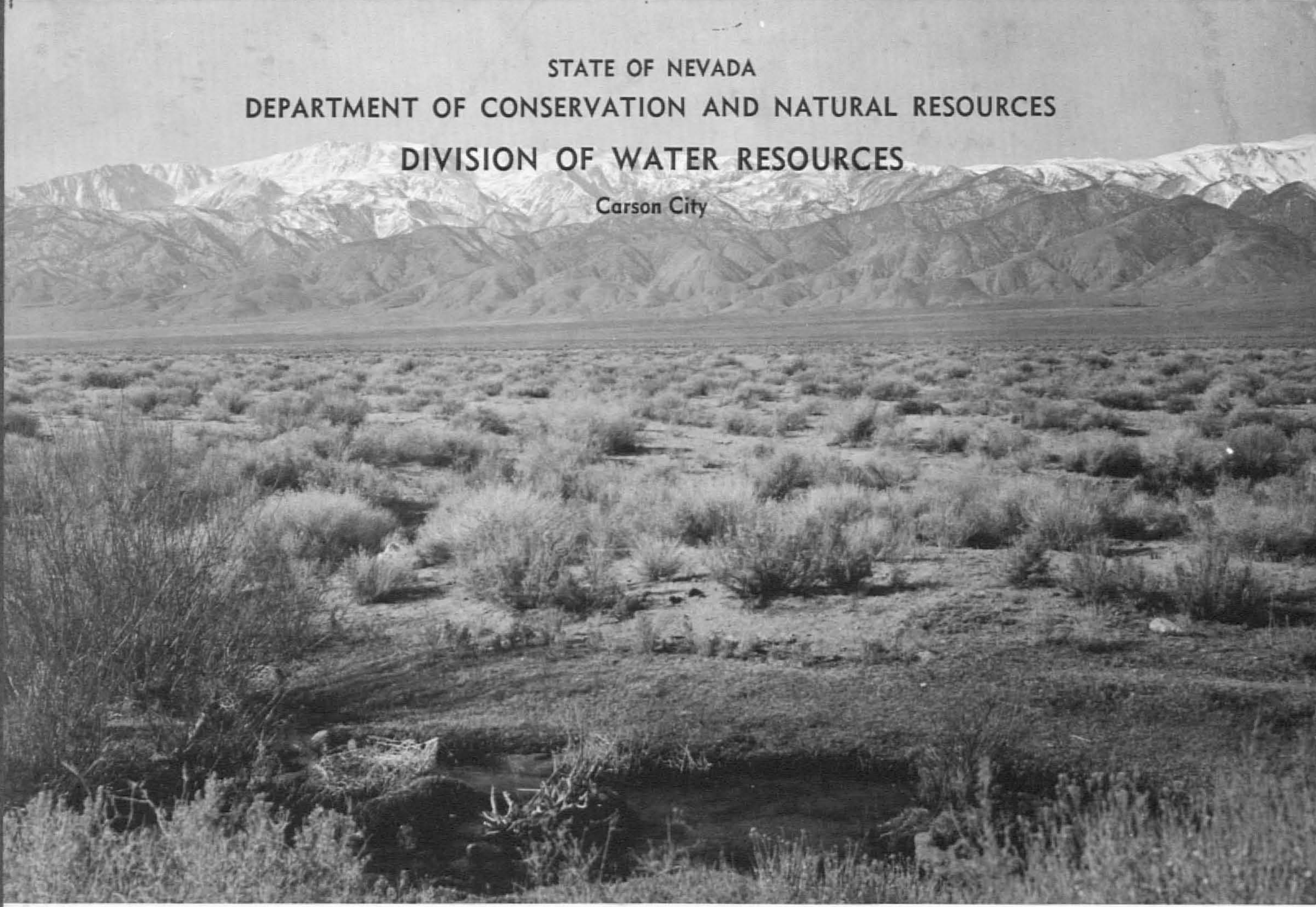
STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
DIVISION OF WATER RESOURCES
Carson City



View of White Mountains with Chiatovich Creek in foreground.

WATER RESOURCES—RECONNAISSANCE SERIES

REPORT 58

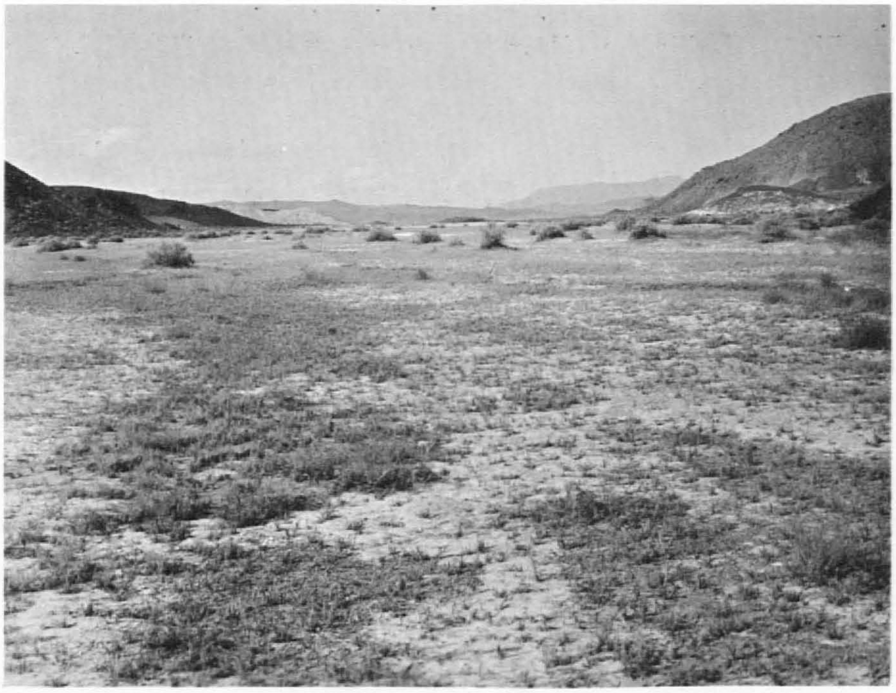
WATER–RESOURCES APPRAISAL OF FISH LAKE VALLEY, NEVADA AND CALIFORNIA

By
F. Eugene Rush
and
T. L. Katzer

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

1973

Well 5/37–20 bd. Note ground subsidence of about one foot beneath the concrete platform.



The gap at north end of the valley. Note the absence of a channel to carry streamflow from Fish Lake Valley to Columbus Salt Marsh Valley.

WATER RESOURCES - RECONNAISSANCE SERIES

REPORT 58

WATER-RESOURCES APPRAISAL OF FISH LAKE VALLEY, NEVADA AND CALIFORNIA

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Hydrologists

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FOREWORD

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

This report is the 58th report prepared by the staff of the Nevada District of the U.S. Geological Survey. These 58 reports describe the hydrology of 212 valleys.

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 reconnaissance-type studies are timely and adequately meet the immediate needs for information on the water resources of the areas covered by the reports.

Roland D. Westergard
State Engineer

Division of Water Resources

1973

CONTENTS

CONTENTS (CONTINUED)

ILLUSTRATIONS

TABLES

TABLES (CONTINUED)

WATER-RESOURCES APPRAISAL OF FISH LAKE VALLEY, NEVADA AND CALIFORNIA

By F. Eugene Rush and T. L. Katzer

SUMMARY

The younger and older alluvium of Fish Lake Valley form the valley-fill reservoir and, except for Fish Lake Spring that flows from carbonate rocks, are the principal source of ground water in the area. The principal water estimates for the valley are summarized as follows:

Ground water in storage in the upper 100 feet of saturated alluvium	2.7 million acre-feet
Perennial static water-level decline in pumped areas through 1971	Minor
Precipitation:	
Range in watershed (fig. 2)	4 to 20 inches
Total (table 5)	465,000 acre-feet per year
Average annual runoff from the mountains (table 4)	38,000 acre-feet
Average annual streamflow (table 3):	
Chiatovich Creek	6,700 acre-feet
Indian Creek	2,300 acre-feet
Leidy Creek	2,000 acre-feet
Perry Aiken Creek	5,400 acre-feet
McAfee Creek	2,600 acre-feet
Cottonwood Creek	4,800 acre-feet
Potential average annual recharge (table 5)	33,000 acre-feet
Average annual evapotranspiration of ground water in phreatophyte areas (table 6)	24,000 acre-feet
Average annual ground-water and surface-water outflow	3,000 acre-feet

Irrigation:	
Average annual growing season	140 ±20 days
Net consumption of streamflow in 1970	5,200 acre-feet
Wells:	
Number of active irrigation wells in 1970	31
Net pumpage for irrigation in 1970	11,000 acre-feet
Other pumpage	Minor
Net consumption from subirrigation in 1970 (table 7)	3,000 acre-feet
Perennial yield	30,000 acre-feet
Transitional storage reserve	1,300,000 acre-feet
Total water development and consumption in 1970 (table 12)	19,000 acre-feet

Most water sources in the valley yield water suitable for irrigation and domestic use.

INTRODUCTION

Fish Lake Valley is in Esmeralda County, Nevada, and the adjoining part of Mono County, California, as shown on plate 1. Fish Lake Valley has a population of perhaps 200 and includes an area of about 1,010 square miles. The local economy is principally ranching and farming; however, some mining is done on an intermittent basis. The nearest trade center is Bishop, California, about 50 road miles southwest of the valley.

Purpose and Scope of the Study

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

Recognizing this need, the State Legislature enacted special legislation (Chapter 181, Statutes of 1960) for beginning a series of reconnaissance studies of the ground-water resources of Nevada. As provided in the legislation, these studies are being made by the U.S. Geological Survey in cooperation with the Nevada Department of Conservation and Natural Resources. This is the 58th report prepared as part of the reconnaissance studies (fig. 1).

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 reservoir, (4) provide preliminary estimates of perennial yield and ground water in storage, and (5) estimate present and evaluate potential water development in the area. The field work was done mostly during August 1970 and March 1971.

Previous Work

Eakin (1950) described the ground-water hydrology and provided the first estimates of the water supply of Fish Lake Valley. The geology has been mapped by Albers and Stewart (1965) and Strand (1967).

The project area has been mapped as part of the 15-minute topographic quadrangle series (scale about 1 inch to the mile) of the U.S. Geological Survey. The maps include Benton, Blanco Mountain, Davis Mountain, Lida Wash, Magruder Mountain, Mount Barcroft, Piper Peak, Rhyolite Ridge, Soldier Pass, and White Mountain Peak.

Many adjacent valleys have been the subjects of similar reconnaissances, as shown in figure 1 and listed in the back of the report.

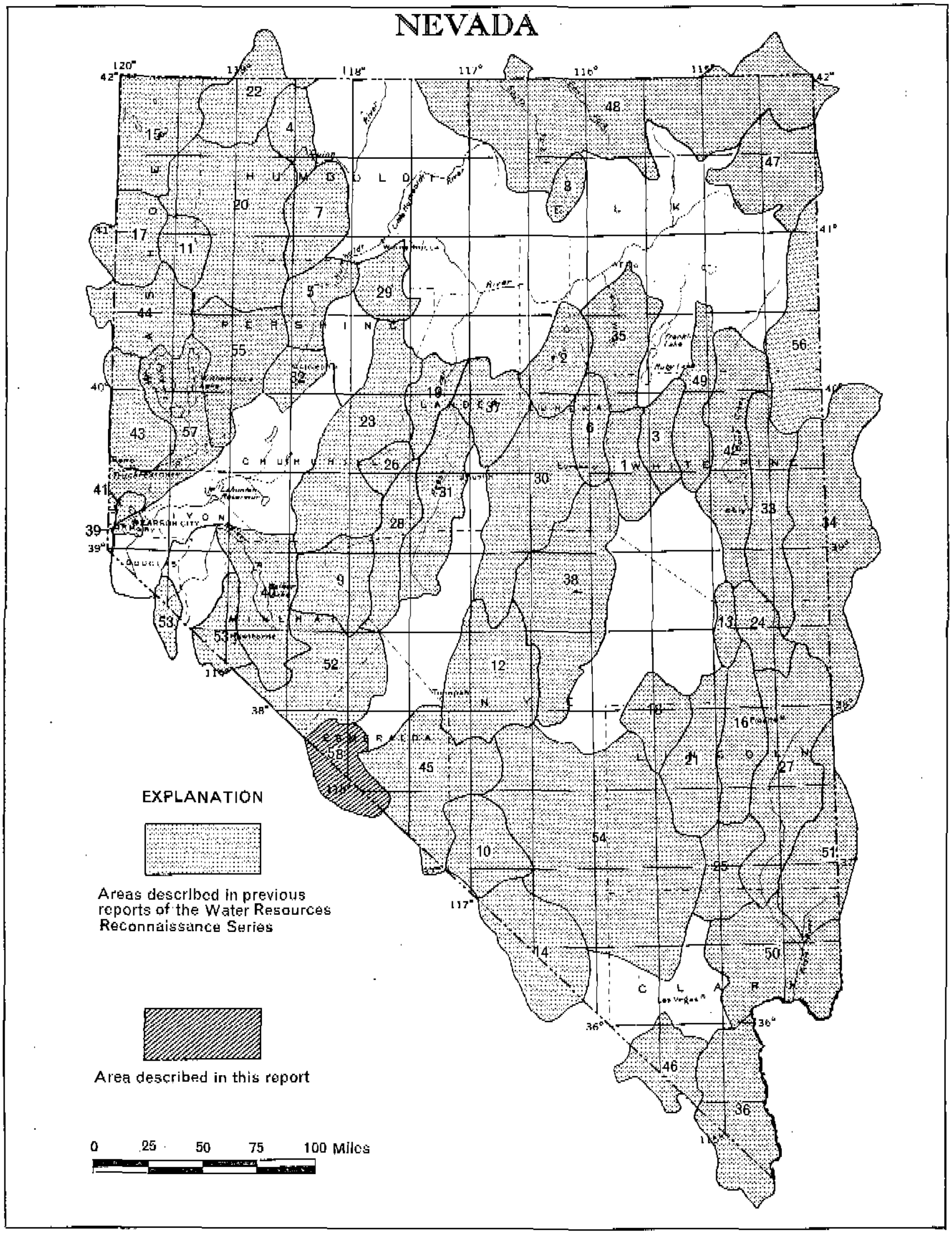


Figure 1.— Index map showing areas in Nevada described in previous reports of the Water Resources Reconnaissance Series and the area described in this report

HYDROLOGIC ENVIRONMENT

Physiography and Drainage

The mountains that border Fish Lake Valley trend northwestward. On the west, the White Mountains (pl. 1) have the highest peak in Nevada, Boundary Peak, altitude 13,140 feet. Farther south in the same range, White Mountain Peak, altitude 14,246 feet, is one of the highest peaks in California. The valley floor generally ranges in altitude from about 5,200 feet near Oasis to about 4,700 feet at the playa in the northeastern part of the valley. The mountains on the east side of the valley do not exceed 10,000 feet.

The following table summarizes some of the geographic features of the valley:

Alluvial area:	
Nevada	308 sq mi
California	64
Consolidated-rock area	
Nevada	418
California	220
Total area	1,010 sq mi

Consolidated rock-alluvium contact altitude:

Western mountains:	
Range	4,800-6,200 feet
Average	5,400 feet
Eastern mountains:	
Range	4,700-7,600 feet
Average	5,600 feet

Three major geomorphic units are recognized in the valley: Complexly folded and faulted mountain ranges, valley floors, and aprons or intermediate slopes between the mountains and the valley floors. The aprons include both alluvial fans and pediments. Pediments are erosional surfaces cut on bedrock, but commonly are mantled with a veneer of unsaturated alluvium ranging in thickness from a few to several tens of feet. By contrast, the alluvial fans are underlain by thick deposits of alluvium, deposited by runoff from the mountains.

Pediments, for example, occur in much of the area shown as older alluvium on plate 1 in the Palmetto Wash drainage area (southeastern part of valley).

Approximately five perennial streams, now diverted for irrigation, would flow to the valley floor under native conditions: Chiatovich, Leidy, Perry Aiken, McAfee, and Cottonwood Creeks. All drain from the White Mountains (pl. 1). The axial drainage in the valley generally is northward to a playa where most runoff, when it occurs, ponds and evaporates. Under unusually wet conditions, some water may flow northward beyond the playa and discharge through The Gap into Columbus Salt Marsh Valley (pl. 1).

Geologic Units and Structural Features

Rocks of the valley have been divided into four lithologic units: Noncarbonate rocks, carbonate rocks, older alluvium, and younger alluvium. This division is based largely on their hydrologic properties; however, the hydrologic properties of all four types may vary widely with differences in their physical and chemical properties. The areal extent of the units is shown on plate 1. The geology is based principally on the Esmeralda County geologic map of Albers and Stewart (1965), geology of the California part of the valley by Strand (1967), aerial-photographs, and interpretation of drillers' logs.

Noncarbonate and carbonate rocks form the mountain masses and underlie the younger and older alluvium at depth. The carbonate rocks, Precambrian(?) to Quaternary in age, are mostly limestone. As shown on plate 1, carbonate rocks are subordinate in the mountain ranges. In Nevada, carbonate rocks commonly contain fractures and solution channels, and therefore the carbonate rocks of this area probably are capable locally of transmitting relatively large volumes of water, such as to Fish Lake Spring (T. 2 S., R. 35 E. on pl. 1).

Noncarbonate rocks, Cambrian to Quaternary in age, are mostly granitic rocks, volcanic flows, and tuff. The noncarbonate rocks are less susceptible to solution than carbonate rocks and are therefore generally much less permeable.

Older alluvium, Pliocene and Pleistocene in age, is composed mostly of clay, silt, sand, and gravel formed from rock debris washed from the adjacent mountains. Older alluvium underlies much of the aprons and valley floor. These deposits are characteristically semiconsolidated to unconsolidated, dissected, and locally faulted and deformed.

Younger alluvium, in contrast to older alluvium, generally is unconsolidated, undissected, moderately well sorted, and undeformed. It is Pleistocene and Holocene in age and is composed of gravel, sand, silt, and clay deposited by the principal streams on the valley floor, as shown on plate 1. Younger alluvium also underlies the playas; the deposits also are of late Pleistocene and Holocene age. The coarse-grained material of the younger alluvium probably is more porous and more permeable than most of the older alluvium.

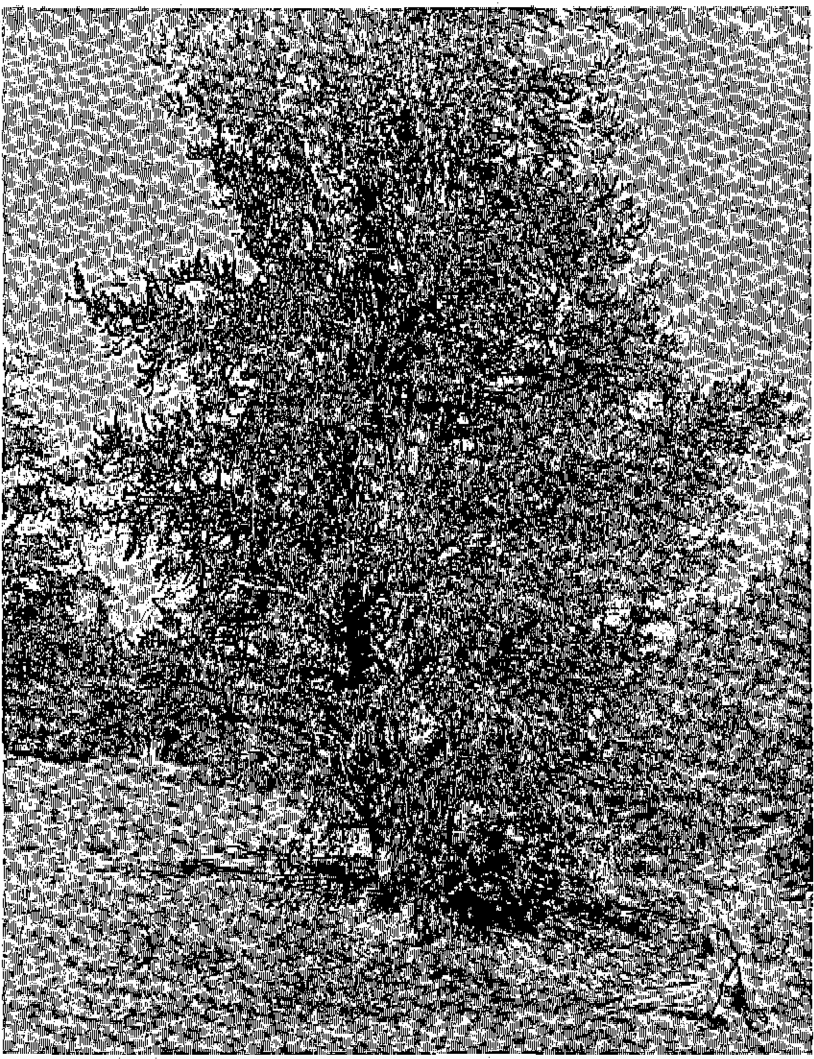
Faults have been mapped by Albers and Stewart (1965) and Strand (1967) and by the writers from aerial photographs. Only those that cut alluvium or are of regional extent are shown on plate 1.

Upper Photograph:

View of one of the many ancient Bristlecone Pines that grow at the higher altitudes of the White Mountains.

Lower Photograph:

View of the large playa, showing both wet and salty conditions. Both conditions are produced by rising ground water.



VALLEY-FILL RESERVOIR

General Characteristics

Younger and older alluvium (pl. 1) form the valley-fill reservoir and, except for Fish Lake Spring that flows from carbonate rocks, is the principal source of ground water in the area. Few wells deeper than 500 feet have been drilled; therefore, little is known about the total thickness of the valley-fill reservoir. Well 2/35-33ac was reportedly drilled to consolidated rock at a depth of 1,010 feet (table 13). The reservoir beneath most of the valley floor probably is at least 1,000 feet thick, and perhaps several thousand feet thick (reportedly 5,100 feet in one test hole). Although bedrock reportedly has been encountered in wells at shallower depths, they were drilled near the bedrock-alluvium contact where the valley-fill reservoir generally is thin.

External hydraulic boundaries are formed by the consolidated rocks (pl. 1), which underlie and form the sides of the valley-fill reservoir, live streams, irrigated fields, and perhaps flooded playas. The consolidated rocks, particularly the carbonate rocks, are leaky in that they may transmit moderate amounts of recharge from the mountains to the valley-fill reservoir by subsurface flow.

The principal internal hydraulic boundaries are the faults cutting the valley fill, as shown on plate 1, and lithologic changes. The extent to which these potential barriers impede ground-water flow probably will not be understood until substantial ground-water development occurs. Based on data for about 40 large-diameter (greater than 12 inches) wells, the transmissivity of the upper 400 feet of the valley-fill reservoir generally is about 100,000 gpd/ft (gallons per day per foot) and in the vicinity of the Bar Double 9 Ranch, it may be as high as 200,000 gpd/ft. A transmissivity of 100,000 gpd/ft is equivalent to an aquifer of coarse sand or a mixture of gravel and coarse sand (permeability of about 1,000 gpd per sq ft) with a thickness of about 100 feet. Related to well performance, it is equivalent to a yield of 3,000 gpm (gallons per minute) with a drawdown of about 35 feet at the end of 24 hours of continuous pumping. The fact that some wells do not perform at this level is related generally to two causes: (1) the valley-fill reservoir has internal variation in lithology and therefore in transmissivity, and (2) the hydraulic efficiency of most wells is less than 100 percent. The transmissivity of the total thickness of the valley-fill reservoir may be much higher.

The variation in depth to water in the valley-fill reservoir is related to vegetation, as shown on plate 1:

Dominant vegetation	Approximate depth to water (feet)
Sagebrush, shadscale, and other nonphreatophytes (not shown on pl. 1)	greater than 50
Greasewood and rabbitbrush	10-50
Saltgrass	5-10
Meadow	0-5
Barren playa	0-5

The maximum depth to water is not known, but it probably is several hundred feet on the upper parts of some alluvial fans.

An oil-exploration well was drilled in the fall of 1970 at 1/36-16ab (pl. 1). The reported total depth of the well was 9,178 feet. Aluvium was reported to a depth of 5,000 feet, volcanic rocks from 5,000 to 6,000 feet. Below the volcanic rocks, various types of rock were reported, including limestone and dolomite. Artesian "water sands" were reported in the alluvium between depths of 580-790 feet and 1,150-1,400 feet. The well was completed as a water well with a reported depth of 536 feet. According to Ted Gray, a local resident (oral commun., 1971), the well can be pumped at a high rate of discharge and produces hot water.

Ground-Water Flow

Within the valley-fill reservoir, ground water occupies the intergranular pores in the zone of saturation and flows from areas of recharge to areas of discharge. The reservoir is recharged in three ways: (1) seepage loss from streams into alluvium, (2) lateral underflow from consolidated rocks of the mountains to the valley-fill reservoir, and (3) precipitation on alluvial areas. Locally, water may enter consolidated rocks from alluvium and streams. Local streamflow and underflow are derived from precipitation within the drainage basin, as generally defined by the topographic divide shown on plate 1. Most recharge is attributed to precipitation on and runoff from the mountains. Type (3) recharge is considered to be very small, and in this part of Nevada probably is not an important source. As a result, ground water migrates from the apron and mountain fronts toward the axis of the valley and then northward along the axis toward the playas, as shown by water-level contours on plate 1. An unknown amount of ground water probably flows from the north end of the valley through alluvium in The Gap (pl.1).

Ground Water in Storage

Recoverable ground water in storage in the valley-fill reservoir is that part of the water moving through the reservoir that will drain by gravity in response to pumping.

Under native conditions, the amount of stored ground water remains nearly constant. Table 1 shows water-level declines under existing conditions. The observed decline in storage is minor.

Recoverable ground water in storage is the product of the specific yield, the area, and the selected saturated thickness of alluvium. In Fish Lake Valley, the average specific yield of the valley-fill reservoir may be about 15 percent. Estimated ground water in storage in the upper 100 feet of saturated alluvium (assume 75 percent of alluvial area listed on page 5 is about 2.7 million acre-feet. The depth below land surface to this block of stored ground water is discussed on page 10.

Table 1.--Water-level decline in selected wells

Well number	Date	Depth to water[1] (feet below land surface)	Water-level decline for period (feet)	Average rate of water-level decline (feet per pumping season)
1N/36-9cc	8-27-70	12.5		
	3-15-71	12.47	0	0
1/35-27ac	11- -69	43		
	3-15-71	49.10	6	6
1/35-34cb	3- -53	18(?)		
	3-18-68	38.69		
	11-20-68	40.59		
	3-15-71	38.74	20?	1.1?
2/35-3cc	10- -52	40		
	3-18-68	43.73		
	11-20-68	42.97		
	3-16-71	39.81	0	0
2/35-16ca	1- -55	72		
	3-16-71	80.55	9	.6
2/35-28dd	6-30-54	66		
	8-26-70	68.72		
	3-16-71	63.17	0	0
2/35-33ab	8- -48	42(?)		
	11- 9-49	55.20		
	3-16-71	54.11	12?	.5?
3/35-26cc	9- -60	81		
	3-16-71	81.09	0	0
3/35-25bb	11-10-49	4.64		
	8-24-70	9.41		
	3-16-71	7.63	3	.1
4/36-15cb	4- -60	16		
	3-16-71	17.72	2	.2

[1] Water levels listed to nearest foot were reported by well driller; water levels listed to a fraction of a foot were measured.

INFLOW TO THE VALLEY-FILL RESERVOIR

Inflow to the valley-fill reservoir is estimated by reconnaissance techniques developed by the Geological Survey in cooperation with the Nevada Department of Conservation and Natural Resources. The components of inflow to the valley-fill reservoir include precipitation, surface-water runoff from the mountains, and subsurface inflow from the mountains through alluvium and carbonate rocks. All three contribute to ground-water recharge of the valley-fill reservoir.

Precipitation

The precipitation pattern in Nevada is related principally to the topography; the weather stations at higher altitudes generally receive more precipitation than those at lower altitudes (Hardman, 1965). However, this relation may be considerably modified by local conditions. The valley floor of the report area probably receives an average of only about 4 to 6 inches of precipitation per year, whereas the highest mountain areas may have an average annual precipitation of 24 inches or more. Figure 2 illustrates the increase in precipitation with altitude. The precipitation data on which this graph is based are listed in table 2.

The two high-altitude stations shown in figure 2 may not record all precipitation. According to Robert Elford, National Weather Service, San Francisco (oral commun., 1971), the two high-altitude stations probably do not record all the precipitation which falls as snow, due to the high winds that generally accompany the storms, as precipitation gages are designed to catch snow falling near vertical. Therefore, a lesser amount is recorded. Using data recorded at 13 stations and the judgements of Robert Elford, an altitude-precipitation relation, as shown by the line in figure 2, was used as the basis to compute estimated average annual precipitation and ground-water recharge in table 5.

On valley floor and apron, where the average annual precipitation is small, little precipitation directly infiltrates into ground-water reservoir. Most precipitation is evaporated before infiltration and some adds to soil moisture. However, intense precipitation during thunderstorms may supply infrequent recharge. Greater precipitation in the mountains provides most of the recharge and runoff.

Data for the mountain stations (table 2) indicate that high-altitude precipitation generally is greatest in February and April and smallest in the fall. On the valley floors of the area, winter and early spring are the wettest periods, early summer and early fall the driest.

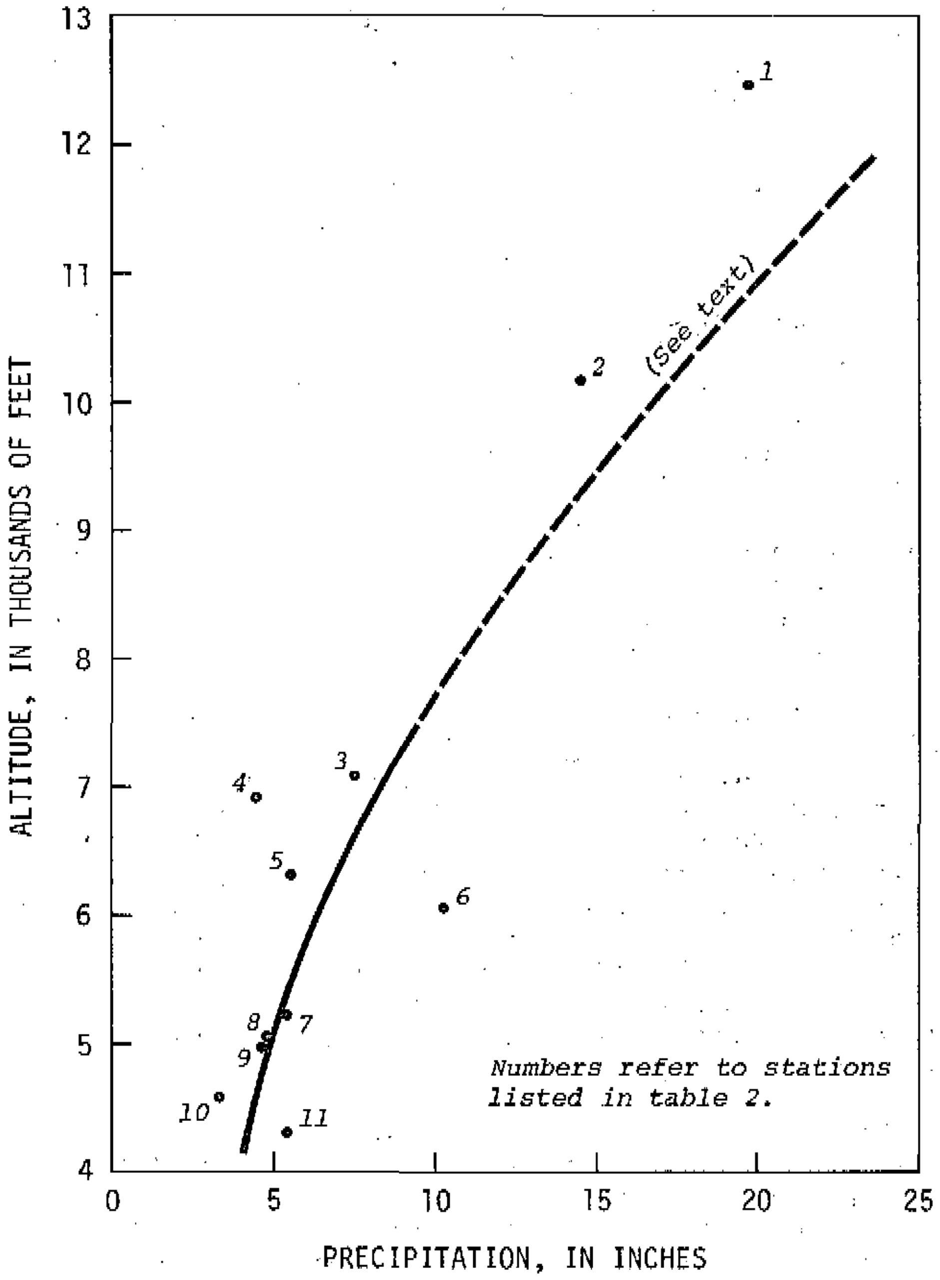


Figure 2.- Approximate relation of precipitation to altitude

Table 2.--Average annual precipitation at weather stations in and near Fish Lake Valley

Number on figure 2	Station	Location as shown on plate 1	Altitude (feet)	Period of record (years)	Average annual precipitation (inches)
1	White Mountain no. 2	4S/34-20d	12,470	1956-69	a 19.7
2	White Mountain no. 1	5S/35-19d	10,150	1956-69	a 14.5
3	Montgomery Maintenance Station	1N/33-5a	7,100	1960-69	7.6
4	Palmetto	near Palmetto[1]	6,900	1945-49	4.5
5	Basalt	2N/33-23d	6,350	1941-57	5.6
6	Lida	5S/40-36c	6,100	1912-18	10.3
7	Deep Spring College	7S/36-1b	5,225	1948-69	5.4
8	Oasis Ranch	5S/37-28a	5,106	1903-19	4.8
9	Dyer 4 SE	4S/36-6c	4,975	1948-69	4.7
10	Coaldale	6 mi NE of valley[1]	4,646	1941-58	3.3
11	Silver Peak	7 mi E of valley[1]	4,320	1968-69	5.4
--	Benton Inspection Station	1S/32-20c	5,461	1965-69	10.4
--	Palmetto	6S/39-6c	6,500	1890-1911	b 17.2
--	Bishop	7S/33-5a	4,118	1946-69	5.5

a. Probably is less than actual precipitation. See text.

b. Seems unrealistically large.

1. Twenty-four miles east of Dyer.

Runoff

Six perennial streams headwatering in the White Mountains flow onto the alluvial apron of Fish Lake Valley. These streams are, from north to south, Chiatovich, Indian, Leidy, Perry Aiken, McAfee, and Cottonwood Creeks (pl. 1). During wet years, flow from these streams reaches and ponds on the playa. No perennial streams flow to the valley floor from the mountains on the north, east, and south.

Of the two types of precipitation, snow and rain, snow is by far the greatest supplier of water. Summer thundershowers provide large quantities of water over small drainage areas for short periods of time, and therefore provide very little water to the overall hydrologic system.

A continuous water-stage recorder has been operated on Chiatovich Creek since October 1961. Table 14 (at back of report) summarizes the measured annual streamflow for this station. Two partial-record gages were installed in May 1967 on tributaries of Palmetto Wash, which drains into the southeast corner of the valley (pl. 1). Table 15 (at back of report) shows the maximum flows recorded at these stations. Several measurements have been made for this report on the perennial streams and are summarized in tables 16 and 17 (at back of report). Indian Creek has been operated as a low-flow partial-record station and table 18 (at back of report) presents these data.

Chiatovich Creek

Figure 3 shows the monthly flow of Chiatovich Creek and the monthly precipitation of U.S. Weather Bureau Station White Mountain no. 2. The water years[1] of low streamflow and no peak flows in excess of 600 acre-feet per month, 1961, 1964, 1966, 1968, and 1971, are characterized by low precipitation and a small winter snowpack.

The runoff pattern of Chiatovich Creek is unusual in that peak flows in excess of 600 acre-feet per month occur late in the water year, usually in July, August, and September, and the resulting recessional flows continue to decrease, with minor fluctuations, until the cycle repeats itself the next year or after several years. Figure 4 shows the mean monthly flow distribution for Chiatovich Creek. The 25 percent quartiles, which are plotted, define those points at which 25 percent of the flows are greater and less than indicated. In general, streams of the Great Basin and nearby Sierra Nevada

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1. A water year is measured from Oct. 1 to Sept. 30.

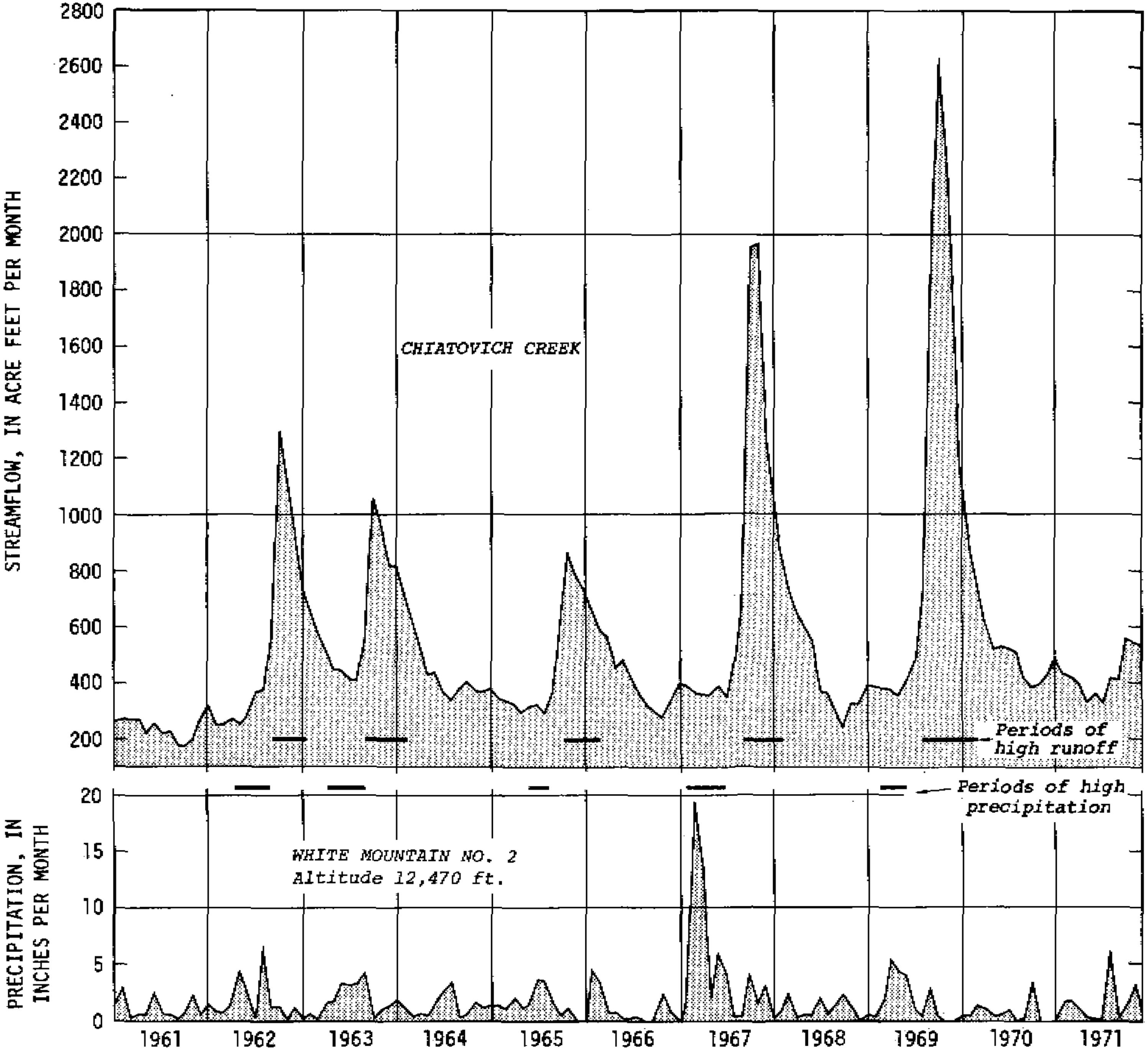

Figure 3.- Relation of streamflow to precipitation for water years 1961-71

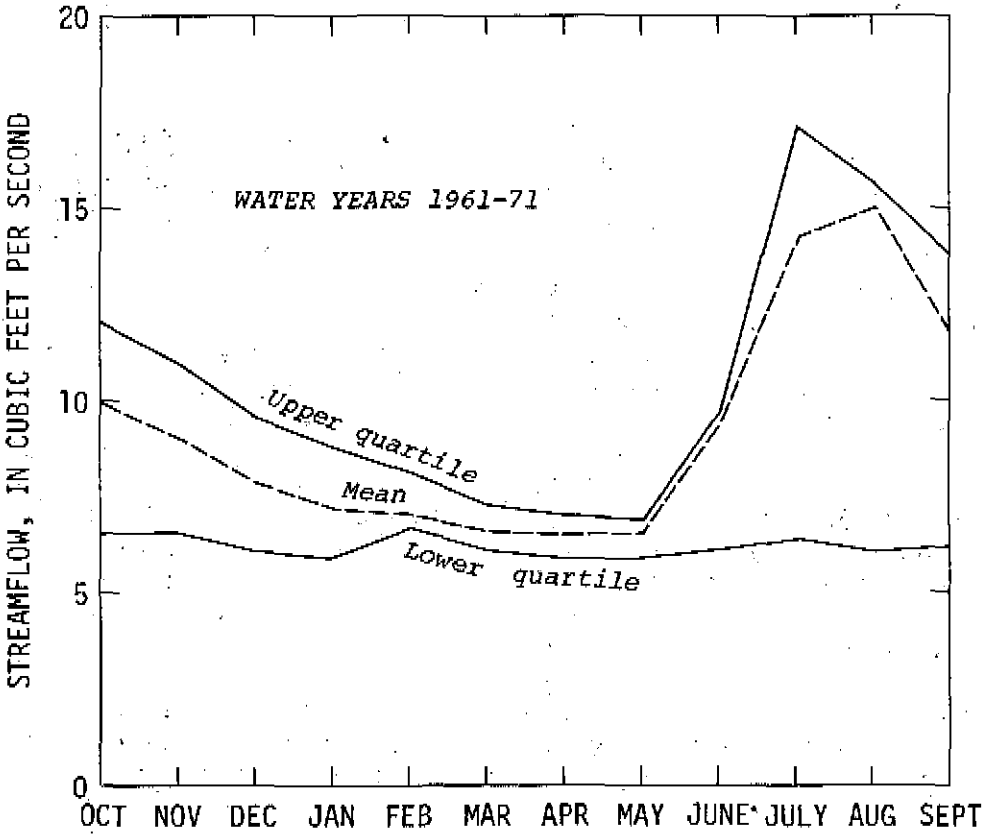

FIGURE 4.- Mean monthly flow distribution of Chiatovich Creek

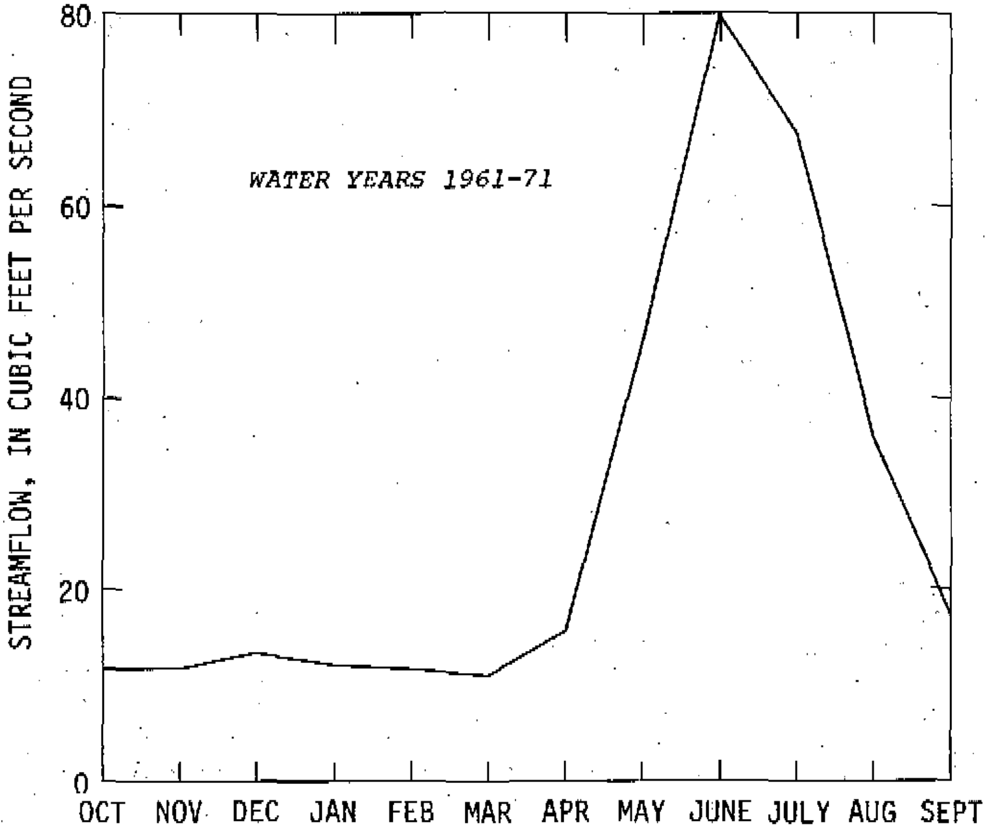

Figure 5.- Mean monthly flow distribution of Rock Creek at Little Round Valley near Bishop, Calif.

peak in late spring to early summer with a late summer recession that drops to base flow during fall and winter. To illustrate this more common runoff pattern, the mean monthly flow distribution for Rock Creek at Little Round Valley near Bishop, California (not on pl. 1), is shown in figure 5. This station is the nearest recording station to Chiatovich Creek. Thus, the peak flows for Chiatovich Creek are later than Rock Creek and the recession period is much longer. The long recessional period may be due in part to the location of the gage on the apron, which measures not only the flow of Chiatovich Creek but also that of the immediate drainages to the south and north, Davis and Middle Creek, respectively. The altitude of the gage is about 6,320 feet, and about 2 miles to the west the average mountain front altitude is about 7,000 feet. Runoff recharges this rather large block of permeable alluvium above the gage, which then drains into Chiatovich Creek and probably accounts in part for the long recessional flow period.

Chiatovich Creek was measured at several sites on its fan (table 16), and these data show that the stream was losing water to the ground-water reservoir or by evapotranspiration. Losses across the fan varied from a high of 40 percent in March 1971 to a low of 8 percent in July 1971; the average of the eight measurements was about 25 percent of the flow at the gage, or about 1,700 acre-feet per year for 1961-71.

Flow-Frequency Characteristics

Frequency curves for Chiatovich Creek, based on only 10 years of record, enable an approximate prediction of the percentage of time that any given flow will be equaled or exceeded and the prediction of recurrence intervals for any given flows. These frequency curves represent an average for the reference period and do not apply to flow distribution for a single or small group of years.

Flow-duration curve.--Figure 6 shows the flow-duration curve for Chiatovich Creek. From this curve, the length of time that any given flow is equaled or exceeded can be determined. For example, a flow of 8 cfs (cubic feet per second) is equaled or exceeded about 40 percent of the time. This does not mean that in any given year this value will be reached, but that if the 10-year period is representative of the long term, it would average out to be about this value.

High- and low-flow frequency curves.--Figure 7 shows the high- and low-flow frequency curves for Chiatovich Creek. These curves show recurrence intervals that may be expected for any given flow for the period of the indicated consecutive days. For example, a high flow of at least 30 cfs for 7 consecutive days has a recurrence interval of 5 years, and a low flow of not greater than 4 cfs for 90 consecutive days has a recurrence interval of 8 years.

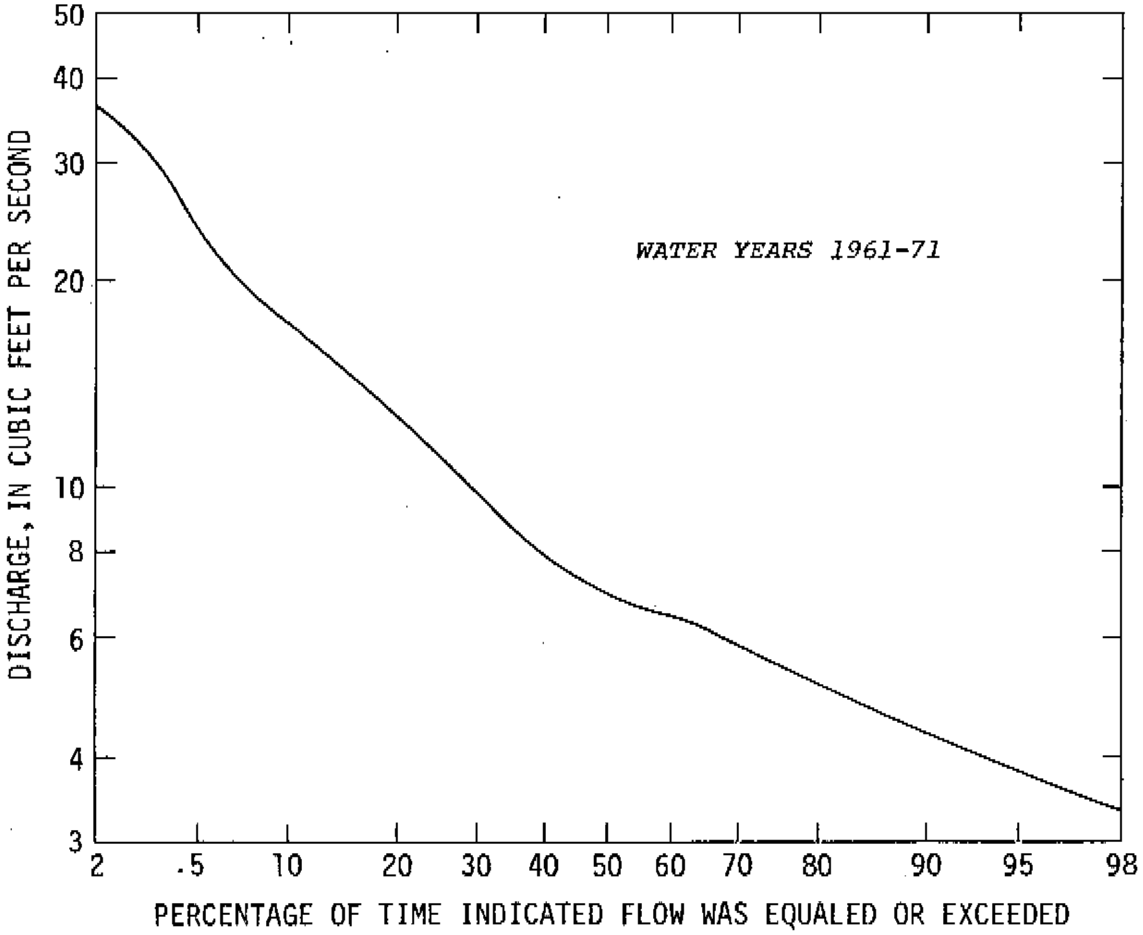

Figure 6.- Flow-duration curve for Chiatovich Creek gaging station

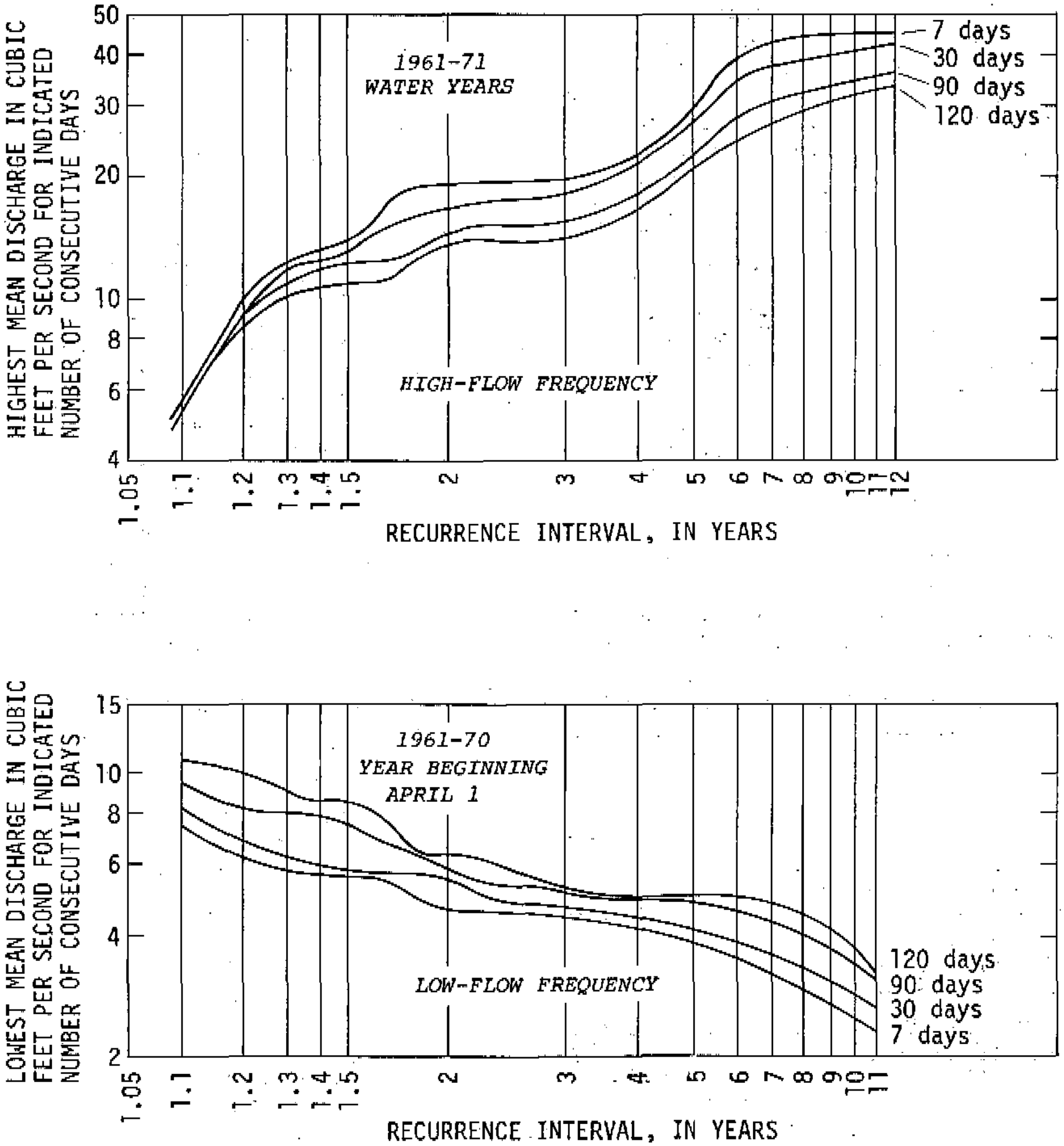

Figure 7.- High and low-flow frequency curves for Chiatovich Creek

The relation between the monthly mean flow for a peak-flow month and the water content of the April 1 snowpack can be used in conjunction with the minimum base-flow recession curve of Chiatovich Creek, figures 8 and 9, respectively. For example, if the April 1 snowpack contains 15 inches of water, then using figure 8, the monthly mean flow during the peak-flow month is expected to be about 35 cfs ±20 percent. Peak flows in excess of 600 acre-feet per month occur in July or August about 90 percent of the time. From figure 4, the mean flow in July and August is about 15 cfs; therefore, 35 cfs would indicate a high-flow year.

Streamflow prediction is possible prior to a flow increase associated with a peak flow. If, for example, the flow rate of Chiatovich Creek was 10 cfs on April 1, the May 1 (1 month later) minimum flow would be 8 cfs (fig. 9), and the June (2 months later) minimum flow, 7 cfs. If the snowpack was minimal, with no resulting peak flow, the flow would decline to a minimum 5 cfs by October (5 months later, as shown in fig. 9) at the end of the growing season. If minimum flow is supplemented by local precipitation occurring after April 1, base flow would be higher, depending on the amount of runoff generated by the precipitation.

Data are not available on the other perennial streams for this type of definition; however, in general, if the flow of Chiatovich Creek is above average, then the other perennial streams can also be expected to have a better-than-average year.

Table 3.--Perennial streamflow from the White Mountains

Stream	1971 water-year streamflow in acre-feet	Average annual streamflow in acre-feet for water years 1961-71[1]
Chiatovich Creek	5,400	6,700
Indian Creek	1,900	2,300
Leidy Creek	1,700	2,000
Perry Aiken Creek	4,500	5,400
McAfee Creek	2,200	2,600
Cottonwood Creek	4,000	4,800
Total (rounded)	20,000	24,000

1. The 1971 Chiatovich Creek flow was 80 percent of its 11-year mean; therefore, the average totals for the other streams are based on 120 percent of 1971 estimates.

Runoff from the Mountains

Runoff estimates of the perennial streams at the mountain front are based on streamflow measurements and channel-geometry methods (Moore, 1968). Estimates for six streams are listed in table 3. Flow probably decreases both upstream and downstream

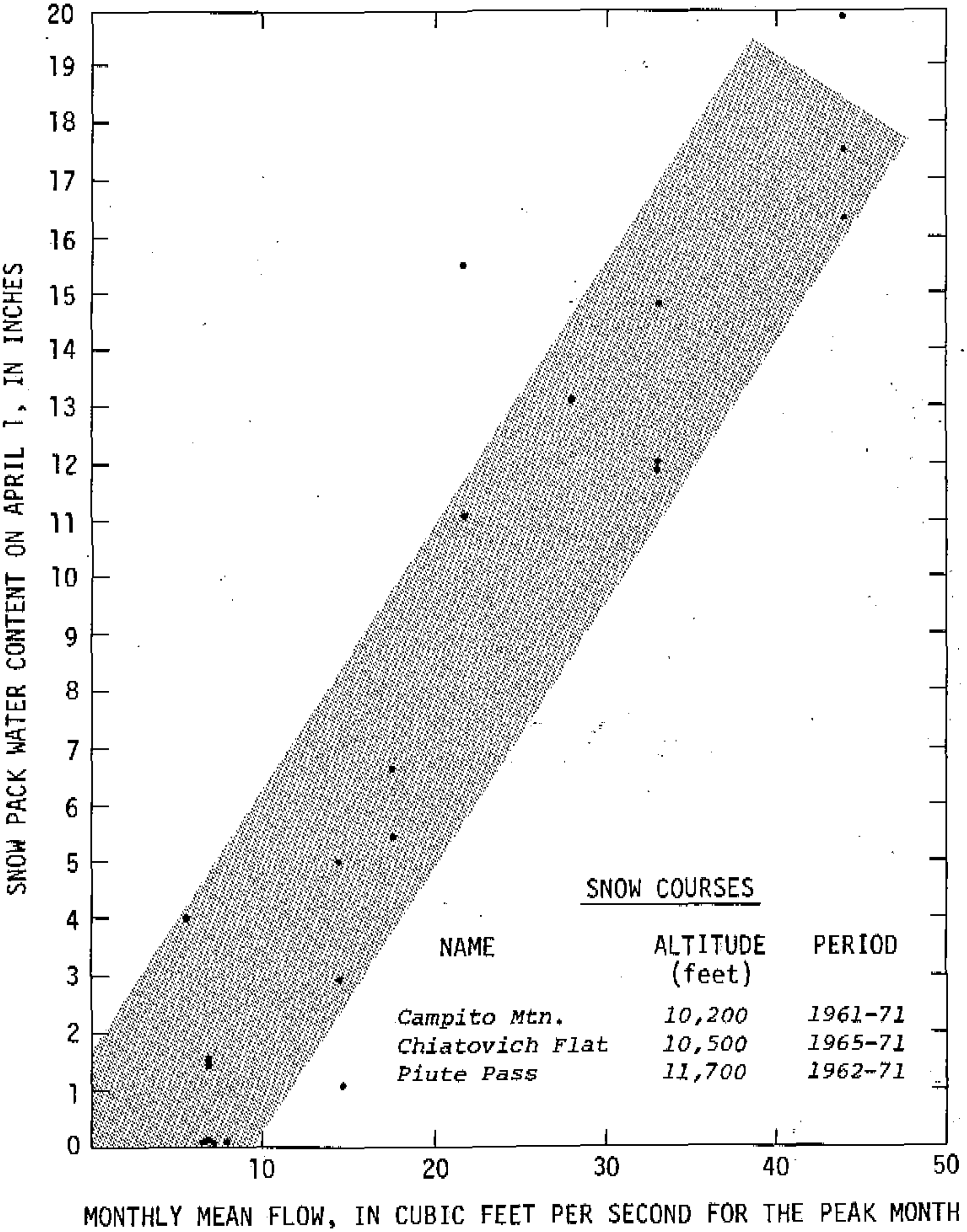

Figure 8.- Relation of snow survey measurements to flow of Chiatovich Creek

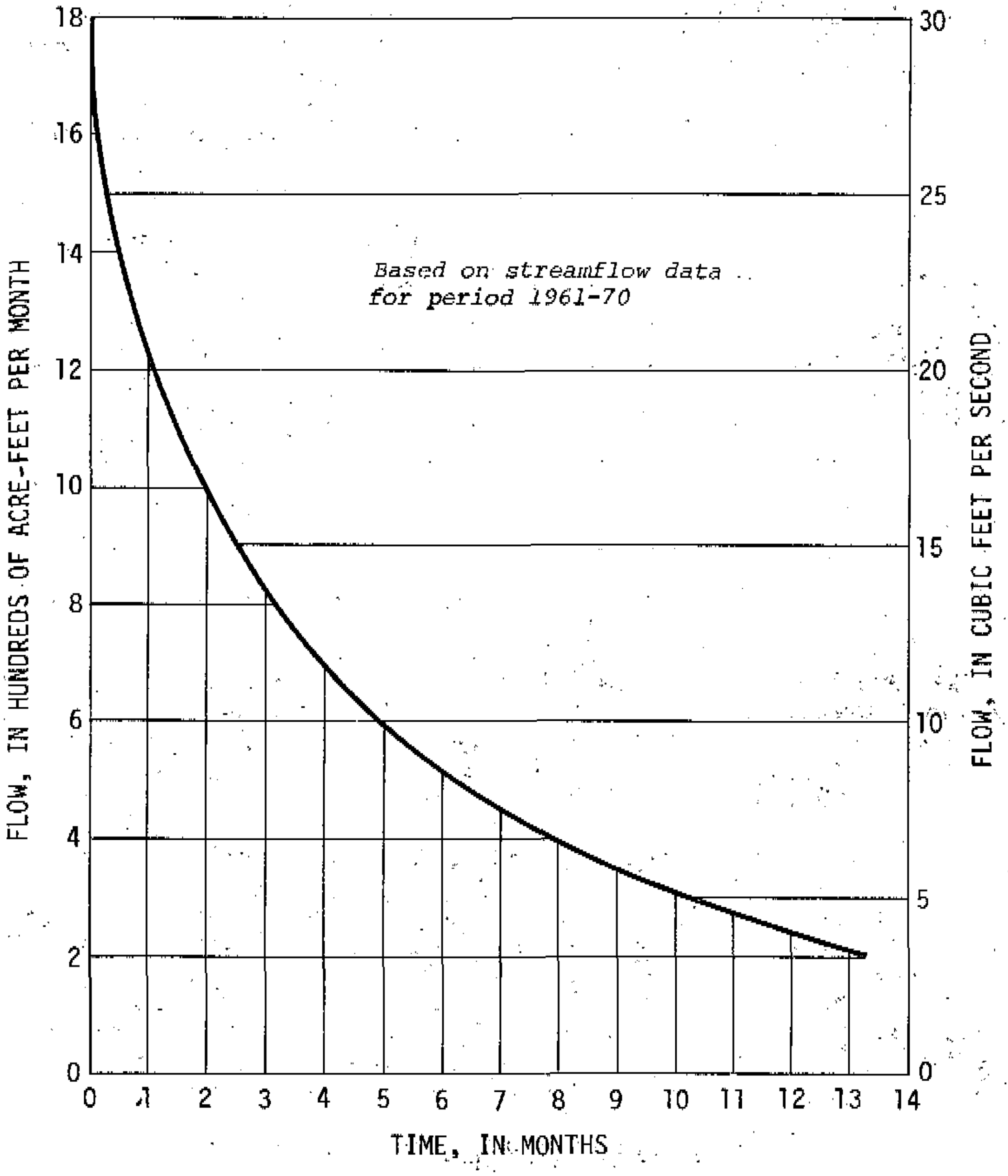

Figure 9.- Recession curve for Chiatovich Creek

from the mountain front and no significant surface runoff originates below an altitude of about 7,000 feet. Therefore, by defining precipitation-altitude zones with corresponding runoff and modifying these values with channel-geometry techniques (both methods developed by Moore, 1968), a moderately reliable average annual runoff value can be assigned to the flow crossing the 7,000-foot contour. Table 4 summarizes the estimated average runoff from the three major mountain blocks; the total is 38,000 acre-feet per year.

Table 4.--Estimated average annual runoff from the mountains

Area	Acres above 7,000 feet (rounded)	Percentage of total area	Runoff in acre-feet	Percentage of total runoff
White Mountains	143,000	65	32,000	84
Silver Peak Range	50,000	22	4,000	11
Palmetto Mountains	28,000	13	2,000	5
Total (rounded)	221,000	100	38,000	100

No estimate was made of the amount of runoff reaching the playa. However, ranchers report that flow ponds on the playa in wet years. The amount may average a few thousand acre-feet per year. In exceptionally wet years, the ponded water may overflow northward through The Gap to Columbus Salt Marsh.

Runoff Crossing the State Line in Fish Lake Valley

Most of the headwater drainages in the White Mountains are in California, but the downstream segments are in Nevada. Of the average annual runoff from the White Mountains, approximately 85 percent, or 27,000 acre-feet, originates in California, and of this amount, about 66 percent, or about 18,000 acre-feet, flows across the State line. The remainder infiltrates to the ground-water reservoir or is consumed in California.

Potential Ground-Water Recharge

A method developed by Eakin and others (1951) was used to compute the estimated potential average annual recharge to the valley-fill reservoir. These computations are summarized in table 5, which shows that about 7 percent of the estimated average annual precipitation potentially recharges the valley-fill reservoir of the valley. The origin of potential recharge from precipitation is as follows: (1) White Mountains, about 90 percent; Silver Peak Range and Palmetto Mountains, about

Table 5.--Estimated average annual precipitation and potential ground-water recharge

Altitude zone (feet)	Area (acres)	Estimated precipitation			Estimated potential recharge	
		Range (inches)	Average (feet)	Average (acre-feet)	Percentage of precipitation	Acre-feet
14,000-14,246	30	>20	1.8	83,000	25	21,000
13,000-14,000	1,330					
12,000-13,000	7,620					
11,000-12,000	15,700					
10,000-11,000	21,300					
9,000-10,000	24,900	15-20	1.5	37,000	15	5,600
8,000-9,000	48,500	12-15	1.1	53,000	7	3,700
7,000-8,000	102,000	8-12	.8	82,000	3	2,500
4,700-7,000	426,000	<8	.5	210,000	minor	--
Total (rounded)	647,000	--	--	465,000	7	[a] 33,000

[a] May be high, because some of the potential recharge from streamflow is rejected in areas of high water level and flows to the playa where it ponds and evaporates.

10 percent; or (2) in terms of the two States, Nevada, about one-third; California, about two-thirds. However, some recharge derived from precipitation in California crosses the State line as runoff and infiltrates to recharge the ground-water reservoir in Nevada. The relation of runoff to recharge is a ratio of 1.2:1, or slightly lower than the average for the entire State.

For the altitude zones above 7,000 feet, estimates of land area and average annual precipitation by Eakin (1950, table 9) were somewhat larger than those shown in table 5. The estimates in this report are considered more accurate because more precipitation data and better topographic maps are now available. Eakin's computed estimate of average annual recharge to the valley of 54,000 acre-feet, for the same reasons stated above, is believed to be too large. However, Eakin (1950, p. 26) also concluded that his computed estimate was too large on which to base potential development.

OUTFLOW FROM THE VALLEY-FILL RESERVOIR

Under native conditions, the components of outflow were evapotranspiration of ground water by phreatophytes, outflow of both surface and ground water to Columbus Salt Marsh Valley from the north end of the valley, and spring flow. Additional man-made discharge includes irrigation and well pumpage associated with mining, stock-watering, and domestic needs, and export of water.

Evapotranspiration of Ground Water

Ground water is discharged by evaporation from soil and transpiration by plants that root in shallow water-table areas. These plants that tap the ground-water reservoir are called, phreatophytes. The phreatophytes essentially are limited to the valley floor, as shown on plate 1. The principal types of phreatophytes are greasewood, rabbitbrush, saltgrass, and various native meadow grasses. Discharge by phreatophytes for native conditions is summarized in table 6. Areas now irrigated have been evaluated in terms of probable prepumping conditions of natural discharge. Rates used in table 6 are based on work done in other areas by Lee (1912), White (1932), Young and Blaney (1942), Robinson (1958, 1965) and Harr and Price (1972). Eakin (1950, table 10) estimated the average annual evapotranspiration by phreatophytes to be 30,000 acre-feet, which is somewhat more than the estimate in this report.

Outflow from the Valley

A small amount of surface water occasionally flows from the north end of Fish Lake Valley to Columbus Salt Marsh Valley at The Gap. Based on stream-channel geometry measurements, the streamflow leaving the valley is estimated to average less than 100 acre-feet per year. The frequency of flow is not known, but it probably occurs infrequently over a period of years.

Ground-water outflow from the valley through the alluvium occurs through a very small cross-sectional area and with a low gradient. As a result, this outflow is estimated to be a minor part of the water budget of Fish Lake Valley; that is, less than 200 acre-feet per year (Van Denburgh and Glancy, 1970, p. 24). However, the water budget for Columbus Salt Marsh (Van Denburgh and Glancy, 1970, p. 30) suggests that subsurface outflow from Fish Lake Valley through volcanic and carbonate rocks could be as much as 3,000 acre-feet per year. In addition, outflow to Clayton Valley could occur through the Silver Peak Range. For the purposes of this reconnaissance, total ground-water outflow is assumed to be 3,000 acre-feet per year.

Table 6.--Estimated evapotranspiration of ground water by phreatophytes and bare soil

[For native conditions; areas shown on plate 1]

Phreatophyte	Depth to water (feet)	Area (acres)	Selected average annual rate of water use (feet)	Estimated recharge (acre-feet per year)
Some greasewood mixed with mostly shadscale and big sage[1]	30-50	4,400	0.1	440
Mostly greasewood and rabbitbrush with minor amounts of saltgrass and shadscale	10-30	45,000	.2	9,000
Mostly saltgrass mixed with some greasewood and rabbitbrush	5-10	15,000	.5	7,500
Wet and dry meadow; mostly meadow grasses and saltgrass[2]	<5	5,500	1.0	5,500
Bare soil of playa; partly covered with saltgrass and salt deposits. Soil damp to surface and very soft	<2	1,900	1.0	1,900
Bare soil of playa; surface dry and hard. Some saltgrass present[3]	<12	700	.7	70
Willow, cottonwood, tules, wildrose, and saltcedar[4]	--	small	--	small
Total (rounded)	--	a 72,000	.3	b 24,000

1. Shown combined with next unit on plate 1.
2. Partly listed as a crop in table 7.
3. Shown combined with preceding unit on plate 1.
4. Not shown on plate 1.
a. Of this amount, 6,900 acres is in California.
b. Of this amount, 1,100 acre-feet is discharged in California.

Springs

The largest spring in the valley is Fish Lake Spring (pl. 1). According to Eakin (1950, p. 25), it had a discharge of about 3 cfs in 1949 and a spring complex, including Fish Lake Spring, had a discharge of about 5.5 cfs. Probably the source of the water is nearby carbonate rocks, as shown on plate 1. At 2/34-17bb, a spring was producing nearly all the flow of Indian Creek (1 cfs) on August 25, 1970. The combined flow of springs and a flowing well drilled in the orifice of a spring at 1/36-20b was estimated to be about 200 gpm. A pipeline was constructed from Busher Spring (3/35-7ad) to a nearby ranch at 3/35-4db where the water reportedly was used to irrigate 20 acres. The spring, now dry, reportedly once had a flow of 90 gpm. A large number of springs are in the Palmetto and Sylvania Mountains (pl. 1), but their discharge is only a few gallons per minute.

Some of the flow from springs supports vegetation, but most of it seeps back to the water table. The net ground-water discharge by springs, where applicable, is included in the estimates of phreatophyte discharge in table 6. Flow from some small springs in Trail Canyon is exported from the valley, as described in a later section.

Irrigation

Air temperature is a major factor in determining the length of the growing season. Such data have been collected at Dyer 4SE for 18 years. The average number of days between temperatures of 32, 28, and 24°F are 118, 142, and 163, respectively. Based on these statistics, the estimated average growing season for alfalfa is about 140 days, and may range between 120 and 160 days.

Table 7 summarizes irrigation and subirrigation by water sources and by crops. Water consumption rates, listed in the table footnotes, are based on the research of Houston (1950) and Dylla and Muckel (1964).

Table 8 summarizes the trend in use of ground water for irrigation and subirrigation since 1949. Ground-water consumption by irrigation and subirrigation has doubled during the period.

In 1970, Chiatovich, Indian, Leidy, Perry Aiken, McAfee, and Cottonwood Creeks were used for irrigation. The net consumption of streamflow in 1970 was about 5,200 acre-feet. In addition, 31 irrigation wells (table 21) had a net consumption of discharge of about 11,000 acre-feet. Gross pumpage from these wells probably was about 15,000 acre-feet.

Table 7.--Summary of irrigation and subirrigation, 1970

[Based on interviews of water users and field observations, August 1970]

Crop	Area irrigated, by water source (acres)					Water consumed[3] (acre-feet)
	Streamflow	Wells	Mixed[1]	Subirrigation[2]	Total	
			NEVADA PART			
Alfalfa	30	a 290	2,000	0	2,300	6,900
Pasture	190	0	2,700	3,000	5,900	8,800
Subtotal (rounded)	220	290	4,700	3,000	8,200	16,000
			CALIFORNIA PART			
Alfalfa	0	660	300	0	960	2,900
Pasture	200	0	0	0	200	400
Subtotal (rounded)	200	660	300	0	1,200	3,300
Total area (rounded)	420	a 950	5,000	3,000	9,400	---
Total water consumed (acre-feet)[3]	870	2,800	b 12,000	3,000	---	19,000

1. Areas where pumpage from wells is used to supplement streamflow.

2. That area of native meadow not replaced by crops. See plate 1 and table 6.

3. Consumption rates used (in acre-feet per acre per year): alfalfa (3 to 4 cuttings), 3.0; irrigated pasture, 2.0; subirrigated pasture, 1.0.

a. Includes 10 acres of apples.

b. Of this amount, about 4,300 acre-feet is streamflow.

Table 8.--Estimated ground-water use for irrigation and subirrigation, 1949-70

Year	Acres	Ground-water consumption (acre-feet)	Remarks
[a] 1949	6,500	7,000	Estimates for entire valley
[b] 1967	4,800	8,000	Nevada part only
[b] 1968	5,100	9,000	Nevada part only
1970	(c)	14,000	Estimates for entire valley
	(d)	12,000	Nevada part only

a. Estimated from Eakin (1950, p. 22-26).
b. Estimates based on irrigated-land inventory by personnel of Nevada State Engineer's Office.
c. Estimated by water source from table 6: wells and subirrigation, 4,000 acres; mixed sources of streamflow and wells, 5,000 acres.
d. Estimated by water sources from table 6: wells and subirrigation, 3,300 acres; mixed sources of streamflow and wells, 4,700 acres.

Other Pumpage

Wells are pumped to supply water for mining operations, stock, and domestic use. Neither of the two mines were reportedly in operation at the time of field work in 1970. The water used for stock watering (which also includes some springs and streamflow) and for domestic use are estimated to be less than 200 acre-feet per year.

Export

A 27-mile pipeline was constructed in 1882 to carry water from springs in Trail Canyon (T. 1 S., R. 33 E.) to the mining town of Candelaria, north of Fish Lake Valley, according to Van Denburgh and Glancy (1970, p. 17). The pipeline (pl. 1) currently extends to Basalt, north of the valley. In May 1968, the flow in the pipeline was 25 gpm. The present export is taken to be about the same, or about 40 acre-feet per year.

GROUND-WATER BUDGET

For natural conditions and over the long-term, inflow to and outflow from a valley are about equal, assuming that long-term climatic conditions remain reasonably unchanged. Thus, a water budget can be used (1) to compare the estimates of inflow to and outflow from a valley, (2) to determine the magnitude of the imbalance in the inflow and outflow estimates, and (3) to select the value that, within the limits of accuracy of this reconnaissance, hopefully represent both inflow and outflow for the valley. This value in turn is utilized in a following section of the report to estimate perennial yield. A ground-water budget is given in table 9.

Table 9 shows that estimated inflow exceeds outflow by 6,000 acre-feet per year. The inflow may be high, owing to rejected recharge previously mentioned. On the other hand, the outflow may be low, if more than 3,000 acre-feet per year leaves the valley as subsurface outflow. Accordingly, the average of the two, or 30,000 acre-feet per year, is the value selected to represent both inflow and outflow.

Table 9.--Ground-water budget for Fish Lake Valley

For native conditions

Budget elements		Acre-feet per year
INFLOW:		
Recharge from precipitation (table 5)	(1)	a 33,000
OUTFLOW:		
Evapotranspiration by phreatophytes (table 6)		24,000
Subsurface outflow (p. 31)		3,000
Total (rounded)	(2)	27,000
IMBALANCE: (1) - (2)		6,000
VALUE SELECTED TO REPRESENT BOTH INFLOW AND OUTFLOW		30,000

a. May be high. See table 5.

CHEMICAL QUALITY OF THE WATER

In the present study, 13 water samples were analyzed in order to make a reconnaissance of the general chemical usability of the water. These analyses, plus 20 additional analyses previously made by the Geological Survey and the California Division of Water Resources during the past two decades, are listed in table 10. Fourteen other analyses of water in Fish Lake Valley have been published by Miller and others (1953).

All of the most recent samples were analyzed at the Geological Survey field office in Carson City and identify only the principal ions. Iron and nitrate generally were not determined, although they are important ions affecting the suitability of water for domestic use.

Precipitation, the ultimate source of water in Fish Lake Valley, is nearly free of dissolved solids. As precipitation enters and flows through the hydrologic systems, contact of the water with vegetation, soil, and rock adds to the dissolved-solids content. Streams, when fed by snowmelt, have a lower dissolved-solids content than at low flow, when ground-water seepage constitutes the principal source of flow. Where water is evaporated from playas or used by phreatophytes (pl. 1), much of the dissolved solids remain and become concentrated at shallow depth in the ground water and soil.

Ground water generally has a temperature near the average annual air temperature (about 55°F), if there is no geothermal input into the valley-fill reservoir. Temperatures as high as 77°F (25°C) were observed, as listed in tables 10 and 19. Increased ground-water temperature is in general associated with (1) an increase in concentration of sodium and chloride ions in relation to the other ions, and (2) a decrease in concentration of calcium, magnesium, and bicarbonate ions in relation to the other ions.

This suggests that the warmer water possibly is the result of the mixing in various proportions of two types of water, (1) cool, calcium magnesium bicarbonate water circulating at shallow depths within alluvium, and (2) hot, sodium chloride water circulating to greater depths and possibly to some extent through consolidated rocks.

The concentrations of dissolved solids in sampled streams, wells, and springs are summarized by specific conductance, an index of dissolved-solids content, in table 11. The dissolved solids in water, in milligrams per liter, is generally 55 to 70 percent of the specific conductance in micromhos per centimeter at 25°C.

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

[Field-office and detailed laboratory analyses by U.S. Geological Survey, except as noted]

				Milligrams per liter (upper number) and milliequivalents per liter (lower number)[1]													Factors affecting suitability for irrigation[2]		
Location[3, 7]	Date sampled	Temperature[4] °F	Temperature[4] °C	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) plus potassium (K)[5]	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Hardness as $CaCO_3$	Boron (B)	Specific conductance (micromhos per cm at 25°C)	pH (lab. determination)	Salinity hazard	Sodium hazard	Residual sodium carbonate (RSC)
								STREAMS										
Trail Canyon Creek at 1/33-11ba	5-16-68	--	--	--	--	--	--	--	--	--	--	--	--	220	--	--	--	--
Chiatovich Creek at 1/34-28ba	6-12-69	50	10	6 0.30	1 0.08	4 0.18	29 0.48	0 0.00	4 0.08	0 0.00	-- --	19	--	55	7.8	L	L	S
Axial drainage at 1/36-10ca	--	71	22	14 .70	4.9 .40	5,029 215.56	1,820 29.83	619 20.63	1,350 28.11	4,530 127.79	14 0.74	--	23	19,300	9.2	U	VH	U
Chiatovich Creek at 1/36-28cb	9-15-70	55	13	7 .35	1 .05	4 .16	32 .52	0 .00	2 .04	0 .00	-- --	20	--	57	7.4	L	L	S
Indian Creek at 2/34-2da	9-15-70	58	14	35 1.75	8 .65	4 .16	120 1.97	4 .13	22 .46	0 .00	-- --	120	--	248	8.5	L	L	S
Leidy Creek at 2/34-35ba	9-16-70	56	13	18 .90	5 .44	6 .26	68 1.12	0 .00	23 .48	0 .00	-- --	67	--	162	8.0	L	L	S
Axial drainage at 2/35-24cc	--	62	17	8 .40	2.9 .24	1,090 45.80	964 15.80	140 4.67	267 5.56	711 20.05	6.7 .35	--	7.4	4,470	9.0	VH	VH	U
Leidy Creek at 2/35-33ab	3-16-71	48	9	28 1.40	6 .50	6 .27	100 1.64	0 .00	24 .50	1 .03	-- --	95	--	222	7.9	L	L	S
Perry Aiken Creek at 3/33-27da	9-16-70	--	--	16 .80	2 .14	6 .25	61 1.00	0 .00	9 .19	0 .00	-- --	47	--	120	7.7	L	L	S
McAfee Creek at 3/35-36	5-25-57	58	14	29 1.45	5.7 .47	6 .24	118 1.93	0 .00	7.8 .16	5.7 .16	0 .00	96	.01	206	8.1	L	L	S
Cottonwood Creek at 5/37-33d[6]	12-28-59	40	4	32 1.60	15 1.25	5 .22	171 2.80	0 .00	7 .15	2 .05	.1 .005	143	0	350	8.0	L	L	S
								SPRINGS										
Sand Spring 1N/34-27dd	5-25-57	74	23	1.1 .06	.6 .05	31 1.31	50 .82	0 .00	22 .46	2 .06	.2 .01	5	.02	144	7.2	L	L	S
North Spring 1/36-20b	11-29-49	69	21	-- --	-- --	-- --	150 2.46	-- --	21 44	31 .87	-- --	--	--	358	--	L	--	--
Fish Spring 2/35-25cb	5-25-57	75	24	13 .65	4 .33	65 2.70	158 2.59	1 .03	38 .79	7 .19	1.5 .08	49	.42	363	8.3	L	L	M
Pigeon Spring 6/39-17ad	2-23-56	57	14	45 2.25	20 1.64	19 .76	207 3.39	0 .00	35 .73	17 .48	.1 .005	194	--	446	7.8	L	L	S
								WELLS										
1N/36-9cc	8-27-70	--	--	5 .25	.4 .03	1,800 78.97	1,580 25.90	709 23.60	74 1.54	1,000 28.21	-- --	14	--	7,320	9.4	VH	VH	U
1/35-9cc	5-25-57	74	23	17 .85	2.7 .22	34 1.41	128 2.10	0 .00	12 .25	3 .08	.2 .01	80	.06	240	7.9	L	L	S
1/35-28bc	5-25-57	53	12	11 .55	.7 .06	6.6 .26	51 .84	0 .00	2.8 .06	1.9 .05	.2 .01	30	0	99	7.1	L	L	S
1/36-16ba	3-15-71	77	25	5 .25	0 .00	300 13.03	251 4.11	7 .23	78 1.62	260 7.33	-- --	13	--	1,500	8.4	M	VH	U
1/36-20bc	5-25-57	77	25	48 2.40	7.4 .61	258 10.85	601 9.85	0 .00	98 2.04	70 1.97	4.2 .22	150	1.7	1,330	7.1	M	M	U
3/35-3bc	3-16-71	69	21	23 1.15	8 .69	34 1.49	130 2.13	0 .00	55 1.14	2 .06	-- --	92	--	343	8.0	L	L	S
2/35-4ba	5-25-57	68	20	11 .55	1.2 .10	8.1 .34	54 .88	0 .00	2.8 .06	3.5 .10	.4 .02	32	.02	108	7.6	L	L	S
2/35-34ad	11-30-49	54	12	51 2.55	22 1.80	4.6 .20	222 3.64	0 .00	36 .75	4 .11	-- --	218	--	414	--	L	L	S
3/35-15da	3-16-71	54	12	66 3.29	14 1.11	7 .31	220 3.61	0 .00	43 .90	7 .20	-- --	220	--	463	8.1	L	L	S
3/35-26ad	5-25-57	54	12	75 3.74	69 5.67	61 2.21	675 11.06	0 .00	27 .56	4 .12	.3 .02	470	.15	1,010	7.2	M	M	S
3/35-26cc	8-25-70	57	14	-- --	-- --	-- --	-- --	-- --	-- --	10 .28	--	--	--	451	--	L	--	--
4/36-3cc	5-25-57	60	16	50 2.50	17 1.40	57 2.36	214 3.51	0 .00	75 1.56	54 1.52	1.0 .05	195	.36	679	7.9	L	L	S
4/36-16da	5-25-57	58	14	41 2.05	20 1.64	23 .93	224 3.67	0 .00	15 .31	24 .68	.4 .02	184	.09	493	4.5	L	L	S
5/37-5bd	3-16-71	55	13	59 2.94	35 2.85	26 1.11	389 6.38	0 .00	21 .44	3 .08	-- --	290	--	620	8.1	L	L	S
5/37-8ac[6]	1- 7-55	--	--	51 2.54	23 1.89	19 .83	* 321 5.26	0 .00	2 .04	6 .17	.1 .005	--	0	502	7.2	L	L	S
5/37-26bd[6]	2- 5-58	44	7	68 3.40	24 2.00	10 .42	278 4.55	0 .00	11 .22	18 .51	0 .00	--	.25	541	7.7	L	L	S
6/37-2ba	3-17-71	--	--	42 2.10	16 1.30	16 .70	230 3.77	0 .00	12 .25	3 .08	-- --	170	--	397	8.1	L	L	S
6/37-24ba[6]	5- 5-55	--	--	23 1.15	7 .58	72 3.00	281 4.60	0 .00	3 .06	5 .14	1.1 .06	--	--	426	8.0	L	L	U

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

FOOTNOTES:

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 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. Townships are south of base line unless otherwise indicated.

4. Water temperatures reported by drillers are listed in table 12.

5. 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.

6. Analysis by California Division of Water Resources.

7. Location is south of the Mount Diablo base line unless identified otherwise.

Table 11.--Summary of specific conductance of water samples[1]

(Specific conductance values in micromhos per centimeter at 25°C)

	Number of samples	Range of values	Median value	Range of most common values
Streams	12	55-19,300	220	55-350
Wells	26	99-7,320	541	240-857
Springs	9	144-446	356	326-363

1. Basic data listed in table 9 and from Miller and others (1953).

The principal ions in all mountain-stream samples were calcium and bicarbonate (table 10). As the water seeps into the ground and flows toward areas of discharge, not only does the dissolved-solids content increase, but the concentrations of sodium and chloride increase more rapidly than all other ions. In discharge areas, these two ions generally dominate in both ground-water and surface-water samples.

Based on the partial chemical analyses in table 10, all streamflow from the mountains is suitable for irrigation. Most alluvial areas yield usable ground water; however, shallow wells on or near the playas might yield unsuitable water, based on criteria established by the United States Salinity Laboratory Staff (1954) and the National Technical Advisory Committee (1968, p. 143-177). If doubt exists as to the quality of an irrigation water, the local County Agricultural Agent or the University of Nevada Cooperative Extension Service can be contacted for advice.

For the chemical constituents listed in table 9, all sampled mountain streams and most sampled wells and springs met the drinking-water standards established for chemical quality by the U.S. Public Health Service (1962). Areas of poor-quality drinking water are generalized as follows: (1) ground water with concentrations exceeding recommended standards for sulfate (250 mg/l), chloride (250 mg/l), fluoride (1.2 mg/l), or dissolved solids (500 mg/l) probably will be encountered by most wells drilled on the playas or in the vicinity of the playas, and (2) shallow wells along the valley's axial drainage in T. 1 N. and T. 1 S. and 2 S.

If doubt exists as to the potability of a water supply, contact the Nevada Bureau of Environmental Health, Carson City, Nevada.

AVAILABLE WATER SUPPLY

Water for development can be and is obtained from streams and the valley-fill reservoir. In the following sections, the conceptual quantities of water, streamflow, perennial yield, and transitional storage reserve are discussed and evaluated.

Streamflow

For practical purposes, the streamflow that can be developed essentially is limited to the flow of the six perennial streams, as summarized in table 3. Because some streamflow percolates to the water table becoming ground water, development of streamflow may ultimately reduce the amount of natural ground-water discharge from the system, and in turn, reduce the amount of ground-water development from wells. On the other hand, pumping ground water in time should cause water levels to decline beneath streams, thereby increasing recharge and decreasing runoff now wasting to the playa.

The amount of average annual flow of the six streams at the mountain front, listed in table 3, is estimated to be about 16,500 acre-feet in the Nevada part of the valley and 7,500 acre-feet in California.

Perennial Yield

The perennial yield of a valley-fill reservoir may be defined as the maximum amount of natural discharge that can be salvaged each year over the long term by pumping without bringing about some undesired result. If wells were drilled in selected areas of Fish Lake Valley so as to salvage all evapotranspiration losses (table 6), if water levels were drawn down so as to increase seepage losses along streams to salvage water now wasting to the playa (p. 6), and if some of the subsurface outflow to adjacent valleys was accomplished by pumping (p. 31), the perennial yield probably would approach 30,000 acre-feet per year. This value is within the range estimated by Eakin (1950, p. 27): "...the long-time average for potential development would be 26,000 to 35,000 acre-feet."

Transitional Storage Reserve

Transitional storage reserve has been defined by Worts (1967) as the quantity of water in storage in a particular ground-water reservoir that can be extracted and beneficially used during the transition period between natural equilibrium conditions and new equilibrium conditions under the perennial-yield concept of water development. In the arid environment of the Great Basin, the transitional storage reserve of such a reservoir is the amount of stored water available for withdrawal by pumping during the nonequilibrium period of development, or period of lowering water levels. Therefore, transitional storage reserve is a specific part of the total ground-water resource that can be taken from storage; it is water that is available in addition to the perennial yield, but on a once-only basis.

Most pertinent is the fact that no ground-water source can be developed without causing storage depletion. The magnitude of depletion varies directly with distance of development from any recharge and discharge boundaries in the ground-water system.

To compute the transitional storage reserve of the valley-fill reservoir, several assumptions are made: (1) wells would be strategically situated in, near, and around areas of natural discharge in the main alluvial area of the valley so that natural losses could be reduced or stopped with a minimum of water-level drawdown in pumped wells; (2) an average water level about 50 feet below land surface would curtail virtually all evapotranspiration losses; (3) over the long term, pumping would cause a moderately uniform depletion of storage throughout most of the valley fill; (4) specific yield of the valley fill is 15 percent; (5) water levels are within the range of economic pumping lift for the intended use; (6) development would have little or no effect on water in adjacent valleys; and (7) water is of suitable chemical quality for the intended use.

The estimated storage reserve in Fish Lake Valley is the product of the area beneath which depletion can be expected to occur (180,000 acres), the average thickness of saturated valley fill to be dewatered (50 feet), and the specific yield (15 percent), or about 1,300,000 acre-feet.

The manner in which transitional storage reserve augments perennial yield has been described by Worts (1967). The relation is shown in its simplest form by the following equation:

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

in which $\underline{Q}$ is the selected or desired rate of diversion (largely ground-water pumping), in acre-feet per year, and $\underline{t}$ is the time, in years, to exhaust the storage reserve. This basic equation, of course, could be modified to allow for changing rates of storage depletion and salvage of natural discharge. The equation, however, is not valid for pumping rates less than the perennial yield.

Using the above equation and the perennial-yield estimate for the valley as an example (transitional storage reserve, 1,300,000 acre-feet; perennial yield, 30,000 acre-feet, p. 45), and using a diversion 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 90 years. This assumes that the diversions would be almost wholly by pumping.

At the end of the estimated time, the transitional storage reserve would be exhausted, subject to the assumptions given in the preceding section. What is not shown by the example is that in the first year virtually all the pumpage would be derived 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 the pumpage would be derived from salvage of natural discharge and virtually none from the storage reserve.

During the period of depletion the ground-water flow nets would be substantially modified. The recharge that originally flowed to areas of natural discharge would ultimately flow directly to pumping wells.

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

WATER USE AND CONSUMPTION IN 1970

Table 12 summarizes the use of the water resources of Fish Lake Valley. Irrigation was the principal use of water in 1970. Because of the variation in streamflow from year to year, the quantity of water used varies accordingly. The quantity used in 1970 probably was at or slightly less than the yearly average because it was a near-normal runoff year. On the other hand, during wet years more streamflow would be used, possibly as much as twice that used in 1970.

Effects of Past and Present Development

The ultimate effects of streamflow diversions are: (1) possibly less water would infiltrate into the valley-fill reservoir, reducing ground-water recharge and discharge within the valley; (2) less runoff from the mountains would reach and pond on the playas where it mostly evaporates.

An estimated 150,000 acre-feet of ground water has been pumped from wells during 1949-70. This pumpage is equivalent to the dewatering of about 1,000,000 acre-feet of aquifer. Visualized in a different way, this volume is equal to lowering the water table about 7 feet beneath an area of six townships, the number of townships that contain active irrigation wells in Fish Lake Valley (table 21). Because only minor perennial dewatering has occurred (table 1), infiltration of streams flowing from the White Mountains has been recharging the valley-fill reservoir in the areas of seasonal dewatering at a rate larger than under prepumping conditions. The net result is that streamflow beyond the areas of irrigation pumpage has been reduced, depriving the large playa in the northeast part of the valley of some streamflow that would pond on the playa under native conditions.

Table 12.--Development and estimated consumption of water in 1970

Use	Acre-feet per year
Irrigation and subirrigation consumption (table 7)	
Surface water	5,200
Ground water (including subirrigation)	14,000
Mining, stock, and domestic pumpage (p. 35)	<200
Export of spring flow (p. 35)	40
Total surface water (rounded)	[a] 5,200
Total ground water (rounded)	[b] 14,000

a. Of this amount, about 900 acre-feet is consumed in California.
b. Of this amount, about 2,400 acre-feet is consumed in California.

Not all the 150,000 acre-feet of pumpage has been consumed. An estimated one-fourth to one-third of this amount has percolated or is percolating back to the water table from canals and fields.

FUTURE DEVELOPMENT

Future development of land and water resources of Fish Lake Valley should take into consideration not only the hydrology and economics of such ventures, but also the effect they will have on the overall environment. Some changes that might affect the ecologic balance of the environment are (1) vegetation removal and resulting potential wind and water erosion, (2) lowering of water levels causing a change from phreatophytes to nonphreatophyte vegetation and a reduction in spring discharge, (3) diversion of streams to pipelines affecting fish and wildlife, (4) the affect of the application of insecticides, herbicides, and fertilizers on water and soil quality, and the general effect of more people, farms, and commerce on the natural beauty of the valley and the White Mountains. Considerations other than those dealing with the availability of water are beyond the scope of this report.

Much greater utilization of the water resources of Fish Lake Valley is hydrologically possible. For 1970, approximately half the perennial yield of the valley was used and consumed.

The following methods of water development, under the perennial yield concept, are discussed in the following sections: (1) installation of pipelines and lined ditches to conduct streamflow to fields, and (2) construction and pumping of wells to salvage natural ground-water discharge.

Pipelines

Leidy, Perry Aiken, McAfee, and Cottonwood Creeks, listed in table 3, have been diverted to pipelines or lined ditches near their canyon mouths. This efficient diversion and conveyance of water could be extended to the other streams which are now allowed to flow in their natural channels or diverted to unlined ditches on the apron. The effect of using pipelines or lined ditches is to deliver the maximum amount of streamflow with minimum conveyance loss to the area of use.

The most productive streams not being diverted to pipelines or lined ditches are Chiatovich and Indian Creeks, as indicated by data in table 3.

The canyon mouth probably is the best general location for the inlet to a pipeline or lined ditch; however, the most efficient location depends on several geologic and hydrologic factors not investigated during this study.

Wells

As described previously, the pumping of irrigation wells probably has been salvaging some of the streamflow that would have ponded and evaporated from the large playa in the northeast part of the valley. Additional pumpage probably can be expected to continue indirectly to salvage more of this evaporation. As pumpage in the valley increases beyond the ability of the system to salvage this streamflow, the water table will experience a perennial decline in areas of heavy pumping. The result will be a gradual removal of the transitional storage reserve and salvage of phreatophyte (groundwater) discharge. (See Transitional Storage Reserve section.) Clearing land of phreatophytes and planting crops would also salvage this discharge for beneficial use.

Diversion of streamflow at canyon mouths to pipelines or lined ditches would reduce, but not eliminate, water available to the valley-fill reservoir for recharge, if no compensating increase in infiltration from fields and canals occurred. As a result, the ground-water system would slowly adjust to the reduced supply by an increase in depths to ground water. As a result of the generally greater depth to water beneath the phreatophyte areas and throughout the valley-fill reservoir, the phreatophyte discharge would progressively become smaller, seeking equilibrium with the reduced supply of water reaching the phreatophytes.

General distribution of irrigation wells under maximum ground-water development is dependent primarily on seven hydrologic factors: (1) distribution of phreatophyte discharge, (2) limitations imposed by land-area development associated with well yield, (3) areal extent of the cone of influence of pumping wells, (4) suitability of soils, (5) extent and location of stream diversions, (6) water quality, and (7) hydraulic boundaries (discussed on p. 9). The most limiting factor should ultimately dictate the general locations of wells.

The distribution of phreatophytes is shown on plate 1 and their discharge is summarized in table 13. If the distribution of phreatophyte discharge is not significantly altered by local changes in the depth to water, the distribution of pumpage to salvage the natural water losses should be about the same as the distribution of phreatophyte discharge.

Minimal spacing of wells, where there is local variation in well spacings, should be controlled by the ability of the valley-fill reservoir to yield water, as reflected by the size and shape of the cone of influence caused by pumping. Based on data provided by Rush and Schroer (1971, p. 60) in nearby Big Smoky Valley (pl. 1), the following set of general conditions are applicable to Fish Lake Valley:

Pumping period (days)	140
Pumping rate (gallons per minute)	2,500±
Aquifer characteristics (assumed values):	
Transmissivity (pgd per ft)	100,000±
Storage coefficient	.15
Seasonal drawdown near a well with the above pumping rate (maximum, in feet):	
0.2 mile from a pumping well	10
0.5 mile from a pumping well	5
Radius of cone of influence (miles)	2.0
Minimum well spacing with interference per nearby well limited to 5 feet	0.5 mile
Maximum drawdown of pumping level from static water level at the well during growing season with no interference from nearby wells (feet)	70

Table 13.--Distribution of phreatophyte discharge

(Based on data in table 6)

Area	Percentage of total evapotranspiration
Northeastern part of the valley east of long 118°00'	20
Northern part of valley west of long 118°00' and north of Dyer Ranch	35
Dyer Ranch south to Dyer Post Office	30
Southeast of Dyer Post Office in Nevada	10
California	5
Total (rounded)	100

NUMBERING SYSTEM FOR HYDROLOGIC SITES

The numbering system for hydrologic sites in this report is based on the rectangular subdivision of the public lands, referenced to the Mount Diablo base line and meridian. This location number consists of three units: the first is the township south of the base line unless as otherwise identified; the second unit, separated from the first by a slant, is the range east of the meridian; the third unit, separated from the second by a dash, designates the section number. The section number is followed by letters that indicate the quarter and quarter-quarter section, the letters a, b, c, and d designate the northeast, northwest, southwest, and southeast quarters, respectively. For example, well 1/33-1aa (table 19) is the well recorded in the NE¼NE¼ sec. 1, T. 1 S., R. 33 E., Mount Diablo base line and meridian. For sites that cannot be located accurately to the quarter-quarter section, only that part of the location number is given that represents the ability to determine the location of the site.

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

SELECTED STREAMFLOW DATA

The following tables, tables 14 through 18, contain streamflow data for Palmetto Wash tributaries and the perennial streams of the valley.

Table 14.--Annual streamflow of Chiatovich Creek for water years 1961-71

[Location shown on plate 1]

Water year	Runoff in acre-feet	Water year	Runoff in acre-feet
1961	2,800	1967	9,000
1962	6,400	1968	6,500
1963	7,700	1969	11,700
1964	5,900	1970	7,100
1965	5,300	1971	5,400
1966	5,500		
Average (rounded)			6,700

Table 15.--Discharge at partial-record stations on Palmetto Wash tributaries

[Location shown on plate 1]

Station name	Location number	Drainage area (sq mi)	Period of record	Annual maximum data		
				Water year	Date	Discharge (cfs)
Palmetto Wash tributary near Lida, Nev.	6/39-6ac	4.73	May 1967 to present	1967	9-24-67	16
				1968	8- 7-68	18
				1969	7- -69	193
				1970	7-15-70	21
				1971	8- -71	a 50
Palmetto Wash tributary near Oasis, Calif.	5/38-33cb	0.24	May 1967 to present	1968	8- 7-68	9.3
				1969	7- -69	a 0.5
				1970	8-15-70	12
				1971	8- -71	a 0.1

a. Estimated.

Table 16.--Instantaneous discharge of Chiatovich Creek and its tributaries

[Locations shown on plate 1]

Stream	Location number	Approximate altitude (feet)	Date	Flow (cfs)	Flow at same time at the Chiatovich gage[1]	Percentage of flow loss between gage and measuring site
Davis Creek	1/34-31ab, about 2.7 miles upstream from gage	7,300	Sept. 16, 1970	2.17	7.3	--
Chiatovich Creek	1/34-30dc, about 2.7 miles upstream from gage	7,200	Sept. 16	3.16		--
Middle Creek	1/34-19bc, about 3.5 miles upstream from gage	7,500	Sept. 15	2.59		--
			Subtotal	7.92		
Chiatovich Creek	1/35-30ac, about 3.6 miles downstream from gage	5,200	Sept. 15	6.93	7.2	4
Chiatovich Creek	1/35-28cb, about 5.5 miles downstream from gage and just upstream from State Highway 3A	5,000	Sept. 15	6.36	7.2	12
			Oct. 7	6.00	7.8	25
			Nov. 27	6.3	7.8	19
			Jan. 22, 1971	3.5	5.5	36
			Mar. 18 [2]	2.1	3.5	40
			Mar. 18 [3]	5.5	8.5	35
			June 10	5.9	6.9	15
			July 20	8.1	8.8	8

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1. Chiatovich gage is in 1/34-28aa, altitude 6,300 feet, drainage area is 37.3 square miles.

2. Measurement at 7:00 a.m.

3. Measurement at 12:00 m.

Table 17.--Instantaneous-discharge measurements of selected creeks

Site number on plate 1	Stream	Drainage area (sq mi)	Location	Approximate altitude (feet)	Date	Flow (cfs)	Remarks
7	Indian Creek	14.4	2/34-9ad	6,500	9-15-70	2.41	
					10- 7-70	1.9	
					11-27-70	3.54	
					1-22-71	2.74	
					3-19-71	3.26	
					6-11-71	2.44	
					7-21-71	1.89	
			2/34-2da[1]		9-15-71	2.14	Measured 1 mile above ranch
8	Leidy Creek	20.6	2/34-35ba (east of Von Schmidt line)	6,300	9-16-70	2.47	
					11-27-70	1.47	
					1-22-71	.62	
					3-18-71	.42	
					6-11-71	5.26	
					6-21-71	6.34	
			2/35-33ab[1]		9-16-70	2.39	Measured 15 feet below in ditch east of highway
9	Perry Aiken Creek	22.3	3/35-27da (west of Von Schmidt line)	5,300	9-16-70	3.59	
					11-27-70	5.24	
					1-22-71	3.87	
					3-18-71	2.74	
					6-10-71	6.18	
					7-20-71	13.2	
					10-21-71	5.38	

Table 17.--Instantaneous-discharge measurements of selected creeks--Continued

Site number on plate 1	Stream	Drainage area (sq mi)	Location	Approximate altitude (feet)	Date	Flow (cfs)	Remarks
10	McAfee Creek	15.4	4/35-3ac	5,600	9-16-70	2.68	
					11-27-70	2.86	
					1-22-71	2.98	
					3-18-71	2.33	
					6-10-71	2.91	
					7-20-71	4.11	
			3/35-36cd (west of Von Schmidt line)[1]	5,300	9-16-70	2.56	Measured in concrete ditch 0.4 mile west of reservoir
11	Cottonwood Creek	50.0	5/37-33cc (Calif.)	5,270	6-22-70	a 3.0	All measurements in diversion channel. Natural channel dry
					8-25-70	a 4.0	
					1-22-71	6.81	
					3-18-71	6.54	
					6-10-71	7.68	
					7-20-71	4.46	
					10-21-71	5.36	

1. Not shown on plate 1.

a. Estimated.

Table 18.--Streamflow data for Indian Creek[1]

[Measured at 2/34-3dc]

Date	Discharge (cfs)	Date	Discharge (cfs)	Date	Discharge (cfs)
4-13-66	2.12	10-15-67	6.43	5- 8-69	1.80
5-12-66	1.86	1-10-68	4.32	7-10-69	3.94
7-12-66	1.63	2-15-68	3.71	10- 6-69	10.2
9-29-66	2.05	3-12-68	3.05	12-14-69	4.73
11-16-66	1.62	4- 9-68	2.65	3-12-70	3.11
1-19-67	2.07	6-12-68	2.72	4-23-70	2.99
4-24-67	1.77	9-17-68	1.51	7- 6-70	2.78
7-18-67	2.58	11-25-68	2.30	8-20-70	2.95
9-12-67	3.20	3-19-69	1.91		

1. For additional data, see table 17.

SELECTED WELL LOGS AND DATA

Selected well data are listed in table 19, selected drillers' logs of wells in table 20, and a list of wells pumped for irrigation in 1970 in table 21. Most of the well data and logs are from the files of the Nevada State Engineer.

Table 19 includes most of the data available on large-diameter wells in the valley. Table 20 contains logs for only a few wells spaced throughout the valley. All 31 irrigation wells used in 1970 are listed in table 21. A similar list was presented by Eakin (1950, p. 25).

Table 19.--Selected well data

Use: I, Irrigation; M, mining or milling; S, stock; U, unused
Water-level measurement: M, measured; R, reported
Log number: State Engineer file number

Location number[1]	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) and drawdown (feet)	Land-surface altitude (feet)	Water-level measurement			Chief aquifer (depth in feet)	Log number	Remarks from drillers' logs
								Depth (feet)	M or R	Date			
1N/36-9cc	--	--	--	48	U	--	4,690	12.50	M	8-27-70	--	--	Located at road intersection
1/33-1aa	B & B Mine	1969	191	10	M	120/63	7,700	27.	R	1969	82-117	10,408	Water temperature, 53°F
1/35-9cc	R. G. Pennebaker	1957	300	16	I,U	--	4,980	104. 100.89	R M	1957 3-18-68	300-345	3696	
--	--	1921	125+	12	S	--	4,890	13.70 13.75 17.49	M M M	11- 8-49 3-15-54 8-26-70	--	--	Windmill
1/35-27ac	Arlemont Ranch No. 2	1969	412	16	I	1,500/--	4,880	43.	R	1969	--	10,785	Water temperature, 53°F. North of buildings
1/35-28ac	Arlemont Ranch No. 1	1960	436	16	I	2,700/73	4,923	48.	R	1960	243-340	5323	Located 1 mile west of buildings
1/35-33dc	Smith Ranch	--	240?	12	I	1,000/--	4,910	54.	R	1970	--	--	
1/35-34cb	Robert Hartman	1953	263	12	I	700/20	4,900	38.69	M	3-18-68	130-190	2198	Test pumped at 1,400 gpm
1/37-29bd	Fish Lake Livestock Co.	1958	87	10	S	--	5,436	67.	R	1958	67-87	4361	
2/35-3cc	Wilmer Hartman	1952	246	14	I	700/126	4,884	43.73	M	3-18-68	40-60	2059	Use rate = 300 gpm. Water temperature, 61°F
2/35-3cc	Wilmer Hartman	1971	300	14	I	1,650/140	4,884	40.	R	1971	--	--	Located 100± feet north of above well
2/35-4ba	Rodney Hudson	1956	300	12	I	400/540	4,933	67.	R	1956	70-140	3,441	Water temperature, 57°F
2/35-13dc	Dyer Ranch	1951	305	18,8	I,U	--	4,760	4.	R	1951	235-305	1007	Water temperature, 58°F
2/35-33ac	Circle L Ranch, Cord No. 1	1967	1,010	16	I	--	--	20	R	1967	155-240	9601	
2/35-34ad	Circle L Ranch	--	50	12	S	--	--	10.50	M	1949	--	--	
2/35-28da	Circle L Ranch, Cord No. 2	1967	501	16	I	--	--	--	-	--	--	9948	
3/35-1ad	Winkonley Ranch	1959	323	6	S	--	5,009	210.	R	1959	312-323	4580	
3/35-15cb	Winkonley Ranch, No. 1	1959	160	12	I	600/52	4,914	68.	R	1959	68-110	4734	Water temperature, 48°F (reported) West of highway
3/35-15cb	Winkonley Ranch, No. 2	1959	140	12	I	1,000/82	4,896	48.	R	1959	59-110	4735	Water temperature, 53°F. East edge of highway
3/35-15ba	Winkonley Ranch, No. 3	1960	163	12	I	2,000/99	4,857	21.	R	1960	84-163	5297	Water temperature, 56°F
3/35-26ad	Bar Double 9 Ranch	1936	125	16	I,U	650/--	--	15.	R	1954	--	--	
3/35-26cc	Bar Double 9 Ranch	1960	412	16	I	2,100/21	4,908	81	R	1960	260-324	5411	Water temperature, 61°F
4/36-3cc	Ted Myers	1951	100	12	D	--	--	10	R	1951	34-100	1836	Water temperature, 58°F
4/36-4cc	Robert Fergus	1961	208	14	I,U	2,200/79	4,864	14	R	1961	179-196	5936	Water temperature, 56°F
4/36-9dd	C. S. Crane	1961	268	14	I,U	2,100/77	4,880	16	R	1961	46-60	5937	Water temperature, 56°F
4/36-15cb	J. P. Wallace	1960	207	14	I	1,360/164	4,891	16	R	1960	47-128	5165	Water temperature, 56°F
4/36-16da	J. P. Wallace	1952	31	8	D	--	--	18	R	1957	--	--	
4/36-21da	--	--	--	10	S	--	4,938	48.06	M	6-22-70	--	--	Windmill
4/36-22aa	John Gamo	1960	205	14	I	2,200/97	4,899	11	R	1960	130-160	--	Water temperature, 58°F
5/37-5ca	State line well	--	49	12	S	--	4,957	29.81 29.55	M M	3-18-68 6-22-70	29-49	--	On State line. Windmill
5/37-15ba	--	--	48	6	S	--	4,982	35.46	M	6-22-70	35-48	--	Windmill
5/37-20bd	--	--	--	6	S	--	5,044	53.34	M	6-22-70	--	--	In California. Windmill
5/37-26bd	Howard Blair	--	--	--	D,U	--	5,030	--	-	--	--	--	Water temperature, 44°F. Behind house
5/37-8ac	--	--	--	12	S	--	4,985	55.20	M	1- 7-55	--	--	Windmill
6/37-24ba	--	--	--	8	S	--	5,070	64.93	M	6-22-70	--	--	In California. Windmill
6/38-23d	American Borides & Reduction Co.	1960	140	10	M	--	7,280	24	R	1960	24-50	5038	In Nevada

[1] Location is south of the Mount Diablo base line unless identified otherwise.

Table 20.--Selected drillers' logs[1]

Material	Thickness (feet)	Depth (feet)
1/35-28ac (Arlemont Ranch No. 1)		
Sand and gravel	127	127
Sand and large boulders	100	227
Sand with clay streaks	57	284
Sand, coarse, and large boulders	56	340
Clay, sandy	3	343
Sand, coarse	23	366
Clay, sandy, red	70	436
2/35-33ac (Cord No. 1)		
Soil and silt	48	48
Sand and gravel	14	62
Clay, hard, brown	10	72
Sand, coarse	22	94
Conglomerate(?), hard	22	116
Sand, coarse	6	122
Conglomerate(?)	28	150
Clay, brown	24	174
Sand, coarse	6	180
Clay, brown, and boulders	8	188
Conglomerate(?)	126	314
Sand, coarse, firm	10	324
Conglomerate(?), very hard	486	810
Clay, brown with white streaks, hard	48	858
(Unlogged lithology)	37	895
Conglomerate(?), hard	20	915
Sand, coarse to fine, and gravel	45	960
Rock, very hard	50	1,010
Granite at bottom of hole	--	1,010
3/35-15ba (Winkonley Ranch No. 3)		
Soil, sandy	18	18
Sand and silt	4	22
Clay, sandy, brown	18	40
Clay, hard, brown	44	84
Sand and gravel	34	114
Conglomerate(?), hard	20	134
Sand and gravel	26	160
Conglomerate(?), hard	3	163
3/35-26cc (Bar Double 9 Ranch)		
Sand	31	31
Sand and gravel	50	81
Clay	15	96
Sand, gravel, and boulders	48	144
Sand	116	260
Sand, gravel, and boulders	64	324
Clay	5	329
Sand and gravel	47	376
Clay, sandy	36	412
4/36-15cb (J. P. Wallace)		
Soil	16	16
Sand and gravel	9	25
Clay and boulders	4	29
Clay, hard, sandy	18	47
Sand and boulders	81	128
Clay, sandy	47	175
Boulders, sand, and gravel	30	205
Conglomerate(?), hard	2	207

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[1] Location is south of the Mount Diablo base line.

Table 21.--Irrigation wells pumped in 1970[1]

[Total irrigation wells drilled in valley to date was about 70; of these, 31 were in use]

Quadrangle map (scale 1:62,500, or about 1 inch equals 1 mile)	Owner or name	Location number[2]	Location in quarter section
Davis Mountain	Arlemont Ranch		
	No. 1	1/35-28ac	
	No. 2	1/35-27ac	
	Robert Hartman	1/35-34cb	
	Smith Ranch	1/35-33dc	
	Rodney Hudson	2/35-4ba	(south of house)
	Wilmer Hartman	2/35-3cc	(northwest corner)
	Hanson Homestead	2/35-16ca	(north of house)
Mt. Barcroft	Circle L Ranch		
	No. 1	2/35-33ab	(southeast corner)
	No. 5	--	
	No. 6	--	
	Lavender	2/35-27cc	(southeast corner)
	Cord No. 1	2/35-33ac	(center)
	Cord No. 2	2/35-28da	(southwest corner)
	Winkonley Ranch		
	No. 1	3/35-15cb	(southwest corner)
	No. 2	3/35-15cb	(north edge)
	No. 3	3/35-15ba	(north edge)
	--	3/35-15db	(southeast corner)
	--	3/35-15da	(northeast corner)
	--	3/35-3bc	(north of house)
	Bar Double 9 Ranch	3/35-26cc	(east side)
Piper Peak	W. S. Wright, Jr.	4/36-10bb	(northwest corner)
	James Wallace	4/36-15cb	(south edge)
	Cemo Ranch	4/36-15dd	
Soldier Pass	Oasis Ranch	5/37-27	
		5/37-28	
	Lazaro Gorrindo	5/37-27cb	
		5/37-27cc	
		5/37-27dc	
	Skilders Ranch	5/37-34dc	(southwest corner)
		5/37-35cc	(northwest corner)
	Wareham Ranch	6/37-2d	(center)

[1] A list of irrigation wells pumped in 1949 was compiled by Eakin (1950, p. 25).

[2] Location is south of the Mount Diablo base line.

REFERENCES

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.

Dylla, A. S., and Muckel, D. C., 1964, Evapotranspiration studies on native meadow grasses: Nevada Univ. College of Agriculture and U.S. Dept. Agriculture, Soil and Water Conserv. Research Div. Rept. R9, 29 p.

Eakin, T. E., 1950, Preliminary report on ground water in Fish Lake Valley, Nevada and California: Nevada State Engineer's Office, Water Res. Bull., no. 11, p. 7-33.

Eakin, T. E., and others, 1951, Contributions to the hydrology of eastern Nevada: Nevada State Engineer's Office, Water Res. Bull., no. 12, 171 p.

Hardman, George, 1965, Nevada precipitation map, adapted from map prepared by Hardman and others, 1936: Nevada Univ. Agr. Expt. Sta. Bull. 183, 57 p.

Harr, R. D., and Price, K. R., 1972, Evapotranspiration from a greasewood-cheatgrass community: Water Resources Research, v. 8, no. 5, p. 1199 - 1203 (October, 1972).

Houston, C. E., 1950, Consumptive use of irrigation water by crops in Nevada: Nevada Univ. Bull. 185, 27 p.

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

Miller, M. R., Hardman, George, and Mason, H. G., 1953, Irrigation waters of Nevada: Reno, Nevada Univ. Agr. Expt. Sta. Bull. no. 187, 63 p.

Moore, D. O., 1968, Estimating mean runoff in ungaged semiarid areas: Internat. Assoc. Sci. Hydrology Bull. XIII^{e} Annee no. 1, p. 29-39; also released as Nevada Dept. Conserv. and Nat. Resources, Water Resources Bull. 36.

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

Robinson, T. W., 1958, Phreatophytes: U.S. Geol. Survey Water-Supply Paper 1423, 84 p.

REFERENCES (CONTINUED)

______, 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.

Rush, F. E., and Schroer, C. V., 1971, Water resources of Big Smoky Valley, Lander, Nye, and Esmeralda Counties, Nevada: Nevada Dept. Conserv. and Nat. Resources, Div. Water Resources Bull. 41, 84 p.

Strand, R. G., 1967, Geologic map of California, Olaf P. Jenkins edition, Mariposa sheet: California Div. Mines Map.

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.

Van Denburgh, A. S., and Glancy, P. A., 1970, Water-resources appraisal of the Columbus Salt Marsh - Soda Spring Valley area, Mineral and Esmeralda Counties, Nevada: Nevada Dept. Conserv. and Nat. Resources, Water Resources - Reconn. Ser. Rept. 52, 66 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 Div. Water Resources Bull. 50, 154 p.

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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 (out of print)
8	Independence*
9	Gabbs (out of print)
10	Sarcobatus and Oasis (out of print)
11	Hualapai Flat*
12	Ralston and Stone Cabin*
13	Cave*
14	Amargosa Desert, Mercury, Rock, Fortymile Canyon, Crater Flat, and Oasis (out of print)
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 (out of print)
31	Upper Reese*
32	Lovelock
33	Spring (near Ely; out of print)
34	Snake, Hamlin, Antelope, Pleasant, and Ferguson Desert*
35	South Fork, Huntington, and Dixie Creek-Tenmile Creek (out of print)
36	Eldorado, Piute, and Colorado River (out of print)
37	Grass (near Austin) and Carico Lake (out of print)
38	Hot Creek, Little Smoky, and Little Fish Lake (out of print)
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*

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47	Thousand Springs and Grouse Creek*		
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49	Butte*		
50	Lower Moapa, Black Mountains, Garnet, Hidden, California Wash, Gold Butte, and Greasewood		
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52	Columbus, Rhodes, Teels, Adobe, Alkali, Garfield Flat, Huntoon, Mono, Monte Cristo, Queen, Soda Spring		
53	Antelope, East Walker area		
54	Cactus Flat, Gold Flat, Kawich, Yucca Flat, Frenchman Flat, Papoose Lake, Groom Lake, Tikapoo, Three Lake, Indian Springs, Las Vegas, Buckboard Mesa, Mercury, Rock, Jackass Flat, Crater Flat		
55	Granite Springs, Kumiva, Fireball, Bradys Hot Springs Area		
56	Pilot Creek Valley Area, Elko and White Pine Counties		
57	Truckee River		

*indicates out of print

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
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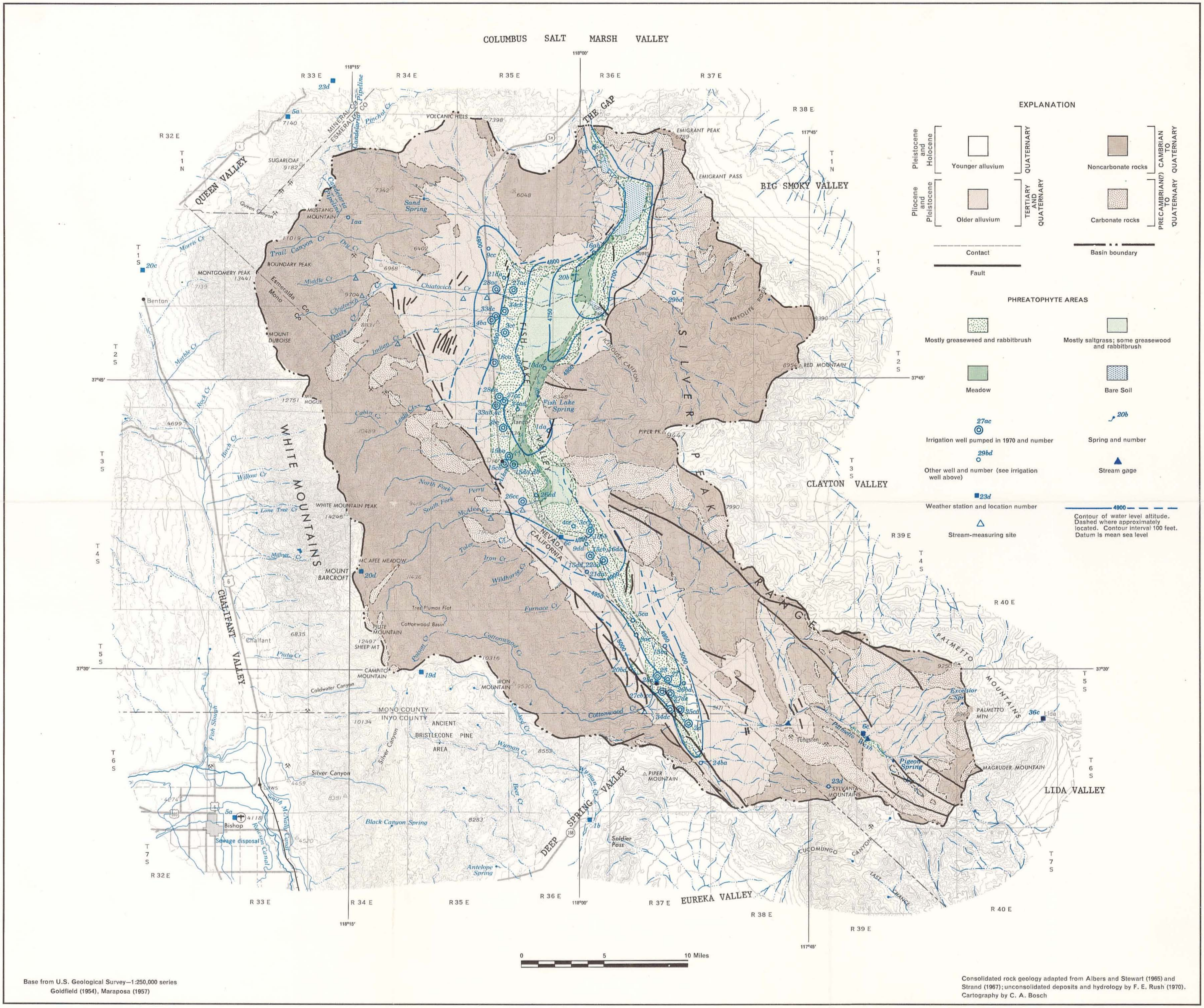

Base from U.S. Geological Survey—1:250,000 series
Goldfield (1954), Maraposa (1957)

Consolidated rock geology adapted from Albers and Stewart (1965) and Strand (1967); unconsolidated deposits and hydrology by F. E. Rush (1970).
Cartography by C. A. Bosch

PLATE 1.—GENERALIZED HYDROGEOLOGY OF FISH LAKE VALLEY, NEVADA AND CALIFORNIA