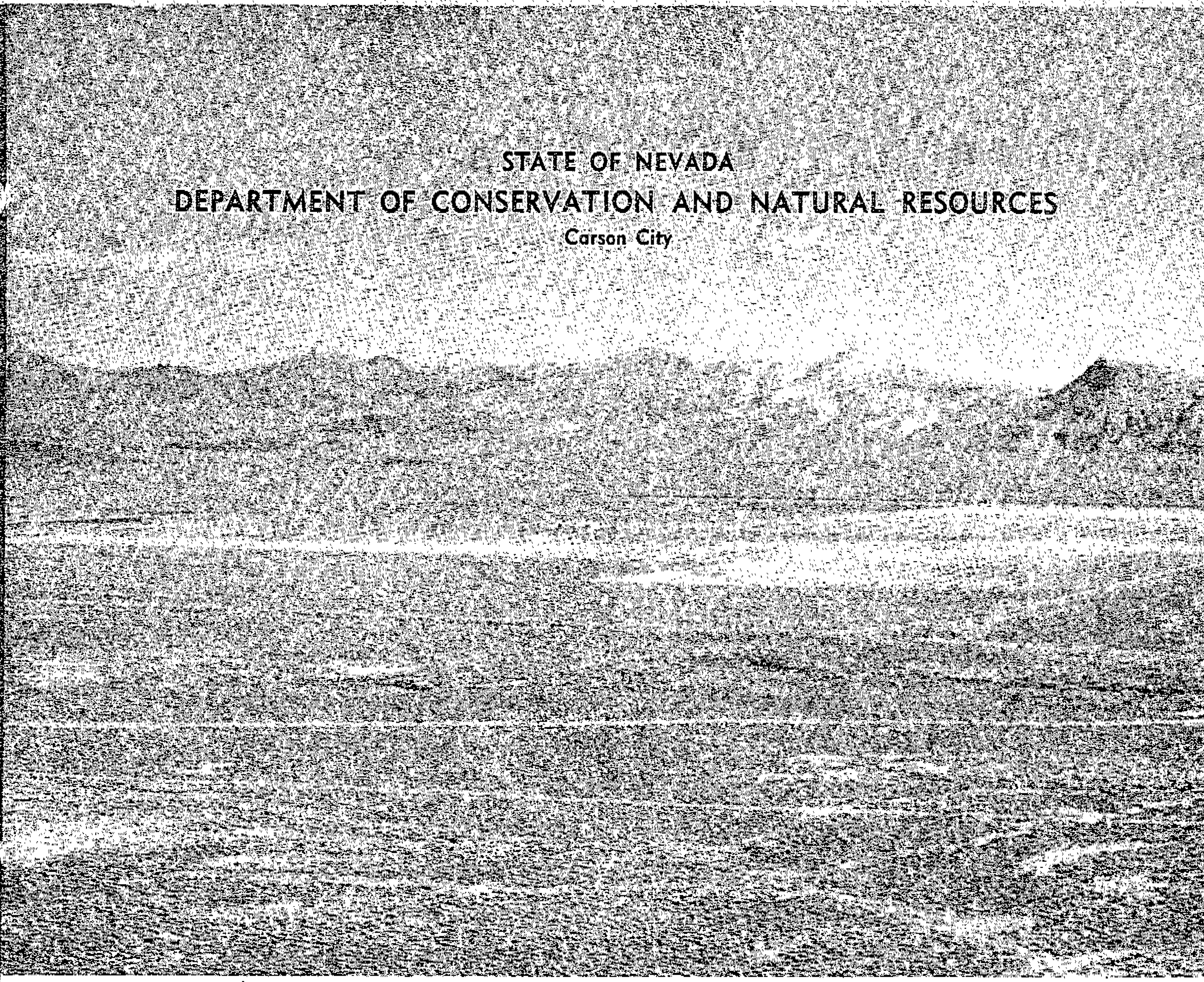
STATE OF NEVADA

DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

Carson City



View of cultivated fields at the north end of Hualapai Flat, with Calico Mountains in the background.

GROUND-WATER RESOURCES – RECONNAISSANCE SERIES

REPORT 11

GROUND–WATER RESOURCES OF HUALAPAI FLAT, WASHOE, PERSHING, AND HUMBOLDT COUNTIES

By

WILLIAM C. SINCLAIR

Geologist

Price $1.00

Prepared cooperatively by the

Geological Survey, U. S. Department of Interior

"The Geyser," this tower of calcium carbonate is being precipitated from the boiling water flowing from well 34/23-1c1 which was drilled in the area of thermal springs about 40 years ago.

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October, 1962

FOREWORD

This is the eleventh report in the current series of ground-water reconnaissance studies and pertains to the ground-water resources of Hualapai Flat in Washoe, Pershing, and Humboldt Counties.

The study and report was made by William C. Sinclair, Geologist, U. S. Geological Survey, in cooperation with the Nevada State Department of Conservation and Natural Resources.

This particular program of reconnaissance ground-water studies was made possible by the 1960 legislature when $7, 500 was appropriated to start this program.

Report No. 12, giving a ground-water appraisal of Ralston and Stonecabin Valleys in Nye County, has been completed and will be available prior to January 1, 1963.

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

October, 1962

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GROUND-WATER RESOURCES OF HUALAPAI FLAT

WASHOE, PERSHING, AND HUMBOLDT COUNTIES, NEVADA

by
William C. Sinclair [1/]
Geologist

ABSTRACT

Hualapai Flat is a small, internally drained, valley in northwestern Nevada. The climate of the valley floor is arid to semiarid; annual precipitation ranges from about 5 inches on the floor of the valley to about 20 inches in the mountains.

The valley is bordered by mountain ranges composed principally of granitic and volcanic rocks. The mountains were uplifted by faulting and tilting during the latter part of the Tertiary period. Material eroded from the uplands has filled the intermontane basin of the valley with at least 500 feet of alluvium, including lake and stream sediments. The amount of ground water stored in the upper few hundred feet of alluvium is estimated at about 3,000 acre-feet per foot of thickness of saturated sediments.

The ground-water reservoir is recharged by streams that drain the bordering mountain ranges. Ground water moves from the areas of recharge toward the center of the valley where, under natural conditions, it is discharged by evaporation and transpiration. The estimated average annual recharge and discharge are on the order of 5,000 acre-feet per year.

Ground water in Hualapai Flat generally is suitable for irrigation and domestic use. The principal exception is water from the area of thermal springs which is unsuitable for irrigation because of the high sodium content, and for domestic use because of the high fluoride content.

Although the discharge of ground water by pumping has been negligible in the past, about 10 large capacity irrigation wells have been drilled within the past year or so and, commencing with the 1962 irrigation season, the withdrawal of ground water by pumping will become one of the most important factors in the hydrologic regimen of the valley.

1/ Publication authorized by the Director,
U. S. Geological Survey

INTRODUCTION

Purpose and Scope of the Investigation

This report is the 11th in a series of reconnaissance studies of the valleys of Nevada. These studies are made by the U. S. Geological Survey in cooperation with the Department of Conservation and Natural Resources, State of Nevada, and are part of a statewide study to evaluate the ground-water resources of Nevada.

The purpose of this study is: (1) To determine the nature and extent of the aquifers; (2) To determine the occurrence and movement of ground water, including the areas of recharge and areas of discharge; (3) To determine the sources of recharge and to estimate the average annual recharge to the aquifers; (4) to estimate the quantity of ground water that can be developed perennially; and (5) to determine the chemical quality of the ground water and its suitability for irrigation and domestic use.

The field work for this report was done during November 1961 and January 1962. It consisted of a brief study of the physiographic features of the area and of the water-bearing character of the geologic units, an inventory of the wells and springs, and collection of samples of water for chemical analysis.

The assistance provided by residents of the area in the form of information about wells and springs is gratefully acknowledged.

Location and Extent of the Area

Hualapai Flat is located about 20 miles north of Gerlach in Northern Washoe County (fig. 1). It also includes a small corner of both Pershing and Humboldt Counties. The valley is bordered on the south and west by the Granite Range and on the north and east by the Calico Mountains. A low ridge trending northward, along the east side of the valley, from the Granite Range almost to the Calico Mountains separates Hualapai Flat from the Black Rock Desert. The valley floor ranges in width from 4 to 5 miles and trends northward and covers an area of about 50 square miles; the drainage area of the entire valley is about 180 square miles.

Nevada 34, a graded road, crosses the valley from south to north connecting Gerlach with the northwestern part of the State and with California and Oregon. Gerlach, a stop on the Western Pacific Railroad, is the local trading center for ranches in the area.

The grazing of cattle and sheep has been the principal occupation in the area with some irrigation of hay and meadowland by streamflow and spring discharge. An unsuccessful attempt at dry farming was made in the early 1920's by a number of families that settled in the valley.

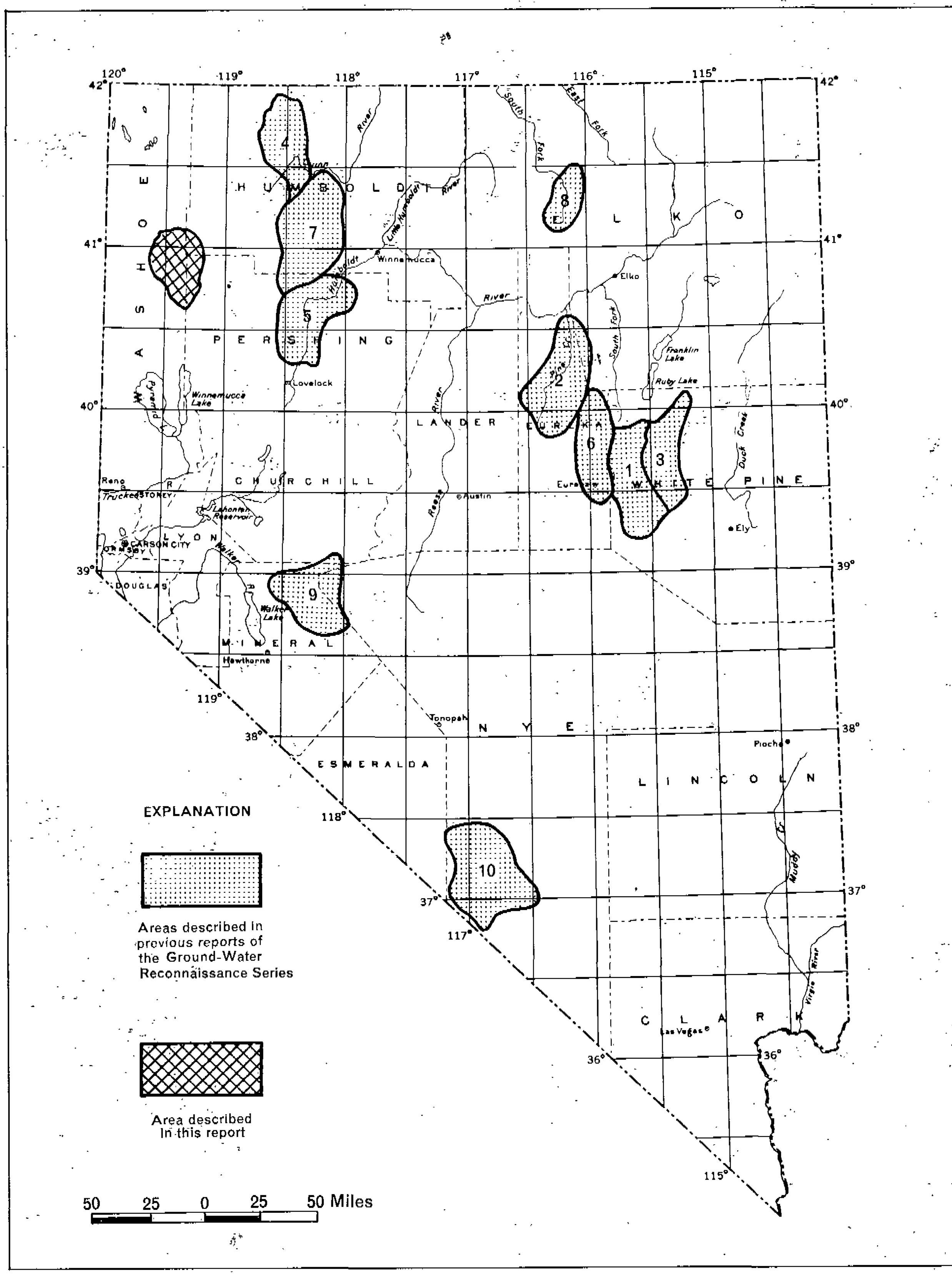

Figure 1. Map of Nevada showing areas described in previous reports of the Ground-Water Reconnaissance Series and the area described in this report.

Within the past few years a considerable number of Desert Land Entries have been filed with the U.S. Bureau of Land Management and patents have been issued on 960 acres. Applications for an additional 7,300 acres are still pending. [1/]

Numbering System for Wells and Springs

The well-numbering system used in this report indicates the location of the wells within the rectangular subdivisions of the public lands referenced to the Mount Diablo meridian and base line. The first two segments of a well number designate the township and range; the third segment is the number of the section followed by a letter which designates the quarter section in which the well or spring is located. Following the letter a number indicates the order in which the well or spring was recorded within the subdivision. The letters a, b, c, and d designate, respectively, the northeast, northwest, southwest, and southeast quarters of the section. For example, well number 35/23-13d1 designates the first well recorded in the SE 1/4 sec. 13, T. 35 N., R. 23 E., Mount Diablo base and meridian.

Plate I shows the location of wells and springs in the valley. The available data on the wells are listed in table 1 and on the springs in table 2. The results of chemical analyses of water from selected wells and springs are in table 3.

GEOGRAPHIC FEATURES

Landforms and Drainage

Hualapai Flat is a structural depression similar to most of the valleys in Nevada where block faulting has created a series of north-trending valleys and mountain ranges.

Precipitation in the area is generally insufficient to support perennial streams. Streamflow from the mountains, typically, infiltrates into the alluvial slopes bordering the mountains, except during flood stages when the streams discharge to the playa lake in the center of the basin, from which the water evaporates in a relatively short time.

Mountains: The Granite Range rises abruptly from the valley floor at the south and west sides of the valley to an altitude of 9,056 feet at Granite Peak; about 5,000 feet above the valley floor.

Northward from the vicinity of Red Mountain Creek, the mountains are less precipitous, being composed, principally, of a thick sequence of volcanic

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1/ U.S. Bureau of Land Management, Department of Interior, Reno, Nevada, April, 1962.

rocks. These volcanic rocks comprise a broad upland region which rises to altitudes of 7,000 to 8,000 feet and constitutes about two-thirds of the total drainage area of the valley.

A south-trending spur of the Calico Mountains forms the northeast boundary of the valley. At its highest point, Division Peak, it is about 4,500 feet above the valley floor. The altitude decreases southward to within a few hundred feet above the valley floor. This ridge is composed of altered volcanic and sedimentary rock and is separated by about a mile of wind-blown silt and lake deposits from a ridge of metamorphosed volcanic and sedimentary rocks which trends northward from the east end of the Granite Range along the eastern side of Hualapai Flat. The alluvium between the two ridges forms a low topographic divide, less than 100 feet above the valley floor and separates Hualapai Flat from the Black Rock Desert to the east.

A seismic profile along this alluvial divide was made in August 1962 by L. D. McGinniss and W.W. Dudley for the Desert Research Institute, University of Nevada. The seismic work indicates that bedrock lies at about 250 feet below the surface. 1/

Piedmont Slope and Valley Floor: The mountains are flanked with alluvium; unconsolidated rock debris which has been washed down the mountainsides to form a transitional zone of decreasing slope bordering the level valley floor.

The valley floor covers about 50 square miles. About one-third of this area is occupied by playa; an ephermeral lake for the few days or weeks following the spring runoff or rain; an alkali flat throughout most of the year. The valley floor is underlain by lake deposits, principally alkaline clays, interbedded at various depths with layers of sand and gravel.

Streams: The streams that drain the mountains surrounding Hualapai Flat, are fed principally by storm runoff and snowmelt. Much of the flow, therefore, is ephermeral and occurs principally during the spring and early summer. As summer progresses, the snowpack in the mountains is depleted, the headwaters of the streams go dry from lack of nourishment, and the decreased flow is insufficient to reach the valley floor due to seepage into the alluvium flanking the mountains. Flow in the perennial streams, then, is limited to the middle reaches which are sustained by the discharge of ground water which has infiltrated the bedrock and alluvium farther upstream.

1/ W. W. Dudley, written communication, August 1962.

Climate:

Precipitation in Nevada is controlled largely by the topography. As the eastward moving air masses are forced upward by a mountain range, the decrease in pressure and temperature causes precipitation. Most of this precipitation occurs on the western flank of the range. As the air mass moves down the eastern flank it is warming and dry. This is well illustrated by the Granite Range whose highest peaks seem to rake moisture from clouds which ordinarily drift on across the valley floor and the Black Rock Desert without a hint of further precipitation.

The average annual precipitation for the 43 years of record at Gerlach and Empire, about 5 miles south of Gerlach, is 5.25 inches. The range in temperature is large, both daily and seasonally, as shown in figure 2. The climate in Hualapai Flat is probably somewhat cooler and wetter than that recorded at Empire because of the proximity of the mountains. The growing season is about 4 to 5 months although freezing temperatures may occur in almost any month of the year.

SUMMARY OF GEOLOGIC HISTORY

The present topography of Hualapai Flat and the surrounding mountains began to take form during the latter part of the Tertiary Period. At that time, the country rock was broken and tilted by extensive faulting which continued into the Pleistocene Epoch, and raised the mountain ranges relative to the valley floor. The extrusion of the volcanic rocks which comprise the mountains north and west of Hualapai Flat was, in part, contemporaneous with this widespread faulting. Erosional debris from the uplifted blocks has partly filled the valley with alluvium.

The Pleistocene Epoch, which is notable for extensive glaciation in other parts of the world, was attended by a series of lakes in many of the arid valleys of the Great Basin. The most recent of these, Lake Lahontan, intermittently covered a large part of western Nevada and attained a maximum altitude of about 4,380 feet. In Hualapai Flat, which was an embayment of Lake Lahontan more than 350 feet deep, the many stages and fluctuations of the lake are recorded in the complexity of the sedimentary deposits which comprise the valley floor and in the shoreline features which terrace the surrounding hillsides.

PHYSICAL CHARACTER AND WATER-BEARING PROPERTIES OF THE ROCKS

Bedrock

The consolidated rocks of the mountains are relatively impermeable and movement of ground water in them is largely through joints and other secondary openings. Volcanic and granitic rocks are the principal types of bedrock in the area. Volcanic rocks, principally rhyolite, comprise the

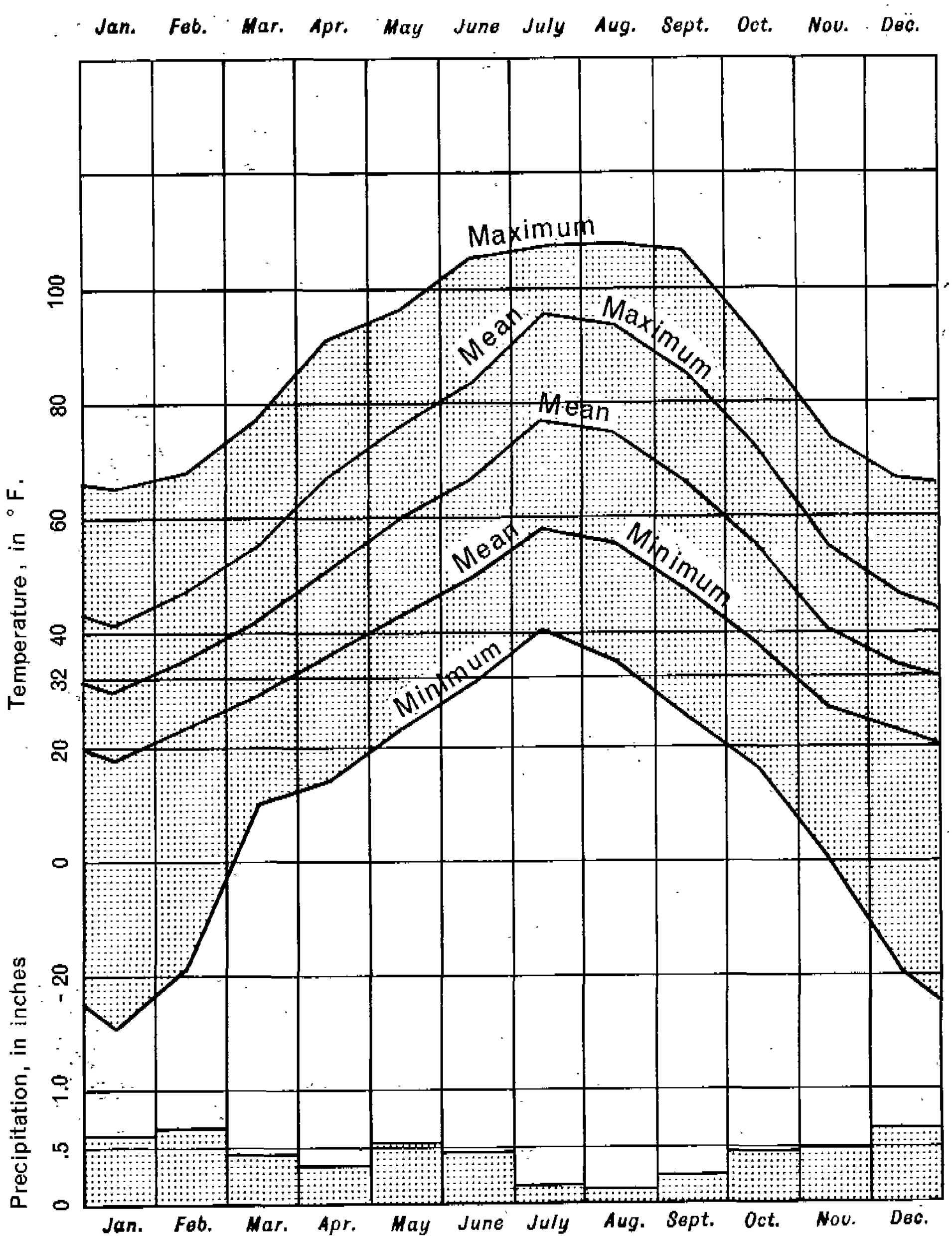

Figure 2. Average monthly precipitation for a 43-year period and mean temperature, mean monthly maximum and mean monthly minimum temperatures, and extreme maximum and extreme minimum temperatures for the period 1931–1952.

mountains bordering the northern rim of Hualapai Flat and extend southward to the vicinity of Red Mountain Creek. These volcanic rocks are locally characterized by closely spaced columnar jointing, as illustrated in figures 3 and 4. Weathering causes the columns to break down into cobble-size pieces and much of the volcanic terrane is littered with the resulting coarse rubble which permits much of the precipitation to infiltrate rapidly into the ground.

Joints in the granitic rocks of the Granite Range, south of Red Mountain Creek, are few and generally quite widely spaced, and consequently infiltration of precipitation is negligible. However, the granitic rocks are mantled by the products of their own weathering which is capable of retaining a considerable volume of water. Runoff from these areas occurs only after the mantle becomes saturated. The many springs in the granite terrane are fed by seepage from this mantle of allubium.

The movement of ground water in the consolidated rocks of the mountain ranges is largely through joints and other secondary openings and in permeable zones between lava flows. Although the total volume of water moving through bedrock may be quite large, as it is assumed to be in the volcanic terrane, the success of a well penetrating the bedrock is dependent on its tapping enough of the secondary water-bearing zones to yield the required amount of water. The chances of intercepting a sufficient number of water-bearing zones are generally so poor that the consolidated bedrock, whether in the mountains or buried beneath the valley fill, probably will not yield large amounts of water to wells.

Alluvium

The valley fill is composed principally of fluvio-lacustrine deposits which are generally termed alluvium. The alluvium in the valley forms the principal ground water reservoir and is the source of practically all the ground water in the valley. Where it consists of fine-grained material, such as silt and clay, or of poorly sorted material, the permeability is low and only small yields can be expected from wells. In contrast, well sorted sand and gravel strata have moderate to high permeabilities and will yield water readily to wells.

Alluvial fans coalesce to form the piedmont slopes which flank the mountains. Along the flanks of the Granite Range this alluvium has been deposited largely by mudflow and flood waters because of the flashy nature of the streams draining the granite terrane. The alluvium is generally of low permeability because of the poor sorting of the various sized particles and because its source material, granite, tends to weather into angular fragments by parting along the crystal faces of the constituent minerals. Granitic alluvium, therefore, is not very permeable and the chance of developing a well of even moderate yield in this material is poor.

Although the volcanic rocks of the area (principally rhyolite) are chemically similar to granite, they are finer grained and the rock is more dense.

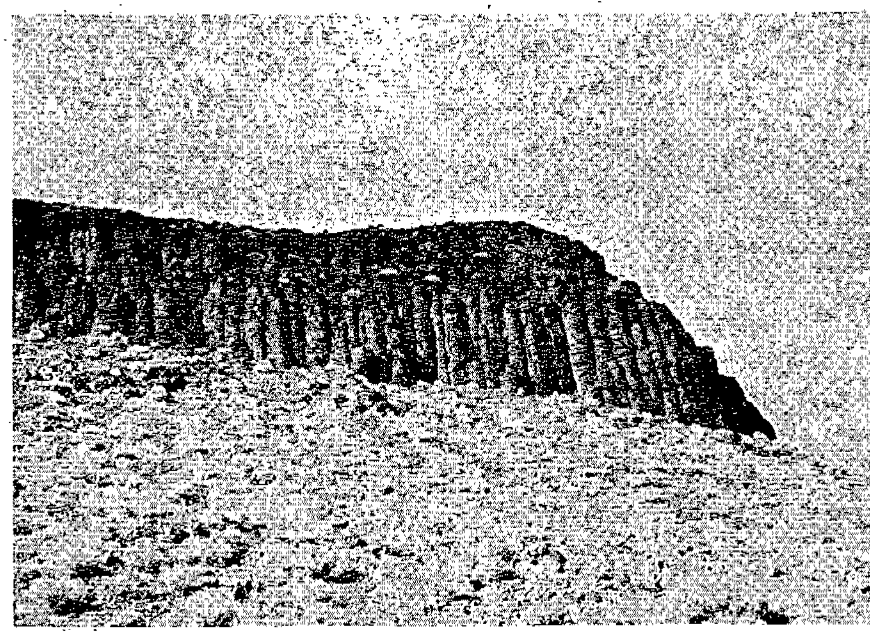

Figure 3. Butte of rhyolite porphyry in sec. 15, T.35 N., R.23 E. showing columnar jointing typical of volcanic rocks.

Figure 4. Close-up of columnar jointing in rhyolite porphyry. Secondary openings created by jointing are an important avenue of ground-water movement in bedrock. Hexagonal columns are about 3 to 4 feet across.

Weathering of volcanic rocks commonly originates along secondary fractures such as the joint planes illustrated in figure 4. The mechanical breakdown of the rock continues as the detritus is moved downslope by the action of gravity and water. Although the permeability may range widely because of variations in sorting, alluvium derived from volcanic rocks is generally more permeable than decomposed granite, and moderate to large yields of water may be obtained from wells tapping this alluvium.

The center of the valley is underlain by lake sediments which were deposited in Lake Lahontan and earlier Pleistocene lakes. These sediments are predominantly silt and clay, which are deep-lake deposits, separated by layers of sand and gravel, which are principally stream deposits and reworked alluvium that accumulated during shallow stages of the lake and periods of emergency of the land surface. The sand and gravel strata are the principal aquifers in the lake sediments and may yield large quantities of water to properly constructed wells. The drillers' logs listed in table 4 are not detailed enough to facilitate correlation of the principal aquifers but the logs do indicate an increase in clay and decrease in sand and gravel toward the south end of the valley. The most promising area for ground-water development, therefore, appears to be the northern part of the valley where development is currently taking place.

GROUND WATER

Occurrence and Movement

Most of the available ground water occurs in the unconsolidated deposits of the valley fill.

Ground water moves from recharge areas, the mountains and piedmont slopes, downgradient toward the playa and surrounding areas of phreatophyte vegetation, where it is discharged by evapotranspiration.

Recharge

The ground-water reservoir beneath Hualapai Flat is recharged by precipitation within the drainage basin. This recharge, which occurs largely by seepage from streams crossing the piedmont slopes, is balanced, under natural conditions, by natural discharge of the ground-water, principally by evapotranspiration from the valley floor.

The approximate amount of precipitation within the drainage area each year can be computed from a map showing precipitation zones in Nevada (Hardman, 1936). Hardman mapped the precipitation zones chiefly on the basis of elevation, type of vegetation, and precipitation data available from the relatively few U.S. Weather Bureau climatological stations in existence at that time. Precipitation within the drainage area of Hualapai Flat is estimated to be about 85,000 acre-feet per year. This figure was derived by subdividing the drainage basin of the valley into precipitation zones as shown below:

Altitude of zone (feet)	Area of Zone (sq. mi.)	(acres)	Precipitation Zone (inches)	(acre-ft./yr.)	Percentage recharged 1/	Approximate recharge (ac.ft/yr.)
7,000	8	5,120	15-20	7,600	15	1,100
6-7,000	44	28,160	12-15	31,700	7	2,200
5-6,000	44	28,160	8-12	23,400	3	700
5,000	84	53,760	8	23,600	0	
Total (rounded)	180	115,000		85,000		4,000

1/ After Eakin (1951)

The amount of precipitation which infiltrates to the ground-water reservoir is determined largely by the vegetation, soil cover, and geology of the area. These and other factors combine to form what may be termed the recharge potential of the terrane, or its capacity to accept recharge. In areas of very little precipitation such as the valley floor, all, or nearly all, of the available moisture may be lost to evapotranspiration.

The principal source of recharge to the ground-water reservoir is seepage from streams crossing the alluvium of the piedmont slopes. The streambeds are composed of permeable gravel and the piedmont surface is generally well above the regional water table. Rapid infiltration is possible under these circumstances.

Recharge in the mountains is determined largely by the geology. The permeability of most consolidated rocks is relatively low; but secondary openings, such as occur along bedding planes, joints, and fractures are important avenues of infiltration. The manner in which the various rock types weather, has a considerable effect on the recharge potential. A mantle of rock debris retards the runoff from precipitation and snowmelt and permits the water to infiltrate. Once beneath the land surface, the water may percolate into the bedrock, or, in the case of less permeable rock types, move downward, through the alluvium, along the surface of the bedrock. Springs and seeps occur where the mantle thins or the bedrock surface outcrops, and are the source of the base flow of many of the small streams draining the mountains.

Even under favorable conditions, the percentage of precipitation that recharges the ground-water reservoir is small, and the percentage for a given amount of precipitation varies considerably with the terrane. A detailed determination of the percentage of precipitation in each zone that recharges ground water is not made. The estimated ground-water recharge from precipitation shown on p. 8 is based on percentages determined empirically by Eakin (1951) from studies in eastern Nevada. Assuming these factors to be valid in Hualapai Flat the average annual recharge to the ground-water reservoir is on the order of 4,000 acre-feet per year.

Discharge

Ground water is discharged from the valley by evapotranspiration, springs, and pumping. Some ground water is also discharged by underflow to the east into the Black Rock Desert. The results of the seismic work conducted by the Desert Research Institute (p.4) indicate that bedrock underlies the alluvial part of the drainage divide separating Hualapai Flat and Black Rock Desert at a depth of about 250 feet. The bedrock is well below the water table in both basins and, thus, is no barrier to ground-water movement. The permeability of unconsolidated lake deposits overlying the bedrock in this area is unknown.

The gradient of the water table between wells 34/24-4b1 and 5b1 is only about 1 foot per mile toward the east. The very low gradient indicates that, even though the ground-water aquifers of Hualapai Flat may be in hydraulic continuity with those of the Black Rock Desert, the volume of water moving eastward out of Hualapai Flat by underflow is probably negligible.

Springs: Thermal springs discharging into about 30 or 40 individual pools have created a grassy mound centered in sections 1 and 2, T. 34 N., R. 23 E. Water in the different pools stands at various elevations and temperatures depending, apparently, upon the drainage from the pool. Much of the discharge is probably by underground seepage into the surrounding alluvium. Most of the surface discharge, however, has been channeled into ditches to irrigate about 500 acres of hay and salt grass in the area south of the springs.

A number of wells have been drilled in the spring area, the most notable of which is well 34/23-1c1, locally known as "The Geyser". This well has been discharging steam and boiling water since it was drilled, about 1920. The water is highly mineralized and precipitation of the chemical constituents at the surface has created a tower of sinter which stands about 15 feet above the surrounding land surface.

The surface discharge of the thermal springs and wells is probably on the order of 500 acre-feet per year and this amount is included in the discharge of ground water by grass in the table on page 11.

Many cold springs and seeps issue from the alluvium of the valley floor. Commonly these areas are overgrown with clumps of buckbrush and rabbitbrush. These are probably artesian springs whose head is maintained by recharge along the piedmont slopes. Actual surface discharge is generally negligible.

Springs and seeps of the gravity type occur along the flanks of the mountains, commonly issuing from the alluvium at the heads of canyons, where the water table intercepts the land surface. The water discharged by these springs is either lost by evaporation and transpiration near the source or along the stream channel into which the spring discharges, or it infiltrates back to the ground-water reservoir. The discharge of these springs is small, commonly a few gallons per minute. Most of the springs are used to water stock. Available information on some of the springs in the valley is given in table 2.

Pumpage: The ground-water regimen in Hualapai Flat has been only slightly affected by pumpage to date. However, large tracts of land have been cleared for irrigation, about 10 large capacity wells have been drilled, and, commencing with the 1962 irrigation season, it seems probable that the discharge of ground water by pumping will become one of the most important factors in the hydrologic regimen of the valley.

Evaporation and Transpiration: Evaporation from the ground-water reservoir occurs in areas where the water table intercepts the land surface, usually indicated by springs or seeps, or in areas where it is near enough to the land surface for the capillary fringe above the water table to lose water to the atmosphere.

Most of the natural discharge of ground water is effected by plants known as phreatophytes, whose roots descent to the water table or to the capillary fringe above it. Greasewood is the most common phreatophyte in the valley and its presence generally indicates that the water table is within about 20 feet or less of the surface. Other common phreatophytes are rabbitbrush, salt grass, willow, and buckbrush. The distribution of the principal types of phreatophytes in Hualapai Flat is shown in plate 1.

The phreatophytes have been grouped on the basis of the dominant species and water use into (1) greasewood, which includes rabbitbrush and buckbrush, and (2) grass. Small, isolated areas of phreatophytes, chiefly willow, thrive along some of the stream beds and at the mouths of some of the canyons, but these areas are small and are not shown in plate 1.

The estimated rate of use of ground water by phreatophytes used in this study is based largely on work done by White (1932, p. 28-93) in Escalante Valley, Utah. The following table summarizes the estimate of discharge of ground water by evapo-transpiration:

Predominant phreatophyte type	Area (acres)	Depth to water (feet)	Estimated rate of use of ground water (feet per year)	Estimated discharge by evapotranspiration (acre-feet per year)
Greasewood	16,000	10-30	0.2	3,200
Grass 1/	1,500	5	1	1,500
			Total (rounded)	5,000

1/ Discharge of water by grass is estimated to be about 2 acre-feet per year (White, 1932, p. 82). One half of the consumptive use supplied by ground water; one half by surface water and precipitation.

Ground-Water Inventory

Under natural conditions the average annual recharge to the ground-water reservoir in Hualapai Flat equals the average annual discharge from the valley. Temporary extremes of drought or flood are compensated for by changes of ground water in storage. Because pumping has not appreciably affected the equilibrium of the system, the estimated recharge should be about equal to the estimated natural discharge.

Exact agreement of the estimates of average annual recharge (4,000 acre-feet per year) and average annual discharge (5,000 acre-feet per year) is not to be expected because of the crude data that were used in estimating the various elements of recharge and discharge. Although the estimates of recharge and discharge differ somewhat, they are of about the same magnitude and probably are within the general range of the actual values.

Perennial Yield

The perennial yield is the maximum rate at which water can be withdrawn from a ground-water system for an indefinite period of time. It is ultimately limited by the amount of recharge available to the system.

The net amount of ground water that can be pumped perennially in Hualapai Flat without causing a continuing decline in ground-water levels is limited to the amount of natural discharge that can be salvaged. The allowable gross pumpage may exceed the net pumpage to the extent that some of the ground water returns to the ground-water reservoir and is suitable for reuse. The actual perennial yield of the valley can be determined only after several years of extensive development.

Ground-Water in Storage

The amount of recoverable ground water in storage in the valley fill of Hualapai Flat is many times the average annual recharge. An estimate of the magnitude of the recoverable water in storage can be obtained by computing the amount of ground water that will drain from the sediments for each foot of lowering of water level in the valley fill. A value of 10 percent is considered to be a conservative estimate of the amount of water by volume that will drain from the sediments. The drainable unconsolidated sediments are estimated to include almost the entire volume of valley fill, and hence to have an area of about 30,000 acres, although, in the area of the thermal springs and southward, much of the ground water may be highly mineralized and, thus, valueless for most purposes.

The ground water recoverable from storage as a result of lower water levels would thus be about 3,000 acre-feet per foot of lowering, or somewhat less than the estimated average annual recharge. If water levels generally were lowered 100 feet, the amount of water removed from storage would roughly equal the total recharge for 75 years. Thus the amount of water that can be developed by pumping from storage is not unlimited, and if the net pumpage is allowed to exceed the average annual recharge the ground-water reservoir will, in time, be exhausted.

CHEMICAL QUALITY OF THE GROUND WATER

The chemical constituents of ground water are acquired by the solution of minerals in the material through which the water percolates. In general, the dissolved-solids content of the water is determined by the solubility of the rock or soil; the area and duration of contact, and other factors such as pressure and temperature.

Water for Irrigation

The suitability of water for irrigation may be evaluated on the basis of the salinity hazard, the sodium (alkali) hazard, and the concentration of bicarbonate, boron, and other ions.

Salinity Hazard: The salinity hazard depends on the concentration of dissolved solids. It is normally measured in terms of the electrical conductivity, or specific conductance, of the water expressed as micromhos per centimeter at 25°C. The electrical conductivity is an approximate measure of the total concentration of the ionized constituents of the water. Water of low conductivity generally is more suitable for irrigation than water of high conductivity.

Sodium (alkali) Hazard: The sodium, or alkali, hazard is indicated by the sodium-adsorption-ratio (SAR), which may be defined by the formula

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

in which concentrations are expressed in equivalents per million. If the proportion of sodium among the cations is high, the alkali hazard is high; but if calcium and magnesium predominate, the alkali hazard is low. An SAR in excess of about 10, or less where specific conductance is high, probably will present a sodium hazard.

Bicarbonate Ion: Residual sodium carbonate (RSC), which may be defined by the formula $RSC = (CO3^{--} + HCO3^{-}) - (Ca^{++} + Mg^{++})$, in which concentrations are expressed in equivalents per million, is a measure of the hazard involved in the use of high-bicarbonate water. If residual sodium carbonate is greater than 2.5 epm (equivalents per million), the water is not suitable for irrigation. The water is marginal if the residual sodium carbonate is between 1.25 and 2.5 epm, and is probably safe if the residual sodium carbonate is less than 1.25 epm.

Boron: Nearly all natural water contains boron in amounts that range from a trace to several parts per million. Although boron in small amounts is essential to plant growth, it is toxic at concentrations slightly higher than the optimum. Scofield (1936, p. 286) proposed limits for boron in irrigation water, depending on the sensitivity of the crops to be irrigated. In general, boron in excess of 3 ppm (parts per million) is injurious to most crops.

Classification and Interpretation of Analyses

The results of chemical analyses of water from 5 wells, 2 springs, and Granite Creek and Nigger Creek are given in table 3. The salinity and alkali hazards of all the samples that were analyzed are plotted on a diagram proposed by Wilcox for the classification of irrigation water (fig. 5). On the basis of this diagram and the residual sodium carbonate column in table 3, most of the ground water in Hualapai Flat can be used safely for the irrigation of crops. The notable exception to this is water from well 34/23-1c1, which may be representative of water in the thermal spring area. This water is more saline than the country water and is characterized by very high sodium content. On this basis it is not suitable for irrigation. The boron content of all the water that was analyzed was not detrimental for any of the crops likely to be grown in the valley.

Temperature

The temperature of water from wells sampled in Hualapai Flat averaged about 62^{o}F and ranged from 60^{o} to 77^{o}F. The temperature of water in the area of thermal springs ranges up to and above the boiling point.

Water for Domestic Use

Water from most of the wells sampled in Hualapai Flat is satisfactory for domestic use according to the requirements of the U.S. Public Health Service (1962).

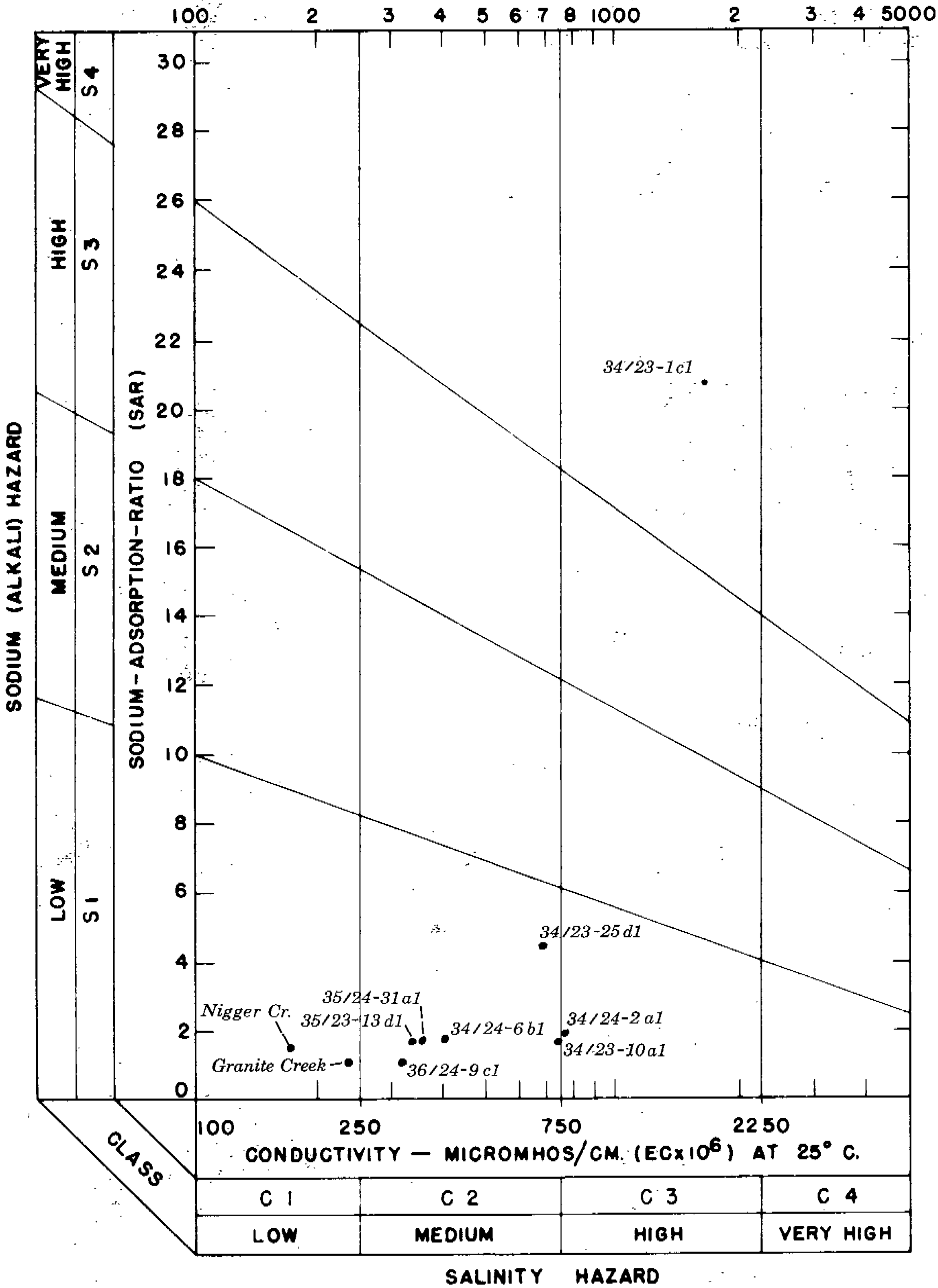

Figure 5. Classification of irrigation water on the basis of conductivity and sodium-adsorption-ratio.

CONCLUSIONS

The most important sources of ground water in Hualapai Flat are the sand and gravel aquifers buried within the less permeable deposits of the valley fill. These aquifers are probably most productive along the margins of the valley floor, and particularly opposite the mouths of canyons where streams have created channels filled with coarse, well sorted material at various depths within the lake sediments underlying the valley floor.

The average annual recharge to the ground-water reservoir of Hualapai Flat is on the order of 4,000 acre-feet. The amount of recoverable ground water in storage in the valley is about 3,000 acre-feet per foot of saturated sediments. Although some ground water must be withdrawn from storage in order to induce movement of water toward a pumping well, the net draft on the ground-water reservoir must not exceed the average annual recharge if a long-term decline in water levels and the complete depletion of all the water in storage is to be avoided.

Chemical analyses indicate that most of the ground water in Hualapai Flat is suitable for irrigation and domestic use. The water in the area of thermal springs is highly mineralized, however, and excessive pumpage could induce this mineralized water to flow toward the area of pumpage.

The most promising area for ground-water development appears to be the northern part of the valley where development is currently taking place. It seems unlikely that large capacity wells can be developed in the granitic alluvium and the playa deposits which underlie the valley floor south of the area of thermal springs.

Hualapai Flat is one of the smallest basins in the state of Nevada and, in its present state of impending development, presents an excellent opportunity for a detailed study of closed-basin hydrology. Because of the small area involved it would be possible to study, intensively, various factors in the hydrologic regimen and their interrelationships. The effect of intensive pumpage on the natural regimen, and on ground water in storage should be an important part of such a study. It seems likely that the results of an intensive study of this model valley, which is so typical of many of the larger valleys in Nevada, would be widely applicable in future studies of the water resources of the state.

Table 1.--Record of wells in Hualapai Flat, Washoe, Pershing, and Humboldt Counties, Nev.
Use of water: D, domestic; I, irrigation; S, stock; T, test.
Water level: M, measured; R, reported.

Well or spring number and location	Owner	Date drilled	Diameter (inches)	Depth (feet)	Depth of main aquifers (feet)	Below measuring point (feet)	M or R	Date	Above land surface (feet)		Use	Remarks
36/23-36a1	Francis McKay	--	16	--	--	111.6	M	5-20-62	0	Top of casing	I	
36/23-36d1	Francis McKay	--	16	285	--	--	-	--	--	--	I	
35/23-10d1	David E. Iveson	--	--	25	--	--	-	--	--	--	D	
35/23-11a1	Francis McKay	--	16	310	--	--	-	--	--	--	I	
35/23-12b1	Francis McKay	--	16	304	--	67.59	M	2-22-62	1	Slot in casing	I	
35/23-12c1	Francis McKay	5-60	16	200	68-125	55	R	5- 2-60	--	--	I	
35/23-13d1	R. and J. Iveson	3-60	16	210	125-131	45	R	3-23-60	--	--	I	
35/23-24b1	David Iveson	4-51	16	206	60-180	45	R	4-10-51	--	--	I	
35/23-24d1	R.A. Cochrane J.H. Pendry	4-60	16	207	112-142	37	R	4-21-60	--	--	I	
35/23-25a1	Aaron Hook	4-60	16	158	127-147	26	R	4- 9-60	--	--	I	
35/23-36d1	--	--	6	300	--	.05"	M	1-12-62	.3	Top of casing	S	
35/23-36d2	--	--	21	30	--	0	M	5-19-62	0	Top of casing	S	
35/23-30c1	Granite Land and Livestock	9-47	6	200	25-140	16	R	9- 7-47	--	--	S	
35/24-31a1	G. A. Jackson	4-60	16	190	157-177	+	M	1-13-62	.5	Hole in pump base	I	
34/23-1a1	--	--	4	200	--	+	M	5-19-62	0	Top of casing	S	Several other flowing wells in this area.
34/23-1a2	Granite Land and Livestock	9-47	6	150	100-150	--	-	--	--	--	S	
34/23-1c1	--	1920±	--	--	--	+20	M	5-19-62	--	--	S	Steam-well
34/23-12c1	Granite Land and Livestock	9-47	4 3/4	150	85-100	15	R	9- 1-47	--	--	S	
34/23-25d1	Granite Land and Livestock	8-47	4 3/4	200	120-135	+ 7	R	8-22-47	--	--	S	
34/23-25d2	Granite Land and Livestock	8-47	4 3/4	200	120-150	4.5	R	8-28-47	--	Top of tee	S	
34/23-35a1	Granite Land and Livestock	7-47	8	400	160-185	15	R	7- -47	--	--	D	
34/23-35a2	Granite Land and Livestock	7-47	8	180	150-160	--	-	--	--	--	D	
34/24-4b1	U.S. Geological Survey	6-62	4	15	--	5.6	M	8-25-62	0	Land surface	T	
34/24-5b1	U.S. Geological Survey	6-62	4	15	--	6.7	M	8-25-62	0	Land surface	T	
34/24-6b1	--	--	4	123	--	+ 2	M	1-13-62	1	Top of casing	S	Flows about 20 gpm
34/24-6b2	--	--	--	--	--	+ 2	M	1-13-62	1	Top of casing	-	Flows about 50 gpm
34/24-8a1	Granite Land and Livestock	10-47	6 3/4	50	--	--	-	--	--	--	S	
34/24-9c1	Granite Land and Livestock	7-47	4	490	30-50	1.5	R	7-24-47	--	--	S	Reported unfit for stock
34/24-19b1	Granite Land and Livestock	8-47	4	200	75-120	+	R	8- -47	--	--	S	Reportedly flows 2-3 gpm

Table 2.--Record of springs in Hualapai Flat, Washoe, Pershing, and Humboldt Counties, Nev.

Use: S, stock; I, irrigation. Discharge is estimated.

Spring number	Name	Discharge gpm	Use	Temperature (°F)	Remarks
37/22-33a1	Corner Spring	--	S	--	
37/22-34c1	Negro Canyon Spring	--	S	--	
37/23-10d1	Chicken Spring	--	S	--	
37/23-17b1	Leadville Spring	--	S	--	
37/23-20a1	Buckhorn Spring	--	S	--	
37/23-22d1	South Willow Creek Spring	--	S	--	
36/22-26b1	Aspin Spring	--	S	--	
36/24-16a1	Caine Spring	--	S	72	Chemical analysis
35/23-36d3	Cold Spring	2-3	S	57	Sp. cond. 480 micromhos
34/23-1c2	Hot Springs	500 ±	S,I	--	Many spring pools at various altitudes and temperatures ranging to boiling.
34/23-6b1	Shedd's Gulch	--	S	--	
34/23-10a1	--	2-3	S	72	Chemical analysis
34/23-12b1	--	2-3	S	56	
34/23-18c1	Iraqui Spring	--	S	--	
34/23-18c2	--	--	S	--	
33/23-6a1	Summit Spring	--	S	--	
33/23-6d1	Howard Spring	--	S	--	
33/23-8a1	No Name Spring	--	S	--	

Table 3.--Chemical analyses of water in Hualapai Flat, Washoe, Pershing, and Humboldt Counties, Nev.

[Analyses by U.S. Geological Survey. Mineral constituents, in parts per million, except as indicated]

Well, spring or stream number	Date collected	Temperature °F	Silica (Si)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (C)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Hardness as $CaCO_3$: Calcium-Magnesium	Hardness as $CaCO_3$: non-carbonate	Specific conductance (micromhos at 25°C)	Dissolved solids (ppm) residue at 180°C	Sodium adsorption ratio (SAR)	Residual sodium carbonate (RSC)-(epm)	pH
Nigger Creek 36/23-18	12-13-61		64	8.4	4.1	21	7.0	0	73	12	13	0.1	0.8	0.1	0	38	188	163	1.5	.44	7.4
Spring 36/24-16a1	12-12-61	70	74	23	8.4	26	10	0	107	22	32	0.1	1.8	0.0	4	92	323	256	1.17	0	7.3
Well 35/23-13d1	5- 3-61	65	61	25	9.0	32	4.7	0	148	16	23	0.2	0.5	.13	0	100	339	245	1.4	.46	7.8
Well 35/24-31a1	5- 3-61		66	26	9.7	33	7.1	0	159	20	25	0.2	0.5	.16	0	104	366	266	1.4	.51	7.7
Well 34/23-1c1	5- 3-61		76	18	4.6	386	16	40	336	205	250	7.9	0.2	2.1	0	64	1840	1170	21.0	5.55	9.0
Spring 34/23-10a1	12-13-61	72	89	72	21	54	10	0	223	67	93	0.1	0.3	0.1	82	265	755	549	1.4	0	7.2
Well 34/23-25d1	12-13-61	55	36	30	9.5	109	2.2	0	220	41	86	0.1	1.5	0.4	0	114	703	452	4.4	1.33	7.3
Granite Creek 34/23-34	12-13-61		18	19	3.8	18	3.5	0	84	9	21	0.1	1.1	0.1	0	63	229	164	1.0	.12	7.5
Well 34/24-6b1	12-12-61	61	69	30	10	38	8.8	0	176	20	27	0.1	0.4	0.1	0	116	409	304	1.5	.58	7.9

Table 4.--Drillers' logs of wells in Hualapai Flat

Washoe, Pershing, and Humboldt Counties, Nev.

35/23-12c1

	Thickness (feet)	Depth (feet)
Sandy loam	28	28
Gravel, dry	12	40
Clay, sandy	22	62
Sand, fine, water	6	68
Gravel, medium to large	57	125
Silt, fine	5	130
Gravel, medium	20	150
Silt, fine	14	164
Gravel, medium	6	170
Silt, fine, some small gravel	24	194
Clay, silty	6	200

35/23-13d1

	Thickness (feet)	Depth (feet)
Sandy loam, brown	32	32
Clay, brown	11	43
Gravel, small	3	46
Clay, sandy, brown	12	58
Sandy, fine, brown	13	71
Clay, sandy, brown	13	84
Gravel, fine to medium	8	92
Clay, yellow	15	107
Gravel, large, cobble	5	112
Clay, sandy, brown	13	125
Gravel, medium to coarse	6	131
Gravel, some sand and clay	36	167
Silt, hard	4	171
Sand, fine, brown	4	175
Clay, brown	8	183
Gravel	7	190

Table 4 (continued)

	Thickness (feet)	Depth (feet)
35/2324a1		
Topsoil	2	2
Clay	43	45
Gravel and clay	15	60
Gravel and sand (drill test 100 gpm)	13	73
Clay	5	78
Gravel and sand - water	4	82
Sand, fine, and clay	5	87
Clay, red	4	91
Clay and gravel - water	9	100
Gravel, large	20	120
Clay, gray	5	125
Gravel - water	15	140
Clay, brown	10	150
Clay and gravel	10	160
Clay	5	165
Gravel - water	15	180
Not reported	26	206

	Thickness (feet)	Depth (feet)
35/23-24c1		
Topsoil	5	5
Gravel, dry	10	15
Clay, brown	32	47
Gravel, small	3	50
Clay, red	12	62
Gravel, medium	6	68
Clay, brown	6	74
Gravel, medium to large	8	82
Clay, brown	10	92
Gravel, medium	3	95
Clay, brown to gray	17	112
Gravel, medium to large	30	142
Clay, brown	10	152
Gravel, medium	16	168
Sand, coarse	4	172
Clay, sandy, brown	11	183
Gravel, medium	2	185
Clay, brown	5	190
Sand, coarse to gravel, large	11	201
Clay, brown, some gravel	6	207

Table 4 (continued)

35/23-25al

	Thickness (feet)	Depth (feet)
Topsoil	15	15
Clay, sandy, brown	10	25
Clay, blue	13	38
Gravel	7	45
Clay, sandy, brown	10	55
Gravel, medium	13	68
Clay, sandy	10	78
Gravel, coarse to cobble	32	110
Clay, sandy	17	127
Gravel, large to cobble	20	147
Gravel, hard, cemented	11	158

35/24-31al

	Thickness (feet)	Depth (feet)
Topsoil	15	15
Marshy with odor	5	20
Gravel, fine to medium	23	43
Clay, brown	12	55
Sand, coarse, to medium gravel	12	67
Clay, blue and brown	29	96
Gravel, medium to coarse	6	102
Clay, brown	38	140
Gravel, medium to coarse	12	152
Clay, sandy, brown	5	157
Gravel, medium to coarse	20	177
Clay, hard, brown	5	182
Gravel, coarse	3	185
Clay, hard, brown	5	190

34/23-13d1

	Thickness (feet)	Depth (feet)
Clay, yellow	10	10
Clay, hard, light green	10	20
Clay, soft, light blue	2	22
Clay, soft, black, sooty, lustrous, gas, loss of mud	6	28
Clay, soft, green	2	30
Clay, black and blue-green alternate	16	46
Clay, blue to green alternate	14	60
Mud, dark blue to green	10	70
Clay, soft, black, lustrous	15	85
Sand and blue-green-black clay - water	15	100
Clay, light green to blue	30	130
Clay, light blue-green-dark green	20	150

34/23-25d1

	Thickness (feet)	Depth (feet)
Clay, light yellow	10	10
Clay, green	10	20
Sand, white, no mica	2	22
Sand, fine and mica	8	30
Sand, fine and mica	30	60
Clay, yellow, sand and gravel	40	100
Sand, fine and clay	10	110
Sand and orange clay	10	120
Sand, fine - water	15	135
Sand and orange clay	35	170
Clay, white and brown alternate, mixed with fine sand	30	200

Table 4 (continued)

34/23-25d2

	Thickness (feet)	Depth (feet)
Black dirt	3	3
Clay, dark green, gas	4	7
Clay, light gray and brown, sand	3	10
Mica, sand, clay, cream	10	20
Gravel and rock, mica and sand	10	30
Granite, green stone, black rocks, lava	10	40
Pure mica, clay, sticky and swelling, sand and gravel	10	50
Clay, mica, orange with sand and gravel	60	110
Sand and small gravel, brown clay	40	150
Sand and fine gravel, lots of mica	20	170
Sand, coarse, fine gravel, light yellow to cream clay	30	200

34/23-35a1

	Thickness (feet)	Depth (feet)
Granite sand, clay seams of fine orange mica	80	80
Coarse sand, fine sand, and fine mica - water	10	90
Bentonite, swelling ground, fine mica	10	100
Same as above, alternate water strata, quicksand, fine orange mica, (end - water)	10	170
Same as above	15	185
Sand, quartz and granite, and clay, cemented hard, brown	5	190
Sand, granite and swelling clay, mica	60	250
Same as above, small water last 5 feet	35	285
Sand, coarse, mica mud, soft	15	300
Clay, white, sand, granite, light color	9	309
Clay, light green, hard	2	311
Water strata, fine orange and black mica cubes, black sand	13	324
Granite, hard, cemented, iron	2	326
Clay, blue, mixed with red mica, clay sticky and swelling	1	327
Clay, light yellow, occasional chunks of white	23	350
Clay, light yellow and white in sand and small gravel	2	352
Mud, light yellow and granite sand	3	355
Clay, blue, and granite sand	15	370
Sand, granite, golden mica - water strata	15	385
Clay, light brown, very soft, mica	15	400

Table 4 (continued)

34/23-35a2

	Thickness (feet)	Depth (feet)
Sand, black, granite and clay, brown	10	10
Clay, brown and gravel	10	20
Clay, brown, last 2 feet yellow	10	30
Clay, brown, sand and large gravel	10	40
Same as above	10	50
Clay, mica, soft, sticky	40	90
Clay, mica, coarse gravel	10	100
Mud, mica, no sand	40	140
Mud, mica, sand, fine, black	10	150
Sand, fine, black - water	10	160
Mud, mica, coarse sand, gravel	7	167
Mica, hard, brown and yellow	2	169
Clay, sticky mica, sand, gravel	5	174
Clay, sticky, swelling clay	6	180

34/24-8a1

	Thickness (feet)	Depth (feet)
Sand and brown clay	6	6
Gravel and brown clay	4	10
Clay, white to cream, sulfur gas, flammable	26	36
Total loss of drilling mud, water dropped 20 feet	4	40
Mud, very soft, blue	9	49
Mud, green, stinking sulfur	1	50

Table 4 (continued)

	Thick-ness (feet)	Depth (feet)
<u>34/24-9c1</u>		
Clay, light green	10	10
Clay, soft, green	10	20
Clay, soft, light green, sulfur smell, gas	10	30
Clay, blue, green, yellow, black	20	50
Sand and clay, blue, tough drilling	20	70
Sand, fine, light blue, green, brown and gray	30	100
Clay, black, stinking, clay, blue, green, yellow and brown	20	120
Sandy mud, light green	20	140
Hard granite boulder or cemented strata, pyrite	2	142
Mud, gray, light green and fine sand	28	170
Clay, soft, light green	10	180
Clay, blue and green alternate	20	200
Clay, soft, light green	100	300
Clay, light green, gray	50	350
Sand, fine, light gray	30	380
Clay, light blue, sand, fine, pyrite, gas bubbles	10	390
Clay, light blue, increase in gas (may be from 30 feet)	20	410
Clay, light gray, pyrite	4	414
Sand, light green, opalized granite, adularia and copperstained	36	450
Clay, light green, sand, fine, pyrite "all rolled together"	20	470
Same as above except coarser sand and gravel	10	480
Same as above except coarser sand and gravel	10	490

Table 4 (continued)

	Thickness (feet)	Depth (feet)
34/24-19b1		
Clay, light green to light yellow	10	10
Same as above	5	15
Alternate layers of black, green, yellow and brown clay	5	20
Clay, soft, black, lustrous	10	30
Clay, soft, black, lustrous	10	40
Clay, black, green, yellow	10	50
Clay, light green	10	60
Clay, light blue	15	75
Clay, light yellow, small clamshells	5	80
Small chunks of black mud and white clamshells	10	90
Alternate strata of light green-blue-gray clay	20	110
Clay, light gray, sulfur gas, bubbles (brown)	20	130
Clay, light green, gas bubbles	40	170
Black mica mud, soft	15	185
Coarse granite sand and clay, gray	8	193
Clay, gray, no sand or gravel	7	200

"Inflammable gas issuing with water, no color. Water heavy with chlorides, salty and soda taste with a little sulfur smell and taste. From 120-180 feet fine sulfides with mud. Heavy sulfides 185-193 feet."

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Ground-Water Resources Reconnaissance Series

Report No.

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EXPLANATION

Alluvium
Unconsolidated rock debris ranging in size from clay to boulders. Includes lake and stream deposits.

Bedrock
Mainly granitic and volcanic

Playa lake

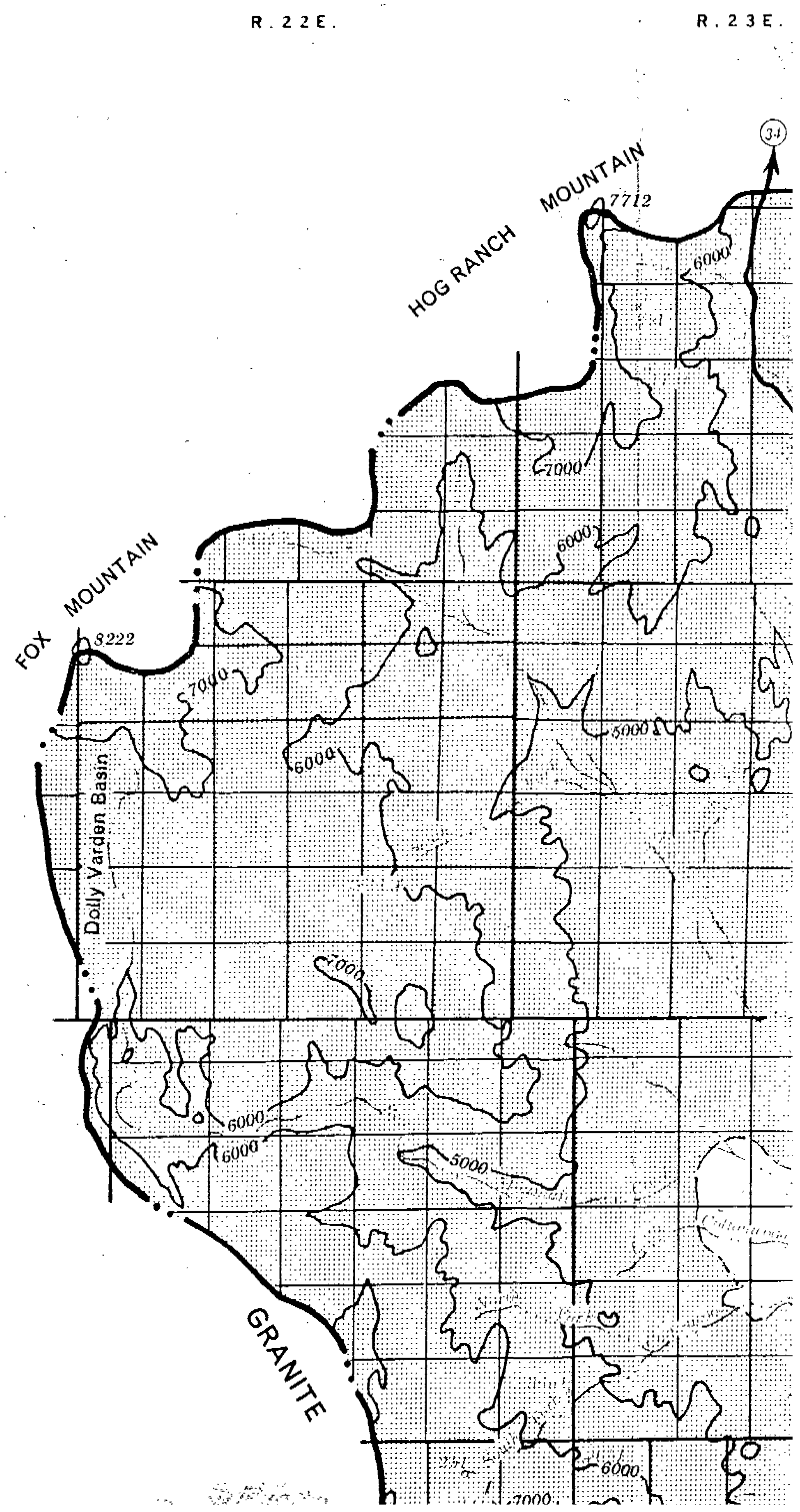
Reservoir

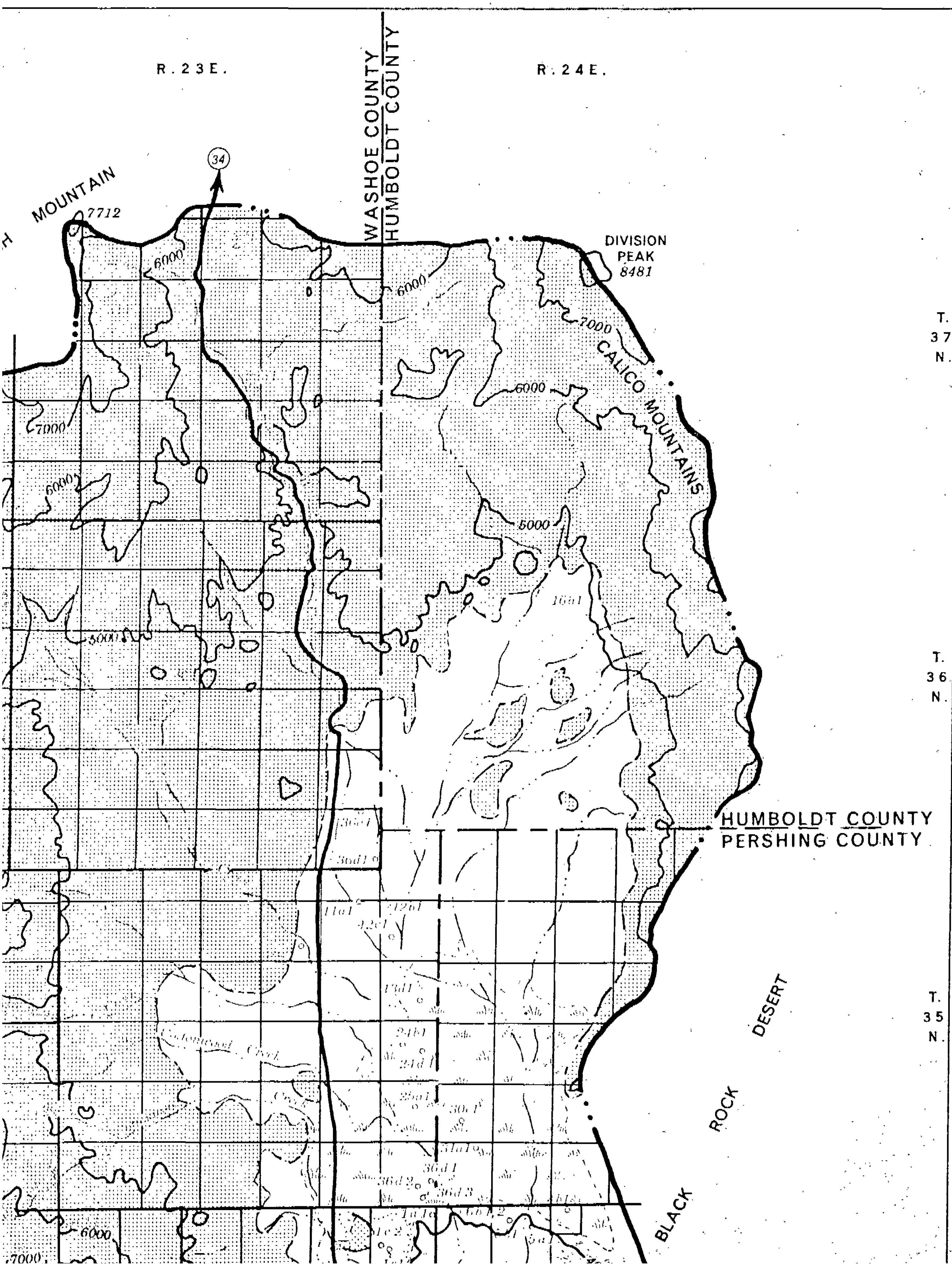
Greasewood, rabbitbrush and buckbrush

Grass

10d1
Well and number

3d1
Spring and number




R. 23 E.
R. 24 E.
WASHOE COUNTY
HUMBOLDT COUNTY
MOUNTAIN
7712
34
DIVISION
PEAK
8481
6000
7000
5000
CALICO MOUNTAINS
T. 37 N.
T. 36 N.
T. 35 N.
HUMBOLDT COUNTY
PERSHING COUNTY
BLACK
ROCK
DESERT

Reservoir

Greasewood,
rabbitbrush and buckbrush

Grass

10d1

Well and number

3d1

Spring and number

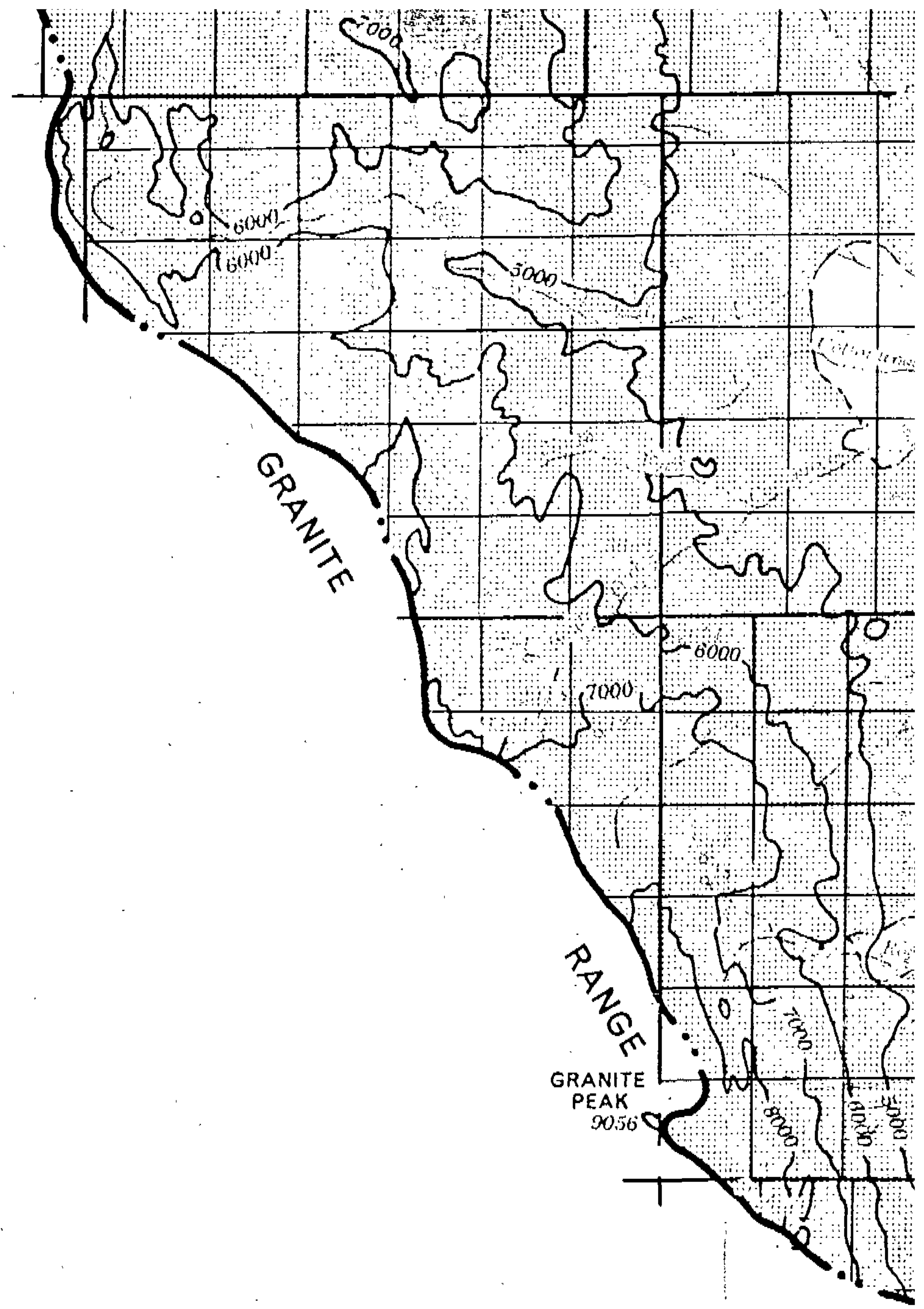
Drainage divide

6000

Contour interval 1000 feet

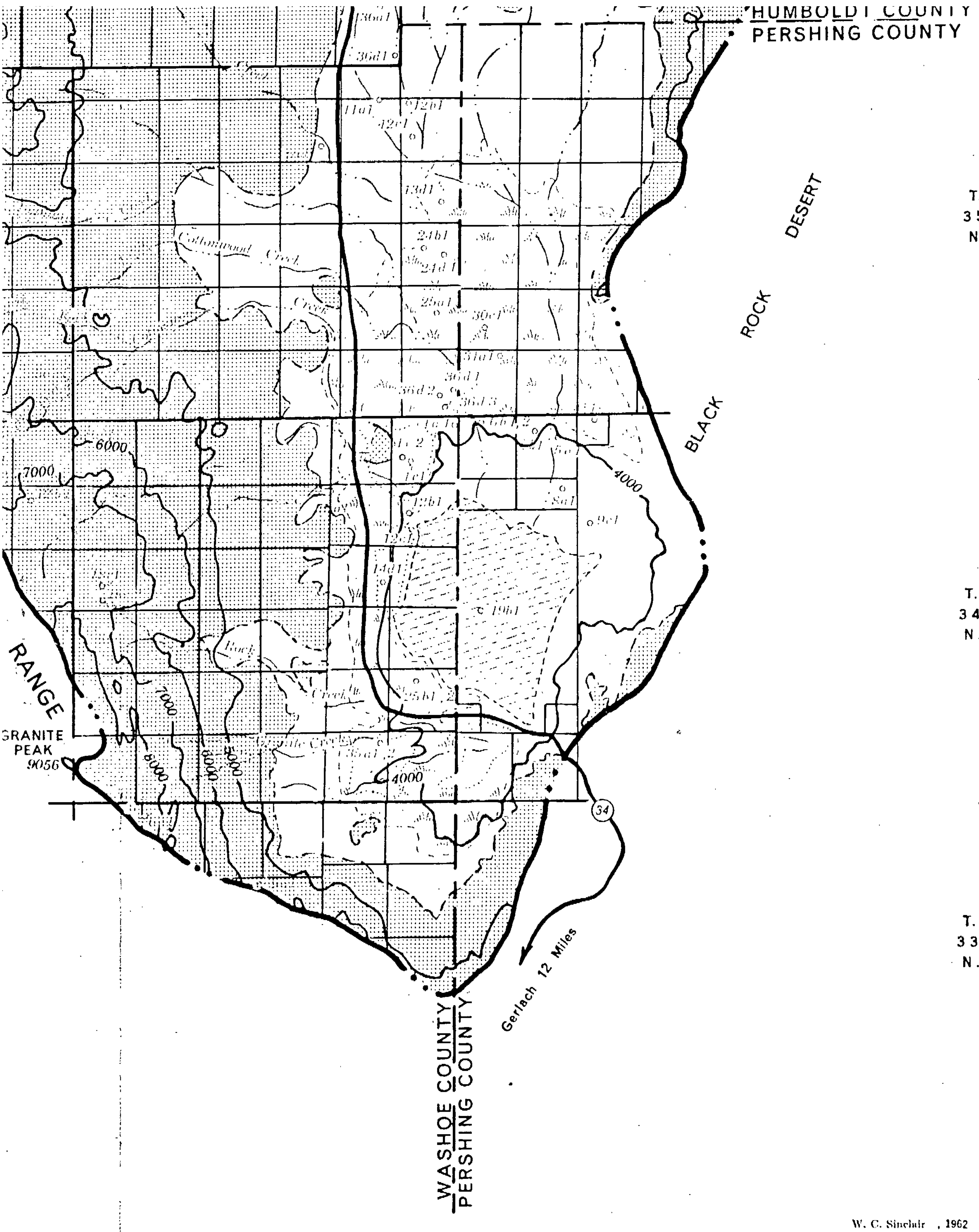
0 5 Miles

September 1962



Base: Army Map Service topographic quadrangles; NK 11-7, NK 11-10. State of Nevada Dept. of Highways; Humboldt, Pershing, and Washoe Counties.

Plate 1. Generalized geologic and hydrologic m
Pershing, and Humboldt Counti



c and hydrologic map of Hualapai Flat, Washoe,
d Humboldt Counties, Nevada.

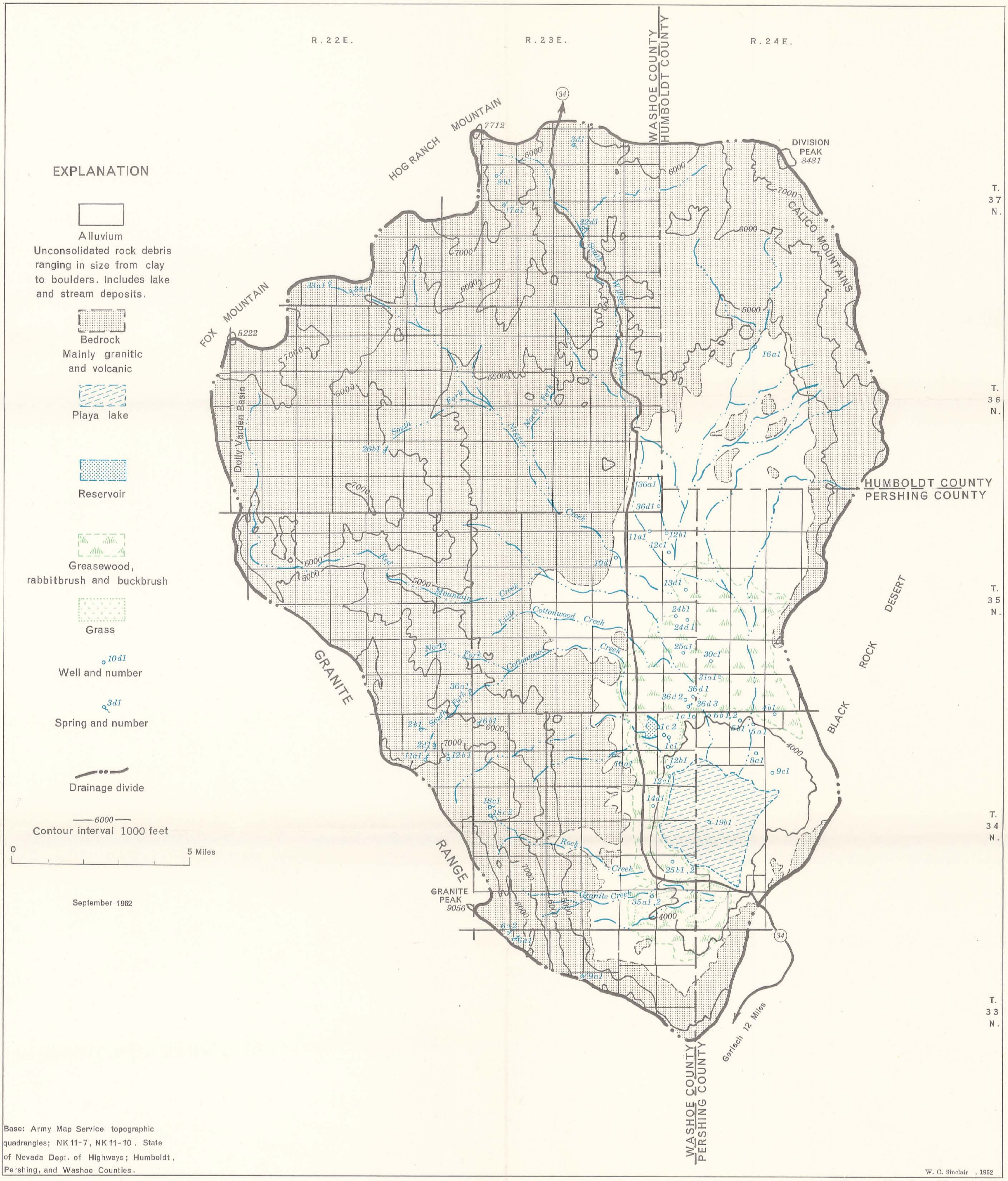


Plate 1. Generalized geologic and hydrologic map of Hualapai Flat, Washoe, Pershing, and Humboldt Counties, Nevada.