant to note that the standing water level in the Raymond and Ely mine shaft, about eight miles northwest of Panaca, is at an elevation of 5,074 feet above sea level, whereas the general elevation of the floor of Meadow Valley is approximately 4,700 feet above sea level. The amount contributed by possible upward percolation along faults is unknown.

The water in the permeable beds of the Panaca formation is confined under hydrostatic pressure by beds of silt and clay lying above and below the permeable material. In the 300-foot well (1S/68–31A1) in Cathedral Gorge the water is reported to have risen about 150 feet above the point at which it was encountered. In the Pioche Rodeo Association well (1N/67–12D3) the water rose 250 feet in the hole and in the 620-foot Panaca town well (2S/68–9B1), where it is reported that water had to be supplied for drilling purposes all the way to the bottom of the hole, the water level on September 20, 1945, stood 21.9 feet below the land surface.

Exploration for water has been undertaken at the margins of the Panaca formation where the more permeable sand and gravel prevail. Deep dissection of the formation in the central valley and along the side washes, however, has caused drainage of at least the upper 800 feet of the formation, and wells drilled along the margins of the Panaca formation yield only a small amount of water. In the centers of the basins, and along the axes of the present valleys, where wells have penetrated silt, sand, and silt-cemented gravel, local aquifers have been encountered. The 620-foot well at Panaca encountered no sand bed exceeding 15 feet in thickness. However, the Pioche Rodeo Association well (1N/67–12D3) in Patterson Wash penetrated 350 feet of impervious silt, below which was 147 feet of fine to coarse water-bearing sand.

Thus far, exploration for water in the Panaca formation has been discouraging. However, if in the future these beds are to be further explored, it is believed that the best locations for wells are not in the centers of the basins, nor along the margins, but at some midpoint; perhaps as much as two or three miles away from the axis of the basin and in the bottoms of the main lateral washes tributary to Meadow Valley Wash. Here, because of the lower altitude, the depth to water-bearing beds would not be so great as at the margin, and the sediments would not be as fine as in the axis of the basin.

Faulting in the Panaca formation may be interpreted to mean that there has been local post-Panaca movement in the underlying crystalline rocks. It is possible that exploration in the vicinity of these zones by deep drilling may develop satisfactory wells. However, the location of these zones is difficult because they are covered by an unknown thickness of the Panaca formation and therefore exploration for them may lead to the drilling of many nonproductive and therefore costly wells.

Discharge of water from the Panaca formation through other than artificial means appears to be small. The only observable discharge is from springs and seepage areas at the base of the lowest terrace cut in the Panaca formation along the west margin of Meadow Valley. It is estimated to be about 300 acre-feet a year. At present only one well, the Panaca town well (2S/68–9B1), draws water from these beds. The withdrawal of water by the well in 1946, based on the hours of operation, was 71 acre-feet. The extent to which water is discharged from the Panaca formation by upward and lateral percolation into the later alluvium is not known.

WATER IN THE PLEISTOCENE AND RECENT ALLUVIUM

Water occurs in both the early Pleistocene gravels and the late Pleistocene and Recent valley fill, which for the purpose of simplicity are referred to as the earlier and later alluvium. Water is much more abundant and widespread in the later alluvium than in the earlier alluvium.

In all the valleys of the area, water occurs in the later alluvium. In Spring, Ursine, and Meadow valleys, however, the earlier alluvium has been drained of its water as a result of dissection by the main stream and the tributary washes. It is from the later alluvium that the greatest development of ground water has taken place. Additional ground water may be developed, particularly in Meadow Valley, to a limited extent in Spring Valley, in the chain of valleys in Ursine Valley, and in Meadow Valley Wash below Caliente.

There are five sources for the recharge of ground water in the alluvium. These are: (1) Runoff from seasonal and torrential storms in the mountain ranges; (2) infiltration from perennial stream and spring flow; (3) underflow from one valley to another; (4) lateral percolation from the buried portion of the Panaca formation and upward percolation; and (5) direct recharge from precipitation. Recharge to the alluvium is discussed by valleys, beginning with the uppermost and continuing downstream.

In Lake and Spring valleys recharge to the alluvium is by infiltration from surface runoff, by infiltration from spring discharge from the Paleozoic rocks and Miocene (?) volcanic rocks, and directly from precipitation.

The alluvium in Ursine Valley is recharged like that in Lake and Spring Valleys. In addition, there is recharge by underflow from Spring Valley and by infiltration from perennial stream flow, which originates as springs in the lower end of Spring Valley. Flatnose Spring, the only spring of consequence in the valley, which appears to have its source in the Miocene(?) volcanics and has an estimated discharge of 400 gallons a minute, contributes water to the alluvium.

The alluvium of Meadow Valley receives recharge from all five sources. Owing to its position (lowermost of the valleys) and size, it receives more recharge than any of the others. Probably the largest sources of recharge are stream flow, spring discharge, and upward percolation in the vicinity of Warm Spring. Records of stream flow at the gaging station at the upper end of Condor Canyon for the two-year period of operation, 1944–1946, show a range in discharge of 2,550 to 4,700 acre-feet. To this must be added the water contributed by Hamlight Canyon, which enters Condor Canyon below the gaging station. Although Hamlight Canyon has no perennial stream, it carries considerable water following torrential storms. The opportunity for recharge is excellent, as the material at the mouth of Condor Canyon and for some distance downstream is coarse. Also, during period of floods the stream channel overflows and the water spreads out over the floor of the valley, saturating the later alluvium.

The opportunity for recharge from spring discharge and upward percolation is also excellent. Warm Spring, the largest spring in the valley, rises near the upper end of the valley and has a discharge of eight cubic feet a second, part of which percolates into the alluvium below the spring. In addition it is very probable that some of the ascending spring waters never reach the land surface but percolate directly into the alluvium. This quantity may be appreciable. Elsewhere, upward percolation is believed to be negligible. There is also some recharge by spring flow at Bullionville Spring and the numerous small seeps and springs rising at the base of the bluffs along the west side of the valley.

Recharge by lateral percolation, underflow from other valleys and precipitation is believed not to be large. The low permeability and presence of only a few springs and seeps of small discharge from the exposed part of the Panaca formation indicates that recharge from this source is probably small. Recharge by underflow from other valleys is possible only through Condor Canyon. This was estimated (p. 65) as 20 acre-feet during 1946. The recharge by dry washes is also small. These washes in their headwater portions are narrow and contain only a few feet of alluvium. On the average the amount of recharge from direct precipitation is believed not to be large. The annual rainfall which on the valley floor is less than 10 inches serves only to temporarily increase the soil moisture, and is eventually used by plant life. Only during prolonged periods of precipitation is there likelihood of recharge to the ground water reservoir.

There is one other source of recharge in Meadow Valley in addition to those already mentioned. This is water pumped from the Caselton mine. Although the pumpage at the mines in 1946 was about 2,100 gallons a minute, only about 200 gallons a minute eventually reached the alluvium of the valley floor, the rest being lost by evaporation and other natural processes in transit. This source, however, cannot be considered as permanent because it will be available only for the life of the mine. Also the total pumpage from the mine is diminishing from year to year, now being only half of what it was in 1936 to 1938. (See p. 50.)

The disposal of water from the alluvium is by three general methods, the first and third of which are common to all of the valleys. They are: (1) Transpiration and evaporation; (2) spring discharge; and (3) underflow out of the valley. Only in Lake Valley is there no discharge of water from the alluvium by springs. Here also the discharge by transpiration and evaporation is probably small, as the water table for the most part is 20 feet or more below the land surface. Spring Valley, as the name implies, has numerous springs and is the source of the perennial stream of Meadow Valley Wash. The spring discharge of Ursine Valley is not large. All the springs are small and are confined to the bottom of the central drainage channel. The disposal of water is greatest in Meadow Valley, largely by transpiration and evaporation from the soil. In addition, below the Mathews dam there is effluent seepage to the entrenched channel of Meadow Valley Wash, which is discharged by surface flow through Cove Canyon.

UNCONFINED AND CONFINED WATER

In permeable rock the upper surface of the zone of saturation is called the water table.[34] The zone of saturation below the water table may be likened to a vast basin containing water-saturated sediments, the surface of the zone of saturation—the water table—being unconfined and free to rise or fall, depending

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[34] Meinzer, O. E., The occurrence of ground water in the United States, with a discussion of principles: U. S. Geol. Survey Water-Supply Paper 489, p. 30, [illegible]

upon whether water is added or withdrawn by artificial or natural means. In sediments consisting of alternating permeable and impermeable beds, however, water recharged at a relatively high elevation may pass beneath extensive beds of impermeable material and so may be confined under artesian pressure. The study of ground water in the Meadow Valley area involves consideration of both unconfined and confined ground water.

The ground water in the alluvium occurs both unconfined and confined. However, only in Meadow Valley is confined water known to occur. Reports of wells tapping water in the alluvium of the other valleys do not indicate that the water encountered was under pressure. However, this does not mean that water under pressure may not be present, because all the alluvial deposits contain beds of silt that may confine water under pressure locally. Throughout Meadow Valley, water occurs under water-table conditions in the upper part of the later alluvium. In the upper part of the valley there are two wells in the alluvium in which the water encountered was under slight pressure. In the lower part of the valley, however, two wells penetrating deeply into the alluvium have encountered water under pressure sufficient to cause artesian flow at the land surface. These wells are the Clyde Mathew's well (2S/68–19C1), and the Geological Survey test well (3S/67–28C2). The head in both these wells was not great, as the water levels in the wells rose only a short distance above the land surface. From the information furnished by wells in the valley, and from a knowledge of the character of the alluvium, it is apparent that most of the water is unconfined, under water-table conditions in the upper part of the valley and poorly confined in the lower part of the valley. Two possible exceptions to this general condition are (1) in the vicinity of Warm Springs, where the upward-percolating spring water may have sufficient head to rise above the water table (the K. Lee well, (1S/68–33C1); and (2) along the lateral margins of the valley, where confining beds may exist owing to the local interfingering of coarse materials with finer materials derived from the Panaca formation, the P. Edwards well, (1S/68–32A2).

That the ground water in the lower part of the valley is poorly confined and the confining beds permit upward leakage is evidenced by the presence of a shallow water table and of springs discharging from the alluvium which give rise to swamp-like areas.

From the evidence cited, the confining material in the upper part of the valley is interpreted to consist of discontinuous fine

sand and silt beds of local extent, overlapping at slightly different horizons in the upper part of the alluvium. The percentage of fine materials in the upper part of the alluvium increases toward the lower end of the valley, increasing their efficiency as a confining bed. Thus, at the Geological Survey test well, in the extreme lower end of the valley, the top 50 feet of material was quite fine, but at the M. Lee well (3S/67–2D1) only the upper 34 feet was predominantly fine-grained, and even this contained some coarse material.

In the section of Meadow Valley Wash below Cove Canyon, wells have been drilled in the alluvium and have encountered conditions similar to those in the central and upper parts of Meadow Valley. Wells drilled near ephemeral springs, however, may be expected to flow periodically. See data in well table for well (4S/67–8C2.)

LOCATION AND DESCRIPTION OF OBSERVATION WELLS

Wells in which the depth to the water level could be measured were located in all the valleys of the area, and periodic measurements of the water level were made during the field season of 1946. Only in Meadow Valley, however, was a detailed observation program undertaken. The general depths to water given in the following paragraphs are indicative of conditions during the year 1946. The water-level measurements are given in Tables 6 and 8.

In Lake Valley three wells were available for observing the water level in the later alluvium. These are Sixmile (2N/67–27D1), Eightmile (2N/67–16C1), and the Fifteenmile (3N/66–23D1) dug wells. The depths to water below the land surface in these wells were 23, 19, and 41 feet, respectively. At the Fifteenmile drilled well (3N/66–23D2), which tapped water in the Panaca formation, the water level stood 41 feet below the land surface.

In Spring Valley water-level observations were made in only one well, the Spring Valley Holding Corral well (4N/69–13B1), which penetrated the Panaca formation. The depth to water was 182 feet.

There are three wells in alluvium in the sub-valleys of Ursine Valley. These are the Lytle well (2N/69–35D2) in Eagle Valley, the Devlin well (1N/69–21D1) in Rose Valley, and the Civilian Conservation Corps well (1S/68–13A1) in Dry Valley. The depths to water level in these wells were 48, 9, and 29 feet, respectively.

The alluvium in Meadow Valley Wash below Meadow Valley has been explored by irrigation, domestic, and industrial wells. The depths to water have been measured in practically all of them. Those chosen for observation purposes are representative of the area; they include the Allec well (4S/67–4C1), a shallow bored well in which the depth to water is 13 feet; and the John Conway irrigation well (4S/66–36B2), in which the depth to water is 30 feet.

The depth to the water table in the alluvium of Meadow Valley was observed at 23 augered holes and 22 irrigation and domestic wells where the ground water is unconfined. The augered wells penetrated to depths of 10 to 25 feet and extended at least five feet below the water table. The materials penetrated by most of the augered wells were silt and fine sand. Only along the mouth of White Wash, two miles south of Panaca and on the east side of Meadow Valley, were appreciable amounts of sand and gravel encountered. Most of the wells were cased with 4-inch standard galvanized downspouting, and in every well at least five feet of this casing was perforated. Additional wells used for observations on the confined water in the alluvium include the Clyde Mathews well (2S/68–19C1) and the U. S. Geological Survey test well (3S/67–28C2). Wells used for observation of the water in the Panaca formation include the Panaca town well (2S/68–9B1), the Press Duffin well (3S/67–22D2), and the Thorley well (1S/67–32C1). Land-surface elevations were determined at all these wells by running stadia elevations from the nearest U. S. Geological Survey or U. S. Coast and Geodetic Survey bench marks.

The augered water-table wells are at approximately one-mile intervals along the axis of Meadow Valley, and in lines of three wells across the valley (Pl. 2). In areas where the water table is at or near the surface the wells were spaced somewhat more closely. In addition, wells were augered within the areas of seepage along the west side of the valley and at Bullionville Springs. The descriptions of these wells and the periodic water-level measurements made in them are included in Table 8. Observations will be continued in a few selected wells in Meadow Valley and the upstream valleys.

POSITION, DEPTH, AND FLUCTUATION OF THE WATER TABLE IN MEADOW VALLEY

The position of the water table in Meadow Valley as of August 1946 is shown on Plate 2 by means of water-table contours. These contours are referred to sea level datum.

In general the water table is flat or nearly so in an east-west direction, that is, across the valley, but longitudinally it has a rather steep slope which averages about 22.5 feet to the mile. Immediately below Condor Canyon the slope is relatively gentle, amounting to about 12 feet to the mile, but it rapidly becomes steeper. The average slope for the first 3 or 3½ miles below Condor Canyon is about 20 feet to the mile, and it increases to 25 to 26 feet to the mile for the rest of the length of the valley. Locally in the upper end of the valley, near the town of Panaca, and in the lower end of the valley the contours are convex upstream. Both these areas are marshy in character and springs emerge on either side of the valley. The shape of the contours indicates that water is being contributed to the alluvium, probably from Warm Spring and Bullionville Spring in the upper area, and from the unnamed springs and seeps at the lateral margins of the valley in the lower area. South of the town of Panaca for a distance of about four miles the contours are convex downstream, indicating that in this area there is recharge from the channel of Meadow Valley Wash into the alluvium. In the remainder of the valley the contours cross the stream channel convex upstream, indicating effluent seepage to the stream. The 4,580-foot contour has a general upstream bulge that is believed to reflect pumping from the Grant Lee (3S/67–2A1) and Murray Lee (3S/67–2D1) irrigation wells.

The depth to the water table has not been shown on Plate 2. Nowhere within the margin of the valley, however, does the depth to the water table exceed 50 feet. The greatest depth is at the Chris Ronnow well (1S/68–28C1) at the mouth of Condor Canyon, where the water stands 46 feet below the land surface. Between this well and the Kenneth Lee well (1S/68–33C1), a distance of about a mile, the water table approaches within about eight feet of the land surface. In the center of the valley, and below the Kenneth Lee well, however, the water table for a distance of about two miles is at or just below the land surface. From here the depth to the water table below the land surface increases until it reaches a depth of about 17 feet at the Grant Lee well (3S/67–2A1), and then decreases until the water table is at the land surface at the upper limit of the marsh area shown at the south end of the valley.

The water table continually fluctuates in elevation, depending upon the season of the year and the amount of ground water entering and leaving the underground reservoir. Generally the lowest stage is reached during the latter part of August, when the recharge from streams is low and the pumping season is drawing to an end. From August to the latter part of March withdrawals from the underground reservoir by pumping are very small, as are those due to evaporation and transpiration, and the water table rises as ground-water storage increases.

POTENTIAL DEVELOPMENT OF GROUND WATER FOR IRRIGATION

All the valleys in the Meadow Valley drainage area have potential supplies of ground water that may be developed for irrigation. The quantity differs from valley to valley and is greatest in Meadow Valley. As the exact quantities of ground water and the amount of land suitable for irrigation are not known for the other valleys, no detailed studies or estimates of the quantity were made for these valleys. In Meadow Valley, however, an estimate was made of the quantity of ground water available for irrigation, and studies by the Soil Conservation Service (see pp. 77–83) show the amount of land suitable for irrigation.

The potentiality of each valley is discussed separately in the following pages. For convenience in discussion the valleys are discussed in the descending order of their occurrence in the drainage system, except for Meadow Valley, which is discussed last.

LAKE VALLEY

There are three possible sources of ground water in Lake Valley, the Panaca formation, the earlier outwash gravels, and the later alluvium.

An appraisal of the possibilities for ground water in Lake Valley can be made only on the basis of the existing wells and from a knowledge of the geology. It seems likely that by a careful selection of well locations some water may be developed from fairly deep wells in the Panaca formation and the earlier alluvium, similar to the Pioche Rodeo Association (1N/67–12D3), the Benchland (3N/67–23C1), the Twentyonemile Holding Corral (3N/66–2D1), and the Poney (6N/66–36C1) wells. These wells, which furnish water for stock, all have a low specific capacity (yield per unit of drawdown) and the yield from additional wells of this type probably will not be large enough for irrigation purposes. There are a few wells in the later alluvium which give information on the availability of water for irrigation. These wells are the Sixmile (2N/67–27D1), Eightmile (2N/67–16C1), and Fifteenmile (3N/66–23D1) dug wells. The depth to the water level at these wells (20 to 43 feet) indicates that pumping for irrigation in the vicinity of these wells is economically feasible. However, as only stock wells have been drilled in the valley, little is known concerning the amount of water wells dug or drilled for irrigation will yield.

SPRING VALLEY

The sources for ground water in Spring Valley are the Panaca formation and the later alluvium. The earlier alluvium probably will not yield much water to wells because, as a result of dissection, the water has been largely drained from it. The Panaca formation has been explored only by the Spring Valley Holding Corral well (4N/69–13B1), which furnishes water for stock. There the water stands 182 feet below the land surface, which is greater than the economic pumping limit for irrigation under prevailing economic conditions and crops. Unless the sands and gravels in the Panaca formation are exceedingly permeable, the prospects of developing irrigation wells from that formation in this locality are not promising. However, water for irrigation may be developed from the sand and gravel strata of the later alluvium. The water level is at or near the surface from the E. Lytle well (3N/70–7A1) south to the entrance of the bedrock constriction above Ursine, an area of about 750 acres. It is estimated that approximately 3,000 acre-feet of water a year is discharged from this area by evaporation and transpiration. Salvage of this water by pumping from wells appears to be feasible if the sands and gravels are sufficiently permeable for large capacity wells.

URSINE VALLEY

The later alluvium furnishes water to wells in the subvalleys in Ursine Valley, but only in Rose and Dry Valleys have attempts been made to use the water for irrigation. However, supplies of water for irrigation may be obtained from the later alluvium in all three subvalleys. The better wells will be those which penetrate to bedrock in areas where the water table is near the surface, and where the later alluvium is thick and highly permeable. In general, the alluvium has a greater thickness in the lower ends of the subvalleys, but the coarsest and most permeable materials are in the upper ends. Therefore, careful location of wells would be necessary, and test drilling would be advisable.

MEADOW VALLEY WASH BELOW MEADOW VALLEY

Ground water occurs in the later alluvium in Meadow Valley Wash below Meadow Valley. It has been drawn from these sediments since the first drilled well was sunk in 1911 by the Union

Pacific Railroad at Caliente. Since that time the increased activities of the railroad and the growth of the town of Caliente have resulted in the construction of additional wells for public supply and railroad use.

Irrigation wells in the later alluvium have been developed as shown by the Culverwell (4S/67–8C2) and Conway (4S/66–25B1) wells. Additional wells of this type may be constructed in areas where the water table has not been influenced greatly by the now degrading Meadow Valley Wash, and where the sediments are coarsest and thickest.

From logs of the existing wells in the area it is seen that the maximum thickness and depth of the alluvial fill are near the center of the wash, and the best-sorted and most permeable material has been encountered below 115 feet. As the depth to bedrock in the deepest part of Meadow Valley Wash has been determined to be about 170 to 190 feet, it seems advisable that wells should penetrate the later alluvium to bedrock. Accordant side washes entering Meadow Valley Wash have undoubtedly dumped their load of coarse sediments at their mouths, further influencing the character of the material deposited along the main streams. As the Culverwell and Conway wells mentioned above have explored areas opposite these accordant side washes and give all indications of being good irrigation wells, it is believed advisable, where possible, to locate wells in such areas.

PANACA AREA, MEADOW VALLEY

The quantity of ground water available for irrigation in the Panaca area of Meadow Valley is the principal factor in determining the amount of land which may be utilized for agriculture. The Panaca area is a filled alluvial channel in Meadow Valley, the upper end and margins of which are receiving water, whereas water is being discharged by evaporation and transpiration within the channel, through wells, and by stream flow and underflow at the lower end. Prior to the drilling of wells such an area is said to be in hydrologic balance, because over a period of years the amount of water entering the debris-filled channel equals the amount leaving it. On the assumption that the natural discharge can be stopped and all the water can be recovered, the quantity of ground water that is discharged from the channel is a measure of the quantity that is available for additional irrigation. For convenience, the water entering the area is termed the inflow and that leaving the area is termed the outflow. In the study of the Panaca area, data were collected to make an inventory of the inflow and outflow, and although the available data are in part only approximate, consideration is given to all factors affecting them, and the minimum rather than the maximum figures are taken. This precaution is necessary when it is realized that the calculations depend upon short-term records rather than on averages of long-term records. As an illustration of yearly variations, the total flow of Meadow Valley Wash, measured at the Meadow Valley Wash gaging station for the water year ending September 30, 1945, was more than 4,700 acre-feet of water, whereas for the water year ending September 30, 1946, it was only 2,550 acre-feet.[35]

Water Inventory

Inflow.—The sources of inflow to the Panaca area are surface flow and underflow through Condor Canyon, spring flow and upward percolation from Warm Springs, other upward or lateral percolation from the basement rocks and the Panaca formation, spring flow from Bullionville Springs and from other small springs along the lateral margins of the valley, pumpage from the Caselton mines, precipitation, and surface flow from tributary washes.

The discharge of Meadow Valley Wash, which flows through Condor Canyon and onto the plain of the Panaca area of Meadow Valley, is based upon the stream-flow records at the Meadow Valley Wash gaging station near Panaca. There is some loss of stream flow by infiltration and evaporation in the 4½-mile reach from the gaging station to the mouth of Condor Canyon. However, Hamlight Canyon, the drainage channel for Lake Valley, enters the Condor Canyon portion of Meadow Valley Wash midway between the gaging station and the mouth of Condor Canyon, and contributes some water to Meadow Valley Wash. The stream-flow records for the water year 1945–1946 indicate that there were only two days during August when the rainfall was great enough for flow from Lake Valley through Hamlight Canyon to the Panaca area of Meadow Valley. The flow from Lake Valley will tend to compensate for the stream losses in the stretch from the gaging station to the mouth of Condor Canyon, and may roughly balance them.

The following tabulation shows the monthly discharge in acre-feet for the period of record, as measured at the Meadow Valley Wash gaging station, near Panaca, Nevada:

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[35] Preliminary records; subject to revision.

DISCHARGE, IN ACRE-FEET, OF MEADOW VALLEY WASH NEAR PANACA, NEVADA, NOVEMBER 1944, TO SEPTEMBER 1946*

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Total
1944–1945	—	116†	303	319	837	970	1,000	209	32	28	848	41	4,700+
1945–1946	322	313	277	306	479	429	157	17.1	21.4	17.5	195	11.9	2,550

*From unpublished records of U. S. Geological Survey, subject to revision.
†Record for month incomplete.

The amount of underflow through the gravel-filled channel at the mouth of Condor Canyon is based upon (1) the coefficient of transmissibility of the water-bearing material determined from a pumping test at the Kenneth Lee well (1S/68–33C1), a short distance downstream from the mouth of Condor Canyon (see Pl. 3), (2) slope of the water table, and (3) the estimated width of the saturated materials at the mouth of Condor Canyon.

The coefficient of transmissibility[36] of water-bearing material may be defined as the amount of water, in gallons per day, percolating under prevailing conditions through each mile of water-bearing bed under investigation measured at right angles to the direction of flow, for each foot per mile of hydraulic gradient. The transmissibility at the Kenneth Lee well (1S/66–33C1), based on a pumping test made on June 11 and 12, 1946, was about 68,000 gallons per day per foot. The slope of the water table at the mouth of Condor Canyon between the Chris Ronnow well (1S/68–28C1) and the A. B. Edwards well (1S/68–33B2) was 12 feet to the mile. The logs of wells in the vicinity of the mouth of the canyon indicate the thickness of the saturated material to be 60 to 65 feet. At the Kenneth Lee well it was 64 feet, and it is assumed to be approximately the same at the mouth of Condor Canyon. The transmissibility likewise is assumed to be about the same. The width of the canyon at its mouth was measured at 125 feet. However, from the slope of the canyon sides it is estimated that the average width of the saturated material is about 100 feet, or about 0.02 mile.

The underflow through the canyon is computed from the following formula:

$$Q = T\,I\,W.$$

Where $Q =$ the underflow in gallons per day,
$T =$ coefficient of transmissibility as defined,
$I =$ hydraulic gradient, in feet per mile,
$W =$ average width of section in miles.

Using these values the underflow is computed to be about 16,000 gallons per day or slightly less than 20 acre-feet a year.

Inflow from Warm Springs is based upon one current-meter measurement made in March 1946. When this measurement was made the spring reservoir was being cleaned and most of the flow of the spring was confined to one channel. There was some additional discharge from small openings below the main orifice

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[36] Theis, C. V., The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground-water storage: Am. Geophys. Union Trans., 1935, p. 520.

and this was estimated. The total measured and estimated flow amounted to eight second-feet, or about 5,800 acre-feet a year.

In addition to this measured flow, it is believed there is upward and lateral percolation of water not visible at the land surface, from the basement rocks and the Panaca formation, which recharges the later alluvium and thus contributes to the total inflow to the Panaca area of Meadow Valley. The amount of this upward percolation is unknown.

The quantity of water contributed by Bullionville Spring and other small perennial springs along the west margin of the Panaca area of Meadow Valley is estimated to be about 300 acre-feet per year.

The quantity of water available from the Caselton mines is based upon the amount of surface flow that reaches the alluvium, which in 1946 was estimated to be about 300 acre-feet. In using this figure, however, it must be borne in mind that this inflow depends upon the continuation of the pumping from the mines at Caselton.

The quantity of water available for recharge from precipitation will vary from year to year, depending upon the variation in rainfall. For the water year ending September 30, 1946, the total quantity of precipitation on the Panaca area is estimated as 6,000 acre-feet. This figure is derived from the precipitation at the Soil Conservation Service rain gage about 5½ miles east of Panaca, which for the period October 1945 through September 1946 was 7.58 inches, and the area of the valley floor, about 9,400 acres. The variation in rainfall is shown by the records of this station for eight complete years in the 11-year period 1936 to 1946. The minimum was 6.69 inches and the maximum 18.90 inches, a ratio of nearly three to one. At Caliente and Pioche the ratio for the period of record is even greater, amounting to five to one and four to one, respectively (see Table 1).

The surface flow into the Panaca area of Meadow Valley from side washes also varies with the rainfall and is dependent to some extent upon the occurrence and severity of thunder showers in the summer months. It is not possible to estimate this quantity, but in 1946 at least it was not believed to be large.

The quantity of inflow to the Panaca area of Meadow Valley is the sum of the contributions from the various sources described. As has been mentioned, the quantity will vary from year to year, depending upon the flow of Meadow Valley Wash, the precipitation, and the surface flow from lateral tributary washes. Sum

sources of inflow, the estimated quantity

for each source, and the estimated total for all sources, in acre-feet for the water year ending September 30, 1946.

Surface flow through Condor Canyon	2,550
Underflow through Condor Canyon	20
Discharge of Warm Spring	5,800
Upward percolation at Warm Spring	Unknown
Other upward or later percolation from the basement rocks and the Panaca formation	Unknown
Discharge of Bullionville Springs and other springs	300
Surface flow from Caselton mines pumpage	300
Direct precipitation on the Panaca area	6,000
Surface flow from lateral drainage	Unknown
Estimated total inflow	14,970+

Outflow—Outflow from the Panaca area of Meadow Valley is the sum total of water discharged by evaporation from the soil and transpiration by plants, surface flow leaving the valley through Cove Canyon, underflow through this debris-filled outlet, and pumpage for irrigation (Pl. 5A).

The water discharged by evaporation and transpiration was estimated by mapping the areal extent of the phreatophyte vegetation, that is, the plants which obtain their water supply from the water table, and by estimating the amount of water discharged per acre. The amount of water discharged by soil evaporation is included in the estimate of that discharged by plant transpiration. The amount of water discharged by evaporation and transpiration depends upon the species of plants, the depth to the water table, the length of the growing season, and the climatic conditions.

No effort was made during the course of the investigation to evaluate the rate of discharge of water by evaporation and transpiration in specific areas, as the limitations on time and personnel did not permit studies of this complex problem. Data for the rate of discharge of water by evaporation and transpiration were taken largely from the work of White,[37] Blaney,[38] and Blaney

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

[38] Blaney, H. F., Water losses under natural conditions from wet areas in Southern California: California Dept. Public Works, Div. Water Resources Bull. 44, 1933.

and Young[39] for plants and conditions similar to those of the Panaca area of Meadow Valley. The work of White in the Escalante Valley, Utah, was particularly valuable as the area is not far distant and the conditions are not unlike those in Meadow Valley.

The vegetation zones mapped to determine the water loss are shown on Plate 3. The mapped vegetation zones, depth to water, and computed water loss in acre-feet per year for the various types of phreatophytes are given in the following table:

TABLE 3

Areas and estimated discharge of water by evaporation and transpiration in the Panaca area of Meadow Valley for the water year ending September 30, 1946.

Vegetation	Acres	Depth to water (feet)	Estimated discharge in acre-feet per acre per year	Total discharge in acre-feet per year
Marsh plant life: tules, sedges and grasses	985	0–2	4.0	3,940
Salt grass and associated rabbit brush and natives grasses	1,930	2–5	1.5	2,900
Greasewood	620	5–10	0.5	310
Associated rabbit brush and greasewood*	1,450	10–15	0.2	290
Total discharge			—	7,440

*Mapped in field but not shown on Plate 2.

In addition to the water discharged by evaporation and transpiration from the water table and the capillary fringe above it, there is also evaporation and transpiration from the soil column above the reach of the capillary fringe. This water is derived primarily from direct precipitation. Some of the water, particularly following heavy rains, may percolate to the water table. However, most of it is believed to increase the soil moisture only temporarily and later it is discharged by plants and by evaporation from the wetted land surface. The amount so discharged varies from year to year, depending upon the amount, frequency, and intensity of the precipitation. It is believed that the yearly discharge approximates closely the yearly contribution by direct precipitation; that is, only a little of the water from precipitation runs off or reaches the water table. On this basis the quantity discharged during the water year ending September 30, 1946, was about 6,000 acre-feet.

Surface flow out of Meadow Valley through Cove Canyon is derived from two sources. One is effluent seepage to Meadow Valley Wash from the ground water reservoir in the Panaca area, and the other is the water in the perennial stream entering the valley at Condor Canyon, a part of which passes through the

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[39] Blaney, H. F., and Young, A. A., Use of water by native vegetation: Cali-fornia Dept. Public Works, Div. Water Resources Bull. 50, 1942.

PLATE 5

A. Grant Lee irrigation well (3S 67–2A1) and irrigated alfalfa field.

B. Weir on Meadow Valley Wash in Cove Canyon. Used to measure effluent ground-water discharge out of Meadow Valley.

valley and out at Cove Canyon. To this amount must also be added any surface flow entering the valley from the lateral tributaries.

In order to measure the effluent seepage a 4-foot rectangular weir was installed in the channel a short distance below the entrance to Cove Canyon. (See Pl. 5B.) Periodic measurements of flow were made here from April 1 to July 31, 1946. During the months of May, June, and July all water entering the valley at Condor Canyon had been diverted for irrigation, and none of the perennial stream flow was passing out of the valley. During this period there was no flow from the lateral washes.

The flow over the weir in this 3-month period therefore consisted entirely of effluent seepage, that is, water discharged into the stream from the ground-water reservoir. The flow ranged from 2.10 cubic feet a second on May 1 to 0.48 cubic foot a second on July 31, and averaged 1.20 cubic feet a second. As this average discharge was determined during the early and middle parts of the growing season, a period when discharge of ground water by evaporation and transpiration was increasing and the water table was declining, the average discharge by effluent seepage for the year is believed to be greater than 1.20 cubic feet a second. Consequently, the computed annual discharge of 900 acre-feet, based on an average flow of 1.20 cubic feet a second, is believed to be conservative.

Generally, during the winter, spring, and late fall there is perennial flow through the valley from Condor Canyon to Cove Canyon. It was not possible to measure the amount of this flow separately, because it is combined with effluent seepage. Neither was it possible to measure the flow resulting from thunderstorms in late July and August, as the 4-foot weir was not large enough to measure these flash flows.

The underflow through Cove Canyon was computed in a manner similar to that for the underflow at Condor Canyon. A pumping test was made on the Geological Survey test well (3S/67–28C2) to determine the coefficient of transmissibility of the water-bearing material. This well, which is located at the entrance to Condor Canyon, was drilled to determine the geologic and hydrologic conditions at the locality. The coefficient of transmissibility was computed as 125,000 gallons per day per foot. The width of the entrance of the canyon at the well was measured as 295 feet, and it was estimated that the average width of the saturated material was about 220 feet or 0.042 mile. Th

hydraulic gradient between the Grant Lee well (3S/67–2A1) and the Geological Survey test well (3S/67–28C2) was about 21.5 feet per mile. On the basis of these data the underflow through Cove Canyon out of Meadow Valley is estimated to be about 113,000 gallons per day or about 125 acre-feet a year.

During the field season of 1946 an inventory was made of the pumpage from eight irrigation wells and one public-supply well in Meadow Valley. The discharge of each well, the total pumping lift, and the number of acres irrigated were recorded. The owners cooperated in furnishing a record of the total hours of operation for the irrigation season. The results of this inventory are given in Table 4. It was found that a total of about 743 acre-feet was pumped during the year. Of this, 672 acre-feet was pumped for irrigation and 71 acre-feet for public supply. The 672 acre-feet for irrigation was withdrawn from the alluvium and the 71 acre-feet from the Panaca formation.

A summary of the total discharge in acre-feet for the hydrologic year ending September 30, 1946, is given below:

Evaporation from soil and transpiration by plants (from water table)	7,440
Evaporation from soil and transpiration by plants (from soil moisture)	6,000
Discharge of effluent ground water measured at the entrance to Cove Canyon	900
Underflow at the entrance to Cove Canyon	125
Perennial stream flow and flow from lateral washes out of Meadow Valley	Unknown
Pumpage for irrigation	743
Total	15,208+

Summary.—The results of the water inventory indicate the magnitude of the inflow to and outflow from the Panaca area of Meadow Valley for the water year ending September 30, 1946. As it was not possible to evaluate all the items of inflow and outflow, the inventory is incomplete. It is believed that for inflow the quantity of water represented by the three items listed as unknown (upward percolation at Warm Springs, other upward or lateral percolation and surface flow from lateral drainage) is not large. Therefore, it seems logical to assume that the estimated inflow is less than but closely approximates the actual inflow.

On the other hand, the item of outflow listed as unknown is also

TABLE 4

Irrigation Wells, Panaca Area of Meadow Valley, Nevada, for the Year 1946

(Kind of power—G, gasoline; D, diesel; E, electric. Kind of Pump—T, turbine; H, horizontal centrifugal.)

Well number and location	Owner	Kind of power and horsepower of pump	Type of pump	Discharge (gallons per minute)	Drawdown (feet)	Specific capacity (gallons per minute per foot of drawdown)	Total lift (feet)	Hours pumped in 1946*	Acre-feet pumped in 1946	Area irrigated in 1946 (acres)
1S/68–28C1	C. Ronnow and K. Lee	G15	T	175	8	21.8	53	500	†16.1	38
1S/68–33B1	E. Lee et al.	D17±	T	225	20	11.3	50?	1,400	†58.0	30
1S/68–33C1	Kenneth Lee	G15	T	725	17	43.5	27	150	†20.0	12
2S/68–5C3	L. Mathews	E10	T	315	17	18.5	42	800	46.4	15
2S/68–8B1	L. Free	E20	T	580	27	21.5	41	720	76.9	25
2S/68–9B1	Panaca (town well)‡	E15	T	70	70	1.0	174	5,520±	71.1±	
2S/67–36B1	E. McGuire	G20?	H	270	20	13.5	42	641	†31.9	10
3S/67–2A1	Grant Lee	E15	T	450	13	34.6	33	§3,672±	304.2±	50
3S/67–2D1	Murray Lee	E15	T	280	28	10.0	44	§2,304±	118.7±	20
	Total								743.0±	200

*From owners' record. †Supplements surface-water supply. ‡For public supply and garden irrigation. §Estimated to nearest full day.

believed not to be large for the period of the inventory. It probably is much less than the stream inflow measured at the gaging station, as the bulk of this water is used for irrigation in the Panaca area of Meadow Valley. In some years thunderstorms may contribute large quantities of water within the drainage of Meadow Valley. However, this would be measured as both inflow and outflow, and as there is little opportunity for loss or use, the amount passing out of the valley would be about the same magnitude as that entering, and so would not unbalance the equation.

RECOVERY OF GROUND WATER BY PUMPING IN THE PANACA AREA OF MEADOW VALLEY

Except for the water pumped for irrigation, a part of which returns to the water table, the items of outflow for which estimates have been made represent not only loss of water from the valley but also from the ground-water reservoir. Recovery of some of the water so lost is believed to be feasible and would be desirable for the agricultural development of the valley. Recovery of this water may be accomplished by pumping from the ground-water reservoir.

Much of the water discharged naturally from the water table by evaporation and transpiration, and much of that discharged as effluent seepage, could be salvaged by pumping from wells. Prevention, or salvage, of the loss by evaporation and transpiration may be accomplished in part by lowering the water table by pumping until the capillary fringe that extends above the water table is below the land surface and below the root zone of the phreatophyte vegetation. In the case of effluent seepage it would be necessary only to lower the water table below the bottom of the existing stream channel. For the area of natural discharge in the valley floor, lowering the water table 10 feet would be sufficient to prevent most of the loss, and a lowering of 15 feet would probably prevent all of it. For example, the estimated rate of discharge by evaporation and transpiration where the water table is 0 to 2 feet below the land surface is 4 acre-feet per acre a year. Lowering the water table 10 feet, to a depth of 10 to 12 feet, would reduce the rate of discharge from 4 to perhaps 0.2 or 0.3 acre-foot per acre a year. Where the water table is 5 to 10 feet below the land surface, a lowering of 10 feet to place it 15 to 20 feet below land surface would reduce the loss essentially to zero. There is in the valley an area estimated as 2,915 acres where the water table is from 0 to 5 feet below the land surface and 2, Table 3) having an estimated annual discharge acre-feet. A lowering of 10 feet in the water level under a, so that it ranged between 10 to 15 feet, would reduce mated rate of discharge to perhaps 0.2 acre-foot per acre, t 600 acre-feet for the year. Thus, the estimated loss be reduced from 6,840 acre-feet to about 600 acre-feet, a ing of about 6,200 acre-feet.

above estimate of the quantity of water that may be sal- y a 10-foot lowering of the water table are for ideal condi- that is, uniform lowering through the area. In actual e this probably could not be achieved. For ideal condi- e wells would be located at definitely spaced intervals as rk over the area. In actual practice the location of the will be governed by land suitability, productivity of the bearing beds, topography, and ownership of the land. The t of water that may be salvaged under actual practice will than that under ideal conditions. It is exceedingly diffi- estimate this amount, but a difference of at least 10 to 20 t is probable.

he area adjacent to the channel of Meadow Valley Wash in ea of effluent seepage, the water table stands from 4 to 5 bove the bottom of the channel, and a 10-foot lowering water table would reduce the loss by effluent seepage ally to zero. Observation of the seepage along Meadow Wash show that locally some of this effluent seepage loss eady reduced, particularly in the summer months, along a portion of the wash paralleling the Grant and Murray Lee in sec. 2, T. 2 S., R. 67 E. As the result of pumping for tion on their farms the water table has been lowered, and g the summer months effluent seepage is no longer con- ing appreciable amounts of water to the stream flow in this h.

e loss due to underflow out of the area probably can never mpletely recovered. It is conceivable, however, that wells e the entrance to Cove Canyon will intercept much of it. To cept the total underflow at Cove Canyon would require such wering of the water table that it would not be practical. It imated, on the basis of data for 1946, that under ideal con- ns between 6,000 and 7,000 acre-feet of water is available for ge in the entire Panaca area by pumping. However, the unt that can be salvaged practicably is less, probably 5,000 feet or less. This is in addition to the pumpage of 743 acre-

Efficient use of the water available as inflow may be effected by utilizing the ground-water reservoir as a storage reservoir. This may be done by pumping from storage during the irrigation season, and then having the ground-water reservoir filled by recharge during the nonirrigation season. Such a method would utilize a portion of the stream flow which normally would discharge from the valley through Cove Canyon, because the water would tend to sink to the lowered water table instead of leaving the area at the surface as at present. Adequate observations of water levels and records of pumpage should be maintained in order to permit limiting the average withdrawal from storage to the amount that can be recharged during an average nonpumping season.

POSSIBILITY OF ARTIFICIAL RECHARGE

Artificial recharge to ground water by water spreading has not been practiced in Nevada. It is practiced successfuly, however, in a number of localities where the conditions are similar to those in Meadow Valley.

In Meadow Valley, favorable conditions appear to exist for artificial recharge in the upper part of the valley from Condor Canyon south to the A. Edwards well (1S/68–33B2). These conditions are: (1) The apparent presence of highly permeable materials from the land surface to the water table in the later alluvial valley fill in this area (p. 54); (2) the fact that these materials are probably interconnected with the gravels penetrated by the irrigation wells throughout the length of Meadow Valley (see Pl. 2); (3) a relatively steep hydraulic gradient to the south throughout the length of the valley.

The feasibility of artificial recharge in this area will depend upon the amount of water available for recharge, the infiltration rates found to be practicable, the area over which water may be spread for infiltration, and the cost of construction of adequate settling ponds and retarding structures.

The determination of infiltration rates, and the area suitable for infiltration, have not been studied in Meadow Valley. At the present stage of ground-water development artificial recharge is not necessary. However, if in the future it becomes desirable to utilize all the water possible, artificial recharge by water spreading offers a possibility that should not be overlooked.

It is worthy of note that the discharge of Warm Springs during the nonirrigating season may be utilized for artificial recharge. By means of a lift of approximately 40 feet this water could be diverted to the upper end of the valley and there spread in the area most promising for infiltration. The most favorable source of water for infiltration, however, is Meadow Valley Wash. By impounding and spreading these waters at times when the water is clear, an appreciable amount of the water normally passing through the valley during the winter months could be stored in the ground-water reservoir and utilized during the following pumping season. In such an undertaking, however, arrangements would probably have to be made to satisfy any downstream water rights.

CLASSIFICATION OF IRRIGABLE LANDS IN THE PANACA AREA OF MEADOW VALLEY

By George Hardman[1] and Henry G. Fox[2]

The cropland soils in the Panaca area of Meadow Valley are alluvial in origin, have been transported long distances, and have been formed from a wide variety of parent materials. A brief summary of the geologic history prior to the formation of the soils will be given as it is necessary for a clear interpretation of their origin and distribution.

In brief, the geologic history involved in the formation of the soils dates back to the initiation of the present geographic landmarks and boundaries in the Meadow Valley Wash drainage area; a period during which faulting uplifted the present ranges and exposed the rocks contained in them to the agencies of weathering and decomposition. Following the formation of the present basin-range topography by extensive block faulting, the closed basins represented by the present Lake, Spring, Ursine, and Meadow Valleys, lying between the elevated land masses, received a constant and undiminishing supply of fine detrital materials derived by weathering of the rocks exposed in the ranges. These detrital materials were derived from limestone and related sediments found in the Chief, Bristol, Highland, Ely, and Fairview Ranges and from medium to basic flows and acid tuffs of volcanic origin found in the Wilson Creek, White Rock, and Morman Ranges. This material was deposited within the shores of a now extinct intermittent lake whose remaining expression is the Pliocene Panaca formation, sediments wherein are found the clues which reveal its origin. This lake at times covered all the area now encompassed by Lake, Spring, Ursine, and Meadow Valleys and is believed to have extended from the narrows at the entrance of Cove Canyon as far north as the vicinity of Geyser. The sediments deposited by both the wind and in shallow intermittent lakes were deposited to a thickness of at least 1,400 feet and buried many of the now existing landmarks to be seen in the vicinity of the town of Panaca. This ancient lake is believed to have reached its maximum extent in late Pliocene time when its shore line touched the bases of the present high ranges at an

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[2] State Soil Scientist for Nevada, U. S. Department of Agriculture, Soil Conservation Service.

elevation of nearly 6,000 feet. In its last stage the lake was completely filled with sediments and is believed to have been represented by shallow, ephemeral bodies of water, and essentially playa conditions.

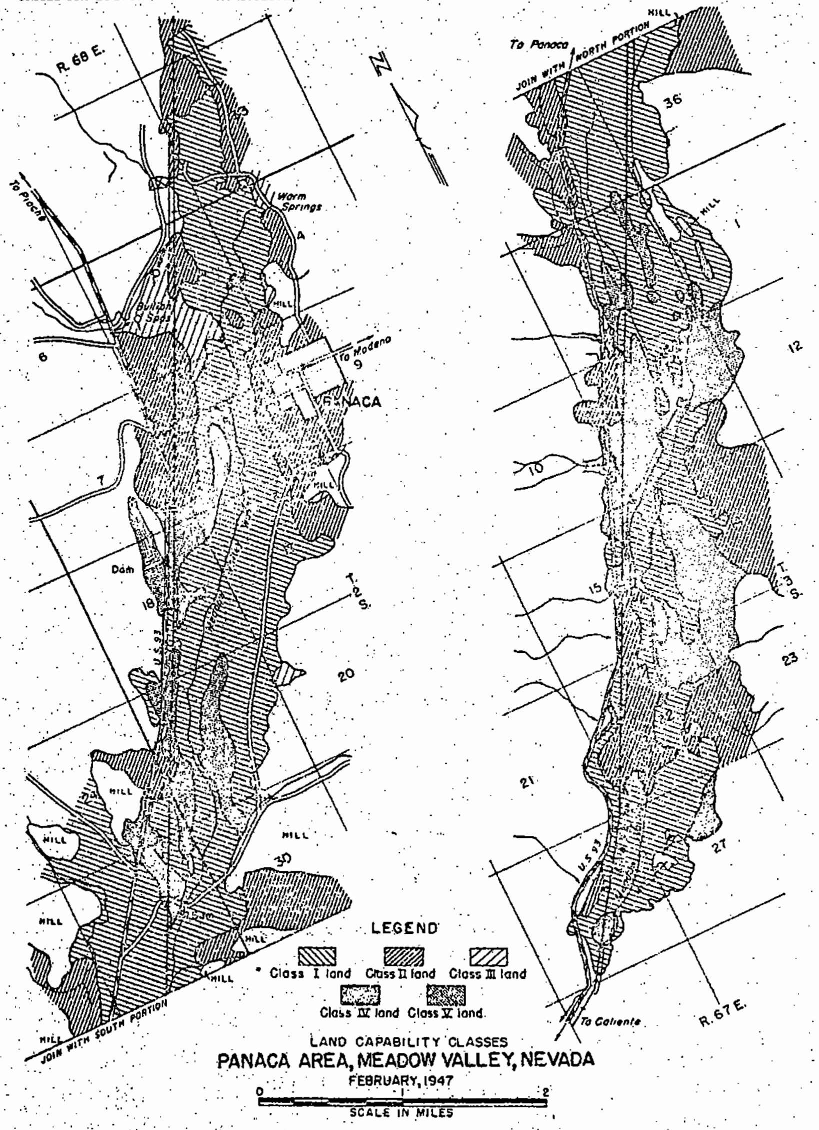
Shortly following the last stage of the ancient "Panaca Lake" a meandering and low-gradient watercourse apparently found an outlet to the sea. This outlet, established during late Pliocene or early Pleistocene time, initiated a new period of erosion and the establishment of a new drainage pattern in the area covered by "Panaca Lake." During this period the watercourse lowered its new outlet, cut channels into the volcanic flows bordering Meadow Valley Wash south of Meadow Valley and into the resistant rocks above Meadow Valley, and incised itself deeply into the Panaca formation. Rock ridges, which had been buried under these sediments, were uncovered by erosion and incised by the new watercourse. These ridges retain sediments of the Panaca formation and help give form to the valleys along Meadow Valley Wash. In the last stage of this period these valleys assumed essentially their present outlines.

Pleistocene time is believed to have been a period of alternating cycles of arid and humid climates. The last period of increased humidity and consequent down-cutting, which is presumed to coincide with the last high-water period in Lake Lahontan in Western Nevada, deepened the central drainage channels in all the basins of the area and served to define more clearly Patterson Wash in Lake Valley, Camp Valley Wash in Spring Valley, and Meadow Valley Wash. During a subsequent period of aridity, deposition has served to build up the present plain in each of these drainages.

As the stream again reached a stabilized grade under conditions of reduced precipitation, which have continued to the present time, a process of alternate deposition and erosion of alluvial materials on the flood plain of the stream began. Thus, it is seen that always some of the materials deposited on the flood plain have been transported by the stream from higher portions of the watershed. To a large extent, however, the deposited materials have been derived from erosion of the sediments of the Panaca formation. Cathedral Gorge, near Panaca, is an excellent example of erosion in this formation. The soils, then, are made up of alluvium, most of which has been recently deposited, derived largely from erosion of the sedimentary deposits of the Panaca formation and modified by materials carried by the stream from higher portions of the watershed.

PLATE 3

UNITED STATES DEPARTMENT OF AGRICULTURE REGION 7 SOIL CONSERVATION SERVICE



LAND CAPABILITY CLASSES
PANACA AREA, MEADOW VALLEY, NEVADA
FEBRUARY, 1947

AGRICULTURAL HISTORY

The Panaca area of Meadow Valley was settled about 70 years ago, and most of the present cropland has been cultivated and irrigated since then. A few farms have been developed in recent years with water supplied by pumping from underground sources, but the acreage is small. The production of forage for livestock feeding has been the important farming enterprise in the area. There has been considerable erosion on the bottom lands from floods which originate on the range lands of the watershed. The severity of the floods probably has been increased through depletion of the range-land vegetation by grazing. Also, erosion on the bottomlands very likely has been accelerated through disturbance of the vegetal cover of these lands.

In addition to the introduction of better range-management practices, some improvement in the methods of farming that have been in general use would seem to be needed to secure the best returns from the resources of the area. The lands should be more carefully leveled to permit better application of irrigation water with less waste, runoff erosion, and waterlogging of the lands. Provision is needed for the return of organic matter and mineral fertilizers used by the crops.

LAND CLASSIFICATION

The survey upon which the following classification of the irrigable land in the Panaca area of Meadow Valley is based was made in 1945 and 1946 by personnel of the Soil Conservation Service, in cooperation with the Meadow Valley Soil Conservation District, and covered this entire district. It was made to provide data for the preparation of farmer-district farm plans, and for the development of over-all plans for the area. The survey covers the lands which are irrigated or may be irrigated in the future and, for this reason, is confined to the bottom lands of the valley and to the gentle slopes adjacent to the valley. (See Pl. 3). No attempt was made to classify the hill lands of the area, which can be used only for grazing. Every condition known to have any influence on the usefulness of the lands was mapped and described in detail. The report on the area was made to the Directors of the Meadow Valley Soil Conservation District, and the complete report and detailed maps may be examined at the Soil Conservation Service office in Caliente, Nevada, or Reno, Nevada. The present report is for Meadow Valley only, which is the area from Condor Canyon to Cove Canyon.

The lands were classified in capability classes which are designed to express the highest use which can be made of the lands without erosion or deterioration. These land classes are determined by those conditions of the soils and of the site which are stable and cannot be changed by any reasonable effort applied to the land. These conditions are referred to as permanent limitations. They include such matters as steep slopes, coarse-textured soil, strong alkali in heavy-textured soils, undrainable areas with a shallow water table, and other permanently adverse conditions. Land capability subclasses are used to express which of these adverse conditions apply to a specific tract of land.

On any tract of land there may be other conditions, such as the presence of alkali, a shallow water table, rough surface topography, or occasional flooding, which can be removed, corrected, or modified in the process of reclamation of the land. Such conditions are referred to as temporary limitations. They are mapped and described, but do not affect the land capability class.

In the Panaca area of Meadow Valley there are five land capability classes and subclasses. These range from Class I, which is good farm land, to Class V, which is useful only for irrigated pasture. Because of the small scale of the map reproduced in this bulletin (Pl. 3), capability subclasses are not shown.

Only the lands in the valley bottom and contiguous gentle slopes are shown. An arbitrary determination was made of the upper limits to which irrigation might be carried in the several dry washes which enter the valley. Elsewhere, the limits of the irrigable lands are defined by the abrupt escarpment which in most places bounds the valley.

The areas given below for the various land capability classes are in gross acreages, and include roads, stream channels, and other minor waste areas. Waste and unusable land probably will equal 20 to 30 percent of the total area.

SUITABLE FOR ROTATION CROPLAND

Land Capability Class I

Lands with deep, permeable, and productive soils on slopes of less than two percent are placed in Land Capability Class I. Large areas of this class of land may have slight to moderate concentrations of alkali or a shallow water table, or may be subject to occasional flooding. However, all these conditions are considered to be temporary and reclamation is considered to be feasible. There are about 4,600 acres of Class I land in the Panaca area of Meadow Valley.

Land Capability Class II

Lands with minor adverse soil or site conditions are placed in Land Capability Class II. These adverse conditions require specific conservation measures to insure continued crop production without erosion or deterioration, and in the Panaca area of Meadow Valley are related to (1) light textures, which reflect low inherent ability to maintain fertility, and (2) location on slopes between two and four percent. The limiting factors may occur alone or in combination. These areas may also have adverse temporary conditions, as discussed under Class I, which can be corrected. There are about 2,500 acres of Class II land in the area.

Land Capability Class III

Lands with major adverse soil or site conditions, which require more intensive application of conservation measures than Class II lands, are placed in Land Capability Class III. The major permanent limitations in the Panaca area of Meadow Valley are confined to (1) coarse-textured soils, which reflect an inherently very low ability to maintain fertility, and (2) light-textured soils on slopes between four and seven percent. Adverse temporary conditions, as discussed under Land Capability Class I, may also occur. Class III land in the area occur in small units with a total of about 300 acres.

SUITABLE FOR OCCASIONAL CULTIVATION

Land Capability Class IV

Lands with such adverse soil or site conditions that only occasional and limited cultivation is feasible are placed in Land Capability Class IV. In the area this class of land has heavy-textured, very slowly permeable soil with excessive amounts of salinity or alkalinity a few inches below the surface. Irrigated pasture with shallow-rooted, alkali-tolerant grasses and clovers is the adapted use. Reclamation may be required to remove one or more temporary limiting conditions before irrigated pastures can be produced. There are about 200 acres of Class IV land in the area.

SUITABLE FOR GRAZING

Land Capability Class V

Lands with such adverse soil or site conditions that no cultivation is feasible are placed in Class V. These lands are suitable for grazing and are susceptible to improvement through water spreading, reseeding, land leveling, and the control and management of livestock. In the Panaca area of Meadow Valley these are lands with heavy-textured, very slowly permeable soils which contain excessive amounts of salinity or alkalinity throughout much of the usable soil depth. Site conditions are often unfavorable for drainage, and protection from floods may not be feasible. There are about 1,400 acres of Class V land in the area.

QUALITY OF SPRING AND WELL WATERS OF THE MEADOW VALLEY WASH DRAINAGE AREA ABOVE THE VICINITY OF CALIENTE.

By George Hardman[1] and M. R. Miller[2]

The writers studied the quality of water in southeastern Nevada and published a bulletin on the subject in 1934.[3] At that time the general conclusion was drawn that the quality of the ground water of the Meadow Valley Wash drainage area was uniformly good. More recent analyses of water samples from sources not covered in the previous studies have served to modify to a slight extent this general conclusion. From the available analyses it now appears that ground water from sources in the Meadow Valley Wash drainage area is generally of good quality.

CLASSIFICATION OF DOMESTIC WATERS

The quality of water for domestic use may be approximately classified on the basis of the total dissolved matters (total solids or total salines) expressed as parts per million. The following table[4] has been found useful in classifying domestic waters:

Very good....	0 to 100 p.p.m. total solids. free from organic matter, clear, odorless, tasteless.
Good............	100 to 500 p.p.m.
Fair..............	500 to 1,000 p.p.m. Sodium or calcium bicarbonate waters passing sodium-sulfate waters.
Poor..............	1,000 to 5,000 p.p.m. Rejecting sodium-sulfate and calcium waters.
Unfit............	Over 5,000 p.p.m.

The predominance of calcium and magnesium in all except the very good water serves to mark the water as "hard." Hard waters are not efficient for laundry purposes because the calcium and magnesium must be removed by excessive amounts of soap before sufficient soap remains in solution to exert a satisfactory detergent action. In order to overcome the effects of "hard" waters when used in the laundry, recourse may be had to the use of a precipitation agent such as sodium carbonate (washing soda) or borax. With the more modern detergents being more frequently used in the laundry the hardness of the water becomes less of a problem. Home installations are now available, also, through which the water supply may be passed and in which sodium is substituted for the calcium and magnesium in the water. Such equipment does not reduce the total dissolved material, but it serves to soften the water and to make it more agreeable for domestic use.

Equipment may be obtained which will reduce the total salines in solution to a point approaching distilled water. For domestic supplies of water, however, these methods are not especially feasible owing to the cost of installation and maintenance.

CLASSIFICATION OF IRRIGATION WATERS

The water used for irrigation becomes a part of the soil system in which crops grow. In addition to supplying the necessary moisture for plant growth, the quality of the water plays an important part in the chemical changes which take place in the soil.

The following table gives the standards for irrigation water:[5]

	Saline Content		
	Total p.p.m.	Tons per acre-feet	Sodium percent
Class 1........	700	1	60
Class 2........	700–2,000	1–3	60–75
Class 3........	2,000	3	75

Class 1........	Excellent to good, suitable for most plants under most conditions.
Class 2........	Good to injurious, probably harmful to the more sensitive crops.
Class 3........	Injurious to unsatisfactory, probably harmful to most crops and unsatisfactory for all but the most tolerant.

Plants in saline soils are adversely affected by high concentrations of salts in the soil solution and by poor physical condition of the soil. Both conditions are greatly affected by the type of irrigation water used. An irrigation water having a high percentage of sodium will, after a time, give rise to a soil having a

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[1] State Conservationist, Soil Conservation Service; formerly Irrigationist, Nevada Agricultural Experiment Station.

[2] Chemist, Nevada Agricultural Experiment Station.

[3] Hardman, George, and Miller, M. R., The quality of the waters of southeastern Nevada, drainage basins and water resources. Univ. of Nevada Agri. Exper. Sta. Bull. No. 136, p. 38, 1934.

[4] Hardman, George, and Miller, M. R., op. cit. p. 21.

[5] Magistad, O. C., and Christiansen, J. E., Saline soils, their nature and management; U. S. Dept. Agr. Circ. No. 707, 1944.

e proportion of replaceable sodium in the colloid, often designed as black alkali soil. Even on sandy soils with good drain- waters of 85 percent sodium or higher will give rise to ermeable soils after prolonged use.

QUALITY IN RELATION TO USE

f the 20 analyses given in Table 5, 19 are of ground waters n wells, springs, and mines within the Meadow Valley Wash nage area. The other, that for Bristol Wells, is given because well, although in the drainage of Dry Lake Valley to the t, is not far removed from the drainage of Meadow Valley h.

he water from Bristol Wells is high in total salts and is poor uality for most uses. It would be classified as a calcium-ride water.

wo analyses indicate the chemical character of ground waters Spring Valley. The water from the E. Lytle well is high in ium, bicarbonate, and chloride, and low in sodium and sul-. It would be classed as a calcium-bicarbonate, calcium-ide water, fair for domestic or irrigation use. The Hollinger g water is relatively low in total solids and in hardness. analysis indicates a water of good quality for both domestic irrigation use.

he mineral character of the ground water in the vicinity of he is shown by five analyses. With the exception of that the Ely Valley mine, all the waters are good for domestic irrigation use. The water from Pioche Floral Spring and he Water Works is harder than water from the Pioche mine t and the Pioche Mines Consolidated 562-foot well. The Ely ey mine water has the highest concentration of total solids y of the waters sampled in the Meadow Valley Wash drain-area, and would be classed as sodium-sulfate water. The y mineralized character of this water is probably due to the association of the water with the sulfide ore bodies. It is in quality for either domestic or irrigation use.

those Spring is located in Dry Valley. The water is slightly l and, therefore, probably is deep-seated in origin. It is rately low in total solids and in hardness. The water is ble for domestic and irrigation use.

r Meadow Valley there are 10 analyses of water from seven ties. The analyses indicate that all the waters are fair to for domestic use, and good for irrigation use. The water ed at the seven localities comes from four different types

of rock. The Civilian Conservation Corps Camp well is believed to draw water from the Tertiary volcanics, although the water may be a combination of water from the Tertiary volcanics and from the alluvium. The Warm Spring yields thermal water from a deep source that probably percolates through limestone for some distance. The water from the Panaca town well comes from the Panaca formation. The other four analyses, for the L. Mathews, G. Lee, and Geological Survey wells and the Duffin Ranch spring, are of ground water from the alluvium. The hardness of waters sampled in Meadow Valley ranges from a low of 104 p.p.m. to a high of 311 p.p.m. With the exception of the L. Mathews, Panaca town, and G. Lee wells, all the waters are low in sulfate. The L. Mathews and G. Lee wells have the highest concentration of total solids for any of the water analyzed in Meadow Valley. The percentage of sodium is about 42 for both wells, and percent of chloride 32 and 18, respectively. The content of sulfate in relation to sodium is low. In time, application of gypsum may be needed to maintain a favorable physical condition in the soils irrigated with these waters. The soils in Meadow Valley are low in gypsum.

The last two analyses in Table 5 are for thermal water in the vicinity of Caliente. The water from the city of Caliente North well may be a mixture of deep-seated thermal water and water from the alluvium, the thermal water predominating. The deep-seated water from the Caliente Hot Springs, though only moderately mineralized, has a high percentage of sodium and bicarbonate. It is good for domestic use, but the high percentage of sodium would make the water rather poor for irrigation. The high amount of silica in the waters of the two wells at Caliente is probably related to their higher temperatures.

TABLE 5

Analyses of Water from Wells, Springs, and Mines in the Meadow Valley Wash Drainage Area Above Caliente, Nevada*

				Parts Per Million												
Well number and location	Source (Owner or place)	Date of collection	Temperature °F.	Dissolved solids	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na and K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Percent sodium	Percent chloride	Total alkalinity as $CaCO_3$	Total hardness as $CaCO_3$
	Dry Lake Valley—															
N/65–21D1	Bristol Wells		----	1,343	36	180	48	144	0	300	211	350	32.6	51.4	246	647
	Spring Valley—															
N/70–7A1	E. Lytle, well	Dec. 1946	58	870	25	168	30	48	0	207	69	287	16.1	62.6	170	543
	K. Hollinger, spring (not on map)	Dec. 1945	----	290	---	46	6	21	0	187	Tr.	24	24.0	18.0	150	143
	Pioche and Vicinity—															
N/66–35A1	Pioche, Floral Springs		----	322	15	69	34	13	7	350	5	7	8.4	3.32	287	312
N/67-	Pioche Water Works†	Oct. 1912	----	324	13	74	33	31	0	263	16	5	17.4	2.93	216	338
	Pioche, mine shaft	June 1936	----	154	20	36	Tr.	11	Tr.	61	Tr.	45	22.0	56.0	50	90
	Pioche Mines Consolidated, 562 foot well	Feb. 1938	----	212	50	31	Tr.	32	0	139	10	16	47.3	15.3	114	77
N/67–17B1	Ely Valley Mine		----	2,512	20	132	38	463	0	12	1384	30	75.0	2.93	10	486
	Dry Valley—															
N/69–34D1	Flatnose Ranch, spring	Dec. 1946	77	247	20	30	10	42	0	162	44	20	44.3	13.6	133	116
	Meadow Valley—															
/68–13A1‡	Civilian Conservation Corps Camp, well at Delume	Oct. 1946	59.5	240		53	8.5	27	0	184	24	33	25.9	20.9	151	167
/68–4B1†	Warm Spring, near Panaca	Oct. 1912	85–88	283	16	40	23	2.1	0	178	27	18	2.30	12.8	146	194
/68–4B1	Warm Spring, near Panaca		----	278	39	18	15	18	0	183	41	20	17.7	12.7	150	182
/68–4B1	Warm Spring, near Panaca		----	273	10	54	15	21	33.6	149	31	25	18.8	16.1	121	197
/68–5C3	L. Mathews, well	Dec. 1945	----	615		52.2	32.8	86.2	15.3	265	68.6	102	41.3	32	215	268
/68–9B1	Panaca, town well	Mar. 1946	----	355	81	36	12	47Na	7	146	78	20	42.5	12.2	120	151
/67–3A1	G. Lee, well	May 1940	65	650	74	55.7	11.7	104	0	366	133	69.1	42.2	18.2	300	311
/67–22D3	Duffin Ranch, spring	Dec. 1946	58	309	62	29	10	46	0	183	20	30	46.8	19.9	150	113
/67–28C2§	Geological Survey, test well	Oct. 1946	66	241	----	28	8.4	55	0	183	28	28	53	18.0	150	104
	Meadow Valley Wash Below Meadow Valley—															
/67–5C1† ¶	W. F. Hubert (Caliente Hot Spring)		115	430	126	33	7	84	0	278	4.5	12	62.2	6.8	228	111
/67–7A1	City of Caliente (North well)		107	352	84	29	10	70	7	232	26	20	57.3	11.4	190	114

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*Analyses by M. R. Miller, University of Nevada, Agricultural Experiment Station, or W. B. Adams, University of Nevada, Department Food and Drugs, Public Service Division, except as noted.

†S. C. Dinsmore, analyst, U. S. Geol. Survey Water-Supply Paper 365, facing p. 30, 1915.

‡W. I. Ettleman, analyst, U. S. Geol. Survey; fluoride 0.4 p.p.m.; nitrate 3.5 p.p.m.

§W. I. Ettleman, analyst, U. S. Geol. Survey; fluoride 1.4 p.p.m.; nitrate 1.8 p.p.m.

¶Nitrate 4 p.p.m.

TABLES

Compiled by David A. Phoenix

The three tables that follow, 6, 7, and 8, comprise a record of ll the wells in the Meadow Valley Wash drainage area, the data ollected concerning drillers' logs of wells, and measurements of water level in observation wells for the year 1946 over the area.

The wells are identified by a numbering system based on the etwork of surveys by the General Land Office. This numbering ystem also serves to locate the well in the township, range, and ection. The first unit is the number of the township, followed by "N" or "S," depending upon whether it is north or south of the Mount Diablo base line. The second unit, separated from the irst by a slant, is the range; the next unit, separated by a dash, hows the section, quarter section, and individual well number. Each section has been divided into four 160-acre tracts, each of which has been assigned a letter. Beginning with the northeast uarter the letters have been assigned in a counterclockwise direc- on. Thus, the northeast quarter is "A," the northwest quarter B," the southwest quarter "C," and the southeast quarter "D." The first well recorded on a given quarter section is designated by the numeral "1," the second "2," and so forth. Thus, the irst well located in the northeast quarter of section 1, Township N., Range 68 E., would be numbered 1N/68–1A1, the second would be 1N/68–1A2, and so forth.

On Plate 1, only that part of the number designating the sec- on, quarter section, and the order in which the well was recorded s shown. The township and range numbers are shown on the dges of Plate 1. On Plate 2, only that part of the number desig- ating the quarter section and the order in which the well was ecorded is shown.

Table 6 is self-explanatory. It is a list of all the known wells the Meadow Valley Wash drainage area, 124 in all. They are ll located on Plates 1 and 2. Some of the data were reported ally, but most of the data were taken from written records or llected in the field.

Table 7 lists available well logs and casing records from well- illing operations in the Meadow Valley Wash drainage area. his information is listed in consecutive order according to the eological Survey well numbers. A total of 56 logs are included the table. Many of the well logs were reported by well drillers from memory by well owners and are designated as "driller's log," or "owners log (from memory)." The descriptions of the materials have generally been copied verbatim from the driller's logs. However, a few have been edited for clarity and consistency. Cuttings from 13 of the wells were examined in the field. In addition, the cuttings from the deep wells in the Panaca formation, the Pioche Rodeo Association well (1N/67–12D3), the Panaca town well (2S/68–9B1), and the Thorley well (1S/67–32C1) were examined under the microscope. Descriptions of these materials are based upon a microscopic examination.

Table 8 lists the measurements of water level in observation wells for 1946. A few water-level measurements are tabulated for the years 1945 and 1947.

TABLE 6

Record of wells in the Meadow Valley Wash drainage area, Nevada

(Type of well—B, bored; Dg, dug; Dr, drilled. Use of water—D, domestic; I, irrigation; N, abandoned or unused; O, observation; P, public supply; R, railroad; S, stock. Producing formation—Qal, Quaternary alluvium; Tp, Panaca formation; Tv, Tertiary volcanic rocks.)

Well number and location	Owner	Type and date drilled	Diameter (inches)	Depth (feet)	Altitude of land surface (feet above sea level)	Water Level		Use	Producing formation	Remarks
						Feet below land-surface datum	Date			
6N/67-36C1	D. Free	Dr, 1945	10	75	—	12.7	4- 7-46	N	—	Log.
6N/67-36C2	D. Free	Dr, 1945	6	—	—	—	—	S		
6N/66-36C1	Bureau of Land Management; Poney well	Dr	6	162	—	130.3	7-26-46	S	Qal	Log.
5N/67-1A1	J. W. Cole	Dr, 1945	6	48	—	—	—	D		
4N/69-13B1	Bureau of Land Management; Spring Valley Holding Corral well	Dr, 1941	6	206	—	182.1	7-31-46	S	Qal, Tp	Log.
4N/66-2C1	Bureau of Land Management; Craw Creek well	Dr, 1937	8	260	—	—	—	S	Qal, Tp	Log.
4N/66-15C1	Bureau of Land Management; Twenty-one mile well	Dr, 1937	6	—	—	—	—	N		
3N/70-7A1	E. Lytle	Dg, old	48x48	30±	—	8±	—	S	Qal	Analysis.
3N/70-32B1	L. Holmes	Dg, old	—	—	—	—	—	—	Qal	
3N/67-23C1	Bureau of Land Management; Benchland well	Dr	6	400	—	368	3-12-42	S	Qal, Tp	Log.
3N/66-2D1	Bureau of Land Management; Twentyone-mile Holding Corral well	Dr, 1937	6	140	—	92.4	4-12-46	S	Qal, Tp	Log.
3N/66-15B1	Jackrabbit Mine	Dr	3	140	—	100±	12-22-46	N	Qal	
3N/66-15B2	Jackrabbit Mine	Dr	6	160	—	—	12-22-46	I, D	—	Bridged at 45 ft. Log.
3N/66-23D1	Unknown; Fifteenmile dug well	Dg, old	72x72	45	—	42.5	4-12-46	N	Qal	Unsurveyed township.
3N/66-23D2	Bureau of Land Management; Fifteen-mile drilled well	Dr, 1937	6	148	—	41.4	4-12-46	S	Qal	Unsurveyed township
2N/70-5C1	D. Francis	Dg, old	—	—	—	—	—	—	Qal	
2N/69-35A1	W. Dyer	Dr, 1935	7	87	—	38±	—	D	Qal	Log.
2N/69-35C1	J. Hammond and K. Hollinger	Dr								
2N/69-35D1	S. J. Hollinger	Dr	6	108	—	46±	—	D	Qal	
2N/69-35D2	E. Lytle	Dr	12	70	—	48.2	4-26-46	D, S	Qal	
2N/69-35D3	H. Hammond	Dg, Dr	12	60	—	37.4	4-26-46	—	Qal	25 ft. dug, 35 ft. drilled.
2N/67-16C1	Unknown; Eightmile dug well	Dr, old	7	21(?)	—	19.5	4-12-46	N	Qal	
2N/67-27D1	Unknown; Sixmile dug well	Dg, old	72x72	40±	—	22.9	4-12-46	S	Qal	
2N/66-25D1	Bureau of Land Management; Airport well	Dr, 1942	6	400	—	348.7	4-12-46	S	Qal	Log.
1N/69-2B1	Mrs. Francis	Dg, old	—	—	—	—	—	D	Qal	
1N/69-2B2	M. Damron	Dr	6	50	—	23±	—	D	Qal	Water from sand and silt.
1N/69-2B3	M. Warren	Dr	10	56	—	26±	—	D	Qal	
1N/69-2B4	S. Hollinger	Dr	8	86	—	25±	—	D	Qal	
1N/69-16C1	F. H. Lytle	Dg, old	60x60	—	—	24±	—	D	Qal	
1N/69-16D1	L. Lytle	Dr, 1941	10	76	—	—	—	D	Qal	Log.
1N/69-16D2	J. Devlin	Dg, old	72x72	—	—	—	—	D	Qal	
1N/69-16D3	J. Devlin	Dg, old	72x72	30	—	12.0	10-22-46	D	—	6-in. casing, 15 to 30 ft.
1N/69-21A1	L. Lytle, east well	Dr, 1941	10	88	—	25.4	10-22-46	I	Qal	Log.
1N/69-21D1	J. Devlin et al.	Dr, 1941	10	87	—	8.6	3-23-46	N	Qal	Log.
1N/67-12B1	Unknown		4	164.5	—	91.8	4- 6-46	N	Tp	
1N/67-12D1	Pioche Rodeo Association	Dr, 1946	—	230	—	—	—	N	—	Log.
1N/67-12D2	Pioche Rodeo Association	Dr, 1946	—	210	—	—	—	N	—	Log.
1N/67-12D3	Pioche Rodeo Association	Dr, 1946	8	530	—	141.6	9- 9-46	S	Tp	Log.
1N/67-14B1	Pioche (mill)	Dr, 1942 (?)	—	500±	—	—	—	N		
1N/66-14C1	Pioche (city well)	Dr	—	—	—	—	—	—	—	Yield 35 g.p.m.
1S/69-7C1	Soil Conservation Service. Test well	Dr	—	65	—	—	—	—	—	Log.
1S/69-7C2	Soil Conservation Service. Test well	Dr	—	78	—	—	—	—	—	Log.
1S/69-7C3	Soil Conservation Service. Test well	Dr	—	33	—	4.4	3-23-46	—	—	Log.
1S/69-7C4	Soil Conservation Service. Test well	Dr	—	62	—	—	—	—	—	Log.

TABLE 6—*Continued*

Well number and location	Owner	Type and date drilled	Diameter (inches)	Depth (feet)	Altitude of land surface (feet above sea level)	WATER LEVEL Feet below land-surface datum	WATER LEVEL Date	Use	Producing formation	Remarks
1S/69-7C5	A. Delmue	Dr	10	90	—	2.5	3-23-46	N	Qal	Log.
1S/69-7D1	A. Delmue	Dr	10	250±	—	10.0±	1941	N	Qal, Tp	Log.
1S/69-20D1	Bureau of Land Management	Dr	6	313	—	263±	—	S	Tp (?)	Log.
1S/68-13A1	Civilian Conservation Corps	Dr	8	76	—	29.5	3-23-46	S, O	Tv (?)	
1S/68-28C1	C. Ronnow and K. Lee	Dr	12	80	4805.6	45.3	3- 1-46	I, O	Qal	Log.
1S/68-28C2	C. Ronnow and K. Lee	Dr	12	92	—	42.3	12-46	N	Qal, Tp	Log.
1S/68-28C3	C. Ronnow and K. Lee	Dr	12	101	—	39.0	12-46	N	Qal	Log.
1S/68-31A1	Nevada State Park	Dr	6	300±	—	—	—	N		
1S/68-32A1	P. Edwards	Dr	12	62	4787.6	33.8	3- 8-46	N	Qal	Log.
1S/68-32A2	P. Edwards	Dr	12	50	4785.2	36.1	3-16-46	N	Qal	Log.
1S/68-32A3	P. Edwards	Dr	10	60	4787.2	35.8	3- 8-46	N, O	Qal	Log.
1S/68-33B1	Elwood Lee et al.	Dr	10	120	4784.7	32.8	3- 1-46	I, O	Qal	Log.
1S/68-33B2	A. B. Edwards	Dr	12	78	4776.4	23.0	3- 8-46	N, O	Qal	Log.
1S/68-33C1	K. Lee	Dr	12	82	4760.0	8.7	3- 8-46	I, O	Qal	Log.
1S/67-32B1	W. R. and A. R. Thorley	Dr, 1946	6	420	—	134.0	4- 8-46	S	Tp	Log.
2S/69-6B1	Soil Conservation Service	Dr	6	300+	—	—	—	S		
2S/68-4C1	Panaca (town well)	Dr. 1940	—	630	—	—	—	N	—	Log.
2S/68-5B1	Geological Survey	B, 1946	4	2	4737.5	1.0	8-26-46	O		
2S/68-5C1	Unknown; Stockyard well	Dg, old	96x96	12	4733.8	10.6	3- 7-46	N, O	Qal	
2S/68-5C2	L. Mathews	Dr	10(?)	80(?)	4736.1	20.7	6-28-46	N	Qal	
2S/68-5C3	L. Mathews	Dr	8	80	4743.0	24.2	3- 7-46	I, O	Qal	
2S/68-6D1	L. Mathews	Dr	—	—	—	—	—	N		Analysis. Log.
2S/68-7A1	A. Findlay	Dr, 1941	10	150	—	—	—	N	—	Log.
2S/68-7A2	P. Findlay	Dr	4	40	4726.5	17.5	3- 7-46	P, O	Qal	
2S/68-7D1	H. Morgan	Dg, old	—	—	4709.5	—	—	D	Qal	
2S/68-7D2	H. Morgan	Dg, old	6x6	28	4709.0	9.4	3- 7-46	—	Qal	
2S/68-8B1	L. Free	Dr, 1945	10	88	4721.7	12.2	3- 7-46	I, O	Qal	Log.
S/68-8B2	Geological Survey	B. 1946	4	16	4717.8	8.9	8-26-46	O	Qal	
S/68-8D1	Geological Survey	B. 1946	4	16	4726.1	4.4	8-26-46	O	Qal	
S/68-9B1	Panaca (town well)	Dr. 1940	6	620	—	22.9	9-20-45	P	Tp	Analysis. Log.
2S/68-16C1	G. Hicks	Dr. 1941	8	300±*	—	—	—	N	—	Dry hole.
2S/68-17B1	Geological Survey	B. 1946	4	16	4705.3	2.3	8-26-46	O	Qal	
2S/68-17C1	Geological Survey	B. 1946	4	16	4700.2	12.0	8-26-46	O	Qal	
2S/68-18A1	Geological Survey	B. 1946	4	20	4700.7	6.6	8-26-46	O	Qal	
2S/68-18D1	L. Free	Dr. 1940	12	300	4701.9	Flow	—	N	Qal, Tp	Log.
2S/68-19C1	C. Mathews	Dr. 1947	12	125	—	Flow	—	N	Qal	Log.
2S/68-19D1	Geological Survey	B. 1946	4	16	4680.8	8.8	8-26-46	O	Qal	
2S/68-30B1	Geological Survey	B. 1946	4	12	4662.3	6.8	6-27-46	O	Qal	
2S/68-30B2	P. Duffin	Dg, old	72x72	10	—	6.3	6-27-46	N	Qal	
2S/67-24D1	P. Duffin; Newman ranch	Dg, old	48x48	10	4677.6	4.0	3- 7-46	N	Qal	
2S/67-25A1	Geological Survey	B. 1946	4	20	4660.0	14.1	8-26-46	O	Qal	
2S/67-25D1	Geological Survey	B. 1946	4	25	4657.4	—	—	—	—	Dry.
2S/67-26D1	Geological Survey	B. 1946	4	25	4641.7	—	—	—	—	Dry.
2S/67-35A1	E. McGuire	Dg, old	—	25±	4643.7	—	—	D		
2S/67-36B1	E. McGuire	Dr, 1941	60x60, 10	80	4645.9	23.2	3- 7-46	I, O	Qal	Log.
3S/67-1B1	Geological Survey	B. 1946	4	20	4588.6	—	—	—	—	Dry.
3S/67-2A1	Grant Lee	Dr, 1940	10	225	4605.1	16.8	3- 1-46	I	Qal	Analysis. Log.
3S/67-2A2	Grant Lee	Dr. 1945	10	120	4610.5	21.2	3- 1-46	N	Qal	Log.
3S/67-2B1	Geological Survey	B. 1946	4	25	4610.0	18.0	12-17-46			
3S/67-2D1	Murray Lee	Dr. 1946	10	105	4592.6	19.2	3-17-46	I	Qal	Log.
3S/67-11A1	Geological Survey	B. 1946	4	20	4576.9	15.8	8-26-46	O	Qal	
3S/67-11B1	Geological Survey	B. 1946	4	20	4579.5	16.2	8-26-46	O	Qal	
3S/67-12B1	Geological Survey	B. 1946	4	20	4524.2	—	—	—	—	Dry.
3S/67-14C1	Geological Survey	B. 1946	4	20	4541.0	12.6	8-26-46	O	Qal	
3S/67-14C2	Geological Survey	B. 1946	4	20	4554.0	—	—	—	—	Dry.
3S/67-15D1	Geological Survey	B. 1946	4	20	4541.1	14.9	8-27-46	O	Qal	
3S/67-21D1	Geological Survey	B. 1946	6	15	4513.1	2.2	4-25-46	O	Qal	
3S/67-22C1	Geological Survey	B. 1946	6	15	4515.8	3.6	3-28-46	O	Qal	
3S/67-22D1	Geological Survey	B. 1946	6	15	4515.6	1.3	3-28-46	O	Qal	
3S/67-22D2	P. Duffin	Dr, 1946	6	48	—	14.7	8-26-46	O, S	Qal, Tp	Log.
3S/67-28A1	Yoachum Ranch	Dg	72x72	16±	—	10±	—	D	Qal	
3S/67-28A2	Geological Survey	B. 1946	6	15	4498.7	3.5	4-25-46	O	Qal	
3S/67-28C1	Cove Inn	Dg	36x36	4±	—	3.2	12-14-46	P	Tv	
3S/67-28C2	Geological Survey; test well	Dr, 1946	6	172	—	+1.8†	12-14-46	O	Qal	Analysis. Log.
3S/67-33B1	Geological Survey	B. 1946	6	15	4472.3	1.9	3- 3-46	O	Qal	
4S/67-4C1	J. Allec	B	8	35	—	12.7	4- 5-46	D	Qal	
4S/67-5C1	W. F. Hubert	Dg, old	60	14±	—	9.7	3-25-46	P, D	Qal	Temp. 115 °F. Analysis.
4S/67-5C2	W. E. Lathrop	Dg, old	60x60	16	—	14.3	3-16-46	D	Qal	Temp. 128 °F. (?)
4S/67-5C3	S. Thompson	Dg, Dr, 1946	48x48, 10	35	—	28.6	6-26-46	N	Qal	Temp. 120 °F. Log.

TABLE 6—*Continued*

Well number and location	Owner	Type and date drilled	Diameter (inches)	Depth (feet)	Altitude of land surface (feet above sea level)	Water Level: Feet below land-surface datum	Water Level: Date	Use	Producing formation	Remarks
S/67-6D1	County Hospital	Dr. old	—	—	—	—	—	P	Qal	
S/67-7A1	City of Caliente; North well	Dr. 1946	12	130	—	10.3	4-30-46	P	Qal	Temp. 107 °F. Log.
S/67-7D1	P. Duffin	Dr. 1941	10	100	—	—	—	N	—	Analysis. Log.*
S/67-8A1	City of Caliente; East well	Dr	10	176	—	20.7	5- 9-46	N		
S/67-8B1	City of Caliente; West well	Dr	8	165	—	19.6	3-16-46	N	Qal	
S/67-8B2	Union Pacific Railroad Co. (Well No. 5)	Dr. 1911	12	116.5	—	18±	8- 1-29	R	Qal	Log.
S/67-8B3	Union Pacific Railroad Co. (Well No. 6)	Dr. 1929	14	150	—	10±	12-21-45	R	Qal	Log.
S/67-8B4	Union Pacific Railroad Co. (Well No. 7)	Dr. 1929	12	180	—	—	—	R	Qal	Log.
S/67-8C1	City of Caliente; South well	Dr	12	181	—	—	—	P	Qal	
S/67-8C2	C. Culverwell	Dr. 1946	12	78	—	6.5	8-26-46	N	Qal	Log.
S/66-25B1	J. Conway	Dr. 1941	—	95	—	—	—	I	Qal	Log.
S/66-25D1	J. Conway	Dr. 1946	12, 10	170	—	3	7-46	I	Qal	Log.
S/66-36B1	J. Conway	Dr. 1941	—	100	—	—	—	N	Qal	Log.
S/66-36B2	J. Conway	Dr. 1941	10	65	—	30.0	5- 6-46	N	Qal	Log.

*Data supplied by E. Muth, formerly Engineer with Soil Conservation Service. †Feet above land-surface.

TABLE 7
LOGS AND CASING RECORDS OF WELLS IN THE MEADOW VALLEY WASH DRAINAGE AREA, NEVADA

6N/67-36C1. D. Free. Drilled by A. W. House. Casing diameter 10 inches to a depth of 68 feet, perforated with knife from 20 to 68 feet. Well developed with air-lift pump, yield less than 150 gallons per minute. Drawdown unknown. Owner's log (from memory).

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Soil	3	3
Sand and gravel, poorly bedded	62	65
Tertiary, Miocene (?)—		
Volcanic bedrock	10	75
Total depth	—	75

6N/66-36C1. Bureau of Land Management; Poney well. Drilled by J. W. Cole. Owner's log (from memory).

Material	Thickness (feet)	Depth (feet)
Quaternary, Earlier Alluvium—		
Silt, cemented gravel at 20 feet	20	20
Sand, black	142	162
Total depth	—	162

4N/60-13B1. Bureau of Land Management; Spring Valley Holding Corral well. Casing diameter 6 inches to a depth of 206 feet, perforations from 166 to 206 feet. Bailing test, 12 gallons per minute. Drawdown 4 feet. Driller's log.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Clay and sand, surface	10	10
Tertiary, Pliocene Panaca (?) Formation—		
"Quartz sand"	196	206
Total depth	—	206

4N/66-2C1. Bureau of Land Management; Craw Creek well. Casing diameter 8 inches to a depth of 34 feet. Driller's log.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Clay, gray, medium-hard	17	17
Rock, white, hard; possibly caliche (?)	23	40
Clay, sandy, rocky, gray, hard	8	48
Tertiary, Pliocene Panaca (?) Formation—		
Clay, sandy, hard, red	50	98
Clay, sandy, rocky, gray, hard	132	230
Sand, medium-hard, black	4	234
Clay, sandy, light-gray, medium-hard	26	260
Total depth	—	260

3N/67-23C1. Bureau of Land Management; Benchland well. Casing diameter 6 inches to a depth of 399 feet, perforations from 375 feet to 399 feet. Water rose 7 feet in casing during drilling operations. Driller's log.

Material	Thickness (feet)	Depth (feet)
Quaternary, Earlier Alluvium—		
Porphyry and clay	400	400
Total depth		400

TABLE 7—*Continued*

3N/66-2D1. Bureau of Land Management; Twentyonemile Holding Corral well. Casing diameter 6⅝ inches to a depth of 139 feet. Water first struck at 112 feet, rose to 90 feet below land surface. Driller's log.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Clay, sandy, dark, medium-hard	9	9
Tertiary, Pliocene Panaca Formation—		
Clay, sandy, red, medium-hard	16	25
Clay, sandy, red, soft	115	140
Total depth	—	140

3N/66-15B2. Jackrabbit Mine. Casing diameter 6 inches to a depth of 160 feet. Perforated from 80 to 100 feet and from 140 to 160 feet. Reportedly water rose when encountered at 80 feet to within 20 feet of land surface. Owner's log (from memory).

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Soil, silt, and fine sand	80	80
Gravel	10	90
Silt, and small amounts of gravel	30	120
Gravel	40	160
Total depth	—	160

2N/69-35A1. William Dyer (in Eagle Valley). Drilled by Andrews. Casing diameter 7 inches to a depth of 87 feet. Owner's log (from memory).

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Soil and boulders	6	6
Sand	11	17
Clay	4	21
Gravel and sand	66	87
Total depth	—	87

2N/66-25D1. Bureau of Land Management; Airport well. Drilled by J. A. Williams. Casing diameter 6 inches to a depth of 600 feet. Driller's log.

Material	Thickness (feet)	Depth (feet)
Quaternary, Earlier Alluvium—		
Cemented lime gravel	378	378
Unknown—		
Bedrock	22	400
Total depth	—	400

1N/69-16D1. Les Lytle. Drilled by J. A. Williams. Diameter casing 10 inches to a depth of 76 feet. Well tested, yield 150 gallons per minute, drawdown 24 feet. Driller's log.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Soil	15	15
Sand, gravel, and some clay	61	76
Total depth	—	76

1N/69-21A1. Les Lytle; East well. Drilled by J. A. Williams. Casing diameter 10 inches to a depth of 88 feet, perforated from 22 to 88 feet, slots 5 inches by ¼ inch. Well tested in 1941, yield 350 gallons per minute, drawdown 8 feet. Well used during summer seasons for irrigation, gradual decline in yield. Well surged and redeveloped September 1946 by D. Free. Deep-well turbine installed, yield 450 gallons per minute, drawdown 26 feet after 1 hour of pumping. Driller's log.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Soil	16	16
Sand and gravel, interbedded	72	88
Total depth	—	88

TABLE 7—*Continued*

1N/69-21D1. John Devlin et al. (in Rose Valley). Drilled by J. A. Williams. Casing diameter 10 inches to a depth of 87 feet, perforated from 15 to 72 feet. Estimated yield 350 gallons per minute, drawdown 11 feet after 4 hours pumping. Driller's log.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Silt and soil	8	8
Sand	9	17
Gravel and sand	68	85
Tertiary, Miocene (?)—		
Volcanic rock	2	87
Total depth	—	87

1N/67-2D3. Pioche Rodeo Association. Well drilled by D. Free and J. A. Williams. Casing diameter 8 inches to a depth of 200 feet; uncased 200 to 425 feet, 6-inch casing from 425 to 530 feet, 6-inch casing perforated. Perforation slots ¼ to ½ by 4 inches staggered in rows, 5 rows in circumference. First water at 425 feet, rose to 138 feet. Deep-well turbine installed October 1946, yield 80 gallons per minute.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Sand, silt, quartzite, and limestone boulders	35	35
Tertiary, Pliocene Panaca Formation—		
Clay, yellow to orange, plastic. Less than 1% sand grains by volume	390	425
Sand and grit, reddish brown, bedded. Composition essentially uniform; brown quartzite, 90%; limestone, 5%; quartz crystals, 2%; volcanic rock fragments, 3%. Small amounts heavy minerals, magnetite (?), galena (?)	105	530
Total depth	—	530

NOTE—Two wells 100 feet away from this well were drilled to depths of 210 and 230 feet, respectively; log similar but no water.

1S/69-7C1. Soil Conservation Service (Delmue's dam site). Well No. 1. Drilled by Soil Conservation Service for test purposes. Driller's log.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Sand	2	2
Gumbo, black	13	15
Sand	2½	17½
Gumbo, black	9½	27
Gumbo, tough	4	31
Sand	2	33
Gumbo, black	14	47
Clay and sand	3	50
Clay	6	56
Sand, yellow	4	60
Gravel, hard	3	63
Tertiary, Miocene (?)—		
Rock, altered volcanic	2	65
Total depth	—	65

1S/69-7C2. Soil Conservation Service (Delmue's dam site). Well No. 2 Drilled by Soil Conservation Service for test purposes. Driller's log.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Sand	4	4
Gumbo, black	11	15
Sand	½	15½
Gumbo, black	15½	31
Clay and sand	2	33
Gumbo, black	3	36
Clay and sand	2	38
Gumbo	16	54
Clay and sand	6	60
Clay	4	64
Silt, soft	6	70
Sandstone, yellow	4	74
Gravel, hard	4	78
Tertiary, Miocene (?)—		
Rock, volcanic	—	78
Total depth		78

TABLE 7—*Continued*

1S/69-7C3. Soil Conservation Service (Delmue's dam site). Well No. 3. Drilled by Soil Conservation Service for test purposes. Driller's log.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Soil	4	4
Sand	2	6
Gumbo, black	10	16
Sand	½	16½
Gumbo, black	9½	26
Clay and gumbo	4	30
Gumbo	3	33
Tertiary, Miocene (?)—		
Rock, volcanic	—	33
Total depth	—	33

1S/69-7C4. Soil Conservation Service (Delmue's dam site). Well No. 4. Drilled by Soil Conservation Service for test purposes. Driller's log.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Gravel	3	3
Gumbo, soft	8	11
Sand	1	12
Gumbo	15	27
Sand	1½	28½
Gumbo	11½	40
Sand	8	48
Clay	4	52
Clay and sand	4	56
Gravel and sand	4	60
Tertiary, Miocene (?)—		
Altered rock	2	62
Rock, volcanic	—	62
Total depth	—	62

1S/69-7C5. Albert Delmue. Drilled by J. A. Williams. Casing diameter 10 inches to a depth of 88 feet, perforated from 52 to 85 feet. Yield 1941, 350 gallons per minute, drawdown 26 feet. Yield 1946, 175 gallons per minute, drawdown 46 feet. Owner's log (from memory).

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Clay, blue	10	10
Silt and clay	45	55
Gravel	5	60
Clay, sand, and silt	25	85
Tertiary, Pliocene Panaca Formation—		
Clay, yellow	5	90
Total depth	—	90

1S/69-7D1. Albert Delmue. Drilled by J. A. Williams. Well abandoned, insufficient water. Owner's log (from memory).

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Silt and soil	10	10
Tertiary, Pliocene Panaca Formation—		
Clay and silt, red-orange	240	250(?)
Total depth	—	250(?)

1S/69-20D1. Bureau of Land Management. Casing diameter 6 inches to a pth of 313 feet. First water at 292 feet, rose to 263 feet. Driller's log.

Material	Thickness (feet)	Depth (feet)
uaternary, Earlier Alluvium—		
Gravel and sand, gray, medium-hard	90	90
ertiary, Pliocene Panaca Formation—		
Sand and clay, brown, medium-hard	150	240
Gravel, hard, gray, cemented	10	250
Clay, brown, medium-hard	10	260
Clay, sand, and rocks, brown, medium-hard	28	288
Hardpan	2	290
Sand and gravel, hard, brown	23	313
Total depth		

TABLE 7—*Continued*

1S/68-28C1. C. Ronnow and K. Lee. Casing diameter 12 inches to a depth of 75 feet, uncased 75 to 80 feet. Yield 175 gallons per minute with 8 feet of drawdown, pump bowls at 65 feet. Owner's log (from memory).

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Gravel and sand, surface	15	15
Tertiary, Pliocene Panaca Formation—		
Gravel and silt, orange	60	75
Unknown—		
Limestone (?)	5	80
Total depth	—	80

1S/68-28C2. C. Ronnow and K. Lee. Drilled by D. Free. Diameter 12 inches. Well tested, yield 20 gallons per minute. Water rose in hole from 77 to 35 feet below land surface. Driller's log.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Sand, gravel, silt; valley fill	20	20
Tertiary, Pliocene Panaca Formation—		
Rock and clay, very tight	70	90
Tertiary, Miocene (?)—		
Volcanic bedrock	2	92
Total depth	—	92

1S/68-28C3. C. Ronnow and K. Lee. Drilled by D. Free. Casing diameter 12 inches to a depth of 100 feet. Developed with 3-inch air-lift pump, yield 125 gallons per minute, drawdown 3 feet. Driller's log.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Sand, gravel, silt	65	65
Gravel, coarse	36	101
Tertiary, Miocene (?)—		
Volcanic bedrock (?) at bottom	—	101
Total depth	—	101

1S/68-32A1. Paul Edwards. Drilled by D. Free. Casing diameter 10 inches to a depth of 63 feet. First water at 37 feet, rose within 33 feet of land surface. Tested with air-lift pump for 8 hours, yield 36 gallons per minute. Drawdown 17 feet. Owner's log (from memory).

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Silt and loam	30	30
Clay	10	40
Gravel and clay, brown, interbedded	2	42
Gravel, rounded, and clay	11	53
Gravel, porous	5	58
Unknown—		
Limestone bedrock	4	62
Total depth	—	62

1S/68-32A2. Paul Edwards. Drilled by D. Free. Well tested with air-lift pump, insufficient yield, abandoned. Owner's log (from memory).

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Loam, no rock	40	40
Gravel and loam	10	50
Total depth	—	50

TABLE 7—*Continued*

1S/68–32A3. Paul Edwards. Drilled by D. Free. Casing diameter 10 inches to a depth of 60 feet. First water at 40 feet, rose within 36 feet of land surface. Reported that while pumping 350 gallons per minute from adjacent well, this well was yielding 100 gallons per minute with no apparent drawdown. Owner's log (from memory).

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Soil with gravel	40	40
Clay and mud	10	50
Gravel and fine sand	10	60
Unknown—		
Limestone bedrock	----	60
Total depth	----	60

1S/68–33B1. Elwood Lee et al., (Lafe Mathews well). Drilled by J. A. Williams. Casing diameter 10 inches to a depth of 80 feet, uncased 80 to 120 feet, perforated from 60 to 80 feet. Reportedly well tested at 350 gallons per minute, drawdown 5 feet. Well caved. Yield June 1946, 225 gallons per minute, drawdown 20 feet. Owner's log (from memory).

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Gravel and clay	30	30
Gravel and sand	80	110
Unknown—		
Limestone (?)	10	120
Total depth	----	120

1S/68–33B2. Albert B. Edwards. Drilled by L. Mathews. Casing diameter [illegible] inches. Well developed with air-lift pump, estimated yield 110 gallons per minute, drawdown 9 feet after 2 hours pumping. Owner's log (from memory).

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Gravel fill	55	55
Gravel, clean	10	65
Clay	5	70
Gravel, poorly sorted	8	78
Total depth	----	78

1S/68–33C1. Kenneth Lee. Drilled by D. Free. Casing diameter 12 inches to a depth of 62 feet. Casing perforated from 18 to 62 feet, perforation slots ¼ to ⅛ by 12 inches staggered in rows, 5 rows in circumference. First water encountered at 18 feet, rose within 8.7 feet of land surface. Yield 725 gallons per minute, drawdown 17 feet after 24 hours of pumping. Driller's log.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Sand and gravel, organic material	18	18
Sand, silt, and gravel, mixed, highly permeable	64	82
Total depth	----	82

1S/67–32C1. W. R. and A. R. Thorley. Drilled by Harry Wilson. Diameter casing 6 inches to a depth of 200 feet, uncased 200 to 420 feet. First water at 20 feet. Test, 8 gallons per minute, drawdown 155 feet after 2 hours pumping. Pump bowls at 310 feet. Driller's log.

Material	Thickness (feet)	Depth (feet)
Tertiary, Pliocene Panaca Formation—		
Silt and sand, brown and orange	192	192
Clay, hard	4	196
Sand, angular, fine	134	330
Gravel, fine, red	5	335
Grit and sand	85	420
Total depth	----	420

TABLE 7—*Continued*

2S/68–4C1. Panaca, town well. Abandoned, insufficient yield. Driller's log.

Material	Thickness (feet)	Depth (feet)
Tertiary, Pliocene Panaca Formation—		
Clay	335	335
Clay, chert beds (?)	5	340
Clay, sand, and fine gravel, angular to subrounded	30	370
Sand and fine gravel, angular to subrounded, clay	30	400
Clay, gray-green. Sand and fine gravel 50% by volume	35	435
Clay, small amounts of sand and fine gravel	50	485
Sand and gravel 60% by volume; clay, gray-green	5	490
Clay	140	630
Total depth	----	630

2S/68–5C3. Lester Mathews. Drilled by Lory Free. Casing diameter 8 inches to a depth of 72 feet, uncased 72 to 80 feet, perforations from 32 to 42 feet. Well tested with turbine pump, yield 315 gallons per minute after 4 hours of pumping, drawdown 17 feet. Pump bowls set at 45 feet. Owner's log (from memory).

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Sandy silt, light-brown	30	30
Sand, fine	2	32
Gravel	7	39
Loam	5	44
Gravel	1	45
Quicksand, some gravel	35	80
Total depth	----	80

2S/68–7A1. Allen Findlay. Drilled by J. A. Williams. Diameter 10 inches, no casing installed. Well tested for 10 hours, at beginning well yielded 290 gallons per minute, drawdown 13 feet; after 2 hours well yielded 200 gallons per minute, drawdown 22 feet. After 10 hours yield was reduced to 163 gallons per minute, drawdown 30 feet. Well abandoned, insufficient yield. Driller's log.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Sandy loam, valley fill	20	20
Gravel and sand, water-bearing	10	30
Silt, clay, and sand	40	70
Tertiary, Pliocene Panaca Formation—		
Red clay, heavy and compact	80	150
Total depth	----	150

2S/68–8B1. Lory Free. Drilled by L. Free. Casing diameter 10 inches to a depth of 76 feet, uncased 76 to 88 feet, perforations believed to be from 20 to 76 feet. Yield 585 gallons per minute, drawdown 28 feet after 24 hours continuous pumping. Owner's log (from memory).

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Sandy loam	20	20
Gravel, fine	4	24
Sandy loam	15	39
Clay, red	4	43
Gravel	2	45
Clay, red	15	60
Gravel	2	62
Clay, blue	8	70
Gravel, coarse	6	76
Clay, blue	12	88
Total depth	----	88

Table 7—*Continued*

2S/68–9B1. Panaca, town well. Diameter 6 inches. Deep-well turbine nstalled, yield 70 gallons per minute, drawdown 150 feet.

Material	Thickness (feet)	Depth (feet)
Tertiary, Pliocene Panaca Formation—		
Silt and sand, fine, light-tan, organic material	25	25
Sand and silt, light-brown; few angular green chert and quartzite fragments	22	47
Silt and clay, green to white; 1 percent angular fragments of quartzite, limestone, and volcanic material, size 1" to 1/16" in diameter. Microscopic examination reveals detrital materials, no shards, abundant diatom tests	18	65
Mudstone and silt, organic material. Dark-gray to white	20	85
Sample from 85 to 200 feet missing	115	200
Clay and fine silt, light-gray to white. Few scattered sand grains. Probably poor representative sample of entire 100 feet. Microscopic examination reveals detrital material, no shards, abundant calcium carbonate	100	300
Limestone, angular fragments imbedded in silt and clay, light-green. Calcium carbonate root casts	5	305
Clay, gray-green; quartzite, limestone, and volcanic fragments, less than 1%	30	335
Silt and clay, light-brown; limestone grains, less than 1%. Organic material	10	345
Clay and silt, white to light-gray; angular subrounded limestone fragments, about 5%. Microscopic examination reveals detrital materials, no shards, abundant calcium carbonate	10	355
Sand and fine gravel. Sample washed, matrix light-gray clay and silt	10	365
Limestone and rhyolitic sand and fine gravel, grains subangular to subrounded. Silt and clay matrix, light-gray	15	380
Limestone and rhyolitic sand and fine gravel. Clay matrix, light gray-green	15	395
Limestone and rhyolitic sand and fine gravel, 40% by volume. Silt and clay, light-gray, 60% by volume	15	410
Silt and clay, light-gray 75% by volume. Fine gravel 25% by volume	15	425
Silt and clay, light-gray to green. Sand, coarse to fine, 50% by volume. Calcium carbonate oolites. Microscopic examination reveals detrital materials, no shards, abundant calcium carbonate	15	440
Silt and clay, light-green, 90% by volume. Coarse limestone and rhyolitic sand	15	455
Silt and clay, light olive green, few angular chert fragments	20	475
Silt and clay, light olive green. Sand and fine gravel, 15% by volume	10	485
Silt and clay, olive-green. Fine sand 50% by volume. Calcium carbonate oolites	20	505
Silt and clay, olive-green. Fine sand 20% by volume	5	510
Silt and clay, light-green. Sand and grit, limestone and rhyolite fragments	5	515
Clay, dark-green to black. Organic material. Microscopic examination reveals silt, carbonate dust (?), no shards; diatom tests	10	525
Clay and silt, green. Limestone sand grains, 50% by volume	10	535
Clay and silt, gray-green. Limestone sand grains, subrounded and less than 1% by volume	10	545
Clay and silt, light-green. Limestone sand grains, about 2% by volume	40	585
Clay and silt, light-brown. Angular limestone, sand grains	35	620
Total depth	----	620

2S/68–16C1. George Hicks. Drilled by J. A. Williams. Well filled, aban-ed. Owner's log (from memory).

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Sand and gravel, little water	30	30
Tertiary, Pliocene Panaca Formation—		
Silt and clay	270±	300±
Total depth	----	300±

Table 7—*Continued*

2S/68–18D1. Lory Free. Drilled by M. W. Hicks. Diameter 12 inches, uncased. Dry hole to 95 feet, at 95 feet water rose within 2 feet below land surface. During winter months well flows at land surface. Tested with air-lift pump, drawdown greater than 100 feet, yield about 40 gallons per minute. Well abandoned, insufficient yield. Owner's log (from memory).

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Clay, hard, yellow-orange	95	95
Gravel	1	96
Clay	3	99
Gravel	1	100
Tertiary, Pliocene Panaca Formation—		
Clay, yellow and blue	80±	180±
Gravel, small	5±	185±
Clay, blue	100±	285±
Gravel	15±	300±
Total depth	----	300±

2S/68–19C1. Clyde Mathews. Drilled by D. Free. Casing diameter 12 inches to a depth of 100 feet, uncased 100 to 125 feet. First water at 12 feet, rose to land surface, natural flow 25 gallons per minute. Well tested with 3-inch air-lift pump for 8 hours, 21 feet of drawdown, natural flow increased to 50 gallons per minute. Driller's log.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Clay and silt, blue	85	85
Sand and silt	15	100
Gravel, coarse	9	109
Gravel, very coarse	16	125
Total depth		125

2S/67–36B1. E. McGuire. Drilled by J. A. and Chet Williams. Wood cribbing 5 feet square to a depth of 25 feet, 10-inch casing from 25 to 60 feet. Horizontal centrifugal pump, yield 270 gallons per minute, drawdown 20 feet. Owners log (from memory).

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Soil, sand, and gravel	30	30
Silt and fine sand	40	70
Gravel and sand	10	80
Total depth	---	80

3S/67–2A1. Grant Lee. Drilled by J. A. Williams. Diameter 10 inches to a depth of 198 feet, perforated from 44 to 198 feet. Reportedly well developed for about 10 days before pump installed. Yield June 1946, 450 gallons per minute. Driller's log.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Silt and clay, light-brown	28	28
Gravel, clay	75	103
Gravel	77	180
Tertiary Pliocene Panaca Formation—		
Clay	45	225
Total depth		225

3S/67–2A2. Grant Lee. Drilled by G. Lee and Lory Free. Casing diameter 10 inches to a depth of 120 feet. Well pumped sand and eventually sanded in and was abandoned. Owner's log (from memory).

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Silt, fine sand, and a little gravel	120	120
Total depth	---	120

TABLE 7—*Continued*

3S/67–2D1. Murray Lee. Drilled by D. Free. Casing diameter 10 inches to a depth of 70 feet, uncased 70 to 105 feet. Perforated from 20 to 70 feet. Perforation slots ¼ to ⅛ inch by 12 inches staggered in rows, 5 rows in circumference. Well developed with air-lift pump. Deep-well turbine installed April 1946. Yield 316 gallons per minute. Owner's log (from memory).

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Clay, brown	18	18
Clay and a little gravel; gravel size ¼-inch to 2-inch	16	34
Mud, gray; sand, black	23	57
Clay and silt	21	78
Clay, gravel, and sand	18	96
Clay	9	105
Total depth	----	105

3S/67–22D2. Press Duffin. Drilled by D. Free. Casing diameter 6 inches to a depth of 48 feet. Casing perforated from 20 to 48 feet. Water rose from 30 feet to within 15 feet of land surface.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Soil	6	6
Tertiary, Pliocene Panaca Formation—		
Clay, red-orange	26	32
Sand, medium	16	48
Total depth	----	48

3S/67–28C2. U. S. Geological Survey; Test well. Drilled by William Deane. Casing diameter 6 inches to a depth of 161 feet, uncased 161 to 172 feet. Casing perforated from 60 to 117 feet, and from 128 to 161 feet. Perforation slots ¼ to ⅛ by 12 inches staggered in rows, 5 rows in circumference. Well developed for 15 hours, natural flow at land surface 25 gallons per minute. Tested with centrifugal pump, yield 200 gallons per minute, drawdown 13 feet.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Clay and silt, blue-gray	50	50
Clay, tan, small amount of sand	12	62
Coarse sand, grit, and fine gravel, interbedded and rounded. Cobbles about 5% by volume. Volcanic debris	104	166
Tertiary, Miocene (?)—		
Bedrock. Andesite, gray	6	172
Total depth	----	172

4S/67–4C1. Joe Allec. Well bored by Joe Allec. Diameter 8 inches to a depth of 35 feet. Owner's log (from memory).

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Clay and sand	35±	35±
Total depth	----	35±

4S/67–5C3. Sam Thompson. Diameter 5 feet to a depth of 15 feet. Casing diameter 12 inches from 15 to 35 feet. Casing perforated entire length. Perforation slots ¼ to ⅛ by 12 inches, staggered in rows, 5 rows in circumference. Thermal water (120°F.), hydrogen sulfide odor. Well is located in extinct hot spring area. Driller's log.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Valley fill. Fine silt and sand containing angular volcanic rocks	35	35
Total depth	----	35

TABLE 7—*Continued*

4S/67–7A1. City of Caliente: North well. Drilled by D. Free. Casing diameter 12 inches to a depth of 128 feet, open hole below. Casing perforated 20 to 128 feet. Perforation slots ¼ to ⅛ by 12 inches, staggered in rows, 5 rows in circumference. During drilling operations first water of 10 feet was thermal (82° F.). Cold water encountered at 15 feet; from about 30 to 100 feet the temperature remained about 78° F.; at 100 feet temperatnre increased to 90° F., and at 128 feet it was 94 degrees F. During 12 hours of intermittent pumping at about 700 gallons per minute, temperature gradually increased to 107° F. Developed for 16 hours by air-lift pump. Deep-well turbine installed, yield after 3 hours of pumping 694 gallons per minute, drawdown 20 feet. This well is in extinct hot spring area.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Silt and loam	10	10
Clay, light-gray to white	2	12
Clay, light-brown	4	16
Silt and clay, light-brown. Sand 2% by volume	9	25
Clay and silt, light-brown to gray. Fine sand ranges from 2% to 4% by volume	30	55
Silt and clay, tan to gray. Sand, rhyolitic and limestone, 30% by volume	10	65
Silt and clay. Sand 15% by volume	15	80
Silt and clay. Sand 20% to 30% by volume	15	95
Clay and silt, gray	5	100
Silt, gray; sand, fine to coarse, 40% to 60% by volume	30	130
Total depth	----	130

4S/67–7D1. Press Duffin. Drilled by J. A. Williams. Well on west edge of Meadow Valley Wash, near bedrock exposures. Casing diameter 10 inches to a depth of 100 feet, perforated from 80 to 100 feet. Reportedly well tested and yielded 200 gallons per minute. Owner's log (from memory).

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Soil	6	6
Clay and silt, blue-gray	74	80
Gravel	20	100
Tertiary, Miocene (?)—		
Volcanic bedrock	----	100
Total depth	----	100

4S/67–8B2. Union Pacific Railroad; Well No. 5. Casing diameter 12 inches, original casing 116 feet of 12-inch heavy drive pipe without perforations; new 10-inch casing installed 1930. Well pumped by air lift. Foot piece at 108 feet. Capacity 300 gallons per minute. Data and log furnished by Union Pacific Railroad Company.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Sand and earth	5	5
Quicksand; water-bearing	30	35
Clay, brown	71	106
Gravel, red	10½	116½
Total depth	----	116½

TABLE 7—*Continued*

4S/67-8B3. Union Pacific Railroad; Well No. 6. Casing diameter 14 inches to a depth of 150 feet. Casing perforated between 113 and 150 feet, 80 perforations measuring ½ inch by 2 inches. Test made April 1929, well furnished 500 gallons per minute, 9-foot drawdown. Data and log furnished by Union Pacific Railroad Company.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Sand and gravel, surface	15	15
Gravel, large, sand, and clay	15	30
Gravel and sand, large, water-bearing	8	38
Sandy clay, brown	12	50
Clay, black gumbo	30	80
Sand, fine, and gravel	8	88
Gravel, coarse, and sand	4	92
Clay, brown gumbo	16	108
Clay, sandy	5	113
Gravel, large, and sand	3	116
Rock and fine sand, and gravel	24	140
Sand and gravel, large rocks, water-bearing	10	150
Total depth	---	150

4S/67-8B4. Union Pacific Railroad; Well No. 7. Casing diameter 12 inches to a depth of 171 feet, with 400 perforations between 70 and 118 feet, measuring ¼ inch by 2 inches. Tested with air-lift pump, well developed 300 gallons per minute, 13-foot drawdown. Tested November 15, 1929, steam pump, well furnished 240 gallons per minute with 8-foot drawdown. Casing reperforated July 1944. From 63 to 120 feet, 311 ⅜-inch by 2 inch perforations, and from 63 to 173 feet, 207 ½ by 2½-inch perforations. Turbine pump installed. Well furnishes 450 gallons per minute with 35-foot drawdown. Data and log furnished by Union Pacific Railroad Company.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Sandy clay	30	30
Sand and gravel, water-bearing	7	37
Sandy clay	28	65
Sand and rocks, water-bearing	5	70
Sand and large rocks, water-bearing	34	104
Hard rock, conglomerate	27	131
Clay, gravel, and sand, cemented	7	138
Rocks, clay, and sand, cemented	19	157
Conglomerate, red	6	163
Rocks, sand, and clay, cemented	15	178
Loose cemented formation, water-bearing	2	180
Total depth		180

4S/67-8C2. Charles Culverwell. Drilled by D. Free. Casing diameter 12 inches to a depth of 76 feet, open hole 76 to 78 feet. Casing perforated from 10 to 76 feet. Perforation slots ¼ to ⅛ by 12 inches staggered in rows, 5 rows in circumference. Well developed with air-lift pump for 8 hours; yield 430 gallons per minute, drawdown 7 feet. Well flowing approximately 20 gallons per minute at land surface in December 1946. Well drilled at site of once-flowing springs.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Silt and clay, gray-blue to black	8	8
Sand and gravel, coarse and in alternate lenses	70	78
Total depth		78

4S/66-25B1. John Conway. Well drilled by J. A. Williams. Well drilled at mouth of Meadow Valley Wash. Reportedly well tested for 48 hours, yield, 225 gallons per minute with 4-foot drawdown; after pumping static level rose 4 feet; well pumped much fine sand and silt. Driller's log.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Gravel and soil	10	10
Sand and gravel, interbedded and mixed	85	95

TABLE 7—*Continued*

4S/66-25D1. John Conway. Drilled by D. Free. Casing diameter 12 inches to a depth of 115 feet. Casing perforated from 15 to 115 feet. Five rows of perforations in casing circumference. Perforation slots ¼ to ⅛ by 12 inches staggered in rows, 5 rows in circumference. Standing water level 10 feet. Air-lift pump installed, yield at first 50 gallons per minute; after 36 hours of pumping yield increased gradually to 250 gallons per minute. Pumped much sand and silt, drawdown greater than 60 feet. Well deepened to 170 feet, casing diameter 10 inches from 115 to 170 feet. Perforated with ax. Standing water level at 4 feet. Tested 4 hours with air-lift pump, yield 420 gallons per minute, drawdown 28 feet; pumped much sand and silt. Well caved.

Pilot hole drilled 6 feet away from first to depth of 85 feet. Thirty-five cubic yards ¼-inch to ½-inch angular volcanic gravel packed around well casing through pilot well. Well surged and pumped during gravel packing. Well cleaned out to 163 feet with air-lift pump and tested with deep-well turbine pump. Yield about 175 gallons per minute, drawdown 55 feet.

After six weeks of intermittent pumping well suddenly yielded about 400 gallons per minute for about 6 hours. After 8 hours of pumping yield declined to less than 200 gallons per minute. Deep-well turbine installed November 1946. Driller's log.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Soil	10	10
Clay, silt, fine sand, gray-blue and black	50	60
Sand, fine, black, and some clay	20	80
Sand, fine, and clay, thin beds	40	120
Sand and gravel, well-rounded and coarse	43	163
Volcanic bedrock	7	170
Total depth		170

4S/66-36B1. John Conway. Drilled by J. A. Williams. Abandoned, insufficient yield. Driller's log.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Gravel and soil	25	25
Gravel	37	62
Hardpan	1	63
Gravel	37	100
Total depth	---	100

4S/66-36B2. John Conway. Drilled by J. A. Williams. Casing diameter 10 inches to a depth of 65 feet. First water at 31 feet, rose within 28 feet of land surface. Driller's log.

Material	Thickness (feet)	Depth (feet)
Quaternary, Later Alluvium—		
Gravel and sand	64	64
Gravel, cemented	1	65
Total depth	---	65

TABLE 8

MEASUREMENTS OF WATER LEVEL IN OBSERVATION WELLS, 1946

3N/66-2D1. Bureau of Land Management; Twentyonemile Holding Corral well. Drilled stock well, diameter 6 inches, depth 140 feet. Measuring point, top of casing, at land surface. Taps water in the Panaca formation.

Date	Water level in feet below measuring point	Date	Water level in feet below measuring point
April 12	92.42	July 26	92.39
May 24	92.92	December 21	89.±

TABLE 8—*Continued*

3N/66-23D1. Bureau of Land Management. Fifteenmile dug well. Unused well dug 6 feet square, depth 45 feet. Measuring point, top of 3 by 4 inch timber marked M with green paint, at land surface. Taps water in later valley fill.

Date	Water level in feet below measuring point	Date	Water level in feet below measuring point
April 12	42.46	June 27	Dry
May 23	42.53	December 20	43.71

1N/69-21D1. John Devlin et al. Drilled irrigation well, diameter 10 inches, depth 87 feet. Measuring point, top of casing, 2.0 feet above land surface. Taps water in later valley fill.

Date	Water level in feet below measuring point	Date	Water level in feet below measuring point
March 23	10.55	July 31	12.91
April 7	6.63	October 22	12.60
April 25	7.93	December 16	13.15
May 24	10.46		

1S/68-13A1. Civilian Conservation Corps. Drilled stock and domestic well, diameter 8 inches, depth 76 feet. Measuring point, top of flange on casing, at land surface. Believed to tap water in Tertiary volcanic rocks.

Date	Water level in feet below measuring point	Date	Water level in feet below measuring point
March 23	29.46	July 31	29.45
April 8	29.34	October 22	29.60
April 25	29.34	December 16	29.30
May 24	29.18		

1S/68-28C1. C. Ronnow and K. Lee. Drilled irrigation well, diameter 12 inches, depth 80 feet. Measuring point, bottom of air line intake slot on north side of casing, 0.5 foot above land surface. Land-surface altitude 4,805.6 feet. Taps water in later valley fill.

Date	Water level in feet below measuring point	Date	Water level in feet below measuring point
September 20 (1945)	46.03	April 5	45.24
March 1	45.81	April 14	45.00
March 7	45.98	April 25	44.73
March 16	45.37	May 26	45.22
March 21	45.35	June 11	48.75
March 28	45.20	July 28	46.59

1S/68-32A3. Paul Edwards. Drilled irrigation well, diameter 10 inches, depth 66 feet. Measuring point, top of casing, 0.9 feet above land surface. Land-surface altitude 4,787.2 feet. Taps water in later valley fill.

Date	Water level in feet below measuring point	Date	Water level in feet below measuring point
March 8	36.68	May 9	33.09
March 16	36.37	May 26	33.87
March 21	35.38	June 26	35.18
April 5	33.97	July 27	36.19
April 14	33.52	August 26	36.79
April 25	32.98	December 16	36.70

TABLE 8—*Continued*

1S/68-33B1. Elwood Lee et al. Drilled irrigation well, diameter 10 in depth 120 feet. Measuring point, top of air line intake hole on pump b 0.3 foot above land surface. Land-surface altitude 4,784.7 feet. Taps w in later alluvium.

Date	Water level in feet below measuring point	Date	Water le in feet be measuring p
March 1	33.06	April 25	30.62
March 7	32.13	May 26	33.1
March 16	33.64	June 27	33.08
March 21	32.32	July 28	33.48
March 28	31.97	November 2	33.72
April 5	31.57	December 16	33.2
April 14	30.83		

1S/68-33B2. Albert B. Edwards. Drilled irrigation well, diamet inches, depth 78 feet. Measuring point, top of casing, 1.0 foot above land face. Land-surface altitude 4,776.4 feet. Taps water in later alluvium.

Date	Water level in feet below measuring point	Date	Water le in feet b measurin
March 8	24.03	May 9	22.1
March 16	23.08	May 26	22.8
March 21	22.95	June 27	24.0
April 5	22.63	July 28	24.6
April 14	21.78	November 2	24.7
April 25	21.78	December 16	24.2

1S/68-33C1. Kenneth Lee. Drilled irrigation well, diameter 12 in depth 82 feet. Measuring point, top of casing, 1.5 feet above land sur Land-surface altitude 4,760.0 feet. Taps water in later alluvium.

Date	Water level in feet below measuring point	Date	Water l in feet b measuring
March 8	10.21	May 9	8.7
March 16	9.10	June 27	11.6
March 21	9.30	July 28	10.7
April 5	8.72	November 2	10.4
April 14	6.47	December 16	10.1
April 25	7.81		

2S/68-5B1. U. S. Geological Survey. Bored observation well, diame inches, depth 2 feet. Measuring point, top of 2-inch wood stake, at land face. Land-surface altitude 4,737.5 feet. Taps water in later alluvium Bullionville Springs. Water level in feet below measuring point, Aug 1.00; Dec. 15, 0.00. (No flow).

2S/68-5C1. Unknown; Stockyard well. Unused dug well 8 feet sq depth 12 feet. Measuring point, top edge of 4-inch by 6-inch timber on s side of head frame, 1.5 feet below land surface. Land-surface altitude 4,7 feet. Taps water in later alluvium.

Date	Water level in feet below measuring point	Date	Water le in feet bel measuring
March 7	9.07	May 26	9.58
March 16	9.07	June 26	10.12
March 21	9.08	July 27	10.64
April 5	9.05	August 26	10.94
April 14	9.18	November 2	10.91
April 25	9.21	December 16	10.37
May 9	9.32		

TABLE 8—*Continued*

2S/68-5C3. Lester Mathews. Drilled irrigation well, diameter 8 inches, th 80 feet. Measuring point, top of casing, 0.8 foot above land surface. surface altitude 4,743.0 feet. Taps water in later alluvium.

Date	Water level in feet below measuring point	Date	Water level in feet below measuring point
tember 20 (1945)	25.8	April 25	24.94
rch 7	25.01	May 9	24.97
rch 16	24.99	May 26	25.36
rch 21	24.98	June 26	25.80
rch 27	24.92	July 27	26.38
il 5	24.94	November 2	26.27
il 14	24.94	December 16	25.83

2S/68-7A2. Pete Findlay. Drilled domestic well, diameter 4 inches, depth feet. Measuring point, top of casing, 0.3 foot below land surface. Land-face altitude 4,726.5 feet. Taps water in later alluvium.

Date	Water level in feet below measuring point	Date	Water level in feet below measuring point
rch 7	17.16	May 9	17.17
rch 16	17.08	May 25	17.42
rch 21	17.15	June 26	18.18
il 5	17.10	July 27	18.49
il 14	17.06	August 26	18.66
il 25	17.12	December 16	17.89

2S/68-7D2. Henry Morgan. Unused bored well, diameter 6 inches square, th 28 feet. Measuring point, top of 6-inch wood casing, 0.8 foot above rface. Land-surface altitude 4,709.0 feet. Taps water in later alluvium.

Date	Water level in feet below measuring point	Date	Water level in feet below measuring point
rch 7	10.23	May 25	10.61
rch 16	10.21	June 26	11.26
rch 21	10.19	July 27	11.65
il 5	10.15	August 26	12.09
il 14	10.16	November 2	11.62
il 25	10.22	December 16	11.03
y 9	10.37		

2S/68-8B1. Lory Free. Drilled irrigation well, diameter 10 inches, depth feet. Measuring point, top of casing, 0.7 foot above land surface. Land-face altitude 4,721.7 feet. Taps water in later alluvium.

Date	Water level in feet below measuring point	Date	Water level in feet below measuring point
rch 7	12.89	May 25	13.32
rch 16	12.87	June 22	14.24
rch 21	12.84	July 27	14.67
il 5	12.80	August 26	14.81
il 14	12.79	November 2	14.29
il 25	12.88	December 16	13.69
y 9	13.02		

2S/68-8B2. U. S. Geological Survey. Bored observation well, diameter 4 hes, depth 16 feet. Measuring point, top of 4-inch galvanized iron casing. et above land surface. Land-surface altitude 4,717.8 feet. Taps water er alluvium. Water level in feet below measuring point, Aug. 26, 10.69; c. 17, 8.80.

2S/68-8D1. U. S. Geological Survey. Bored observation well, diameter 4 hes, depth 16 feet. Measuring point, top of 2-inch wood stake, at land face. Land-surface altitude 4,726.1 feet. Taps water in later alluvium. ter level in feet below measuring point, Aug. 26, 4.39; Dec. 15, 3.65.

TABLE 8—*Continued*

2S/68-17B1. U. S. Geological Survey. Bored observation well, diameter 4 inches, depth 16 feet. Measuring point, top of 2-inch wood stake, at land surface. Land-surface altitude 4,705.3 feet. Taps water in later alluvium. Water level in feet below measuring point, Aug. 26, 2.33; Dec. 15, 0.00.

2S/68-17C1. U. S. Geological Survey. Bored observation well, diameter 4 inches, depth 16 feet. Measuring point, top of galvanized iron casing, 3.8 feet above land surface. Land-surface altitude 4,700.2 feet. Taps water in later alluvium. Water level in feet below measuring point, Aug. 26, 15.75; Dec. 15, 14.73.

2S/68-18A1. U. S. Geological Survey. Bored observation well, diameter 4 inches, depth 20 feet. Measuring point, top of galvanized iron casing, 3.6 feet above land surface. Land-surface altitude 4,700.7 feet. Taps water in later alluvium. Water level in feet below measuring point, Aug. 26, 10.15; Dec. 17, 8.18.

2S/68-19D1. U. S. Geological Survey. Bored observation well, diameter 4 inches, depth 16 feet. Measuring point, top of galvanized iron casing, 4.0 feet above land surface. Land-surface altitude 4,680.8 feet. Taps water in later alluvium. Water level in feet below measuring point, Aug. 26, 12.76; Dec. 15, 11.50.

2S/68-30B1. U. S. Geological Survey. Driven observation well, diameter 1½ inches, depth 15 feet. Measuring point, top of pipe, 0.1 foot above land surface. Land-surface altitude 4,662.3. Taps water in later alluvium. Water level in feet below measuring point, Aug. 26, 7.93; Dec. 15, 5.30.

2S/67-24D1. P. Duffin (Newman Ranch). Unused dug well, diameter 4 feet square, depth 10 feet. Measuring point, top of vertical wood cribbing marked M.P., 1.8 feet above land surface. Land-surface altitude 4,677.6 feet. Taps water in later alluvium.

Date	Water level in feet below measuring point	Date	Water level in feet below measuring point
March 7	5.80	May 25	6.22
March 16	5.79	June 26	6.67
March 21	5.75	July 27	6.80
April 5	5.79	August 26	7.00
April 14	5.79	November 2	6.50
April 25	5.89	December 16	6.14
May 9	6.04		

2S/67-25A1. U. S. Geological Survey. Bored observation well, diameter 4 inches, depth 20 feet. Measuring point, top of 2-inch wood stake, 0.2 foot above land surface. Land-surface altitude 4,660.0 feet. Taps water in later alluvium. Water level in feet below measuring point, Aug. 26, 14.26; Dec. 14, 12.80.

2S/67-25D1. U. S. Geological Survey. Bored observation well, diameter 4 inches, depth 25 feet. Measuring point, top of 2-inch wood stake, at land surface. Land-surface altitude 4,657.4 feet. On Aug. 26, well was dry at 25 feet below measuring point.

2S/67-26D1. U. S. Geological Survey. Bored observation well, diameter 4 inches, depth 25 feet. Measuring point, top of 2-inch wood stake, at land surface. Land-surface altitude 4,641.7 feet. On Aug. 26, well was dry at 25 feet below measuring point.

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TABLE 8—*Continued*

2S/67-36B1. E. McGuire. Dug and drilled irrigation well, dug 5 feet square to 25 feet, diameter 10 inches from 25 to 80 feet, depth 80 feet. Measuring point, top of square set, 0.2 foot below land surface. Land-surface altitude 4,645.9 feet. Taps water in later alluvium.

Date	Water level in feet below measuring point	Date	Water level in feet below measuring point
March 7	23.00	April 25	22.86
March 16	22.94	May 9	23.11
March 21	22.96	August 26	22.71
April 5	23.40	November 2	21.27
April 14	22.86	December 20	19.95

3S/67-1B1. U. S. Geological Survey. Bored observation well, diameter 4 inches, depth 20 feet. Measuring point, top of 2-inch wood stake, at land surface. Land-surface altitude 4,588.6 feet. Taps water in later alluvium. On Aug. 26, well was dry at 20 feet below measuring point.

3S/67-2A1. Grant Lee. Drilled irrigation well, diameter 10 inches, depth 225 feet. Measuring point, top of 10-inch casing, 0.4 foot above land surface. Land-surface altitude 4,605.1 feet. Taps water in later alluvium.

Date	Water level in feet below measuring point	Date	Water level in feet below measuring point
March 1	17.19	April 5	17.11
March 7	17.11	June 13	21.76
March 16	16.43	July 27	19.41
March 21	17.00	November 2	18.52
March 27	17.03	December 12	18.05

3S/67-2A2. Grant Lee. Unused drilled irrigation well, diameter 10 inches, depth 120 feet. Measuring point, top of 10-inch casing, 1.9 feet above land surface. Land-surface altitude 4,610.5 feet. Taps water in later alluvium.

Date	Water level in feet below measuring point	Date	Water level in feet below measuring point
March 1	23.06	July 27	23.21
March 21	22.66	August 26	23.63
March 27	21.94	November 2	22.53
April 5	20.50	December 14	21.94
June 26	23.29		

3S/67-2B1. U. S. Geological Survey. Bored observation well, diameter 4 inches, depth 25 feet. Measuring point, top of galvanized iron casing, 3.5 feet above land surface. Land-surface altitude 4,610.0 feet. Taps water in later alluvium. Depth to water in feet below measuring point, Aug. 26, dry at 20 feet; Dec. 17, 21.5 feet.

3S/67-2D1. Murray Lee. Drilled irrigation well, diameter 10 inches, depth 105 feet. Measuring point, base of pump at air-line inlet, 1.05 feet above land surface. Land-surface altitude 4,592.6 feet. Taps water in later alluvium.

Date	Water level in feet below measuring point	Date	Water level in feet below measuring point
March 17	20.22	May 9	18.16
March 21	18.70	May 25	17.61
March 27	18.50	June 26	19.27
April 5	18.78	July 27	17.20
April 14	18.72	November 2	18.50
April 24	17.09	December 14	18.52
May 2	17.68		

3S/67-11A1. U. S. Geological Survey. Bored observation well, diameter 4 inches, depth 20 feet. Measuring point, top of galvanized iron casing, 3.7 feet above land surface. Land-surface altitude 4,576.9 feet. Taps water in later alluvium. Depth to water in feet below land surface, Aug. 26, 19.55; Dec. 14, 18.56.

TABLE 8—*Continued*

3S/67-11B1. U. S. Geological Survey. Bored observation well, diame inches, depth 20 feet. Measuring point, top of galvanized iron casing, 4 above land surface. Land-surface altitude 4.579.5 feet. Taps water in alluvium. Depth to water in feet below land surface, Aug. 26, 20.42 16, 18.78.

3S/67-12B1. U. S. Geological Survey. Bored observation well, dia 4 inches, depth 20 feet. Measuring point, top of 2-inch wood stake, a surface. Land-surface altitude 4,524.2 feet. On Aug. 26, well was dry feet below measuring point.

3S/67-14C1. U. S. Geological Survey. Bored observation well, diam inches, depth 20 feet. Measuring point, top of 2-inch wood stake, at lan face. Land-surface altitude 4.541.0 feet. Taps water in later alluvium. to water in feet below measuring point, Aug. 26, 12.63.

3S/67-14C2. U. S. Geological Survey. Bored observation well, diame inches, depth 20 feet. Measuring point, top of 2-inch wood stake, at surface. Land-surface altitude 4,554.0 feet. On Aug. 26, well was dry feet below measuring point.

3S/67-15D1. U. S. Geological Survey. Bored observation well, diame inches, depth 20 feet. Measuring point, top of galvanized iron casing, 0. below land surface. Land-surface altitude 4,541.1 feet. Taps water in alluvium. Depth to water in feet below measuring point, Aug. 27. Dec. 14, 14.80.

3S/67-21D1. U. S. Geological Survey. Bored observation well, dia 6 inches, depth 15 feet. Measuring point, top of galvanized iron casing, feet above land surface. Land-surface altitude 4,513.1 feet. Taps wate later alluvium, near spring area.

Date	Water level in feet below measuring point	Date	Water le in feet be measuring
April 25	4.0	July 27	5.30
May 9	4.46	August 26	5.36
May 25	4.59	December 14	3.50
June 26	5.57		

3S/67-22C1. U. S. Geological Survey. Bored observation well, diamet inches, depth 14 feet. Measuring point, top of galvanized iron casing, 1.0 above land surface. Land-surface altitude 4,515.8 feet. Taps water in alluvium.

Date	Water level in feet below measuring point	Date	Water level in feet be measuring
March 28	4.65	June 26	6.12
April 6	4.77	July 27	6.89
April 14	5.02	August 26	7.35
April 25	5.47	September 26	Dry-caved
May 9	5.78		

3S/67-22D1. U. S. Geological Survey. Bored observation well, diamete inches, depth 12 feet. Measuring point, top of galvanized iron casing, 1.6 fe above land surface. Land-surface altitude 4,515.6 feet. Taps water in la alluvium.

Date	Water level in feet below measuring point	Date	Water le in feet be measuring
March 28	2.88	May 25	3.57
April 5	2.87	June 26	3.86
April 14	2.94	July 27	3.71
April 25	3.09	August 26	3.81
May 9	3.32	December 13	2.70

TABLE 8—*Continued*

3S/67-22D2. Press Duffin. Drilled stock well, diameter 6 inches, depth 48 feet. Measuring point, top of casing, at land surface. Taps water in later alluvium and Panaca formation.

Date	Water level in feet below measuring point	Date	Water level in feet below measuring point
August 26	14.72	December 13	13.97
November 2	14.23		

3S/67-28A2. U. S. Geological Survey. Bored observation well, diameter 6 inches, depth 15 feet. Measuring point, top of galvanized iron casing, 1.0 foot above land surface. Land-surface altitude 4,498.7 feet. Taps water in later alluvium.

Date	Water level in feet below measuring point	Date	Water level in feet below measuring point
April 25	4.46	June 26	5.94
May 9	5.0	August 26	6.36
May 25	5.5	December 13	2.80

3S/67-28C2. U. S. Geological Survey. Drilled observation well, diameter 6 inches, depth 172 feet. Measuring point, top of casing, 3.0 feet above land surface. Taps water in later alluvium.

Date	Water level in feet below measuring point	Date	Water level in feet below measuring point
November 3	1.45	February 17†	.94
November 27	1.20	March 4†	.95
December 13	1.19	March 18†	.94
December 30	1.05	March 31†	.97
January 16†	1.11	March 14†	.98
February 3†	1.01	May 2†	.95

†1947.

3S/67-33B1. U. S. Geological Survey. Bored observation well, diameter 6 inches, depth 15 feet. Measuring point, top of 6-inch galvanized iron casing, 1.4 feet above land surface. Land-surface altitude 4,472.3 feet. Taps water in later alluvium.

Date	Water level in feet below measuring point	Date	Water level in feet below measuring point
March 3	3.33	May 25	3.85
April 5	3.41	June 26	5.47
April 14	3.55	August 27	6.10
April 25	3.85	December 13	3.64
May 9	4.14		

4S/67-4C1. Joe Allec. Bored domestic well, diameter 8 inches, depth 35 feet. Measuring point, pump base, at land surface. Taps water in later alluvium.

Date	Water level in feet below measuring point	Date	Water level in feet below measuring point
April 5	12.74	June 26	12.97
April 14	12.33	July 27	13.93
April 25	12.26	August 26	13.72
May 9	12.44	November 2	12.63
May 25	12.61	December 17	11.66

4S/67-8B1. City of Caliente. Drilled public-supply well, diameter 8 inches, depth 165 feet. Measuring point, cement floor in pump house, at land surface. Taps water in later alluvium.

Date	Water level in feet below measuring point	Date	Water level in feet below measuring point
March 16	19.64	May 25	21.30
April 16	20.1	August 26	21.82
May 9	20.47		

TABLE 8—*Continued*

4S/67-8C2. Charles Culverwell. Drilled irrigation well, diameter 12 inches, depth 78 feet. Measuring point, top of 12-inch casing, 1.5 feet above land surface. Taps water in later alluvium.

Date	Water level in feet below measuring point
August 26	7.99
December 16	Flowing 15 gallons per minute
February 10 (1947)	Flowing 200± gallons per minute

4S/66-36B2. John Conway. Unused drilled irrigation well, diameter 10 inches, depth 65 feet. Measuring point, top edge of casing, at land surface. Taps water in later alluvium.

Date	Water level in feet below measuring point	Date	Water level in feet below measuring point
May 6	30.00	August 26	28.56
June 12	29.19	December 18	27.23
July 27	29.59		

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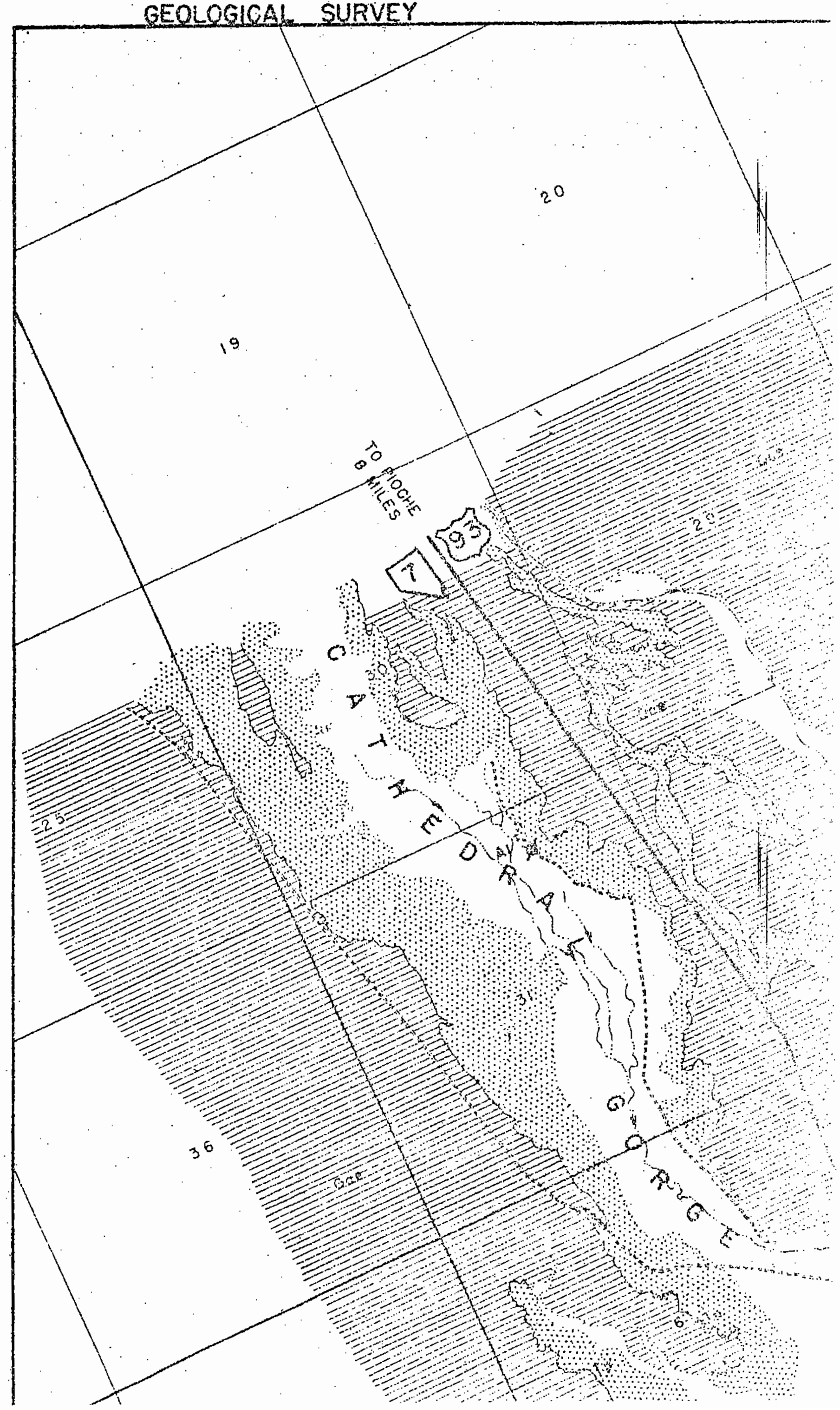
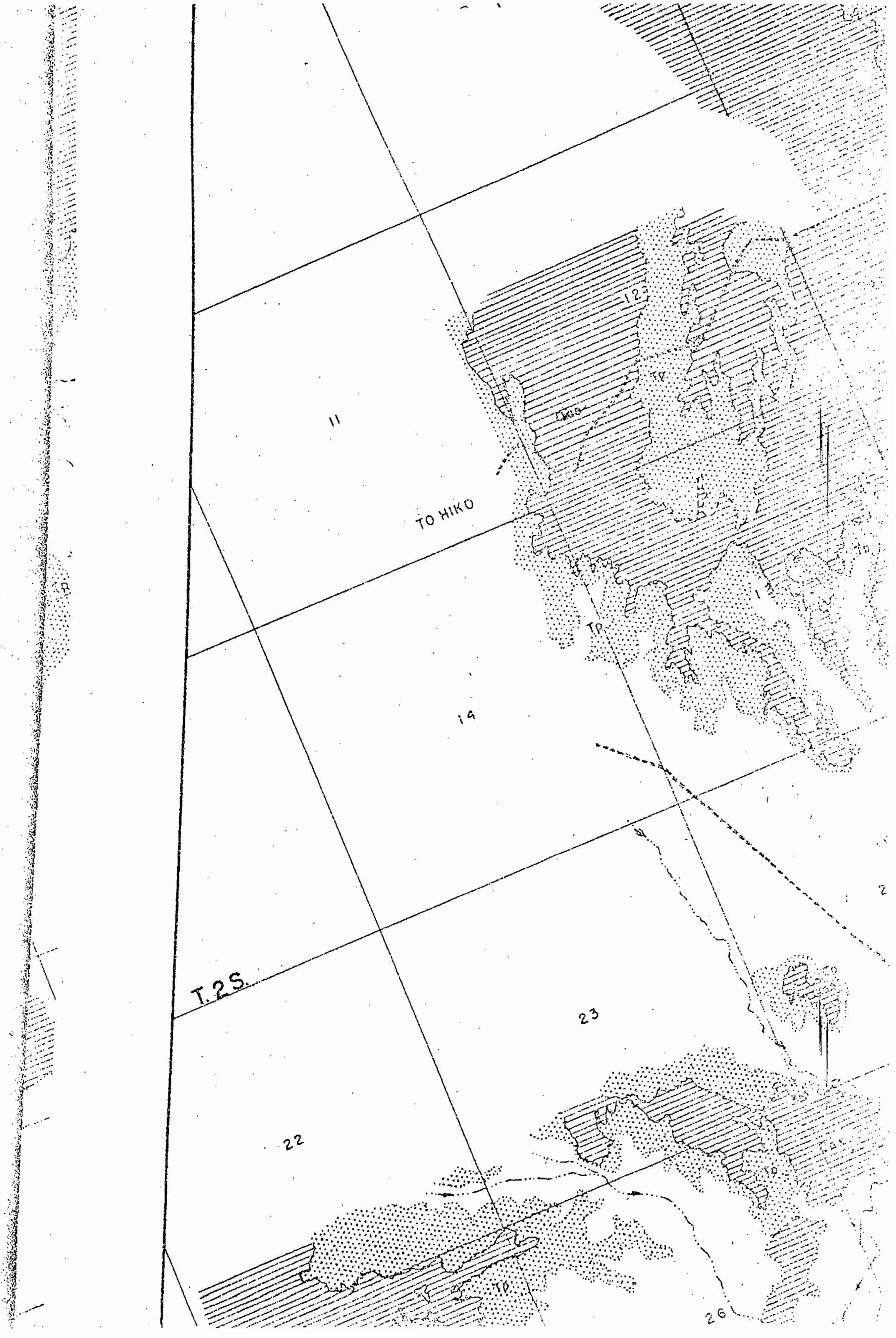
UNITED STATES DEPARTMENT OF INTERIOR
GEOLOGICAL SURVEY

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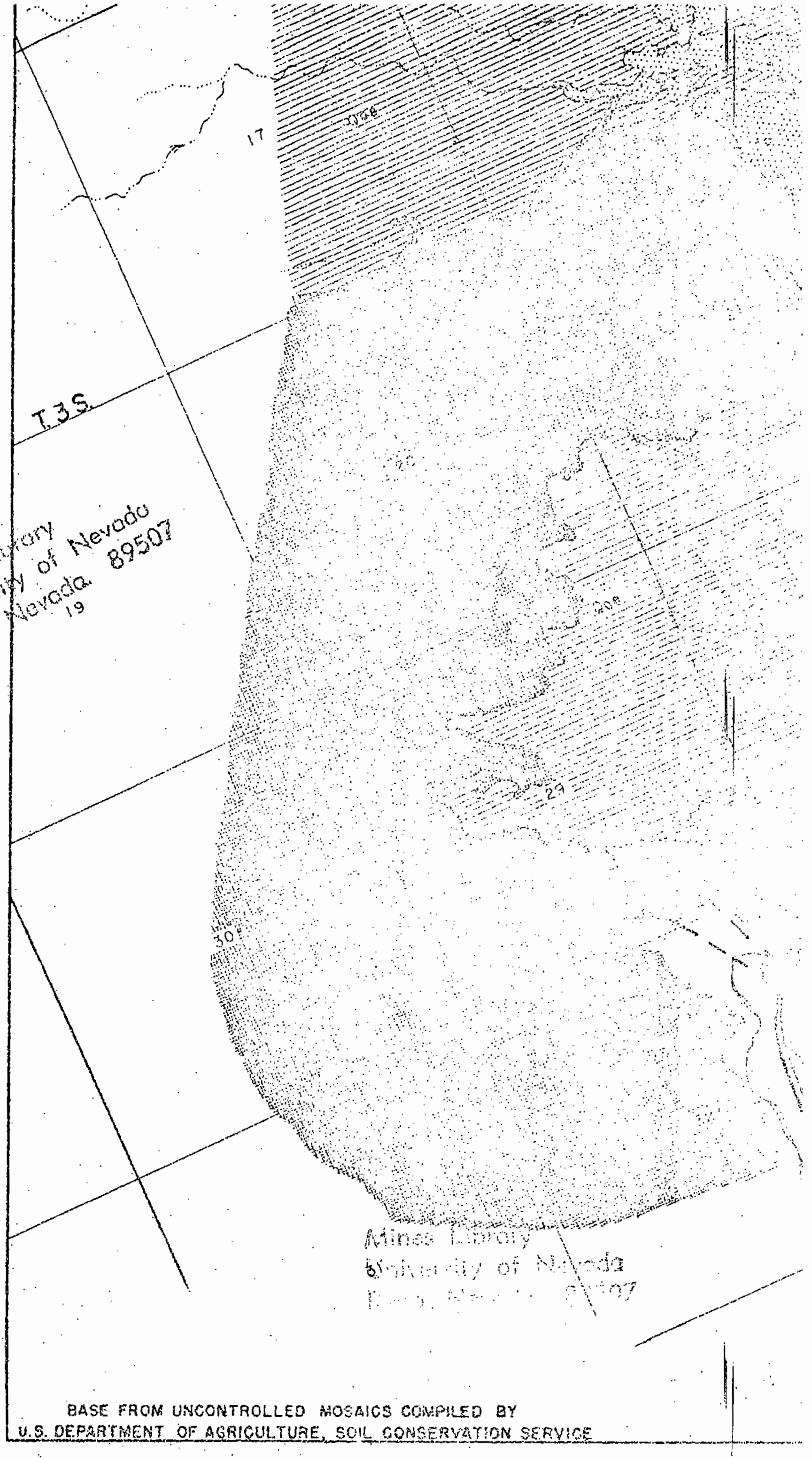
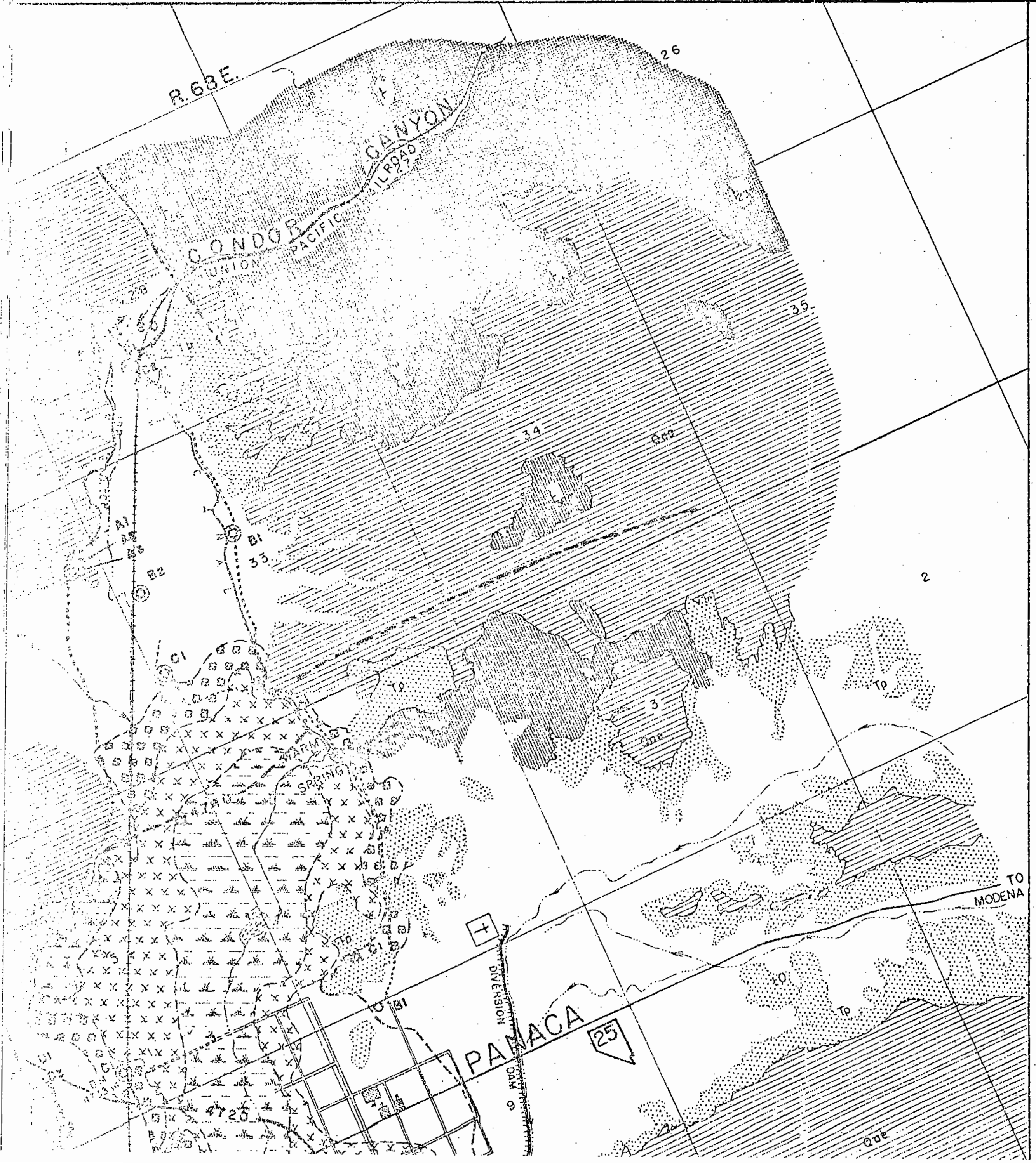
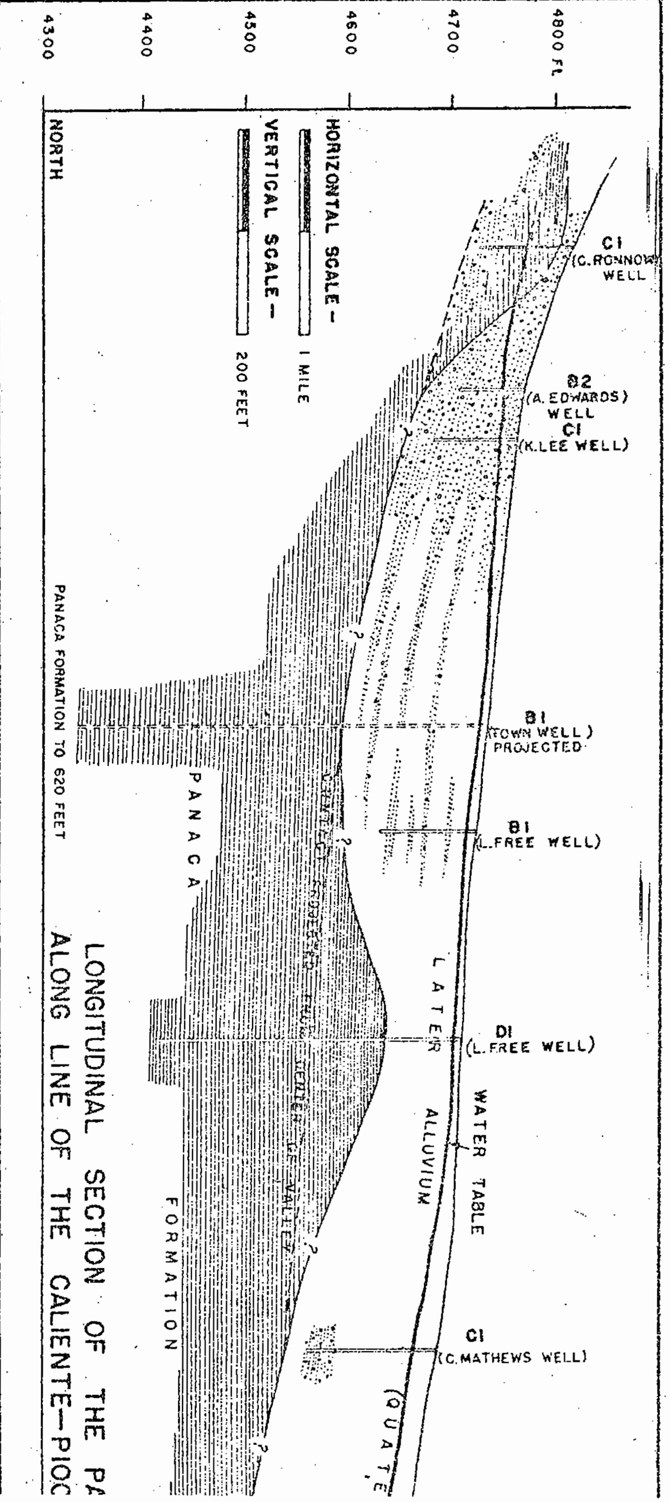


BASE FROM UNCONTROLLED MOSAICS COMPILED BY
U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

STATE ENGINEER OF NEVADA

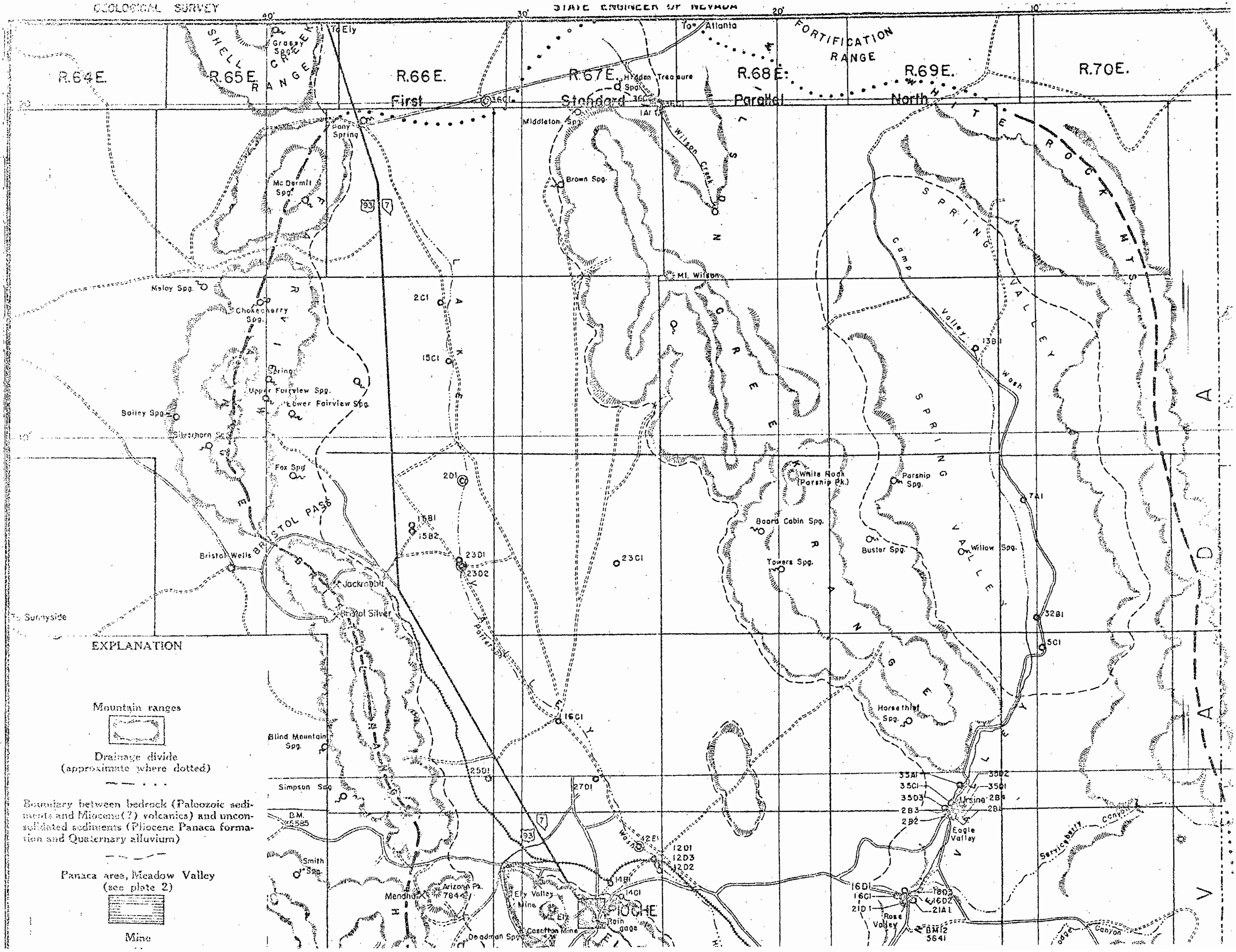
WATER RESOURCES BULLETIN No 7, PLATE 2

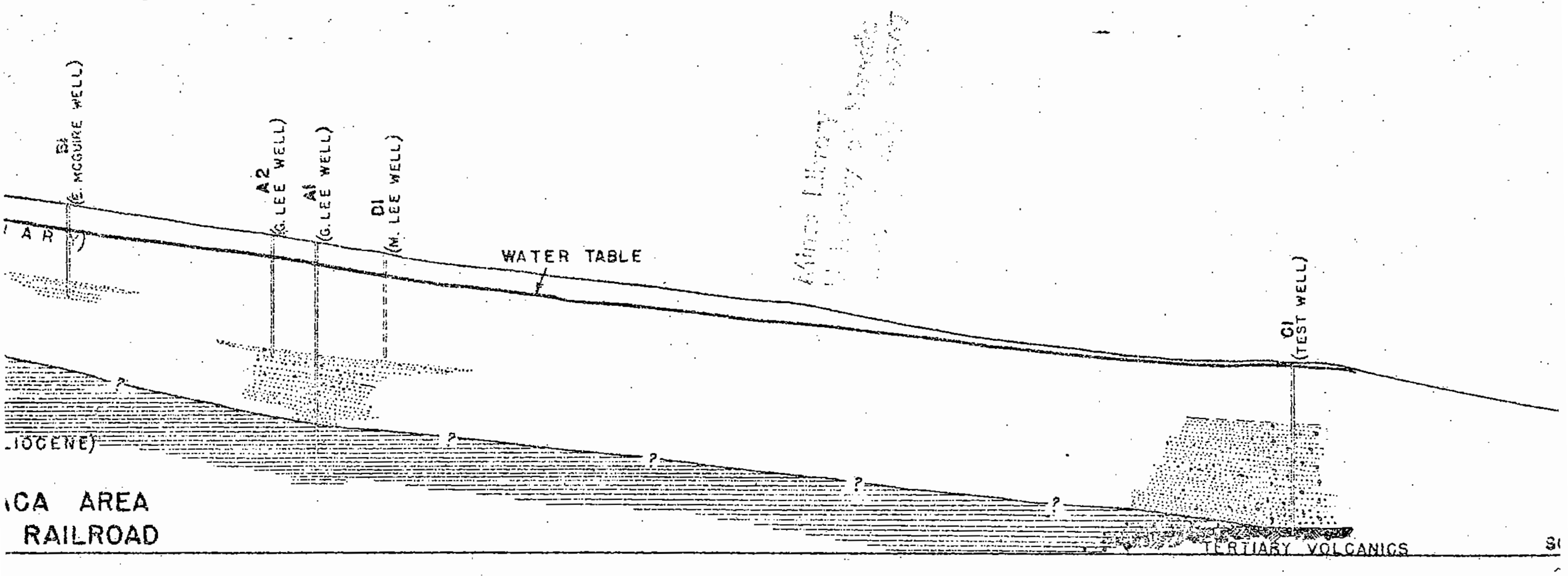


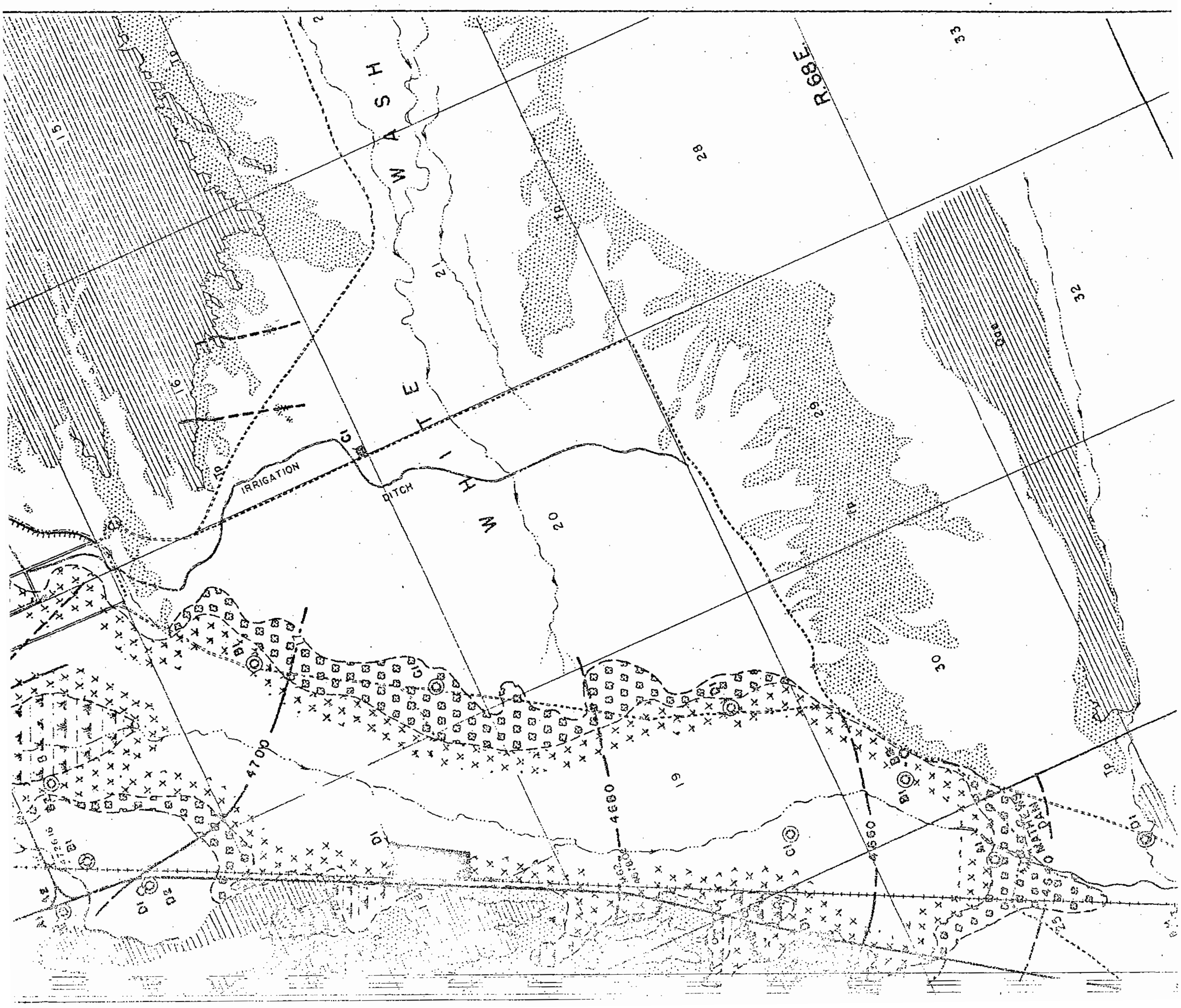


LONGITUDINAL SECTION OF THE PA

ALONG LINE OF THE CALIENTE—PIOC


GEOLOGICAL SURVEY
STATE ENGINEER OF NEVADA
40'
30'
20'
10'
R.64E.
R.65E.
R.66E.
R.67E.
R.68E.
R.69E.
R.70E.
First Standard Parallel North
SHELL CREEK RANGE
FORTIFICATION RANGE
WHITE ROCK MTS
SCHELL CREEK RANGE
WILSON CREEK RANGE
LAKE VALLEY
SPRING VALLEY
SPRING VALLEY
To Ely
To Atlanta
To Sunnyside
Grassy Spg.
Pony Spring
McDermit Spg.
Hidden Treasure Spg.
Middleton Spg.
Brown Spg.
Wilson Creek
Mt. Wilson
Maloy Spg.
Chokecherry Spg.
Spring
Upper Fairview Spg.
Lower Fairview Spg.
Bailey Spg.
Silverhorn Spg.
Fox Spg.
BRISTOL PASS
Bristol Wells
Jackrabbit
Bristol Silver
Patterson
White Rock (Parsnip Pk.)
Parsnip Spg.
Board Cabin Spg.
Buster Spg.
Willow Spg.
Towers Spg.
Horsethief Spg.
Camp Valley Wash
Blind Mountain Spg.
Simpson Spg.
B.M. 6585
Smith Spg.
Mendha
Arizona Pk. 7844
Ely Valley Mine
Castleton Mine
Deadman Spg.
PIOCHE
Rain gage
Wash
Ursine
Eagle Valley
Rose Valley
B.M.12 5641
Serviceberry Canyon
Canyon
36C1
36C1
1A1
36D1
2C1
15C1
2D1
15B1
15B2
23D1
23D2
23C1
16C1
25D1
27D1
12E1
12D1
12D3
12D2
14B1
14C1
13B1
7A1
32B1
5C1
33A1
35C1
35D3
2B3
2B2
35D2
35D1
2B4
2B1
16D1
16C1
21D1
18D3
16D2
21A1
V
A
D
A
93
7
EXPLANATION
Mountain ranges
Drainage divide (approximate where dotted)
Boundary between bedrock (Paleozoic sediments and Miocene(?) volcanics) and unconsolidated sediments (Pliocene Panaca formation and Quaternary alluvium)
Panaca area, Meadow Valley (see plate 2)
Mine


B1
(E. MCGUIRE WELL)
A2
(G. LEE WELL)
A1
(G. LEE WELL)
D1
(M. LEE WELL)
WATER TABLE
C1
(TEST WELL)
AR
LIOCENE)
?
?
?
?
?
ICA AREA
RAILROAD
TERTIARY VOLCANICS


WHITE WASH
IRRIGATION
DITCH
R.68E
15
16
19
20
21
28
29
30
32
33
Tp
Tp
Tp
Tp
Tp
Qae
C1
C1
C1
C1
B1
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B1
D1
D1
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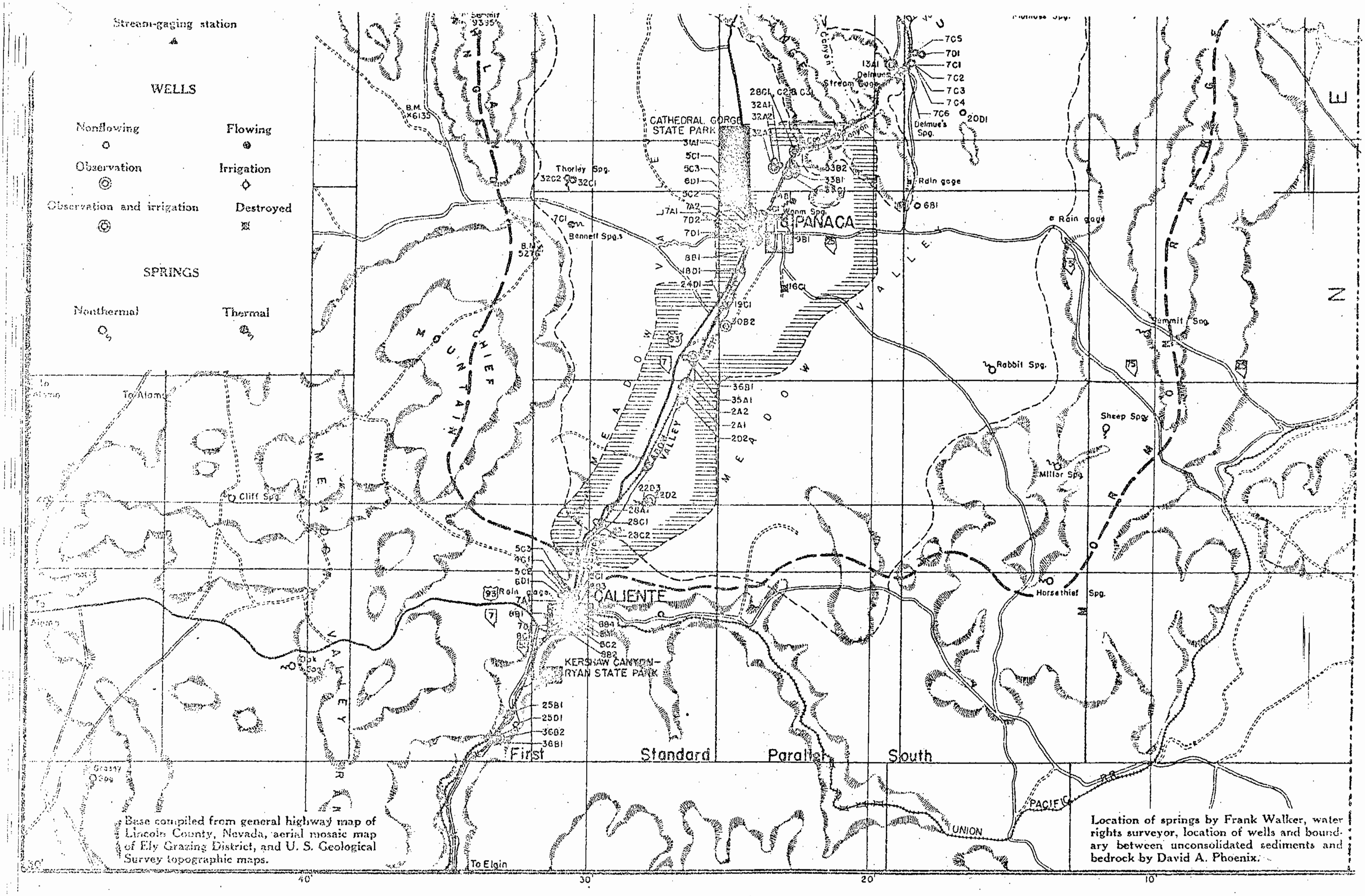
D2
A1
A2
4600
4660
4700
MATHEWS DAM
25



Base compiled from general highway map of Lincoln County, Nevada, aerial mosaic map of Ely Grazing District, and U. S. Geological Survey topographic maps.

Location of springs by Frank Walker, water rights surveyor, location of wells and boundary between unconsolidated sediments and bedrock by David A. Phoenix.

MAP OF THE MEADOW VALLEY WASH DRAINAGE AREA, LINCOLN COUNTY, NEVADA

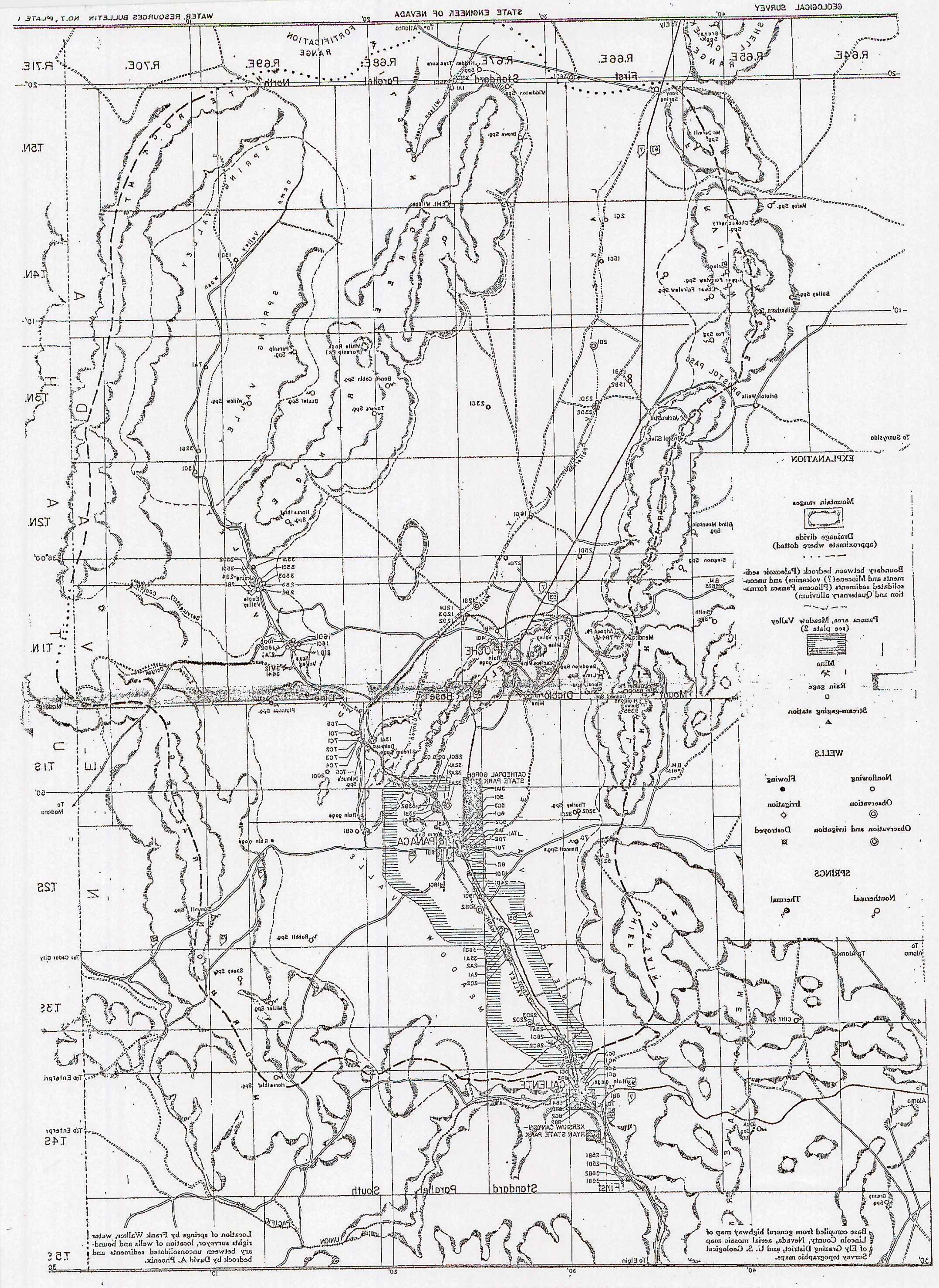
Showing physiographic features, areas of unconsolidated sediments, and location of wells, springs, rain gages, and stream gaging station.

Scale

WATER RESOURCES BULLETIN NO. 7, PLATE 1

STATE ENGINEER OF NEVADA

UNITED STATES DEPARTMENT OF INTERIOR
GEOLOGICAL SURVEY



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Showing physiographic features, areas of unconsolidated sediments, and location of wells, springs, rain gages, and stream gaging station.

Scale

MAP AND SECTION OF THE PANACA AREA, MEADOW VALLEY LINCOLN COUNTY, NEVADA

SHOWING GEOLOGY, ZONES OF VEGETATION, LOCATION OF WELLS AND SPRINGS, AREAS IRRIGATED FROM WELLS AND WATER TABLE CONTOURS
FOR AUGUST 1946.

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University of Nevada
Reno, Nevada 89507