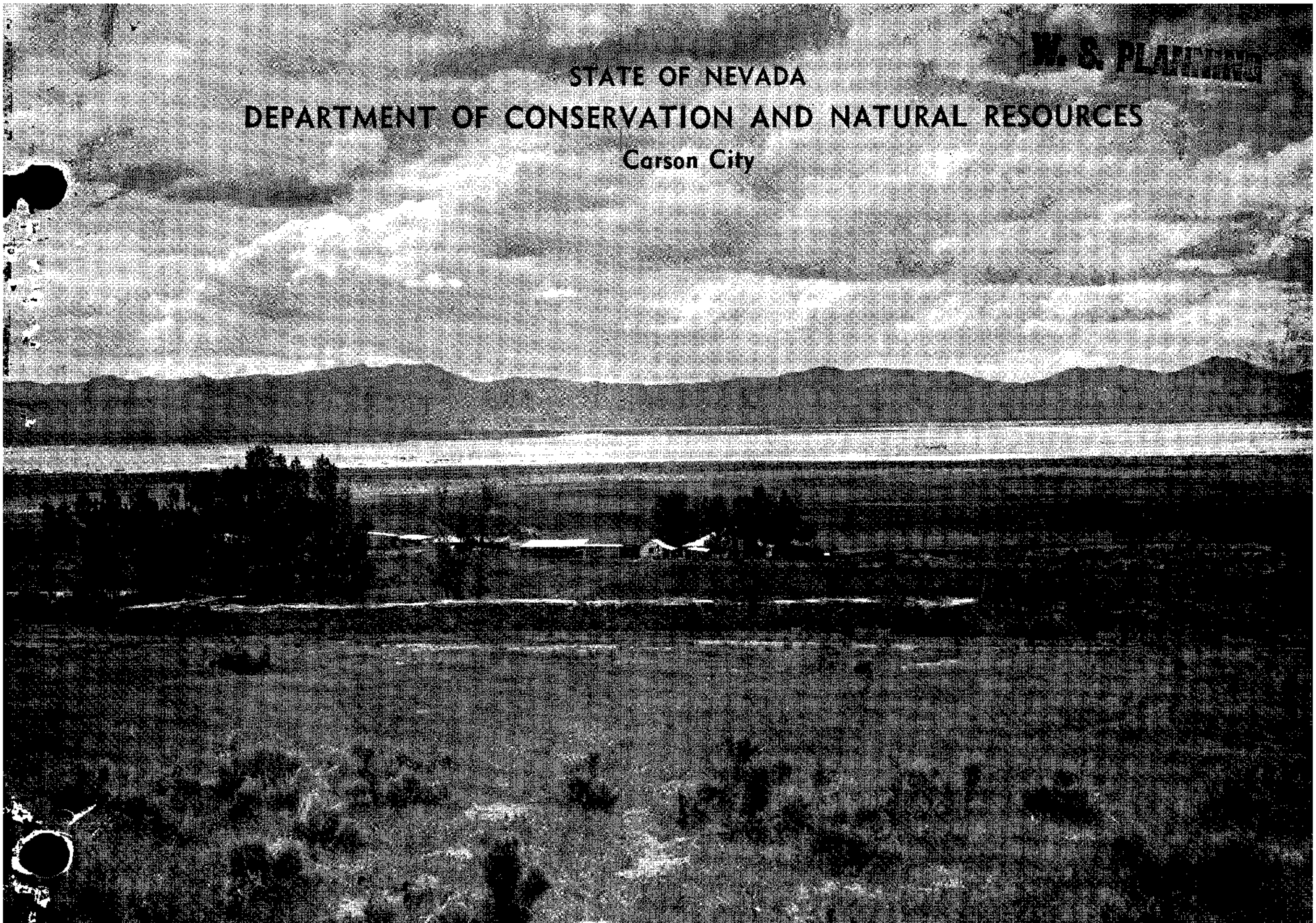
STATE OF NEVADA

DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

Carson City



View of Walti Ranch, Grass Valley.

WATER RESOURCES–RECONNAISSANCE SERIES

REPORT 37

A BRIEF APPRAISAL OF THE WATER RESOURCES OF GRASS AND CARICO LAKE VALLEYS, LANDER AND EUREKA COUNTIES, NEVADA

By
D. E. Everett
Chemist
and
F. Eugene Rush
Geologist

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

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A BRIEF APPRAISAL OF THE WATER RESOURCES OF GRASS AND CARICO LAKE VALLEYS, LANDER AND EUREKA COUNTIES, NEVADA

by D. E. Everett and F. Eugene Rush

SUMMARY

Grass Valley is a topographically and hydrologically closed valley; Carico Lake Valley has surface and subsurface drainage through Rocky Pass into Crescent Valley. The source of practically all the ground water is precipitation within the drainage basins.

The estimated average annual surface-water runoff in Grass and Carico Lake Valleys is 9,000 and 3,000 acre-feet, respectively. In Grass Valley, about 75 percent occurs on the eastern side of the valley. In Carico Lake Valley, about 90 percent occurs in the Mt. Callaghan area of the Toiyabe Range in the southeastern part of the valley.

The estimated average annual increments of recharge to the ground-water reservoirs in Grass and Carico Lake Valleys are 13,000 acre-feet and 4,300 acre-feet, respectively. Most of the ground water is discharged by evaporation from land surface, evapotranspiration by phreatophytes and crops, and subsurface outflow through Rocky Pass. The estimated average annual discharge is 13,000 acre-feet in Grass Valley and 4,500 acre-feet in Carico Lake Valley. Preliminary estimates of perennial yield are 13,000 acre-feet for Grass Valley and 4,000 acre-feet for Carico Lake Valley.

Most of the available ground water occurs in the alluvium; about 16,000 acre-feet is in storage in each saturated foot of alluvial deposits in Grass Valley and about 8,000 acre-feet is in storage in each saturated foot of alluvial deposits in Carico Lake Valley.

Ten chemical analyses suggest that the ground water generally is suitable for most agricultural uses. However, adequate drainage would have to be maintained.

Present development of water in the project area consists of irrigation of about 2,500 acres of alfalfa and pasture. The bulk of the water used is surface water. About 400 acre-feet of ground water is used to supplement streamflow during periods of low flow. The most favorable areas for development of ground water are south and west of the playa in Grass Valley and south of the playa in Carico Lake Valley.

INTRODUCTION

Purpose and Scope of the Study

Ground-water development in Nevada has shown a substantial increase in recent years. A part of this increase is due to the effort by private and public interests to bring new land into cultivation. The increasing interest in ground-water development has created a substantial demand for information on ground-water resources throughout the State.

Recognizing this need, the State Legislature enacted special legislation (Chapt. 181. Stats, 1960) for beginning a series of reconnaissance studies of the ground-water resources of Nevada. As provided in the legislation, these studies are being made by the U. S. Geological Survey in cooperation with the Nevada Department of Conservation and Natural Resources. This is the thirty-seventh report prepared as part of the reconnaissance studies (fig. 1).

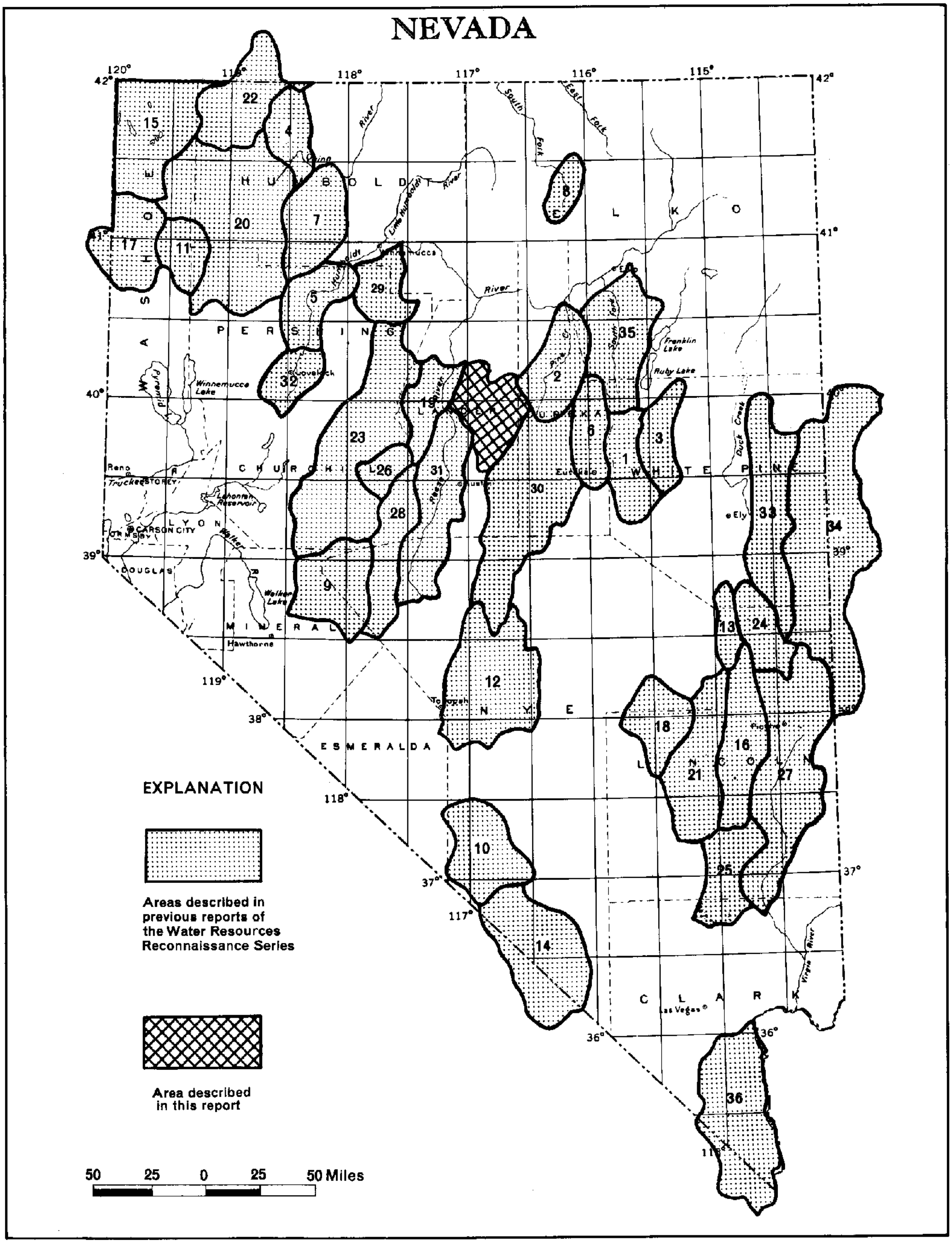
During the course of the ground-water studies to date, it was recognized that there also was a deficiency of information on the surface-water resources. Accordingly, this reconnaissance series has been broadened to include preliminary evaluations of the surface-water resources in the valleys studied.

The objectives of the reconnaissance studies and this report are to (1) appraise the source, occurrence, movement, storage, and chemical quality of water in the area, (2) estimate average annual recharge to and discharge from the ground-water reservoir, (3) to provide a general evaluation of surface-water resources in the valleys, and (4) provide a preliminary estimate of the perennial yield.

The investigation was made under the general supervision of G. F. Worts, Jr., District Chief in charge of hydrologic studies by the Geological Survey in Nevada.

Location and General Geographic Features

Grass Valley, in central Nevada, is approximately enclosed by lat 39° 35' and 40° 10' N.; long 116° 30' and 117° 00' W. (fig. 1). It is in the eastern part of Lander County and the western part of Eureka County (pl. 1). It is about 40 miles long, 18 miles wide, and covers an area of about 590 square miles. Principal access to the valley is by State Highway 21, which connects with U.S. Highway 50 about 5 miles east of Austin. Trails or unimproved roads provide access to most other points in the valley.



MAP OF NEVADA

Figure 1.— showing areas described in previous reports of the Water Resources Reconnaissance Series and the area described in this report

Carico Lake Valley lies northwest of Grass Valley and is approximately enclosed by lat 39° 45' and 40° 15' N.; long 116° 45' and 117° 10' W. (fig. 1). It is in the central part of Lander County (pl. 1). The valley is about 40 miles long, 10 miles wide, and covers an area of about 380 square miles. Principal access to the valley is by a gravel road which connects with State Highway 8A about 30 miles north of Austin. Unimproved roads provide access to most other points in the valley.

Physiography and Drainage

Grass Valley is a hydrologically and topographically closed valley in the Great Basin Section of the Basin and Range physiographic province (Fennemen, 1931). It is a north-trending valley bordered on the east and south by the Simpson Park Mountains, on the west by the Toiyabe Range, and on the north by the Cortez Mountains. Carico Lake Valley, which is also in the Great Basin section of the Basin and Range physiographic province, is a north-trending valley bordered on the east and south by the Toiyabe Range and on the north and west by the Shoshone Range. The valley is hydrologically and topographically open with both surface and subsurface drainage into Crescent Valley to the north through Rocky Pass.

Mt. Callaghan, altitude 10,187 feet, in the Toiyabe Range, which separates Grass and Carico Lake Valleys, is the highest peak in the area. The lowest point in Grass Valley, 5,611 feet, is at the playa; the lowest point in Carico Lake Valley, 5,020 feet, is in Rocky Pass between Carico Lake and Crescent Valleys. Accordingly, the maximum relief is about 4,600 feet in Grass Valley and 5,200 feet in Carico Lake Valley.

The principal surface drainage in Grass Valley is toward the playa. In the valley lowland, south of the playa, the gradient of Callaghan Creek is about 10 feet per mile. North of the playa the valley gradient is about 25 feet per mile. In Carico Lake Valley, the principal drainage is northward into Crescent Valley. In the valley lowland, the gradient of Carico Lake Wash is about 10 feet per mile. In the project area, gradients on the alluvial apron, which lies between the mountains and the lowlands, commonly range from 100 to 300 feet per mile. In the mountains, erosion has produced steep-sided canyons, and stream-channel gradients generally are in excess of 300 feet per mile. Locally they may be as much as 1,000 feet per mile.

Climate

The climate in the area generally is semiarid in the valleys and subhumid in the higher mountains. Precipitation and humidity generally are low; summer temperatures and evaporation rates are high. Precipitation varies widely in amount but generally is least on the valley floor and greatest in the mountains. Snow is common during the winter months, and localized thundershowers provide much of the summer precipitation. The daily temperature range is commonly about 50°F.

Precipitation records are not available for Grass or Carico Lake Valleys; however, long-term records are available for Austin, 15 miles southwest of the area, and Battle Mountain, 25 miles northwest of the area. The average annual precipitation at Austin, altitude 6,594 feet, during the period 1877-1964 was 12.06 inches (table 3). The recorded maximum annual precipitation, 21.07 inches, occurred in 1891, and the minimum annual precipitation, 5.90 inches, occurred in 1959. At Battle Mountain, altitude 4,513 feet, the average annual precipitation during the period 1870-1964 was 6.63 inches. The maximum annual precipitation, 14.03 inches, occurred in 1884, and the minimum annual precipitation, 2.40 inches, occurred in 1918.

The average monthly and annual temperatures for the period of record at Austin and Battle Mountain are listed in table 1. The average growing season has not been determined, but an approximation may be obtained by reference to the middle Humboldt River area (Battle Mountain) and the upper Reese River area. Houston (1950, p. 14, 16) lists the average growing season for the middle Humboldt River area and the upper Reese River area as 120 and 117 days, respectively. Because these nearby valleys are at about the same altitude as the study area, the length of the growing season in Grass and Carico Lake Valleys may be within the range of the two values.

Table 1.--Average monthly and annual temperatures in degrees Fahrenheit, at two stations near Grass and Carico Lake Valleys, Nevada

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

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Battle Mountain 1/	26.1	32.8	38.9	46.8	55.7	64.3	73.9	70.5	60.2	49.7	37.3	29.2	48.8
Austin 2/	28.6	31.4	36.0	43.8	51.6	60.6	70.4	68.4	60.2	49.4	38.0	31.7	47.5

1. Average for period 1920-64; continuing record. Altitude 4,513 feet.
2. Average for period 1931-64; continuing record. Altitude 6,594 feet.

Numbering System for Wells and Springs

The numbering system for wells and springs in this report is based on the rectangular subdivision of the public lands, referenced to the Mount Diablo base line and meridian. It consists of three units: the first is the township north of the base line; the second unit, separated from the first by a slant, is the range east of the meridian; the third unit, separated from the second by a dash, designates the section number. The section number is followed by a letter that indicates the quarter section: the letters a, b, c, and d designate the northeast, northwest, southwest, and southeast quarters, respectively. Following the letter, a number indicates the order in which the well or spring was recorded within the 160-acre tract. For example, well 22/47-10a1 is the first well recorded in the NE 1/4 sec. 10, T. 22 N., R. 47 E., Mount Diablo base line and meridian.

Because of the limitation of space, wells and springs are identified on plate 1 only by the section number, quarter section letter, and number. Township and range numbers are shown along the margins of the area on plate 1.

SURFACE WATER

General Conditions

Surface water in Carico Lake and Grass Valleys is derived from precipitation within the drainage areas, most of which is derived from precipitation in the mountains. On the valley floor, where precipitation is light, little streamflow occurs, except that which is fed by mountain streams.

Most of the snow and rain in the mountains is lost by evapotranspiration, but part infiltrates the rock material, becoming ground water, and part collects into small streams. These streams in turn feed the major mountain streams that flow onto the alluvial apron where much of the streamflow is absorbed by the alluvium. Under native conditions, only the major mountain streams flowed to the playa areas in the valleys, and then probably only during periods of high runoff. Most of the larger mountain streams have been diverted and utilized for irrigation, thus reducing flow to the lower parts of the valley floors. Estimates or measurements of streamflow were made at 27 points, as shown on plate 1 and listed in table 2.

The largest stream in Carico Lake Valley is Iowa Creek, which has its source in the Toiyabe Range near Mt. Callaghan (T. 22 N., R, 45 E.). No gaging station has been maintained on this or other creeks in the report area, but three estimates of the flow have been made on Iowa Creek as part of this study (table 2). The flow, 8 cfs (cubic feet per second) in June, about 3 cfs in July, and 0.57 cfs in October, was observed in the bedrock area just above the reservoir where flow would be expected to be at its maximum rate. For the several times of the year the observed flow probably was above normal, as were most of the creeks of Nevada following the wet winter of 1964-65.

The flow as observed at the mountain front in Iowa Creek and Hall Creek during the early summer did not extend to the valley lowlands, but was absorbed by the alluvium. Streamflow of other creeks and springs in Carico Lake Valley was minor (table 2).

In Grass Valley, the largest stream is Skull Creek whose headwaters drain the northeast flank of Mt. Callaghan. Flow was estimated to be 15 cfs on June 14 but only 0.59 cfs on October 22 (table 2, site 10). Skull Creek and Steiner Creek are the principal tributaries to Callaghan Creek, which flows northward toward the Grass Valley playa. Below the area of diversions, Callaghan Creek maintained a flow of about 5 cfs on June 14 (table 2, site 16), but was nearly dry near the playa. McClusky Creek and the combined runoff of Cowboy Rest and Rosebush Creeks produced sufficient flow for irrigation.

Table 2.--Streamflow in Carico Lake and Grass Valleys, Nevada

[Estimated, except as indicated]

Map number on plate 1	Site	Location: Township	Location: Range	Date		Discharge (cfs)
	CARICO LAKE VALLEY					
1	Iowa Cr. above reservoir	23 N.	44 E.	6-16-65		8
				7-15-65	a	2.85
				10-23-65	a	0.57
2	Hall Cr. at diversion	23 N.	45 E.	5-14-65	a	5.78
				7-13-65		2
				10-23-65	a	0.32
3	Hall Creek	25 N.	44 E.	7-12-65		0
4	Unnamed spring	26 N.	45 E.	7-12-65		.01
5	Cooks Cr. at crossing	27 N.	45 E.	7-12-65		.02
6	Rocky Pass Spring	27 N.	46 E.	7-12-65		.1
7	Carico Lake Wash	27 N.	46 E.	7-12-65		0
	GRASS VALLEY					
8	Callaghan Cr. above ranch	21 N.	45 E.	6-14-65		5
				10-22-65	a	1.05
9	Callaghan Cr. at crossing	21 N.	46 E.	6-14-65		3
10	Skull Creek	21 N.	46 E.	6-14-65		15
				10-22-65	a	0.59
11	Unnamed creek at crossing	21 N.	46 E.	6-14-65		.5
12	Skull Cr. at crossing	21 N.	46 E.	6-14-65		10
13	Cottonwood Spring at road	20 N.	45 E.	6-14-65		0
14	Steiner Creek	21 N.	46 E.	5-14-65	a	3.40
				10-22-65	a	0.17
15	Ox Corral Cr. at crossing	21 N.	46 E.	6-15-65		4
16	Callaghan Cr. at crossing	22 N.	47 E.	6-14-65		5
17	Unnamed creek	21 N.	46 E.	5-14-65	a	.51
				6-14-65		1.25
18	Cowboy Rest and Rosebush Creeks	23 N.	46 E.	6-14-65		2
19	Unnamed creek at crossing	23 N.	46 E.	6-15-65		.2
20	Unnamed creek at crossing	23 N.	46 E.	6-15-65		.4
21	Corral Canyon Creek at crossing	23 N.	46 E.	6-15-65		.1
22	Callaghan Cr. at crossing	23 N.	47 E.	6-15-65		.05
23	Unnamed creek at crossing	23 N.	48 E.	6-15-65		.2
24	Walti Hot Springs	23½ N.	48 E.	6-15-65		2
25	Dry Canyon Wash at crossing	24 N.	46 E.	6-15-65		0
26	Hot Springs	24 N.	47 E.	6-15-65		0
27	McClusky Cr. at bridge	24 N.	48 E.	5-14-65	a	3.45
				6-15-65		2
				10-23-65	a	0.17

a. Flow measured with current meter.

All other streamflow, as observed in June 1965, was minor, except for that which was produced by Walti Hot Springs. The latter is discussed in the ground-water section of this report.

Estimated Average Annual Runoff

By D. O. Moore

A method of estimating runoff in Nevada has recently been devised by Riggs and Moore (1965) and is applicable to areas of Nevada where little or no streamflow data are available. The method is a reconnaissance technique, still in the development stage, and is useful in showing the magnitude and distribution of runoff in the valleys.

Briefly, the method for estimating the average annual runoff is based on the general condition that the higher altitudes received more precipitation than the lower altitudes. (See discussion of recharge.) Accordingly, areas at higher altitudes are assumed to produce more runoff than areas of lower altitudes. Because the relations of precipitation, altitude, and runoff are different in the various parts of the State, different correlation factors are used to adjust the altitude-runoff relation for the several mountain areas. This adjustment is based on streamflow measurements, differences in vegetation, amounts of precipitation, and geology.

Using the above technique, the estimated average annual runoff in Grass and Carico Lake Valleys is 9,000 and 3,000 acre-feet, respectively. In this area the runoff is estimated at the bedrock-alluvium contact, which ranges in altitude from about 5,800 to about 7,200 feet. The average altitude was estimated to be about 6,000 feet.

Runoff is not evenly distributed throughout the mountains. In Grass Valley, about 75 percent probably occurs in the mountains of the Toiyabe Range on the eastern side of the valley. In Carico Lake Valley, about 90 percent of the runoff probably occurs in the Mt. Callaghan area of the Toiyabe Range in the southeastern part of the valley.

GENERAL HYDROGEOLOGIC FEATURES

Geomorphic Features

The mountain ranges of the report area are complexly folded and faulted blocks of igneous, metamorphic, and sedimentary rocks. The present topographic relief is largely the result of movement along many north- to northeast-trending faults.

The alluvial aprons of the report area generally have poorly developed alluvial fans. Only in the southeastern part of Grass Valley, where recent faulting has occurred, are there fans, and these are not large. The best developed fan is formed by Indian Creek in the northern part of T. 22 N. and the southern part of T. 21 N., R. 47 E. The apex of this fan stands about 500 feet higher than its toe, and extends out from the mountain front about 3 miles. The fans appear to be younger than the remainder of the alluvial apron and have developed in an area where the mountains rise abruptly.

The valley floor of Grass Valley is relatively flat and level; much of it is occupied by an unnamed playa, or dry lake. The valley floor of Carico Lake Valley is less well developed; in most places it is only as wide as the narrow flood plain along Carico Lake Wash. However, a small playa, 2 miles long and a maximum of three quarters of a mile wide, is in T. 26 N., R. 45 E.

Lithologic and Hydrologic Features of the Rocks

Rocks of the report area are divided into three lithologic units: consolidated rocks, older alluvium, and younger alluvium. This division corresponds roughly with the hydrologic properties of the rocks; however, the hydrologic properties of the consolidated rocks vary widely with differences in their physical and chemical properties. Surface exposures of the units are shown on plate 1. The geologic mapping is based principally on aerial photograph interpretation, field checking of rock types at widely separated locations, and the recent work of Gilluly and Gates (1965).

Consolidated rocks

The consolidated rocks of the report area include basalt, tuff, rhyolite, granite, quartzite, and limestone. The limestone is in the Simpson Park Range near the Walti Ranch and overlies a section of granite.

The rocks generally have low permeability; hence, they are among the least economic sources of water in the area, except where they give rise to large springs, such as at the Walti Ranch. Limestone in Nevada commonly contains solution channels and can transmit large amounts of water. However, in this area, because of their topographic position in the mountains, they presently are not considered an economic source of water.

Older Alluvium

Older alluvium is debris derived from the adjacent mountains during Cenozoic time. It is mostly composed of beds or lenses of gravel, sand, silt, and clay, unconsolidated or poorly consolidated, extensively dissected, poorly sorted, and commonly deformed. Therefore, the older alluvium characteristically yields water to wells at low to moderate rates.

Younger Alluvium

The younger alluvium is a thin deposit, overlying the older alluvium. It is generally finer-grained, better sorted, unconsolidated, undissected, and less disturbed than the older alluvium. Where saturated the younger alluvium probably will yield small to large quantities of water to wells. In Grass Valley, the valley floor is underlain by an unknown thickness of silt and clay deposited in a Pleistocene lake, and subsequently by playa deposits. The highest recognizable lake features are at an altitude of about 5,750 feet, or about 150 feet above the present playa surface. The maximum extent of the lake, and therefore the fine-grained deposits, is enclosed by the high-lake level, as shown on plate 1. The lake deposits are generally low in permeability and are therefore poor sources of water. Gravel bars and other wave-deposited features are around the margins of the ancient lake, and are more permeable and may yield small to moderate supplies of water; however, the hydrologic characteristics of these deposits are highly variable.

Most of the economically available ground water in the report area is stored in the older and younger alluvium, which comprises the principal ground-water reservoir. There is a general lack of development of ground water in the area, and therefore little is known about the water-yielding character of the alluvium. However, well 24/48-15a1, on the Baumann Ranch in Grass Valley, reportedly pumps 1,400 gpm (gallons per minute). The well was drilled to a depth of 327 feet. According to the driller's log, all but the top 10 feet of the deposits encountered were logged as gravel (table 8). The thick deposit of gravel strongly suggests that other large-capacity wells could be developed in this part of Grass Valley. The potential yield of wells in Carico Lake Valley has not been explored. Drillers' logs of wells in these two valleys show the types of materials composing the alluvium (table 8).

GROUND-WATER HYDROLOGY

Source and Occurrence

The source of ground water in the project area is precipitation within the drainage basin. Most of the ground water is contained in the older and younger alluvium and occurs under both artesian and water-table conditions. Well 25/45-5c1, the only known flowing well in Carico Lake Valley, had an estimated flow of 1gpm on July 21, 1965 (table 7).

The thickness of the ground-water reservoir is not known, because wells near the center of the valleys do not penetrate its full thickness. Well 24/48-15c1, in Grass Valley, was drilled to a depth of 327 feet and did not encounter bedrock, according to the driller's log (table 8).

Some ground water occurs in the consolidated rocks as is evidenced by springs discharging from them. However, because of their low permeability, yields from any wells tapping them probably would be small compared to those in the alluvium.

Movement

Ground water, like surface water, moves from areas of higher head to areas of lower head. Unlike surface water, however, it moves very slowly, commonly at rates ranging from a fraction of a foot to several hundred feet per year, depending on permeability and hydraulic gradient.

In Grass Valley, ground water moves from recharge areas in the mountains to discharge areas in the valley lowlands. The principal lateral direction of movement is toward the playa in the northern part of the valley. Flow in Carico Lake Valley generally is toward the axis of the valley and then northward where it drains through Rocky Pass into Crescent Valley.

Recharge

Recharge to the project area is derived from precipitation within the drainage area. However, because most of the precipitation is lost through evapotranspiration, only a small percentage recharges the ground-water reservoir. The mountains receive more precipitation than the lowlands, and accordingly, contribute more runoff and recharge to the area. During the spring as the snow melts, some of the resulting streamflow infiltrates into cracks in the consolidated rocks and moves toward the valley as ground-water underflow. A small part of the precipitation on the alluvial apron and some of the streamflow crossing the alluvial apron also infiltrate to the ground-water reservoir in the alluvium. Because average annual precipitation on the valley floors is small, virtually none infiltrates to the ground-water reservoir, except during some years of above-average precipitation.

Eakin and others (1951, p. 79-81) developed a method of estimating average annual recharge. The method is based on the assumption that a percentage of the average annual precipitation ultimately recharges the ground-water reservoir. Because of the numerous variables that influence the percentage of precipitation that becomes recharge in any particular locality, the computations based on this method provide only highly generalized estimates.

Although records of precipitation are not available for Grass or Carico Lake Valleys, the magnitude of monthly and annual precipitation in the lower parts of the valleys may be approximately represented by the records for Battle Mountain. The record of precipitation for Austin may represent approximately the precipitation on the higher parts of the alluvial aprons. The long-term data for Battle Mountain and Austin (table 3) indicate the general precipitation pattern in Nevada; that is, the station at the lowest altitude records the least precipitation.

The precipitation map of Nevada (Hardman and Mason, 1949, p. 10) has been adjusted (Hardman, oral communication, 1964) to the improved topographic base maps (scale 1:250,000) now available for the whole State. Hardman showed that the average annual precipitation is closely related to altitude. This map was used to estimate the precipitation at selected altitude zones.

Table 4 lists the altitude zones, the estimated average annual precipitation, and the estimated percentage of the precipitation in each zone that ultimately recharges the ground-water reservoir. The estimated average annual precipitation for Grass and Carico Lake Valleys is 290,000 acre-feet and 160,000 acre-feet, respectively, and the estimated average annual recharge is 13,000 acre-feet and 4,300 acre-feet, respectively. The estimated recharge may appear high, if compared to the estimated surface-water runoff in Grass and Carico Lake Valleys, which is 9,000 acre-feet and 3,000 acre-feet respectively, because in general most ground-water recharge is derived from runoff. However, the estimates for recharge are in reasonable agreement with the estimate of ground-water discharge by evapotranspiration discussed later in this report. This apparent disparity between the runoff and recharge estimates has not been resolved in this reconnaissance.

Table 3.--Average monthly and annual precipitation, in inches, at two stations near Grass and Carico Lake Valleys, Nev.

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

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Battle Mountain[1/]	0.78	0.69	0.65	0.75	0.80	0.50	0.18	0.16	0.28	0.53	0.57	0.74	6.63
Austin[2/]	1.14	1.14	1.46	1.64	1.43	.80	.60	.53	.48	.93	.85	1.06	12.06

1. Altitude 4,513 feet. In sec. 35, T. 32 N., R. 45 E., 25 miles north of project area. Average for period 1870-1964; continuing record.

2. Altitude 6,594 feet. In sec. 19, T. 19 N., R. 44 E., 15 miles south of project area. Average for period 1877-1964; continuing record.

Table 4.--Estimated average annual precipitation and ground-water recharge in Grass and Carico Lake Valleys, Nevada

Altitude zone (feet)	Area (acres)	Estimated annual precipitation: Range (in inches)	Average (in feet)	Average (in acre-feet)	Estimated recharge: Assumed percentage of precipitation	(acre-feet per year)
GRASS VALLEY						
Above 9,000	2,300	more than 20	1.75	4,000	25	1,000
8,000-9,000	17,000	15 to 20	1.46	25,000	15	3,700
7,000-8,000	55,600	12 to 15	1.12	62,000	7	4,400
6,000-7,000	141,000	8 to 12	.83	120,000	3	3,500
Below 6,000	168,000	less than 8	.50	84,000	--	--
Total (rounded)	384,000	--	--	290,000	--	13,000
CARICO LAKE VALLEY						
Above 9,000	500	more than 20	1.75	900	25	220
8,000-9,000	3,200	15 to 20	1.46	4,700	15	700
7,000-8,000	22,000	12 to 15	1.12	25,000	7	1,700
6,000-7,000	68,000	8 to 12	.83	56,000	3	1,700
Below 6,000	149,000	less than 8	.50	74,000	--	--
Total (rounded)	243,000	--	--	160,000	--	4,300

Discharge

Prior to development by man, all the ground water in the area was discharged by evaporation, transpiration, and by surface and subsurface outflow to Crescent Valley. With the advent of mining and agriculture, spring flow was diverted and wells were pumped to satisfy irrigation, domestic, stock, and mining needs. The result has been a slight increase in the draft on the ground-water reservoir and a modest depletion of streamflow downstream from the springs.

Much of the ground water discharged by evapotranspiration is consumed by phreatophytes. In Grass Valley these plants grow over much of the flood plain and in a band around the playa. In Carico Lake Valley they grow along the main drainage channel in the central and northwestern parts of the valley. The principal phreatophytes are greasewood, rabbitbrush, and saltgrass. Cottonwood and willow are found along some of the principal mountain creeks and at some of the springs.

Table 5 lists the estimated average annual evapotranspiration for each valley. These estimates are based on the rates of evapotranspiration determined by Lee (1912), White (1932), and Young and Blaney (1942). The estimated total average annual evapotranspiration of ground water by phreatophytes is about 12,000 acre-feet in Grass Valley and 3,800 acre-feet in Carico Lake Valley.

Domestic and stock wells are numerous in both valleys; however, their total discharge in each valley is estimated to be less than 200 acre-feet per year.

Table 5.--Estimated average annual evapotranspiration of ground water by phreatophytes and bare soil in Grass and Carico Lake Valleys, Nev.

Phreatophyte	Area (acres)	Areal density (percent)	Depth to water (feet)	Evapotranspiration acre-feet per acre	Evapotranspiration acre-feet (rounded)
GRASS VALLEY					
Greasewood and rabbitbrush	51,000	15 to 30	10 to 50	0.2	10,000
Saltgrass	500	--	0 to 10	.5	250
Cottonwood and willow	trace	--	1 to 5	2.0	trace
Bare soil	17,000	--	5 to 15	.1	1,700
Total	68,500	--	--	--	12,000
CARICO LAKE VALLEY					
Greasewood and rabbitbrush	16,000	15 to 30	10 to 50	.2	3,200
Saltgrass	1,000	--	0 to 10	.5	500
Cottonwood and willow	trace	--	1 to 5	2.0	trace
Bare soil	1,000	--	5 to 15	.1	100
Total	18,000	--	--	--	3,800

Some ground water from Carico Lake Valley rises to the surface at the gap at Rocky Pass and flows into Crescent Valley. In addition, excess irrigation water from the Henry Fillippini Ranch at Rocky Pass flows into Crescent Valley. Most of this surface-water outflow occurs during the non-growing season; Zones (1961, p.20) estimated that it averages 200 to 300 acre-feet per year.

In addition, ground-water underflow through Rocky Pass from Carico Lake Valley is estimated to be no larger than 300 acre-feet per year. This estimate is based on the assumption that the alluvium in the pass has a coefficient of transmissibility no larger than 50,000 gpd per foot, a ground-water gradient of 25 feet in a quarter mile, and an effective width of about 0.06 mile.

Numerous springs occur in the project area. However, most discharge only a few gallons per minute. An exception is Walti Hot Springs in Grass Valley which discharges about 1,500 acre-feet per year. This group of springs is used to irrigate about 200 acres of alfalfa and meadow grass. It is estimated that about 500 acre-feet is consumed by these crops and the remaining 1,000 acre-feet returns to the ground-water reservoir where it is eventually transpired by phreatophytes.

Leakage from the valley through bedrock to adjacent valleys having a lower altitude is a possibility, but this brief reconnaissance provided no field evidence to indicate that it occurs.

The above estimates suggest that the total average annual discharge from Grass and Carico Lake Valleys is about 13,000 and 4,500 acre-feet, respectively, as shown in the following table.

	Grass Valley (acre-feet)	Carico Lake Valley (acre-feet)
Evapotranspiration	12,000	3,800
Surface-water outflow	--	200
Ground-water outflow	--	300
Pumpage	200	200
Springs (net use by crops)	500	--
Total (rounded)	13,000	4,500

Perennial Yield

The perennial yield of a ground-water reservoir may be defined as the maximum amount of water of usable chemical quality that can be withdrawn economically each year for an indefinite period of time. If the perennial yield is continually exceeded, water levels will decline until the ground-water reservoir is depleted of water of usable quality or the pumping lifts become uneconomical to maintain. The perennial yield, therefore, cannot exceed the natural recharge to an area unless induced or artificial recharge is started. In the final analysis, the yield is limited to the maximum amount of natural discharge that can be economically salvaged for beneficial use.

Under long-term natural conditions, the valleys had little or no net change in the volume of ground water in storage and the average annual recharge and discharge were equal. In Grass Valley, the estimated average annual recharge and discharge are both about 13,000 acre-feet. Similarly, in Carico Lake Valley, the estimated average annual recharge and discharge are 4,300 and 4,500 acre-feet, respectively. The close agreement of these estimates in each valley does not demonstrate a high degree of accuracy because of inaccuracies in the values used to compute the several elements of recharge and discharge.

With proper well location, most of the natural discharge in Grass Valley probably could be salvaged. Thus the preliminary estimate of perennial yield is about 13,000 acre-feet. In Carico Lake Valley, much of the surface-water and ground-water outflow probably could not be economically salvaged by pumping. Therefore, the preliminary estimate of perennial yield is somewhat less than the estimated natural discharge, or is about 4,000 acre-feet.

When considering the location of wells to salvage the natural discharge, the following table shows the location and approximate percentage of the total discharge in the two valleys:

Location	Approximate percentage of total discharge
GRASS VALLEY	
(estimated discharge 13,000 acre-feet per year)	
Tps. 21 and 22 N.	25
Tps. 23 and 24 N.	55
Tps. 25 and 26 N.	20
CARICO LAKE VALLEY	
(estimated discharge 4,500 acre-feet per year)	
Tps. 24 and 25 N.	60
Tps. 26 and 27 N.	a 40

a. Most of the surface-water and ground-water outflow to Crescent Valley, which is 5 to 10 percent of the total discharge, probably is not salvable.

If pumpage were distributed in or near the areas of natural discharge in about the proportions shown in the above table, the possibility of local overdraft would be greatly reduced, and the perennial yields of the two valleys could be closely approached, subject principally to the limitations caused by the build up of salts due to the recycling of ground water by pumping.

Storage

The amount of recoverable ground water in storage in Grass and Carico Lake Valleys is equal to the volume of saturated material multiplied by the specific yield of the material. Specific yield of a deposit is the ratio of (1) the volume of water which, after being saturated, it will yield by gravity to (2) its own volume, commonly expressed as a percentage.

In Grass and Carico Lake Valleys, the specific yield of the uppermost 100 feet of saturated material may be on the order of 10 percent. For

Grass Valley the estimated area underlain by 100 or more feet of saturated material is about 160,000 acres, or 80 percent of the 200,000 acres mapped as younger and older alluvium (pl. 1). Accordingly, the amount of ground water in storage in the uppermost 100 feet of the zone of saturation beneath this area is about 1,600,000 acre-feet, or about 16,000 acre-feet for each foot of saturated material.

For Carico Lake Valley the estimated area underlain by 100 or more feet of saturated material is about 80,000 acres, or about 70 percent of the 110,000 acres mapped as younger and older alluvium (pl. 1). Accordingly, the amount of ground water in storage in the uppermost 100 feet of the zone of saturation beneath this area is about 800,000 acre-feet, or about 8,000 acre-feet for each foot of saturated material.

Although the above estimates of ground water in storage are large, the amount where the depth to water is less than 100 feet and where suitable land is available for cultivation is appreciably less. The amount of usable ground water in storage that is available on an economic basis depends in part on the distribution of water-storing deposits, the distribution and range in chemical quality of the ground water, and the number and distribution of the pumped wells.

Chemical Quality

Ten water samples were analyzed as part of the present study to make a generalized appraisal of the suitability of the ground water for agricultural use and to help define potential water-quality problems. The analyses are listed in table 6.

Suitability for Agricultural Use

According to the Salinity Laboratory Staff, U.S. Department of Agriculture (1954, p. 69), the most significant factors with regard to the chemical suitability of water for irrigation are dissolved-solids content, the relative proportion of sodium to calcium and magnesium, and the concentration of elements and compounds that are toxic to plants. Dissolved-solids content commonly is expressed as "salinity hazard," and the relative proportion of sodium to calcium and magnesium as "alkali hazard."

Sampling sites were chosen in Grass and Carico Lake Valleys to achieve the widest possible areal coverage. All the wells and springs sampled yield water which probably is suitable for irrigation. However, water from spring 27/46-28b2 had a medium alkali hazard and a very high salinity hazard. Without adequate drainage, this water probably would be marginal if used for irrigation. Boron hazard might be evaluated by inference. Boron has not been a problem to agriculture in similar terrains; thus, it is unlikely to affect the use here.

Table 6.--Chemical analyses, in parts per million, of water from selected wells and springs in Grass and Carico Lake Valley, Nev.

(Field analyses by the U.S. Geological Survey)

Location	Date of collection	Temperature (°F)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) plus potassium[1] (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Chloride (Cl)	Sulfate (SO_4)	Hardness as $CaCO_3$: Calcium magnesium	Hardness as $CaCO_3$: Noncarbonate	SAR	RSC (epm)	Specific conductance (micromhos at 25°C)	pH
GRASS VALLEY															
21/46-9d1	6-15-65	60	47	7.2	91	331	0	18	45	147	0	3.2	2.5	592	7.5
22/47-10a1	6-17-65	52	55	19	48	252	0	18	86	217	11	1.4	.0	545	7.5
23/47-29a1	6-17-65	52	33	4.3	80	236	0	22	48	100	0	3.5	1.9	493	7.5
23/47-36c1	6-17-65	60	68	30	30	264	0	14	116	292	75	.8	.0	719	7.9
a24/48-33c1	6-17-65	160	57	12	70	315	0	14	65	192	0	2.2	1.3	609	7.1
CARICO LAKE VALLEY															
24/44-5c1	7-12-65	57	63	21	103	224	0	137	88	245	62	2.8	.0	953	7.6
b26/45-15a1	7-12-65	72	54	18	111	396	0	18	95	207	0	3.4	2.4	806	7.9
26/45-28c1	7-12-65	59	42	6.1	88	264	0	34	54	130	0	3.3	1.7	616	7.7
27/46-28b1	7-12-65	55	50	23	79	204	0	97	84	220	53	2.3	.0	776	8.1
b27/46-28b2	7-12-65	72	141	61	292	540	0	332	315	605	162	5.2	.0	2,330	7.8

1. Computed by difference.
a. Walti Hot Springs.
b. Unnamed spring.

Water Quality and its Relation to the Ground-Water System

The quality of ground water in the project area varies from place to place. However, in general, the dissolved-solids content is low in the recharge areas in the mountains and increases as it moves toward the areas of discharge in the lower parts of the valley. For example, in Grass Valley water from well 21/46-9d1 has a specific-conductance value of 592 micromhos per centimeter. The source of much of this water probably is recharge derived from precipitation on the Toiyabe Range and Simpson Park Mountains. As the ground water moves northward, it dissolves additional mineral matter, and the specific conductance of water from well 23/47-36c1 is 719 micromhos. Although some of the chemical constituents in the water in the area are derived from ground-water underflow from the south, the small change in specific conductance suggests that much of the water is derived from recharge resulting from precipitation on the nearby Simpson Park Mountains.

Most ground water in the area is a sodium bicarbonate type. However, water from wells 22/47-10a1 and 23/47-36c1 is a calcium bicarbonate type, and water from well 24/44-5c1 is a mixed sodium chloride-bicarbonate type. Ground water which surfaces at Rocky Pass (spring 27/46-28b2) is a mixed sodium chloride-bicarbonate type but also has a high concentration of sulfate. It is presumed that the large concentrations of sodium, chloride, and sulfate are derived from evaporites in the lacustrine deposits through which the water has passed.

Development

The development of water in Carico Lake and Grass Valleys in 1965 consisted of irrigation of about 2,500 acres of alfalfa and pasture in large part from streamflow and in small part from wells. The principal ranches, type and acreage of crops, and source of water are listed below:

Ranch	Crop irrigated	Area (acres)	Source of water	Remarks
		Carico Lake Valley		
Carico Lake	Meadow grass	600	Carico Lake Wash and wells	Wells used to supplement creek flow
Hall Creek	Meadow grass	250	Hall Creek	Subirrigated
Iowa Creek	Alfalfa and meadow grass	160	Iowa Creek	Reservoir
Wholey	Meadow grass	200	Wells	
Total (rounded)	--	1,200	--	--
		Grass Valley		
Allen	Alfalfa	40	McClusky Creek and well	Well used to supplement creek flow
Baumann	Alfalfa Meadow grass	80 60	McClusky Creek and well	Well used to supplement creek flow
Grass Valley	Alfalfa Meadow grass	150 650	Skull and Callaghan Creeks	
Quarter Circle One	Alfalfa Meadow grass	60 100	Callaghan Creek	
Walti	Alfalfa and meadow grass	200	Walti Hot Springs	Flows about 2 cfs
Total (rounded)	--	1,300	--	--

In addition, a small amount of water from streams and pumped wells supplied livestock and domestic requirements. The total amount used probably was less than 200 acre-feet per year.

Additional development of ground water in Grass Valley is possible. Although data are not available, the general geologic and hydrologic conditions suggest that areas south and west of the playa may be the most favorable areas for the development of moderate to large-capacity wells, where depths to water are moderate and where the chemical quality of the ground water may be relatively good. However, this does not preclude other areas as being suitable for development. The combination of good water-yielding zones, moderate to shallow depth to water, and suitable chemical quality results in an area favorable for development of ground water. In Grass Valley, these conditions might be expected generally along the lower parts of the alluvial apron and upper parts of the valley lowlands, marginal to the area of discharge. In Carico Lake Valley, additional ground-water development may be possible south of the playa along the axis of the valley.

Table 7.--Records of selected wells in Grass and Carico Lake Valleys, Nevada.

Type of well: Dr, drilled; Dg, dug
Water level: M, measured; R, reported
Depth: M, measured; R, reported
Use: D, domestic; S, stock; I, irrigation; U, unused

Well number or location	Owner	Type of well	Date completed	Casing diameter (inches)	Depth (feet)	Water level: Below land surface datum	Water level: Date measured or reported	Use	Remarks
20/45- 2c1	Bertrand Arambel	Dr.	1947	6	20	10 R	4-19-48	S	Log.
21/46- 1b1	Dick Magee	Dr.	1960	12	60	17 R	12-12-60	D	Log.
21/46- 9a1	Dick Magee	Dr.	1960	12	32	9 R	12-12-60	S	Log.
21/46- 9d1	Dick Magee	Dg; Dr.	--	48-12	--	53.22 M	6-15-65	D	Chemical analysis
22/47-10a1	- -	Dr.	--	8	--	6.14 M	6-17-65	S	Chemical analysis
23/47-29a1	- -	Dr.	--	8	--	8.68 M	6-17-65	S	Chemical analysis
23/47-36c1	- -	Dg.	--	48	--	4.97 M	6-17-65	S	Chemical analysis
24/44- 5c1	John Ansolabehere	Dr.	1948	6	120	72.85 M	7-12-65	S	Log.
24/44-17c1	W. W. Whitaker	Dr.	1948	6	162	99.81 M	7-12-65	S	Log.
24/44-20b1	W. W. Whitaker	Dr.	1948	6	162	99 R	12-16-48	S	Log.
24/44-24b1	John Tibouda	Dr.	1950	6	220	170 R	11-20-50	S,D	Log.
24/48- 8c1	- -	Dr.	--	6	--	31.12 M	6-17-65	I	
24/48-15a1	Emil Baumann	Dr.	1960	12	327	145.40 M	7-12-65	I	Log.
25/44-13a1	- -	Dg.	--	36	--	5.78 M	7-12-65	U	
25/44-15d1	- -	Dr.	--	6	--	37.60 M	7-12-65	S	
25/45- 5c1	Henry Fillippini	Dr.	1953	6	205	Flowing	3-25-53	S	Log; estimated flow 1 gpm; chemical analysis
25/45- 9c1	Henry Fillippini	Dr.	--	8	--	66.75 M	7-12-65	S	
26/45-28c1	- -	Dr.	--	10	--	5.31 M	7-12-65	S	Chemical analysis
26/45-32c1	- -	Dr.	--	4	--	4.17 M	7-12-65	U	
26/45-33b1	- -	Dr.	--	14	--	4.27 M	7-12-65	I	
27/46-20c1	Henry Fillippini	Dr.	1961	8	44	13 R	11-22-61	S	Log.
27/46-20c2	Henry Fillippini	Dr.	1961	8	39	5 R	11-22-61	S	Log.
27/46-28b1	Henry Fillippini	Dr.	--	8	--	2.73 M	7-12-65	S	Log; chemical analysis

Table 8.--Drillers' logs of selected wells in Grass and Carico Lake Valleys, Nevada

Material	Thickness (feet)	Depth (feet)
20/45-2c1		
Topsoil	5	5
Clay	10	15
Sand and gravel	5	20
21/46-1b1		
Surface clay	6	6
Sand, hard	6	12
Clay, sandy	4	16
Clay	3	19
Sand	3	22
Clay	10	32
Sand, coarse	12	44
Conglomerate	6	50
Gravel	6	56
Conglomerate	2	58
Gravel	2	60
21/46-9a1		
Surface clay	9	9
Sand, hard	9	18
Clay	4	22
Conglomerate	5	27
Gravel	5	32
24/44-5c1		
Silt	11	11
Gravel	8	19
Gravel and clay	48	67
Gravel	15	82
Sand, water	16	98
Gravel	22	120
24/44-17c1		
Silt	5	5
Gravel and clay	123	128
Gravel, water	2	130
Clay, brown	11	141
Sand, water	6	147
Clay, brown	7	154
Sand, water	8	162
24/44-20b1		
Silt	5	5
Gravel and clay	123	128
Gravel, water	2	130
Clay, brown	11	141
Sand, water	6	147
Clay, brown	7	154
Gravel and sand	8	162
24/44-24b1		
Gravel and boulders	78	78
Clay	36	114
Gravel	4	118
Clay	9	127
Gravel	13	140
Clay	3	143
Clay, hard	19	162
Clay, soft, blue	8	170
Sand and gravel, water	46	216
Clay	4	220
24/48-15a1		
Clay	10	10
Gravel	317	327

Table 8.--Continued

Material	Thickness (feet)	Depth (feet)
24/45-5c1		
Clay, yellow	12	12
Gravel	12	24
Clay, yellow	123	147
Gravel	4	151
Clay, yellow	34	185
Gravel	3	188
Clay, sandy, yellow	17	205
27/46-20c1		
Topsoil	14	14
Gravel, waterbearing	1	15
Clay, gravely	17	32
Rock, hard	8	40
Clay	4	44
27/46-20c2		
Clay	33	33
Hardpan	2	35
Gravel, waterbearing	4	39
27/46-28b1		
Clay	33	33
Hardpan	2	35
Gravel, waterbearing	4	39

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24	Lake		

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

PLATE 1.—GENERALIZED HYDROGEOLOGIC MAP OF GRASS AND CARICO LAKE VALLEYS LANDER AND EUREKA COUNTIES, NEVADA