STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
Carson City

View of Pueblo Valley.

GROUND-WATER RESOURCES – RECONNAISSANCE SERIES

REPORT 22

GROUND–WATER APPRAISAL OF THE PUEBLO VALLEY–CONTINENTAL LAKE REGION, HUMBOLDT COUNTY, NEVADA

By
WILLIAM C. SINCLAIR
Geologist

Price $1.00

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

NOVEMBER 1963

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FOREWORD

This report, the 22nd in the series of ground-water studies, which were initiated following authorization by the Legislature in 1960, deals with the underground water resources of the Pueblo Valley-Continental Lake Region of Humboldt County, Nevada.

The area consists of four valleys with surface connections, though apparently with independent ground-water supplies. Virgin Valley on the west and Gridley Lake Valley on the south are tributary to Continental Lake. This lake has a surface connection with Pueblo Valley, which in turn is a tributary to Alvord Lake in Oregon, but only in extremely wet periods does Continental Lake overflow.

The appraisal of this area was made by William C. Sinclair, geologist, U. S. Geological Survey.

These reconnaissance ground-water resources studies make available pertinent information of great value to many State and Federal agencies. As development takes place in any area, demands for more detailed information will arise and studies to supply such information will be undertaken. In the meantime these reconnaissance-type studies are timely and adequately meet the needs for information on the ground-water resources of the areas on which reports are prepared.

Hugh A. Shamberger
Director
Department of Conservation
and Natural Resources

November 1963

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ILLUSTRATIONS

GROUND-WATER APPRAISAL OF THE PUEBLO VALLEY

CONTINENTAL LAKE REGION, HUMBOLDT COUNTY, NEVADA

by
William C. Sinclair

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ABSTRACT

The Pueblo Valley-Continental Lake region is an area of about 1,500 square miles in northern Humboldt County, Nevada. The typical basin and range topography of the eastern part of the area is buried beneath volcanic flows, tuffs, and lake beds throughout the western watershed. The area comprises four sub-watersheds which spill, one to another, during periods of excessive runoff, but from the standpoint of ground water, are independent basins. The climate in the area is semiarid.

Layers of sand and gravel within the alluvium constitute the most productive aquifers in the region and will yield moderate to large amounts of water to properly constructed and developed wells.

Chemical analyses of several samples of ground water from the region indicate that, except in the playa areas, the water generally is low in dissolved-solids content and is suitable for irrigation and domestic use.

This reconnaissance suggests that the perennial yield of the four principal ground-water sub-basins in the region is: Virgin Valley, 6,000 acre-feet; Gridley Lake Valley, 3,000 acre-feet; Continental Lake Valley, 11,000 acre-feet; Pueblo Valley, 2,000 acre-feet.

INTRODUCTION

Location and Extent of the Area:

The Pueblo Valley-Continental Lake watershed covers an area of about 1,500 square miles in northern Humboldt County, Nevada (fig. 1). An additional 280 square miles drains southward from southern Oregon, toward Continental Lake, along the west flank of the Pueblo Mountains. The study area comprises four principal basins:, Virgin Valley, Pueblo Valley, and the unnamed valleys containing Gridley Lake and Continental Lake. (Plate 1).

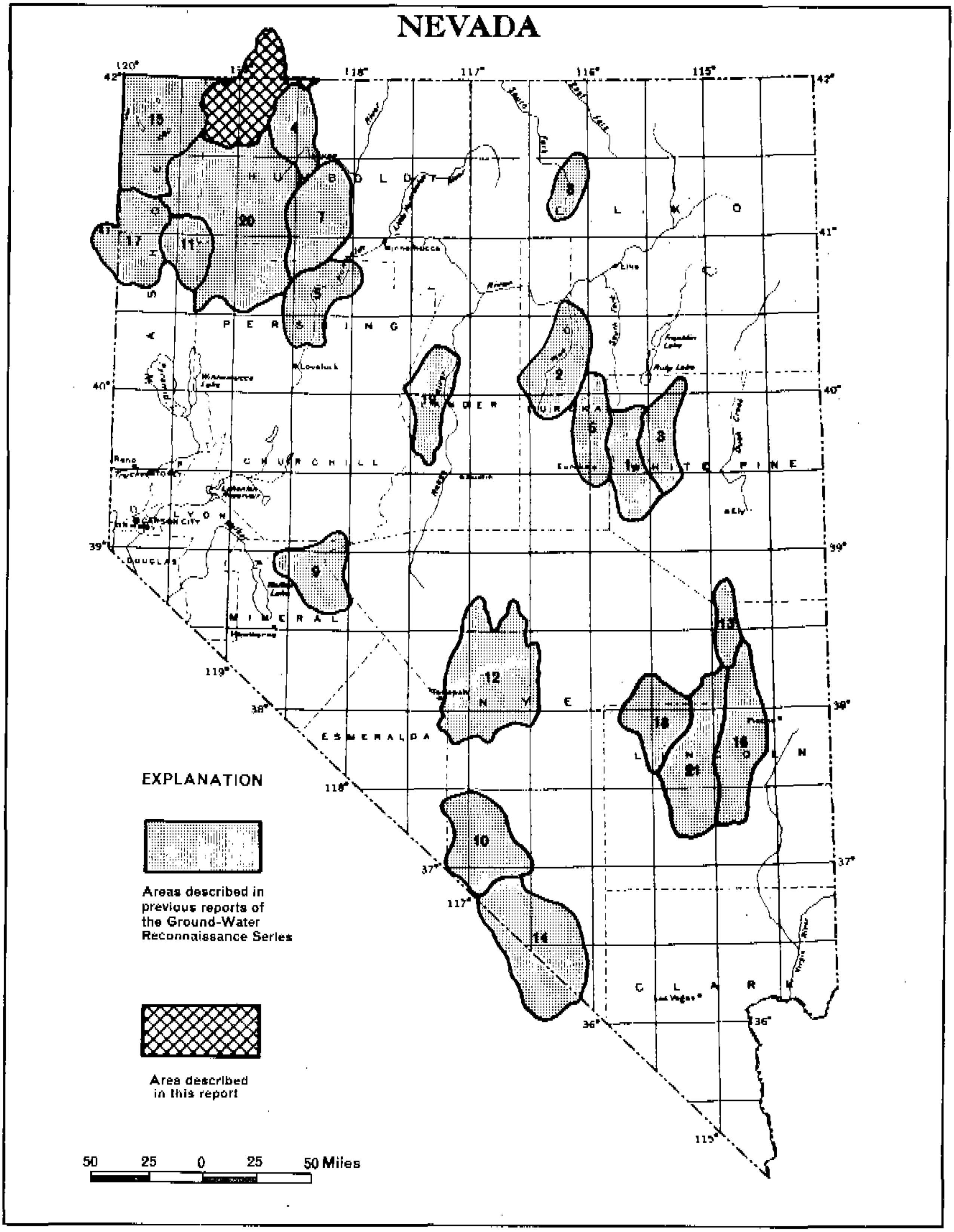


Figure 1. MAP OF NEVADA

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

The Pine Forest Range trends northward, dividing the southwestern watershed of Pueblo Valley from the eastern drainage of the Continental Lake region. The range decreases in altitude toward the north, and ends about 4 miles south of the Nevada-Oregon Boundary. The Pueblo Mountains extend southward into Nevada about 7 miles, and are separated from the Pine Forest Range on the south by a narrow gap. During periods of excessive flow, Continental Lake spills northeastward through this gap into Pueblo Valley, which is tributary to the Alvord Desert in southeastern Oregon.

Pueblo Valley covers an area of about 110 square miles in Nevada. Wilder Creek, which drains the southeast part of the watershed, is the main tributary. The valley floor covers an area of about 26 square miles.

Continental Lake lies in what is sometimes called Thousand Creek Valley. The valley floor is about 95 square miles in extent and receives drainage from Alder and Craine Creeks from the south and Rincon Creek from the north, in addition to Thousand Creek which drains about half of the Continental Lake watershed through Thousand Creek Gorge from the west. The western watershed is in marked contrast to the rugged topography and high relief of the Pueblo and Pine Forest Mountains in the east, and is composed largely of rolling uplands and relatively flat plateaus which are rather deeply incised by the Virgin and other creeks tributary to Thousand Creek.

The principal business in the area is the grazing of cattle and sheep and, to some extent, the cultivation of supplemental forage crops. In recent years, several hundred acres in Pueblo Valley have been developed for the production of alfalfa seed and, to a lesser extent, mint. The introduction of electric power to the area has improved the economic feasibility of pumping ground water for irrigation.

Denio, a small town just south of the Oregon border, is the local trading center. Winnemucca is about 100 miles southeast of Denio and is the major source of supply to the area. Winnemucca is served by the Western Pacific and Southern Pacific Railroads and U.S. Highway 40.

The Pueblo Valley-Continental Lake region is traversed by the Winnemucca-to-the-sea Highway, which is paved from Winnemucca westward to Crescent City, California, on the Pacific Coast. Nevada Highways 8A and 34 are graded roads that connect Denio with Cedarville, California, about 100 miles west. Other graded or improved roads serve the ranches in the area.

Purpose and Scope of the Investigation:

This report is last of a series of eight reconnaissance studies of the valleys of northwestern Nevada. The studies were 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 in June 1963. It consisted of a brief study of the physiographic features of the area and of the waterbearing character of the geologic units, and an inventory of the wells and springs.

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

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. In Oregon the Willamette meridian and base line are used. The first two segments of a well number designate the township north and range east; the third segment is the number of the selection 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 quarter section. The letters a, b, c, and d designate respectively, the northeast, northwest, southwest, and southeast quarters of the section. For example, well number 47/30-15c1 designates the first well recorded in the SW 1/4 sec. 15, T. 47 N., R. 30 E., Mount Diablo base line and meridian.

Plate 1 shows the location of wells and springs in the valley. The data on the wells are in tables 3 and 4. The results of chemical analyses of water from selected wells are in table 5.

GEOGRAPHIC FEATURES

In northwestern Nevada, north-trending mountain ranges separate desert basins which characteristically have no drainage outlet under the present semiarid climate. The relief of the area is due to the vertical displacement of large mountain blocks by faulting, and to their subsequent sculpture by erosion. The valleys are generally underlain by the down-faulted blocks. They are the catchment areas for the streamflow from the surrounding mountains and have been filled, commonly to great thicknesses, with rock debris eroded from the mountains. In the western part of the Continental Lake region the fault-block topography is buried, except for a few relatively recent fault scarps, beneath a thick section of volcanic flow rocks and their sedimentary derivatives.

Mountains:

The Pine Forest Range is a massif of predominantly granitic rocks forming the eastern watershed of the Continental Lake region. Duffer Peak rises to an altitude of 9,458 feet near the central part of the range, towering about 5,000 feet above the floors of the surrounding valleys (pl. 1). The range trends northward, decreasing in altitude toward its terminus, about 4 miles south of the Oregon border. Near the northern end of the range, a low spur extends northeastward, coalescing with the northwest slope of the Bilk Creek Range to form the southern watershed of Pueblo Valley. The Bilk Creek Range reaches an altitude of 8,507 feet at Trident Peak.

The Pueblo Mountains trend southward into Nevada, and nearly join the Pine Forest Range on the south; the gap between them is about a mile wide through which Continental Lake sometimes spills into Pueblo Valley. The east front of the Pueblo Mountains, which is composed largely of metamorphic rocks, rises abruptly more than 2,000 feet from the valley floor west of Denio, to the crest at an altitude of about 6,500 feet.

The western part of the range is composed of volcanic rocks; a sequence of flows and ash beds, which conformably overlie one another and dip westward at about 20 degrees. More than 1,000 feet of this sequence is exposed in the cliff bordering the west side of Continental Lake.

McGee Mountain, and Big Mountain to the south, form the western border of the Craine Creek drainage. These mountains, which are made up of a thick sequence of rhyolite flows, rise abruptly along an escarpment more than 1,000 feet above the valley floor of Craine Creek. Westward from the top of the escarpment, the terrain is characterized by relatively flat, or gently rolling, upland surfaces which are cut by nearly vertical canyon walls. The aspect is one of dissected plateaus whose altitudes are about 6,000 feet. The Rincon Creek drainage in southern Oregon has a similar aspect.

Valleys:

The major valleys in the region are structural troughs, or depressions, which were displaced downward by faulting relative to the mountain ranges and have become the catchment areas for streamflow from the surrounding mountains and the sediment load which the streams carry. The valley floors are characteristically flat and their altitudes are controlled by the amount of vertical displacement of the fault blocks and the amount of subsequent filling.

The lower mountainsides are buried under the products of weathering and erosion derived from the higher mountainous areas. This debris forms transitional slopes grading valleyward from the steep mountainsides to the level floors of the valleys.

The floor of Pueblo Valley within Nevada is roughly triangular. It is about 6 miles wide at the Oregon border and narrows toward the south. The valley floor slopes northward at about 50 feet per mile.

The gap between the Pueblo and Pine Forest Mountains is about a mile wide. The braided channel which meanders through the gap is mantled with powdery white alkali and usually is dry.

Continental Lake lies at the southwest end of the gap and is the sump for the 1,400 square-mile watershed to the south and west. The valley here is narrow, ranging from 2 to 5 miles wide and is nearly 30 miles long. The valley extends northward along Rincon Creek into Oregon and southward along Craine Creek to within 5 miles of the southern drainage divide. The valley of Thousand Creek is generally less than 1 mile wide. Along the foot of Thousand Creek Cliff, it trends eastward.

Virgin Valley is a narrow sinuous ravine deeply incised in the thick section of volcanic tuff and lake beds which occur west of McGee Mountain. The valley walls rise steeply from the stream channel, or series of ponds and marshes which occupy the valley floor, to the basalt-capped plateau several hundred feet above.

Drainage:

The streams that drain the mountains of northern Nevada are fed principally by storm runoff and snowmelt. Much of the flow, therefore, is ephemeral and occurs principally during the spring and early summer. As summer progresses, the snowpack in the mountains is depleted and the head-waters of the streams go dry. The small flow of the few perennial streams is insufficient to reach the valley floor due to seepage into the alluvium flanking the mountains and to losses by evaporation and transpiration. Perennial flow in the 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.

Some of the streams carry sufficient flow, during flood periods, for their channels to have become incised in the valley floor. The most notable of these are Craine Creek, Thousand Creek, and the channel draining northward from Continental Lake into Pueblo Valley.

Continental Lake apparently is created by an impermeable barrier beneath the alluvium in the gap between the Pueblo and Pine Forest Mountains. Here the bedrock may be close to the surface, impeding underflow of ground water through the gap and impounding it to form an area of shallow ground water to the south.

At the north end of Gridley Lake, Craine Creek valley narrows and bedrock is exposed, suggesting that a similar situation exists here also. Underflow from the south watershed is impounded behind a buried impermeable barrier and forms a lake and marsh. Surface runoff is also impeded at this constriction.

The tuff and lake beds in the Virgin Valley are softer and more easily erosible than the rhyolite of McGee Mountain and Thousand Creek Cliff. Although Thousand Creek Gorge is deeply incised in the rhyolite, it still forms a sill which constitutes the base level for drainage in Virgin Valley and impedes the underflow of ground water from the valley.

In summary, then, the area comprises several sub-watersheds whose surface runoff, though impeded, spills from one basin into another. The inter-basin movement of ground water is effectively blocked, as is indicated by the marshy conditions upgradient from the sills.

When the volume of ground water in storage in a basin is increased, however, as is generally the case during the spring of the year, the water table rises until it intersects the stream channels. This effluent ground water may then move over the barrier as streamflow to recharge the ground-water reservoir of the next sub-basin by infiltration into the streambed.

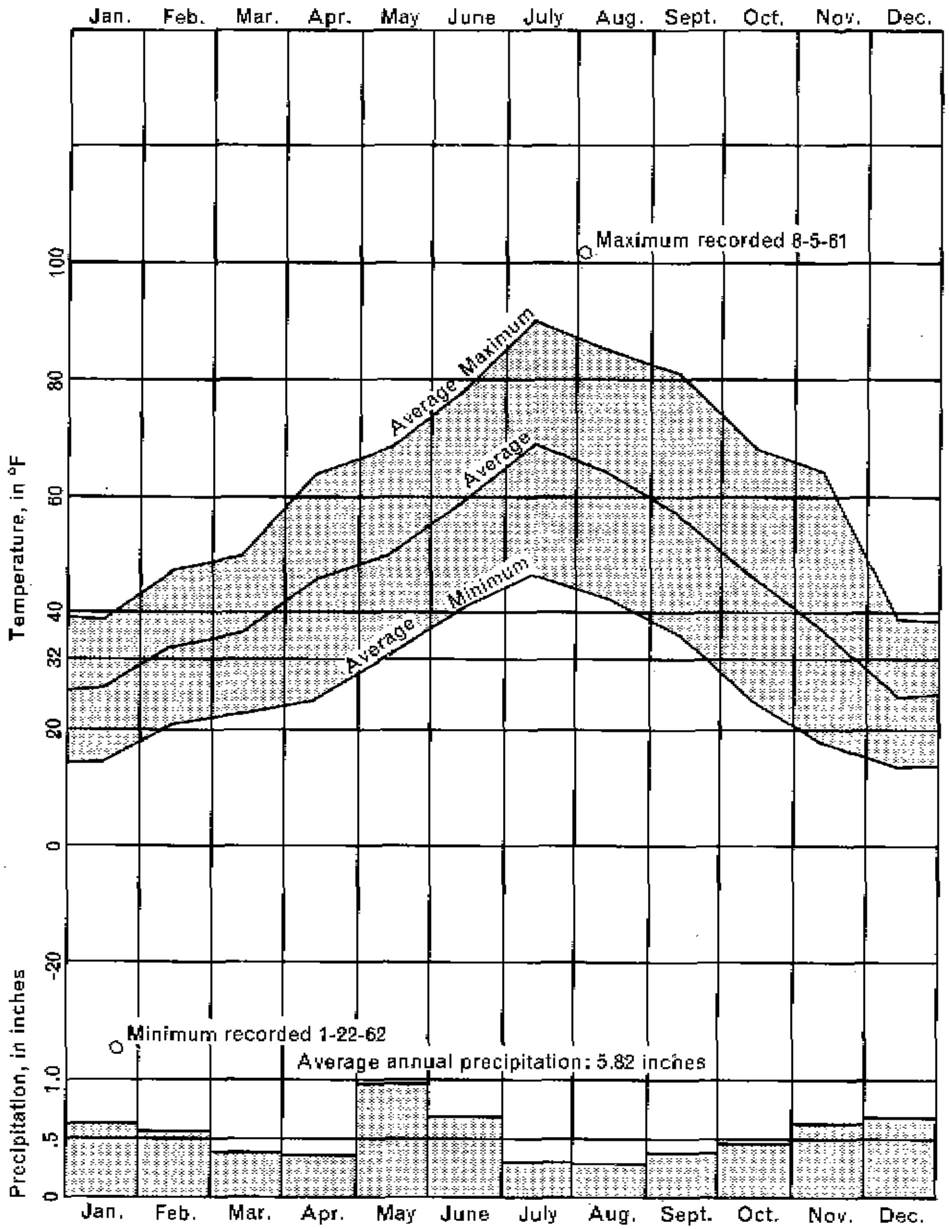
Climate:

Rainfall in Nevada is controlled largely by the topography. As the eastward moving air masses are forced upward by the mountain ranges, the decrease in pressure and temperature causes precipitation. The high mountains of California intercept much of the moist air contained in the storms moving eastward from the Pacific Ocean; thus Nevada, lying in the rain shadow of these mountains, has a climate ranging from arid to semiarid.

U. S. Weather Bureau stations have been maintained at Denio from 1952 to 1961, and at Virgin Valley from 1952 to the present. Although somewhat intermittent, these records, shown graphically in figure 2, illustrate the climatic conditions in the area for the past 10 years and give an indication of what may be expected in the future.

Although the range in temperature is nearly the same at both stations, the actual values recorded are generally somewhat lower at Virgin Valley; perhaps because the station is about 600 feet higher than Denio. Precipitation at Virgin Valley has averaged 5.82 inches a year for the period of record. The meager precipitation may be due, in part at least, to the relatively low relief of the desert plateaus throughout the Virgin Valley area and westward. The prevailing westerly winds encounter their first major barrier east of California in the Pine Forest and Pueblo Mountains. As the eastward moving air masses are forced upward, the decrease in pressure and temperature causes precipitation. Most of this precipitation occurs on the western flanks of the ranges.

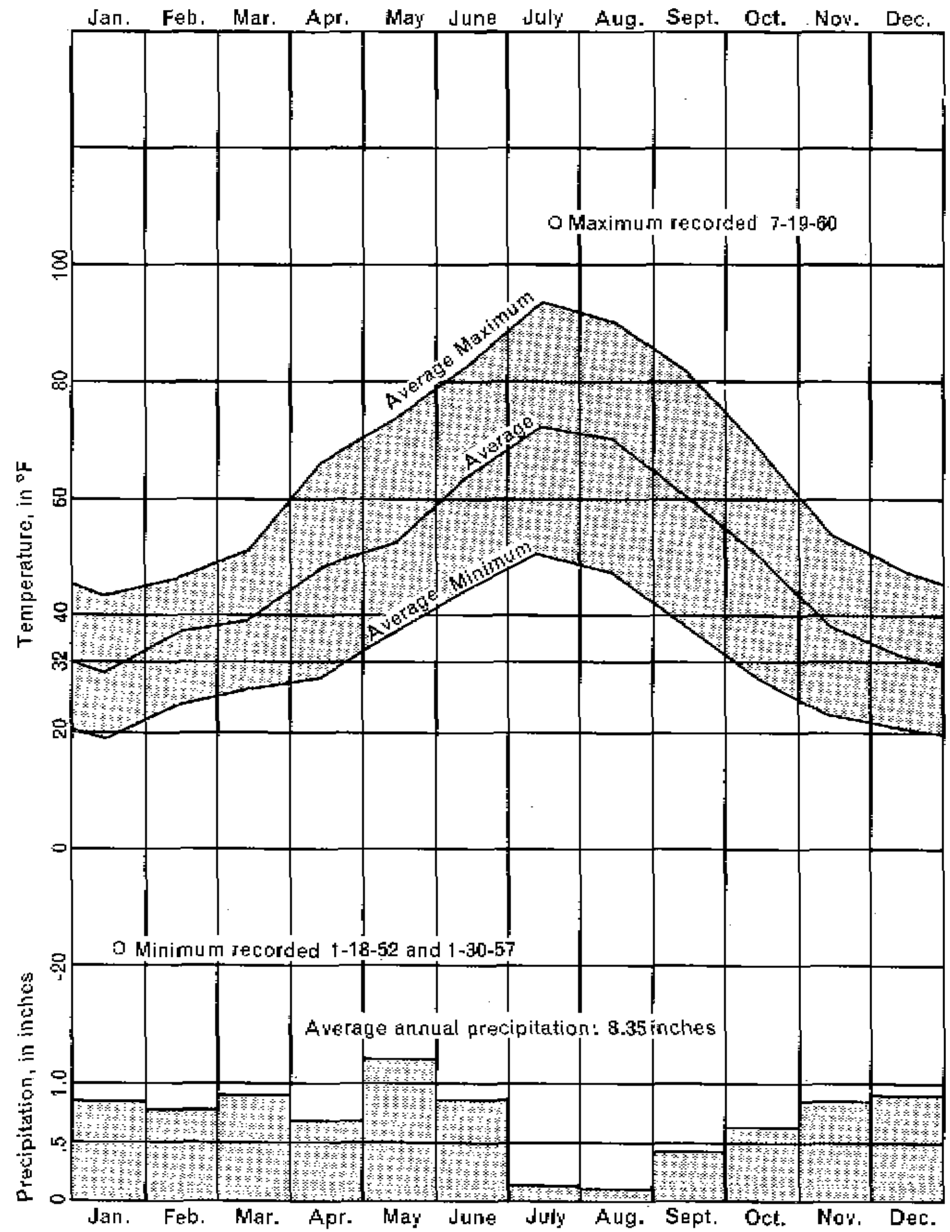
Although Denio is on the floor of Pueblo Valley, it lies close against the east face of the Pueblo Mountains, which rise abruptly more than 2,000 feet above the valley floor. The recorded precipitation averages 8.35 inches



VIRGIN VALLEY

Altitude 4,805

Average monthly precipitation and temperature data for the period 1952-1956 and 1960-1962



DENIO

Altitude 4,185

Average monthly precipitation and temperature data for the period 1952-1961

Figure 2.—Graphs illustrating the climatic conditions at the U.S. Weather Bureau stations at Denio and Virgin Valley.

a year which, due to the proximity of the mountains, probably is somewhat higher than the average throughout the rest of the valley floor.

The rate of evaporation from a free water surface in the region is about 48 inches a year, according to Kohler, Norderson, and Baker (1959, pl. 2). This rate of evaporation is roughly 6 to 8 times the annual precipitation on the valley floors or in the desert plateau region to the west.

PREVIOUS INVESTIGATIONS

The earliest discussion of geology of the Pueblo Valley-Continental Lake region is contained in a short paper, "On the Pueblo Range of Mountains", by James Blake (1875). J. C. Merriam (1910) described the "Tertiary Mammal beds of Virgin Valley and Thousand Creek in northwestern Nevada", which contains an appraisal of the geologic setting of the region. The "Preliminary geologic map of Humboldt County, Nevada", by Ronald Willden (1961) was published by the U. S. Geological Survey. Several articles concerning the Virgin Valley opal field have appeared in various popular mineral magazines. The pluvial history of the region was discussed briefly by Hubbs and Miller (1948).

HYDROLOGIC SETTING

The Pueblo Valley-Continental Lake region, according to Gianella and Bonham (1963), lies in a transitional zone between the Basin and Range and the Columbia River Plateau physiographic provinces. The north-trending Pueblo and Pine Forest Mountains are typical of the fault block mountains which characterize the Basin and Range province. They are composed largely of granitic and metamorphic rocks and apparently were created by vertical movement along an extensive system of faults during early to mid-Tertiary time. The vertical displacement along the major range-front faults was even greater than the present relief would indicate. Erosional debris from the uplifted areas has filled the basins with an unknown thickness of alluvium, which includes stream and lake deposits.

Volcanic rocks and lake beds of late Tertiary age are exposed throughout the area west of these two major ranges. Structural deformation is less common and less intense in this sequence of younger rocks. The sequence of intercalated flow rocks and tuff, which flank the west side of the Pueblo Mountains, dip westward at about 20 degrees beneath the valley floor. This section, called the Pueblo Range Series by Merriam (1910), is well exposed in the cliff west of Continental Lake and was first described by Blake in 1875. The rhyolite of McGee Mountain and southward (Canyon rhyolite of Merriam, 1910) is considered by Merriam to be possibly correlative with the rhyolite which forms the upper strata of the Pueblo Range Series. Flat-lying beds of Miocene age (Thousand Creek beds of Merriam, 1910) unconformably overlie the rhyolite along both edges of the basin and presumably underlie the entire Continental Lake basin.

West of McGee Mountain, the rhyolite dips gently westward beneath the Virgin Valley beds, appearing again in the hills which form the western watershed of the region. Throughout this structural basin the Canyon Rhyolite forms the basement for the Virgin Valley beds; a thick sequence of volcanic ash and lake deposits, which Merriam considered to be partly older and partly correlative with the Thousand Creek beds.

Following the deposition of the Virgin Valley and Thousand Creek beds in their respective basins, the area was covered by a relatively thin but extensive basalt flow.

The Thousand Creek Cliff is a dramatic example of post-basalt faulting, but most of the topography in the western part of the region is erosional. The basalt forms a protective cap over the softer and more easily erosible tuff and lake beds so that the valleys and canyons, though deeply incised, are generally quite narrow. The overall aspect of the region is one of steep-sided mesas of black basalt isolated from one another by deep canyons.

Erosion in one area, of course, is accompanied by deposition elsewhere. Continental Lake and Pueblo Valleys are underlain by an unknown thickness of erosional debris. A well at Knott Creek Ranch (43/27-4a1) encountered granite 1,148 feet below the valley floor. The log of this well (table 4) shows a typical section of valley-fill material, including the strata of volcanic rocks, overlying the granitic basement rocks.

The Pleistocene epoch was characterized by worldwide climatic changes which resulted in the formation of a series of lakes in many of the undrained basins of Nevada. Pluvial Lake Alvord (Smith and Young, 1926), about 35 miles north of Denio, rose until Continental Lake and Pueblo Valleys were inundated to a depth of several hundred feet. To a large extent, the present valley floors are underlain by lake deposits and represent the configuration of the Pleistocene lake bottom. Many stages and fluctuations of the lakes are recorded in these deposits and in the shoreline features which terrace the surrounding hillsides.

PHYSICAL CHARACTER AND WATER-BEARING PROPERTIES OF THE ROCKS

Bedrock:

Most of the rocks in the region are of volcanic origin, although the Pine Forest Range and the Trident Peak area comprise mainly granitic and metamorphic rocks. The primary permeability of these rocks appears to be relatively low, and movement of ground water in them is largely through joints, fractures, and other secondary openings.

Although the total volume of water moving through bedrock may be quite large, 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, is not considered a potential source of ground-water supply.

Alluvium:

The alluvium of the valley fill is composed of rock debris eroded from the surrounding mountains and deposited largely by mudflow and flood waters because of the flashy nature of the streams. As a result, it is composed of poorly-sorted rock particles ranging in size from clay to boulders.

The permeability of alluvium, although much greater than that of bedrock, is generally low to moderate, depending on the size and degree of sorting of the rock particles. Layers and lenses of well-sorted sand and gravel are found at various levels within the alluvium. These are best developed off the mouths of the canyons where streamflow has sorted the particles according to size and weight, carrying the finest particles farthest out toward the center of the basin. The texture of the source rock is also a controlling factor affecting the permeability of the alluvium. Tuff and lake beds contribute a large proportion of silt and clay to the alluvium, thereby reducing the permeability. Weathered granite is also of generally low permeability due to the angularity of the fragments and the high proportion of mica.

The alluvium mantling the mountainsides has been reworked extensively by wave action in the lakes which have filled the valleys to various levels in the past. The winnowing action of the waves removed much of the fine material from the shores leaving beaches and bars of well-sorted sand and gravel ringing the valleys at several elevations, both above and below the present valley floor. In the central parts of the valleys, the valley floor is underlain by silt and clay deposited in the relatively still, deep parts of the lakes.

Around the margins of the valleys the thick clay and silt sections are interbedded with relatively thin layers and lenses of sand and gravel which are principally stream deposits and reworked alluvium that accumulated during shallow stages of the lakes and periods of desiccation. These sheets of sand and gravel, though thin, may be quite extensive and probably constitute the most important aquifers in the area. They are best developed along the edges of the valleys but thin basinward as they interfinger with the silt and clay.

GROUND WATER

Occurrence and Movement:

Ground water moves from recharge areas in the mountains and alluvial slopes downgradient toward the central parts of the valleys where, under natural conditions, it is discharged by evaporation from bare soil, springs, and seeps and transpired by plants.

Most of the available ground water in the area occurs in the unconsolidated deposits of the valley fill. Where the valley fill consists of fine-grained material, such as silt and clay or of poorly-sorted alluvium, the permeability is low, and only small yields can be expected from wells. In contrast, lenses of well-sorted sand and gravel have moderate to high permeabilities and will yield water readily to properly constructed wells.

Effective barriers to ground-water flow apparently occur northeast of Continental Lake, north of Gridley Lake, and at Thousand Creek Gorge, as previously mentioned. Although some underflow probably moves through the barriers, and effluent ground water may at times contribute to streamflow spilling over the barriers, for practical considerations the area may be subdivided into four ground-water basins: Virgin Valley, Gridley Lake Valley, Continental Lake Valley, and Pueblo Valley.

Recharge:

The ultimate source of recharge to the ground-water reservoirs of the Pueblo Valley-Continental Lake region is precipitation within the watershed. Although the average annual precipitation is probably less than 8 inches on the valley floors (p. 14), precipitation increases with increasing altitude, as described by Hardman and Mason (1949), and the area can be subdivided into precipitation zones, based largely on altitude, exposure, and aspect vegetation, as shown in table 1. The western half of the watershed is gently rolling or plateau country, as previously mentioned, notably lacking in the high relief which generates precipitation in the mountain watersheds. The aspect vegetation of this desert plateau country, in conjunction with the low annual precipitation recorded at Virgin Valley, suggests that the watershed west of Rincon and Craine Creeks probably receives an average precipitation within the range of 8 to 12 inches a year.

Only a small part of the total precipitation ever reaches the ground-water reservoir in the valleys. Most of it is transpired and evaporated. Part of the remainder runs off immediately and part infiltrates into the rocks of the mountain ranges and the alluvial fans from which it eventually moves directly into the valley fill or comes to the surface along the stream courses and at springs. Further loss by evaporation and transpiration takes place along the stream courses.

The percentage of precipitation that recharges the ground-water reservoirs, even under favorable conditions, is small, and the percentage for a given amount of precipitation varies considerably with the terrane. A detailed determination of the percentage of precipitation that infiltrates to the water table is virtually impossible. The estimates of ground-water recharge from precipitation are shown in table 1 and are based on percentages determined empirically by Eakin and others (1951) from studies in eastern Nevada, and may be in the proper order of magnitude.

Table 1.--Estimated precipitation and recharge to the ground-water reservoirs of the Pueblo Valley-Continental Lake region, Humboldt County, Nevada.

Drainage area	Precipitation zone (inches)	Altitude of zone (feet)	Area of zone (acres, rounded)	Precipitation (acre-feet per year, rounded)	Percent recharged	Estimated recharge (acre-ft. per year rounded)
Virgin Valley	8-12	5,000-6,000+	280,000	230,000	3	7,000
Gridley Lake Valley						
Western watershed	8-12	4,500-6,000+	64,000	53,000	3	1,600
Eastern watershed	8-12	4,500-6,000	30,700	25,500	3	800
	12-15	6,000-7,000	9,300	10,500	7	700
	15-20	above 7,000	6,100	8,900	15	1,300
						4,500
Continental Lake Valley	less than 8	below 4,500	60,000			
Western watershed	8-12	4,500-6,000+	182,000	151,000	3	4,500
Eastern watershed	8-12	4,500-6,000	72,000	60,000	3	1,800
	12-15	6,000-7,000	20,300	23,000	7	1,600
	15-20	above 7,000	13,800	20,200	15	3,000
						11,000
Pueblo Valley	less than 8	below 4,500	16,500			
	8-12	4,500-6,000	40,500	33,700	3	1,000
	12-15	6,000-7,000	13,000	14,600	7	1,000
						2,000

Discharge:

Ground water is discharged at the surface by springs, seeps, and pumping. It is returned to the atmosphere by evaporation from the land surface and by transpiration through plants; or it may move from one area to another by underflow through permeable material.

Springs: Springs and seeps are common in the mountains of the Pueblo Valley-Continental Lake region. They are principally the gravity type, occurring where the land surface intercepts the water table or where infiltrating ground water encounters an impermeable rock strata and is forced laterally to the surface. This latter situation is common in the Virgin Valley watershed. Water percolates rather easily through the basalt capping the mesas, but the indurated tuff and lake beds underlying the basalt are relatively impermeable and the water moves along the surface of the impermeable rock to the canyon wall where it is discharged. A few springs and seeps in the central parts of the valley floors are fed by upward leakage from underlying artesian aquifers.

Two major thermal springs, Bog Hot Spring and Continental Hot Springs, issue from the valley floor. These springs discharge about 1,000 and 200 gallons per minute, respectively, and are probably associated with active fault zones which provide paths along which ground water moving from recharge areas and heated at depth, can rise to the surface.

The discharge of the springs on the valley floor is included in the estimate of ground water discharged by transpiration. Though not tabulated, the total discharge of the many small springs in the mountains, taken in aggregate, may represent a considerable volume of ground water.

Pumpage: Withdrawal of ground water to supplement surface irrigation is becoming increasingly common in Nevada. One large-capacity well (43/27-4a1) at Knot Creek Ranch, south of Gridley Lake, and two others (45/28-22a1 and 45/28-34a1) at Alder Creek Ranch have been drilled in recent years. Judging from the performance characteristics of these wells as reported in the drillers' logs submitted to the State Engineer's Office, and depending on the amount of surface-water runoff in a given year, the withdrawal of ground water for supplemental irrigation may range from 200 to 500 acre-feet at Knot Creek Ranch, and from 500 to 700 acre-feet at Alder Creek Ranch.

Pine Forest Farms, a few miles south of Denio in Pueblo Valley, is a several hundred acre development relying solely on ground water for irrigation. Mr. Richard Bailey of Denio, manager of the farms, estimates that pumpage for the 1963 irrigation season will be on the order of 1,000 acre-feet, principally from well 47/30-15d1. (See cover photograph)

Most of the other wells in the region are of low capacity and are used to water stock or for domestic supply. As of 1963 the total discharge of ground water by pumping has not been of sufficient magnitude to affect appreciably the hydrologic regimen of the valleys.

Underflow: Ground water in the Nevada segment of Pueblo Valley moves northward into Oregon by subsurface outflow. The amount is controlled by the hydraulic gradient and the transmissibility and width of the valley fill.

In the absence of data for transmissibility, a crude approximation of underflow at the State boundary can be made from the estimates of recharge and discharge within the Nevada segment of the valley. Table 1 shows that the estimated recharge in the Nevada segment is about 2, 000 acre-feet per year, and table 2 shows that the estimated discharge by evapotranspiration is roughly 1, 200 acre-feet per year. The difference between the estimates, roughly 1, 000 acre-feet, is a measure of the underflow moving into Oregon.

Evaporation: Evaporation from the ground-water reservoirs occurs where the capillary fringe reaches or is near the land surface. Continental Lake and Gridley Lake are both playas which cover about 1, 250 and 500 acres, respectively. Much of the water which reaches the playas is the result of storm runoff, but ground water is also discharged from the playas in areas where the land surface intersects the capillary fringe.

In the spring of a normal year the lake areas are generally completely inundated by runoff, but the depth of water over the entire area may average no more than half a foot. The rate of evaporation from a free-water surface of about 48 inches (p. 16) is more than enough to dry up the lakes by the end of summer. The lakes rarely become completely dry, however, but withdraw to a sump area where a residual body of water generally persists. These perennially wet areas are maintained by discharge from the ground-water reservoirs. The area of standing water, or wetted surface due to ground-water discharge, may be on the order of 750 and 300 acres for Continental and Gridley Lakes, respectively, as shown in table 2.

Transpiration: Large quantities of ground water are transpired by plants, known as phreatophytes, whose roots descend to the water table or to the capillary fringe above it. Greasewood is the most common phreatophyte in the region, and its presence is an indication that the water table is within about 30 feet or less of the surface. Other, less common phreatophytes are saltgrass and rabbitbrush. Saltgrass is generally an indication that the depth to water is 10 feet or less. The areas of phreatophyte growth in the Pueblo Valley-Continental Lake region are shown in plate 1.

The estimated rate of use of ground water by greasewood shown in table 2 is based largely on work done by White (1932, p. 28-93) in Escalente Valley, Utah. The results of investigations by Young and Blaney in California (1942, p. 41-246) are the basis for the estimated rate of use of water in the marshes of Virgin Valley.

Assuming these rate-of-use factors to be valid for the Pueblo Valley-Continental Lake region, the average annual discharge of ground water from each of the sub-basins may be in the order of magnitude shown in table 2.

Table 2.--Estimated natural discharge from the ground-water reservoirs of the Pueblo Valley-Continental Lake region.

	Area of evapo-transpiration (acres)	Estimated rate of discharge (ft. per year)	Estimated discharge (acre-feet per year) rounded
Virgin Valley			
Ponds, marshes and wet meadows 1/	3,000	2.0	6,000
Gridley Lake valley			
Greasewood	3,800	0.2	800
Playa and Saltgrass	300	4.0	1,200
			2,000
Continental Lake valley			
Greasewood	28,000	0.2	5,500
Playa and Saltgrass 2/	750	4.0	3,000
Bog Hot Spring 3/		2.8 cfs	2,000
			10,500
Pueblo Valley			
	a 6,000	0.2	1,200

1. Includes phreatophytes supported by discharge from Big Spring (100 gpm±) and Thousand Creek Spring (500 gpm±).

2. Includes about 100 acres of Saltgrass supported by discharge from Continental Hot Springs (100 gpm±).
3. Discharged by evaporation from reservoir, loss to phreatophytes and hydrophytes in reservoir, and by irrigation of about 500 acs. meadowland.
a. In large part greasewood.

Perennial Yield:

The perennial yield of a ground-water reservoir may be defined as the amount of water that can be pumped, or otherwise diverted from the reservoir, without causing an excessive depletion of the stored water. In other terms, perennial yield is the amount of water that can be salvaged from natural discharge, and is ultimately limited by the amount of recharge to the reservoir.

This three-part definition of perennial yield has been included in several reports of this series without comment. Inasmuch as these reports are designed to aid the State Engineer's office in the management of the ground-water resources of Nevada as well as to inform the general public, a brief discussion of the perennial yield concept, in this respect, might be of value.

In many of the valleys of Nevada, including those considered in this report, ground water moves from the mountains, where it was received as precipitation, downgradient toward the central part of the valley floor becoming increasingly more saline as it percolates through the alluvium.

The better soils are commonly found around the margins of the valleys, as are the more productive aquifers. In some instances, therefore, optimum development of the ground-water resources of an area might require the withdrawal of large volumes of ground water from storage, deliberately causing depletion of the stored water to extend the cone of influence surrounding the pumping wells and to divert as much of the ground water as possible toward the area of use thereby preventing its being wasted.

The most commonly suggested method for salvaging natural discharge, as prescribed in the perennial yield concept, is to pump "properly spaced" wells to draw down the water table below the root zone of the low value phreatophytes, which consume most of the natural discharge. Wells that are properly spaced to draw down the water table throughout an area of natural discharge, however, may not be properly spaced so that the pumpage can be used efficiently. As is so often the case, the area of development, or with potential for development, is commonly far removed from the area of natural discharge.

Although perennial yield, as defined, is limited by the amount of recharge to the reservoir, the actual amount of water available for use may be more than this amount. Estimates vary, but in some areas of Nevada possibly as much as 50 percent of the water pumped for irrigation infiltrates to the ground-water reservoir and is available for re-use. In areas of marginal water quality and saline soils, of course, this reuse, recycling, is limited by the salt-tolerance of the crops. The concept of perennial yield, though effectively preventing over-development of the water resources of a basin, if applied indiscriminantly may result in under-development of the water resources.

As a preliminary guide to development of the Pueblo Valley-Continental Lake region, the perennial yield of the sub-basins is estimated to be in the order of magnitude shown for the estimates of recharge and discharge in tables 1 and 2. The estimates shown in these tables suggest that the perennial yield of Virgin Valley is at least 6,000 acre-feet; Gridley Lake valley, about 3,000 acre-feet; Continental Lake valley, about 11,000 acre-feet; and that part of Pueblo Valley in Nevada, about 2,000 acre-feet.

These values represent a minimum, however. As development continues in the area and as pumpage increases, more reliable and useful data will become available in the form of well logs, chemical analyses of water, pumpage, and the effect of pumpage on the aquifers. Full development of the water resources of the region, beyond the estimated values of perennial yield, can eventually be achieved by interpretation of these more factual data.

Ground Water in Storage:

An estimate of the amount of recoverable ground water in storage in the alluvium of the valleys can be obtained by computing the amount of ground water that will drain from the deposits for each foot of lowering of water level. An average specific yield of 10 percent is considered to be a conservative estimate of the amount of water by volume that will drain from the alluvium. The floor of Continental Lake Valley, for example, covers an area of about 60,000 acres. Thus, the amount of ground water that could be recovered by a uniform lowering of water levels throughout the valley would be on the order of 6,000 acre-feet per foot of lowering. This estimate serves to show that, although the amount of water in storage beneath the valley floor is considerable, it is not unlimited.

Much of the water in storage within the alluvium may be of poor chemical quality, particularly in and near the centers of the valleys. In addition, in some areas the permeability may be so low that it would not be feasible to attempt development of ground-water supplies. Thus, the amount of usable ground water in storage that is economically available may be considerably less than that calculated in the above sample.

CHEMICAL QUALITY OF THE GROUND WATER

The chemical constituents in 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.

Table 5 lists the chemical analyses of water from three wells in the area and from Bog Hot Spring. Four samples are not an adequate representation of the water quality throughout the area, but they serve to illustrate the possible types of water and water-quality problems that may be encountered.

The analyses show that the water sampled is of good chemical quality and is suitable for irrigation and domestic use, except that the sample from Bog Hot Spring had slightly more fluoride than is desirable for domestic use and the sodium (alkali) hazard was much higher than most crops will tolerate. In addition, the residual sodium carbonate in the sample from 46/28-31a1 (table 5) is more than the tolerable limit (2.5 equivalents per million) for most crops. This well is in the central part of the valley floor where the underlying ground water locally may be highly mineralized.

CONCLUSIONS

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

Estimates of the perennial yield for the four sub-basins in the region are: Virgin Valley, 6,000 acre-feet; Gridley Lake Valley, 3,000 acre-feet; Continental Lake Valley, 11,000 acre-feet; Pueblo Valley, 2,000 acre-feet. These estimates are subject to revision as more factual data become available from drilling and water records.

The chemical quality of the ground water in the region probably is satisfactory for irrigation and domestic uses, although large areas in the central parts of the valleys may be underlain by saline water.

Table 3.--Records of wells in Pueblo Valley-Continental Lake region, Humboldt County, Nev.

Owner: BLM, Bureau of Land Management.
Water level: M, measured; R, reported.
Use of water: D, Domestic; I, Irrigation; S, Stock; PS, Public Supply.
Remarks: Number is log number in files of State Engineer

						Water level				
Well no. and location	Owner	Date drilled	Diameter (inches)	Depth (feet)	Depth of principal aquifers (feet)	Below measuring point (feet)	M or R	Date	Use	Remarks
47/30-4b1	Joe Erquaga	1950	24	248	80-115	4	R	5-10-50	I	Log 1287
47/30-4b2	- -	- -	10-6	40	- -	33	R	- -	PS	- -
47/30-4b3	Paul Ortlip	1959	6	60	46- 60	28	R	4-28-59	D	Log 6487
47/30-4b4	Irvin Smith	1959	6	100	83-100	28	R	4-31-59	D	Log 5871
47/30-4b5	Irvin Smith	1959	12	113	103-113	26	R	5- 6-59	I	Log 5872
47/30-15d1	Pine Forest Farms	- -	16	350	- -	45	R	- -	I	- -
47/30-15c1	Pine Forest Farms	- -	16	300	- -	35	R	- -	I	- -
47/30-15b1	Pine Forest Farms	- -	16	200	- -	30	R	- -	I	- -
46/26-31d1	- -	- -	6	39	- -	-	-	- -	D	- -
46/28-31a1	- -	- -	10-8	-	- -	19	M	5- 6-61	S	Measuring Point, top of casing, 2 feet above land surface.
45/28-6d1	Bureau of reclamation	1956	6	128	68-128	65	R	12- 1-56	S	Log 3586
45/28-14c1	Alder Creek Ranch	1955	8	48	8- 48	6	R	4- -55	S	Log 5861
45/28-22a1	Claude E. Morris	- -	16	200	- -	5	R	6-19-63	I	- -
45/28-34a1	Alder Creek Ranch	1950	6	118	104-118	59	R	10- 5-50	S	Log 1444
45/28-34c1	Alder Creek Ranch	1951	14	493	- -	27	R	3- 9-51	I	Log 1566
45/28-34d1	Alder Creek Ranch	- -	-	- -	- -	-	-	- -	S	- -
44/28-10c1	Alder Creek Ranch	1950	6	51	16- 51	8	R	8-31-50	S	Log 1445
43/27-3b1	Alder Creek Ranch	1956	6	47	15- 47	14	R	3-18-56	S	Log 3675
43/27-4a1	Alder Creek Ranch	1958	16	1150	- -	-	-	- -	-	Log 4093
42/27-1d1	Alder Creek Ranch	1956	6	77	55- 77	26	R	3-16-56	S	Log 3673

Table 4.--Driller's logs of wells in Pueblo Valley-Continental Lake Region, Humboldt County, Nevada.

	Thickness (feet)	Depth (feet)
47/30-4b1		
Casing perforated 48-248' 3/16" x 6"		
Topsoil	5	5
Gravel, small; water	3	8
Clay	25	33
Gravel	17	50
Clay	20	70
Hardpan, sandy	10	80
Gravel, very fine	35	115
Clay	20	135
Gravel	10	145
Clay	20	165
Gravel	10	175
Hardpan	25	200
Gravel	20	220
Clay	10	230
Gravel	15	245
Clay	3	248
Total depth		248
47/30-4b3		
Casing perforated 1/8" x 3"		
Clay, sandy, topsoil	11	11
Clay and sand, fine, seams	35	46
Sand, clean; water	14	60
Total depth		60
47/30-4b4		
Casing perforated 55-100' 1/8" x 6"		
Clay, sandy; topsoil	11	11
Clay and fine seams of sand	37	48
Sand, fine; water	35	83
Pea gravel, fine, sand	17	100
Total depth		100
47/30-4b5		
Casing perforated 52-113' 1/8" x 4"		
Clay, sandy; topsoil	13	13
Clay	21	34
Clay, sandy	18	52
Sand, fine; water	32	84
Sand, coarse	19	103
Pea gravel, fine and sand	10	113
Clay, sandy and small seams of sand	18	131
Gravel, fine	2	133
Total depth		133
45/28-6d1		
Casing perforated 70-125' 3/16" x 6"		
Topsoil	2.5	2.5
Clay, hardpan	16.5	19
Clay, silty, sandy, blue with thin sand streaks, seeping water from 68-128"	111	130
Total depth		130
45/28-14c1		
Casing perforated 25-45' 3/16" x 6"		
Topsoil	8	8
Sand, fine, with coarse gravel streaks	40	48
Total depth		48

	Thickness (feet)	Depth (feet)
45/28-34a1		
Casing perforated 78-118' 1/4"x6"		
Topsoil	10	10
Gravel, cemented	88	98
Clay	6	104
Sand	14	118
Total depth		118
45/28-34c1		
Casing perforated 80-370' 3/8" x 3"		
Topsoil	8	8
Clay, sandy	17	25
Gravel, cemented	10	35
Boulders, sand, and gravel	3	38
Gravel, cemented	52	90
Gravel, loose	7	97
Clay, brown	2	99
Gravel, cemented	31	130
Gravel, loose	7	137
Gravel, cemented	44	181
Clay, brown, some gravel	19	200
Gravel, cemented	18	218
Gravel, loose	9	227
Gravel, cemented	38	265
Gravel, loose	7	272
Clay, little gravel	28	300
Gravel, cemented	27	327
Clay	21	348
Lava, decomposed, and clay	12	360
Lava, decomposed, and gravel	14	374
Clay	9	383
Gravel, cemented (drilling open)	102	485
Gravel, cemented (some caving)	8	493
Total depth		493

	Thickness (feet)	Depth (feet)
44/28-10c1		
Casing perforated 12-51' 1/8" x 8"		
Topsoil	16	16
Gravel	1	17
Clay	10	27
Sand	5	32
Clay	10	42
Sand	9	51
Total depth		51
43/27-3b1		
Casing perforated 25-43' 3/16" x 6"		
Topsoil	1.5	1.5
Gravel and small boulders	10.5	12
Clay, sandy	3	15
Sand and coarse gravel	32	47
Total depth		47
43/27-4a1		
Casing perforated 50' 3/16" x 2"		
Topsoil	2	2
Clay, hardpan	16	18
Clay, gravely	24	42
Sand, water seep	2	44
Clay, sandy	48	92
Sand and gravel	10	102
Clay, sticky	4	106
Sand and gravel	19	125
Clay, sandy	75	200
Clay, sticky	28	228
Clay, sandy	64	292
Gravel, cemented	9	301
Clay, sticky	19	320
Gravel, cemented	5	325
Clay, sticky	19	344
Gravel, cemented	4	348
Clay, sandy	5	353
Gravel, cemented	3	356

43/27-4a1 (continued)

	Thickness (feet)	Depth (feet)
Clay, sandy	13	369
Volcanic rock	7	376
Clay, sticky	3	379
Gravel, cemented	2	381
Clay, sandy	11	392
Gravel, cemented	3	395
Clay, sticky	2	397
Gravel, cemented	4	401
Clay, sandy with thin sand streaks and some sticky streaks	35	436
Sand, cemented	14	450
Clay, sticky	4	454
Clay, broken and sand and gravel	5	459
Sand, fine	10	469
Clay, sandy with thin sand streaks and sticky streaks	29	598
Clay, sandy	62	660
Sand and fine gravel	2	662
Clay, sticky	19	681
Sand and fine gravel	8	689
Clay, sticky	3	692
Sand and fine gravel	4	696
Clay, sandy with sticky streaks	31	727
Volcanic rock	12	739
Clay, sticky	3	742
Sand and fine gravel	3	745
Volcanic rock	13	758
Sand and fine gravel	3	761
Clay, sandy with sticky streaks	24	785
Volcanic rock	3	788
Clay, broken, some sticky, some sandy, and some gravel	32	820
Sand and fine gravel	15	835
Clay, gravely	25	860
Clay, sticky and sandy	100	960
Sand, coarse	25	985

43/27-4a1 (continued)

	Thickness (feet)	Depth (feet)
Clay, sandy	10	995
Sand, coarse and fine	7	1002
Clay, sandy	33	1035
Clay, sticky	6	1041
Clay, sandy	77	1118
Sand and gravel	6	1124
Clay, sandy	24	1148
Granite	2	1150
Total depth		1150

42/27-1d1

Casing perforated 56-73' 3/16" x 6"

	Thickness (feet)	Depth (feet)
Topsoil	3	3
Clay, sandy, brown	34	37
Clay, sandy, grayish	7	44
Volcanic rock	11	55
Sand and gravel	22	77
Total depth		77

TABLE 5.--Chemical analyses [1] of ground water in the Pueblo Valley-Continental Lake region, Nev.

Constituents in parts per million

Well or spring	47/30-4b2	46/28-18b1 Bog Hot Spr.	46/28-31a1	45/28-34d1
Date of collection	5-6-61	5-6-61	5-6-61	5-6-61
Temperature	-	132	52	53
Silica (Si)	38	51	45	31
Calcium	64	.4	22	28
Magnesium (Mg)	23	0	7.3	7.8
Sodium (Na)	34	78	104	22
Potassium (K)	5.2	.6	14	1.7
Carbonate (CO_3)	0	6	0	0
Bicarbonate (HCO_3)	219	113	353	167
Sulfate (SO_4)	115	41	19	23
Chloride (Cl)	26	15	16	22
Fluoride (F)	0.5	2.0	.8	.2
Nitrate (NO_3)	3.6	.5	.2	6.4
Boron (B)	0.16	.66	.57	.09
Dissolved solids residue at 180°C	414	262	557	266
Hardness as $CaCO_3$ Calcium and Magnesium	253	1	85	151
non-carbonate	73	0	0	14
Specific conductance (micromhos at 25°C)	627	345	622	392
Sodium adsorption ratio (SAR)	.94	34	4.9	.78
Residual sodium carbonate (RSC) in equivalents per million	0	1.8	4.1	0
pH	8.0	8.4	7.5	7.4

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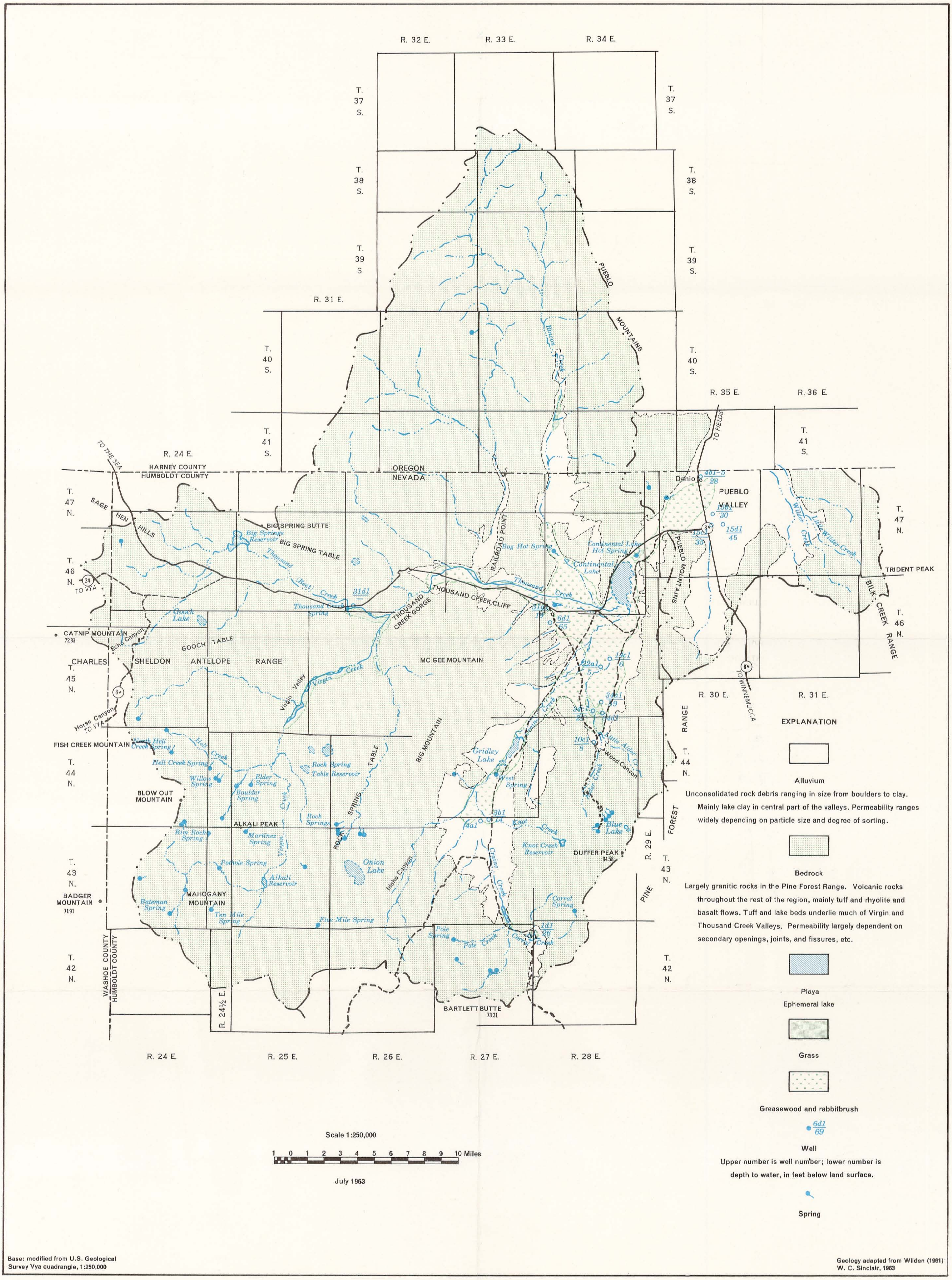

PLATE 1.—GENERALIZED GEOLOGIC AND HYDROLOGIC MAP OF PUEBLO VALLEY-CONTINENTAL LAKE REGION, HUMBOLDT COUNTY, NEVADA.