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

GEOHYDROLOGY OF SMITH VALLEY, NEVADA, WITH SPECIAL REFERENCE TO THE WATER-USE PERIOD, 1953-72

By F. E. Rush
and
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CONVERSION FACTORS

For those readers who may prefer to use metric units rather than English units, the conversion factors for terms in this report are listed below:

English unit	Metric unit	Multiplication factor to convert from English to metric quantity
Acres	Square metres (m^2)	4,050
Acre-feet (acre-ft)	Cubic metres (m^3)	1,230
Cubic feet per second (cfs)	Litres per second (l/s)	28.3
Do.	Cubic metres per second (m^3/s)	.0283
Feet (ft)	Metres (m)	.305
Gallons	Litres (l)	3.78
Gallons per minute (gpm)	Litres per second (l/s)	.0631
Inches (in)	Millimetres (mm)	25.4
Miles (mi)	Kilometres (km)	1.61
Square miles (mi^2)	Square kilometres (km^2)	2.59

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ABSTRACT

The principal source of water for Smith Valley is the West Walker River. Most ground-water replenishment is infiltration from cropland and canals.

The average annual inflow of the West Walker River for the period of record (1958-72) was 179,000 acre-feet; outflow was 133,000 acre-feet. The amount of water stored in the upper 100 feet of saturated alluvium is about 1,500,000 acre-feet.

Most waters sampled were suitable for their intended use, but fluoride and arsenic concentrations in many samples were higher than desirable if these waters were to be used for human consumption.

About 160,000 acre-feet of water moved through the hydrologic system in 1972. Of this amount, 46,000 acre-feet was consumed by irrigation, although 93,000 acre-feet reached the irrigated areas. During 1972, a ground-water pumpage of 20,000 acre-feet contributed to a ground-water storage depletion of 6,000 acre-feet.

The system yield is estimated to be 62,000 acre-feet per year. About 9,000 acre-feet per year of ground water and 6,000 acre-feet per year of surface water remain to be developed in the Artesia Lake area.

The conjunctive-use volume during near normal years is about 90,000 acre-feet.

INTRODUCTION

Purpose and Scope

This is the second report on the hydrology of Smith Valley prepared by the U.S. Geological Survey in cooperation with the Office of the State Engineer. The first report was made by Loeltz and Eakin (1953) and described conditions in the valley as of 1950.

This study of the geohydrology of Smith Valley is concerned principally with the effects of water use on the hydrologic system for the period 1953 to 1972. The purposes of the study are to define the geohydrology, the effects of water use since 1953, the effects during the calendar year 1972, and the effects that might be expected with continued increase in water use and consumption.

The scope of the report includes: (1) a description of the geohydrologic setting, (2) appraisal of the elements of inflow and outflow in the hydrologic system, (3) a description of the surface-water supply and the ground-water storage systems, (4) estimation of surface-water and ground-water use, (5) effects of this use on the hydrologic system, (6) definition of the chemical character of water, and (7) an evaluation of future water supply and effects of its development.

The field work began in October 1970 and has been conducted intermittently through the winter of 1973-74. The year 1972 is the base year for water budgets developed in this study.

The numbering system used for hydrologic sites is explained in the appendix.

Location and General Features

Smith Valley is in the central part of the Walker River drainage basin of Nevada and California, as shown in figure 1. Most of the flow in the river is generated in the Sierra Nevada from melting snow. The river terminates at Walker Lake, a remnant of ancient (Pleistocene) Lake Lahontan. The north boundary of the valley is 40 miles southeast of Reno. Mountains that generally range in altitude from 6,000 feet to over 10,000 feet surround the valley. The highest peak in the area is Mt. Patterson, at the south end of the basin. The lowest point in the valley is Artesia Lake. The West Walker River crosses Smith Valley from west to east (fig. 1). Smith, a small community near the center of the valley, is at an altitude of 4,780 feet. The valley has an area of about 479 square miles (Rush, 1968, p. 19).

The population of the valley in 1972 was between 300 and 500. Most people's employment is directly or indirectly related to the approximate 80 farming and ranching units.

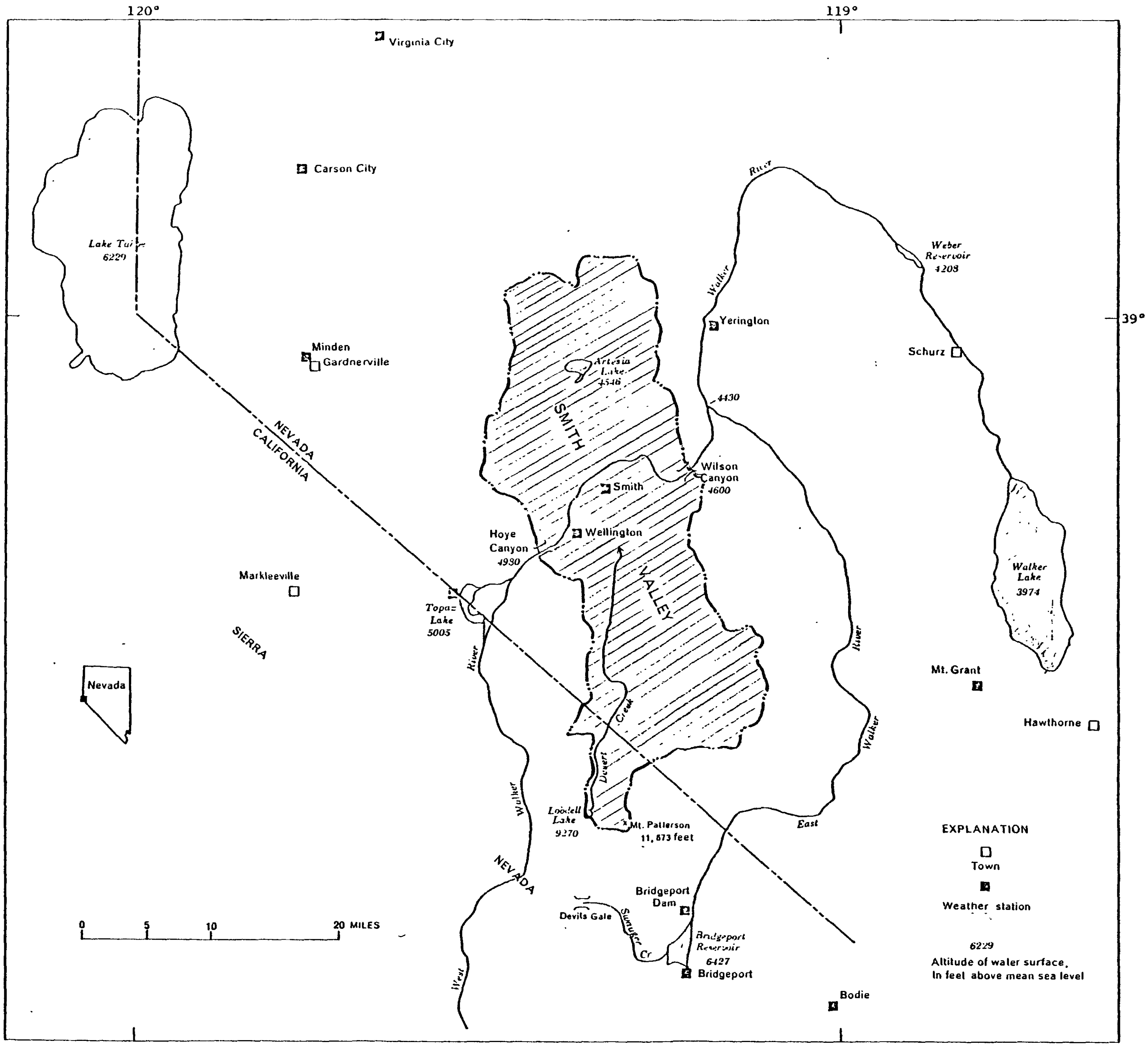

Figure 1.--Index map of Smith Valley and adjacent areas.

Previous Work

Several reports that describe various aspects of the geology or hydrology of Smith Valley have been published. The following is a brief summary of the more important publications. Miller and others (1953, p. 36) listed 34 chemical analyses of water samples collected in Smith Valley from 1933 to 1952. Of these samples, 16 were from wells and five from springs.

Loeltz and Eakin (1963) authored a semiquantitative report on the geology and hydrology of the valley. This report contains descriptions of most aspects of the hydrologic system and 27 pages of well and water-quality data.

A preliminary geologic map, which includes Smith Valley, was authored by Moore (1961). More recently, a report describing the geologic development of the basin was published by Gilbert and Reynolds (1973).

Domenico and others (1966) evaluated the economic and physical aspects of pumping irrigation wells to supplement diversions from the West Walker River. They concluded that more water could be pumped cheaper with the existing wells if the operation were centralized to provide water for the benefit of the entire area.

The U.S. Department of Agriculture (Nevada River Basin Survey Staff, 1969) made a survey of the Walker River Basin in which they presented findings and conclusions concerning water and related land resources. They concluded that (1) economic activity could be increased, (2) water quality could be improved, (3) streams could be better regulated and flood damage decreased, (4) land productivity could be increased, and (5) recreational opportunity could be enhanced.

The present report is one of a series that describes the hydrology of the Walker River Basin. The other reports in this series are, in downstream order: (1) Glancy (1971), Antelope Valley and the East Walker Area; (2) Rush and Hill (1972), bathymetry of Topaz Lake; (3) Huxel (1969), Mason Valley; (4) Everett and Rush (1967), Walker Lake Valley; (5) Katzer and Harmsen (1973), bathymetry of Weber Reservoir; and (6) Rush (1970), bathymetry of Walker Lake.

In addition, continuously recorded streamflow gaging data have been published for the valley. These data are presented in various U.S. Geological Survey Water-Supply Papers and open-file reports.

Acknowledgments

During this study the authors received abundant cooperation and help from many farmers and ranchers, especially irrigation-well owners. In addition, the Walker River Irrigation District was helpful in providing stream and canal diversion data. All help was greatly appreciated.

HISTORY OF WATER-RESOURCES DEVELOPMENT

Surface Water

Apparently the first irrigation diversion of surface water in Smith Valley was from Desert Creek by J. B. Lobdel in 1861. The first large diversion ditch was constructed in 1862, followed by the construction of several ditches during the next few years. In 1876, south of the river, an 8-mile long ditch was dug, which may have been the beginning of either the Saroni or the Plymouth Canal. In the next few years the Colony Canal, the principal ditch extending northward from the river was constructed (Loeltz and Eakin, 1953, p. 27).

Prior to 1881, about 6,000 acres was cultivated. The principal crops were hay, vegetables, and fruit. By 1919, river diversions were becoming so large that the Walker River Irrigation District was formed to administer the diversions. In 1922, Topaz Lake was added to the river system as an off-channel reservoir west of and upstream from Smith Valley (fig. 1). In 1937, the usable storage capacity of Topaz Lake was increased from 45,000 acre-feet to 59,000 acre-feet (Loeltz and Eakin, 1953, p. 7).

Annual natural-flow appropriations for Smith Valley from the West Walker River amount to about 45,000 acre-feet, with storage rights in Topaz Lake adding an additional 28,000 acre-feet (Domenico and others, 1966, p. 6).

Ground Water

In general terms, the history of ground-water development in Smith Valley is summarized in figure 2 and table 1. Most of the development has been in the last 20 years. Two types of irrigation development can be identified: (1) Water from ground-water sources to supplement diversions from the West Walker River and Desert Creek, and (2) pumping of wells as the sole source of water for irrigation. Supplemental ground water was the objective of most of the well construction through about 1965. These wells were constructed throughout the areas where surface water is used (pl. 2). Because of drought conditions during the period 1959-61, many supplemental wells were drilled and pumped. Since about 1965, a growing proportion of the new wells has been constructed to irrigate areas not supplied with surface water. North of the river, these lands are mostly in sec. 12, T. 11 N., R. 23 E., and sec. 31, T. 12 N., R. 24 E. South of the river, two such wells are in secs. 16 and 21, T. 10 N., R. 24 E.

In addition, Nevada Hot Springs (12/23-16dc; see p. 122 for location system), the Ambassador Gold Mining Company well (13/23-25ca), and many low-yield flowing wells (Loeltz and Eakin, 1953, p. 29 and 48) remain sources of ground water.

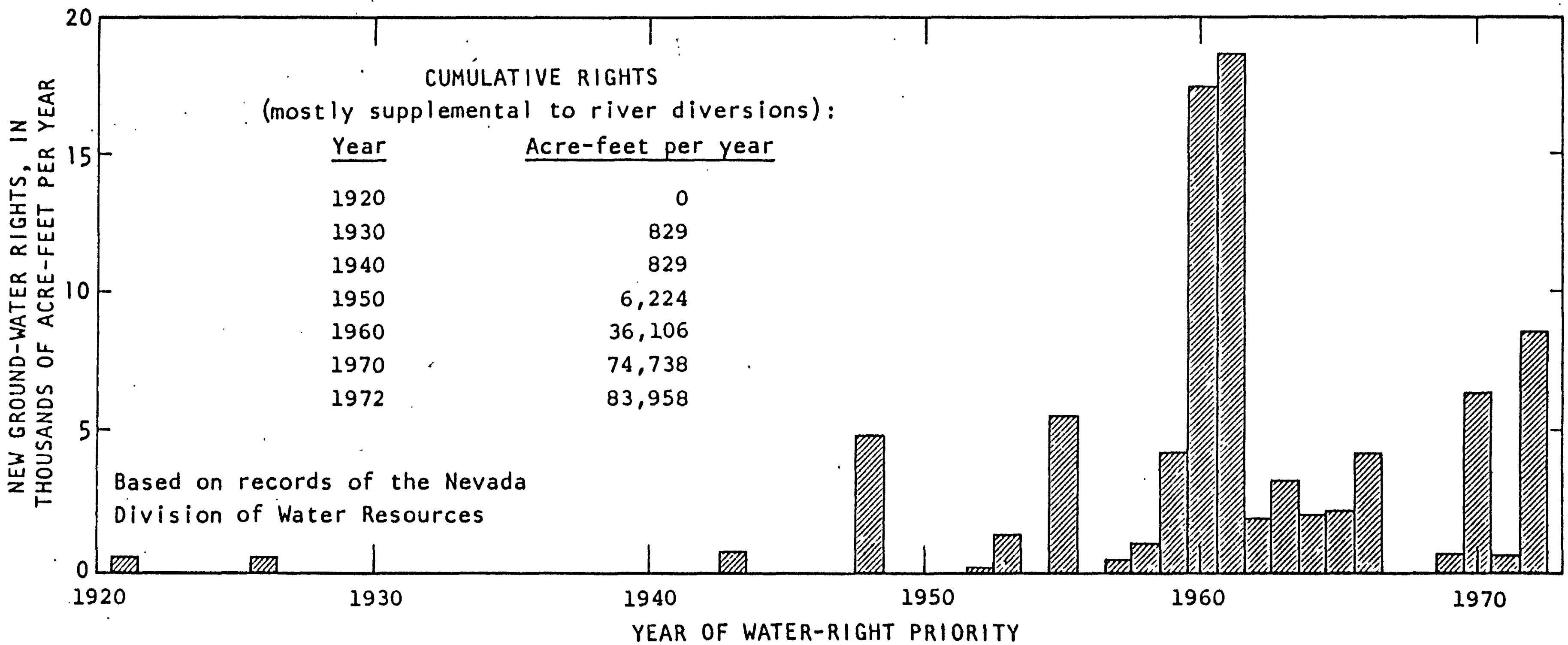

Figure 2.--Growth of ground-water rights for irrigation.

Table I.--*Ground-water use chronology*

Year	Item
1921	Ground-water rights totaled 430 acre-feet per year to irrigate 88 acres according to DWR (Nevada Division of Water Resources).
1932	First large-diameter (14-inch), deep well (155 feet), drilled by Ambassador Gold Mining Co. Later and currently used for irrigation.
1949	Irrigated crop land was 18,290 acres (Hardman and Mason, 1949, p. 36).
1952	Ground-water rights totaled 6,395 acre-feet per year to irrigate 1,610 acres according to DWR.
1958-60	Ground-water pumpage for each year was 3,000 acre-feet, according to DWR.
1960-61	Seventeen irrigation wells drilled. Only 11 previously in existence. Ground-water pumpage in 1961 was 18,000 acre-feet, according to DWR.
1964	Ground-water pumpage was 13,500 acre-feet from 24 irrigation wells, according to DWR.
1965	Irrigated land equaled 22,199 acres (U.S. Department of Agriculture, Nevada River Basin Survey Staff, 1969, p. 52). Ground-water rights totaled 63,722 acre-feet per year to irrigate 16,045 acres, according to DWR.
1972	Irrigated crop land was 22,600 acres, on the basis of an inventory made as part of this study. Forty-eight irrigation wells have been drilled to date; 39 were pumped during 1972. Estimated ground-water pumpage for irrigation was 20,000 acre-feet. Ground-water rights totaled 83,958 acre-feet for 21,102 acres (fig. 2).

HYDROLOGIC ENVIRONMENT

Climate

Smith Valley is arid to semiarid. Average annual precipitation on the valley floor probably ranges from about 6 to 10 inches. The annual potential lake evaporation is about 48 inches (Kohler and others, 1959, pl. 2). The surrounding mountains receive somewhat more precipitation--in some areas as much as 20 inches. To the west, in the headwater area of the West Walker River, a thick snowpack accumulates in most winters.

The highest monthly rates of precipitation generally are in the period November to March, as shown in figure 3. Long-term trends in precipitation are shown in figure 4. Based on records from nearby areas, the period 1860-1919 probably had above-normal precipitation.

Air temperatures in Smith Valley are moderate. Overnight lows in January average about 10°F (-12°C); daytime highs in July average near 90°F (32°C). Day to night fluctuations are commonly 30 to 40°F (17 to 22°C) throughout the year.

Table 2 summarizes growing season data for the valley. It shows that a 28°F (-2°C) growing season generally lasts between 110 and 140 days.

Table 2.--*Growing-season temperature data for stations in and near Smith Valley*

[Compiled from published records of the National Weather Service]

Station[1]	Period of record (years)	Average number of days above specified temperature		
		24°F (-4°C)	28°F (-2°C)	32°F (0°C)
Smith	1948-66	149	118	75
Topaz Lake	1959-71	155	132	99
Wellington Ranger Station	1948-71	181	154	129
Yerington	1948-71	170	139	108
Estimate for most of Smith Valley floor		140-170	110-140	70-120

1. For locations, see figure 1.

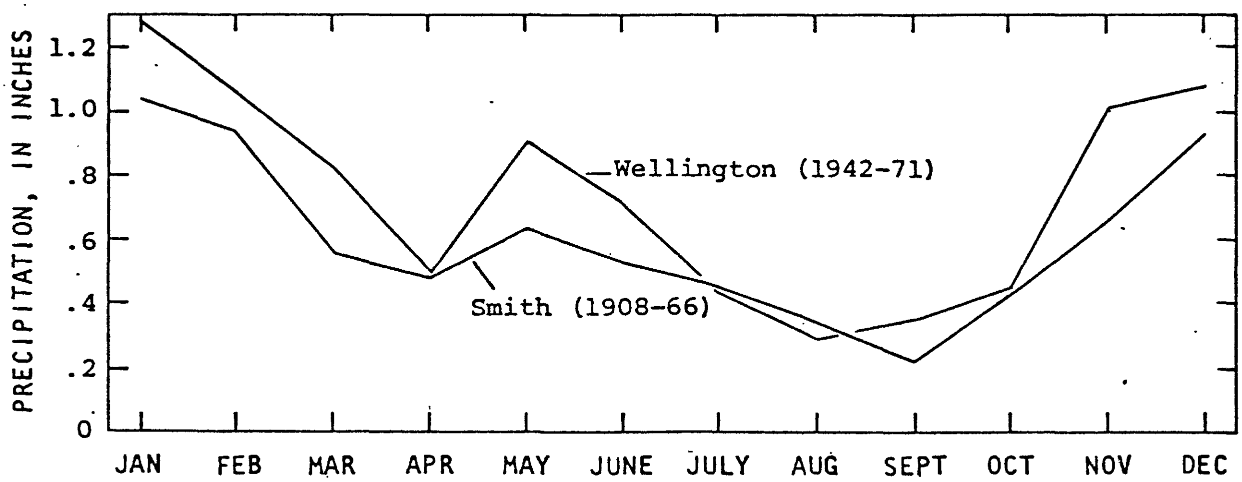

Figure 3.--Average monthly distribution of precipitation at Smith and Wellington.

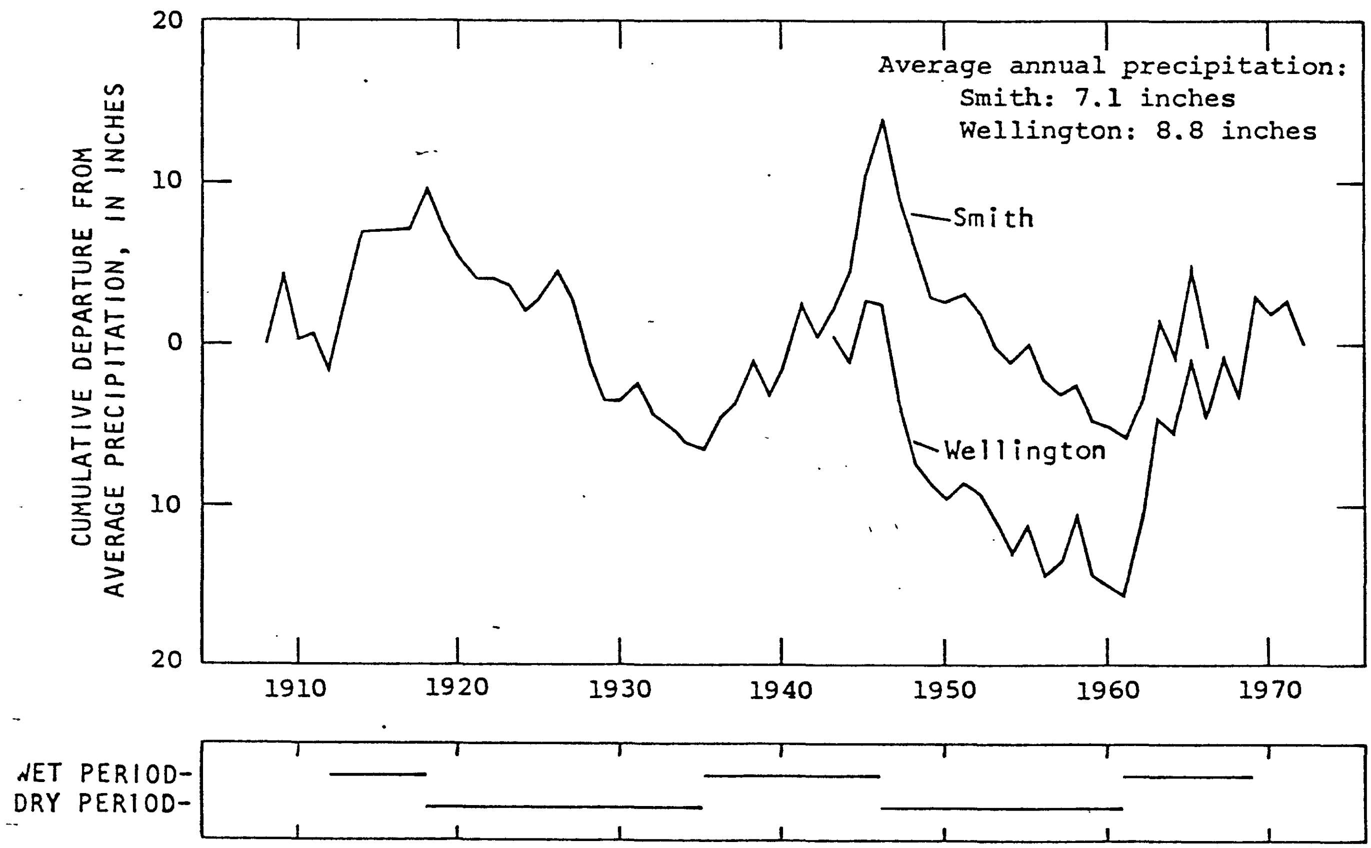

Figure 4.--Cumulative departure from average annual precipitation at Smith and Wellington.

Lithologic Units and Structural Features

For the purposes of this report, the rock types of Smith Valley were grouped into four consolidated-rock units and three alluvial units, as shown on plate 1. The division was made on the basis of the published geologic map of the area (Moore, 1961), aerial photograph interpretation, and field inspection of a few alluvial outcrops. Table 3 is a summary of these lithologic units.

The structural features of principal interest in the hydrologic study were the range-front faults and those that cut alluvium. Both may be important hydrologically in that they may either be avenues along which ground water flows or barriers to across-fault flow of ground water. Both types of faults are shown on plate 1. Other faults are present in the mountains, but are not shown. Undoubtedly many additional faults remain to be identified and mapped.

Source, Movement, and Discharge of Water

Sources of water for the valley are precipitation that falls within the topographic basin, especially snow in the mountains, and inflow of West Walker River from the west. In addition, a small amount of streamflow is diverted from a high-altitude tributary of West Walker River in California to Lobdell Lake, near the headwaters of Desert Creek, at the south end of the valley (pl. 1).

Ground-water movement is generally perpendicular to the water-level contours shown on plate 2. A ground-water divide separates the valley-fill reservoir into two flow systems. The larger system occupies the southern two-thirds of the valley; ground-water flow in this system is generally toward the river from both the north and the south. In the northern one-third of the valley, flow is generally toward centrally located Artesia Lake.

In both flow systems, the immediate source of most of the subsurface flow is infiltration from fields and canals. A secondary source of flow is from recharge due to precipitation in the mountains.

Irrigated land is a discharge area for irrigation water diverted from West Walker River, wells, and Desert Creek, and, as described above, it is also a source area for ground water. The distribution of irrigated land in 1972 is shown on plate 2. Most irrigated lands receive water through canals from West Walker River. The phreatophyte (native ground-water consuming plants) areas, shown on plate 2, are also discharge areas. Diverted river water is supplemented with pumped well water in many irrigated areas.

A minor but significant geothermal heating of ground water is indicated in parts of the area (table 4). The most impressive discharge of hot water in the valley is Nevada Hot Springs (12/23-16dc), in the northwestern part of the valley (table 5, and pl. 2). The springs, like most hot springs in Nevada, are on a fault which probably forms a permeable zone for upward flow.

Table 3.--Principal lithologic units

Age		Unit designation		Thickness (feet)	Lithologic units shown on plate 1		General hydrologic properties
QUATERNARY	Pleistocene and Holocene	Playa deposits	Valley fill	Up to several hundred	Silt, clay, and evaporites. Occur beneath Artesia Lake.	Valley-fill reservoir	Very high porosity and very low permeability. Yield only small quantities of water to wells.
QUATERNARY	Pleistocene and Holocene	Younger alluvium	Valley fill	0-100±	Unconsolidated lenses of gravel, sand, silt, and clay in stream channel and lake deposits; represents detritus from adjoining mountains. Includes dune sand east of Artesia Lake.	Valley-fill reservoir	Sand and gravel deposits, moderately to highly permeable, and capable of yielding moderate to large quantities of water to wells. Lake-bottom deposits of fine-grained sand, silt, and clay are much less capable of yielding water to wells.
TERTIARY AND QUATERNARY	Pliocene and Pleistocene	Older alluvium	Valley fill	Probably up to several thousand	Semiconsolidated to unconsolidated lenses of gravel, sand, silt, and clay underlying alluvial fans, slope-wash areas, and upland alluvial surfaces. Occurs at depth beneath playa deposits and younger alluvium.	Valley-fill reservoir	Sand and gravel deposits have moderate permeability and are capable of yielding moderate quantities of water to wells. Yields of large-diameter wells are as much as 2,800 gal/min.
TERTIARY AND QUATERNARY	Pliocene and Pleistocene	Volcanic rock	Consolidated rocks	--	Mostly flow breccia, lava flows, and agglomerate of andesite, dacite, and basalt. Some rhyolite tuff.		Not tapped by wells. Scoriaceous and interflow zones may be good aquifers where saturated.
TERTIARY		Sedimentary rock	Consolidated rocks	--	Mostly sandstone, mudstone, and shale. Some minor outcrops of limestone.		Not tapped by wells. Generally does not readily transmit water, except in areas of intense structural deformation where some water may be transmitted along fractures.
CRETACEOUS		Granitic rock	Consolidated rocks	--	Mostly quartz monzonite, granodiorite, and granite porphyry.		Not tapped by wells. Virtually no interstitial porosity and permeability. May transmit small amounts of water through near-surface fractures and weathered zones. Transmits large amounts of water to Nevada Hot Springs through a fault zone.
TRIASSIC AND JURASSIC		Metasedimentary rock	Consolidated rocks	--	Mostly green schist, shale, slate, siltstone, sandstone, and graywacke.		Same as for Tertiary sedimentary rocks.

Warm water from wells that penetrate alluvium probably is a mixture of normal-temperature water of 54-59°F (12-15°C) with much warmer thermal water. The thermal water probably reaches the alluvium through fracture zones or faults in the underlying bedrock. Many of these faults or fracture zones have not been located, other than by the presence of warm water.

Table 4.--*Range and distribution of ground-water temperatures*

Temperature classification1/	Temperature range (°F)	(°C)	Number of samples	Location
Normal	54-59	12-15	25	Mostly along axis of valley
Slightly warm	60-64	16-18	16	Mostly along valley margins south of river and west of Owens Fault (pl. 2)
Moderately warm	65-69	18-21	3	Scattered occurrences
Very warm	70-100	21-38	5	East of Owens Fault and north of Artesia Lake
Hot	>100	>38	2	Nevada Hot Spring and a well at Wellington
Summary:	54-144°F 12-62°C		Total 51	

1. Classification designed for hydrologic conditions in Smith Valley.

Table 5.--*Measured discharge and water temperature of Nevada Hot Springs*

Date	Discharge (cfs)	Temperature of water (°F)	(°C)
8-17-72	1.26	128	53
2- 8-73	1.14	122	50
4-26-73	.93	108	42
7-23-73	1.29	--	--
Average (rounded)	1.2 = 540 gal/min	--	--
6-30-72	Highest temperature measured at a spring orifice	144	62

Streamflow Characteristics

The principal stream in Smith Valley is the West Walker River, which enters the valley through Hoye Canyon from the west and flows eastward out of the valley through Wilson Canyon (fig. 1). Desert Creek drainage (fig. 1) is entirely within the valley, having its headwaters in the mountains at the south and flowing northward toward the West Walker River. Under native conditions, some flow from Desert Creek, reached the West Walker River in most years. Under present conditions, most of the flow of Desert Creek is diverted, and little reaches the river.

Minor streams, such as Sheep Creek, and flow in Burbank, Red, and Pipeline Canyons, are only a trickle during most of the year (pl. 2). Other channels have flow only during short periods of rapid winter or spring snowmelt, or intense summer thunderstorms. An approximate areal distribution of annual streamflow in Smith Valley follows:

Stream	Percent of total
West Walker River	94
Desert Creek	5
All others	1
Total	100

In addition to the usual stream-gaging and streamflow measurements made during hydrologic studies, estimates of mean annual flow were made using a channel-geometry method described by Moore (1968). This method was used mostly on ephemeral channels, but also was used on perennial streams to provide additional checks on values of mean annual flow determined from flow data.

VALLEY-FILL RESERVOIR

Extent and Boundaries

The valley-fill reservoir consists of the older and younger alluvium and playa deposits that underlie the valley floor and apron (pl. 1). Its areal extent is shown on plate 2. Its full thickness is unknown, because no well fully penetrate it, other than near its margins where it is thin. The reservoir is probably several thousand feet thick along the western side of the valley and thinner to the east. The external hydraulic boundaries are formed by low-permeability consolidated rocks which underlie and form the sides of the reservoir. Recharge boundaries are formed by West Walker River, Desert Creek, the flow from Nevada Hot Springs, canals, irrigated fields, and thermal water rising from consolidated rocks. Because of the low permeability of the bed of Artesia Lake, ponded water in the lake probably cannot be considered a significant source of recharge.

The principal internal hydrologic boundaries are faults (pls. 1 and 2) and extensive lithologic changes in the alluvium, such as transition from sand and gravel to the fine-grained playa deposits underlying Artesia Lake. Because of the extensive cultivation and land leveling in the valley, more faults probably are present than have been detected. The Owens fault in the northern part of the valley (pl. 2) has been established during this study as an effective boundary to lateral ground-water flow, yet the fault zone is a conduit of rising thermal water. The result is that on the east side of the fault, two irrigation wells (12/24-31bd and 12/24-31db, table 25) have experienced excessive drawdowns. This is discussed further in a later section of the report that describes the effects of man's activities. Indirect evidence indicates that another fault may be present near or between wells 10/24-21ba and 10/24-20ab in the southern part of the valley, and may be an extension of a fault farther to the south (pl. 1). The first well yielded water with a temperature of 67°F (19°C); the latter, 54°F (12°C). The latter temperature is near that expected without geothermal input. The wells are slightly less than one mile apart.

Hydraulic Properties

Transmissivity and permeability of aquifers in the upper 500 feet of saturated alluvium have been evaluated; the results are presented in figures 5-7. Twenty-seven short-term pumping tests of irrigation wells were the principal bases for the evaluation, but in addition, well logs, pumping rates, and general geologic interpretations were used.

The transmissivity map (fig. 5) shows that the Red Canyon-Burbank Canyon fan is the area where water can most easily be transmitted to wells by pumping. The area of the flood plain of the West Walker River and Desert Creek are intermediate in value. The bulk of the valley-floor area generally has values less than 50,000 gpd/ft (gallons per day per foot).

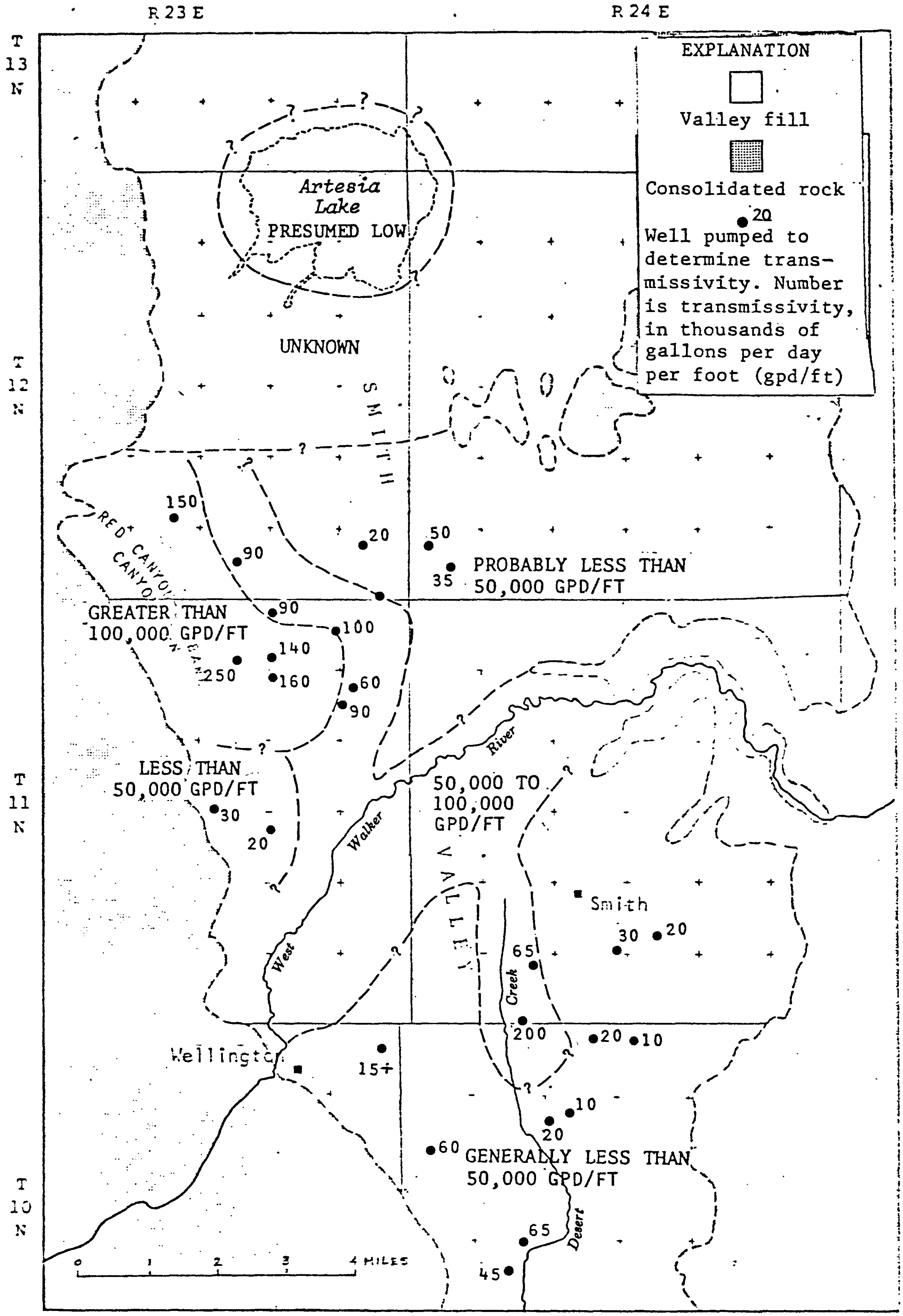

Figure 5.--Generalized transmissivity of the upper 500 feet of saturated valley fill.

Within any one area, the data in figure 5 show a large numerical variation in transmissivity. As a result, the map should be used only as a general guide. For any specific site, the transmissivity of the upper 500 feet of saturated alluvium could be within a fairly wide range of values.

To translate the transmissivity shown in figure 5 to terms a well owner could use, the following approximate relation exists for a well at the end of 24 hours of continuous pumping:

$$\text{Specific capacity} \approx \frac{\text{Transmissivity in gpd/ft}}{2{,}000}$$

where specific capacity is the yield of the well, in gallons per minute per foot of drawdown. This assumes that there are no nearby subsurface restrictions (boundaries) to flow, and that well efficiency is high. For example, assume that a pumping test yielded a transmissivity value of 100,000 gpd/ft. At the end of 24 hours of pumping, the well would have a specific capacity of about 50 gal/min per foot of drawdown. If the well were pumping 2,000 gpm, then the drawdown would be about 40 feet below the prepumping (static) water level if the efficiency of the well is high. After a longer period of time the specific capacity would be smaller because of the continuous, slow decline in pumping level. The relation of transmissivity and specific capacity to pumping rates and pump size for the existing irrigation wells is given in figure 6. Generally, to maintain a given discharge, wells in lower-transmissivity materials require larger pumps than wells in high-transmissivity materials.

Figure 7 shows the distribution of permeability of the average aquifer material in the upper 500 feet of saturated alluvium. This map is based on transmissivity values obtained from pumping tests and an evaluation of sand and gravel (aquifer) thicknesses as reported in drillers' logs. The relation between transmissivity and permeability is:

$$\text{Transmissivity} = \text{permeability} \times \text{aquifer thickness.}$$

The map shows that the aquifers associated with the Red Canyon-Burbank Canyon fan have permeabilities equivalent to well-sorted beds of sand or sand and gravel. Cautions regarding the use of figure 7 are the same as those described above for the transmissivity data.

The storage coefficient for most of the valley-fill reservoir, for a prolonged period of pumping, will equal the specific yield, or about 0.15. In the short term, semiconfined (artesian) aquifers, where present in the area east of Owens fault (fig. 7), have coefficients several orders of magnitude smaller.

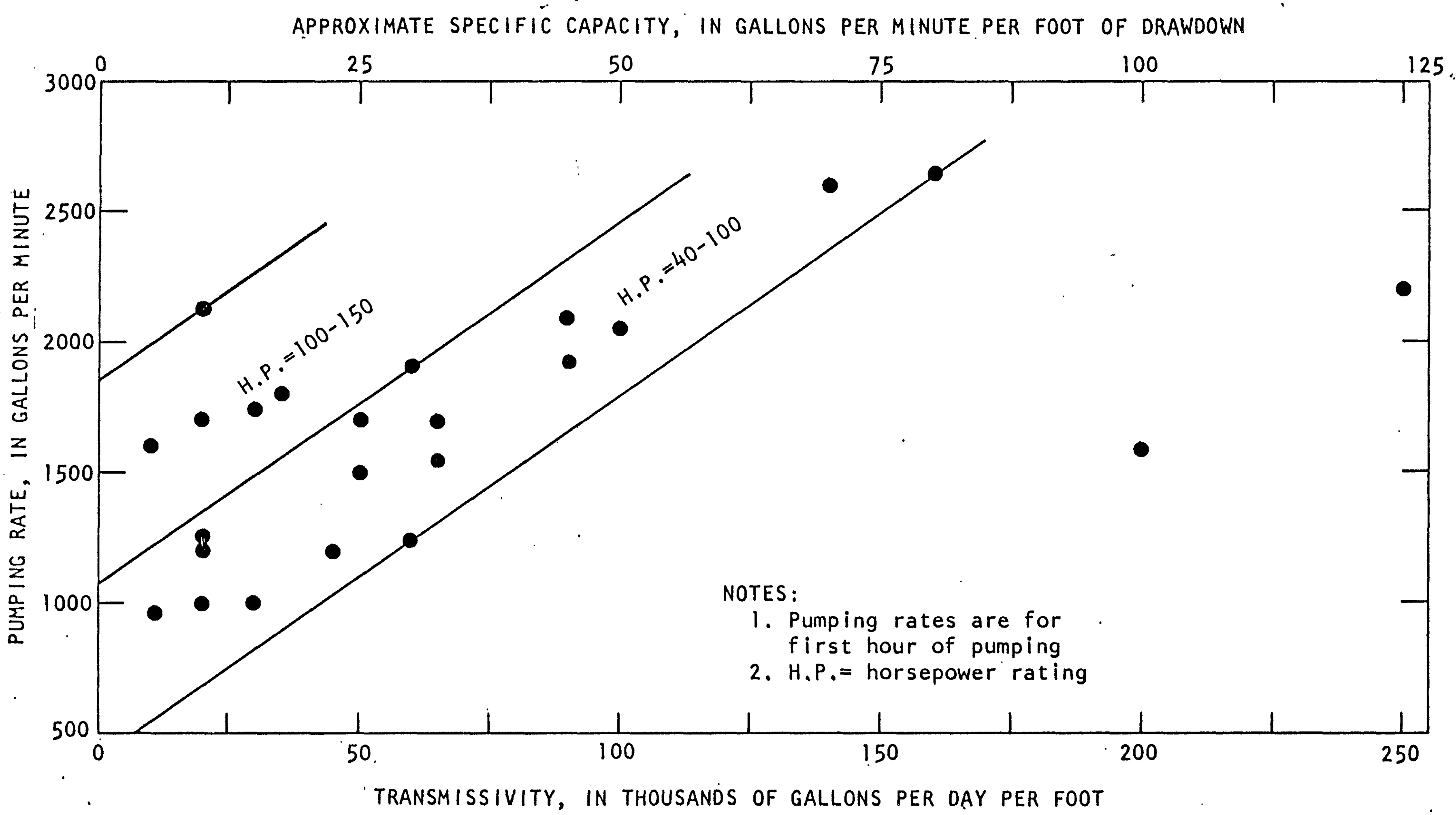

Figure 6.--General relation of well-pumping rate to transmissivity, specific capacity, and pump horsepower in Smith Valley.

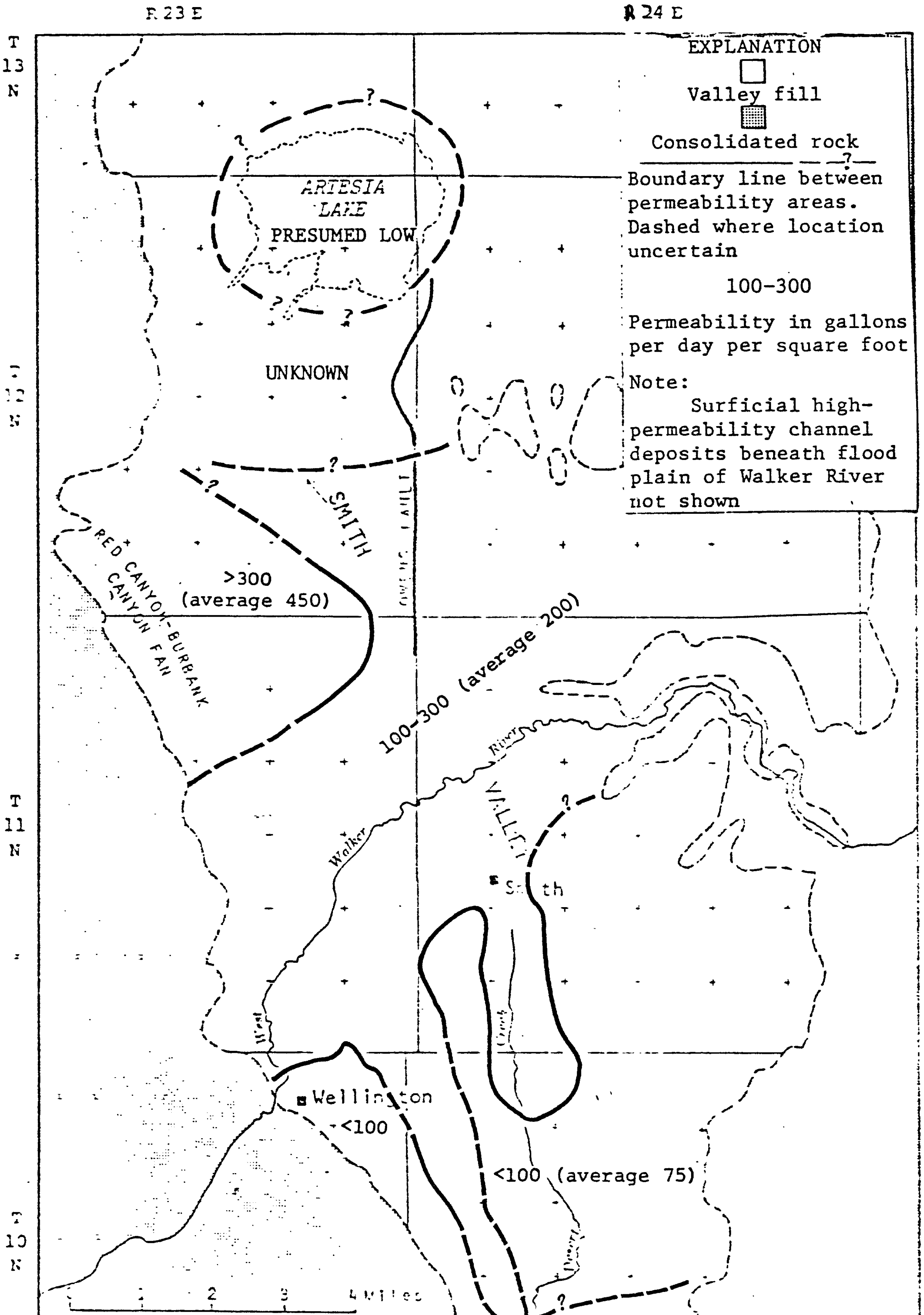

Figure 7.--Generalized distribution of average aquifer permeability in the upper 500 feet of saturated valley fill.

The valley-fill reservoir contains water both semiconfined by overlying, relatively impermeable beds and under unconfined conditions. Semiconfined conditions are: (1) east of Owens fault in the area of wells 12/24-31ba and 12/24-31db, and (2) in low-lying areas of flowing wells and springs (a) around Artesia Lake and extending southward along the valley floor to about the south boundary of T. 12 N., and (b) extending southward from the West Walker River about 2 miles. The area of artesian-well flow was mapped by Loeltz and Eakin (1953, pl. 2). In 1972 it remained about the same size and shape, except for seasonal reduction in head and the consequent diminishing of flow associated with the pumping of nearby irrigation wells. The wells east of Owens fault do not flow.

Ground Water in Storage

The valley-fill reservoir contains a large amount of water that is slowly moving through the system; the direction of flow is generally downgradient and perpendicular to the water-level contours shown on plate 2. The estimated volume of this water, using a specific yield of 0.15 and an effective area of valley fill of 100,000 acres, is about 15,000 acre-feet per foot of saturated material, or 1,500,000 acre-feet in the upper 100 feet of saturated valley fill. This is a very large amount of water in relation to the volume of water moving through the hydrologic system each year. For example, the storage in the upper 100 feet of saturated alluvium is nearly four times larger than the average annual precipitation that falls in the basin, and roughly 10 times larger than the inflow to the valley in the West Walker River in 1972 (table 6). The storage in the entire thickness of alluvium is not known because the alluvial thickness is not known; however, only a fraction of the total stored water would be available to wells. The main sources of this water are infiltration of (1) precipitation that falls principally in the mountains of the basin, (2) water that has been diverted by irrigation canals from West Walker River, and (3) Desert Creek. The depth to this mass of stored water is shown in figure 8.

Loeltz and Eakin (1953, p. 29-34) documented large-scale water-level rises prior to 1950. These rises were attributed mostly to percolation of irrigation water. The rise in ground-water level has been much smaller since 1950, and changes are more localized. Figure 9 shows a gradual rise in the water level of well 11/24-27cb from 1919 to about 1935, then a dramatic rise of about 65 feet from 1935 to 1950, but only about a 5-foot rise from 1950 to 1973. Well 11/24-32ca, a few tens of feet southeast of Ralph Nuti's home, has a similar water-level history: 27-foot depth to water in 1937 (Loeltz and Eakin, 1953, p. 32) but a water level at land surface in 1948 and 1973.

Some lowering of water levels has resulted from two factors: (1) reduced infiltration of irrigation water and natural recharge during a drought period and (2) increased pumping for irrigation during the same period. In figure 10, wells 11/24-32dc and 11/23-3dc show this type of water-level decline during the drought period 1959-62, resulting in a lowering of 20 and 16 feet, respectively. Well 10/24-4cd possibly has a similar history, as interpolated from the incomplete record (fig. 10).

Table 6.--*Annual flows of, and diversions from, West Walker River, calendar years 1953-72*

[Based on published records of the U.S. Geological Survey except as indicated; all values in acre-feet, rounded.]

Calendar year	Inflow to Smith Valley (1)	Outflow from Smith Valley (2)	Net decrease in flow (3)=(1)-(2)	Diversions to canals in Smith Valley 1/ (4)
1953	--	131,000	--	87,000
1954	--	98,000	--	78,000
1955	--	98,000	--	52,000
1956	--	218,000	--	99,000
1957	--	118,000	--	81,000
1958	246,000	190,000	56,000	96,000
1959	120,000	80,000	40,000	62,000
1960	80,000	64,000	16,000	29,000
1961	71,000	57,000	14,000	19,000
1962	151,000	91,000	60,000	79,000
1963	216,000	161,000	55,000	82,000
1964	125,000	85,000	40,000	61,000
1965	229,000	167,000	62,000	91,000
1966	148,000	100,000	48,000	73,000
1967	286,000	217,000	69,000	90,000
1968	146,000	106,000	40,000	62,000
1969	338,000	300,000	38,000	104,000
1970	195,000	135,000	60,000	88,000
1971	186,000	135,000	51,000	92,000
1972	142,000	101,000	41,000	69,000
Average 1958-72	179,000	133,000	46,000	73,000
Average 1953-72	--	133,000	--	75,000

1. Data from Walker River Irrigation District records.

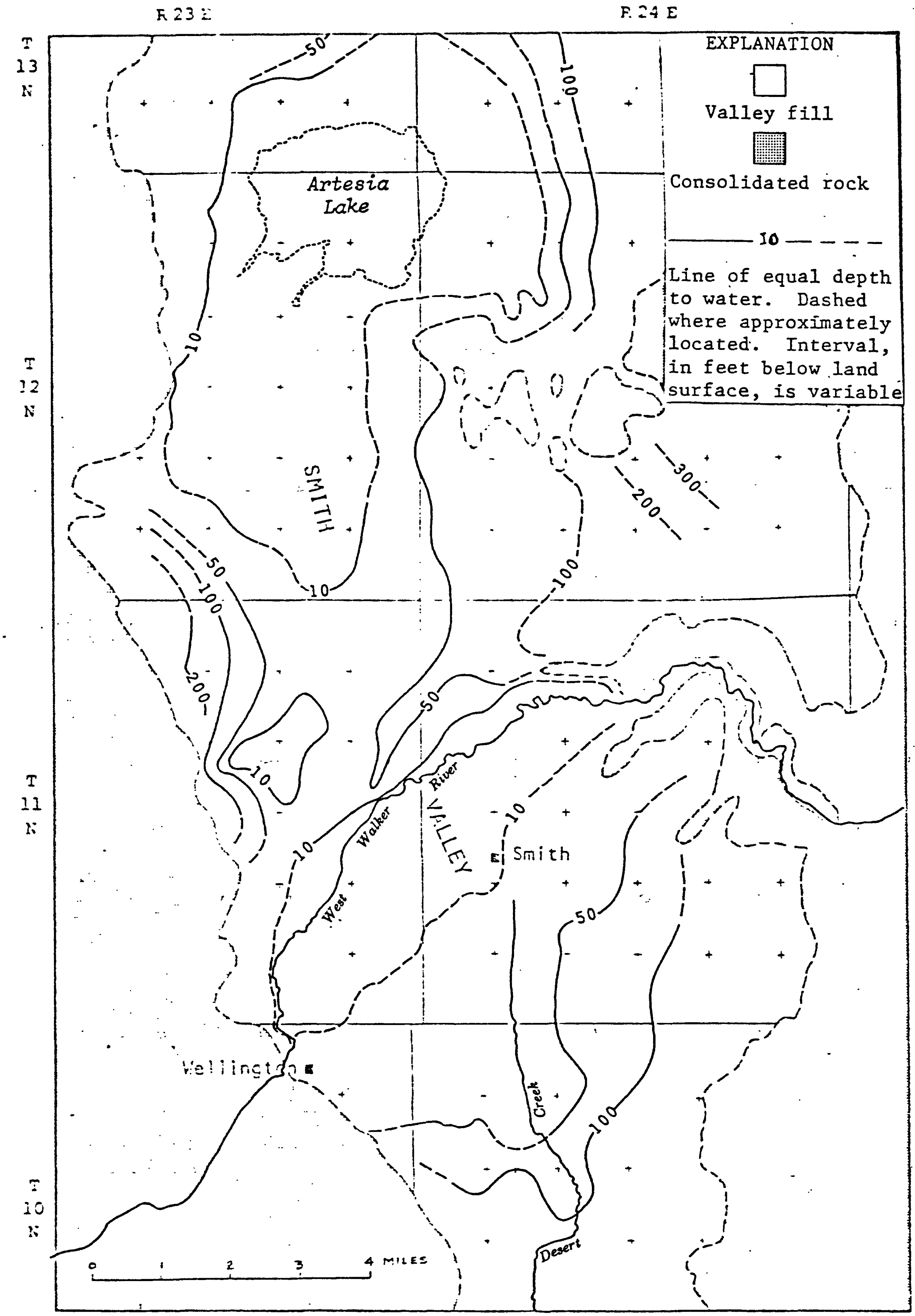

Figure 8.--Depth to ground water, Spring 1972.

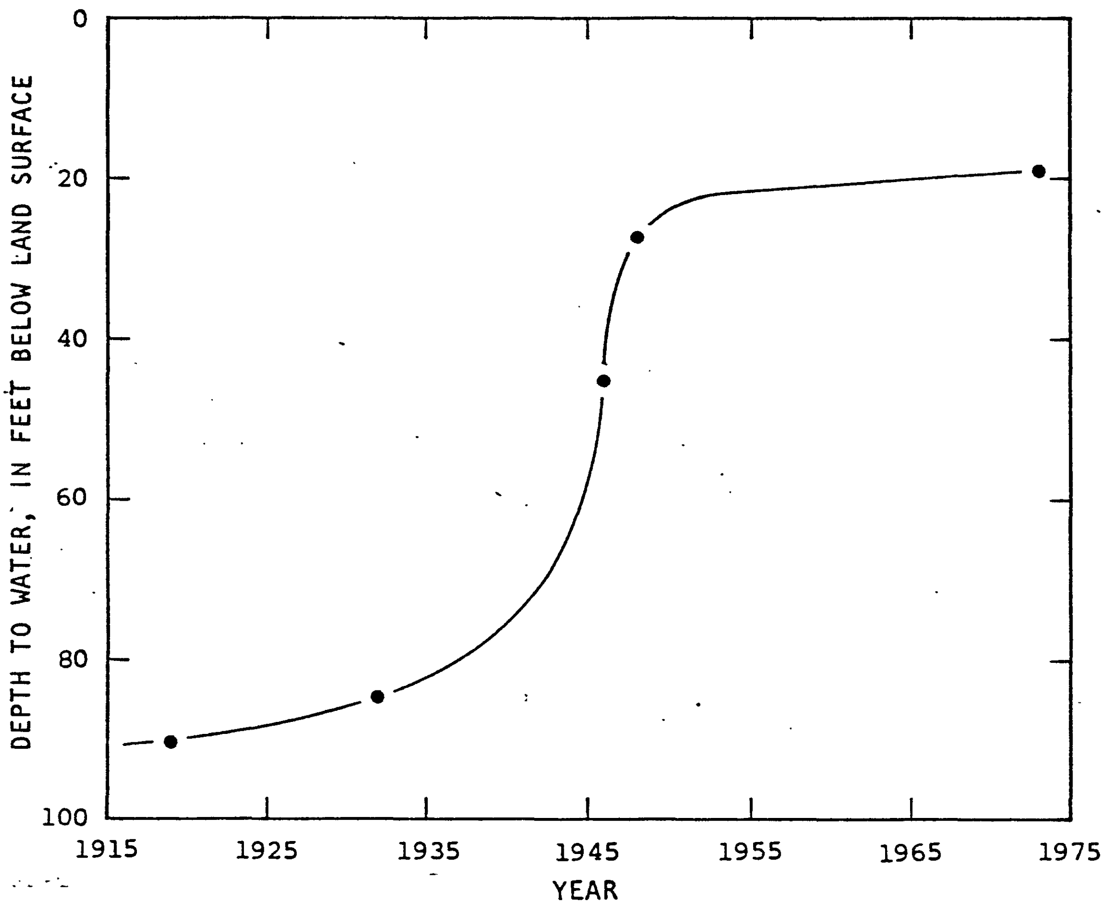

Figure 9.--Water-level rise in well 11/24-27cb.

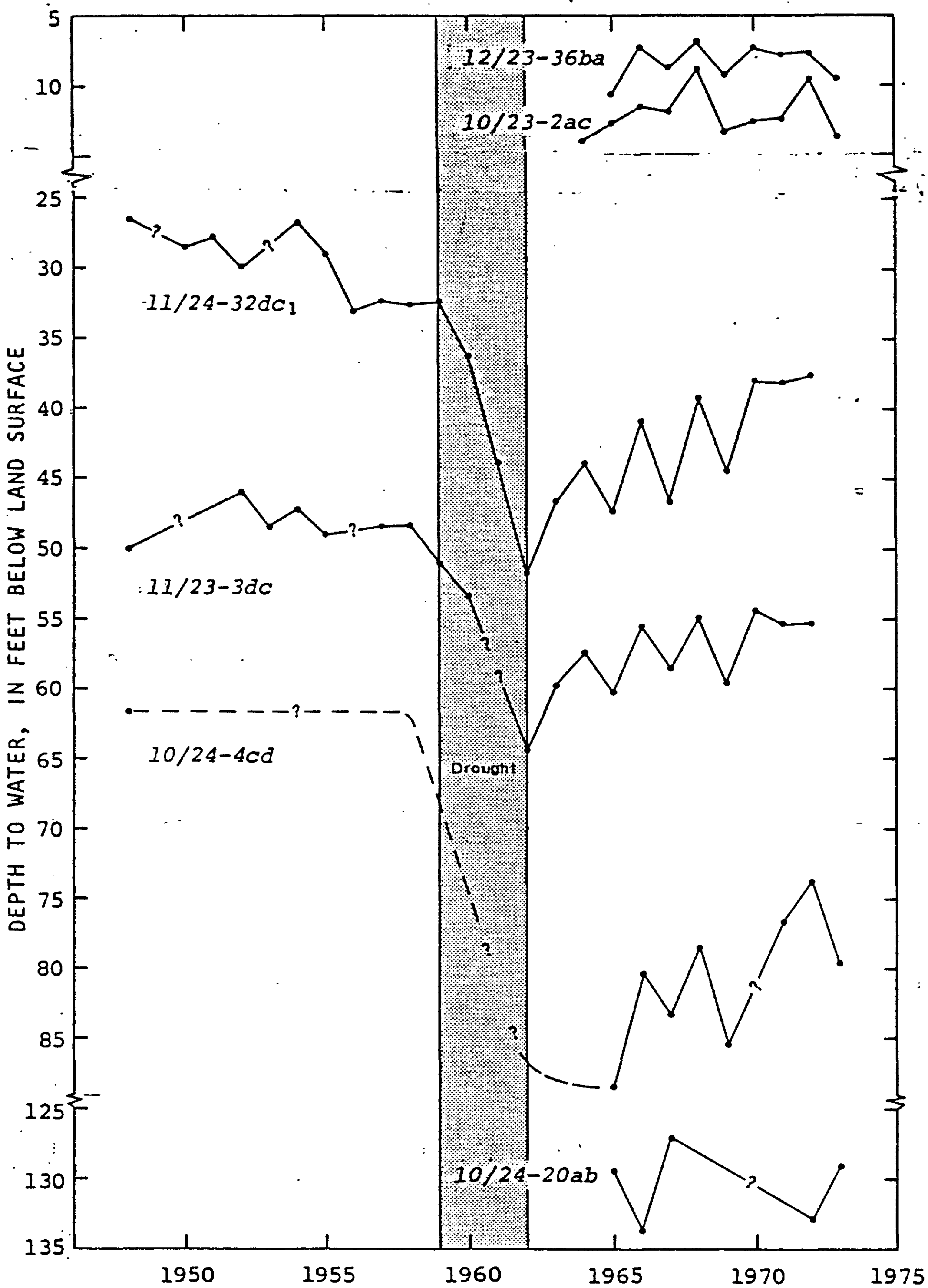

Figure 10.--Changes in water level in selected wells, on basis of measurements prior to irrigation season.

All three wells show a slow recovery since 1962, with the recovery process still incomplete by 1973. No additional data are available to show the extent of this dewatering and slow recovery; therefore, no estimate can be made of the net decrease of stored water in the valley. However, the distribution of heavy pumping and dewatering were somewhat the same. The general distribution of existing irrigation wells in those years can be determined from drilling dates listed in table 25. The other three wells shown in figure 10 have records too short to show the effects, if any, of the drought period. However, during their period of record, 1964 or 1965 to 1973, the net change in water levels has not been significant. Water-level changes in 1972 and their causes are evaluated in a later section of the report.

CHEMICAL QUALITY OF THE WATER

Relation to the Flow System

Because virtually all the water moving through the hydrologic system in Smith Valley originates as precipitation, the water initially has a very low dissolved-solids concentration. As the water moves through the system, either over the land surface or through the subsurface, it dissolves rock and soil constituents. The farther it flows and the longer the length of time it is in contact with rock and soil, generally the greater the concentration of dissolved solids. Rock and soil types and the activities of man also have a strong influence on dissolved solids.

West Walker River, where it enters Smith Valley, has a specific conductance commonly between 200 and 250 micromhos (table 26)1/. Desert Creek, where it crosses the bedrock-alluvium contact, has similar if not lower values. Outflow in the West Walker River to Mason Valley has higher values--as great as 500 micromhos--because of the return flow of water through the ground-water system. Highest concentrations probably are in the fall, when return flow constitutes the largest part of the total river flow. Return flow to the river also carries fertilizer and other agricultural wastes such as those from feed lots.

The ground water beneath the agricultural areas has a specific conductance ranging between 170 and 900 micromhos, as determined from data in table 26. Because the human population of the valley is small, domestic and commercial wastes are small sources of mineralization of either ground water or streamflow. Figure 11 shows the distribution of specific conductance of ground water in the valley.

The ground water of the valley can be classified on the basis of the predominant cation and anion expressed in milliequivalents per litre. The generalized distribution of ground-water types is shown in figure 12. Mixed bicarbonate type dominates the agricultural areas, with two major exceptions--calcium-magnesium bicarbonate is the principal type beneath the Red Canyon-Burbank Canyon fan and an area southeast of Smith. The ground water in this latter area also has rather high dissolved-solids concentrations, as shown in figure 11. Sodium bicarbonate water is possibly the dominant type in the Artesia Lake area, whereas Nevada Hot Springs and well 10/23-2db (Miller and others, 1953, p. 36) yield hot water dominated by sodium and sulfate.

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1. Specific conductance, which is a measure of a water's ability to conduct electric current, is closely related to dissolved-solids concentration. The dissolved-solids concentration, in milligrams per litre, is generally 55-70 percent of the specific-conductance value. The complete unit of measure for specific conductance is "micromhos per centimeter at 25°C (Celsius)." For convenience, the abbreviation "micromhos" is used in this report.

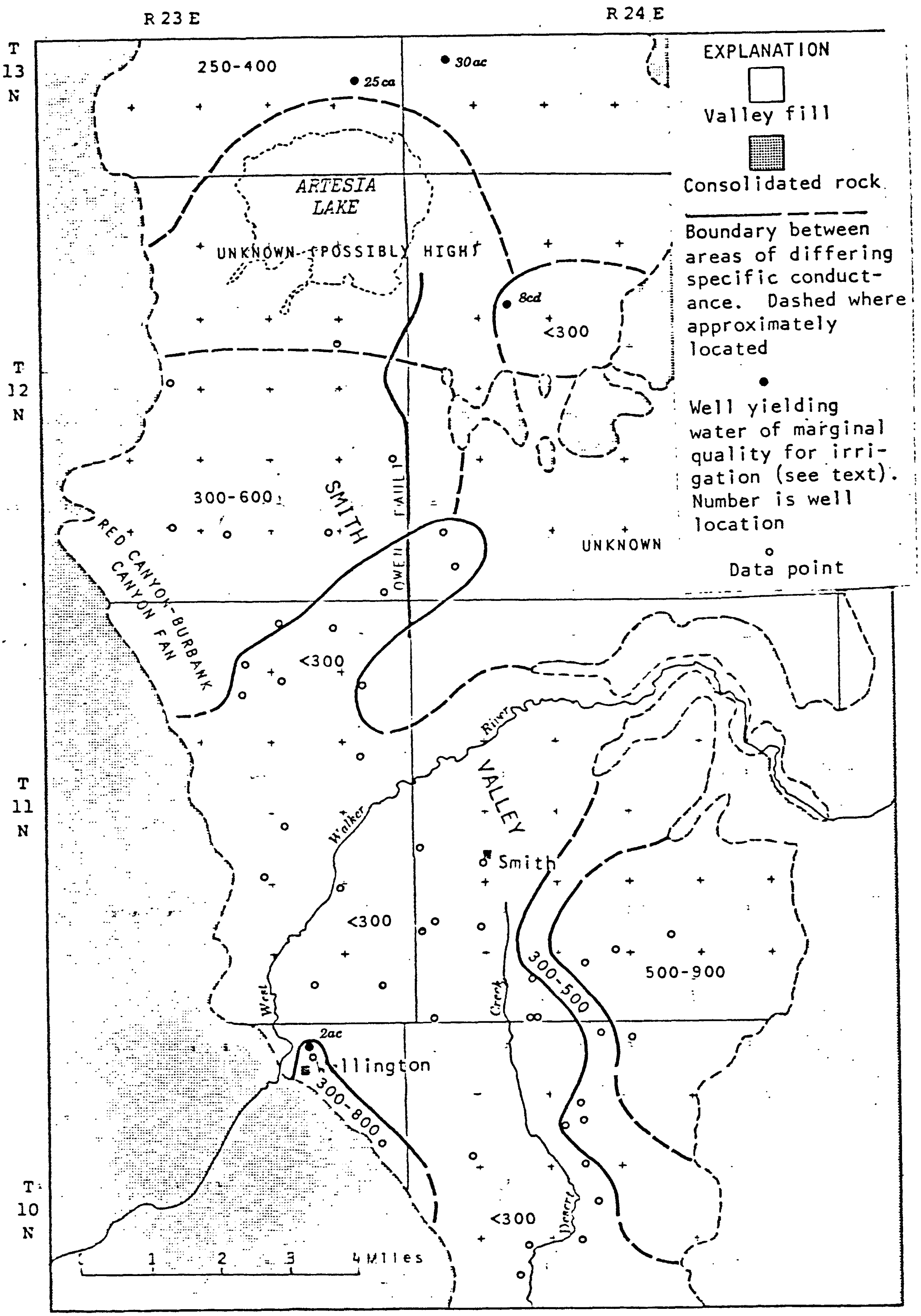

Figure 11.--General distribution of specific conductance of ground water.

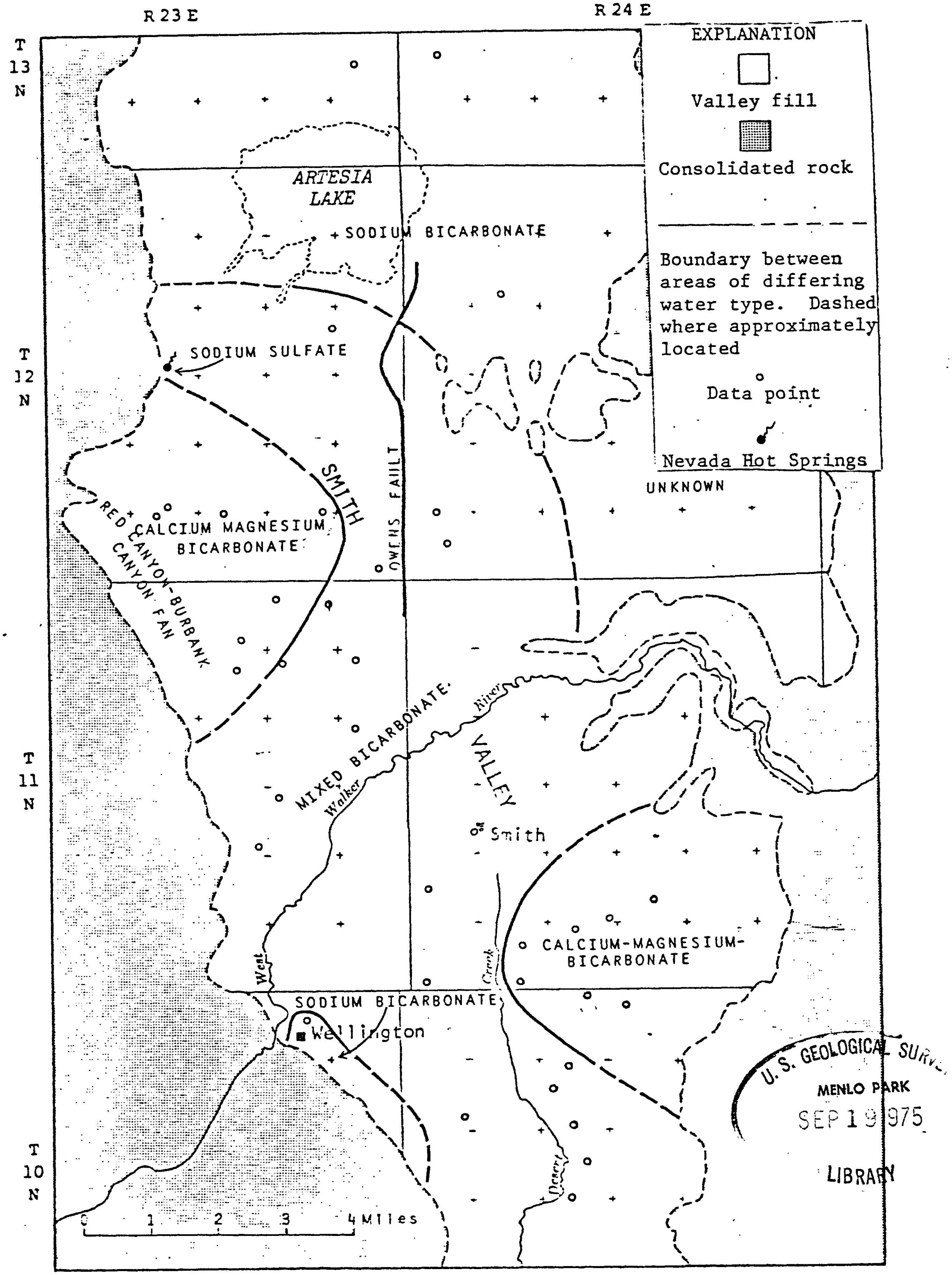

Figure 12.--Generalized distribution of water types.

Suitability for Irrigation

The concentration and composition of dissolved constituents in a water determine its quality for any use. Much of the following discussion of irrigation water is based on chapter 4 of Diagnosis and Improvement of Saline and Alkaline Soils (U.S. Salinity Laboratory Staff, 1954). The characteristics of an irrigation water that appear to be most important in determining its quality are: (1) total concentration of dissolved solids, as indicated by salinity hazard of the water; (2) relative proportion of sodium to other cations, as indexed by sodium hazard; (3) concentration of boron and other elements that may be toxic; and (4) under some conditions, the bicarbonate concentration as related to the concentration of calcium plus magnesium, as indexed by residual sodium carbonate (RSC). Recommendations as to the use of a water of a given quality must take into account such additional factors as drainage and management practices of croplands. These two factors are beyond the scope of this survey.

The following scale is used to rate salinity hazard in table 26 (Committee on Water Quality Criteria, 1973, p. 335):

Specific conductance (micromhos)	Hazard class
<750	Low (no detrimental effects usually noticed)
750-1,500	Medium (can have detrimental effects on sensitive crops)
1,500-3,000	High (can have adverse effects on many crops; requires careful management practices)
3,000-7,500	Very high (can be used for tolerant plants on permeable soils with careful management practices)
>7,500	Unsuitable

Sodium hazard is rated on a scale of low, medium, high, and very high. This classification is based primarily on the effect of sodium on the physical condition of the soil and secondarily on plant sensitivity to sodium. High sodium hazard would require special soil management, such as good drainage, high leaching, and the addition of organic matter. RSC is rated on a scale of safe, marginal, and unsafe. Based on limited data, the Salinity Laboratory Staff believes that good management practices and proper use of additives might make it possible to use successfully some marginal waters for irrigation.

Water supplies that are known to have some water-quality limitations for irrigation are listed below and are shown in figure 11:

Well	Limiting factor	Classification
10/23-2ac	RSC	Unsafe
12/24-8cd	RSC	Marginal
13/23-25ca	RSC	Marginal
13/24-30ac	RSC	Marginal

If crops that are irrigated by these wells appear to have less than satisfactory yields, advice on management practices should be requested from the local County Agricultural Extension Agent.

The toxic element boron was analyzed in 39 samples. The concentrations ranged from 0.00 mg/l (milligrams per litre) to 1.0 mg/l, with all but one of the values less than 0.4 mg/l. None of the crops grown in Smith Valley during 1972 were sensitive to these low concentrations of boron; therefore, these waters were not a problem. However, concentrations of 1 mg/l could be a problem for sensitive crops, such as most fruit trees.

Suitability for Domestic Use

The U.S. Public Health Service (1962, p. 7-8) has formulated standards that are generally accepted as a guideline for drinking waters; in fact, these standards have been adopted by the Nevada Bureau of Environmental Health as regulations for public supplies. The standards, as they apply to data listed in table 26, are as follows:

Constituent	Recommended maximum concentration (milligrams per litre)
Arsenic (As)	a/ 0.01
Iron (Fe)	.3
Sulfate (SO_4)	250
Chloride (Cl)	250
Fluoride (F)	b/ About 1
Nitrate (NO_3)	45
Dissolved-solids concentration	c/ 500

a. Water containing more than 0.05 mg/l of arsenic should not be consumed regularly.

b. Based on annual average maximum daily air temperature.

c. Equivalent to a specific conductance of about 750 micromhos.

The arsenic concentration in drinking water is particularly important because of the possibility of cumulative poisoning. The element's concentration was determined on 23 irrigation and stock waters (fig. 13). Eleven of the samples contained more than 0.01 mg/l of arsenic, and two, from wells 13/23-25ca and 13/23-30ac, contained more than 0.05 mg/l. The latter two waters would not be suitable for drinking. Because of the limited number of samples collected and analyzed for arsenic, a further study should be made before conclusions are drawn as to the distribution of arsenic in the ground-water system and its potential effect on human health.

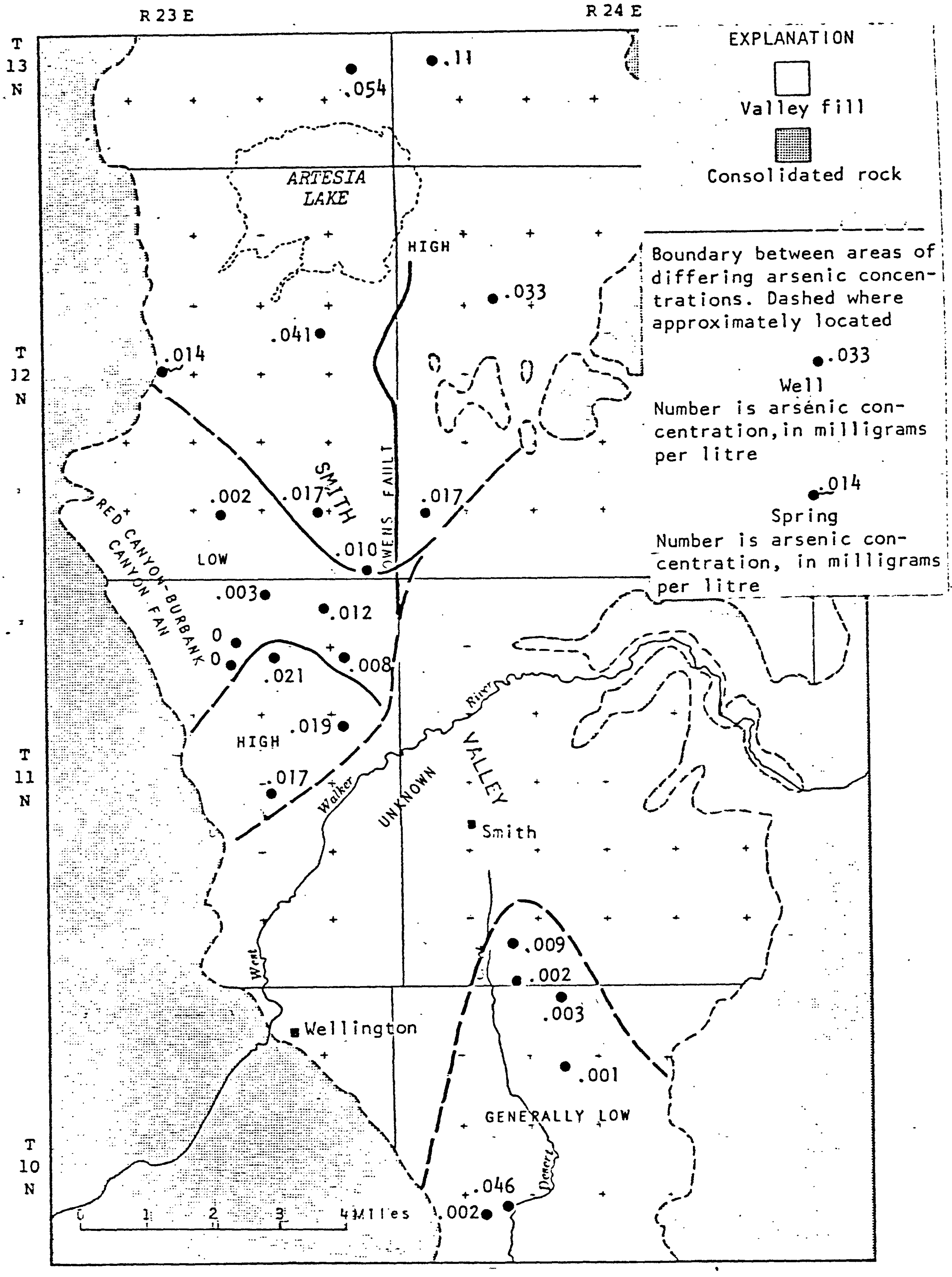

Figure 13.--Generalized distribution of arsenic in ground water.

Excessive fluoride tends to mottle teeth, especially those of children. Fluoride concentrations were determined for 33 samples, and wells 10/23-2db (Loeltz and Eakin, 1953, p. 56) and 11/24-18aa (incorrectly reported by Loeltz and Eakin (1953, p. 56) as 0.2 mg/l), Nevada Hot Springs (12/23-16dc) and 13/23-30ac had higher than desirable concentrations; that is greater than about 1 mg/l.

Of the 26 samples analyzed for nitrate, only one--from irrigation well 11/24-28dd--contained more than the Public Health Service's recommended limit. The source of the nitrate is unknown, but probably is from one of two sources, fertilizer applied to irrigation fields or naturally occurring nitrate minerals.

Concentrations of all other analyzed constituents affecting water quality were very near or within the limits set by the Public Health Service.

Water hardness, a factor that affects soap consumption, is shown for ground water in figure 14. The hardness scale used (from Hem, 1970, p. 225) is as follows: soft, 0-60 mg/l; moderately hard, 61-120 mg/l; hard, 121-180 mg/l; and very hard, 180 mg/l. The entire range is present in Smith Valley; from soft to very hard. The map was based on 54 samples.

Salt Balance

Over the long term, dissolved salts not extracted by plants from soil and water will generally increase in concentration unless leaching occurs. The increase will gradually lower the productivity of a soil. Salt balance generally is not a problem in the part of Smith Valley that drains to the West Walker River. In this area, surface water of low salt content is used for irrigation. The water not consumed by crops percolates to the water table, transporting much of the salt with it. As a result, the ground water has slightly higher salt concentrations than the water applied to the fields, but for agricultural use, still quite low. This ground water generally flows toward the river and flows from the valley. Because of the pumping of wells, some of the ground water is recycled across fields, but because pumpage represents only a small part of the total quantity of water percolating to the water table beneath the agricultural areas, the water quality had not been degraded appreciably as of 1972.

In the irrigation section of this report, leaching requirements are quantified. As of 1972, more than enough water was moving through the ground-water system to meet this general leaching need.

In the Artesia Lake ground-water basin, salt is slowly accumulating because this area is hydrologically closed. For a successful farming operation, salt must be leached from cropland soils. In a closed basin, the leached salts are flushed to a "storage area;" the "tail end" of this flow system at Artesia Lake. Over the long term the basin's salt balance probably would have to be managed accordingly if the water resource is developed principally through irrigation agriculture. As a result, ground-water flow to the lake area, and the accompanying transport of salts, probably should not be entirely prevented by ground-water development.

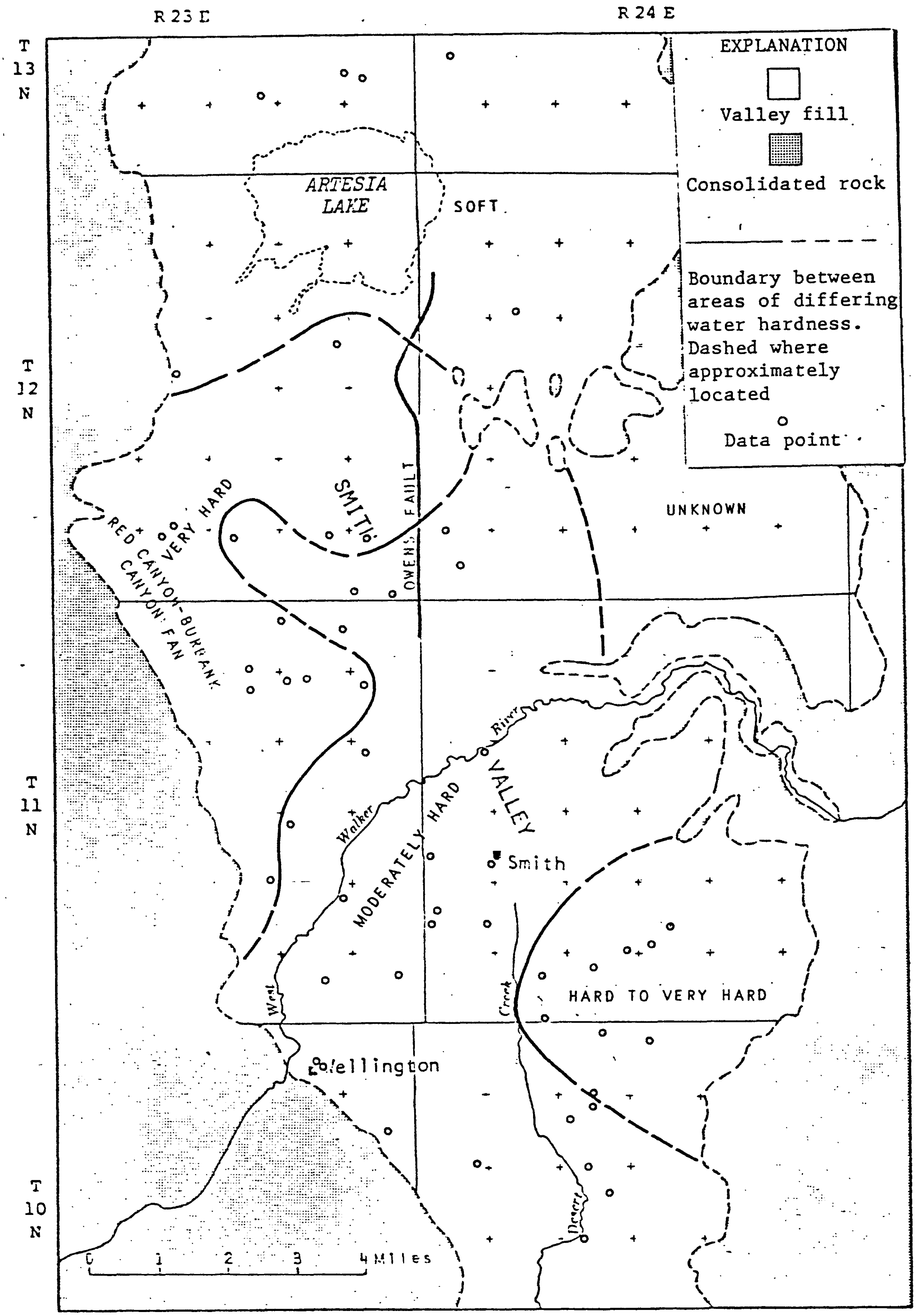

Figure 14.--Generalized distribution of ground-water hardness.

Because salt accumulates at the surface of the dry lake bed during the evaporation process, and subsequently is partly blown away, not all salt flushed to this area remains in the lake or in its underlying beds.

INFLOW TO THE VALLEY

Within this section of the report, quantitative estimates are made of the primary sources of water for Smith Valley (fig. 23): Precipitation, importation, and inflow of West Walker River. In addition, the secondary sources of water for the valley--surface-water runoff from the mountains and ground-water recharge--are evaluated.

Elements of inflow, as well as the elements of outflow, are evaluated for the base year 1972. If antecedent conditions are not important in the relation between an element of inflow and the hydrologic system in the hydrologic budget, that element, such as river inflow or importation of water, is evaluated on the basis of data from 1972. If, however, antecedent conditions are an important factor in the relation, average annual values have been developed, such as for precipitation, runoff, and ground-water recharge.

Precipitation

In the Great Basin, a strong relation exists between altitude of land surface and amount of precipitation. The higher altitudes receive more precipitation, as shown in figure 15. The Pine Nut and Sweetwater Mountains, on the west side of the valley, receive about twice as much rain and snow as the eastern mountains, the Singatse Range and Pine Grove Hills. As a result, two curves were used to characterize each general precipitation condition (fig. 15). The altitude-precipitation relations represented by these lines are used in this study to estimate the average annual precipitation for the basin. The volume of precipitation is computed in table 8 to average about 260,000 acre-feet per year.

Streamflow

West Walker River

The average annual inflow to Smith Valley in the West Walker River (at Hoye Canyon) is 179,000 acre-feet for the period 1958-72. The average annual outflow from the valley (at Wilson Canyon) is 133,000 acre-feet for the same period. Data on which these values are based are presented in table 6. The decrease in flow is principally the result of extensive diversions from the river for irrigation. However, of the amount diverted and applied to crops, a substantial part returns to the river as ground-water return flow (table 6, columns 3 and 4). Little tailwater was observed to return to the river.

Inflow of the West Walker River to Smith Valley during 1972 was 142,000 acre-feet, or 79 percent of the annual average of 179,000 acre-feet for the base period 1958-72, as listed in table 6. The average for 1958-72 probably was almost equivalent to the long-term average, on the basis of comparisons using a partly synthesized 50-year record (1919-69) for the West Walker River below Little Walker River, near Coleville, Calif. (data from D. O. Moore, U.S. Geol. Survey, 1970).

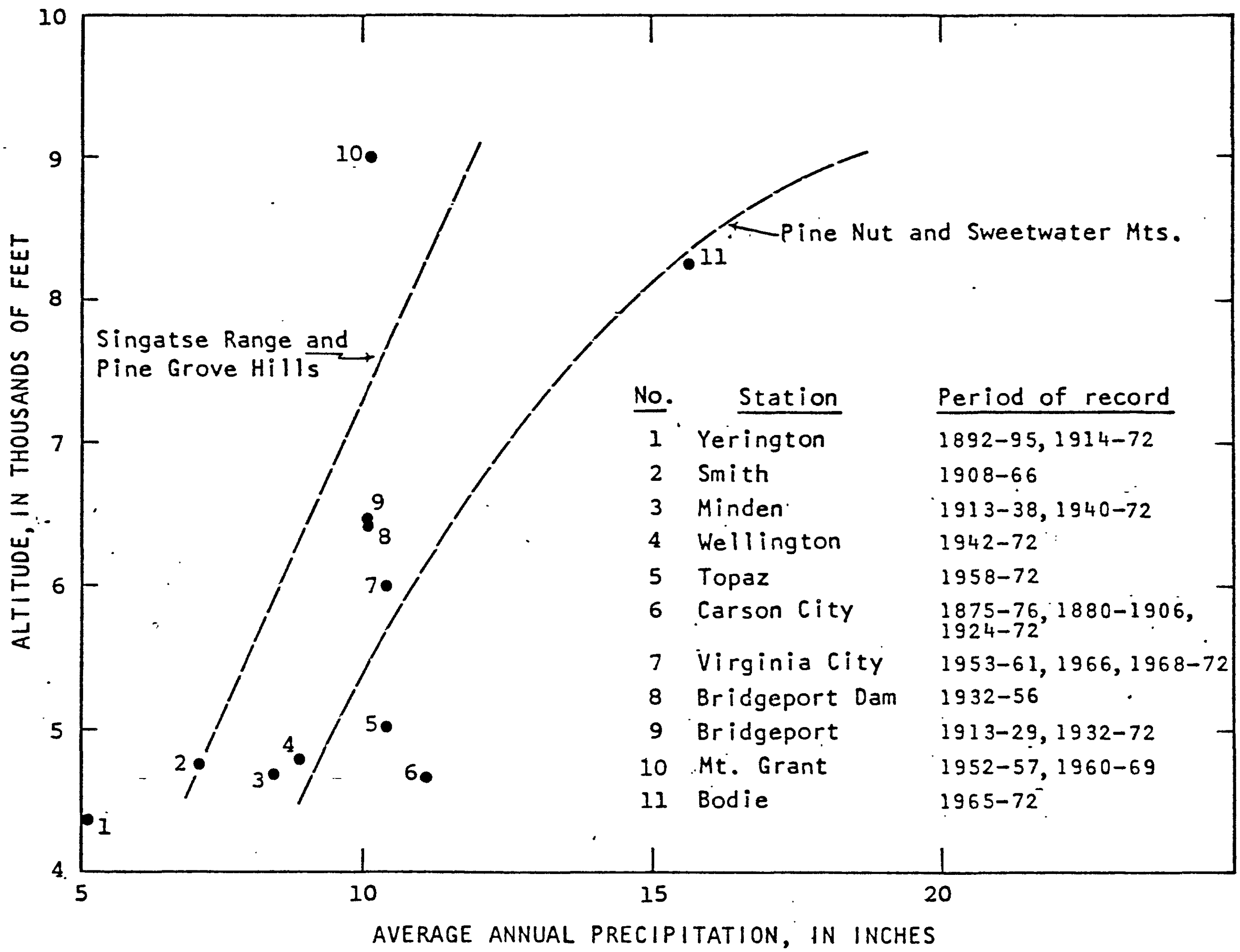

Figure 15.--Precipitation-altitude relation.

The distribution of flow during the year is shown in figure 16. Peak flows generally occur during the period May through July, and are subject to upstream regulation at Topaz Lake. Monthly inflow exceeds monthly outflow, except during the low-flow months of November through March. The gain in the river during these months is due to ground-water return flow exceeding diversions.

Instantaneous flow of the river ranges from less than 5 cfs to more than 2,000 cfs.

Desert Creek

Because the period of streamflow record is only 5 years (1965-69) and 2 of these years were extremely wet (1967 and 1969), the available data are not representative of long-term flow. As a result, statistical correlations were made with flow of two nearby gaged streams, Buckeye Creek, and Little Walker River near Bridgeport, Calif., a few miles south of the valley. These streams have 10 and 28 years of recorded flow data, respectively. The computed long-term average discharge for Desert Creek is 8,500 acre-feet per year at the mountain front. Recorded flow for the short period of record on Desert Creek, as measured at the mountain front (pl. 2), averaged 12,000 acre-feet per year. The estimated flow in 1972 was 66 percent of the long-term average annual flow, or 5,600 acre-feet. Of this amount, 4,500 acre-feet or 80 percent occurred during the growing season.

Monthly distribution of flow during the 5-year period of record is shown in figure 17. This distribution is generally representative of long-term flow of this stream and other small perennial streams in the valley.

A duration curve for Desert Creek, figure 18, was developed for the year 1971, based on periodic discharge measurements, runoff data for 1971, and records on streams outside but near Smith Valley. This curve provides an approximation for individual rates of flow that can be expected in an average year, and a graphic comparison of base-flow characteristics with additional streams described below. Desert Creek has a relatively high direct surface runoff in relation to base flow.

Instantaneous flow of Desert Creek during the period 1965-72 had a range from less than 1 cfs to 260 cfs.

Other Streams

Flow was measured periodically in Sheep Creek and Burbank, Red, and Pipeline Canyons (pl. 2). Using these measurements and data from Desert Creek, duration curves were synthesized for these streams (fig. 19). Like Desert Creek, flow in Burbank and Red Canyons has a relatively high direct surface runoff in relation to base flow, whereas Pipeline Canyon and Sheep Creek are characteristically spring-fed streams, having a high base flow in relation to direct surface runoff.

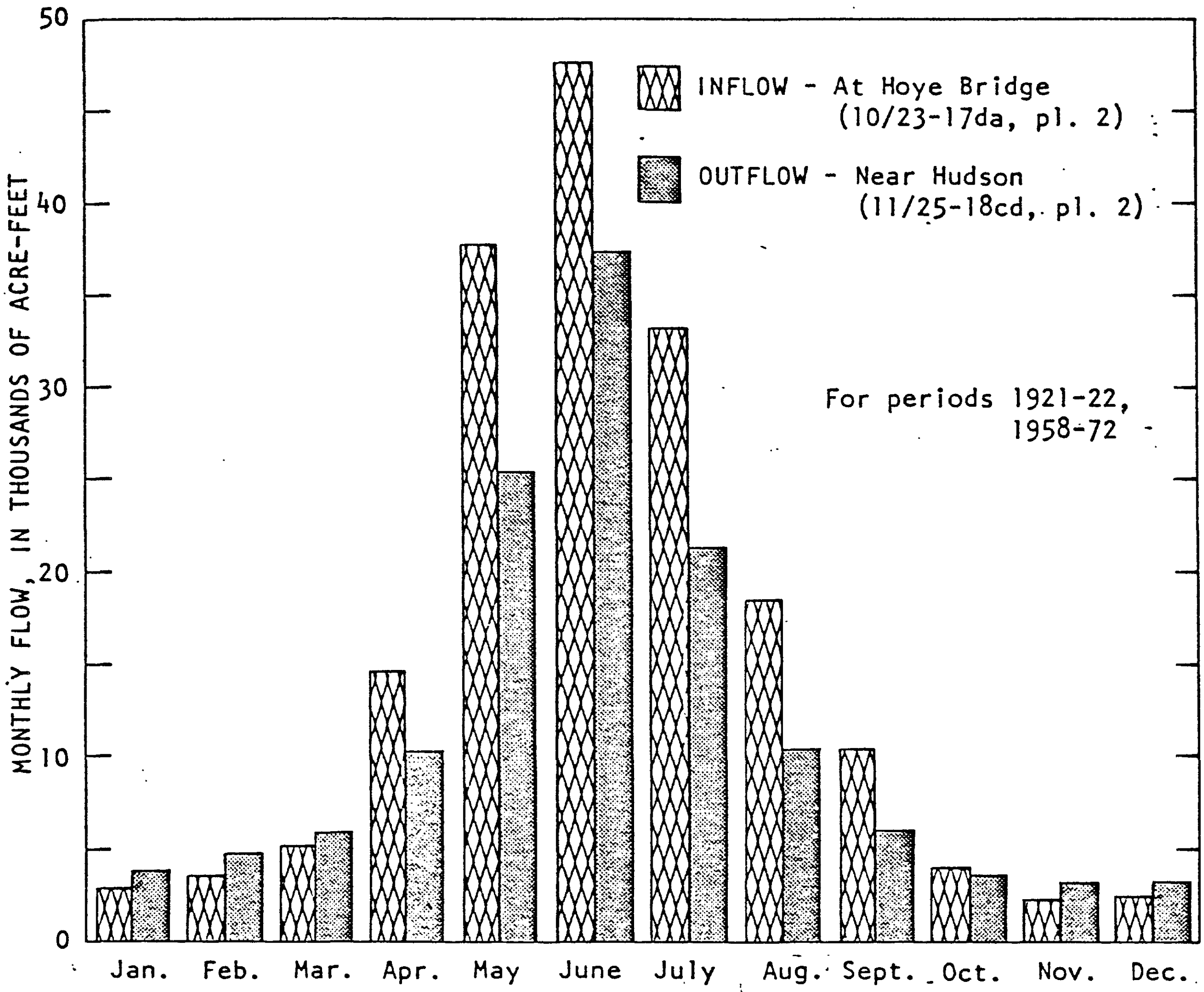

Figure 16.--Average monthly flows of West Walker River entering and leaving Smith Valley.

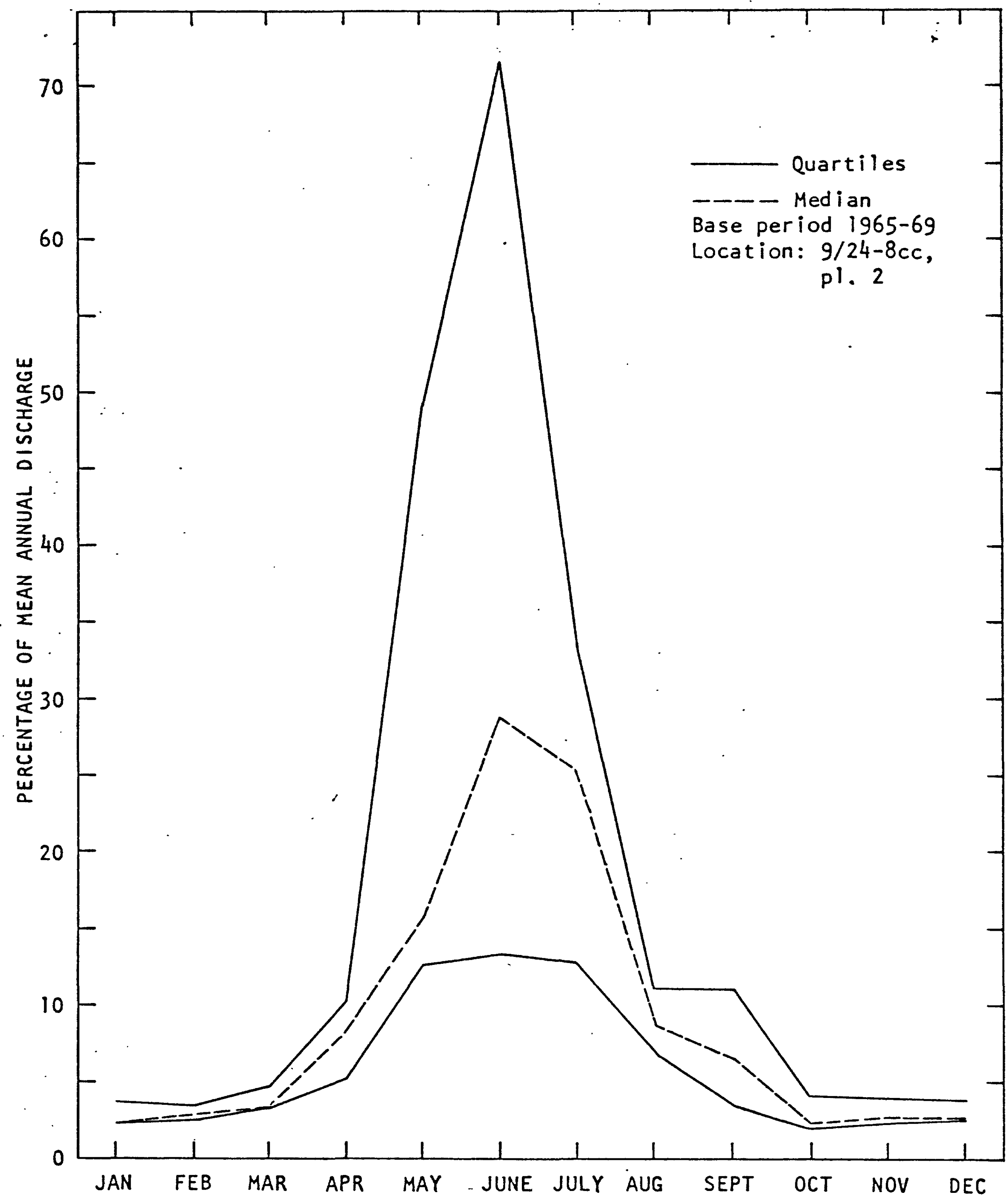

Figure 17.--Monthly discharge of Desert Creek as a percentage of mean annual discharge.

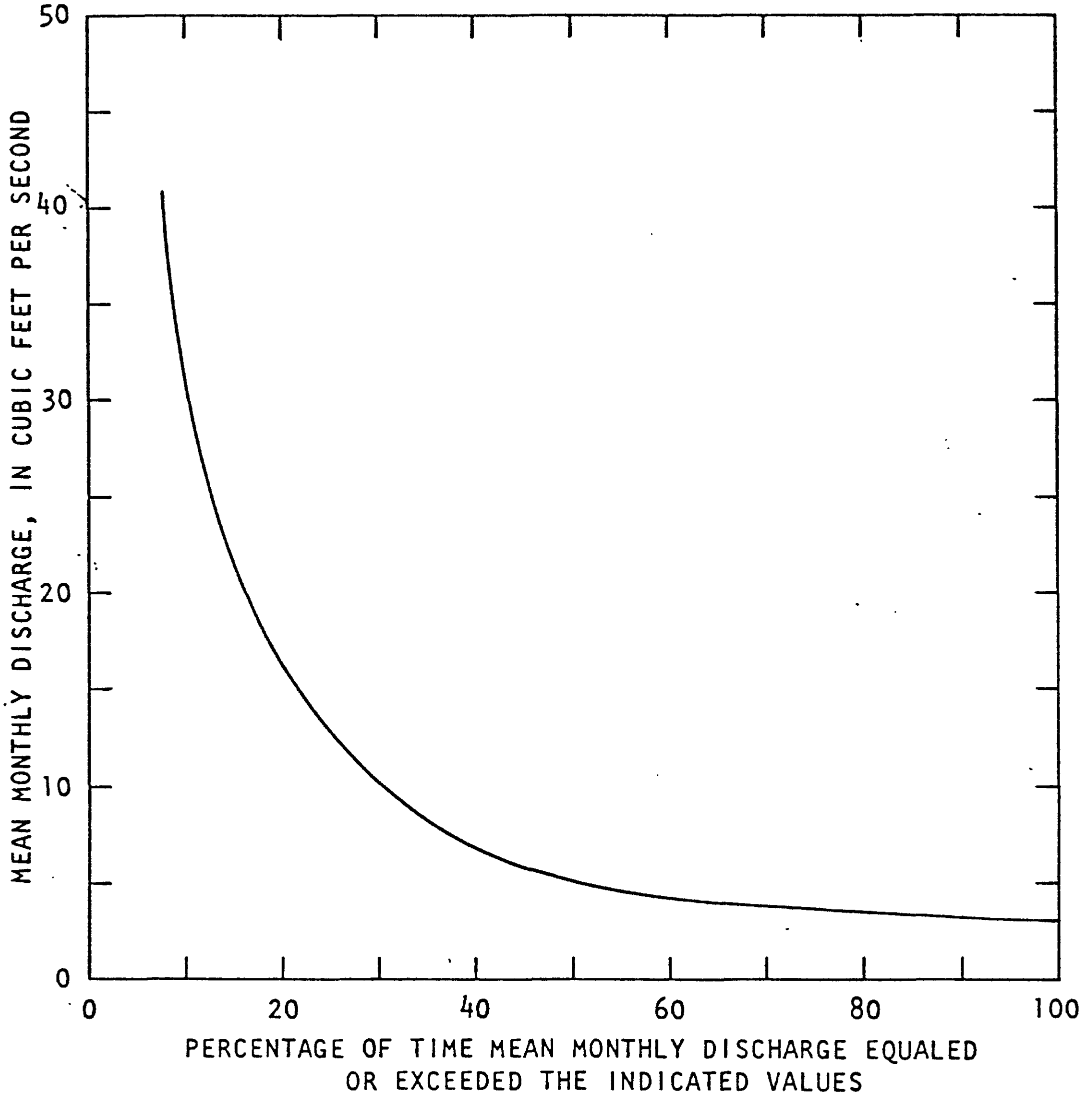

Figure 18.--Flow-duration curve for Desert Creek during 1971.

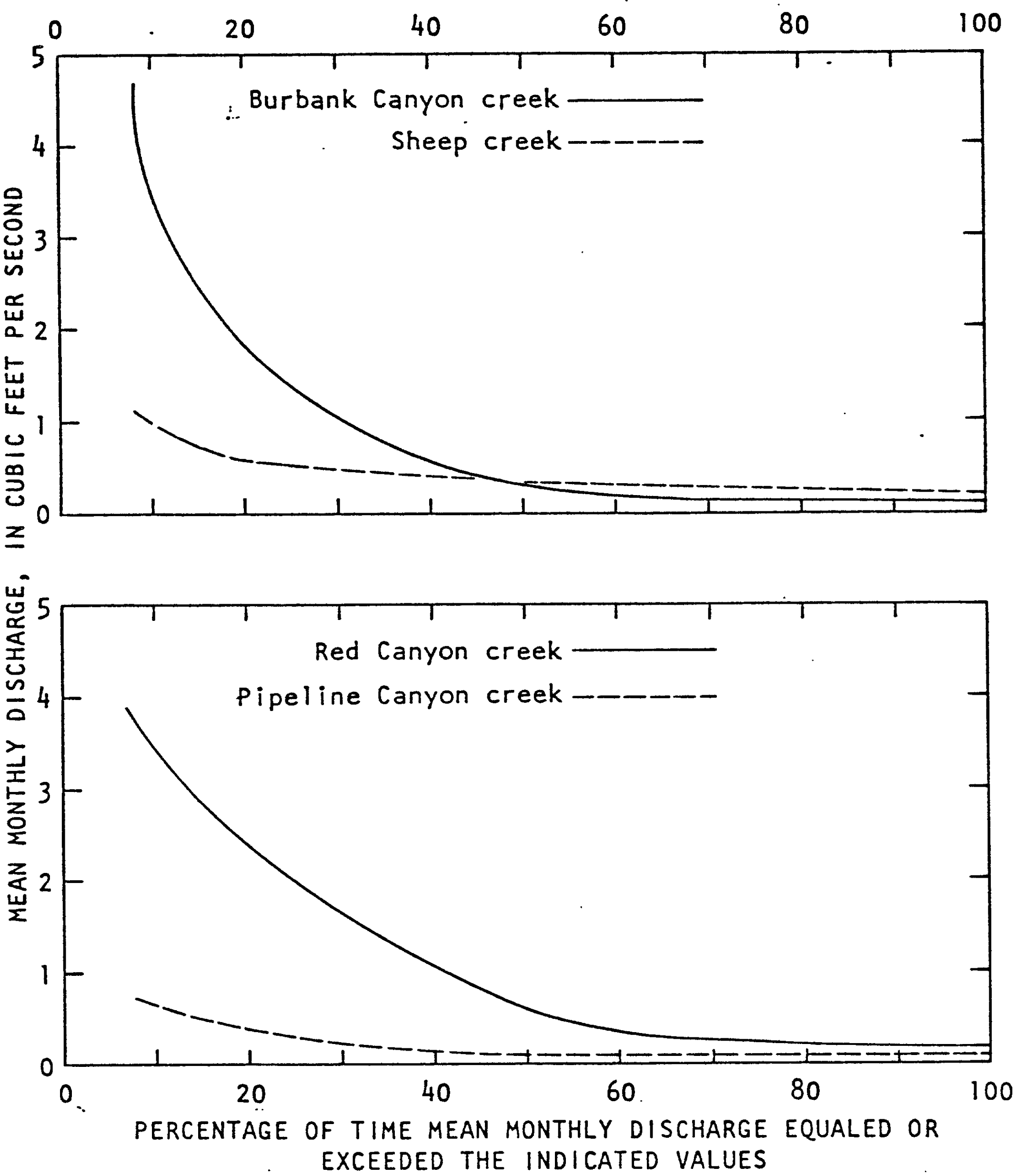

Figure 19.--Flow duration curves for several small streams during 1971.

Runoff from the Mountains

Snowmelt produces most of the streamflow that is generated within Smith Valley. This flow is characteristically at its peak during May-July (fig. 16).

Most mountain streams generally have their maximum flow at the mountain front, which is shown on plate 1 as the consolidated rock-alluvium contact. Thus, flow across the consolidated rock-alluvium contact is an index to the amount of surface water generated within the basin that is potentially available for development. Streamflow generally decreases with flow distance down the alluvial apron, due to infiltration.

Small local streams occasionally flow for short periods on the alluvial aprons as a result of high-intensity storms, but this type of streamflow is so erratic in frequency and duration that without storage structures it has little potential for direct use.

The method used to estimate runoff from the mountains was described in detail by Moore (1968). In this method, altitude-runoff relations for regions in Nevada have been developed on the basis of long-term records of streamflow and precipitation, along with supplementary streamflow data and measurements of stream-channel geometry as related to long-term flow.

The runoff estimated using the above method was compared with computed streamflow for individual drainage areas. The computed streamflow had been estimated from synthesized hydrographs based on periodic discharge measurements and hydrographic comparison with other streams, in addition to channel-geometry measurements. An adjustment factor was then used to determine runoff from the remaining ungaged parts of individual subareas of the valley.

A summary of estimated average annual runoff from individual subareas of the basin is presented in table 7; the total generated within the valley is about 12,000 acre-feet per year. The 1972 runoff probably was about 8,000 acre-feet. Due to (1) the seasonal distribution of flow, (2) infiltration to the ground-water reservoir, and (3) evapotranspiration, the percentage of this flow that is diverted for use can not be estimated. The Buckskin and Singatse Ranges on the north and northeast sides of the valley reach only low altitudes and yield little runoff. In contrast, the Desert Creek drainage area, which comprises only 12 percent of the total drainage area, contributes three-fourths of the runoff generated within the valley. It is the principal source of water within the valley.

The northern part of the Pine Nut Mountains, though high in altitude and substantial in area, contributes negligible surface runoff. The alluvial apron and valley floor below this area contain numerous springs, the largest being Nevada Hot Springs. Water that might otherwise run off may be infiltrating fractured rocks and in part migrating to the springs.

Table 7.--*Estimated long-term average annual runoff from surrounding mountains of Smith Valley*

Area	Percent of runoff area (311,700 acres)	Estimated average annual runoff	
		Acre-feet 1/	Percent of total runoff
Buckskin and Singatse Ranges	20	50	small
Pine Grove Hills and eastern part of Sweetwater Mountains	34	1,300	12
Sweetwater Mountains (Desert Creek drainage area)	12	8,500	73
Wellington Hills	9	100	1
Pine Nut Mountains	25	a 1,600	14
Total (rounded)	100	12,000	100

1. Runoff values for 1972 were about two-thirds of these values.

a. Most of this runoff, 1,300 acre-feet, is generated in the Burbank, Red, and Pipeline Canyon drainage areas.

Recharge from Precipitation

Recharge to the ground-water reservoir results from precipitation and percolation losses of irrigation water from canals and fields. As of 1972, the West Walker River did not directly recharge the ground-water reservoir, but rather acted as a drain, continuously receiving water from the ground-water system (pl. 2).

A method developed by Eakin and others (1951) has been used to compute the estimated average annual recharge from precipitation. These computations are summarized in table 8, and show that an estimated 7 percent of the precipitation, or 17,000 acre-feet per year, recharges the ground-water system over the long term.

No direct determination was made of the overall seepage losses from canals and fields, but an indirect method is used to determine the quantity in a later section of the report.

Importation to Lobdell Lake

At the headwaters of Desert Creek, diversions are made into the Smith Valley basin from an unnamed creek that flows westward to the West Walker River in California. This diverted water is stored in Lobdell Lake (T. 7 N., R. 24 E.; pl. 1), a small reservoir with a surface area of about 35 acres and a stage of about 9,200 feet above sea level. Releases from the reservoir are made to Desert Creek. No records are available of the diversions to or the releases from the reservoir, but they probably are only a few hundred acre-feet in most years, including 1972.

Table 8.--*Estimated long-term average annual precipitation and ground-water recharge*

Precipitation zone (feet)	Area (acres)	Estimated precipitation 1/ Range (inches)	Average (feet)	Average (acre-feet)	Estimated recharge Percentage of precipitation	(acre-feet per year)
PINE NUT AND SWEETWATER MOUNTAINS AND THE WELLINGTON HILLS 2/						
9,000-11,673	12,300	>20	2.0	25,000	25	a 6,200
8,000-9,000	15,800	15-20	1.5	24,000	15	3,600
7,000-8,000	33,700	12-15	1.1	71,000	7	5,000
6,000-7,000	31,100					
4,546-6,000	69,600	8-12	.8	56,000	3	1,700
Subtotal (rounded)	162,000			180,000		16,000
BUCKSKIN AND SINGATSE RANGES AND PINE GROVE HILLS2/						
9,000-9,544	500	>12	1.1	9,000	7	630
8,000-9,000	7,900					
7,000-8,000	19,800	8-12	.8	16,000	3	480
6,000-7,000	22,600	<8	.5	61,000	Minor	--
4,546-6,000	98,800					
Subtotal (rounded)	150,000			86,000		1,100
TOTAL (rounded)	312,000		0.8	260,000		b 17,000

1. Based on graphs in figure 15.
2. Includes adjoining parts of the valley floor.
a. A large part of this amount runs off in Desert Creek and is used for irrigation; there, some of it infiltrates to the ground-water system.
b. Of this amount, about 3,700 acre-feet is recharged to the Artesia Lake Ground-Water Basin.

OUTFLOW FROM THE VALLEY

Quantitative estimates are made for the several elements of discharge from the hydrologic system, which are shown diagrammatically in figure 23, for the base year 1972. The principal elements of outflow are surface-water outflow, irrigation, and evapotranspiration by low-value phreatophytes.

Surface-Water Outflow

Outflow of the West Walker River during 1972 was about 101,000 acre-feet, or about 76 percent of the 1958-72 annual average of 133,000 acre-feet, as listed in table 6.

Irrigation and Subirrigation

Water Application

Most water is spread across fields from irrigation head ditches. The amount of land irrigated by sprinklers was only about 440 acres in 1972; all the sprinkler water was from wells 11/23-12bb, 12/24-32ba, and 12/24-31db (table 23), in the northeastern part of the valley. Subirrigation is a significant source of water where the depth to the water table is less than 10 feet (fig. 8).

The amount of water delivered to the irrigated part of the valley is summarized in table 9. As shown in the table, the bulk of the irrigation water is from the West Walker River, delivered through an extensive canal system, the principal canals of which are shown on plate 2. About half the water delivered to the irrigated areas of the valley is lost, mostly by percolation to the ground-water system--an estimated 47,000 acre-feet, the difference between total delivery (table 9) and total crop consumption (table 14). Little tailwater flows directly to the West Walker River, but larger amounts flow to Artesia Lake.

Table 9.--*Water delivered to the irrigated part of Smith Valley in 1972*

Source	Amount (acre-feet)	Remarks
West Walker River	a 69,000	Total diversion to canals (from table 6).
Desert Creek	3,700	Estimated to be two-thirds of the 1972 flow of 5,600 acre-feet.
Pipeline Canyon	Small	
Irrigation wells	20,000	Pumpage from 38 wells plus one flowing well (from table 11).
Nevada Hot Springs	170	
Total (rounded)	93,000	

a. Of this total, 22,000 acre-feet was delivered through canals to the Artesia Lake Ground-Water Basin.

River diversions.--There are nine direct river diversions near the mouth of Hoye Canyon. The locations of these canals are shown on plate 2. Most of the diversions are measured by Parshall flumes with records maintained by the Walker River Irrigation District, Yerington, Nev. Current-meter discharge measurements were made on four of the major diversions in 1971-72 to provide a check on the accuracy of the flumes and a general measure of control for the purposes of this study. In general, the theoretical ratings for the Parshall flumes provided satisfactory results. A summary of spot checks comparing current-meter discharge versus flume discharge is provided in table 24 (at back of report). The consistently higher flume values on Saroni Canal probably indicate a 5 to 10 percent flume error. Data on the other flumes indicate reasonable flume accuracy, or were inconclusive due to conditions at time of measurements.

Table 10 is a summary of the average annual diversions to the nine canals. Of the 20-year average of 30,000 acre-feet diverted annually from the Colony Ditch, the average percentage used in each of the subareas north and south of the ground-water divide is unknown. However, during 1971 and 1972, 74 and 79 percent, respectively, were diverted to the Artesia Lake ground-water basin north of the divide.

Table 10.--*Diversions from West Walker River, 1953-72*

[All values in acre-feet, rounded]

Canal or ditch	Annual average, 1953-72 1/	1971 1/	1972 1/
	SOUTH OF RIVER		
Saroni Canal	a 19,000	a 24,000	a 17,000
Plymouth Canal	11,000	14,000	13,000
Dickerson Ditch	480	560	560
River Simpson ditch	3,400	4,000	2,900
Upper Fulstone ditch	2,600	3,100	2,000
West Walker Ditch	3,100	3,300	2,800
Gage Peterson ditch	3,800	3,600	3,000
Subtotal (rounded)	43,000	53,000	41,000
	NORTH OF RIVER		
Colony Ditch:			
Delivered to Artesia Lake Ground-Water Basin	--	29,000	22,000
Delivered within river basin	--	10,000	5,700
Colony Ditch total	30,000	39,000	28,000
Lower Fulstone ditch	830	690	630
Subtotal (rounded)	31,000	40,000	29,000
TOTAL (rounded)	74,000	93,000	70,000

1. Based on records of the Walker River Irrigation District.
a. Values may be high by 5 to 10 percent; see text.

Attempts to document the magnitude of canal losses within the valley provided inconclusive results. Most losses are believed to be small. Indeed, during the late summer months the reaches investigated often showed slight gains, indicating that many of the ditches were functioning to some degree as drains for the irrigated fields. Figure 20 summarizes the results of three seepage determinations. The mainstem Saroni Canal generally gained flow between points of diversion during the two-day study. Only the first and third reaches of the canal had seepage losses. The Plymouth Canal had a loss of about 5 percent in a 2.85-mile reach, not including diversions. The distributary ditch of Saroni Canal gained about 4 percent in flow in a 1.1-mile reach.

Wells.--During 1972, irrigation pumpage continued throughout the year, except for January, as shown in table 11. However, 88 percent of the 20,000 acre-feet pumped was during the period May through September. The areal distribution of this pumpage is shown in figure 21--about 11,000 acre-feet was pumped north of Walker River, and about 9,000 acre-feet was pumped south of the river. Flowing irrigation well 13/23-25ca, north of Artesia Lake, is also shown on the map. The well had an annual discharge of about 640 acre-feet, which is included in the 20,000-acre-foot total.

Table 11.--*Monthly irrigation-well pumpage during 1972*

[Based mostly on electric-power consumption]

Month	Wells pumped for irrigation	Percentage of total pumpage 1/	Acre-feet (rounded)
January	0	0	0
February	3	1	200
March	12	2	400
April	17	3	600
May	29	12	2,300
June	34	20	4,000
July	33	16	3,200
August	34	20	4,000
September	36	20	4,000
October	18	4	900
November	4	1	300
December	4	1	100
Year	a 39	100	b 20,000

1. Much of the pumpage during early spring and late fall is from the O'Banion well, 11/23-15cc. The water is used for raising fish during this time of the year and, in addition, for irrigation during the growing season.

a. Includes 38 pumped wells and one flowing well.

b. Includes 1972 flow from artesian well 13/23-25ca of about 640 acre-feet.

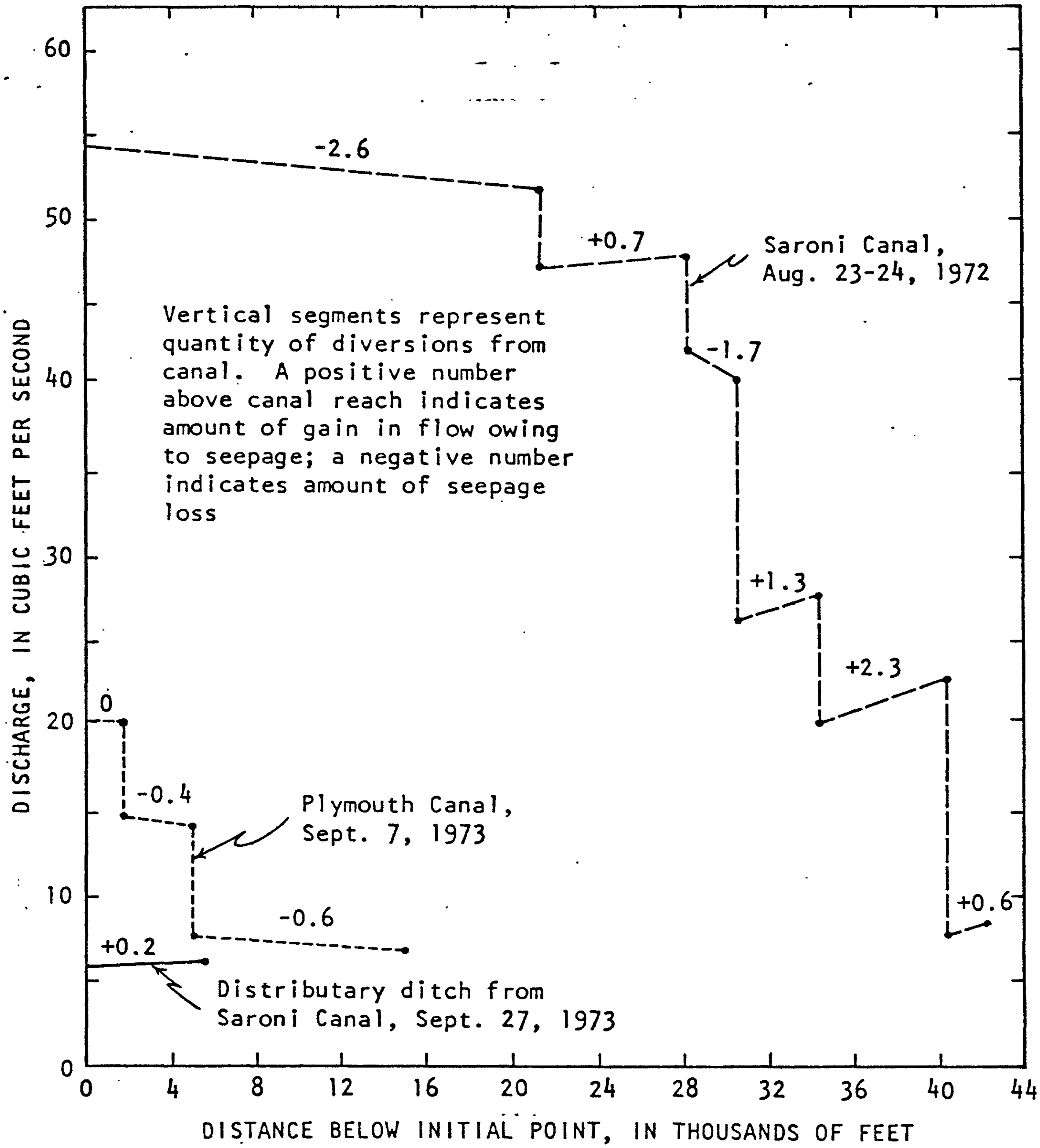

Figure 20.--Canal seepage losses and gains.

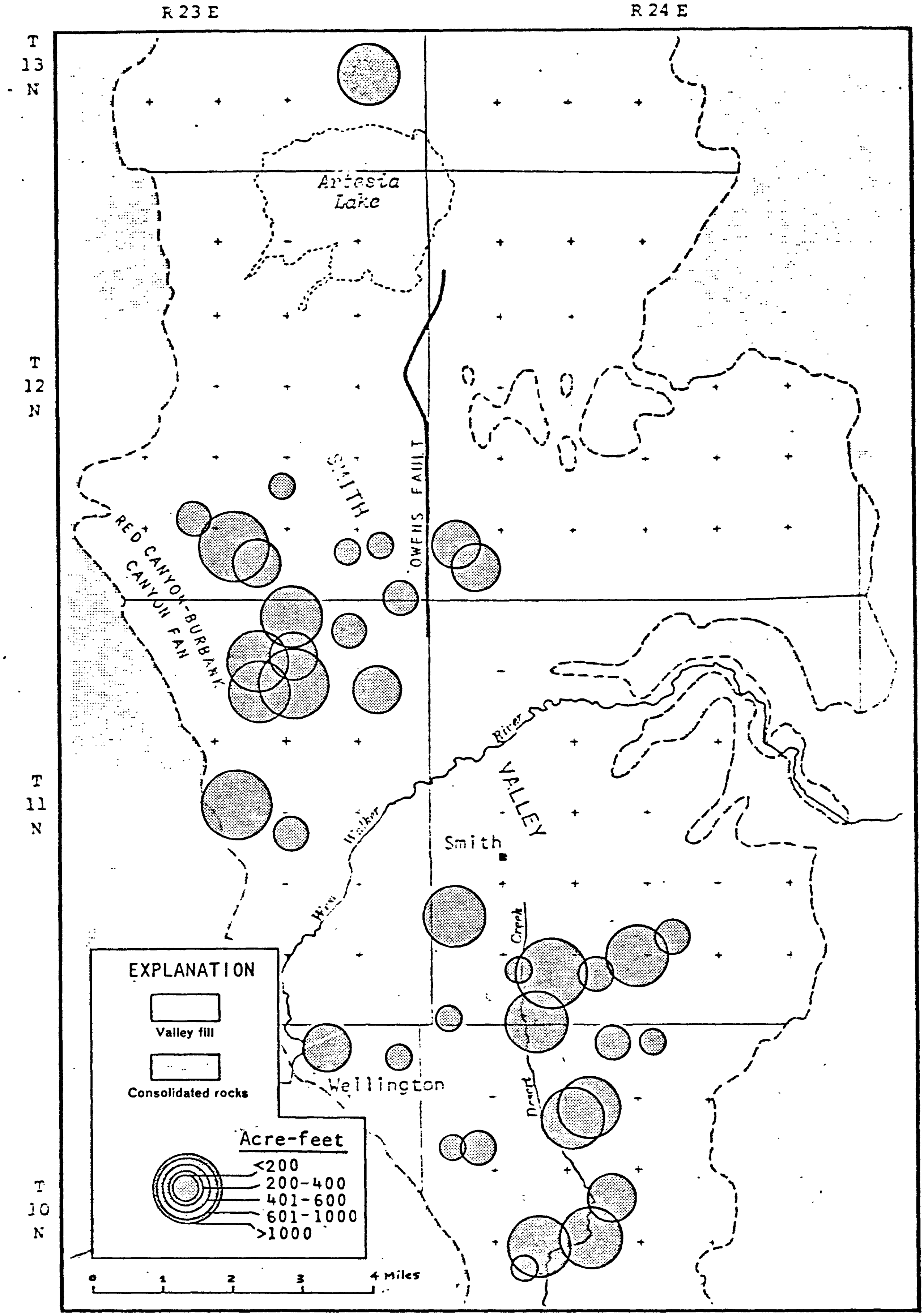

Figure 21.--Distribution of irrigation-well pumpage in 1972.

A summary of power consumption and well operation is given in tables 12 and 13. The average pumping cost of ground water in the valley is $4.00 per acre-foot, but the range in costs is considerable.

The "power-consumption rating" is lower north of the river than south. This is principally the result of shallower static water levels and a smaller drawdown (from pumping) due to generally larger transmissivities and storage coefficients north of the river.

Table 12.--*Summary of irrigation-well operation in 1972*

Wells:		
Electric powered	36	
Diesel powered	2	
Flowing	1	
Total	39	
Water pumped:	acre-feet	
Total discharge	20,000	
Minimum per well	27	
Maximum per well	1,400	
Mean (39 wells)	510	
Electric power consumed:		
Total (36 wells)	5,103,000 kwh (kilowatt-hour)	
Mean (33 wells) 1/	136,000 kwh	
Mean power consumption per acre-foot (33 wells)		270 kwh
(Also, see table 13)		
Mean pumping lift (feet below land surface)		140 ± 10 feet
Pumping costs per acre-foot (33 wells 2/):		
Minimum	$1.60	
Maximum	$8.25	
Mean	$4.00 3/	

1. Does not include wells pumping to sprinklers; average power consumption at these three wells was 211,000 kwh.
2. Based on an electric-power rate of 1.5 cents per kwh.
3. Average pumping cost per acre-foot for the three wells pumping to sprinklers was $5.90.

Table 13.--*Power-consumption ratings for irrigation wells in 1972*
[Electrically-powered pumps only]

Power consumption rating 1/	Range, in kilowatt-hours/ ac-ft 2/	Average lift (ft)	Total number of wells	Distribution	
				North of river	South of river
Very low	100-200	85	12	11	1
Low	200-400	165	18	6	12
Medium	400-480	245	4	0	4
High	480-550	285	2	0	2
Total	100-550		a 36	17	19

1. Rating developed for use in this report.
2. Does not include energy requirements for operating sprinklers.
a. In addition, two wells were pumped with diesel power; they are not included in this table.

Water Consumption

The irrigation-water consumption in the valley for 1972 is summarized in table 14. Approximately 22,600 acres were irrigated or subirrigated with an estimated 46,000 acre-feet of net consumption. About twice this amount of water, approximately 93,000 acre-feet (table 9), was diverted to the irrigated parts of the valley.

About 10,000 acres of land was subject to varying amounts of subirrigation. Most of this land supported either native-grass pasture or grass hay. Of the total water consumption on this land in 1972 (about 18,000 acre-feet), an estimated 5,000 acre-feet was supplied through subirrigation.

Leaching Requirements

Dissolved salts are present in the water used for irrigation in Smith Valley. Plant roots remove molecules of water from soil, but most of the salt remains in the root zone unless it is removed by percolating water. Crops differ in salt tolerance. Data on salt tolerance and leaching requirements are given in table 15. Requirements are for specific conductances of 200 and 450 micromhos, generally the highest values found for surface water and ground water, respectively, in the valley during this study. Average specific conductances for these waters are about half the maximum values. The leaching requirements listed in table 15 are for a crop-yield reduction of no more than 10 percent. On the basis of this information and the estimates in tables 14 and 26, the amount of water needed for leaching during 1972 was as follows:

Table 14.--*Consumption of water by irrigated and subirrigated crops in 1972*

[Crop acreage based on aerial photographs and field inventory]

Crop	Area irrigated (acres)	Average annual water-use rate 1/ (feet)	Consumed water (acre-feet, rounded)
	RIVER BASIN, NORTH OF RIVER		
Alfalfa hay	1,470	2.3	3,400
Grass pasture and hay	1,970	1.8	3,500
Grain, mostly barley, wheat, and oats	30	1.2	40
Subtotal (rounded)	3,470		6,900
	RIVER BASIN, SOUTH OF RIVER		
Alfalfa hay	7,710	2.3	18,000
Grass pasture and hay	4,190	1.8	7,500
Grain, mostly barley, wheat, and oats	660	1.2	790
Garlic	80	1.6	130
Potatoes	25	1.7	40
Subtotal (rounded)	12,700		26,000
RIVER-BASIN TOTAL (rounded)	16,200	2.0	33,000
	ARTESIA LAKE GROUND-WATER BASIN		
Alfalfa hay	2,130	2.3	4,900
Grass pasture and hay	a 4,140	1.8	7,500
Grain, mostly barley, wheat, and oats	70	1.2	80
Garlic	100	1.6	160
ARTESIA BASIN TOTAL (rounded)	a 6,440	2.0	13,000
VALLEY TOTAL (rounded)	22,600	2.0	46,000

1. Net consumptive irrigation requirements as determined by Nevada River Basin/Watershed Planning Staff (Soil Conservation Service, written commun., 1973).

a. Includes 110 acres of subirrigated native grass west and north of Artesia Lake and 2,500 acres of partially subirrigated grass pasture south of Artesia Lake in T. 12 N., R. 23 E.

	Acre-feet
West Walker River Basin:	
North of river	240
South of river	1,100
Subtotal (rounded)	1,300
Artesia Lake Basin:	400
Valley total (rounded)	1,700

The leaching requirements add an additional 4 percent to the water-use needs for the cropland. Under present irrigation practices in the valley, the leaching requirements are generally satisfied.

Table 15.--*Leaching requirements*

[Based on findings of Fuller (1965) and Bernstein (1964)]

Crop	Specific conductance at 10 percent yield reduction (micromhos)	Leaching requirements 1/	
		200 micromhos (maximum for surface water)	450 micromhos (maximum for ground water)
Alfalfa	3,000	7	15
Grass, fescue	7,000	3	6
Barley	12,000	2	4
Wheat	7,000	3	6
Garlic	a 2,000	10	20
Potatoes	2,500	8	18

1. Requirements as a percentage of water consumed by crop.
a. For onions; assumed to apply to garlic also.

Percolation to the Ground-Water System

As part of the present irrigation process in Smith Valley, water is lost to the ground-water system from canals, ditches, and irrigated fields. The principal canals do not seem to lose very much water, as described in an earlier section of the report; rather, the principal losses probably are from fields. As a result, the irrigated areas are the principal areas of man-induced ground-water recharge. As stated previously, the percolation of irrigation water to the ground-water system was about 47,000 acre-feet in 1972, and resulted from a total delivery of 93,000 acre-feet and a net crop consumption of 46,000 acre-feet. Of the 47,000 acre-feet of percolation, only about 1,700 acre-feet is needed to maintain a desirable salt balance.

Return Flow

Under native conditions, both surface water and ground water flowed to Artesia Lake and the West Walker River. The ground-water flow was virtually constant, resulting from a low, constant gradient. Surface flow to the lake and the river was intermittent, generally restricted to periods when snowmelt was rapid or during summer thunderstorms.

Under native conditions, the ground-water flow equaled recharge minus discharge by evaporation and phreatophytes over a period of years. The amount of evapotranspiration under those conditions is unknown, but probably was somewhat less than the computed average recharge of 17,000 acre-feet per year.

With the construction of canals and extensive irrigation of crops, natural streamflow to the lake and river was reduced, but ground-water flow was increased greatly. This increase resulted from a steepening of the ground-water gradient toward the lake and river, in turn caused by mounding of ground water beneath croplands on both sides of the river (pl. 2).

As of 1972, the ground-water mound beneath croplands on both sides of the river had nearly stabilized. Therefore, in spite of heavy pumping at some distance from the river, there appeared to be little seasonal or year-to-year variation in ground-water gradient toward the river.

Return flow to the West Walker River was measured on Oct. 26, 1972; the results are summarized in table 16. The net return flow, as indicated by the flow increase in the river through the irrigated area, was about 41 cfs. The return flow may be about constant throughout the year; if so, the annual total would be about 30,000 acre-feet. Thus, the average net diversion from the river would equal the average total diversion of about 73,000 acre-feet per year (table 6) minus the return flow of 30,000 acre-feet (table 16), or 43,000 acre-feet annually. This agrees closely with the measured net decrease in streamflow of 46,000 acre-feet (table 6, column 3).

In the consolidated-rock areas and along the apron, river flow fluctuated on Oct. 26, 1972, due to gains and losses; however, across the main part of the valley floor, steady gains were measured. The maximum rate of gain per mile was between sites 11/23-26cc and 11/23-13cd.

Ground water flows northward within the Artesia Lake ground-water basin from the irrigated area toward Artesia Lake (pl. 2). A rough estimate of flow at the north end of the agricultural area (pl. 2) is based on a flow width (W) of 3 miles, an average gradient (I) of about 80 feet per mile, and a transmissivity (T) of perhaps 10,000 to 15,000 gpd per foot (1,340 to 2,000 ft^2/day). Based on the equation $Q = 0.00112\ TIW$, the flow (Q) possibly is on the order of 3,000 to 4,000 acre-feet per year.

Table 16.--*Ground-water return flow to the West Walker River in 1972*

[Data for October 26, 1972]

River location	Distance downstream from initial site (miles)	Measuring site (pl. 2)	River flow 1/ (cfs)	Increase (+) or decrease (-) (cfs)	Accumulated return flow through ground-water system (cfs)
0/23-17da	0	Gage in Hoye Canyon	43.5		
10/23-16aa	1.5	--	42.0	-1.5	--
0/23-10cc	1.7	Diversion to Saroni Canal (4.3 cfs)	39.3	+1.6	--
0/23-10aa	3.2	Diversion to Colony Ditch and Plymouth Canal (23.5 cfs)	13.4	-2.4	--
10/23-2cc	3.7	Diversions to Dickenson, Simpson, and Upper Fulstone ditches	14.8	+1.4	--
10/23-2ba	4.5	Diversions to West Walker Ditch and Gage Peterson (3.3 cfs)	10.5	-1.0	--
/23-26cc	6.0	Lower Fulstone Diversion	14.3	+3.8	3.8
/23-26aa	7.0	--	20.0	+5.7	9.5
11/23-13cd	8.5	Ditch from Beaman Lakes (Inflow = 0.34 cfs)	30.8	+10.5	20.0
/24-18aa	10.5	At bridge north of Smith	38.8	+8.0	28.0
11/24-8ac	11.7	--	43.4	+4.6	32.6
11/24-9ad	13.4	--	46.8	+3.4	36.0
/24-3dd	14.7	At Hudson bridge	51.4	+4.6	40.6
11/24-13bc	16.7	--	50.4	-1.0	--
11/25-18cd	18.5	Gage near Hudson	49.4	-1.0	--
/25-17ac	20.0	Wilson Canyon	50.6	+1.2	--
Net gain (rounded)				38	41
uivalent net annual gain, in acre-feet (rounded)			28,000		30,000

At diversions, flow listed in that of river downstream from point of diversion.

Return flow to West Walker River can be used as a check on the aquifer transmissivity. Using the data in table 16, and assuming that the quantity of return flow was nearly constant throughout 1972 (p. 54), about 30,000 acre-feet of flow may have returned to the river during the year. With the existing average gradients toward the river from the north and south of about 25 to 30 feet per mile and a straight-line flow width of 7 miles on each side of the river (pl. 2), a transmissivity of about 70,000 gpd per foot (9,400 ft^2/day) is needed to transmit the flow of water to the river. This value agrees reasonably well with the range of 50,000-100,000 gpd per foot (fig. 5) derived from pumping-test data.

Evapotranspiration by Low-Value Phreatophytes

Much of the vegetation that grows in areas where the depth to ground water is less than about 50 feet commonly roots down to the water table and thus removes water directly from the ground-water system. These deep-rooting plants are called phreatophytes. Some of them, such as grasses, are of economic value, whereas others such as greasewood and rabbitbrush have low value. In areas of fine-grained soils, where the depth to water is less than about 10 feet, ground water is discharged by evaporation. These types of ground-water discharge are summarized in table 17. Evapotranspiration rates are based on research done by Lee (1912), White (1932), Young and Blaney (1942), Houston (1950), Robinson (1965), and Harr and Price (1972) in other areas.

In Smith Valley, these plants and discharging bare soil occupy an area of about 15,000 acres and discharge about 13,000 acre-feet per year (table 17). Some of this discharge might be salvaged for more beneficial use. This possibility is discussed in a later section of the report.

Evaporation of Surface Water

Water evaporates from Artesia Lake, Beaman Lakes, canals, and streams. During 1972, Artesia Lake contained water reportedly for a shorter-than-average period of time. During the 1971-72 winter, rising ground water plus stream and canal inflow flooded the playa; however, by mid-summer 1972 the lake had completely evaporated. No measurements were made of the evaporation rate or the inflow to the lake, but intermittent observations suggest that on the order of 1,000 acre-feet of surface water was evaporated. This is based on a flooded area of 2,000 acres and an estimated evaporation of 0.5 foot of water. During average years, probably about 6,000 acre-feet of surface water would be evaporated (3,000 acres x 2 feet of evaporation) in addition to the 6,000 acre-feet of ground water estimated in table 17. This latter estimate is based on descriptions of the lake by local residents. of water surface. The estimated evaporation from the lakes was about 400 acre-feet in 1972. Because a ditch drains the lakes at higher stages, the 1972 evaporation rate is probably near the long-term average.

Table 17.--*Evapotranspiration of ground water by low-value phreatophytes and from bare soil*

[Does not include meadow grass]

Type of water loss	Phreatophyte ground cover (percent)	Depth to water table (feet)	Area (acres)	Average annual Evapotranspiration	
				Acre-feet per acre	Acre-feet (rounded)
		ARTESIA LAKE GROUND-WATER BASIN			
Mostly greasewood and rabbitbrush; mixed with various amounts of big sage, shadscale, and saltgrass	5-20	5-50	8,000	0.2	a 2,000
Mostly saltgrass and rabbitbrush near Artesia Lake		1-5	2,000	.5	1,000
Artesia Lake playa	0	0-1	3,000	b 2.0	c 6,000
Subtotal (rounded)			d 13,000		9,000
		WEST WALKER RIVER BASIN			
Tules around Beaman Lakes	--	0-5	300	1.0	300
Cottonwood, willow, and various types of brush on the West Walker River flood plain	--	0-5	d 1,000	4.0	e 4,000
Mostly greasewood and saltgrass. Mostly in 10/24-18 and 20, south of Saroni Canal	5-20	f 40-100	d 280	.2	60
Subtotal (rounded)			1,600		e 4,400
TOTAL (rounded)			15,000		e 13,000

a. Does not include discharge by 110 acres of meadow grass, supported by springs and flowing wells, northwest of Artesia Lake in township 13 N. Discharge by grass included in crop inventory.
b. Estimated rate of consumption of ground water only.
c. Includes evaporation of ground water and ponded water rising from the subsurface. Additional surface-water runoff collects in lake and evaporates. Entire area of 3,000 acres remains wet during most years and total evaporation of surface and ground water equals about 12,000 acre-feet per year.
d. Shown on plate 2.
e. Value is approximate.
f. Phreatophytes probably supported by percolating water perched above the water table.

Flowing water in the West Walker River, Desert Creek, canals, and the few small streams in the Pine Nut Mountains is subject to evaporation. The combined surface area of these streams is estimated to be about 300 acres and the evaporation rate about 4 feet per year; therefore, the total evaporation of flowing water is about 1,200 acre-feet per year during most years, including 1972. The estimated total of all surface-water evaporation for 1972 was about 3,000 acre-feet. For average years, the evaporation is estimated to be about 8,000 acre-feet.

Springs

Nevada Hot Spring is the principal spring in the valley. All other springs, mostly west and north of Artesia Lake (pl. 2), are small. During the period August 1972-July 1973, Nevada Hot Spring had an average flow of about 540 gpm (table 5), or a projected rate of 870 acre-feet per year. The total spring discharge for the valley is estimated to be about 1,000 acre-feet per year.

Most of the spring flow either seeps back to the water table or is discharged by crops or phreatophytes; the volume of spring flow is included in estimates of discharge in the water budgets (tables 19 and 20).

Domestic and Stock Use

The human population of Smith Valley, as estimated earlier in the report, was 300 to 500 in 1972. Per capita use of water, as based on estimates developed in other parts of northern Nevada, was probably about 100 gallons per day, giving a total of about 50 acre-feet per year. Of this total, about two-thirds, or 35 acre-feet, returns to the ground-water system from private, domestic sewage-disposal systems. The remainder, about 15 acre-feet per year, is the estimated net discharge for 1972.

The Soil Conservation Service (written commun., 1972) estimated that in Lyon County, which includes most of Smith Valley, the livestock population in 1969 was about 55,000 head, using about 500 acre-feet of water. The 1972 population and consumption rate is probably similar; therefore, from these data the stockwatering consumption of Smith Valley is probably about one-fourth the total use, or on the order of 125 acre-feet.

The domestic and stockwater consumption in Smith Valley in 1972 was about 140 acre-feet. Of this amount, less than 50 acre-feet was consumed in the Artesia Lake ground-water basin.

EFFECTS OF WATER USE ON THE HYDROLOGIC SYSTEM DURING 1972

The long-term effects of large-scale irrigation in Smith Valley are described in an earlier part of the report. Short-term effects were observed in 1972.

During the period extending from late March to early November 1972, the ground-water reservoir had a net water-storage decline of about 15,000 acre-feet. This was the result of two contributing factors: (1) a reduction in the amount of irrigation with water diverted from the West Walker River, and (2) the pumping of 20,000 acre-feet from irrigation wells. Because much of the pumping was in the same areas as reduced surface-water availability, the effects of the two factors cannot be separated. However, the principal factor was probably the large-scale pumping.

Throughout the 1972 irrigation season, in particular, and during the entire year, in general, irrigation water was percolating to the water table. Storage decline resulted from a faster rate of water removal than recharge to the system. When most of the irrigation wells were shut off, the inflow-outflow relation reversed, and storage in the ground-water reservoir began to increase. As a result, the 15,000-acre-foot depletion during the growing season was reduced to about 6,000 acre-feet by the beginning of the next growing season in late March 1973. About 1,000 acre-feet of the net 1972 depletion was in the Artesia Lake ground-water basin.

The area and depth of dewatering during the 1972 irrigation season are shown in figure 22. The factors that contribute to the shape are: (1) distribution of pumping, (2) distribution of areas where the amount of irrigation water available from the West Walker River was less than average during the year, (3) distribution of the hydraulic properties of the aquifer, and (4) location and effectiveness of hydraulic boundaries.

A comparison of figures 21 and 22 shows that south of the river, the center of dewatering mainly coincides with the center of pumping. However, north of the river the pattern is different. The pumping is greatest along the toe of the Red Canyon-Burbank Canyon fan, but the maximum dewatering is centered along the Owens fault several miles to the east. This distribution is caused by three factors: (1) the barrier effect of the fault to horizontal ground-water flow, (2) the very small storage coefficient associated with semiconfined conditions east of the fault, and (3) the lower transmissivity near the fault in contrast to the high values along the toe of the fan.

Table 18 is a summary of dewatering for the year from spring 1972 to spring 1973.

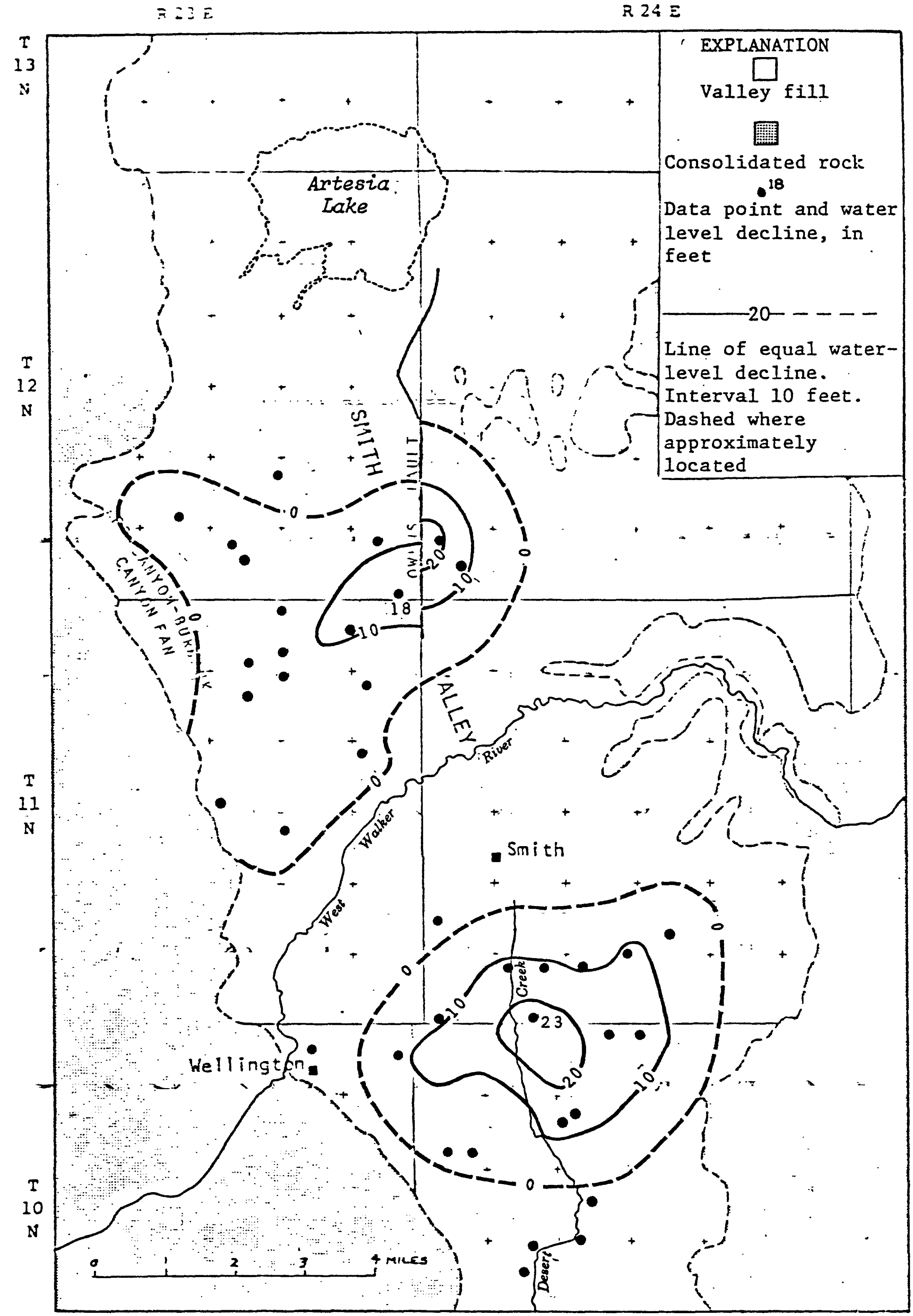

Figure 22.--Decline of ground-water levels during the 1972 irrigation season.

Table 18.--*Summary of water-level decline and reduction of ground water in storage, spring 1972 to spring 1973*

	Area north of river (fig. 22)	Area south of river (fig. 22)	Total
Pumpage (acre-feet)	a 10,000	9,000	a 19,000
Area of water-level decline (acres)	11,000	9,000	20,000
Net water-level change in wells (feet)			
Maximum	-5.5	-7.9	--
Minimum	0	0	--
Average	-1.2	-3.2	--
Storage reduction (acre-feet, rounded)	b 2,000	b 4,000	b 6,000

a. Does not include flow from well 13/23-25ca, north of Artesia Lake (fig. 21).

b. Estimated specific-yield value of 0.15 used in storage computations.

WATER BUDGET, 1972

During a multiyear period, most natural hydrologic systems approach dynamic equilibrium; that is, inflow equals outflow.

This means that although no single year will have a perfect balance, over the long term the inflow and outflow will approximately balance. If a large change is made in any of the flow elements, considerable time, perhaps as long as several decades, would be needed to again balance the system. If the system is out of balance, the amount of ground water in storage would be changing and the equation would be:

$$\text{Inflow} = \text{Outflow} \pm \text{storage change.}$$

During the early part of the twentieth century, when a large general rise in water levels occurred in Smith Valley (Loeltz and Eakin, 1953, p. 31), inflow was larger than outflow, resulting in a correspondingly large increase in storage. During the growing season of 1972 and the period from spring 1972 to spring 1973, outflow exceeded inflow, and some storage was removed from the system as indicated by the net decline in water levels (table 18 and fig. 22).

A water budget for Smith Valley for the calendar year 1972 is presented in table 19. The only element of inflow not included is local runoff within the valley, which is largely accounted for in the estimate of ground-water recharge. Discharge from springs is not included as an outflow element in the budget because it is accounted for by phreatophyte and crop evapotranspiration. Net irrigation consumption, rather than gross water application to the irrigated part of the valley, is used because infiltration to the water table is not a loss from the hydrologic system. Likewise, leaching of salts does not directly consume water.

Approximately 160,000 acre-feet of water moved through the system in 1972; consumption totaled about 60,000 acre-feet and depletion of stored ground water was about 6,000 acre-feet during the year. The budget nearly balances, with an imbalance of only 2,000 acre-feet, or about 1 percent.

The use of surface water in Smith Valley probably has been developed to its fullest extent within the water-right allocations. The use of ground water, on the other hand, has been increasing, not only to supplement the surface-water supply, but also to develop irrigated agriculture in areas not served by the surface-water supplies. Accordingly, a budget pertaining only to the ground-water system is given in table 20. In time, increased pumpage could salvage some of 13,000 acre-feet per year now consumed by evaporation and low-value phreatophytes.

Table 19.--*Water budget for 1972*

[All values in acre-feet]

Inflow to the valley-fill reservoir:	
West Walker River (table 6)	142,000
Recharge from precipitation (table 8)	17,000
Importation, Lobdell Lake (p. 42)	only a few
Total inflow (rounded) (1)	159,000
Outflow from the valley-fill reservoir:	
West Walker River outflow (table 6)	101,000
Irrigation and subirrigation consumption (table 14)	46,000
Transpiration by low-value phreatophytes (table 17)	13,000
Evaporation of surface water (p. 57)	3,000
Domestic and stock consumption (p. 57)	140
Total outflow (rounded) (2)	163,000
Inflow (1) - Outflow (2) = (3)	- 4,000
Depletion of ground water in storage (table 18) (4)	- 6,000
Budget imbalance: (3) - (4)	2,000

Table 20.--*Ground-water budget for 1972*

Budget element	Acre-feet
INFLOW:	
Recharge from precipitation (table 8)	17,000
Infiltration of irrigation water (p. 44)	47,000
Total inflow (1)	64,000
OUTFLOW:	
Pumpage (table 11)	20,000
Phreatophyte and bare-soil discharge (table 17)	13,000
Springs (p. 57)	1,000
Subirrigation (p. 50)	5,000
Ground-water return flow to the river (table 16)	30,000
Total outflow (2)	69,000
INFLOW (1) - OUTFLOW (2) = (3)	- 5,000
STORAGE DEPLETION: (4) (table 18)	- 6,000
BUDGET IMBALANCE: (3) - (4)	1,000

All the known elements of water inflow, outflow, and ground-water storage change have been identified and evaluated in the foregoing sections of the report for the year 1972. This information forms the basis for the conceptual model of water flow of Smith Valley for 1972 and is summarized in figure 23. Routing of water is shown by three weights of lines, the more substantial the line, the greater the relative flow. For example, "West Walker River" flows through the valley, with a major reduction by diversion to "canals and ditches" and ultimately to irrigated fields. Substantial amounts of the "field irrigation" water infiltrate to the ground-water reservoir; part of this infiltration flows toward the river in the subsurface, where it reenters the river and flows out of the valley to the east.

How does this model change for other years? What is the nature of the model for long-term average conditions? The second question can be answered more easily. A long-term average budget does not have much meaning in Smith Valley, because land use and water use are undergoing marked changes. The year 1972 was a period of increasing land cultivation and irrigation-well use. There is a transition from a dominant reliance on surface-water flow prior to about 1960 to more conjunctive use of surface water and supplemental ground water during years of low river flow and reliance on wells as the sole source of water for some croplands.

For years when more surface water is available than in 1972, the model would have the following characteristics: (1) river inflow, river through-flow, and canal diversions, crop consumption, evaporation from Artesia Lake, and percolation of irrigation water to the water table would be larger. Well discharge would be smaller in areas of surface-water deliveries. The amount of stored ground water would increase, or at least the decrease in storage would be smaller than in 1972, if other conditions remained constant. The principal controls on the hydrologic response during these short periods are the variations in annual flow in the West Walker River, the corresponding changes in the diversions from the river, and the amount of ground-water pumpage.

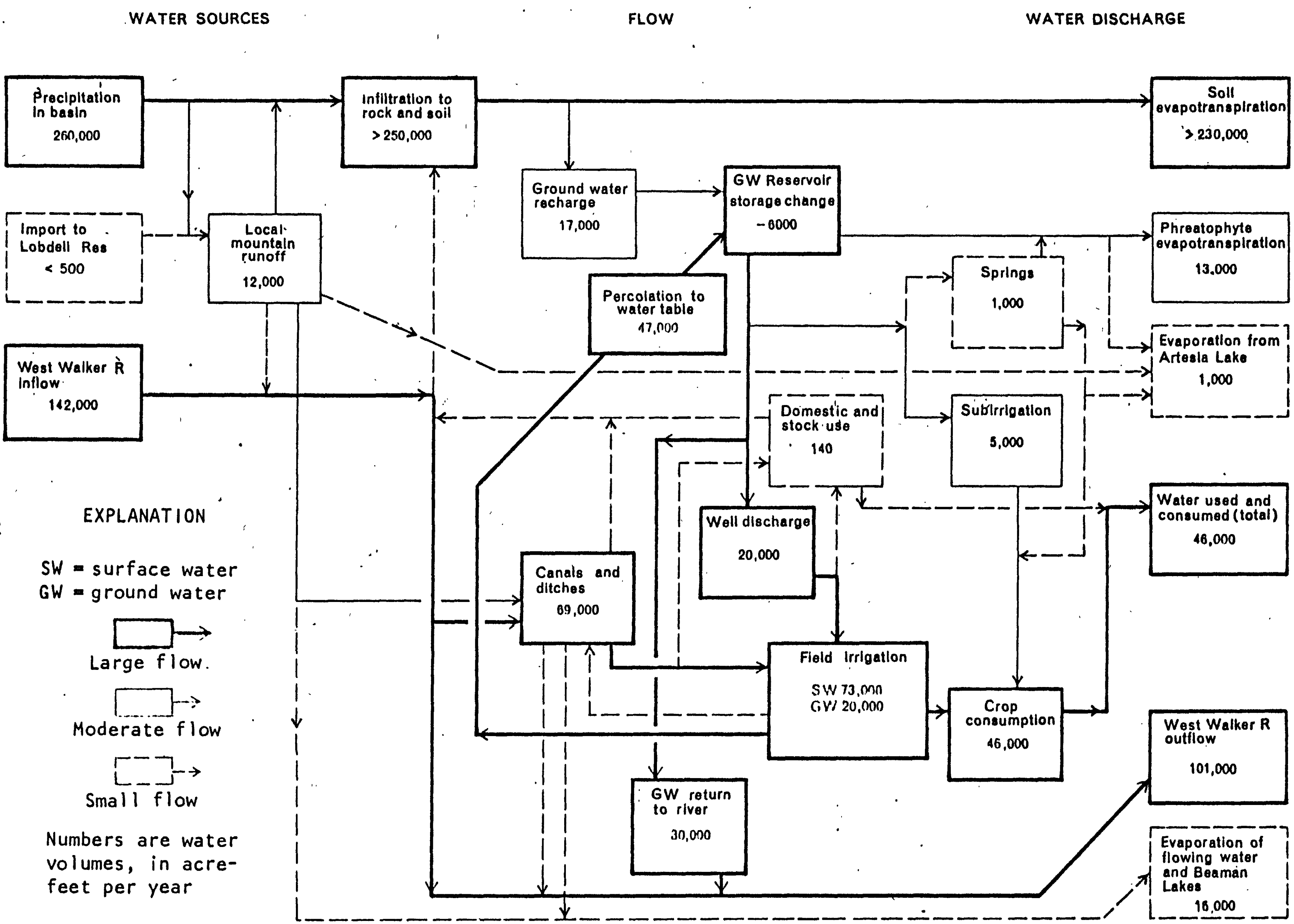

Figure 23.--Conceptual water-flow model of Smith Valley for 1972.

AVAILABLE WATER RESOURCES

System Yield

The yield of the hydrologic system of the valley is the maximum amount of water that could be consumed each year in the valley without continually removing ground water from storage or reducing outflow to downstream users. For the purposes of this report, the period of record 1953-72 is used as a basis for evaluating the system yield. This period is considered one of near-average precipitation and hence water supply, as described on page 34. Thus, the yield summarized below is representative for average conditions:

	Acre-feet
Average annual river diversions (table 6)	75,000
Recharge from precipitation (table 8)	17,000
Sum	92,000
Return flow to the river (table 16) (Part of downstream water rights)	-30,000
Long-term net storage change, considered to be	0
SYSTEM YIELD	62,000
Present water consumed	-46,000
Undeveloped water	16,000

The distribution of the available undeveloped water supply is discussed in the following sections.

West Walker River

The Walker River Irrigation District systematically distributes water from the West Walker River. As long as the operating criteria remain unchanged, the resulting distribution of water would remain generally the same, unless long-term river flow changes significantly. Therefore, the average annual diversion to Smith Valley from the river, about 75,000 acre-feet (tables 6 and 10), would be nearly constant over the long term.

Local Mountain Streams

Desert Creek, with an average annual flow of about 8,500 acre-feet (table 7), is the only source of appreciable streamflow originating within Smith Valley. During the 1972 growing season, most of its flow, about 3,500 acre-feet, was utilized for irrigation. The average annual use probably is larger. Most of the nongrowing-season flow has not been directly used and is available for further development; however, development of this additional water would reduce recharge to the ground-water reservoir. The amount not directly used is estimated to average about 4,000 acre-feet.

Red, Burbank, and Pipeline Canyons have very limited potential because of generally small, undependable flows.

Ground-Water System

Natural discharge could be captured to a limited extent. In the ground-water budget (table 20), the elements of natural discharge that remain to be captured are phreatophyte transpiration and bare soil evaporation. In the Artesia Lake basin, most of the phreatophyte and playa (bare soil) discharge, about 9,000 acre-feet (table 17), might be captured by lowering the water level from the shallow native equilibrium level to a new equilibrium level having a minimum depth to water of about 50 feet below land surface--the depth considered necessary to kill the deep-rooted phreatophytes.

Phreatophyte discharge in the Beaman Lakes area might be reduced by improving the present drainage-canal system, but the amount of reduction would be small. Trees and bushes on the flood plain of the West Walker River could be removed to eliminate their discharge, but large evaporation losses would continue. All these conservation measures taken together might salvage a part of the 13,000 feet (table 17), but their environmental effects, including erosion and effects in the river, probably would be considered unfortunate by many.

In summary, probably the least disruptive method of capturing ground-water discharge, from an environmental viewpoint, might be the reduction of phreatophyte and playa (bare soil) discharge in the Artesia Lake ground-water basin. If water quality imposed a severe constraint on use, it may not be feasible to capture the entire discharge of 9,000 acre-feet per year. For example, the annual capture would be somewhat less for irrigation because of the need to leach salts from cropland soils, as described on p. 31.

Transitional Storage Reserve in the Artesia Lake Ground-Water Basin

In reducing phreatophyte and shallow ground-water discharge, a large volume of water would have to be removed from the ground-water system in order to lower water levels at least 50 feet below land surface. This volume of water is called the transitional storage reserve.

Transitional storage reserve also has been defined by Worts (1967, p. 50) as the quantity of water in storage in the ground-water reservoir that can be extracted and beneficially used during the transition period between native equilibrium conditions and new equilibrium conditions under perennial-yield water development. In the arid environment of the Great Basin, the transitional storage reserve of such a reservoir is the amount of stored ground water available for withdrawal by pumping during the nonequilibrium period of development--the 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 supply, but on a once-only basis.

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 Artesia Lake ground-water basin, several assumptions are made: (1) wells would be strategically situated in and around areas of natural discharge in the main alluvial area of the basin, 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 averages 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 parts of Smith Valley; and (7) water is of suitable chemical quality for the intended use.

The estimated storage reserve in the Artesia Lake ground-water basin is the product of the area beneath which depletion could be expected to occur (23,000 acres), the average thickness of saturated valley fill to be dewatered (50 feet), and the specific yield (15 percent), or about 170,000 acre-feet.

The manner in which transitional storage reserve would augment the supply has been described by Worts (1967, p. 52). The relation is shown in its simplest form by the following equation:

$$Q = \frac{\text{Transitional storage reserve}}{t} + \frac{\text{Natural discharge}}{2}$$

in which $\underline{Q}$ is the selected 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 capture of natural discharge. The equation, however, is not valid for pumping rates less than the natural discharge.

Using the above equation and the natural discharge for the basin as an example (transitional storage reserve, 170,000 acre-feet; natural discharge, 9,000 acre-feet), and using a diversion rate (Q) equal to the natural discharge, the time (t) to deplete the transitional storage reserve is computed to be nearly 40 years.

At the end of the estimated time, the transitional storage reserve would be exhausted, subject to the assumptions given in the preceding section. The example does not show 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. In contrast, 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 of the basin would be substantially modified. The recharge that originally flowed to areas of natural discharge at and adjacent to Artesia Lake playa would ultimately flow directly to pumping wells.

To meet the needs of an emergency or other special purpose requiring ground-water pumpage in excess of the natural discharge for specific periods of time, the transitional storage reserve could be depleted at a more rapid rate than the example given. The above equation could be used to compute the time required to exhaust the storage reserve for any selected pumping rate equal to or in excess of the natural discharge. However, once the transitional storage reserve was exhausted, the pumping rate would have to be reduced to 9,000 acre-feet to prevent overdraft, otherwise pumping lifts would continue to increase and the amount of stored water would continue to be depleted.

Other Sources of Water

Salvage of surface-water evaporation in most cased probably is not practical. Evaporation from streams and canals will continue, with the only potential areas of salvage being Desert Creek and Artesia Lake. For Artesia Lake, the principal source of water probably is the irrigated areas to the south. The water reaches the lake as flow in ditches, fed in part by rising ground water. This flow, estimated to average 6,000 acre-feet per year (table 17), could be reduced by lowering the ground-water levels by pumping wells and by constructing storage reservoirs or by diversions upstream from Artesia Lake. Once the water reaches the lake, its value for irrigation is lost because of increased salinity and undesirable location.

Thus, under 1972 conditions, possible additional water sources are:

Additional water source	Acre-feet per year
Desert Creek (p. 65)	a 4,000
Artesia Lake ground-water basin:	
Phreatophyte and playa salvage (p. 66)	9,000
Surface flow to Artesia Lake (p. 68)	6,000
Subtotal	15,000
Smith Valley (total)	19,000

a. Development probably would cause a substantial decrease in ground-water recharge.

The above summation does not include possible reduction of discharge by trees and brush on the West Walker River flood plain (table 17).

Conjunctive-Use Areas

To maximize the use of irrigated land and water, the supplementing of streamflow diversions with irrigation-well pumpage has been demonstrated in Smith Valley to be a desirable procedure. Using data from 1972 and taking into consideration the storage depletion during that year, a conjunctive-use value of 90,000 10,000 acre-feet per year is computed in table 21. This value is valid only if (1) no significant changes are made in irrigation practices that would affect the amount and distribution of water reaching the irrigated areas and the infiltration to the ground-water system, and (2) if annual diversions from the river are near the average of 73,000 acre-feet; that is, from about 80 to about 120 percent of average (table 6), or within the range of approximately 60,000 to 90,000 acre-feet. The corresponding well pumpage would be limited to a range from zero to about 30,000 acre-feet.

Table 21.--*Conjunctive-use volume*

[Based on hydrologic conditions in 1972]

	1972 Acre-feet	Desirable average under near-normal conditions (see text)
Diversions from river (table 6)	69,000	75,000
Desert Creek flow (p. 36)	4,500	
Ground-water pumpage (p. 46)	20,000	15,000
Sum (rounded)	94,000	90,000 ± 10,000
Draft on storage (p. 58)	6,000	0
Difference	88,000	

During years when it is not possible to divert as much as 80 percent of the average (that is, about 60,000 acre-feet), such as in 1955, 1960, and 1961, the total amount of irrigation water available would be less than the conjunctive-use volume if this scheme were followed. Larger pumping volumes than the limit described above, withdrawn over a multiyear period, would remove a very large volume of stored ground water and would have an adverse effect on pumping lifts and pumping costs. To refill the reservoir, correspondingly large volumes of river water would have to be infiltrated each year, and this apparently is not practical as indicated in table 6. For example, 1969 was a record year for flow in West Walker River, but only 104,000 acre-feet was diverted for irrigation. This was only 12,000 acre-feet more than in 1971 when the river flow was about 55 percent of the 1969 volume.

To further illustrate the significance of the conclusions in the above paragraph, an example can be given based on the diversion data in table 6. If irrigation wells had supplemented river diversions to maintain a constant conjunctive-use supply of 90,000 acre-feet annually during the drought period 1959-61, the net volume removed from ground-water storage would have been on the order of 100,000 acre-feet. This removal would have resulted in a net dewatering of about 700,000 acre-feet of aquifer. Scaled against the irrigated land of 22,600 acres, this would be a dewatering of about 30 feet of aquifer. By 1972, 11 years after the short drought, about 30,000 acre-feet of ground water would still have remained unreplenished. Several more years of greater-than-average diversion from the river and less-than-average well pumping would have been required to bring the ground-water storage back to equilibrium. Such a long recovery period for a short (3-year) drought indicates that a longer-term drought would require an even more expansive period of recovery to restore equilibrium.

The volume of water reaching the land surface in the conjunctive-use areas should be about 90,000 acre-feet during near-normal years if the "ideal" water-use scheme of table 21 is followed. Under the scheme, surface-water diversions and pumpage would average 75,000 and 15,000 acre-feet per year, respectively.

Domenico and others (1966) provide an extensive discussion of the physical and economic aspects of conjunctive use in Smith Valley.

Potential Overdraft Areas

Potential areas of local overdraft can be delineated, based on several criteria: observed dewatering during the 1972 irrigation season, effects of faults, hydraulic characteristics of the aquifer, and well spacing.

Figure 22 shows the effects of ground-water pumping during the 1972 irrigation season. Most pumps were shut off for the season in late September or early October. At the time of shutoff, drawdowns in wells were generally at their maximum, but the areal extents of the cones of depression resulting from pumping were localized to the vicinity of each well. In figure 22, areas where dewatering exceeded 15 to 20 feet may be subject to overdraft if additional pumping occurs, especially during drought periods extending over several years.

Faults that impede the lateral flow of ground water, such as Owens fault, have had undesirable effects on pumping levels where wells were located within a distance of half a mile. To minimize such barrier effects, limitations in locating high-yield wells in these areas may be desirable.

Table 22.--*Examples of well interference under various conditions at the end of a 100-day pumping period 1/*

[Computations assume absence of hydraulic boundaries]

Aquifer transmissivity (gpd/ft)	Pumping rate (gpm)	Distance between wells = 0.5 mile			Distance between wells = 0.75 mile		
		Drawdown by pumping well (feet)	Interference by nearby wells 2/ (feet)	Total drawdown in pumped well (feet)	Drawdown by pumping well (feet)	Interference by nearby wells 2/ (feet)	Total drawdown in pumped well (feet)
25,000	1,000	71	7	78	71	0	71
50,000	1,500	55	16	71	55	5	60
100,000	2,000	38	19	57	38	10	48
150,000	2,500	33	20	53	33	11	44
200,000	3,000	31	25	56	31	13	44

1. For a storage coefficient of 0.15. Data assumes 100 percent well efficiency.
2. Assuming a rectangular well-spacing pattern.

Wells pumped in areas of low aquifer transmissivity (that is, less than 50,000 gpd/ft as shown in fig. 5) generally would have excessive drawdowns, if discharge is not kept below 1,500 gpm. Low coefficients of storage, such as for the semiconfined aquifer east of Owens fault, also would contribute to large drawdowns. Where transmissivity exceeds 50,000 gpd/ft, most irrigation wells discharge more than 1,500 gpm. These variations in pumping rates have been included in calculations mentioned in the next paragraph.

Data on well interference for several ground-water development conditions are given in table 22, and are based on a drawdown chart of Theis (1963). If 15 feet of interference, that is the lowering of water level in a well resulting from the combined effects of nearby pumping wells, is judged to be a reasonable limit, then where transmissivity is more than 50,000 gpd/ft, irrigation wells should be spaced more than 0.5 mile apart. For lower transmissivities, 0.5-mile minimum spacing probably would be suitable for irrigation wells if no other overdraft factors are operating.

SUMMARY

This study describes the geohydrology and evaluates the effect that irrigation development has had on the surface-water and ground-water resources of Smith Valley during the period 1953-72. (A previous study by Loeltz and Eakin (1953) provided some quantitative information on the water supply and status of development as of 1950.) The principal findings of this study are listed below.

1. Sources of water for Smith Valley are precipitation that falls within the topographic basin, especially in the mountains, and inflow of West Walker River. The immediate source of most of the ground-water replenishment is infiltration of irrigation water from fields and canals.

2. The average annual inflow of the West Walker River to Smith Valley, for the period 1958-72 was 179,000 acre-feet. The average annual river flow from the valley is 133,000 acre-feet. Desert Creek, the only significant stream originating within the valley, has a long-term average flow of 8,500 acre-feet per year.

3. The amount of ground water stored in the upper 100 feet of saturated alluvium is about 1,500,000 acre-feet.

4. Most of the waters sampled in the valley were suitable for their intended uses; that is, in most instances, irrigation. For human consumption, fluoride and arsenic concentrations in some samples were higher than desirable. Because of the large amounts of irrigation-water infiltration, salt accumulation is not a problem in most parts of the valley.

5. Water budgets for Smith Valley show about 160,000 acre-feet of water moving through the hydrologic system during 1972. Of this amount, about 46,000 acre-feet was consumed through irrigation of crops, and 101,000 acre-feet left the area as river outflow. About half the 93,000 acre-feet of water reaching the irrigated areas from both surface-water and ground-water sources was consumed. Gross pumpage in 1972 was 20,000 acre-feet. The net ground-water storage depletion for the year was 6,000 acre-feet.

6. The system yield is estimated to be 62,000 acre-feet. About 9,000 acre-feet per year of ground water and about 6,000 acre-feet per year of surface water remain to be developed in the Artesia Lake area. Additionally, about 4,000 acre-feet of the annual flow in Desert Creek could be utilized more extensively, but such a development could reduce infiltration and ground-water recharge.

7. Local overdraft would occur if the spacing of irrigation wells is too close. Using 15 feet of interference from nearby wells as a reasonable limit, in areas where transmissivity is more than 50,000 gpd/ft, irrigation wells would have to be spaced more than 0.5 mile apart. For lower transmissivity values, if no other overdraft factors are operating, a 0.5-mile minimum spacing probably would be suitable.

8. The volume of water reaching the irrigated land in the conjunctive-use area would have to be about 90,000 acre-feet during near-normal years to enable the hydrologically ideal scheme of water-use to be followed.

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APPENDIX

Location Numbers 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. The location numbers consist of three units: The first is the township north of the base line; the second unit, separated from the first by a slant, is the range east of the meridian; the third unit, separated from the second by a dash, designates the section number. The section number is followed by letters that indicate the quarter section and quarter-quarter section; the letters a, b, c, and d designate the northeast, northwest, southwest, and southeast quarters, respectively. For example, well 10/23-1cb is in the NW¼SW¼ sec. 1, T. 10 N., R. 23 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.

Township and range numbers are shown along the margins of plates 1 and 2.

Tables of Basic Data

The following tables contain data on streamflow, flow in canals, well data, and results of chemical analyses of water samples. Table 23 lists periodic discharge measurements made during the period 1970-72 on eight streams. Tables 24 compares flume and current-meter measurements of flow in four canals. Table 25 contains selected data for all irrigation wells and a few stock and domestic wells. Table 26 contains 48 chemical analyses, most of which are for samples from irrigation wells. No well logs are included in the report because the Nevada Division of Water Resources (Carson City) has an extensive file, open to the public.

Table 23.--*Periodic streamflow measurements*

Stream	Location	Drainage area (sq mi)	Date	Discharge (cfs)
Dalzell Canyon 1/	9/24-14cd	89.4	10-26-70	0.06
			3-16-71	.03
			5- 5-71	.06
			6-12-71	.06
			7-27-71	.05
			4-24-72	.04
			9-15-72	.05
Sheep Creek	8/24-35 (unsurveyed)	1.78	10-26-70	0.30
			5- 5-71	.55
			6-12-71	1.22
			4-24-72	.39
			9-15-72	.25
Desert Creek	9/24-8cc	50.4	3-15-71	2.63
			4- 6-71	5.90
			5- 5-71	7.29
			5-13-71	14.0
			6-12-71	41.3
			7-30-71	15.1
			4-24-72	6.89
			9-15-72	3.84
			11-30-72	1.53
			2- 8-73	3.38
			7-23-73	22.5
Spring Gulch	10/23-15bd	3.04	10-26-70	0.16
			3-15-71	.25
			5- 5-71	.16
			6-12-71	.20
			7-27-71	.14
			4-24-72	.21
Burbank Canyon	11/23-9bd	4.24	10-27-70	0.15
			3-15-71	.46
			5- 5-71	.51
			6-12-71	5.21
			7-30-71	.22
			4-24-72	.23
			9-15-72	.06
Red Canyon	11/23-5ac	10.7	10-27-70	0.18
			3-15-71	1.44
			5- 5-71	2.18
			6-12-71	4.15
			7-30-71	.85
			4-24-72	1.33
			9-15-72	.76
Pipeline Canyon	12/23-29bc	3.10	10-27-70	0.19
			3-15-71	.28
			5- 5-71	.30
			6-12-71	.77
			7-30-71	.12
			4-24-72	.31
			9-15-72	.15

1. Fed by nearby spring flow.

Table 24.--*Accuracy of canal-flow data based on flume ratings, as determined by current-meter measurements*

Diversion	Date	Flume gage-height (feet)	Discharge (cfs) Flume	Discharge (cfs) Current meter	Remarks
Saroni Canal (two 6-ft Parshall flumes)	8-23-72	1.14	59.2	54.1	
	10-26-72	.24	4.92	4.29	
	9- 4-73	1.22	65.9	62.2	
Plymouth Canal (one 8-ft Parshall flume)	9-21-72	0.85	24.6	25.4	
Colony Ditch (two 6-ft Parshall flumes)	9-21-72	0.35	9.00	9.82	Light algae growth on flume.
	10-26-72	.60	21.2	21.9	
Gage Peterson ditch (one 4-ft Parshall flume)	10-26-72	0.32	2.65	3.11	Moss in upper end of flume.

Table 25.--Selected well data--Continued

Location	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) /drawdown (feet)	Land surface altitude (feet)	Static water level Date	Static water level Depth (feet)	Casing perforation interval (feet)	Used for irrigation in 1972	Remarks
12/23-36dc (south well)	Glen Smith	1960	508	12,10	I	1,500/--	4,780	1960	20 R	147-508	X	T=61°F(4-14-72)
								3-24-72	21.61			
								10-26-72	39.49			
								12-20-72	33.12			
								3-29-73	24.87			
12/24-4ba	BLM, Delphi well	1968	140	6	S	--	4,700	1968	82 R	115-130		Located 50 yds southeast of road intersection
-27da	BLM, Hudson well	--	--	--	S	--	5,000	8-22-72	277.50	--		In metal shed
-30dc	BLM	--	--	--	S	--	4,795	6- 9-72	133.70	--		Windmill
								10-31-72	76.11			
								3-29-73	60.44			
-31ba (north well)	Bill Walker	1968	540	14	I	1,500/--	4,800	1968	40 R	270-534	X	T=80.5°F(7-11-72). Water applied with sprinklers
								1-12-71	50			
								3-15-72	50			
								10-31-72	70.41			
								3-29-73	54.56			
12/24-31db	Dale Husboe	1971	587	14	I	1,700/63	4,810	1971	65 R	199-587	X	Water temperature reported as 72°F by driller. T=70°F (6-16-72). Water applied with sprinklers
								3-24-72	65.40			
								10-31-72	76.35			
								3-29-73	61.03			
13/23-25ca	Ambassador Gold Mining Co.	1932	155	14	I	400/--	4,590	8-23-72	flowing	--	X	Depth when drilled was 540 ft. Flowed 400 gpm in 1948 and 1973. T=80°F(8-23-72). H_2S smell
13/24-20bb	--	--	--	--	U(M)	--	4,730	8-22-72	81.93	--		In metal shed
-28bd	BLM	--	--	--	S	--	4,770	8-22-72	125.00	--		In metal shed
-30ac	Buckskin Ranch	--	--	--	I,D	--	4,615	8-23-72	flowing	--		Small flow supports native grass. T=65°F(8-23-72). H_2S smell. Located 15 ft northwest of house
14/24-31da	--	--	--	6	S	--	5,480	8-23-72	32.84	--		On concrete floor, 6 ft square. Another well in metal building 200 yds north