STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
DIVISION OF WATER RESOURCES
Carson City

WATER RESOURCES–RECONNAISSANCE SERIES

REPORT 52

WATER–RESOURCES APPRAISAL OF THE COLUMBUS SALT MARSH–SODA SPRING VALLEY AREA, MINERAL AND ESMERALDA COUNTIES, NEVADA

By
A. S. Van Denburgh
and
Patrick A. Glancy

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

1970

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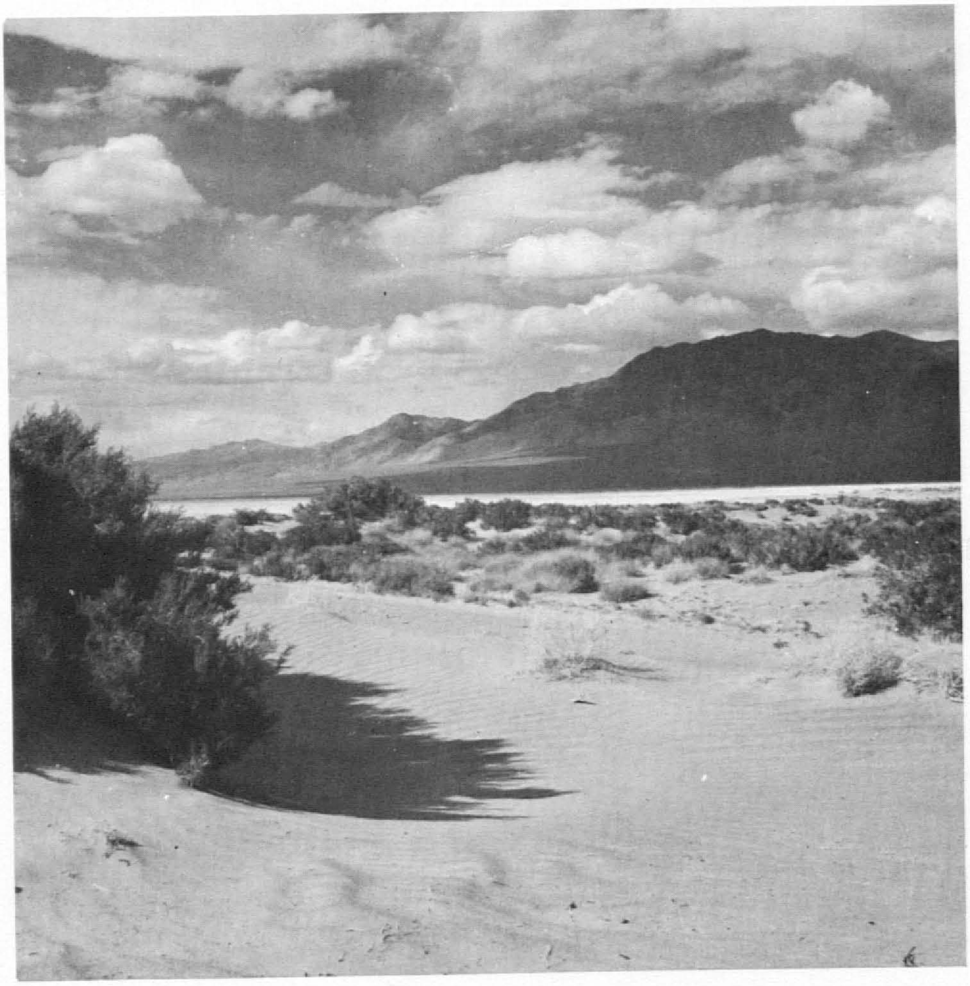

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FOREWORD

The program of reconnaissance water-resources studies was authorized by the 1960 Legislature to be carried on by the U.S. Geological Survey in cooperation with the Department of Conservation and Natural Resources, Division of Water Resources.

This report is the 52d report prepared by the staff of the Nevada District Office of the U.S. Geological Survey. These 52 reports describe the hydrology of 172 hydrographic areas.

The reconnaissance surveys make available pertinent information of great and immediate value to many State and Federal agencies, the State cooperating agency, and the public. 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 timely reconnaissance-type studies meet the immediate needs for information on the water resources.

Roland D. Westergard
State Engineer

1970

Division of Water Resources

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WATER-RESOURCES APPRAISAL OF THE COLUMBUS SALT MARSH - SODA SPRING VALLEY AREA, MINERAL AND ESMERALDA COUNTIES, NEVADA

By A. S. Van Denburgh and Patrick A. Glancy

SUMMARY

The 1,940-square-mile area covered by this study area lies in the southwestern part of the Great Basin, and encompasses 13 valleys (table 1). Altitudes in the area range from 4,370 feet on the floor of Rhodes Salt Marsh Valley to 13,140 feet at the crest of Boundary Peak. Precipitation averages 3-6 inches at the lower altitudes and 20 inches or more in the highest mountain areas. The growing season (based on a minimum temperature of 28°F) averages 170-200 days on the lower valley floors, and less than 100-150 days at higher altitudes.

Table 1 summarizes the quantitative hydrologic character of each valley. At present (1968), successful wells yield ground water solely from the alluvium at depths that generally range from 30 to 300 feet. Ground-water withdrawals are minor (less than 5-10 acre-feet per year) in all but eastern Soda Spring Valley, where they are about 30 acre-feet per year.

The chemical character of water in the report area is highly variable, even within a single valley. Sampled ground water in Columbus and Rhodes Salt Marsh Valleys is characteristically the least suitable for domestic and agricultural use, whereas most water in the other valleys is generally acceptable. In some places, excessive fluoride is or may be a problem for domestic use.

Table 1.--Hydrologic summary

[Estimates in acre-feet per year, except as indicated]

Valley	Valley area (sq mi)	Surface-water runoff from mountains	Potential ground-water recharge from precipitation	Occurrence of subsurface inflow (I) or outflow (O)	Outflow via		Preliminary estimate of perennial yield	Preliminary estimate of transitional storage reserve (total acre-feet)
					Streams	Evapo-trans-piration		
Adobe[1/]	15	500	300	O	500	40	150	800
Alkali								
Northern	18	700	400	--	0	300	300	16,000
Southern	69	3,200	1,400	O	0	0	700	a 960
Columbus Salt Marsh	370	2,000	700	I	0	4,000	4,000	360,000
Garfield Flat	92	800	300	O	0	0	150	a 1,500
Huntoon	140	1,600	800	O	0	300	500	42,000
Mono[1/]	27	1,400	700	O	minor	0	300	a 220
Monte Cristo	284	1,700	500	--	0	400	400	140,000
Queen[1/]	65	4,200	2,000	O	900	0	600	a 960
Rhodes Salt Marsh	199	1,300	500	I	0	1,000	1,000	170,000
Soda Spring								
Eastern	246	1,600	600	IO	0	300	600	64,000
Western	130	400	100	IO	0	30	200	28,000
Teels Marsh	323	3,200	1,300	I?	0	1,400	1,400	130,000

1. Estimates for Nevada part of valley only.

a. Acre-feet per foot of dewatered thickness.

INTRODUCTION

Purpose and Scope of the Study

Ground-water development in Nevada has increased substantially in recent years. Part of this increase is due to the effort to bring new land into cultivation. The growing 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 (Chapter 181, Statutes of 1960) authorizing 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, Division of Water Resources. This is the 52d report prepared as part of the reconnaissance studies (fig. 1 and p. 63).

In the early studies, little information on the surface-water resources was presented. Accordingly, this reconnaissance series was broadened to include a preliminary quantitative evaluation of surface water in the valleys studied.

The objectives of the reconnaissance studies and this report are to (1) describe the hydrologic environment, (2) appraise the source, occurrence, movement, and chemical quality of water in the area, (3) estimate average annual recharge to and discharge from the ground-water reservoirs, (4) evaluate the surface-water resources of the valleys, (5) provide preliminary estimates of perennial yield and transitional storage reserve, and (6) estimate present and evaluate potential water development in the area. The field work for this report was done during May 1968.

Acknowledgments

Many individual well owners throughout the report area provided helpful information. In addition, C. T. Snyder of the U.S. Geological Survey provided valuable data on well and spring locations and ground-water quality. Likewise, Dick Holland and Eddie Mayo of the U.S. Bureau of Land Management contributed important information on wells, springs, and livestock. The help of all these people is certainly appreciated, as is the field assistance provided by Jack L. Cardinalli of the Nevada Department of Conservation and Natural Resources.

HYDROLOGIC ENVIRONMENT

General Setting

The 1,940-square-mile study area lies in the Great Basin of southwestern Nevada (lat 37°50'-38°40' N., long 117°40'-119° W; see fig. 1). Though largely desolate today, the rugged, starkly beautiful area abounds with an intriguing folklore of frontier mining and railroading. The nearly 2,000 square miles encompass 13 hydrographic areas, two of which--southern Alkali and Huntoon Valleys--include small segments in California (see pl. 1). All of the 13 areas are topographically closed, although for three of them--Mono, Adobe, and Queen--the report discusses only the Nevada part. The 13 areas are separated by drainage divides that range from low alluvial mounds, such as that between Soda Spring and Rhodes Salt Marsh Valleys, to lofty mountains, such as those between Teels Marsh Valley and Garfield Flat. (Hereafter, Columbus Salt Marsh Valley, Rhodes Salt Marsh Valley, and Teels Marsh Valley will be referred to as Columbus, Rhodes, and Teels Valleys.) The highest point in the report area, snow-clad Boundary Peak (13,140 feet), is also the highest in all of Nevada. Its crest is almost 10,000 feet above salt-encrusted Rhodes playa, the area's lowest point. Table 2 summarizes the physiographic features of the valleys.

Three major geomorphic units characterize the area: mountain ranges, valley floors, and the intermediate slopes between the mountains and valley floors.

Feth (1964) and Snyder and others (1964) indicate that lakes occupied the floors of all but Adobe and Queen Valleys within the report area during the Pleistocene epoch, more than 7,000 years ago. Many of the lakes were shallow, being confined to the vicinity of present-day playas; such lakes did not develop gravel bars or other prominent lacustrine features. Deeper Pleistocene lakes occupied Alkali, Columbus, and Rhodes Valleys.

At the height of mining activity in the late 1800's, populous towns and mining camps such as Candelaria, Silver Star, Belleville, Marietta, and Sodaville flourished briefly. Today, in contrast, the only sizeable communities within the report area are Mina, at the southern end of Soda Spring Valley, and Luning, $8\frac{1}{2}$ miles to the north. The two towns have populations of about 400 and 80, respectively.

At one time, diminutive steam engines of the narrow-guage Carson and Colorado Railroad struggled up the steep grades to Montgomery pass on the line connecting the legendary Virginia and Truckee with

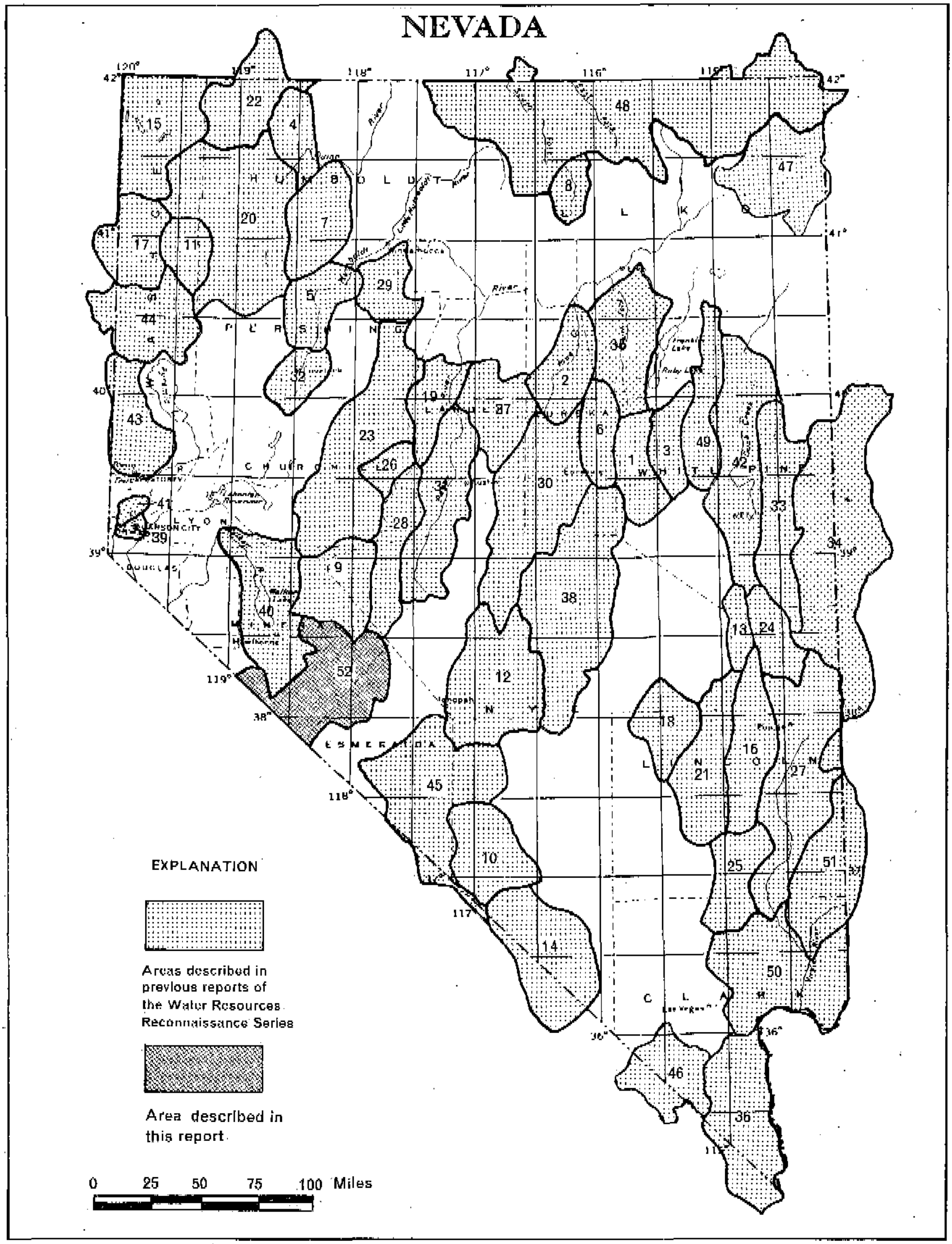


Figure 1.—Areas in Nevada described in previous reports of this series, and the area described in this report.

Table 2.--Physiographic summary of the valleys

Valley (listed alphabetically)	Basin area (sq mi)[1]	Principal alluvial areas (acres)[2]	Altitude (feet)		
			Highest	Lowest	Lowest divide
Adobe[3]	15	a 250	8,509	7,280	7,500
Alkali					
Northern part	18	5,100	9,097	7,030	7,150
Southern part	b 69	12,000	9,545	6,750	6,780
Columbus	370	90,000	10,350	4,505	4,660
Garfield Flat	92	19,000	8,690	5,575	5,800
Huntoon	c 104	15,000	8,460	5,635	5,980
Mono[3]	27	2,800	8,820	7,000	7,100
Monte Cristo	284	90,000	8,900	5,265	5,650
Queen[3]	65	12,000	13,140	5,800	7,150
Rhodes	199	45,000	9,187	4,370	4,590
Soda Spring					
Eastern part	246	54,000	9,187	4,440	4,550
Western part	130	35,000	8,014	4,365	4,525
Teels	323	45,000	8,805	4,905	5,820

1. Based on data from Rush (1968b, table 1).

2. Does not include small, isolated, or nearly isolated areas of alluvium on plate 1, except that of McBride Flat (Adobe Valley).

3. Data are for Nevada part of valley only.

a. McBride Flat.

b. Includes 4 square miles in California.

c. Includes 7 square miles in California.

Owens Valley, by way of Mina. In fact, for many years Mina was a major division point on the line, and boasted extensive railroad facilities that included an engine shed of a dozen stalls. Today, the line is owned by the Southern Pacific; it now extends only as far south as Mina, and has been standard guage since 1905 (Myrick, 1962, p. 166-210).

Geologic Units

Rocks in the report area can be grouped in three gross lithologic units: carbonate rocks, noncarbonate rocks, and alluvium (valley fill). This division is based largely on hydrologic properties, though such properties can vary widely depending on physical and chemical differences. The surficial extent of the units is shown on plate 1, based principally on the geologic map of Esmeralda County by Albers and Stewart (1965), the geologic map of Mineral County by Ross (1961), and interpretation from aerial photographs.

Consolidated rocks form the mountain masses and underlie the alluvium. In the southern part of the report area, carbonate rocks are a small part of the total rocks mapped; however, the proportion of carbonate rocks there may increase with depth. To the north, carbonates form a substantial part of the exposed bedrock. Carbonate rocks commonly contain fractures and solution channels, and locally may be moderately permeable; these rocks therefore are capable of transmitting water through mountain blocks from one valley to another.

The alluvium is Pliocene(?) to Holocene in age. Adjacent to the mountains, it consists largely of stream-deposited gravel and sand that is poorly sorted, unconsolidated to semiconsolidated, and, in places, dissected. Beneath the valley floors, the alluvium characteristically is lake- and stream-deposited sand, silt, and clay that is moderately well sorted, unconsolidated, and undissected.

Most of the economically available ground water in the report area is stored in the alluvium, which constitutes the valley-fill reservoir.

Climate

Airmasses that move into the report area are characteristically deficient in moisture. During the winter, most precipitation falls as snow from storms from the west that have lost most of their moisture while passing over the Sierra Nevada. In summer, thundershowers provide most of the precipitation.

Table 3 and the data of Hardman and Mason (1949, p. 10) show that precipitation at selected stations averages 3 to 6 inches at lower altitudes, and 20 inches or more in the highest mountain areas.

Growing-season temperature data for six stations in and adjacent to the report area are summarized in table 4. Because killing frosts vary with the type of crop, temperatures of 32°, 28°, and 24°F are listed as indicators of growing-season duration. The data suggest that 28°F growing seasons average 170-200 days on the lower-altitude valley floors, and less than 100-150 days at higher altitudes. For any one year, the length of growing season can vary from the average by as much as 40 days.

Table 3.--Average annual precipitation at weather stations in and adjacent to the report area

[From published records of the U.S. Weather Bureau]

Station[1]	Approximate location	Altitude (feet)	Period of reliable, full-year record	Average annual precipitation (inches)[2]
1. White Mtn. no. 2, Calif.	4S/34-20	12,470	1956-67	20.0
2. White Mtn. no. 1, Calif.	5S/35-19	10,150	1956-67	14.3
3. Mt. Grant (storage gage)	8N/28-12	9,000	July 1960-June 1965	12
4. Bodie, Calif.	4N/32-17	8,370	1965-67	19.2
5. Montgomery Maint. Station	1N/33-5	7,100	1960-67	8.2
6. Ione 11 SE (storage gage)	11N/40-4	6,986	1953-65	10
7. Mono Lake, Calif.	2N/26-19	6,520	1951-67	12.8
8. Bridgeport, Calif.	5N/25-33	6,470	1958-67	9.1
9. Bridgeport Dam, Calif.	6N/25-34	6,420	1932-56	10.1
10. Basalt	2N/33-23	6,350	1942-50, 1952-57	5.6
11. Candelaria	4N/35-33	6,180	1890, 1893, 1896-98, 1900, 1903, 1904	5.0
12. Tonopah	3N/42-35	6,090	1907-53	5.0
13. Goldfield	3S/42-2	5,690	1906-49, 1959-63, 1965-67	5.6
14. Smoky Valley	11N/43-29	5,625	1950, 1952-57, 1960-67	6.4
15. Benton Inspection Station, Calif.	1S/32-20	5,461	1965-67	9.5
16. Tonopah Airport	3N/44-31	5,426	1955-67	4.3
17. Dyer 4 SE	4S/36-6	4,975	1954-67	5.1
18. Coaldale	2N/37-8	4,646	1942, 1946, 1949, 1951-54, 1956-58	3.5
19. Mina	6N/35-8	4,552	1907-67	3.8
20. Thorne	9N/30-36	4,200	1919-49	3.3
21. Hawthorne-Babbitt	8N/30-17	4,180	1938-50, 1952-53	4.1

1. In Nevada, except as noted; see fig. 2. Stations are listed in descending order of altitude.
2. Averages are for period of record only. Long-term averages for several of the key stations are estimated as follows (station number in parentheses): (1) 17 in.; (2) 12 in.; (3) 9 in.; (4) 13 in.; (5) 6½ in.; (6) 9 in.; (7) 12 in.; (8) 7½ in.; and (15) 6 in.

Table 4.--Growing-season temperature data at weather stations in and adjacent to the report area

[From published records of the U.S. Weather Bureau]

Station[1]	Altitude (feet)	Period of record	Average number of consecutive days during which minimum temperature exceeds: 32°F	28°F	24°F
5. Montgomery Maint. Station	7,100	1960, 1963, 1965-67	77	100	146
8. Bridgeport, Calif.	6,470	1958-67	35	68	98
10. Basalt	6,350	1948-55, 1957	127	150	171
16. Tonopah Airport	5,426	1955-67	149	176	199
18. Coaldale	4,646	1949-53, 1957	162	186	215
19. Mina	4,552	1948-57, 1959-63, 1966-67	157	188	209

1. In Nevada, except as noted. For locations, see table 3. Station numbers correspond to those in table 3.

VALLEY-FILL RESERVOIRS

Extent and Boundaries

Alluvium (pl. 1) forms the valley-fill reservoirs, which are the principal source of ground water in the area. Few deep wells have been drilled as yet, so little is known about the thickness of the valley fill. The deepest wells that have, or are thought to have, penetrated alluvium at least 100 feet below the nearby playa surfaces are as follows (no near-playa well is known to have encountered bedrock):

Valley	Deepest well (well number)	Well depth (feet)	Net depth below playa surface (feet, rounded)
Columbus	3/36-24ccc	296	280
Garfield	6/33-20bdc	558	510
Monte Cristo	6/37-21d	300	250
Rhodes	5/35-26bcc	650	600
Soda Spring (eastern part)	6/35-8caa	600	600
Teels	4/33-17db	695	690

The reservoirs beneath most of the valley floors probably are at least 500 feet thick, and at the center of Columbus, Rhodes, and Teels Valleys they probably are several times that thick. Although bedrock reportedly has been encountered in wells at shallower depths, these wells are near the bedrock-alluvium contact, where the valley-fill reservoir is generally thin.

External hydraulic boundaries are formed by the consolidated rocks (pl. 1), which underlie and surround the valley-fill reservoir. These boundaries are leaky to varying degrees. Carbonate rocks, where they occur, may contribute moderate amounts of recharge from the mountains to the valley-fill reservoir by subsurface inflow.

The principal internal hydraulic boundaries are lithologic changes and faults that may cut the valley fill. The extent to which these lithologic and structural barriers impede ground-water flow probably will not be determined until substantial ground-water development occurs.

Regional Ground-Water Flow

Ground water, like surface water, moves from areas of higher head (water-level altitude) 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 the permeability of the deposits and the hydraulic gradient. Ground-water levels in and adjacent to the area are shown in figure 2. The small inset map on plate 1 shows diagrammatically the known or suspected directions of regional ground-water flow. Three "sinks," or terminal discharge areas, have been identified: (1) A system that probably terminates in western Soda Spring Valley or in Walker Lake Valley; it receives inflow through alluvium from eastern Soda Spring Valley. (2) A system that terminates in Rhodes Valley; it receives inflow through alluvium from eastern Soda Spring Valley and through consolidated rocks from Garfield Flat. (3) A system that terminates in Columbus Valley; it receives inflow through alluvium and probably through consolidated rocks from Fish Lake Valley and possibly through consolidated rocks from Big Smoky Valley.

Along the Nevada-California line, (1) the main part of Mono Valley in California receives ground-water inflow through alluvium and consolidated rocks from an arm of the valley in Nevada, and probably from southern Alkali Valley; (2) the main part of Adobe Valley in California receives inflow from the small part of its valley in Nevada; and (3) Benton Valley in California receives inflow, probably through alluvium, from Queen Valley in Nevada.

Monte Cristo, Teels, Huntoon, and northern Alkali Valleys may not be involved in intervalley flow, although the imbalances in water budgets (table 8) suggest that such flow may occur. Quantitative estimates of intervalley flow are made in the section, "Subsurface inflow."

INFLOW TO THE VALLEY-FILL RESERVOIR

Runoff

by D. O. Moore

Runoff in the report area originates at the higher altitudes during periods of snowmelt and intense thundershowers. This surface water flows to areas of generally less than 7,000 feet altitude, and most of it is lost by infiltration and evapotranspiration. Occasionally, part of the runoff reaches the playas, where it evaporates. Because precipitation in the report area is characteristically seasonal and only light to moderate, perennial streams are few, and most of them are in the mountains in the higher and wetter southwestern part of the area.

No records of daily streamflow have been obtained in the report area. Annual peak discharges have been measured from 1961 to date (1968) on an ephemeral tributary to Rhodes Valley by use of a crest-stage gage. This gage is in sec. 22, T. 4 N., R. 34 E., at a culvert on State Highway 10, 7 miles west of Candelaria. The drainage area above the gage is approximately 2 square miles. The only recorded flow at this site occurred Aug. 15, 1965, when the peak discharge was 900 cfs (cubic feet per second). For another ephemeral tributary to Rhodes Valley in NW$\frac{1}{4}$ sec. 15, T. 4 N., R. 34 E., about a mile southwest of Belleville, a peak discharge on Aug. 15, 1965, of about 6,000 cfs was estimated. The drainage area above this site is approximately 32 square miles.

In Queen Valley, streamflow has been measured occasionally on Morris Creek in the mouth of the canyon in sec. 11, T. 1 S., R. 32 E., about 6 miles northeast of Benton, Calif. The results are as follows:

Date	Discharge (cfs)	Date	Discharge (cfs)	Date	Discharge (cfs)
7-22-65	1.66	9-13-65	2.09	5-12-66	1.57
8-10-65	2.31	10-16-65	1.94	7-12-66	1.13

The amount of runoff from the mountains that reaches the valley fill in the report area cannot be computed directly because of the absence of streamflow data. Therefore, runoff is estimated using methods devised by Moore (1968), which employ runoff-altitude relations and stream-channel geometry. The mean annual runoff to the edge of the valley fill from surrounding mountains is summarized

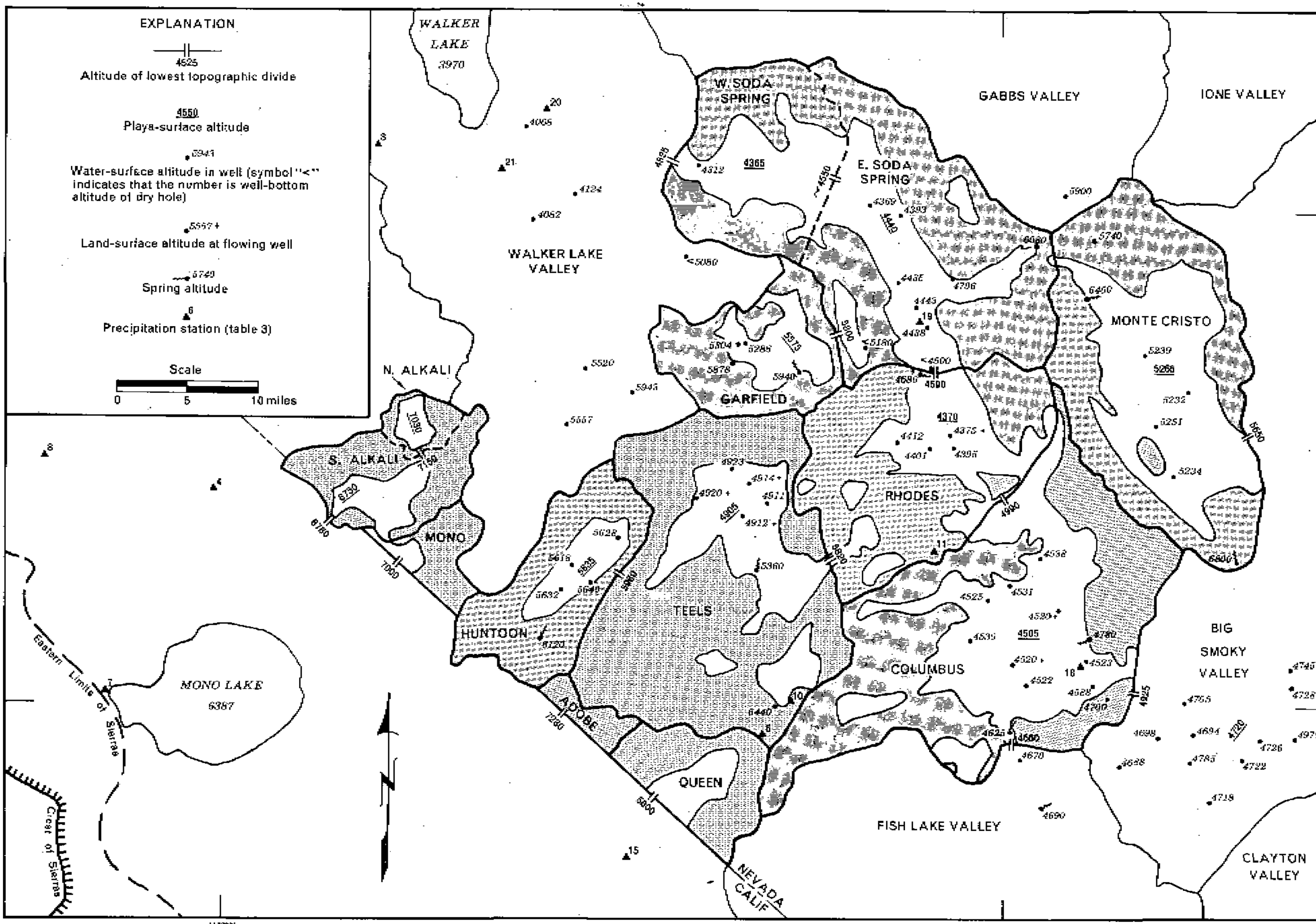


Figure 2.—Altitude of playas, lowest topographic divides, and ground-water surfaces; precipitation stations; and areas of bedrock (patterned) and alluvium (unpatterned)

in table 5. Only about 48 percent of the total report area--most of it above 7,000 feet--is assumed to contribute tangibly to runoff.

Occasional runoff locally may occur on the alluvial fans and lowlands in response to thunderstorms and snowmelt, but this type of runoff generally is so erratic in frequency and duration that it is of little value to economic development. The only developed supplies are those at or near the mountain fronts.

The only present-day streamflow between basins occurs intermittently in the channel connecting Fish Lake and Columbus Valleys, 7 miles southwest of Coaldale Junction. There, the flow, which is north into Columbus Valley, may average about 70 acre-feet per year, on the basis of channel geometry. The discharge is highly variable from year to year (in many years there probably is none), and it presumably results from northward flow out of shallow Fish Lake during extremely wet periods.

Imported Water

A 27-mile pipeline was constructed in 1882 to supply the mining boomtown of Candelaria (pl. 1). The pipeline intake is in Trail Canyon, a tributary to Fish Lake Valley. In 1968, the usable segment of pipe extended only to the Basalt area, the remainder having disintegrated in the 1940's.

The pipeline now serves several stock tanks, a few residents, and a small park for tourists at Basalt, plus the open-pit diatomite-mining operations of the Dicalite Division of Grefco, Inc., 2½ miles east of Basalt. At the mining camp, the water is used domestically by about a dozen permanent residents. Industrial use there is restricted mostly to sprinkling of dirt roads for dust suppression.

In May 1968, the pipeline flow, measured at a concrete box in Pinchot Canyon (1/33-22d), was about 25 gpm (gallons per minute). Presumably, little of this supply infiltrates to the ground-water reservoir in either Columbus or Teels Valleys, and therefore it is not considered a significant element in the ground-water budget (table 8).

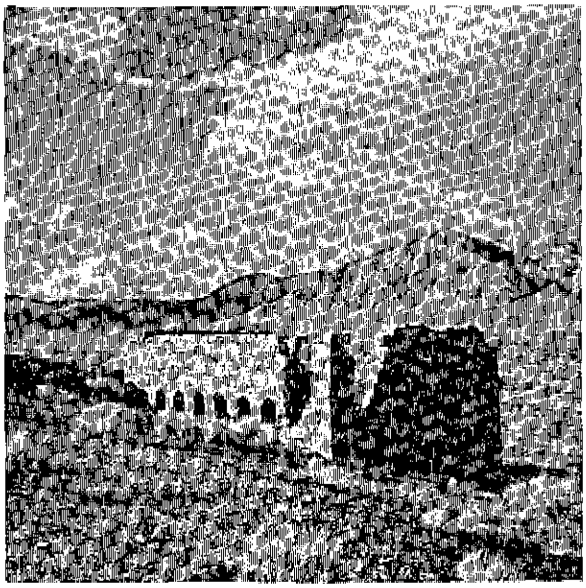
Ground-Water Recharge

On the valley floor, where precipitation quantities are small, direct infiltration to the ground-water reservoir on the average is minimal. Most of the recharge is provided instead by greater precipitation in the adjacent mountains, with the water reaching the ground-water reservoir by seepage loss from streams on the alluvial apron and by underflow from the consolidated rocks. Even in the mountains, however, most of the precipitation is evaporated

Table 5.--Estimates of average annual runoff reaching the valley fill

Valley	Area contributing runoff (acres)	Estimated runoff (acre-feet per year)
Adobe[1]	7,410	500
Alkali		
Northern part	11,200	700
Southern part	43,300	3,200
Columbus	63,400	2,000
Garfield Flat	39,400	800
Huntoon	53,600	1,600
Mono[1]	18,400	1,400
Monte Cristo	76,600	1,700
Queen[1]	39,600	4,200
Rhodes	38,300	1,300
Soda Spring		
Eastern part	63,000	1,600
Western part	22,400	400
Teels	126,000	3,200

1. Data are for Nevada part of valley only.



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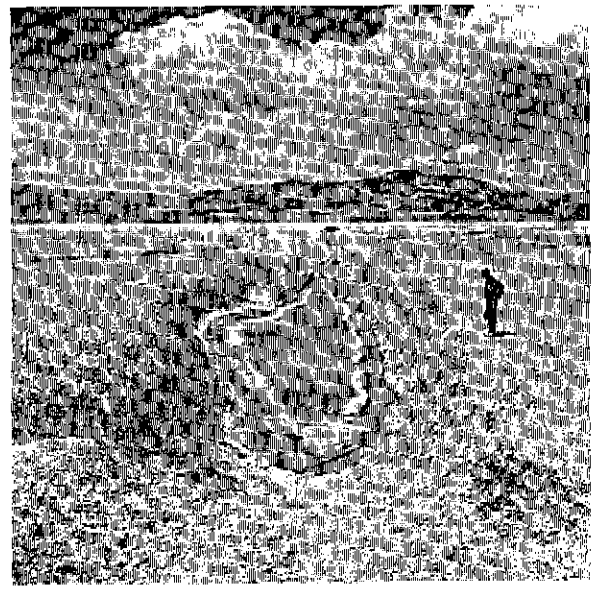

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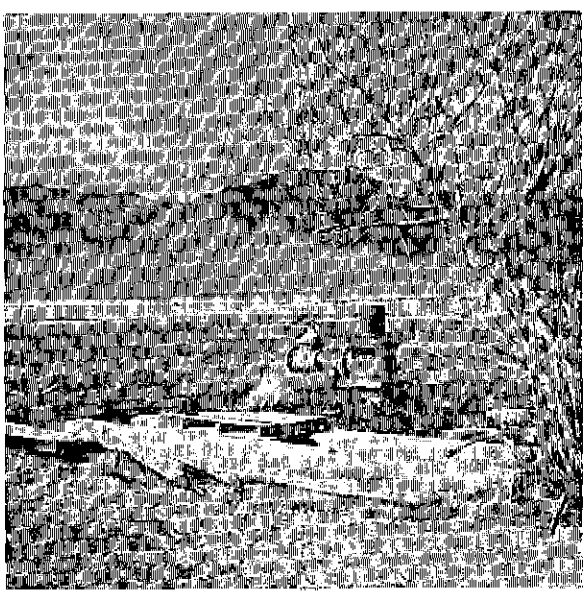
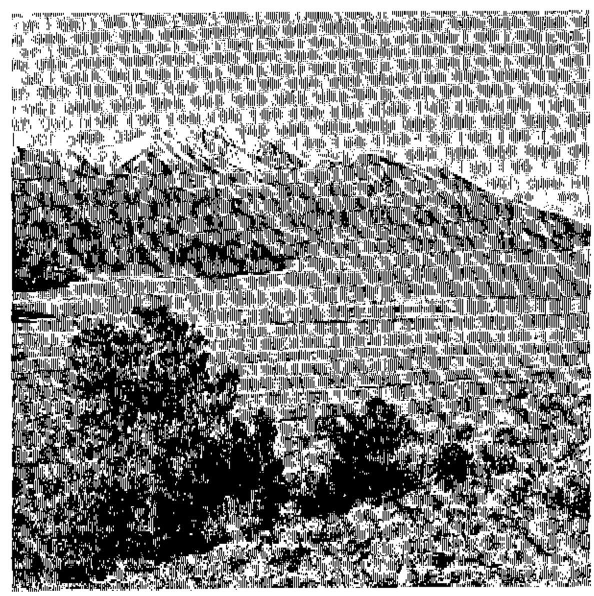


C



D

Photographs 3A-D.--A. Abandoned ore mill near Sodaville. B. Trench on eastern margin of Columbus Valley playa (3/36-24ccc); amber brine at depth of about 8 feet. C. Flowing well 5/35-22aca, on southern margin of Rhodes Valley playa; Pilot Mtns. in background. D. Queen Valley, in the shadow of 13,000-foot Boundary and Montgomery Peaks; Queen Valley Ranch in middleground.

before infiltration, and some of the rest adds to soil moisture. Thus only a very small percentage actually finds its way to the reservoir.

The general method described by Eakin and others (1951, p. 79-81) is used in this report to estimate the potential recharge. The method assumes that for any given altitude zone, a particular percentage of total precipitation potentially recharges the ground-water reservoir, with that percentage depending on the average amount of snow and rainfall within the zone.

Table 6 shows the estimates of precipitation and recharge for the report area. Estimates of long-term average precipitation at several high-altitude weather stations adjacent to the present report area (table 3, footnote 2) suggest that precipitation above 7,000 feet may be less than that estimated recently by Everett and Rush (1967, table 4) and by Rush (1968a, table 5) for the adjacent Walker Lake and Clayton Valley areas. Nonetheless, their altitude-precipitation zones and recharge percentages are used in the present report because the few high-altitude precipitation data in table 3 are not conclusive, and because available information is not as yet adequate to permit reevaluation of the recharge percentages

Recharge quantities listed in table 6 range from as much as 5 percent of total precipitation to less than 1 percent. The lower percentages are for basins such as Columbus Valley, in which only a small proportion of the total area is above 7,000 feet (arbitrarily considered the lower altitude limit for effective recharge by precipitation in the report area).

Subsurface Inflow

Subsurface inflow to the valley-fill reservoirs is of two types: (1) inflow from an adjacent valley through alluvium or consolidated rocks, as previously described; and (2) inflow from the surrounding consolidated rocks within a valley watershed, which originates in the mountains as infiltrated precipitation and runoff. This second type of inflow is included in the estimates of recharge in table 6; it is assumed to be a moderately small part of the total recharge in each valley.

Ground-water inflow to a valley through alluvium can be computed by means of a form of Darcy's law:

$$Q = 0.00112\,TIW$$

in which $\underline{Q}$ is the quantity of flow, in acre-feet per year; $\underline{T}$ is the transmissivity, in gallons per day per foot; $\underline{I}$ is the hydraulic

Table 6.--Estimates of average annual precipitation and ground-water recharge

Altitude zone (feet)	Area (acres)1/	Estimated annual precipitation: Range (inches)	Average: Feet	Average: Acre-feet	Estimated recharge from precipitation: Percentage recharged	Acre-feet per year
ADOBE VALLEY2/						
8,000-8,509	1,510	>12	1.1	1,700	7	120
7,280-8,000	5,900	8-12	.8	4,700	3	140
Total (rounded)	7,410	--	--	6,400	--	a 300
ALKALI VALLEY, NORTHERN PART						
9,000-9,097	minor	>15	1.5	minor	15	minor
8,000-9,000	1,720	12-15	1.1	1,900	7	130
7,030-8,000	9,520	8-12	.8	7,600	3	230
Total (rounded)	11,200	--	--	9,500	--	400
ALKALI VALLEY, SOUTHERN PART						
9,000-9,545	360	>15	1.5	540	15	80
8,000-9,000	9,050	12-15	1.1	10,000	7	700
7,000-8,000	24,500	8-12	.8	20,000	3	600
6,750-7,000	9,360	<8	.6	5,600	minor	--
Total (rounded)	43,300	--	--	36,000	--	1,400
COLUMBUS VALLEY						
10,000-10,350	minor	>20		minor	25	minor
9,000-10,000	930	15-20	1.5	1,400	15	210
8,000-9,000	3,000	12-15	1.1	3,300	7	230
7,000-8,000	10,700	8-12	.8	8,600	3	260
4,510-7,000	227,000	<8	.4	91,000	minor	--
Total (rounded)	242,000	--	--	100,000	--	700
GARFIELD FLAT						
8,000-8,690	620	>12	1.1	680	7	50
7,000-8,000	10,900	8-12	.8	8,700	3	260
5,575-7,000	49,900	<8	.5	25,000	minor	--
Total (rounded)	61,400	--	--	34,000	--	300

Table 6.--Continued

Altitude zone (feet)	Area (acres)[1/]	Estimated annual precipitation: Range (inches)	Average: Feet	Average: Acre-feet	Estimated recharge from precipitation: Percentage recharged	Acre-feet per year
			HUNTOON VALLEY			
8,000-8,460	2,030	>12	1.1	2,200	7	150
7,000-8,000	24,500	8-12	.8	20,000	3	600
5,640-7,000	42,100	<8	.5	21,000	minor	--
Total (rounded)	68,600	--	--	43,000	--	800
			MONO VALLEY[2/]			
8,000-8,820	4,520	>12	1.1	5,000	7	350
7,000-8,000	13,900	8-12	.8	11,000	3	330
Total (rounded)	18,400	--	--	16,000	--	700
			MONTE CRISTO VALLEY			
8,000-8,900	2,940	>12	1.1	3,200	7	220
7,000-8,000	11,200	8-12	.8	9,000	3	270
5,280-7,000	164,000	<8	.5	82,000	minor	--
Total (rounded)	178,000	--	--	94,000	--	500
			QUEEN VALLEY[2/]			
13,000-13,140	minor					
12,000-13,000	130					
11,000-12,000	250	>20	1.8	3,100	25	620
10,000-11,000	1,320					
9,000-10,000	2,640	15-20	1.5	4,000	15	600
8,000-9,000	5,420	12-15	1.1	6,000	7	420
7,000-8,000	14,700	8-12	.8	12,000	3	360
6,000-7,000	15,000					
5,800-6,000	930	<8	.6	9,500	minor	--
Total (rounded)	40,400	--	--	35,000	--	2,000
			RHODES VALLEY			
9,000-9,187	minor	>15	--	minor	15	minor
8,000-9,000	3,020	12-15	1.1	3,300	7	230
7,000-8,000	10,400	8-12	.8	8,300	3	250
4,370-7,000	117,000	<8	.4	47,000	minor	--
Total (rounded)	130,000	--	--	59,000	--	500

Table 6.--Continued

Altitude zone (feet)	Area (acres)[1]	Estimated annual precipitation: Range (inches)	Average: Feet	Average: Acre-feet	Estimated recharge from precipitation: Percentage recharged	Acre-feet per year
		SODA SPRING VALLEY, EASTERN PART				
9,000-9,187	minor	>15	1.5	minor	15	minor
8,000-9,000	2,280	12-15	1.1	2,500	7	180
7,000-8,000	17,700	8-12	.8	14,000	3	420
4,440-7,000	140,000	<8	.4	56,000	minor	--
Total (rounded)	160,000	--	--	72,000	--	600
		SODA SPRING VALLEY, WESTERN PART				
8,000-8,014	minor	>8	0.8	3,100	3	90
7,000-8,000	3,900					
4,365-7,000	81,000	<8	.4	32,000	minor	--
Total (rounded)	84,900	--	--	35,000	--	100
		TEELS VALLEY				
8,000-8,805	3,980	>12	1.1	4,400	7	310
7,000-8,000	42,400	8-12	.8	34,000	3	1,000
4,905-7,000	155,000	<8	.5	78,000	minor	--
Total (rounded)	201,000	--	--	120,000	--	1,300

1. Areas are based on planimeter data using U.S. Geological Survey 1:250,000-scale topographic maps. They do not agree exactly with those listed in table 2, which were obtained from a less accurate 1:500,000-scale map.

2. Data are for Nevada part of valley only.

a. Total includes about 40 acre-feet tributary to McBride flat, a 2.4-square-mile closed basin (pl. 1).

gradient in feet per mile, W is the width of the flow section, in miles; and the factor 0.00112 converts gallons per day to acre-feet per year. Computations of this type for valleys of the report area are given in table 7.

Inflow to several of the valleys is the result of ground-water outflow from an adjacent valley. In Garfield Flat, for example, minimum depths to water in the valley fill exceed 50 feet, with the result that no natural discharge by evapotranspiration from ground water occurs within the watershed. This means that all recharge to the valley fill (an estimated 300 acre-feet per year) must be dissipated by subsurface outflow to adjacent valleys, through consolidated rocks. The ground-water gradient indicated by wells 6/33-20acd and 20bdc, and the hydrogeographic position of prolific Soda Springs (6/35-29; see pl. 1), suggest that the outflow is in an easterly direction. The springs, which straddle the topographic divide between Rhodes and eastern Soda Spring Valleys, presumably represent the surface and near-surface emergence of much of the leakage from Garfield Flat. For lack of positive information, Rhodes and eastern Soda Spring Valleys are assumed to receive 100 and 200 acre-feet per year, respectively, from Garfield Flat.

Because the quantities of inflow to Columbus Valley from Fish Lake and Big Smoky Valleys, and to Teels or Walker Lake Valleys from Huntoon, cannot be computed directly, they have been estimated by difference in the section entitled "Ground-water budgets." The two quantities are about 3,000 and 300-400 acre-feet per year, respectively.

Table 7.--Estimated ground-water inflow to valleys of the report area through alluvium

Inflow to	From	Location of flow section	Assumed transmissivity (gpd/foot) (T)	Estimated hydraulic gradient (feet per mile) (I)	Approximate width of section (miles) (W)	Estimated subsurface flow (ac-ft/yr) (Q)
Western Soda Spring Valley	Eastern Soda Spring Valley	At surface divide	50,000	6	1	300
Rhodes Valley	Eastern Soda Spring Valley	At surface divide	50,000	6	0.8	300
Columbus Valley	Fish Lake Valley	At Gap (pl. 1)	25,000	25	0.3	200

OUTFLOW FROM THE VALLEY-FILL RESERVOIR

Surface-Water Outflow

Surface water leaves the study area by way of intermittent streams in Adobe and Queen Valleys (pl. 1). The annual quantities may average about 500 and 900 acre-feet, respectively (on the basis of stream-channel geometry).

Streamflow into Calfornia from the Nevada part of Mono Valley is considered negligible, also on the basis of stream-channel examination.

Surface flow out of southern Alkali Valley by way of Trench Canyon probably has been minimal or nonexistent during historical time. The outlet is 30-40 feet above the small playa where local runoff collects. More than 10,000 years ago the basin was filled to a maximum depth of about 250 feet by an arm of Pleistocene Lake Russell (of which Mono Lake is the present-day remnant).

Ground-Water Outflow

Evapotranspiration

In areas of shallow ground water, discharge occurs by evaporation from soil and by transpiration from plants whose roots tap the ground water. These plants are called phreatophytes, and their distribution is shown on plate 1. The principal phreatophytes are greasewood, rabbitbrush, and saltgrass. Ground-water levels are shallow enough beneath four playas within the report area--Columbus, Rhodes, Teels, and northern Alkali--to permit natural discharge by evaporation of soil moisture fed by ground water. Table 8 summarizes the estimated transpiration and evaporation of ground water from the phreatophytic and playa areas. The rates used are based on the work done in other areas by Lee (1912), White (1932), Young and Blaney (1942), and Robinson (1965).

Pumpage from Wells

Ground water is pumped from wells for public-supply, domestic, and stockwatering use. (See table 14 at end of report.) Wells are used in both Mina and Luning as a source of public supply. At Mina, newly completed well 6/35-7ddc is now (1968) the principal source of water to supplement the flow of Martin Springs (6/35-23aaa) during April-October, and wells 7/35-27cbc and -27cda are on standby. Pumpage in 1968 was about 20 acre-feet, on the basis of data supplied by R. W. Going, City Water Supt. At Luning, well 7/34-3abb provides the sole municipal supply, with a pumpage in 1968 of about 10 acre-feet, on the basis of an estimated population of about 80, and an

Table 8.--Estimates of average annual ground-water evapotranspiration[1]

Type of water loss	Area (acres)	Depth to water (feet)	Evapotranspiration Feet per year	Evapotranspiration Acre-feet per year
ADOBE VALLEY (McBRIDE FLAT)				
Possibly playa, saltgrass, and rabbitbrush	200-300	--	--	(a)
ALKALI VALLEY, NORTHERN PART				
Playa, saltgrass, rabbitbrush	350	5-10	0.5	180
Saltgrass, rabbitbrush	70	0-50	.4	30
Scattered saltgrass, rabbitbrush	630	10-50	.2	130
Total (rounded)	1,000	--	--	300
COLUMBUS VALLEY				
Playa	18,000	1-10	0.1	1,900
Meadowgrass, some tules[2]	15	0-5	1	15
Saltgrass[2]	65	5-15	.5	30
Scattered greasewood, some weak saltgrass, plus bare soil	7,000	<10	.2	1,400
Scattered greasewood	7,000	10-50	.1	700
Total (rounded)	32,900	--	--	4,000
HUNTOON VALLEY				
Greasewood, rabbitbrush	1,100	15-50	0.2	220
Scattered greasewood, some rabbitbrush	700	15-50	.1	70
Total (rounded)	1,800	--	--	300
MONTE CRISTO VALLEY				
Greasewood, rabbitbrush	3,700	30-50	0.1	370
Total (rounded)	3,700	--	--	400

(continued)

Table 8.--Estimates of evapotranspiration (continued)

Type of water loss	Area (acres)	Depth to water (feet)	Evapotranspiration: Feet per year	Evapotranspiration: Acre-feet per year
RHODES VALLEY				
Playa	1,600	1-5	0.1	160
Tules, meadowgrass2/	15	0-5	1	15
Saltgrass2/	20	5-15	.5	10
Scattered saltgrass, greasewood, rabbitbrush	600	5-15	.3	270
Scattered saltgrass, greasewood	1,200	5-50	.2	240
Scattered greasewood	2,600	5-50	.1	260
Total (rounded)	6,300	--	--	1,000
SODA SPRING VALLEY, EASTERN PART				
Tules, meadowgrass2/	15	0-5	1	15
Saltgrass2/	30	5-15	.5	15
Scattered greasewood	2,500	30-50	.1	250
Total (rounded)	2,500	--	--	300
SODA SPRING VALLEY, WESTERN PART				
Scattered greasewood	280	30-50	0.1	30
TEELS VALLEY				
Playa	3,500	0-5	0.2	700
Saltgrass, greasewood, scattered rabbitbrush	120	5-10	.4	50
Greasewood, scattered rabbitbrush	1,400	5-40	.2	280
Scattered greasewood; some saltgrass near playa	4,600	10-50	.1	460
Total (rounded)	9,600	--	--	1,400

1. Most playa and phreatophyte areas are shown on plate 1. Evapotranspiration associated with minor springs is not included.

2. Phreatophytes associated with Gap Springs (Columbus Valley, 1/36-5a and 2/32-32d) and Soda Springs (Rhodes and eastern Soda Spring Valleys, 6/35-29d). Southern (warmer) Soda Spring group is topographically tributary to Rhodes Valley, whereas northern (cooler) group is tributary to eastern Soda Spring Valley. Phreatophyte areas are too small to show on plate 1.

a. Area inaccessible at time of study; evapotranspiration, estimated from aerial photographs, may be about 40 acre-feet per year.

estimated use rate of about 100 gpd (gallons per day) per person. /Harrill and Worts (1969, p. 18) have estimated an annual pumpage of 24 acre-feet, using a higher per-capita use rate./

Domestic and tourist use of well water at Coaldale Junction and Montgomery Pass Lodge may total about 6 and 2 acre-feet per year, respectively. Elsewhere in the report area, domestic use, by a scattered population that probably totaled less than 20 in 1968, was less than 5 acre-feet.

In 1968, livestock consumed an acre-foot or less of well water in every valley except Monte Cristo, where the use may have been as much as 2-5 acre-feet (these estimates are based on grazing-permit data from the U.S. Bureau of Land Management).

Springs

In the mountains, small springs issue from consolidated rocks. In most valleys their combined discharge is minor; they support small areas of willow, rabbitbrush, and wildrose. Much of their flow seeps back into the ground and reenters the ground-water system. Table 16 (at end of report) presents data on springs. The discharge of major springs is consumed largely by evapotranspiration losses, estimates of which are included in table 8.

One of the largest and best-known spring systems in the report area is at Sodaville, 3½ miles south of Mina. There, a pair of spring clusters, 6/35-29caa and 29dcc, yielded a measured flow of 75 gpm (120 acre-feet per year) in May 1968. At present (1968), the discharge is unused, and is either dissipated by phreatophytes or returned to the ground-water reservoir. In the past, however, the springs played an important role in the area's economic development. The readily available water supply prompted construction of an ore smelter in the 1880's, and "the two springs of curative waters . . . from which the town /Soda Springs, later renamed Sodaville/ derived its name drew a lively business for the hotel and bathhouses of Martin Brazzanovich." (Myrick, 1962, p. 175.)

Martin Spring (6/35-23aaa; also known as Peppermint Spring), in a rugged canyon 3½ miles northeast of Sodaville, presently yields about 40 gpm (60 acre-feet per year), most of which is used by the people of Mina and the two residents of Sodaville. According to John Sinkey of Sodaville (oral commun., 1968), the flow originally was almost twice the present-day quantity. Martin Spring played an indirect role in the founding of Mina and the demise of Sodaville. In the early 1900's, the Southern Pacific Railroad planned to expand its facilities at Sodaville, but was unable to obtain water rights to Martin Spring at anything less than an exorbitant price. As a result, the company looked to the north and discovered an abundant supply, which they named Southern Pacific Spring (7/35-34add). Railroad facilities were installed $3\frac{1}{2}$ miles southwest of the spring, and the town of Mina was born (Myrick, 1962, p. 203).

Subsurface Outflow

The amounts of ground-water outflow through alluvium and consolidated rocks are listed for several valleys in the section entitled "Subsurface inflow." As indicated in that section, outflow occurs from Garfield Flat to Rhodes and eastern Soda Spring Valleys, from eastern Soda Spring Valley to Rhodes and western Soda Spring Valleys, and perhaps from Huntoon Valley to Teels Valley. In addition, ground water leaves the report area from several other valleys. In southern Alkali and Queen Valleys, as well as the segments of Mono and Adobe Valleys (not including McBride Flat) in Nevada, the absence of phreatophytes means that all recharge or potential recharge must be dissipated by outflow to California. In southern Alkali and Mono Valleys, all the outflow (about 1,400 and 700 acre-feet per year, respectively) leaves by way of consolidated rocks and (or) alluvium. In Adobe and Queen Valleys, some of the recharge leaves in this manner, whereas the remainder departs as streamflow that reaches the ground-water reservoir farther downstream. Ground water also may leave the report area from western Soda Spring and Huntoon Valleys, as suggested by imbalances in their water budgets (table 9). For both valleys, the outflow (perhaps about 300-400 and 300 acre-feet per year, respectively; see p. 30-31) would be toward Walker Lake.

GROUND-WATER BUDGETS

For long-term natural conditions, ground-water inflow to and outflow from an area are about equal, assuming that climatic conditions remain reasonably constant. Thus, a ground-water budget can be used (1) to compare the estimates of natural inflow to and outflow from each valley, (2) to determine the magnitude of errors in the two estimates, provided that one or more elements are not calculated by difference, and (3) to select a value that best seems to represent both inflow and outflow, within the limits of reconnaissance accuracy. This value in turn is utilized in a following section of the report to estimate the perennial yield of each area.

Table 9 presents ground-water budgets for each valley, and shows the reconnaissance value selected to represent both inflow and outflow under natural or near-natural conditions. Where direct estimates of recharge and discharge have been made, imbalances for northern Alkali, Monte Cristo, Rhodes, eastern Soda Spring, and Teels Valleys are small and probably within the limits of error of the data and methods used. In contrast, the imbalances for Columbus, Huntoon, and western Soda Spring Valleys seem too large to be ascribed entirely to computational uncertainties. These large imbalances therefore suggest substantial intervalley flow.

Columbus Valley, where estimated discharge far exceeds recharge, may receive subsurface inflow from Fish Lake Valley through consolidated rocks as well as alluvium, and possibly from Big Smoky Valley. Eakin (1950, p. 22-23) estimated that recharge in Fish Lake Valley was considerably in excess of the natural discharge. Some of the surplus water could be moving through the faulted volcanic and sedimentary rocks in the Gap area (Albers and Stewart, 1965) to Columbus Valley. In Big Smoky Valley, Rush (1968a, p. 26) has indicated that recharge exceeds discharge, and has concluded that most of the excess moves to Clayton Valley. However, some could move to Columbus Valley through faulted rocks of the Esmeralda Formation (Albers and Stewart, 1965), or underlying bedrock. The imbalance in table 9 suggests that the total subsurface inflow through consolidated rocks is roughly 3,000 acre-feet per year.

The imbalance in Huntoon Valley, where estimated recharge is more than twice the estimated evapotranspiration discharge, may be accounted for by subsurface outflow through consolidated rocks to Teels Valley or possibly to Walker Lake Valley, where water levels are lower (fig. 2). The largely granitic consolidated rocks north of the Huntoon Valley floor (Ross, 1961, pl. 2) seem inhospitable to ground-water movement of significant magnitude. The predominantly volcanic rocks to the northeast, as well as the prescence of faulting, seem more conducive to interbasin flow, but the hydrologic budget for Teels Valley (table 9) gives little hint of an imbalance favorable to ground-water movement in that direction. Regardless of destination, the estimates in table 9 suggest that the outflow from Huntoon Valley is 300 acre-feet or more per year.

For western Soda Spring Valley, where the estimated recharge plus ground-water inflow is more than 10 times the estimated evapotranspiration discharge, the imbalance may be accounted for by subsurface outflow through alluvium and volcanic rocks to Walker Lake Valley, where water levels are lower (fig. 2). The imbalance in table 9 suggests that the outflow is 300-400 acre-feet per year.

Table 9.--Preliminary ground-water budgets--continued

Budget elements	Valleys						
	Mono 1/	Monte Cristo	Queen 1/	Rhodes	Eastern Soda Spring	Western Soda Spring	Teels
INFLOW							
Ground-water recharge from precipitation (table 6)	700	500	2,000	500	600	100	1,300
Subsurface inflow (p.19 -23)	0	0	0	400	200	b 300	--
TOTAL (rounded)	700	500	2,000	900	800	400	1,300
OUTFLOW							
Evapotranspiration (table 8)	0	400	0	1,000	300	30	1,400
Subsurface outflow (p.29)	700	--	(d)	0	b 600	--	0
TOTAL	700	400	2,000	1,000	900	30	1,400
IMBALANCE BETWEEN INFLOW AND OUTFLOW	(e)	100	(e)	100	100	370	100
VALUE SELECTED TO REPRESENT INFLOW AND OUTFLOW	700	400	2,000	1,000	800	300	1,400

1. Budget is for Nevada part of valley only.

a. Recharge from 70 acre-feet of average annual stream inflow from Fish Lake Valley is assumed to average less than 50 acre-feet per year.

b. Computed inflow or outflow through alluvium (table 7).

c. Computed as difference between total inflow and evapotranspiration.

d. Quantity of subsurface outflow is uncertain, because an unknown increment of the potential recharge leaves the report area as streamflow, and reaches the ground-water reservoir farther downstream. In Adobe Valley, subsurface outflow presumably is not greater than about 260 acre-feet per year (arithmetic difference between total inflow and evapotranspiration). In Queen Valley, subsurface outflow apparently is at least 1,100 acre-feet per year, because estimated recharge is about 2,000 acre-feet per year whereas stream outflow is only 900 acre-feet per year.

e. Imbalance is zero because one of the elements is estimated by difference.

Table 9.--Preliminary ground-water budgets for natural or near-natural conditions

[All estimates are in acre-feet per year]

Budget elements	Valleys					
	Adobe[1/]	Northern Alkali	Southern Alkali	Columbus	Garfield Flat	Huntoon
INFLOW						
Ground-water recharge from precipitation (table 6)	300	400	1,400	a 700	300	800
Subsurface inflow (p. 19 -23)	--	0	--	b 200	0	0
TOTAL	300	400	1,400	900	300	800
OUTFLOW						
Evapotranspiration (table 8)	40	300	0	4,000	0	300
Subsurface outflow (p. 29)	(d)	--	c 1,400	0	300	--
TOTAL	300	300	1,400	4,000	300	300
IMBALANCE BETWEEN INFLOW AND OUTFLOW	(e)	100	(e)	3,100	(e)	500
VALUE SELECTED TO REPRESENT INFLOW AND OUTFLOW	300	300	1,400	4,000	300	600

(Continued)

CHEMICAL QUALITY OF THE WATER

General Chemical Character

Table 10 lists analyses of water from the report area. The specific conductances in table 10 can be used as a preliminary indication of chemical character, because the concentration of dissolved solids in a water, in milligrams per liter, is generally 55 to 70 percent of the specific conductance (in micromhos per centimeter at 25°C; hereafter abbreviated "micromhos"). Milligrams per liter are equivalent to parts per million in most waters; see footnote 1, table 10.

The data in table 10 show that water in the report area is highly variable chemically, even within a single valley. Characteristically, the more dilute waters occur in basins from which outflow occurs. Even in many closed basins, however, dilute water can be obtained in areas away from the central playa. In fact, in Rhodes and Teels Valleys, deep artesian wells immediately adjacent to the salt-encrusted playas yield relatively dilute water (see analyses 5/35-22aca and 4/32-14abb, table 10). These characteristics may not be true of Columbus Valley, where all ground water tested was saline regardless of location and depth. Fresher water may occur at greater depth in some parts of Columbus Valley, however (see p. 47).

The relative proportions of major dissolved constituents in water of the report area also are variable. Although sodium is typically more abundant than calcium or magnesium among the positive ions, the principal negative ion ranges from bicarbonate (for example, analysis 3/30-36bcc, Huntoon Valley) to sulfate (6/35-29dcc, Rhodes Valley) to chloride (3/35-35da, Columbus Valley).

The playas of Columbus, Rhodes, and Teels Valleys harbor large quantities of salts in the form of crystalline surficial deposits and interstitial brines. The Rhodes and Teels deposits were mined in the 1860's to provide sodium chloride for processing ores from Candelaria, Virginia City, Aurora, Belmont, and other mining districts All three playas were worked for borax in the 1870's, and sodium sulfate was mined briefly at Rhodes playa in the early 1930's (Vanderburg, 1937, p. 64-66, 77-78; Horton, 1964, p. 251-253). The chemical similarities and differences between interstitial brines from the three playas are suggested by the following comparison:

Table 10.--Chemical analyses of well, spring, and stream waters

[Field-office and detailed laboratory analyses by the U.S. Geological Survey]

Part I

Location	Source (with well depth where appropriate)	Date sampled	Temperature °F	Temperature °C	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) plus potassium (K)[3]	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Hardness as $CaCO_3$	Specific conductance (micromhos per cm at 25°C)	pH (lab. determination)	Salinity hazard	Sodium-adsorption ratio (SAR)	Sodium hazard	Residual sodium carbonate (RSC)
					Milligrams per liter (upper number) and milliequivalents per liter (lower number)[1]										Factors affecting suitability for irrigation[2]			
ALKALI VALLEY, NORTHERN PART																		
5/29-17add	Well (7.5 ft)[5]	5-15-68	--	--	11 0.55	1 0.11	26 1.12	84 1.38	0 0.00	9 0.19	8 0.21	33 0.66	190	7.6	Low	1.9	Low	0.72(S)
COLUMBUS VALLEY																		
2/36-8adb	Well (56 ft)[5]	5-24-57	60	16	4.4 .22	.1 .01	(5)	97 1.59	149 4.97	254 5.29	1,680 47.38	12 .23	6,410	9.3	Very high	167	Very high	6.33(U)
-21aab	Well (5,300± ft)[5]	5-25-68	--	--	30 1.50	26 2.12	1,220 52.92	669 10.96	0 .00	631 13.14	1,150 32.44	181 3.62	6,400	8.1	do.	39	do.	7.34(U)
-32dc	Cap Spring[5]	5-24-57	73	23	38 1.90	38 3.13	(5)	720 11.80	0 .00	323 6.72	860 24.25	254 5.03	4,280	7.9	do.	22	do.	6.77(U)
2/37-17dba	Well (246 ft)	5-23-68	--	--	312 15.57	13 1.05	2,220 96.48	36 .59	0 .00	2,640 54.96	2,040 57.55	832 16.32	12,000	7.6	Unsuitable	33	do.	.00(S)
-21cda	Well (292 ft)[5]	5-23-68	--	--	22 1.10	15 1.26	1,560 67.77	401 6.57	0 .00	2,080 43.31	718 20.25	118 2.36	7,500	8.2	Very high	62	do.	4.21(U)
3/35-35da	Well (54 ft)[5]	5-24-68	--	--	138 6.89	27 2.20	734 31.90	108 1.77	0 .00	217 4.52	1,230 34.70	455 9.09	5,000	7.7	do.	15	do.	.00(S)
3/36-2bcb	Well (145 ft)[5]	5-23-68	--	--	104 5.19	2 .20	963 41.85	107 1.75	0 .00	505 10.51	1,240 34.98	270 5.39	5,600	7.6	do.	25	do.	.00(S)
-18cdc	Well (17 ft)	5-24-68	55	13	71 3.54	75 6.19	244 10.61	223 3.65	19 .63	522 10.87	184 5.19	487 9.73	2,200	8.4	High	4.8	Medium	.00(S)
-24ccc	Well (206 ft)	5-23-68	58	14	0 .00	0 .00	5,630 244.69	1,420 23.27	2,220 73.99	1,770 36.85	3,920 110.58	0 .00	22,000	9.5	Unsuitable	Very high	Very high	97.26(U)
GARFIELD FLAT																		
6/33-20bdc	Well (558 ft)[5]	5-19-68	--	--	16 .80	6 .50	44 1.92	138 2.26	0 .00	26 .54	15 .42	65 1.30	330	7.7	Low	2.4	Low	.96(S)
-35adb	Garfield Spring	5-19-68	50	10	48 2.40	13 1.06	61 2.66	203 3.33	0 .00	93 1.94	30 .85	173 3.46	610	7.6	do.	2.0	do.	.00(S)
HUNTOON VALLEY																		
3/30-36bc	Huntoon Spring	5-20-68	53	12	34 1.70	16 1.28	37 1.63	218 3.57	0 .00	27 .56	17 .48	149 2.98	450	7.7	do.	1.3	do.	.59(S)
3/31-5cd	Well (32 ft)[5]	5-20-68	--	--	26 1.28	0 .00	446 19.38	762 12.49	34 1.13	10 .21	242 6.83	64 1.28	2,000	8.7	High	24	Very high	12.34(U)
-7ca	Well (64 ft)	5-20-68	78	26	26 1.30	8 .66	27 1.19	144 2.36	0 .00	23 .48	11 .31	98 1.96	360	7.7	Low	1.2	Low	.40(S)
4/31-27ad	Well (298 ft)	5-20-68	--	--	28 1.40	7 .60	70 3.03	122 2.00	0 .00	98 2.04	35 .99	100 2.00	530	7.3	do.	3.0	do.	.00(S)
MONTE CRISTO VALLEY																		
4/38-5bb	Well (305 ft)	5-17-68	--	--	3 .13	0 .03	125 5.43	0[6] .00	37 1.23	94 1.96	81 2.28	8 .16	680	10.5	do.	19	Very high	1.19(S)
5/37-13d	Well (120 ft)[5]	4-17-68	--	--	17 .85	3 .27	102 4.45	180 2.95	0 .00	63 1.33	45 1.27	56 1.12	580	7.9	do.	5.9	Low	1.83(M)
5/38-4cb	Well (100 ft)[5]	5-17-68	--	--	7 .37	6 .53	182 7.91	322 5.28	9 .30	82 1.71	54 1.52	45 .90	860	8.5	Medium	12	High	4.68(U)
6/37-21d	Well (300 ft)[5]	5-17-68	--	--	46 2.30	25 2.06	167 7.28	453 7.42	0 .00	140 2.91	47 1.33	219 4.38	1,100	8.0	do.	4.9	Low	3.04(U)
		8-1-69	--	--	53 2.64	34 2.81	218 9.46	364 5.97	0 .00	253 5.27	130 3.67	273 5.45	1,500	8.1	do.	5.8	Medium	.52(S)
7/36½-13b	Well (283 ft)[5]	10-28-60	62	17	14 .70	6.6 .54	(5)	197 3.23	0 .00	35 .73	4.2 .12	62 1.24	387	7.7	Low	3.6	Low	1.99(M)
		5-17-68	52	11	15 .75	5 .41	70 3.05	211 3.46	0 .00	28 .58	6 .17	58 1.16	420	7.7	do.	4.0	do.	2.30(M)
QUEEN VALLEY																		
1/32-25dcd	Queen Canyon Creek	5-16-68	--	--	67 3.34	15 1.20	9 .38	178 2.92	0 .00	90 1.87	4 .13	227 4.54	510	8.0	do.	.3	do.	.00(S)
RHODES VALLEY																		
5/34-24ddu	Well (132 ft)[5]	5-22-68	--	--	31 1.55	6 .53	83 3.61	30 .49	0 .00	125 2.60	92 2.60	104 2.08	730	7.1	do.	3.5	do.	.00(S)
5/35-21acb	Well (16 ft)[4,5]	3-27-59	48	9	8.6 .43	2.1 .17	(5)	260 4.26	90 3.00	850 17.70	494 13.93	30 .60	3,740	8.8	Very high	69	Very high	6.66(U)
-22acа	Well (550+ft)[5]	6-12-61	72	22	--	--	(5)	218 3.57	0 .00	220[7] 4.5	165 4.65	16 .32	1,340	8.2	Medium	30	do.	3.23(U)
-22bbb	Well[5]	3-27-59	60	16	15 .75	2.2 .18	(5)	115 1.88	364 12.13	1,830 38.10	2,110 59.50	46 .93	11,000	9.5	Unsuitable	163	do.	13.08(U)
-26bcc	Well (500±ft)	5-22-68	--	--	49 2.45	4 .37	245 10.64	152 2.49	0 .00	387 8.06	103 2.01	141 2.82	1,600	7.8	High	9.0	Medium	.00(S)
6/35-29dcc	Soda Spring (south group)	5-25-68	86	30	44 2.20	3 .24	303 13.16	119 1.95	0 .00	561 11.68	70 1.97	122 2.44	1,900	8.0	do.	12	High	.00(S)
SODA SPRING VALLEY, EASTERN PART																		
6/35-5cbd	Well (106 ft)[5]	5-17-68	--	--	33 1.65	19 1.53	26 1.15	103 1.69	0 .00	116 2.42	8 .22	159 3.18	480	7.8	Low	.9	Low	.00(S)
-7ddc	Well (304 ft)	5-16-68	63	17	15 .75	1 .05	188 8.18	211 3.46	0 .00	222 4.62	32 .90	40 .80	950	7.9	Medium	13	High	2.66(U)
		7-31-69	--	--	26 1.30	1 .10	242 10.54	173 2.84	0 .00	368 7.66	51 1.44	70 1.40	1,300	8.1	do.	13	do.	1.44(M)
-8caa	Well (600 ft)[8]	Early 1943	--	--	152 7.58	85 6.99	151 6.55	36 .59	0 .00	744 15.49	162 4.57	729 14.57	--	7.4	High	2.4	Low	.00(S)
-8cad	Well (137 ft)[8]	Early 1943	--	--	143 7.14	95 7.81	148 6.44	159 2.61	0 .00	698 14.53	134 3.78	748 14.95	--	7.2	do.	2.4	do.	.00(S)
-23aaa	Martin Spring	5-26-68	--	--	64 3.19	41 3.36	18 .79	249 4.08	0 .00	139 2.89	13 .37	328 6.55	670	8.2	Low	.4	do.	.00(S)
7/34-3abb	Well (264 ft)	5-18-68	--	--	96 4.79	40 3.26	253 11.01	336 5.51	0 .00	560 11.66	67 1.89	403 8.05	1,800	7.6	High	5.5	Medium	.00(S)
7/35-27cda	Well (108 ft)	5-26-68	--	--	68 3.39	24 1.96	35 1.54	211 3.46	0 .00	143 2.98	16 .45	268 5.35	660	7.7	Low	.9	Low	.00(S)
-34add	So. Pacific Spring[8]	Early 1943	--	--	38 1.90	12 .99	104 4.51	173 2.87	0 .00	161 3.35	42 1.18	145 2.89	--	7.4	do.	3.8	do.	.00(S)

Table 10.--Chemical analyses of well, spring, and stream waters--continued

Part I--continued

Location	Source (with well depth where appropriate)	Date sampled	Temperature °F	Temperature °C	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) plus potassium (K)[3]	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Hardness as $CaCO_3$	Specific conductance (micromhos per cm at 25°C)	pH (lab. determination)	Salinity hazard	Sodium-adsorption ratio (SAR)	Sodium hazard	Residual sodium carbonate (RSC)
					Milligrams per liter (upper number) and milliequivalents per liter (lower number)[1]										Factors affecting suitability for irrigation[2]			
					SODA SPRING VALLEY, EASTERN PART--continued													
7/36-15ad	Well (22.5 ft)[4]	4-17-68	--	--	54 2.69	11 0.87	49 2.13	167 2.74	0 0.00	82 1.71	44 1.24	178 3.56	500	7.4	Low	1.6	Low	0.00(S)
8/34-33a2	Well (314 ft)[8]	6-13-61	68	20	--	--	(3)	174 2.85	0 .00	140[7] 3.0	58 1.64	167 3.34	746	7.6	do.	3.1	do.	.00(S)
		5-18-68	--	--	45 2.25	25 2.07	107 4.65	166 2.72	0 .00	178 3.71	90 2.54	216 4.32	930	8.1	Medium	3.2	do.	.00(S)
-34db	Well (145 ft)[4]	5-18-68	--	--	26 1.30	13 1.04	81 3.54	215 3.52	0 .00	89 1.85	18 .51	117 2.34	590	8.2	Low	3.3	do.	1.18(S)
					SODA SPRING VALLEY, WESTERN PART													
8/32-22aa	Well (90 ft)[8]	6-13-61	70	21	--	--	(5)	216 3.54	0 .00	350[7] 7.2	200 5.64	124 2.48	1,670	7.8	High	12	High	1.06(S)
		5-19-68	--	--	25 1.25	7 .57	279 12.12	171 2.80	0 .00	337 7.02	146 4.12	91 1.82	1,500	7.7	do.	12	do.	.98(S)
					TEELS VALLEY													
2/33-32ddc1	Well (190 ft)	5-16-68	--	--	36 1.80	12 1.02	31 1.34	107 1.75	0 .00	37 .77	58 1.64	141 2.82	480	7.7	Low	1.1	Low	.00(S)
4/32-14abb	Well (423 ft)[5]	5-21-68	66	19	21 1.06	0 .00	295 12.84	59 .97	3 .10	218 4.54	294 8.29	53 1.06	1,700	8.5	High	18	Very high	.01(S)
4/33-6aab	Well (28 ft)	5-20-68	--	--	45 2.25	3 .23	133 5.77	91 1.49	0 .00	161 3.35	121 3.41	124 2.48	900	7.6	Medium	5.2	Low	.00(S)
-31ddd	Company Spring	5-21-68	62	17	30 1.50	11 .90	224 9.76	377 6.18	0 .00	88 1.83	147 4.15	120 2.40	1,400	8.2	do.	8.9	Medium	3.78(U)

Additional determinations from detailed analyses

Part II

Location	Silica (SiO_2)	Iron (Fe)	Arsenic (As)	Sodium (Na)	Potassium (K)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Boron (B)	Dissolved-solids content[9]
	Milligrams per liter (upper number) and milliequivalents per liter (lower number)[1]									
2/36-8adb	47	0.27	0.20	1,300 56.55	86 2.20	2.3 0.12	0.0 0.00	0.7	--	3,600
-32dc	23	.80	.20	792 34.45	60 1.53	3.2 .17	.0 .00	.4	9.8	2,500
4/32-14abb[10]	--	--	--	--	--	--	--	--	1.0	950
5/35-21acb	49	.15	--	874 38.02	30 .77	15 .79	--	1.5	--	2,540
-22acs	--	--	--	275 11.96	--	--	--	--	6.2	--
-22bbb	121	.04	.62	2,550 110.92	70 1.79	32 1.68	--	2.8	55	7,210
7/36½-13b	36	--	--	65 2.83	8.1 .21	.5 .03	.0 .00	--	.1	266
8/32-22aa	--	--	--	310 13.48	--	--	--	--	2.0	--
8/34-33a2	--	--	--	91 3.96	--	--	--	--	1.1	--

1. Milligrams per liter and milliequivalents per liter are metric units of measure that are virtually identical to parts per million and equivalents per million, respectively, for all waters having a specific conductance less than about 10,000 micromhos. The metric system of measurement is receiving increased use throughout the United States because of its value as an international form of scientific communication. Therefore, the U.S. Geological Survey recently has adopted the system for reporting all water-quality data. Where only one number is shown, it is milligrams per liter.

2. Salinity hazard is based on specific conductance (in micromhos) as follows: 0-750, low hazard (water suitable for almost all applications); 750-1,500, medium (can be detrimental to sensitive crops); 1,500-3,000, high (can be detrimental to many crops); 3,000-7,500, very high (should be used only for tolerant plants on permeable soils); >7,500, unsuitable. Sodium-adsorption ratio (SAR) provides an indication of what affect an irrigation water will have on soil-drainage characteristics. SAR is calculated as follows, using milliequivalents per liter: $SAR = Na/\sqrt{(Ca + Mg)/2}$. Sodium hazard is based on an empirical relation between salinity hazard and sodium-adsorption ratio. Residual sodium carbonate (expressed in milliequivalents per liter) is tentatively related to suitability for irrigation as follows: safe, 0-1.25; marginal, 1.26-2.50; unsuitable >2.50. The several factors should be used as general indicators only, because the suitability of a water for irrigation also depends on climate, type of soil, drainage characteristics, plant type, and amount of water applied. These and other aspects of water quality for irrigation are discussed by the National Technical Advisory Committee (1968, p. 143-177), and the U.S. Salinity Laboratory Staff (1954).

3. Computed as the milliequivalent-per-liter difference between the determined negative and positive ions; expressed as sodium (the concentration of sodium generally is at least 10 times that of potassium). Computation assumes that concentrations of undetermined negative ions--especially nitrate--are small.

4. Sample bailed from unused well; may not represent chemical character of water yielded by well after appreciable pumping. For example, see difference between bailed sample (5-17-68) from well 6/37-21d (Monte Cristo Valley) and later sample collected after well had been pumped.

5. Detailed laboratory analysis; additional determinations are listed in Part II of this table.

6. Hydroxide (OH), 2 mg/l (0.12 me/l).

7. Estimated.

8. Data from Southern Pacific Co. Both well waters also contained 20 mg/l of nitrate (NO_3).

9. Computed sum, with bicarbonate expressed as carbonate.

10. Analyses for boron and dissolved-solids content by exploration company (dissolved-solids content presumably determined by "evaporation residue" method). Similar determinations for wells 4/32-14ac, 4/33-5ddd, and 4/33-17ab (table 14) are: boron, 0.8, 0.3, and 1.0 mg/l; dissolved-solids content, 1,000, 500, and 2,100 mg/l. All samples collected shortly after drilling, in late April 1968.

Playa[1]	Relative abundance, in percent[2]			
	Sodium	Carbonate-bicarbonate	Sulfate	Chloride
Columbus	97	1	6	93
Rhodes	98	13	33	52
Teels	98	24	7	69

1. Brine samples from Columbus and Rhodes playas collected by B. F. Jones, U.S. Geol. Survey, in 1959. Sample from Teels Marsh collected by R. L. Hay, Univ. of California, in 1963. Analyses by U.S. Geol. Survey.

2. Percentage of total positive or negative ions on the basis of milliequivalents per liter.

Among streams in the report area, only Queen Canyon Creek in Queen Valley was sampled for chemical analysis (table 10). The water was relatively dilute when sampled, with calcium and bicarbonate the principal ions.

Suitability for Domestic Use

The U.S. Public Health Service (1962, p. 7-8) has formulated drinking water standards that are generally accepted as a guideline for public supplies. The standards, as they apply to data listed in table 10, are as follows:

Constituent	Recommended maximum concentration (milligrams per liter)
Iron (Fe)	0.3
Sulfate (SO_4)	250
Chloride (Cl)	250
Fluoride (F)	a About 1.0
Nitrate (NO_3)	45
Dissolved-solids content	b 500

a. The optimum concentration is about 0.8 mg/l. Water containing more than about 1.6 mg/l should not be consumed regularly, espec ally by children.

b. Equivalent to a specific conductance of about 750 micromhos

Most of these are only recommended limits, and water therefore may be acceptable to many users despite concentrations exceeding the given values.

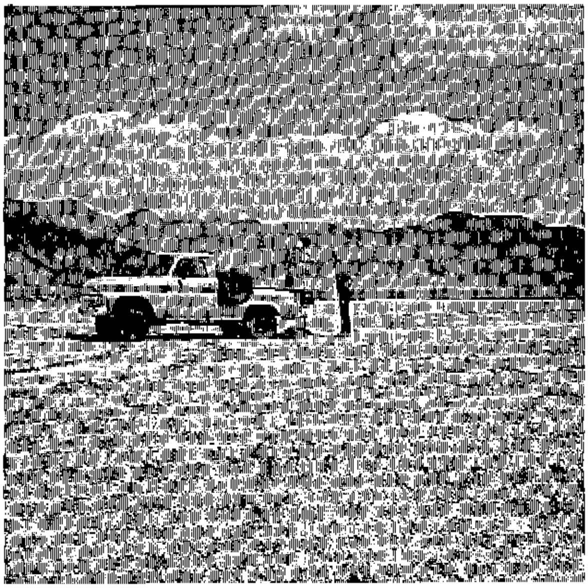
Among the listed constituents, excessive iron causes staining of porcelain fixtures and clothes, large concentrations of chloride and dissolved solids impart an unpleasant taste, and sulfate can have a laxative effect on persons who are drinking a particular water for the first time. Excessive fluoride tends to stain teeth, especially of children, and a large amount of nitrate is dangerous during pregnancy and infancy because it may increase the possibility of "blue-baby" disease.

The arsenic content of drinking water is particularly important because of the possibility of long-term poisoning. The U.S. Public Health Service (1962, p. 8) strongly recommends that arsenic should not exceed 0.05 mg/l in drinking water. The bacteriological quality of drinking water also is important, but is outside the scope of this report.

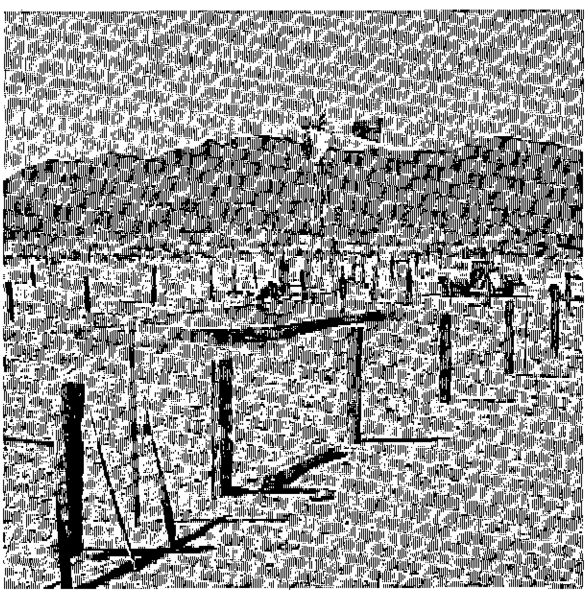
The hardness of a water is of concern to many users. Therefore, the U.S. Geological Survey has adapted the following rating:

Hardness, as $CaCO_3$ (milligrams per liter)	Rating and remarks
0-60	Soft (suitable for most uses without artificial softening)
61-120	Moderately hard (usable except in some industrial applications; softening profitable for laundries)
121-180	Hard (softening required by laundries and some other industries)
More than 180	Very hard (softening desirable for most purposes)

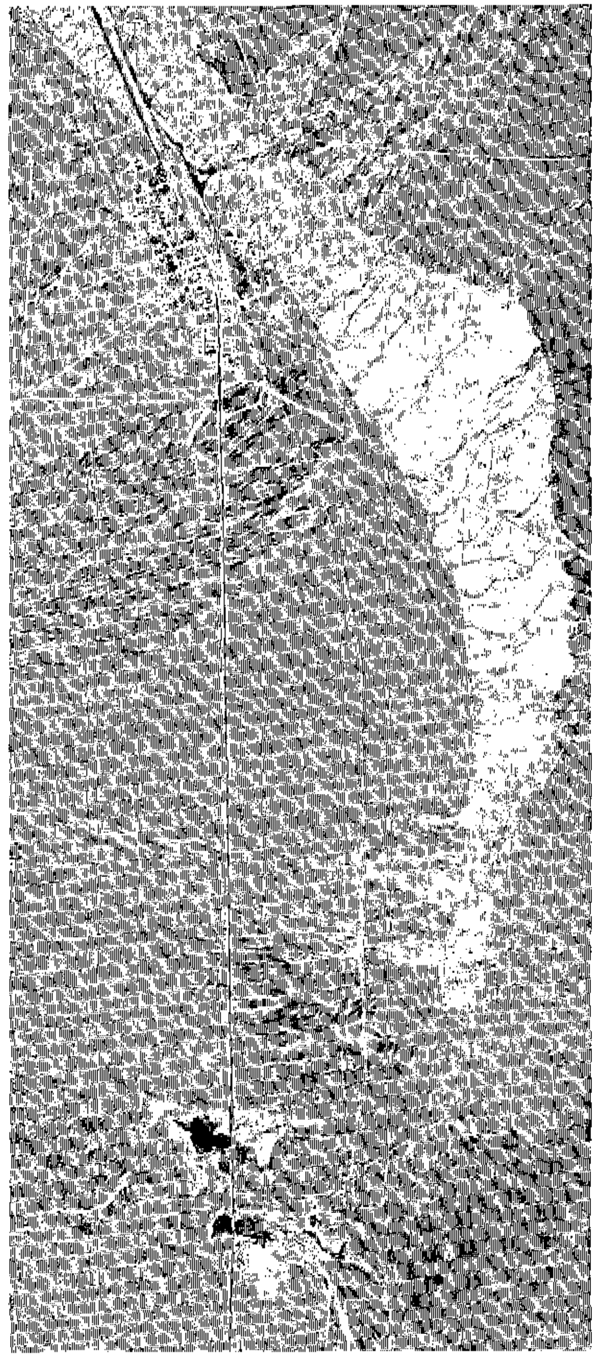
Table 11 summarizes the general suitability of ground water throughout most of the report area for domestic use. The tabulation shows that water in Columbus and Rhodes Valleys is the most consistently unsuitable, whereas water in most of the other valleys is generally acceptable. One drinking-water supply not listed in tables 10 or 11 is that of the Candelaria pipeline (p. 17). This water, with a specific conductance of only 220



A



B



C

Photographs 4A-C.--A. Augering to determine ground-water level on west side of Teels Valley playa (4/32-14ac; depth to water about 3½ ft); Excelsior Mtns. in background. B. Stock-watering well in northern Monte Cristo Valley (7/36½-13b). C. Vertical aerial view of the Mina-Sodaville area (north at top); small dark patches near bottom of picture are phreatophytes associated with Soda Springs (6/35-29).

Table 11.--Summary of chemical suitability for domestic use and irrigation

Valley, and total number of sample sites	Number of samples in the following ranges:				
	Sulfate >250 mg/1	Chloride >250 mg/1	Hardness >180 mg/1	Specific conductance >750 micromhos 1/	Sodium hazard high or very high
Columbus (9)	8	8	6	9	8
Garfield (2)	0	0	0	0	0
Huntoon (4)	0	0	0	1	1
Monte Cristo (5)	1	0	1	2	2
Rhodes (6)	4	2	0	5	4
Soda Spring (east and west) (11)	5	0	6	6	2
Teels (4)	0	1	0	3	1

1. A specific conductance greater than 750 micromhos (which is equivalent to a dissolved-solids concentration greater than about 500 mg/1) indicates a medium to very high salinity hazard.

micromhos, is probably the most chemically suitable domestic supply in the entire report area.

On the basis of partial analyses, the well and spring waters used as public supplies for Mina and Luning, in eastern Soda Spring Valley (analyses 6/35-7ddc, -23aaa, and 7/35-27cda for Mina, and 7/34-3abb for Luning, table 10), are marginally acceptable, though 3 of the 4 waters are very hard, and 2 of the 4 contain more than 500 mg/l of dissolved solids.

The chemical quality of water from the new Mina municipal well (6/35-7ddc) deteriorated somewhat during the first year of heavy pumping (table 10). These data, plus other indirect evidence, suggest that the quality of ground water in some parts of the report area may decrease noticeably at depth. Thus, occasional monitoring of heavily pumped new wells seems advisable to ensure that the chemical quality does not deteriorate beyond limits of acceptability.

Not enough data are available for arsenic, fluoride, and nitrate (table 10) to permit specific comments regarding their abundance throughout the report area. Fluoride and arsenic analyses by the Nevada Department of Health (not listed in table 10) for municipal well waters sampled on July 8, 1969, at Mina and Luning indicate the following:

Source	Fluoride (mg/l)	Arsenic (mg/l as As)
Well 6/35-7ddc (Mina)	5.0	0.05
Spring 6/35-23aaa (Mina)	.2	.008
Well 7/34-3abb (Luning)	2.4	.08

All values except those for the spring equal or exceed the limits recommended for drinking water by the U.S. Public Health Service (see above). At Mina, the spring and well waters are mixed before use, with the spring providing most of the total supply. Therefore, concentrations of fluoride and arsenic in the resulting blend presumably are below the limiting values at most times. The limited additional data in table 10 suggest that fluoride, and perhaps arsenic, locally may be a problem in other water supplies as well. However, almost all of these data are for saline waters, and they therefore may not be indicative of fluoride or arsenic concentrations in water of suitable dissolved-solids content for domestic use.

If any doubt exists regarding the acceptability of a water supply for domestic use, contact the Nevada Health Division's Bureau of Environmental Health, Reno.

Suitability for Agricultural Use

In evaluating the desirability of a water for irrigation, the most critical considerations include dissolved-solids concentration, the relative proportion of sodium to calcium plus magnesium, and the abundance of constituents such as boron that can be toxic to plants. Four factors used by the U.S. Salinity Laboratory Staff (1954, p. 69-82) to evaluate the suitability of irrigation water are listed in table 10, and are discussed briefly in footnote 2 of that table. Minor amounts of boron (up to about 0.5 mg/l) are essential to plant nutrition, but larger concentrations can be highly toxic. The approximate upper limits recommended for boron in water irrigating sensitive, semitolerant, and tolerant crops are, respectively, 0.5-1.0, 1.0-2.0, and 2.0-4.0 mg/l (National Technical Advisory Committee, 1968, p. 153).

The suitability of water in the report area for irrigation is variable. On the basis of the summary of specific conductance (salinity hazard) and sodium hazard in table 11, ground water in Columbus and Rhodes Valleys is least suitable, whereas all but the most concentrated waters in the other valleys are generally acceptable for irrigation.

Information on boron is scarce (table 10), but the available data suggest that the element may be a problem in some parts of the report area.

As a precaution, the water from a newly drilled irrigation well should be analyzed to determine its chemical acceptability. The sample should be collected after the well is test-pumped for a period of time sufficient to provide water truly representative of the water-bearing strata. Analyses may be obtained free of charge by contacting the University of Nevada's Cooperative Extension Service agent in Tonopah or Yerington.

Most animals are more tolerant of poor water than man. Although available data are somewhat conflicting, a dissolved-solids content less than 4,000-7,000 mg/l (equivalent to a specific conductance of about 6,000-10,000 micromhos) apparently is safe and acceptable (McKee and Wolf, 1963, p. 112-113), provided that specific undesirable constituents are not present in excessive concentrations. Thus, almost all sampled water within the study area may be sufficiently dilute for livestock.

AVAILABLE GROUND-WATER SUPPLY

The available ground-water supply in the report area consists of two interrelated quantities: the perennial yield and the transitional storage reserve.

Perennial Yield

The perennial yield of a ground-water reservoir may be defined as the maximum amount of water of adequate quality that can be withdrawn and consumed economically each year for an indefinite period. If the perennial yield is continually exceeded, water levels will decline until the usable ground water is depleted or until the pumping lifts become uneconomical to maintain. Perennial yield cannot exceed the natural recharge to an area, and ultimately is limited to the maximum amount of natural discharge that can be salvaged for beneficial use. This salvage implies diversion of ground water presently destined for areas of natural discharge, including outflow, to areas of pumping. The diversion can be accomplished by lowering water levels in and near areas of natural discharge, utilizing the transitional storage reserve, as discussed below.

The estimated perennial yields for valleys in the report area are listed in table 12. In valleys that lose water by subsurface outflow, the amount salvable is difficult to determine because the type of leakage is uncertain. If outflow leaves the valley by moving over a consolidated-rock "spillway," most of the loss could be salvaged by drawing down the ground-water level below the outlet level. In contrast, if outflow occurs through a thick section of valley fill, through permeable consolidated rocks, or at considerable depth, only a moderate part could be salvaged by pumping within the valley. For this report, subsurface geohydrologic controls are assumed to permit salvage of about half of the ground-water outflow. However, if all or part of this quantity is salvaged in an upgradient valley, that amount can no longer be considered available in the downgradient valley. Nonetheless, because the pattern of future development is not known, the salvable part is included in the perennial yields of both contributing and receiving valleys to determine the maximum yield of each.

Transitional Storage Reserve

The transitional storage reserve has been defined by Worts (1967, p. 50) as the quantity of ground water in storage that can be extracted and beneficially used during the period of transition between natural equilibrium conditions and new equilibrium conditions

Table 12.--Preliminary estimates of perennial yield

Valley	Estimated perennial yield (acre-feet per year)	Assumptions regarding quantities salvaged (see table 9)
Adobe[1]	150	All evapotranspiration, plus about half of subsurface outflow (see table 9, footnote d)
Alkali		
Northern part	300	All evapotranspiration
Southern part	700	About half of subsurface outflow
Columbus	a 4,000	All evapotranspiration
Garfield Flat	150	About half of subsurface outflow
Huntoon	500	All evapotranspiration, plus about half of subsurface outflow
Mono[1]	300	About half of subsurface outflow
Monte Cristo	400	All evapotranspiration
Queen[1]	600	About half of subsurface outflow (see table 9, footnote d)
Rhodes	1,000	All evapotranspiration
Soda Spring		
Eastern part	600	All evapotranspiration, plus about half of subsurface outflow
Western part	200	Do.
Teels	1,400	All evapotranspiration

1. Estimate is for Nevada part of valley only.

a. The generally poor quality of ground water may limit development.

under the perennial-yield concept of ground-water development. Thus, the transitional storage reserve is a specific part of the ground-water resource; it is a quantity that is available in addition to the annual recharge, but it can be withdrawn from storage on a once-only basis unless replenished.

Ground-water development inherently involves storage depletion. The magnitude of depletion depends upon the amount of pumpage, the hydraulic characteristics of the aquifer, and the location of wells with respect to recharge and discharge boundaries.

Computation of the transitional storage reserve for valleys in the report area is based on the following assumptions: (1) Development wells would be strategically located in or near the areas of natural discharge, so that any subsurface outflow could be reduced and any evapotranspiration stopped with a minimum of water-level drawdown in the pumped wells. (2) In general, water levels would be lowered to and stabilized at a depth 50 feet below the land surface in areas of phreatophyte growth, which would curtail virtually all evapotranspiration from the ground-water reservoir. (3) Long-term pumping would cause a moderately uniform depletion of storage throughout the valley-fill reservoir, except possibly in the very fine-grained playa deposits, where transmissibility and storage coefficients are small. (4) The specific yield of the valley fill is about 10 percent. (5) Water levels are within the range of economic pumping lift for the intended use. (6) The pumping development causes little or no effect on adjacent valleys. (7) The water is of suitable quality for the desired use.

Table 13 lists the preliminary estimates of transitional storage reserve for valleys of the report area. For each valley, the estimated reserve is the product of (1) the area beneath which storage depletion is expected, (2) the average thickness of valley fill to be dewatered to eliminate evapotranspiration losses or to salvage part of the ground-water outflow (except as indicated by footnotes a and b) and (3) an assumed yield of 10 percent.

The manner in which transitional storage reserve augments the perennial yield has been described by Worts (1967, p. 52), and is shown in its simplified form by the following equation:

$$Q = \frac{\text{Transitional storage reserve}}{t} + \frac{\text{Perennial yield}}{2}$$

in which *Q* is the pumping rate, in acre-feet per year, and *t* is the time, in years, required to exhaust the storage reserve.

Table 13.--Preliminary estimates of transitional storage reserve

Valley	Selected area of depletion (acres)[1]	Selected thickness of depletion (feet)	Transitional storage reserve (acre-feet)
Adobe (McBride Flat only)[2]	200	40	800
Alkali			
Northern part	4,100	40	16,000
Southern part	9,600	(a)	b 960
Columbus	53,000	50	260,000
Garfield Flat	15,000	(a)	b 1,500
Huntoon	12,000	35	42,000
Mono[2]	2,200	(a)	b 220
Monte Cristo	72,000	20	140,000
Queen[2]	9,600	(a)	b 960
Rhodes	34,000	50	170,000
Soda Spring			
Eastern part	43,000	15	c 64,000
Western part	28,000	10	c 28,000
Teels	26,000	50	130,000

1. Assumed to be about 80 percent of the alluvial areas listed in table 2, because of inward-sloping contact between valley fill and consolidated rocks, and because some alluvial areas are underlain at shallow depth by pediments. In addition, areas of saline, discharging playa are excluded in Columbus, Rhodes, and Teels Valleys (table 8). In Teels Valley, alluvial area near Basalt also is excluded.

2. Estimates are for Nevada part of valley only.

a. Thickness of dewatering required to salvage about half of the subsurface outflow (table 12) is unknown.

b. Transitional storage reserve per foot of dewatered thickness.

c. Additional but unknown amount of dewatering may be necessary to salvage about half of the subsurface outflow (table 12).

This basic equation can be modified to allow for changing rates of storage depletion and salvage of natural discharge, but it is not valid for pumping rates less than the perennial yield.

The equation can be used to estimate the time (t) necessary for depletion of the transitional storage reserve in a particular valley. Using the above equation and the estimates for Columbus Valley as an example (transitional storage reserve 260,000 acre-feet, table 13; perennial yield 4,000 acre-feet, table 12) and using a pumping rate, Q, equal to perennial yield in accordance with the general intent of Nevada water law, the time, t, to deplete the transitional storage reserve is computed to be about 130 years.

What the above equation does not indicate is that in the first year of transition, virtually all pumpage would be supplied from storage, and very little, if any, would be derived by salvage of natural discharge. On the other hand, during the last year of the period, nearly all pumpage would be derived by salvage, with virtually none from the storage reserve.

During the period of depletion, the directions of ground-water flow in the valley would be modified substantially. Ground water that originally flowed from the peripheral areas of recharge to the central area of natural discharge would ultimately flow directly to the pumping wells.

To meet the needs of an emergency or other special purpose requiring pumpage in excess of the perennial yield for specified periods of time, the transitional storage reserve would be depleted at a more rapid rate than in the example given. The above equation can be used to compute the time required to exhaust the storage reserve for any selected pumping rate in excess of the perennial yield. However, once the transitional storage reserve is exhausted, the pumping rate should then be reduced to the perennial yield. Pumpage in excess of the perennial yield would result in an overdraft, and pumping lifts would continue to increase until some undesired result occurred.

FUTURE DEVELOPMENT

Present-day (1968) development of water resources in the 1,900-square-mile report area is slight: consumptive use for domestic, public-supply, and agricultural purposes totals less than 100 acre-feet per year. Properly planned farming development might be successful on many of the valley floors and adjacent alluvial slopes, provided that soils are suitable. The growing seasons for all but the highest valley floors are favorable: they average 160-185 days per year for a 28°F frost. However, in several of the valleys, the individual perennial yields are small enough (only 100-500 acre-feet; table 12) to preclude extensive agricultural development.

Places that may be unsuitable for farming include Garfield Flat (because of uneconomically large pumping lifts), all of Columbus Valley except perhaps the area near the mouth of Pinchot Creek (because of poor water quality), and the central playa areas of Rhodes and Teels Valleys (because of poor soil quality).

Brines and saline-mineral deposits on and beneath several of the playas provide a resource that as yet has received only limited exploitation. A near-surface deposit of sodium sulfate beneath Rhodes Valley playa is thought to total at least 3 million tons (Vanderburg, 1937, p. 65). At Columbus Valley playa, test drilling to depths as great as 82 feet (tables 14, 15) failed to disclose highly saline brines or saline-mineral accumulations. No deep test drilling at either Columbus or Rhodes Valley playas is known to have evaluated the possibility of saline accumulations at greater than near-surface depths. In Rhodes Valley, however, the presence of drinkable artesian ground water at the playa margin in 450-foot well 5/35-22aca (table 10) would seem to reduce the possibility of extensive saline accumulations.

In Teels Valley, recent test drilling to depths as great as 695 feet adjacent to the playa (tables 14, 15) encountered no saline deposits. Four of the drill holes tapped artesian ground water that contained only 500-2,100 mg/l of dissolved solids (table 10).

Worthwhile future investigations include: (1) deep test drilling at the playa centers in Columbus, Rhodes, and Teels Valleys to evaluate the water and saline-mineral resources; and (2) test drilling in Columbus Valley on the alluvial fan at the mouth of Pinchot Creek Canyon (approximate location, 2/35-14, 15, 22, 23) to evaluate the availability and quality of ground water for domestic or agricultural use.

NUMBERING SYSTEM FOR HYDROLOGIC SITES

The numbering system for hydrologic sites in this report indicates location on the basis of the rectangular subdivision of public lands, referenced to the Mount Diablo base line and meridian. Each number 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 square-mile section. The section number is followed by letters that indicate the quarter section, quarter-quarter section, and so on; the letters a, b, c, and d designate the northeast, northwest, southwest, and southeast quarters, respectively. For example, well 6/35-7ddc is in SW$\frac{1}{4}$SE$\frac{1}{4}$SE$\frac{1}{4}$ sec. 7, T. 6 N., R. 35 E. In this report, most wells identified with three letters are in areas where detailed U.S. Geological Survey topographic mapping (scale, 1:24,000) is available. Most other wells have been located using aerial photographs and less detailed 1:62,500- and 1:250,000-scale maps. An index to Geological Survey topographic maps in Nevada can be obtained free of charge from the Distribution Section, Geological Survey, Federal Center, Denver, Colo., 80225.

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

Table 14.--Well data

Depth: Depths followed by asterisk were measured by U.S. Geological Survey personnel (in feet below top of casing) at time of water-level measurement; all others are reported depths.

Use: C, commercial; D, domestic; E, exploratory; I, industrial; Ir, irrigation; P, public supply; S, stock; U, unused or abandoned (intended use in parentheses).

Water level: Depth in feet below measuring point (most commonly top of casing, less than 2 feet above land surface). Depths to tenths of a foot were measured by U.S. Geological Survey personnel; depths to nearest foot were reported by well driller or owner.

Remarks: R, reported well depth when drilled; T, length of time between start of pump test and measurement of drawdown, in hours; F, depth, in feet, of first water encountered during drilling; S, log in files of State Engineer (State log number is indicated); L, driller's log in table 15; C, chemical analysis in table 10.

Location (see p.)	Owner	Year drilled or dug	Depth (feet)	Diameter (inches)	Use	Yield (gpm) and drawdown (feet)	Land-surface altitude (feet)	Water-level measurement: Depth (feet)	Water-level measurement: Date measured	Remarks
					ALKALI VALLEY, NORTHERN PART					
5/29-17add	--	--	7.5*	36	S	--	7,080	5.0	5-15-68	C.
					COLUMBUS VALLEY 1/					
2/36-5dcc	U.S. Geological Survey	1912	82	--	U(E)		4,520	--	--	Well no. 800. L.
-8adb	--	1940's?	56*	12	U(I)	3/--	4,520	Flows	5-24-68	C.
-8bcd1	U.S. Geological Survey	1912	41	--	U(E)	--	4,520	2	7- -12	Well no. 400.
-8bcd2	U.S. Geological Survey	1913	67	--	U(E)	--	4,520	--	--	Well no. 900. L.
-9bbd	U.S. Geological Survey	1912	32	--	U(E)	--	4,520	--	--	Well no. 700. F = 4½.
-12dcb	U.S. Geological Survey	1912	50½	--	U(E)	--	4,525	--	--	Well no. 200. L.
-13cdb	U.S. Geological Survey	1912	32	--	U(E)	--	4,525	--	--	Well no. 100. Penetrated sandy mud, with fine gravel layer at 25 ft; F=7.
-21aab	--	1923±	5,300±	12	U(E)	--	4,535	13.2	5-25-68	C. Oil exploration well. Casing perforated from land surface to unknown depth below water surface.
2/37-8cbb	--	--	112*	10	U(D)	--	4,590	67.4	5-23-68	
-17dba	Elton Parsons	1961	246	6	C	--	4,665	77.8	5-23-68	F = 183; S = 6031; L; C.
-21cda	Elton Parsons	1963	292	8	U(C)	20/95	4,810	110 111.2	11- -63 5-23-68	F = 275; S = 7483; L; C.
3/35-35da	--	1967?	54*	8	U(E)	--	4,538	8.2	5-24-68	C.
3/36-2bcb	--	1957	145*	16	U(I)	200/--	4,580	44 42.6	1- -57 5-23-68	R = 187; F = 45; S; L; C.
-15cbc	U.S. Geological Survey	1912	49	--	U(E)	--	4,515	--	--	Well no. 600. Penetrated mostly clay, light colored to 10 ft, dark gray to black below.
-17aac	Argentum Mining Co.	1958	95*	12	U(I)	440/45	4,569	40 40.2	8- -58 5-24-68	R = 103; T = 25; F = 49; S = 4334; spec. cond. of bailed sample 5,000 micromhos.
-17acb	Argentum Mining Co.	1951	85	6	U(I)	200/--	4,538	8	2- -51	F = 22; S = 1576; L.
-18cdc	Tom McGrath	1870±	17*	36x60	D	--	4,540	16.8	5-24-68	C.
-24ccc	--	--	296?*	12,8	U(I)	--	4,520	Flows	5-23-68	C.
-31aad	U.S. Geological Survey	1912	49½	--	U(E)	--	4,510	--	--	Well no. 500. Penetrated moist clay yielding little water.
-35aab	U.S. Geological Survey	1912	50	--	U(E)	--	4,510	--	--	Well no. 300. F = 17; L.
4/36-(28?) 2/	Newmont Mining Co.	1959	600	12,8	U(E)	--	--	Dry	1- -50	L. Not shown on plate 1; location too uncertain.

Table 14.--Well data--(continued)

Location (see p.)	Owner	Year drilled or dug	Depth (feet)	Diameter (inches)	Use	Yield (gpm) and drawdown (feet)	Land-surface altitude (feet)	Water-level measurement: Depth (feet)	Water-level measurement: Date measured	Remarks
					GARFIELD FLAT					
6/33-20acd	--	--	--	6	S	--	5,609	322.1	5-19-68	
-20bdc	--	--	558*	8	U	--	5,622	321.0	5-19-68	C.
-30bdd	--	--	10+	36	U(S)	--	5,888	10.1	6-12-61	Completely filled in as of 5-19-68.
					HUNTOON VALLEY					
3/31-3cd	John A. Bellford	--	32*	8	U(Ir)	--	5,635	17.2	5-20-68	C.
-7ca	Bureau of Land Management #2	1940	64*	6	S	--	5,648	20.8	5-20-68	R = 65; C.
-16bb	Bureau of Land Management #3	1953	58*	8	S	--	5,660	21	2- -53	R = 55; F = 31; L; spec. cond. of
								24.2	5-20-68	bailed sample 490 micromhos.
-18bd	--	--	103*	8	U(Ir)	--	5,680	48.6	5-20-68	
4/31-27ad	Bureau of Land Management #1	1940	298	8	S	--	5,875	247.7	7-31-69	C.
					MONO VALLEY (See table 17 for additional wells outside report area)					
4/29-31ccd	--	--	78+*	6	U	--	7,030	Dry	5-15-68	
					MONTE CRISTO VALLEY					
4/38-5bb	--	1966	305	8	S	--	5,505	271.7	5-17-68	C.
5/37-13d	--	1965	120	--	S	--	5,339	89.2	4-17-68	C.
5/38-4cb	--	1966	100	8	U(S)	--	5,300	69.1	5-17-68	C.
6/37-21d	Lindsay Mining Co.	1949	300	8	U(I)	425/15	5,312	70	9- -49	T = 60; F = 80; S = 1102; L; C.
								74.6	5-17-68	
7/36½-13b	Bureau of Land Management (Cedar Mountain well)	1949	283	6	S	--	6,000	263.2	5-17-68	L; C.
					QUEEN VALLEY					
1/33-18?[2]	Queen Valley Ranch Corp.	1961	305	8	U	--	--	Dry	5- -61	S = 5874; L. Not shown on plate 1; location too uncertain.
					RHODES VALLEY					
4/35-25ba	--	--	190+*	36	U	--	5,200	Dry	5-16-68	
5/34-24dda	Bureau of Land Management (Baker well)	1943	132*	6	U(S)	--	4,520	110.0	5-22-68	R = 138; F = 130; L; C.
5/35-21acb	--	--	16*	--	U(I)	--	4,380	--	--	C.
-22aca	St. Regis Paper Co.?	1930	450±	16-10	U(I)	250-300/--	4,375	Flows	5-22-68	C.
-22bbb	St. Regis Paper Co.?	1930±	--	3	U(I)	--	4,370	Flows	5-22-68	C.
-23bbb[2]	St. Regis Paper Co.?	1930	420±	16-10	U(I)	--	4,375	Flows	5-22-68	
-26bcc	Ernest Johns	1950	500±	8,6	D,Ir	--	4,425	32	9- -50	R = 650; F = 40; S = 1426; L; C.
-28acc	--	--	65*	4	U(C)	--	4,410	11.9	6- 8-61	
					SODA SPRING VALLEY, EASTERN PART					
6/34-23[2]	Bureau of Land Management (Douglas well)	--	235	--	U(S)	--	5,420	Dry	--	
6/35-5cbd	--	--	106*	6	U(I)	--	4,540	97.1	5-17-68	C.
-7cdc	Mineral County Power System	1967	304	8	P	25/70	4,655	229.2	5-26-68	T = 96; S = 9630, 9692; C.
-8caa	Southern Pacific Co.	1907	600	12	U(C)	95/30	4,545	115	Unknown	C.
-8cad	Southern Pacific Co.	1906	135	72x96	U(C)	70/6	4,545	122	Unknown	C.

Table 14.--Well data--(continued)

Location (see p.)	Owner	Year drilled or dug	Depth (feet)	Diameter (inches)	Use	Yield (gpm) and drawdown (feet)	Land-surface altitude (feet)	Water-level measurement Depth (feet)	Water-level measurement Date measured	Remarks
				SODA SPRING VALLEY, EASTERN PART (continued)						
6/35-8cca	--	1953	303	8,6	U(I)	100/--	4,550	120	1- -53	F = 122; S = 2170; L.
								113.0	5-17-68	
-28ccb	--	--	92+*	100x100	U	--	4,590	Dry	5-26-68	
7/34-1daa	--	1913?	--	55x55	U(I)	--	4,444	51.0	5-18-68	
-3abb	Mineral County Power System	1963	264	10	P	60/66	4,500	135	9- -63	F = 140; S = 8595; L; C.
-25aca	Earl Buffington	1963±	120±	30	Ir	--	4,480	45.9	5-18-68	
-25bdd	Earl Buffington	--	141*	10	D	--	4,498	57.3	6- -61	
7/35-27cbc	Mineral County Power System	--	--	--	P	--	4,820	--	--	
-27cca	Mineral County Power System	1958	108	10	P	--	4,860	64	2- -58	S = 4513; L; C.
7/36-15ac	--	--	22.5*	36	U(S)	--	6,100	23.3	4-17-68	C. New "Battle's" well.
8/34-33a1	Basic Inc.	1937±	255	8	U(I)	--	4,506	137.3	11-28-49	Water-level observation well, 1949-67.
								137.3	9-19-66	Destroyed in 1968.
-33a2	Basic Inc.	1942±	314	14	D	450/20	4,499	131.3	3-20-50	T = 72; C.
-34db	Mineral County Power System	1963?	145*	10	U(P)	--	4,455	83.1	5-18-68	C. Unused because of too much sand.
-34dc	Mineral County Power System	1952	229	6	U(P)	70/--	4,460	91	8- -52	F = 94; S = 2028; L.
								90.7	5-18-68	
-36ba[2]	Bureau of Land Management	1943	170	6	S	--	--	90	4- -43	L; F = 65.
8/35-22a[2]	Bureau of Land Management	--	265±	--	U(S)	--	6,800	Dry	--	
-27c[2]	Bureau of Land Management	--	255±	--	U(S)	--	6,800	Dry	--	
					SODA SPRING VALLEY, WESTERN PART					
8/32-14cd	--	--	55*	72x72	U(S)	--	4,368	55.0	5-19-68	
-22aa	Crown Silver, Inc.	--	90	8	D(I)	--	4,368	58.5	5-19-68	C.
					TEELS VALLEY					
1/33-3a[2]	Nevada Dept. of Highways	1956	151	6	D	20/--	--	69	10- -56	F = 85; S = 3575; L.
2/33-27bd	Queen Valley Ranch Corp.	1961	226	7	S	220/13	6,495	33	5- -61	F = 51; S = 5938; L.
								54.5	5-16-68	
-32dcd	Montgomery Pass Lodge	--	48±	--	C	--	7,170	16.7	5-16-68	
-32ddc1	Montgomery Pass Lodge	1952±	190±	--	C	--	7,110	--	--	C.
-32ddc2	Montgomery Pass Lodge	1968	190±	6	C	30/0	7,110	99.2	5-16-68	T = 78; F = 170±.
4/32-1caa[2]	--	1968	500	--	U(E)	--	5,015	100	5- 3-68	L.
-12abc	--	1968	86*	--	U(E)	--	4,990	73.3	5-21-68	R = 500; L.
-14abb	--	1968	423	--	U(E)	5-10/--	4,920	Flows	5-21-68	L; C.
-14ac[2]	--	1968	455	--	U(E)	8/--	4,910	Flows	4-27-68	C (footnote 10).
-23abc	--	1968	500	--	U(E)	--	4,915	2	4-24-68	
-23cdb	--	1968	500	--	U(E)	--	4,915	--	--	L.
4/33-4acc	--	--	39*	60x60	D	--	4,960	36.8	5-13-48	Partially caved in as of 5-68.
-5ddc[2]	--	1968	500	--	U(E)	1/--	4,914	Flows	4-17-68	L; C (footnote 10).
-6aab	Roy Ladd	--	28*	48x72	D	--	4,945	22.4	5-20-68	C.
-6ca[2]	--	1968	476	--	U(E)	--	4,950	15	4-21-68	L.
-10cc[2]	--	1968	500	--	U(E)	--	4,920	--	--	L.
-15bbb	--	--	8*	60	U(I)	--	4,915	4.5	5-21-68	Spec. conduct. of bailed sample 3,400 micromhos.
-17db[2]	--	1968	695	--	U(E)	1/--	4,912	Flows	4-18-68	L; C (footnote 10).
-21cc[2]	--	1968	500	--	U(E)	--	4,975	--	--	L.
5/33-31ddd	--	--	--	60x60	U	--	4,960	50.2	5-21-68	

1. Data for U.S. Geological Survey exploratory wells from Gale, 1914 (wells 100-800), and Hicks, 1916 (well 900, plus accurate locations for wells 100-800).
2. Well not visited by U.S. Geological Survey personnel. Exact location is uncertain.

Table 15.--Well logs

(Asterisk indicates principal water-bearing zone)

Material	Thickness (feet)	Depth (feet)
1/33-5a (cased to 151 ft; perforated from 85 to 150 ft)		
Clay, gray	65	65
Clay, gray, and volcanic rock	21	86
Volcanic rock, water-bearing	6	92
Volcanic rock and red clay, water-bearing	9	101
Rock, hard, water-bearing	49	150
1/33-18?		
Topsoil and clay	20	20
Gravel, coarse, and clay	29	49
Clay, sandy	24	73
Clay, sandy, hard	201	274
Clay, hard	29	303
Very hard (no sample)	2	305
2/33-27bd (cased to 212 ft; perforated from 51 to 212 ft)		
Clay	16	16
Gravel, coarse	35	51
Gravel, coarse, with boulders, water-bearing	11	62
Sand and boulders, water-bearing	10	72
Clay, red	17	89
Gravel, coarse, water-bearing	9	98
Clay, gray	10	108
Sand and boulders, water-bearing*	104	212
Clay, red, and hard boulders	14	226
2/36-5dcd (Description from Gale, 1914, p. 427)		
Salt crust	½	½
Sand, light brown	1½	2
Sand and clay, light yellow; small flow of salty water encountered at 6 ft	4	6
Clay, dark blue, smooth	1	7
Mud, black, smooth, sticky	5	12
Same, but wet; medium flow of nonsalty water encountered at 16 ft; water level rose to 4 ft below land surface	4	16
Sand, black, wet; strong flow of water fresh enough for horses to drink encountered at 19 ft; water level rose to 1 ft	3	19
Gravel, fine, containing crystals	1½	20½
Sand, fine, containing crystals	3	23½
Clay and sand, light blue, containing hard, coarse particles	7½	31
Clay, light gray, containing hard, coarse particles	4	35
Clay, black and yellow, containing hard, coarse particles	3	38
Clay, dark blue, containing hard, coarse particles; soft and wet	6	44
Same, but black	3	47

(continued)

Table 15.--Well logs--continued

Material	Thickness (feet)	Depth (feet)
2/36-5dcd--continued		
Clay, light gray and black, smooth, soft, and wet; black, foul-smelling seepage encountered at 48 ft	1	48
Clay and mud, black, containing hard, coarse particles; wet	5	53
Clay, smooth, dry; black to 57 ft, black and yellow to 61 ft, light yellow to 65 ft, dark green to 69 ft, and yellowish green and black to 74 ft; medium flow of slightly salty water encountered at 74 ft; water level rose to 3 ft	21	74
Sand and quicksand	8	82
2/36-8bcd2 (Description from Hicks, 1916, p. 5)		
Surface crust of crystallized salt and sand	¼	¼
Sand with small amount of clay, greenish yellow; brine (205,000 ppm) encountered at 2.5 ft	3 3/4	4
Clay, light gray and black, wet	½	4½
Sand, black with foul odor, very wet	5	9½
Clay, black, sticky	½	10
Sand and gravel, dark gray, moist; strong flow of water (6,200 ppm) encountered at 15 ft; water level rose to 1½ ft below land surface	7	17
Sand with a small amount of clay, light gray, moist	2½	19½
2/36-8bcd2--continued		
Clay, with a small amount of sand, light gray	½	20
Sand, fine, light gray, very moist; moderate flow of water (5,900 ppm) encountered at 23 ft	3½	23½
Hardpan, clay, and consolidated material	2½	26
Sand, nearly black, wet; without saline taste; strong flow of water (5,000 ppm) encountered at 27 ft; water level rose to 2 ft	3	29
Clay, greenish gray, smooth	½	29½
Sand, black, very moist	1	30½
Hardpan, alternating layers of clay and more consolidated material; weak flow of water (6,600 ppm) encountered at 37 ft	6½	37
Clay, alternating layers of light gray and black	2½	39½
Hardpan, alternating layers of clay and more consolidated material; strong flow of foul-smelling water (3,800 ppm) encountered at 42 ft; water level rose to 1 ft	5½	45
Sand, coarse, nearly black; weak flow of water (8,700 ppm) encountered at 47 ft	3	48
Clay, black, sticky, soft	4	52
Hardpan	1	53
Sand, quicksand, nearly black, foul odor; strong flow of foul-smelling water (3,100 ppm) encountered at 54 ft; water level rose to 16 ft	1½	54½

(continued)

Table 15.--Well logs--continued

Material	Thickness (feet)	Depth (feet)
2/36-8bcd2--continued		
Clay, light gray, soft, sticky; weak flow of water encountered at 61 ft	7	61½
Sand, quicksand, nearly black	½	62
Clay, light gray, very sticky	½	62½
Sand, mostly quicksand, with some fine gravel; weak flow of water (4,700 ppm) encountered at 66 ft	4½	67
2/36-12dcb (Description from Gale, 1914, p. 425)		
Mud, dry, saline	1	1
Sand, cemented, underlain by moist, sticky mud with some water-bearing sand	17	18
Sand, gray, cemented	7	25
Mud, dark, sticky, water-bearing at intervals	25½	50½
2/37-17dba (cased to 246 ft; perforated from 100 to 246 ft)		
Surface sand, silt, and cobblestones	37	37
Shale, blue, hard	146	183
Gravel, coarse, water-bearing*	3	186
Shale, blue, hard	40	226
Cobblestones, very rough, water-bearing	2	228
Shale, blue, hard	18	246
2/37-21cda (cased to 292 ft; perforated from 232 to 292 ft)		
Clay, yellow	50	50
Shale, brown	45	95
Shale, blue	75	170
Shale, brown	35	205
Shale, blue	25	230
Shale, brown	45	275
Sand, blue, water-bearing	7	282
Bedrock, hard	10	292
3/31-16bbc (cased to 50 ft; perforated from 30 to 50 ft)		
Sand	11	11
Sand and clay	20	31
Sand, water-bearing	9	40
Pumice	10	50
Quicksand	5	55
3/36-2bcb (cased to 150 ft; perforated from 45 to 130 ft)		
Clay and gravel	45	45
Gravel, water-bearing	10	55
Clay and gravel	13	68
Gravel, loose, water-bearing	4	72
Clay	4	76
Gravel, water-bearing*	18	94
Clay and gravel	28	122
Sand, water-bearing	4	126
Clay and gravel	18	144
Rhyolite, decomposed	43	187
3/36-17acb (cased to 85 ft; perforated from 30 to 85 ft)		
Clay and sand	22	22
Sand and gravel, water-bearing	63	85
3/36-35aab (Description from Gale, 1914, p. 425)		
Clay, light-colored to yellowish green, with some sand; water encountered at 17 ft	17	17
"Limestone"	1	18
Clay, same as above	2	20
Clay, black	30	50

Table 15.--Well logs--continued

Material	Thickness (feet)	Depth (feet)
4/32-1caa (uncased)		
Gravel	60	60
Gravel, with some tan clay	40	100
Sand, gravel, and tan clay	60	160
Silt, fine, tan, with some sand	20	180
Silt, fine, tan, with some sand and gravel	20	200
Silt, fine, tan, with some sand	15	215
Clay and silt, tan	10	225
Sand and tan clay, with some gravel	40	265
Silt, fine, tan, and sand, with some tan clay	60	325
Sand and tan, gray, and white clay	60	385
Silt, fine, tan, and sand, with some tan clay	55	440
Silt, fine, tan, and sand, with some tan, red, and gray clay	60	500
4/32-12abc (uncased)		
Gravel	55	55
Gravel, with some tan clay	35	90
Gravel and gray and tan clay	60	150
Gravel, sand, and clay	30	180
Clay, tan, and sand, with some gravel	60	240
Clay, tan and gray, and sand	90	330
Clay, gray and red, and sand	40	370
Sand, with some pebbles and tan clay	80	450
Clay, tan, and sand	20	470
Clay, tan and red, and sand	30	500

Material	Thickness (feet)	Depth (feet)
4/32-14abb (uncased)		
Clay, red	5	5
Clay, black, gray, and red, carbonaceous	55	60
Clay, gray and tan	25	85
Clay, gray and brown, with some sand and pebbles	40	125
Clay, gray and brown, and sand	20	145
Clay, tan and reddish, and sand, with some pebbles	40	185
Clay, gray, black, and red, and sand	40	225
Same, but with some pebbles	60	285
Sand and tan clay	45	330
Sand and white, tan, and black clay, with some pebbles	15	345
Sand and tan and dark gray clay, with some pebbles	55	400
Sand and gray clay	23	423

Limey intervals: 15-125, 295-365, 385-390 ft.

Hydrogen sulfide odor: 15-65, 120-125, 365-385 ft.

Material	Thickness (feet)	Depth (feet)
4/32-23cdb (uncased)		
Clay, tan and gray, with some sand	10	10
Sand, reddish black, and gray clay	25	35
Sand, black, and gray and tan clay	15	50
Clay, gray, with some gray-black sand	55	105
Clay, gray and tan, with some reddish gray sand	25	130
Clay, tan and gray, with some sand	20	150

(continued)

Table 15.--Well logs--continued

Material	Thickness (feet)	Depth (feet)
4/32-23cdb--continued		
Clay, tan, with some sand		
Sand, very fine, with tan and gray clay	50	200
Clay, tan, with some sand	15	215
Sand, with some tan clay	30	245
Clay, tan, with some sand	15	260
Sand and tan clay	35	295
Silt, with some sand and tan clay	35	330
Clay, tan and gray, with some reddish black sand	35	365
Sand and fine silt, with some tan clay	135	500

Limey intervals: 35-220, 340-350 ft.
Hydrogen sulfide odor: 0-35 ft.

Material	Thickness (feet)	Depth (feet)
4/33-5ddd (uncased)		
Silt, tan, and blow sand	15	15
Clay, silty, gray to black, carbonaceous	55	70
Clay, black, and dark gray silt; carbonaceous	35	105
Clay, dark gray and tan, with some dark gray silt; carbonaceous	135	240
Clay, dark gray to black, with some grit; carbonaceous	60	300
Clay, dark gray and olive-tan, with some grit; carbonaceous	75	375
Clay, dark gray, with some grit	60	435
Clay, brown and gray, with some grit; carbonaceous	65	500

Limey intervals: 0-70; 120-135 ft.
Hydrogen sulfide odor: 0-405, 445-500 ft.

Material	Thickness (feet)	Depth (feet)
4/33-6ca (uncased)		
Blow sand, tan	30	30
Sand, pebbles, and white to brown clay	140	170
Sand, with some gray silty clay and pebbles	15	185
Sand and tan and gray clay, with some pebbles	15	200
Sand and tan silty clay, with some pebbles	115	315
Sand and tan, black, and white silty clay, with some pebbles	65	380
Clay, black and tan, silty, and fine sand	20	400
Clay, black, with fine sand and tan silt	15	415
Silt? (No cuttings)	10	425
Sand, tan silty clay, and rounded pebbles	51	476

Limey zone: 315-476 ft.
Hydrogen sulfide odor: 410-476 ft.

Material	Thickness (feet)	Depth (feet)
4/33-10cc (uncased)		
Clay, tan and gray, and sand	85	85
Clay, light tan, light gray, and gray; sand; with some gravel below 125 ft	140	225
Gravel, with some tan clay	65	290
Sand, fine, with some gray clay	20	310
Gravel and gray clay	10	320
Clay, light gray, and sand	20	340
Clay, dark gray, with some sand	60	400
Clay, gray and light gray, with some sand	35	435
Clay, gray and tan, carbonaceous, with some rounded sand	65	500

Limey zone: 0-500 ft.
Hydrogen sulfide odor: 435-500 ft.

Table 15.--Well logs--continued

Material	Thickness (feet)	Depth (feet)
4/33-17db (uncased)		
Blow sand and tan silt	15	15
Silt, dark gray, carbonaceous	30	45
Silt, dark gray to black, carbonaceous	45	90
Clay and silt, black, carbonaceous	15	105
Clay, black and dark gray, carbonaceous	20	125
Clay, silty, gray to black, carbonaceous	75	200
Clay, gray, tan, and dark gray, carbonaceous, with some silt	85	285
Clay, gray and dark gray, carbonaceous	15	300
Clay, gray and olive gray, carbonaceous, with some silt	180	480
Silt, black, with some olive-gray clay; carbonaceous	20	500
Silt, black, carbonaceous	15	515
Clay, gray, and black silt; carbonaceous	55	570
Same, but with some pebbles	30	600
Silt, black, with some pebbles	15	615
Clay, gray, and black silt; carbonaceous, with some pebbles	50	665
Clay, black and gray, carbonaceous	30	695

Limey intervals: 0-105, 125-215, 235-255, 280-305, 320-695(?) ft.

Hydrogen sulfide odor: 0-695 ft.

Material	Thickness (feet)	Depth (feet)
4/33-21cc (uncased)		
Gravel, with some tan clay	70	70
Gravel, with some white and tan clay	30	100
Gravel	80	180
Sand	5	185
Gravel, with some gray and white clay	25	210
Clay, dark gray, tan, and white, with sand	30	240
Sand, with some pebbles and gray clay	65	305
Clay, dark gray and black, carbonaceous	15	320
Clay, gray and black, carbonaceous, with some sand	35	355
Sand and pebbles, with some gray clay	10	365
Clay, black and gray, carbonaceous	60	425
Silt, black and gray, with some black and gray clay; carbonaceous	15	440
Gravel, sand, and some carbonaceous black clay	15	455
Clay, black and gray, carbonaceous, with some sand	45	500

Limey intervals: 70-100, 180-210, 305-500 ft.

Hydrogen sulfide odor: 305-500 ft.

Material	Thickness (feet)	Depth (feet)
4/36-(28?)		
Gravel	50	50
Lava, loose	55	105
Lava, solid	60	165
Lava, loose	15	180
Lava, solid	90	270
Rhyolite	120	390
"Malpais" (basalt)	35	425
Rhyolite, red	115	540
Rhyolite, white	60	600

Table 15.--Well logs--continued

Material	Thickness (feet)	Depth (feet)
5/34-24dda		
Boulders, gray, hard	125	125
Sandstone, gray, hard	5	130
Sand, black, soft, water-bearing	8	138
5/35-26bcc (cased to 650 ft; perforated from 65 to 650 ft)		
Topsoil, sandy	40	40
Sand (water-bearing, but cased and cemented off)	16	56
Clay, brown, with thin beds of sand	44	100
Lava and cinders	16	116
Clay, brown, hard, and rock	42	158
Sand, coarse, water-bearing	14	172
Clay, brown, hard	102	274
Conglomerate, hard	26	300
Sand, coarse, water-bearing	25	325
Sand, hard	125	450
Clay, blue	109	559
Sand, blue, water-bearing	21	580
Clay, blue	30	610
Sand, blue, water-bearing	12	622
Clay, blue	28	650
6/35-8dca (cased to 303 ft; perforated from 120 to 303 ft)		
Topsoil, clay, and gravel	122	122
Sand and gravel, water-bearing	2	124
Conglomerate, hard	64	188
Clay and gravel	52	240
Gravel, coarse, water-bearing*	10	250
Clay and small rocks	20	270
Gravel and sand, loose, water-bearing	14	284
Sand and gravel, water-bearing	19	303
6/37-21d (cased to 300 ft; perforated from 72 to 300 ft)		
Rock and soil	18	18
Conglomerate	30	48
Clay, rocky, brown	32	80
Gravel, water-bearing	4	84
Clay, brown	56	140
Clay, blue	52	192
Gravel and sand, blue, water-bearing	38	230
Clay, blue, streaked with blue sand	70	300
7/34-3abb (cased to 264 ft; perforated from 135 to 263 ft)		
Clay and boulders	31	31
Rock, broken, and clay	19	50
Clay and broken rock, hard	16	66
Clay and rough small gravel	29	95
Clay and gravel	20	115
Clay, gray	3	118
Clay and gravel, water-bearing below 140 ft	24	142
Clay, broken rock, and some sand; water-bearing*	20	162
Clay, sand, and gravel; water-bearing	56	218
Clay, sandy, and gravel; water-bearing	22	240
Clay and gravel, water-bearing	24	264
7/35-27cda (cased to 108 ft; perforated from 50 to 90 ft)		
Gravel and silt	60	60
Gravel, water-bearing below 64 ft	30	90
Clay, dark	10	100
Bedrock	8	108

Table 15.--Well logs--continued

Material	Thickness (feet)	Depth (feet)
7/36½-13b		
"Adobe," small rocks	20	20
Sand, coarse	60	80
Hardpan	5	85
Sand, coarse	30	115
Clay, dark gray	16	131
Boulders	2	133
Sand, small rocks	56	189
Sand, black	45	234
Clay, blue	20	254
Sand, fine	4	258
Gravel, water-bearing	25	283
Clay, blue		at 283
8/34-34dc (cased to 229 ft; perforated from 94 to 227 ft)		
Gravel and clay	94	94
Siltstone, water-bearing	36	130
Sand and fine gravel, water-bearing	20	150
Clay	12	162
Sand and gravel, coarser toward bottom, water-bearing*	67	229
8/34-36ba (cased to 141 ft; perforated from 120 to 141 ft)		
Sand	10	10
Clay, red	35	45
Sandstone, hard, some water	20	65
Clay, soft, water-bearing	40	105
Clay, soft, and sandstone, water-bearing	65	170

Table 16.--Spring data

Location	Name	Approximate land-surface altitude (feet)	Estimated flow (gpm)	Temperature °F	Temperature °C	Field determinations: Chloride (mg/l)	Hardness as $CaCO_3$ (mg/l)	Specific conductance (micromhos)
2/36-28ccc	--	4,600	1±	81	27	578	--	3,900
-32dc	Gap	4,625-4,650	10±	73	23	860	254	a 4,280
2/37-8aaa[1]	--	4,780	<½	--	--	1,940	230	10,000
3/30-36bcc	Huntoon	6,100-6,150	--	53	12	17	149	a 450
3/32-1db[2]	Rock House	5,380	--	--	--	460	220	3,500
3/33-4cdc[2]	German	5,350-5,375	--	--	--	210	170	1,400
3/38-1cb[3]	Cook	6,800±	2	--	--	--	--	--
4/33-31ddd	Company	5,150	--	62	17	147	120	1,400
4/38½-15dd[3]	Laundry	6,500±	1	--	--	--	--	--
5/28-34 [2,4]	--	--	½	--	--	--	--	--
5/29-21c[2,4]	--	--	--	--	--	930	40	6,000
5/33-26a[2]	Belleville	6,200-6,400	<½	--	--	--	--	--
5/34-6ba[2]	Pepper	6,500	5+	54	12	50	170	320
5/35-21[2,4]	--	--	--	--	--	160	20	1,400
6/33-35adb	Garfield	5,880-5,960	--	50	10	30	173	a 610
6/35-23aaa	Martin	5,950	40	--	--	13	328	a 670
-29caa	Soda	4,660-4,680	25	70	21	--	--	1,800
-29dcc	do.	4,660-4,680	50	86	30	70	122	a 1,900
6/36-7c[2,4]	--	--	<½	55	13	50	530	750
-15b[2,4]	--	--	--	44	7	50	320	390
-22a[2,4]	--	--	1	57	14	50	290	430
-27b[2,4]	--	--	½	48	9	60	290	450
-28a[2,4]	--	--	10	50	10	40	310	450
6/36½-1ba[2]	Graham	6,400±	3	58	14	80	320	480
7/35-34add[5]	Southern Pacific	5,050	80	--	--	42	145	a --

1. Data from Nevada State Dept. of Health.
2. Data from C. T. Snyder, U.S. Geol. Survey, Menlo Park, Calif.
3. Data from Eddie Mayo, U.S. Bur. Land Management, Las Vegas, Nev.
4. Not shown on plate 1; exact location uncertain.
5. Data from Southern Pacific Co., Sacramento, Calif.

a. More complete analysis in table 10.

Table 17.--Data for selected wells adjacent to the report area

Location	Depth (feet)	Land-surface altitude (feet)	Water level: Depth below land surface (feet)	Water level: Date measured
		BIG SMOKY VALLEY[1]		
1/37-14b	--	5,234	546	7-30-69
1/38-2a	50	4,724	17	7-29-69
-3c	97	4,742	48	7-29-69
-6b	324	4,882	184	5-23-68
-9d	3	4,788	3	9-17-68
-26c	--	4,982	264	9-17-68
1/39-3a	--	4,983	13	9-17-68
-5a	59	4,777	51	7-29-69
-7b	--	4,780	58	7-29-69
2/38-17d	--	4,879	>167	9-17-68
-20d	114	4,812	107	7-30-69
-34d	45	4,734	28	7-29-69
2/39-11c	20	4,728	0	7-30-69
3/39-31db	--	4,750	5	7-24-69
		FISH LAKE VALLEY		
1/36-9cc	14	4,690±	14	10-13-49
		GABBS VALLEY		
8/36-25d	130	6,000±	97	5-17-68
		MONO VALLEY		
3/27-24bbc	--	6,510	37	5-15-68
3/28-16bbb	233	6,700	172	5-15-68
3/29-19cba	--	6,785	247	5-15-68
		WALKER LAKE VALLEY[2]		
5/31-1dab	--	6,030	87	2-15-66
-19ac	345	5,862	305	2-15-66
6/31-33bba	132	5,566	46	2-15-66
7/30-2cdb	610	4,560	478	11-21-52
7/32-21a	503	5,580	dry	--
8/30-3d	514	4,120	52	2-17-66
8/31-32b	452	4,370	246	2-16-66

1. Most data from F. E. Rush (U.S. Geol. Survey, written commun., 1968).

2. Most data from Everett and Rush (1967, table 9).

LIST OF PREVIOUSLY PUBLISHED REPORTS IN THIS SERIES

(See fig. 1)

Report no.	Valley or area
1	Newark (out of print)
2	Pine (out of print)
3	Long (out of print)
4	Pine Forest (out of print)
5	Imlay area (out of print)
6	Diamond (out of print)
7	Desert
8	Independence
9	Gabbs
10	Sarcobatus and Oasis
11	Hualapai Flat
12	Ralston and Stone Cabin
13	Cave
14	Amargosa Desert, Mercury, Rock, Fortymile Canyon, Crater Flat, and Oasis
15	Sage Hen, Guano, Swan Lake, Massacre Lake, Long, Macy Flat, Coleman, Mosquito, Warner, and Surprise
16	Dry Lake and Delamar
17	Duck Lake
18	Garden and Coal
19	Middle Reese and Antelope
20	Black Rock Desert, Granite Basin, High Rock Lake, Mud Meadow, and Summit Lake
21	Pahranagat and Pahroc
22	Pueblo, Continental Lake, Virgin, and Gridley Lake
23	Dixie, Stingaree, Fairview, Pleasant, Eastgate, Jersey, and Cowkick
24	Lake
25	Coyote Spring, Kane Springs, and Muddy River Springs
26	Edwards Creek
27	Lower Meadow, Patterson, Spring (near Panaca), Rose, Panaca, Eagle, Clover, and Dry
28	Smith Creek and Ione
29	Grass (near Winnemucca)
30	Monitor, Antelope, Kobeh, and Stevens Basin
31	Upper Reese
32	Lovelock
33	Spring (near Ely; out of print)
34	Snake, Hamlin, Antelope, Pleasant, and Ferguson Desert (out of print)
35	South Fork, Huntington, and Dixie Creek-Tenmile Creek (out of print)
36	Eldorado, Piute, and Colorado River
37	Grass (near Austin) and Carico Lake
38	Hot Creek, Little Smoky, and Little Fish Lake
39	Eagle (Ormsby County)
40	Walker Lake and Rawhide Flats
41	Washoe
42	Steptoe
43	Honey Lake, Warm Springs, Newcomb Lake, Cold Spring, Dry, Lemmon, Red Rock, Spanish Springs, Bedell Flat, Sun, and Antelope
44	Smoke Creek Desert, San Emidio Desert, Pilgrim Flat, Painters Flat, Skedaddle Creek, Dry (near Sand Pass), and Sano
45	Clayton, Stonewall Flat, Alkali Spring, Oriental Wash, Lida, and Grapevine Canyon
46	Mesquite, Ivanpah, Jean Lake, and Hidden
47	Thousand Springs and Grouse Creek
48	Little Owyhee River, South Fork Owyhee River, Independence, Owyhee River, Bruneau River, Jarbidge River, Salmon Falls Creek, and Goose Creek
49	Butte
50	Lower Moapa, Black Mountains, Garnet, Hidden, California Wash, Gold Butte, and Greasewood
51	Virgin River, Tule Desert, and Escalante Desert

REFERENCES CITED

Albers, J. P., and Stewart, J. H., 1965, Preliminary geologic map of Esmeralda County, Nevada: U.S. Geol. Survey Mineral Inv. Field Studies Map MF-298.

Eakin, T. E., 1950, Preliminary report on ground water in Fish Lake Valley, Nevada and California: Nev. State Engineer's Office, Water Res. Bull. 11, 37 p.

Eakin, T. E., and others, 1951, Contributions to the hydrology of eastern Nevada: Nev. State Engineer's Office, Water Res. Bull. 12, 171 p.

Everett, D. E., and Rush, F. E., 1967, A brief appraisal of the water resources of the Walker Lake area, Mineral, Lyon, and Churchill Counties, Nevada: Nevada Dept. Conserv. and Nat. Resources, Water Resources - Reconn. Ser. Rept. 40, 44 p.

Feth, J. H., 1964, Review and annotated bibliography of ancient lake deposits (Precambrian to Pleistocene) in the western States: U.S. Geol. Survey Bull. 1080, 119 p.

Gale, H. S., 1914, Potash tests at Columbus Marsh, Nevada, in Contributions to economic geology: U.S. Geol. Survey Bull. 540-N, p. 422-427.

Harrill, J. R., and Worts, G. F., Jr., 1968, Estimated water use in Nevada, 1950-65: Nevada Dept. Conserv. and Nat. Resources, Div. Water Resources, Inf. Ser. Rept. 7, 37 p.

Hardman, George, and Mason, H. G., 1949, Irrigated lands of Nevada: Nevada Univ. Agr. Expt. Sta. Bull. 183, 57 p.

Hicks, W. B., 1916, The composition of muds from Columbus Marsh, Nevada: U.S. Geol. Survey Prof. Paper 95-A, p. 1-11.

Horton, R. C., 1964, Sodium compounds, in U.S. Geological Survey and Nevada Bureau of Mines, Mineral and water resources of Nevada: Nev. Bur. Mines Bull. 65, p. 247-254.

Lee, C. H., 1912, An intensive study of the water resources of part of Owens Valley, California: U.S. Geol. Survey Water-Supply Paper 294, 135 p.

McKee, J. E., and Wolf, H. W., 1963, Water quality criteria, 2nd ed.: California Water Quality Control Board Pub. 3-A, 548 p.

Moore, D. O., 1968, Estimating mean runoff in ungaged semiarid areas: Nevada Dept. Conserv. and Nat. Resources, Water Resources Bull. 36, 11 p.

Myrick, D. F., 1962, Railroads of Nevada and eastern California, vol. 1 - The northern roads: Berkeley, Calif., Howell-North, 453 p.

National Technical Advisory Committee, 1968, Water quality criteria: Federal Water Pollution Control Adm., 234 p.

Robinson, T. W., 1965, Water use studies utilizing evapotranspiration tanks, in Cohen, Philip, and others, Water resources of the Humboldt River Valley near Winnemucca, Nevada: U.S. Geol. Survey Water-Supply Paper 1795, p. 83-91.

Ross, D. C., 1961, Geology and mineral deposits of Mineral County, Nevada: Nevada Bur. Mines Bull. 58, 98 p.

Rush, F. E., 1968a, Water-resources appraisal of Clayton Valley-Stonewall Flat area, Nevada and California: Nevada Dept. Conserv. and Nat. Resources, Water Resources - Reconn. Ser. Rept. 45, 54 p.

_____ 1968b, Index of hydrographic areas in Nevada: Nevada Dept. Conserv. and Nat. Resources, Div. Water Resources, Water Resources - Info. Ser. Rept. 6, 38 p.

Snyder, C. T., Hardman, George, and Zdenek, F. F., 1964, Pleistocene lakes in the Great Basin: U.S. Geol. Survey Misc. Geol. Inv. Map I-416.

U.S. Public Health Service, 1962, Drinking water standards, 1962: U.S. Public Health Service Pub. 956, 61 p.

U.S. Salinity Laboratory Staff, 1954, Diagnosis and improvement of saline and alkali soils: U.S. Dept. Agriculture Handb. 60, 160 p.

Vanderburg, W. O., 1937, Reconnaissance of mining districts in Mineral County, Nevada: U.S. Bur. Mines Inf. Circ. 6941, 79 p.

White, W. N., 1932, A method of estimating ground-water supplies based on discharge by plants and evaporation from soil: U.S. Geol. Survey Water-Supply Paper 659-A, 105 p.

Worts, G. F., Jr., 1967, The available water supply, in Rush, F. E., and Glancy, P. A., Water-resources appraisal of the Warm Springs-Lemmon Valley area, Washoe County, Nevada: Nevada Dept. Conserv. and Nat. Resources, Water Resources - Reconn. Ser. Rept. 43, p. 48-53.

Young, A. A., and Blaney, H. F., 1942, Use of water by native vegetation: California Dept. Pub. Works, Div. Water Resources Bull. 50, 154 p.

UNITED STATES DEPARTMENT OF THE INTERIOR
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STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
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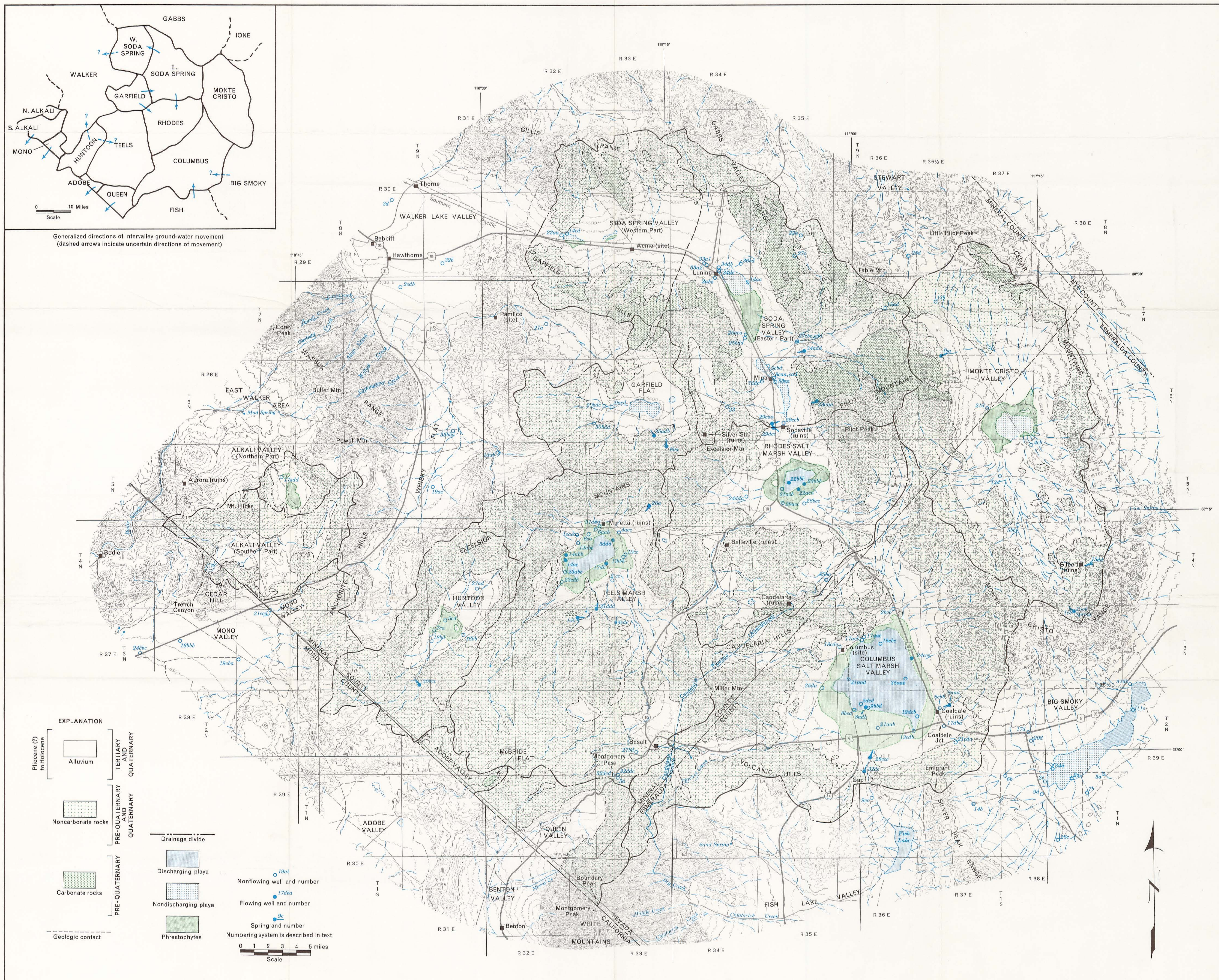

Base from U.S. Geological Survey 1:250,000 series: Walker Lake (1957), Tonopah (1962), Goldfield (1962), and Mariposa (1945)

Hydrology by A.S. Van Denburgh and Patrick A. Glancy, 1968; geology adapted from Ross (1961) and Albers and Stewart (1965)

PLATE 1.—GENERALIZED HYDROGEOLOGIC MAP OF THE COLUMBUS SALT MARSH - SODA SPRING VALLEY AREA, MINERAL AND ESMERALDA COUNTIES, NEVADA