STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
Carson City

Northwest view of Carson City, Eagle Valley, and Sierra Nevada.

WATER RESOURCES – RECONNAISSANCE SERIES

REPORT 39

HYDROLOGIC APPRAISAL OF EAGLE VALLEY, ORMSBY COUNTY, NEVADA

By
G. F. Worts, Jr.
and
G. T. Malmberg

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

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HYDROLOGIC APPRAISAL OF EAGLE VALLEY, ORMSBY COUNTY, NEVADA

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SUMMARY

Eagle Valley is in western Nevada at the foot of the Sierra Nevada. Carson City, the State capital, is the principal city. The need for the study was brought about by the rapid population growth in the area and the concurrent need for information on the water supply. Population was nearly 15,000 in 1965 and has been increasing at a rate of about 1,000 per year. During the past 5 years, water use has been increasing at a rate of nearly 200 acre-feet per year, and in 1965 water use for public and rural supply was about 2,700 acre-feet.

Clear, Kings Canyon, and Ash Canyon Creeks, flowing from the Sierra Nevada, provide most of the water diverted for public supply and irrigation use as well as most of the ground-water recharge. Of the estimated total runoff of 13,000 acre-feet per year, about half flows to the Carson River. Of the remainder about 2,500 acre-feet in 1965 was diverted for use and about 4,000 acre-feet was consumed by natural water losses. Ground-water pumpage in 1965 was minor--about 450 acre-feet from four wells for public supply and 500 acre-feet from about 300 wells for rural use. Water is imported through the State-owned Marlette Water System for public supply, and in 1965 the import was about 425 acre-feet.

The estimated system yield of Eagle Valley, or the firm supply from both surface-water and ground-water sources, without surface-storage reservoirs and excluding imported water, is at least 10,000 acre-feet per year--roughly a potential of 3,000 acre-feet by diversions from springs and streams and 7,000 acre-feet by pumping. In 1965 about 85 percent of the spring and streamflow but less than 15 percent of ground-water supply had been developed for use. Based on projected population growth and water needs (Montgomery Engineers, 1965), the system yield estimated in this report if fully developed, would meet the needs of Eagle Valley until about 1980.

INTRODUCTION

Purpose and Scope of the Study and Report

This reconnaissance of the hydrology of Eagle Valley was undertaken by the U.S. Geological Survey in cooperation with the Nevada Department of Conservation and Natural Resources. The need for the study was brought about by the rapid population growth in the area and the concurrent need for water-resources information.

Eagle Valley is in western Nevada, about 30 miles south of Reno and 10 miles east of Lake Tahoe (1 mile west of pl. 1). The valley, bordered on the west by the precipitous Sierra Nevada, is well watered. Compared to most Nevada valleys, it is small, covering only about 71 square miles. Carson City, the State capital, is the principal community. Stewart, headquarters for the U.S. Bureau of Indian Affairs, Nevada Indian Agency, and New Empire are the other communities.

In 1965 the problems of water-resources development in Eagle Valley pertained principally to the present and future water supply of Carson City, the State-owned water system, the development of individual domestic supplies by rural home owners, natural waterlogging in the central and topographically low parts of the valley largely in and around Carson City, potential local contamination, and concern whether local ground-water and surface-water supplies were ample to meet all or part of the future needs by water users in the valley. One major problem has been the inability to develop many large-capacity wells throughout most of the valley lowlands.

As in many parts of the west, most of these water problems are brought about by the large influx of people and industry. The population of Eagle Valley has nearly tripled in the past decade, increasing from about 5,000 in 1955 to 14,500 in 1964 (Nevada Department of Economic Development, 1965). Similarly during the same period the population of Carson City has increased from about 3,500 to 10,300. The growth has resulted in replacement of much of the agricultural land by rural and urban development accompanied by a corresponding increase in the size of the incorporated limits of Carson City. Montgomery Engineers (1965) suggest that by the year 2000: the population of the valley will be 70,000; a large part of Eagle Valley will be within the city limits; and most of the agricultural land will be converted to housing and light industry.

Most of the water presently used is supplied from springs and streams in the Carson Range of the Sierra Nevada. Because most of the firm low-flow supply from these sources has been developed, additional water probably must be obtained from wells or imported from outside sources. In 1965 the total use in the valley was about 3,700 acre-feet. According to projections by

Montgomery Engineers (1965), the water requirements by the year 2000 may be more than 20,000 acre-feet per year.

Accordingly, the principal purpose of this report is to estimate the magnitude of the water supply of Eagle Valley so that those concerned with water management and development can use the information for future planning. Because only a few large-capacity wells have been successfully completed, an additional objective is to evaluate the water-bearing character of the valley fill with respect to possible future development of water supplies from this source.

To reach these objectives within the limitations of a hydrologic reconnaissance, this report (1) briefly discusses the controlling geologic features and environment as they relate to the water-bearing character of the ground-water reservoir, (2) estimates the several elements of inflow and outflow, (3) analyzes the system response to water development by use of water budgets, (4) discusses the quality of water, (5) estimates the system yield, and (6) discusses the principal water problems and possible sources of water supply.

This report is the 39th in the series of reconnaissance studies (fig. 1). The study of Eagle Valley was begun in September 1963 and was worked on intermittently through December 1965. The bulk of the field work was done during the summer 1964 and spring 1965. John Welsh and Otis Purkiss, U.S. Geological Survey, canvassed wells and collected well data for this study.

Acknowledgments

The authors wish to acknowledge the water information provided by R. H. Shriver, Manager, Carson Water Co.; W. F. Gulley, Northern Division Manager, Southwest Gas Corp. (owner of Carson Water Co.); R. T. Kruse, former Administrator, R. R. Jenkins, Administrator, and R. T. Lane, Chief Assistant, Nevada Division of Buildings and Grounds; W. J. Dunn, Plant Superintendent, Carson City Sewage Treatment Plant; and A. W. Saxton, Plant Superintendent, Nevada Indian Agency, Stewart.

Information provided by the many private well owners and ranchers and their permission to measure wells and do other necessary field work are greatly appreciated.

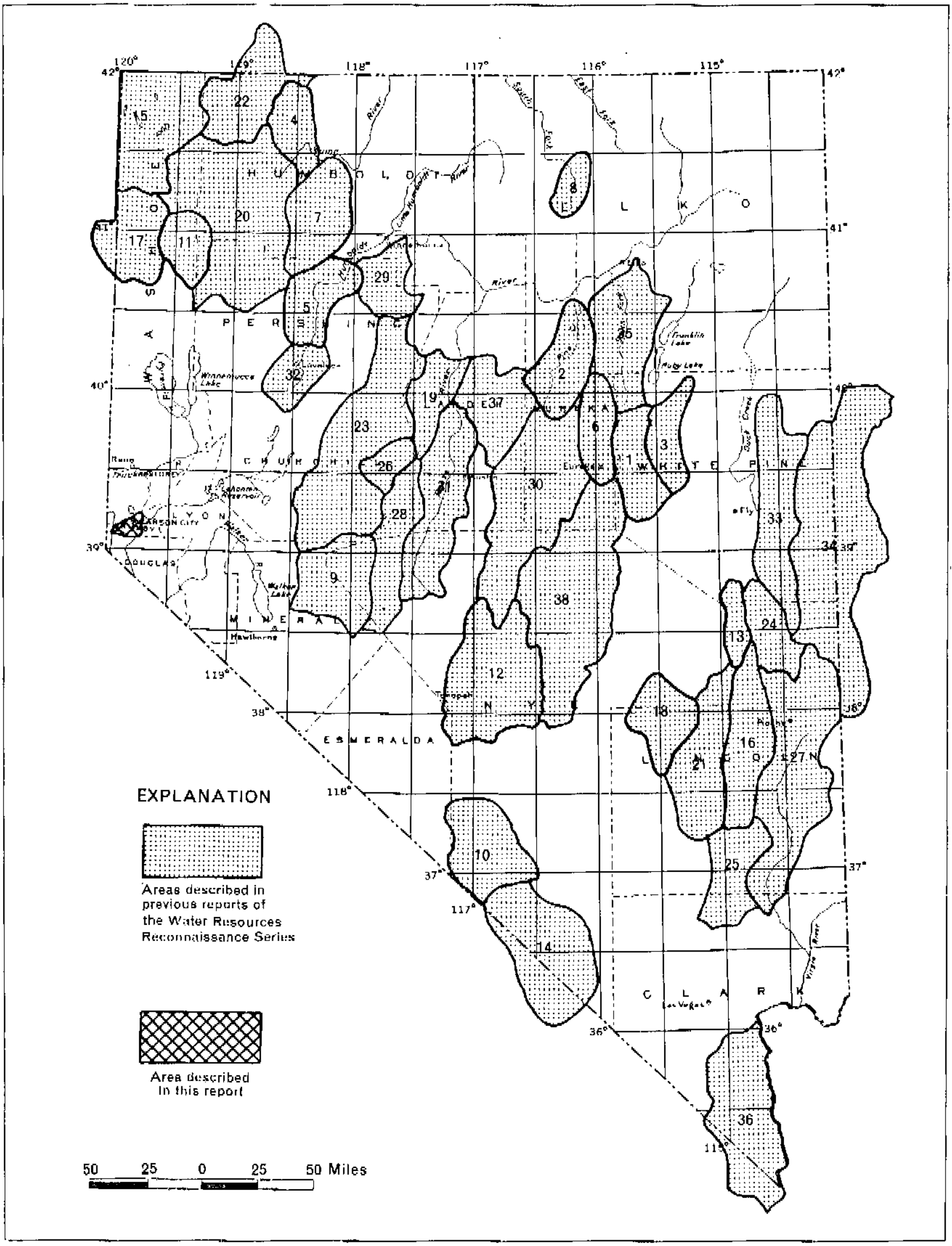

Figure 1.—Index map showing areas in Nevada described in previous reports of the Water Resources Reconnaissance Series and the area described in this report

HYDROLOGIC ENVIRONMENT

Landforms

Eagle Valley is bordered on the west by the spectacular, pine-covered Carson Range of the Sierra Nevada, which rises to an altitude of more than 9,000 feet (pl. 1). To the north the valley is bordered by the barren Virginia Range, which rises to an altitude of 7,000 feet, and to the southeast by the sage-covered Prison Hill, which rises to 5,700 feet. The southern end of the valley is separated from Carson Valley by a low alluvial divide near Stewart.

The valley floor slopes eastward, and the streams rising in the Sierra Nevada cross it to discharge into the Carson River, about 3 miles east of Carson City (pl. 1). Clear Creek flows across the south end of Eagle Valley, then turns southeastward and flows across the north end of Carson Valley before discharging into the Carson River. The creek is a part of the hydrologic systems of both valleys.

Altitude of the valley floor ranges from 4,600 feet at the valley outlet, about half a mile east of the sewage disposal plant, to about 4,800 feet along the foot of the Sierra Nevada. The area covered by the lowlands is about 20 square miles; the surrounding mountains cover about 50 square miles.

Geologic Units and Structural Features

Geologic units shown on plate 1 are a simplified version of the preliminary geologic map prepared by Moore (1961). One major modification is in the classification of the type and distribution of the valley-fill deposits, which form the principal ground-water reservoir in Eagle Valley and along the Carson River to the east. Table 1 shows the age, stratigraphic relation, thickness, general character, and water-bearing properties of the geologic units.

The principal structural features that are pertinent to the occurrence and flow of ground water in the valley fill include the north-trending arcuate fault through Carson City and along the west side of the airport; the outcrops of metamorphic rocks at Lone Mountain and to the east; and the faults of small extent north of the State Prison and west of Carson City (pl. 1). The fault through Carson City has been active in recent time, because it has offset all but the most recent stream-laid deposits. The streams flowing from Kings and Ash Canyons have modified the escarpment, which is about 50 feet high at the south edge of town and 25 to 40 feet high elsewhere. The fault may control the occurrence of Carson Hot Springs.

Table 1.--Geologic units of Eagle Valley

Geologic age		Geologic unit		Thickness (feet)	General character and extent	Water-bearing properties
Quaternary	Recent and Pleistocene	Valley fill	Younger alluvium	0- 50±	Unconsolidated lenses of gravel, sand, silt, and clay comprising stream-channel and alluvial-fan deposits; composed mostly of granitic and metamorphic detritus from the Sierra Nevada; granitic outwash commonly is decomposed.	Yields water to domestic and stock wells; where decomposed, well yields are small.
						The younger and older alluvium together form the valley-fill reservoir, the principal source of water for wells in Eagle Valley.
	Pleistocene		Older alluvium	0-500±	Semiconsolidated to unconsolidated lenses of gravel, sand, silt, and clay exposed largely around margins of valley and buried at shallow depth beneath younger alluvium. Composed mostly of granitic and metamorphic detritus from the Sierra Nevada; granitic debris commonly is decomposed.	Most wells more than 50 feet deep obtain supply from older alluvium; yields range from 50 gpm in small wells to 1,000 gpm in a few large-diameter deep wells.

Table 1.--Geologic units of Eagle Valley--continued

	Geologic age	Geologic unit	Thickness (feet)	General Character and extent	Water-bearing properties
Tertiary	Pliocene and Miocene	Sedimentary rocks	--	Principally lacustrine and fluviatile sandstone, mudstone, shale, marl, and limestone; interbedded with volcanic rocks. Exposed locally near State Prison. Sandstone used to construct prison, State Capitol building, and museum.	Probably would yield very little water to wells.
Tertiary	Pliocene, Miocene, and Oligocene(?)	Volcanic rocks	--	Basalt, andesite, dacite, rhyolite, and rhyolite tuff. Exposed principally in the Virginia Range and locally in the Sierra Nevada (andesite). Probably underlie older alluvium in northeast part of the valley.	Not tapped by wells. Scoriaceous beds and interflow zones probably would be good aquifers where saturated.

Table 1.--Geologic units of Eagle Valley--continued

	Geologic age	Geologic unit	Thickness (feet)	General character and extent	Water-bearing properties
Cretaceous	--	Granitic rocks	--	Granodiorite and quartz monzonite; exposed principally in the Sierra Nevada and western part of the Virginia Range. Probably underlie older alluvium in northwestern and southern parts of the valley. Decomposes to form residuum 10 to 20 feet thick.	Not tapped by wells; residuum where thick and saturated would provide sufficient water for domestic and stock use; supplies water to springs in mountains.
Triassic and Jurassic	--	Metavolcanic and metasedimentary rocks	--	Metamorphosed andesite breccia, tuff, and flows; basalt and rhyolite; shale, slate, and sandstone. Exposed in the Sierra Nevada and Prison Hill; probably underlie older alluvium in the central part of the valley.	Not tapped by wells; probably would not yield much water to wells. Detritus from Kings Canyon area should form alluvium of moderate permeability; supplies water to springs in mountains.

Climate

The climate of Eagle Valley is characterized by long moderately cold winters and short warm summers. Figure 2 shows the monthly temperature distribution at Carson City. During January and sometimes from December to March, the ground freezes to a depth of 6 inches to a foot. Below freezing average minimum temperatures occur in 5 months of the year. The average frost-free period is 119 days, from May 23 to September 20; however, the recorded minimum is only 62 days, from June 20 to August 21, 1924. Temperature extremes are: highest, 105°F July 20, 1931; lowest, -23°F January 21, 1937.

Figure 3 shows the monthly precipitation distribution at Carson City. Most of the precipitation occurs in the period November to April; in December to February it falls largely as snow. Cyclonic storms moving inland from the Pacific Ocean account for virtually all the winter precipitation. Thunderstorms account for most of the summer precipitation. During the past 90 years at Carson City, annual precipitation has ranged from about 3.5 inches in 1947 to about 24 inches in 1950 and has averaged about 11 inches.

The relative humidity commonly is low in the summer and moderate in the winter.

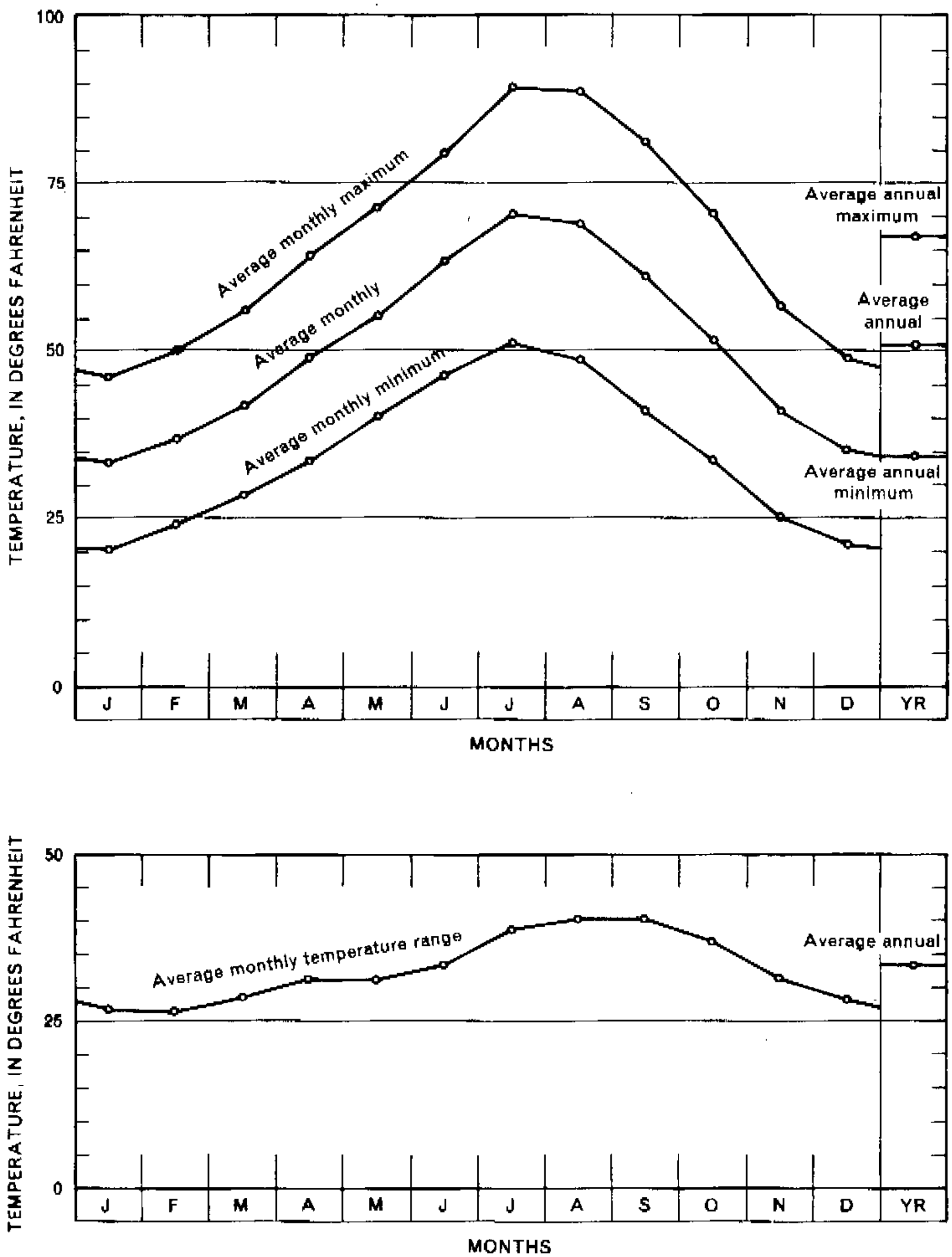

Figure 2.—Temperature data at Carson City, 1926-61 (Records from Nevada Highway Dept.)

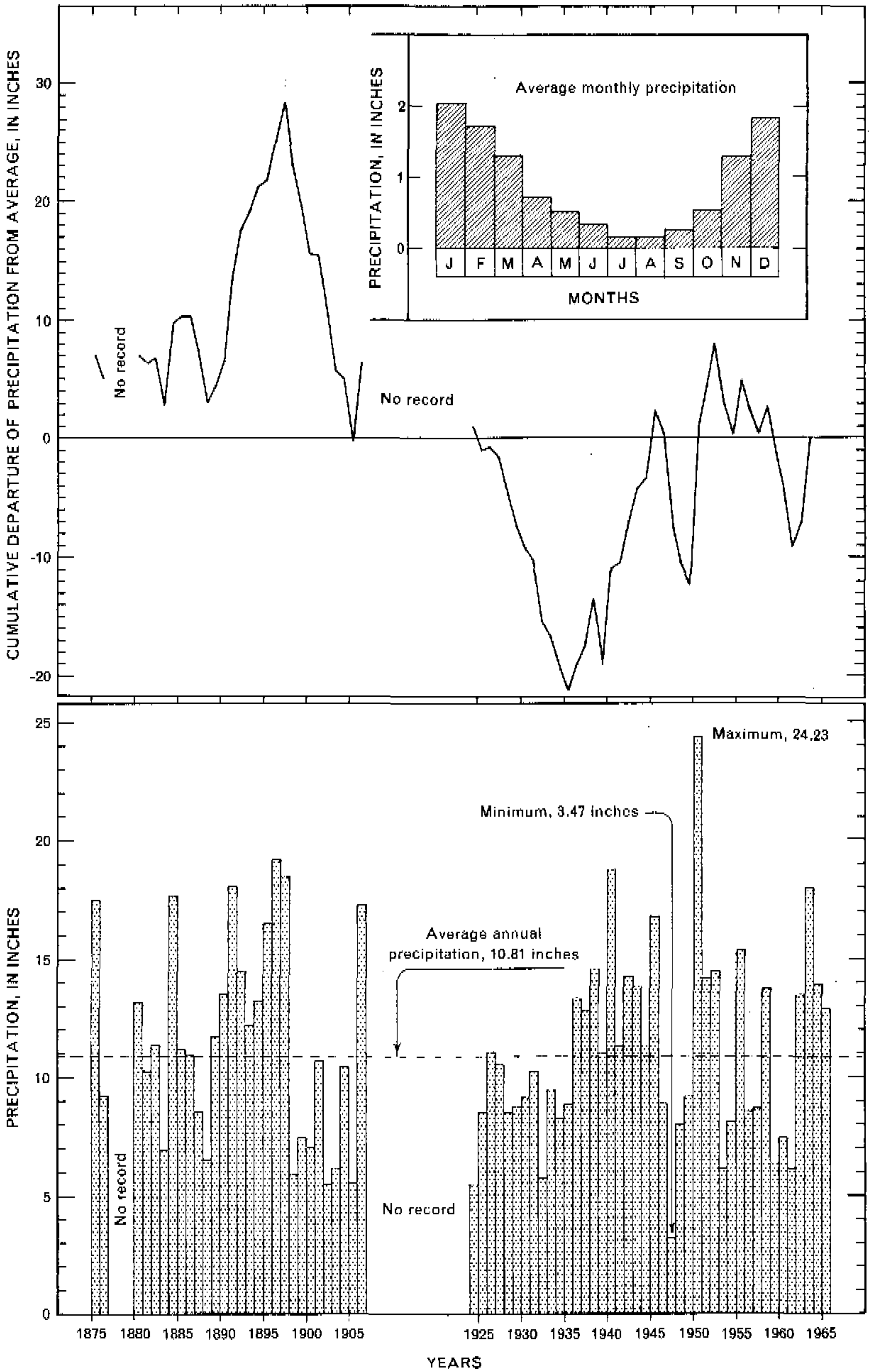

Figure 3.—Precipitation data at *Carson City*, 1875-65 (Records from Nevada Highway Dept.)

VALLEY-FILL RESERVOIR

Extent and Boundaries

The younger and older alluvium form the valley-fill reservoir, which contains the principal ground-water supply in Eagle Valley. It is about 6 miles long, 3 to 5 miles wide, and underlies an area of about 13,000 acres. The reservoir in most places is not much more than 500 feet thick, which is considerably less than that in most alluvial basins in Nevada. Although bedrock reportedly has been encountered in many places at depths of 300 to 400 feet, several wells have been drilled to depths of 600 feet without penetrating the entire thickness of the older alluvium. However, the deeper deposits in the eastern part of the valley are largely fine-grained.

The external hydraulic boundaries of the reservoir are formed by the older rocks (table 1 and pl. 1), all of which are leaky to varying degrees. The volcanic rocks, particularly the basalt and scoria in the Virginia Range, may contribute some water to the valley-fill reservoir by subsurface flow. Similarly, weathered granitic rocks and the joints and fractures in the granitic and metamorphic rocks in the Carson Range probably contribute moderate amounts of water to the valley-fill reservoir.

A natural ground-water divide near Stewart, shown by the water-level contours on figure 4, is the hydrologic separation between ground water moving northward to discharge areas east of Carson City and ground water moving southeastward along Clear Creek. East of New Empire, the valley-fill reservoir drains eastward into the younger alluvium deposited by the Carson River. The divide symbol shown on plate 1 is dashed in this reach and merely shows the eastern limit of the study area, not a hydrologic divide.

Within Eagle Valley local recharge boundaries are formed by the live-stream segments of Clear, Ash Canyon, and Kings Canyon Creeks where they flow across the valley floor. Clear Creek commonly flows across the valley-fill reservoir all year, whereas the flow in Ash Canyon and Kings Canyon Creeks usually crosses only in the winter and spring.

The one principal internal hydraulic boundary is the fault passing northward through Carson City. Minor faults cutting the valley-fill reservoir also may form hydraulic barriers to ground-water flow. When substantial ground-water development occurs, it may be possible to evaluate the effectiveness of these barriers.

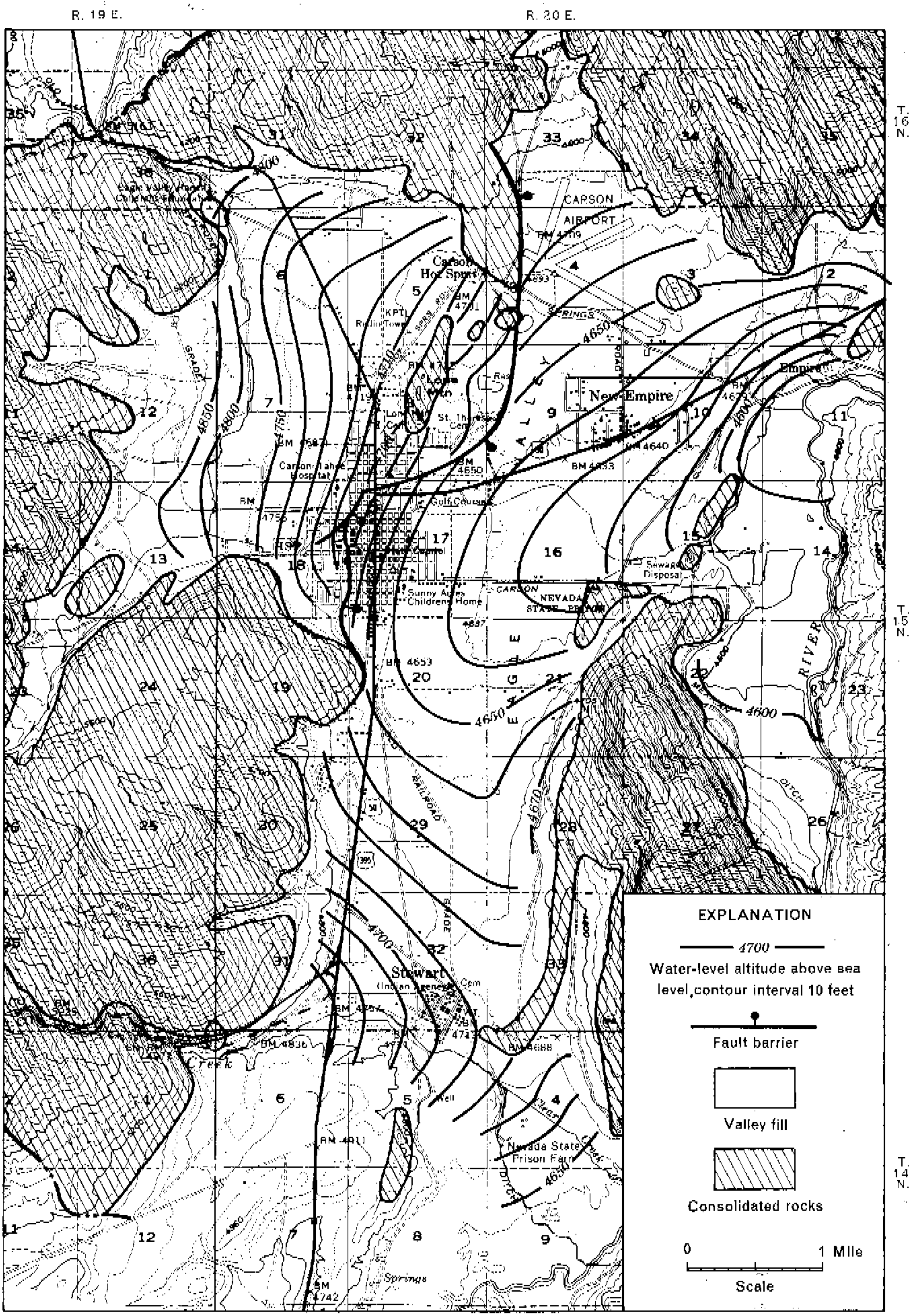

Figure 4.—Approximate water-level altitude in 1964

Transmissibility and Storage Coefficients

The coefficient of transmissibility is a measure of the rate of ground-water flow in an aquifer or underground reservoir system. The coefficient of storage for a heterogeneous valley-fill reservoir is a measure of the amount of water that would drain from the deposits as water levels are drawn down by pumping. When utilized together in mathematical models or simulated in electrical models, the two coefficients define the hydraulic diffusivity of the system; or in simpler terms, the two coefficients can be used to describe the distribution and amount of water-level change that would result under certain or selected pumping and boundary conditions.

The transmissibility of the valley-fill reservoir in Eagle Valley has not been determined directly. However, a few widely-scattered wells, more than 300 feet deep, have specific capacities ranging from 10 to 30 gpm per foot (gallons per minute per foot of drawdown), suggesting coefficients of transmissibility of 20,000 to 50,000 gpd (gallons per day) per foot (approximated by use of a form of the Thiem (1906) formula). On the other hand, many wells 200 feet deep or less have been drilled in the valley, and most reportedly have small yields (table 13), suggesting that the upper part of the valley fill has a low transmissibility.

The small yields of several deep wells drilled in the valley might be construed to indicate locally low transmissibilities (table 13). It more likely indicates difficulty in obtaining full development from sand lenses which form the principal aquifers.

The coefficient of storage, which over the long term is considered to be nearly equal to the specific yield, of the valley fill is computed from well logs to average about 0.15, or about equivalent to a specific yield of 15 percent. (See section on ground water in storage.) The valley fill is composed of lenticular beds composed of mixtures of gravel, sand, silt, and clay. Clay lenses act as semiconfining beds. As a result, flowing wells are obtained over an area of several square miles principally in the northwestern part of the valley (fig. 5). However, under long-term pumping stress, wells would cease flowing and all these deposits would drain slowly.

Depth to Water

Figure 5 shows the approximate depth to water below the land surface in Eagle Valley in 1964. Except along the west and north sides of the valley, where the alluvial fans rise steeply to the mountains, the depth to water generally is less than 20 feet; beneath most of Carson City it is less than 5 feet, and locally it is at or very close to land surface. The depth to water actually varies seasonally and from year to year at any one place. Thus, depth to water shown on figure 5 is a general representation.

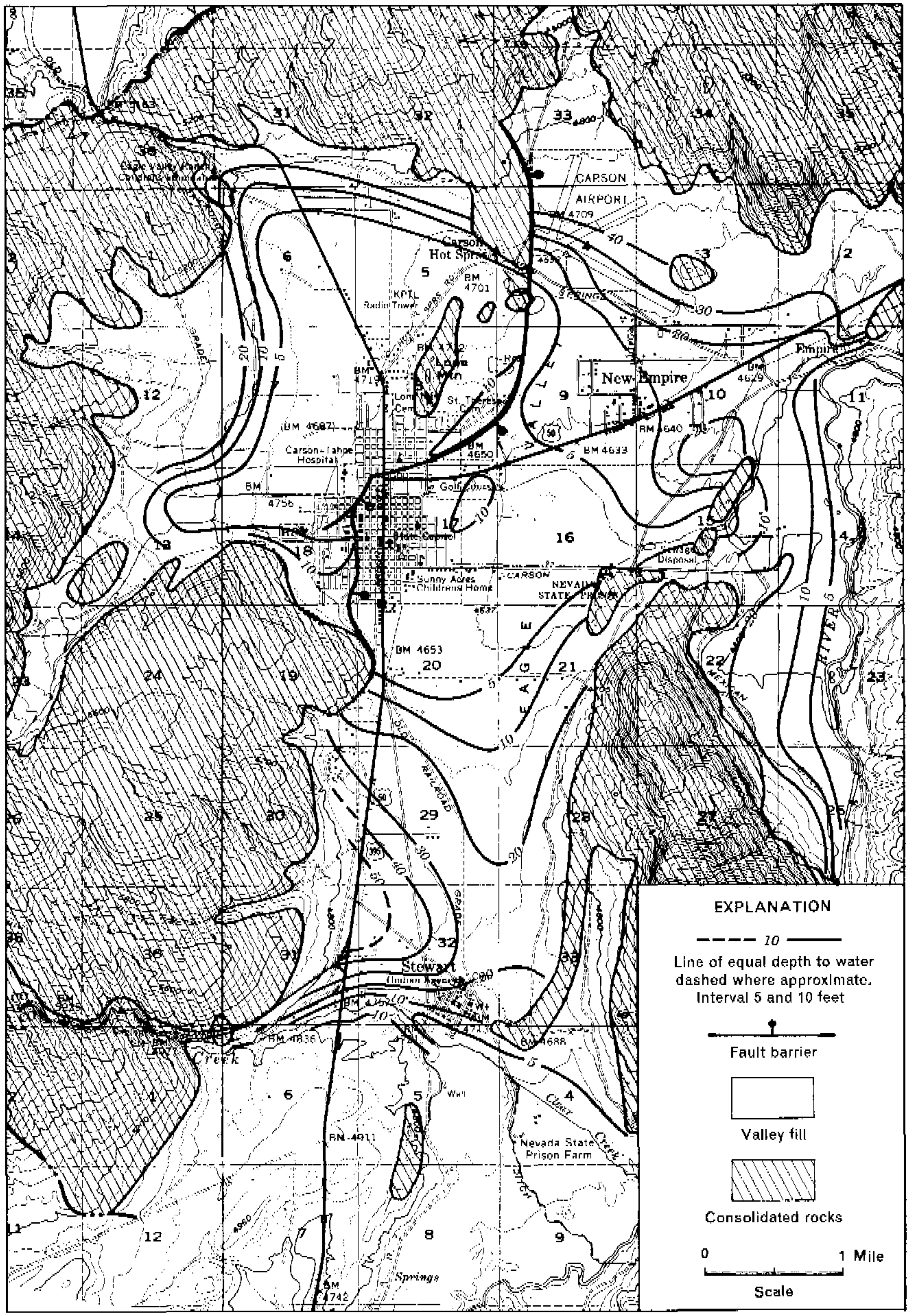

Figure 5.—Approximate depth to water in 1964

Ground Water in Storage

The amount of recoverable ground water stored, or more precisely in transient storage, in the valley-fill reservoir to any selected depth below the water surface is the product of the area, the selected depth, and the specific yield of the deposits. The selected depth for this study is the uppermost 100 feet of saturation below the 1964 water levels (figs. 4 and 5).

The specific yield of a deposit with respect to water is the ratio of (1) the volume of water which, after being saturated, the deposit will yield by gravity to (2) its own volume, commonly expressed as a percentage (Meinzer, 1923). The average specific yield of the materials in the upper 100 feet of saturation was estimated from drillers' logs of 43 representative wells to about 15 percent. The method used to estimate specific yield was described by Davis and others (1959, p. 202-206).

Using the surface area of the valley-fill reservoir, the estimated recoverable ground water in storage is the area of about 13,000 acres times the selected depth of 100 feet times the drainable volume of 15 percent, which is about 200,000 acre-feet. Because the depth to water beneath most of the valley is 20 feet or less (fig. 5), nearly all this water occurs within 120 feet of land surface.

Ground-Water Flow

Ground-water flow in the valley-fill reservoir is from the areas of recharge toward areas of discharge. The water-level contours on figure 4 show the general configuration of the ground-water surface in 1964. The direction of ground-water flow is at right angles to the contours and from higher to lower levels. This two-dimensional expression of flow does not show the downward component of flow in areas of recharge and the upward component of flow in areas of discharge, such as in the areas of evapotranspiration (fig. 7). This concept of near-vertical flow in the intake and discharge areas of a ground-water reservoir was described by Meinzer (1923) and recently in Nevada by Cohen (1964, figs. 17 and 18) in the Humboldt River Interagency Research project.

The water-level contours in figure 4 show that in the northern half of the valley ground water is moving generally eastward from the foot of the Sierra Nevada to the Carson River; in the south-central part of the valley, movement is generally northward, then eastward toward the river. South of the ground-water divide, near Stewart, water is moving southeastward into Carson Valley, then to the Carson River.

The Nonequilibrium Condition

As a result of man's activities in Eagle Valley, the water-level contours in figure 4 presumably have changed position somewhat from natural conditions. Man has diverted the flow principally from Vicee Canyon, Ash Canyon, Kings Canyon, and Clear Creeks for irrigation and public supply. Spreading water on fields around Carson City has resulted in slightly higher heads in the ground-water reservoir than originally existed, pumpage through 1965 has been small but has caused local water-level declines, and the surface-water outflow has been reduced.

As man continues to modify the flow system to meet his needs, the imposed stress causes changes in the magnitude of the flow components. Thus, the changes, though minor through 1965, are continuing and have resulted in a nonequilibrium condition.

INFLOW TO THE VALLEY-FILL RESERVOIR

Inflow to the valley-fill reservoir is estimated by reconnaissance techniques developed by the Geological Survey in cooperation with the Nevada Department of Conservation and Natural Resources. The valley-fill reservoir receives inflow from streams, imported water, precipitation on the valley floor, and secondary inflow by return flow to ground water from irrigation of crops and lawns and infiltration of sewage effluent from rural disposal systems. The magnitude of the return flow is discussed in the sections on diversions for irrigation, pumpage, and water use by Carson City.

Precipitation

Distribution and Amount

Precipitation is the source of virtually all water entering the hydrologic system of Eagle Valley. Hardman (1936) established the gross relation between precipitation and altitude in Nevada. For Eagle Valley the two curves in figure 6 show the general relation between altitude and precipitation. Based on these two curves and the computed areas involved, the estimated average annual precipitation is nearly 60,000 acre-feet, of which about 13,000 acre-feet falls on the valley-fill reservoir (table 2).

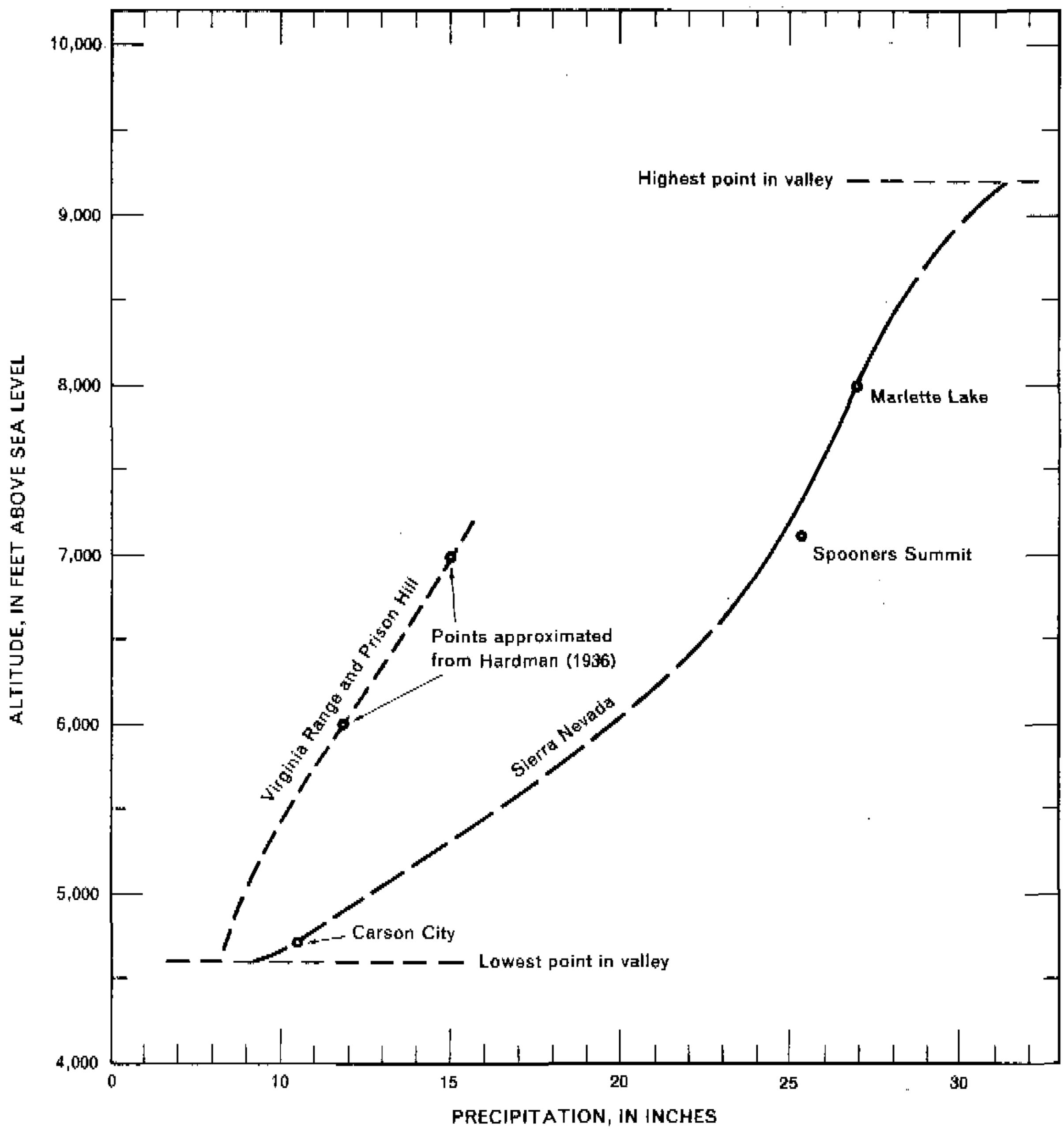

Figure 6.—Relation between precipitation and altitude

Ground-Water Recharge

Ground-water recharge to the valley-fill reservoir is principally by seepage loss from streams; some occurs by subsurface flow across the bedrock-alluvial contact, which forms the leaky external hydraulic boundary of the reservoir, and a minor amount occurs by direct infiltration of precipitation on the valley floor. Eakin and others (1951) devised a method of estimating total recharge, or potential recharge, to a ground-water reservoir by all the above processes, based on the relation between precipitation and altitude and an empirical relation between this calculated precipitation and recharge. The method is used in this report principally to obtain an approximation of total potential recharge. The term potential recharge is used because about 50 percent of the runoff reaching the valley floor is rejected as recharge as it flows across the saturated deposits and out of the area (table 4).

Table 2 shows the several values used to estimate the precipitation and potential recharge in Eagle Valley. The estimated recharge of 8,700 acre-feet per year is about 15 percent of the estimated total precipitation of 58,000 acre-feet per year. This percentage is about three times the amount usually obtained by this method for the desert basins of Nevada, and is accounted for by the unusually large precipitation in the Sierra Nevada, which is one of the wettest areas in the State. As computed from the table, more than 95 percent of the estimated recharge is from the Sierra Nevada.

Table 2.--Estimated average annual precipitation and potential ground-water recharge

Precipitation zone (feet)	Area (acres)	Estimated precipitation			Estimated recharge	
		Range (inches)	Average (feet)	Average (acre-feet)	Percentage of precipitation	(acre-feet per year)
Carson Range of the Sierra Nevada						
9,000 - 9,200	100	>30	2.6	260	25	6,800
8,000 - 9,000	2,900	27 - 30	2.4	7,000		
7,000 - 8,000	4,600	25 - 27	2.2	10,000		
6,000 - 7,000	5,500	20 - 25	1.9	10,000		
5,000 - 6,000	10,000	12 - 20	1.3	13,000	10	1,300
4,600 - 5,000	a16,100	8 - 12	.8	13,000	3	400
Subtotal (rounded)	39,200			53,000		8,500
Virginia Range and Prison Hill						
6,000 - 7,000	980	12 - 15	1.1	1,100	7	80
5,000 - 6,000	5,200	8 - 12	.8	4,200	3	130
Subtotal (rounded)	6,180			5,300		200
Total (rounded)	45,400			58,000		8,700

a. Largely the valley floor and in small part the foothills.

That part of the total recharge that occurs by subsurface flow across the bedrock-alluvial contact can not be estimated directly with the data and techniques now available. In other areas of Nevada where more detailed studies have been made, the subsurface inflow has been estimated by indirect methods to range between 5 and 20 percent of the total recharge. Accordingly, for this area where the consolidated rocks are deeply weathered and fractured, particularly along the Sierra Nevada front, the inflow may be 10 to 15 percent of the estimated total recharge of 8,700 acre-feet, or about 1,000 acre-feet per year. This is equivalent to a continuous flow of somewhat less than 100 gallons per minute per mile along the base of the Sierra Nevada.

Runoff

By D. O. Moore and J. E. Parkes

Most of the runoff in Eagle Valley is in Clear, Kings Canyon, and Ash Canyon Creeks, all of which drain the eastern slope of the Carson Range of the Sierra Nevada. A gaging station was maintained on Clear Creek during the years 1948-62, and its location is shown on plate 1. The average annual discharge for the 14-year period of record was 3,920 acre-feet (U.S. Geol. Survey, 1962). In 1964 periodic measurements of streamflow were made on Clear, Kings Canyon, and Ash Canyon Creeks to provide a basis for estimating annual runoff. The measurements are shown in table 3; the measuring sites are shown on plate 1.

The natural surface-water inflow to the valley floor has been estimated by a method described by Eakin, Moore, and Everett (1965), Lamke and Moore (1965), and Riggs and Moore (1965). For Eagle Valley, the record for Clear Creek was used as a guide for correlating the annual flow in the remaining ungaged streams. The periodic measurements in 1964 for Kings Canyon and Ash Canyon Creeks also provided a basis for synthesizing the annual runoff. Table 4 shows the estimated surface-water inflow to the valley floor. Also shown is the estimated surface-water outflow at the two valley outlets: Clear Creek near Stewart and Kings Canyon and Ash Canyon Creeks combined, about half a mile east of the sewage disposal plant.

The difference between the estimated surface-water inflow and outflow of 6,500 acre-feet is the seepage losses and diversions. Most of the diversions on or near the valley floor are for irrigation: near Stewart from Clear Creek and west of Carson City from Kings Canyon and Ash Canyon Creeks.

Table 3.--Miscellaneous streamflow measurements, 1964

Date	Streamflow, in cubic-feet per second[1]		
	Clear Creek	Kings Canyon	Ash Canyon
May 1	5.21	0.92	3.29
June 19	3.05	1.34	3.45
July 24	1.84	1.52	2.17
Aug. 25	1.50	1.26	1.48
Sept. 22	2.09	1.25	1.77
Nov. 23	2.89	1.09	1.95

1. Some diversions upstream from measuring sites not included.

Table 4.--Estimated average annual runoff

	Runoff (acre-feet)
INFLOW:	
Sierra Nevada	12,600
Virginia Range	500
Prison Hill	400
Total (rounded) (1)	13,000
OUTFLOW	
Clear Creek, near Stewart	a 3,000
Kings Canyon and Ash Canyon Creeks, east of sewage disposal plant	b 3,500
Total (2)	6,500
STREAM LOSS: (1) - (2)	6,500

a. Includes about 70 acre-feet per year of sewage effluent from Nevada Indian Agency at Stewart.

b. Excludes effluent from Carson City sewage plant.

Imported Water

The State Capitol and associated office buildings form a complex in the south-central part of Carson City. To assure a supply for State use, the Legislature in 1963 purchased the Marlette Water System and attendant water rights and structures. This system originally was developed in 1873-76 to supply Virginia City, Gold Hill, and Silver City at the peak of the gold and silver mining industry. Marlette Lake is west of the divide in the Sierra Nevada (pl. 1) and drains naturally to Lake Tahoe (west of pl. 1). By use of a dam, flumes, and a tunnel the water in the past was conveyed from Marlette Lake to Hobart Creek Reservoir, which is in Washoe Valley, then across the north edge of Eagle Valley at Lakeview through an inverted siphon (pl. 1) to Virginia City. The tunnel has caved, and the supply from Marlette Lake (potential of about 2,000 acre-feet per year) no longer supplies the water system. Near the intake point of the siphon, a line was laid into Carson City to supply the State buildings. Over the years, some of the water has been purchased by the Carson Water Company for use by Carson City. The imports are shown in table 5.

Table 5.--Water imported from Marlette Water System 1962-65

(Records from Nevada Division of Buildings and Grounds and Carson Water Co.)

Year	Purchased by Carson Water Co. (acre-feet)	Used by State (acre-feet)	Total (acre-feet)
1962	230	190	420
1963	140	150	290
1964[a/]	260	165	425
1965[a/]	135	290	425

a. Diversions to Virginia City were about 170 acre-feet in 1964 and 150 acre-feet in 1965. Total water supplied by Marlette Water System: about 600 acre-feet in 1964 and 575 acre-feet in 1965.

OUTFLOW FROM THE VALLEY-FILL RESERVOIR

The major components of outflow are surface-water outflow along the eastern side of the valley and evapotranspiration from ground water in areas of phreatophytes. The remaining components include subsurface outflow, consumptive use from diversions for irrigation and public supply, sewage effluent, pumpage, and spring discharge. In 1965, the estimated total outflow averaged about 5,000 acre-feet; under natural conditions the total was somewhat less (table 11).

Surface Water

Outflow from the Valley

Table 4 shows that in recent years the estimated surface-water outflow from Eagle Valley, through Clear Creek and the combined channel of the creeks formed principally by Kings, Ash, and Vicee Canyons west of the sewage disposal plant, averaged about 6,500 acre-feet per year. This estimated outflow does not include the sewage effluent, which discharges into the creek near the valley outlet (pl. 1).

Diversions for Public Supply

Table 6 shows the approximate diversions for use by Carson Water Company, State of Nevada, and Nevada Indian Agency at Stewart. In recent years, all the water diverted by the Nevada Indian Agency has been used to irrigate lawns and shrubs at the Agency headquarters.

Table 6.--Approximate stream and spring diversions for public supply

(Records from Carson Water Co., Nevada Division of Buildings and Grounds, and Nevada Indian Agency)

Year	Carson Water Company 1/ (acre-feet)	State of Nevada 2/ (acre-feet)	Nevada Indian Agency 3/ (acre-feet)	Total (acre-feet)
1962	700	150	50	900
1963	700	150	50	900
1964	900	150	50	1,100
1965	1,100	150	50	1,300

1. Diversions principally from Kings Canyon and Ash Canyon Creeks.

2. Diversions principally from Upper and Lower Rose Springs in Vicee Canyon.

3. Diversion from Clear Creek, about 10 feet downstream from site of U. S. Geological Survey Clear Creek gage. Agency has rights to divert additional water farther downstream, near U.S. Highway 395.

Diversions for Irrigation

Diversions principally from Clear, Kings Canyon, and Ash Canyon Creeks are used by the local ranchers to irrigate lands west of Carson City and near Stewart. In 1965 for about 700 acres of land, the diversions may have been 1,000 acre-feet. Most of the land is native pasture. Of the estimated diversions, possibly 300 acre-feet was lost from conveyance ditches and in areas where the water table was more than a few feet below land surface. The bulk of the water lost by these processes seeped downward to the ground-water system.

Beneath about 600 of the 700 acres of irrigated land, and including about 100 acres of trees, the water table was high during the spring and early summer, and an estimated 600 acre-feet of ground water was consumed by subirrigation (table 8). Thus, the consumptive use totaled about 1,300 acre-feet, 700 being derived from surface-water diversions and 600 from ground water.

As land use has changed from rural to urban, the amount of water diverted for irrigation has been slowly decreasing. Moreover, the amount can be expected to decrease at a faster rate in the future as the urbanized area expands more rapidly into the agricultural lands.

Seepage Loss from Streams

A preliminary estimate of the seepage from streams, or recharge to ground water, in Eagle Valley in recent years is suggested by the difference between the stream loss within the valley, estimated to average 6,500 acre-feet per year (table 4), and the diversions for irrigation (above) and public supply (table 6) for the years 1962-65, estimated to average about 2,000 acre-feet per year, which is about 4,500 acre-feet per year. The bulk of the seepage loss occurs along the western side of the valley as the streams cross the alluvial fans where the depth to water generally is in excess of 10 feet (fig. 5).

Pumpage

The Carson Water Co., State of Nevada, and Nevada Indian Agency have wells to supplement the locally derived and imported surface-water supplies. In 1965 the water company used three wells, 15/19-12da (acquired in 1965), 15/20-8bb, and 15/20-17bd; the State did not use its only well 15/20-17cl; and the Indian Agency used well 15/20-32dd1 but not its standby well 15/20-32dd2 (table 13 and pl. 1). The estimated pumpage by these agencies and by private wells (rural use) is shown in table 7.

Much of the valley is served by private wells. The domestic and stock-water use in the outlying areas is estimated to have increased from about 150 acre-feet in 1955 for a rural population of almost 1,500 to about 500 acre-feet in 1965 for a rural population of nearly 5,000.

Table 7.--Estimated pumpage, in acre-feet, for public supply and rural use

(Information from Carson Water Co., Nevada Division of Buildings and Grounds, Nevada Indian Agency, and Carson City Chamber of Commerce)

Year	Rural use	Carson Water Company[1]	Nevada Indian Agency[1]	State of Nevada[1]	Total (rounded)
1962	400	300	100	20	800
1963	400	300	100	20	800
1964	400	300	100	17	900
1965	500	350	100	0	950

1. Total public supply pumpage is the sum of the pumpage by Carson Water Company, Nevada Indian Agency, and State of Nevada.

Sewage Effluent

Sewage effluent from the Carson City plant, in sec. 15, T. 15 N., R. 20 E. (pl. 1), totaled about 750 acre-feet in 1962, 860 in 1963, 900 in 1964, and about 1,300 acre-feet in 1965. The effluent in 1964 was about 60 percent of the total volume entering the Carson Water Co. system. The effluent is discharged into oxidation ponds east of the plant, and overflows into the stream formed by Ash Canyon and Kings Canyon Creeks. It leaves the area near the center of sec. 15. According to W. L. Dunn, Plant Superintendent (oral communication, 1966), the 50 percent increase in effluent from 1964 to 1965 was due in large part to ground water entering the sewer lines as a result of the unusually large precipitation in late December 1964 and resulting high ground-water levels in succeeding months.

At the Nevada Indian Agency, sewage is oxidized in two lagoons, then spills into Clear Creek. The discharge reportedly averages nearly 50 gpm, or roughly 70 acre-feet per year. This is about 70 percent of the estimated pumpage.

In rural areas, most home owners have septic tanks. As the city expands, the rural areas in time probably will be included in a valley-wide sewage disposal system. The disposal through septic tanks and leaching lines and fields plus percolation from watering lawns and shrubs is estimated to be at least half the rural pumpage (table 7), or roughly 300 acre-feet in 1965; most of this water returns to the ground-water system.

Evapotranspiration

Evapotranspiration losses from areas of phreatophytes and bare soil occur in and around Carson City and Stewart, as shown on figure 7. The principal phreatophytes are native pasture (largely grasses), saltgrass, rabbitbrush, greasewood, wildrose, cottonwood, Lombardi poplar, weeping willow, and other ornamental trees. Although houses, buildings, streets, and parking lots probably cover a few hundred acres in the city, little reduction in evapotranspiration losses probably has occurred as a result, largely because the same amount of water is forced to discharge in or near the same areas. Table 8 shows the estimated ground-water discharge by evapotranspiration in Eagle Valley. The rates used are based on work done by Lee (1912), White (1932), and Robinson (1963).

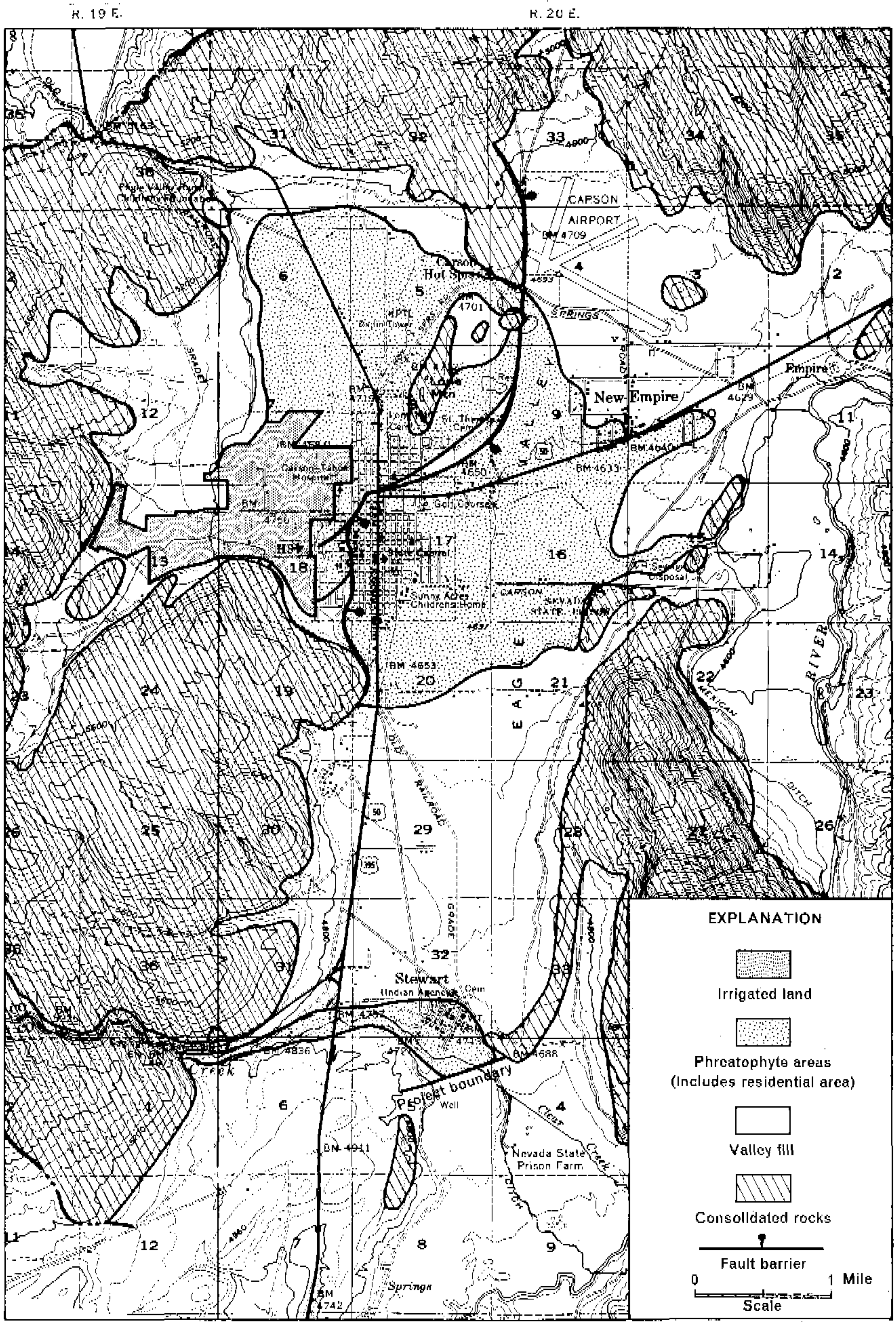

Figure 7.—Approximate areas of irrigation and evapotranspiration in 1964

Table 8.--Estimated annual ground-water discharge by evapotranspiration

Phreatophyte	Area (acres)	Depth to water (feet)	Annual use (feet)	Estimated discharge[1] (acre-feet)
Meadowgrass and associated grasses[2]	1,500	1-10	1.5	2,200
Subirrigated pasture[3]	600	1-10	1.0	600
Rabbitbrush and greasewood; some wildrose	3,000	5-30	0.3	1,000
Total (rounded)	5,100			4,000

1. Includes evaporation from bare soil where water level generally is less than 10 feet.
2. Includes trees in city and at ranches, which collectively would cover roughly 100 acres and have a use of about 3 feet per year.
3. Pasture primarily irrigated by diversions from Clear, Kings Canyon, and Ash Canyon Creeks.

Subsurface Outflow

Ground water moving generally eastward across the valley, if not otherwise discharged, leaves the area through the valley fill beneath Clear Creek, east of the sewage disposal plant, and the moderately broad upland area east of New Empire (fig. 4). Water leaving the valley by subsurface outflow moves into the alluvial deposits adjacent to the Carson River.

The ground-water flow at these three lines of section can be computed by means of a form of Darcy's law:

$$Q = 0.00112TIW$$

in which $\underline{Q}$ is the quantity of flow, in acre-feet per year; $\underline{T}$ is the coefficient of transmissibility, in gallons per day per foot; $\underline{I}$ is the hydraulic gradient, in feet per mile; $\underline{W}$ is the width of the flow section, in miles; and 0.00112 is a factor for converting gallons per day to acre-feet per year. Table 9 shows the estimated outflow from Eagle Valley. Because the saturated thickness and hydraulic gradients have not been changed appreciably by pumping or stream diversions, the estimates are virtually the same for native conditions as for 1965.

Streamflow measurements at the gaging station Carson River near Carson City (14/20-2b) and miscellaneous measurements near Brunswick (pl. 1) indicate a gain in streamflow of about 3 cubic feet per second (about 2,000 acre-feet per year). Presumably, a part of the gain is supplied by the outflow west of New Empire.

Table 9.--Estimated annual subsurface outflow

	Assumed transmissibility (gpd/ft)	Hydraulic gradient (ft/mi)	Effective width (miles)	Estimated outflow (acre-feet)
Beneath Clear Creek, 1 mile southeast of Stewart	ab 30,000	40	0.5	600
Beneath creek 0.5 mile east of sewage disposal plant	a 50,000	25	0.05	100
Beneath upland, 1 mile east of New Empire	b 20,000	70	1.0	1,500
Total, roughly	--			2,000

a. Younger alluvium (pl. 1).

b. Older alluvium (pl. 1).

Springs

Carson Hot Springs, 15/20-5ad, are the largest springs on the valley floor, discharging about 60 gpm of 120°F water (table 13). The water is used for mineral baths, but ultimately most of the discharge is consumed by evapotranspiration in areas east of the springs. Steinheimer Springs, 15/20-8db, are nearly as large and are the only other major springs on the valley floor; they discharge about 50 gpm of 60°F water (table 13). Several minor springs occur along the fault through Carson City and in the area west of the city. Most of the discharge of all springs is consumed by evapotranspiration. The total discharge of the springs, excluding those in the Sierra Nevada, probably does not exceed 200 acre-feet per year.

The principal springs along the west side of Eagle Valley in the Sierra Nevada have been developed by the State and Carson Water Co. for public supply and by the ranchers for irrigation. The flow was not estimated during this study, but the diversions are included in estimates given in the preceding sections of the report.

Summary of Water Use by Carson City

Montgomery Engineers (1965) have compiled the historic water use by Carson City, which is summarized in table 10. As previously described, the three sources of the water are: diversions from streams and springs in Eagle Valley, which supply the bulk of water needs (table 6), pumpage from wells (table 7), and purchase from the State of water from the Marlette Water System (table 5).

The use shown in table 10 is the metered amount as delivered to the consumer, not the amount at the points of diversion. For many public-supply systems the line losses between points of diversion and use commonly are 10 percent. Including line losses and deep percolation from watering lawns and shrubs, the amount of water in 1965 that reached the ground-water system may have been about 500 acre-feet.

Net Water Use for Public and Rural Supplies

The sources and disposition of the water for public supply in Eagle Valley, as described in the preceding sections, are somewhat complex. The net use, or amount actually consumed within the valley for public and rural supply in 1965, is shown in table 10a.

The estimates indicate that of the total supply of 2,700 acre-feet, less than 20 percent was consumed for home and city uses. Approximately 50 percent flowed out of the valley as sewage effluent. About 30 percent reached the ground-water system where it subsequently has been, or will be, discharged from the valley-fill reservoir by other processes, such as evapotranspiration and subsurface outflow; or some may even be reused, if pumped from wells.

Table 10.--Water use by Carson City

/Records from Montgomery Engineers (1965)/

Year	Use (million gallons)	Use (acre-feet)
1949	111	340
1950	123	377
51	128	392
52	125	385
53	137	420
54	165	506
1955	167	513
56	187	575
57	213	655
58	222	680
59	266	816
1960	281	863
61	281	864
62	391	1,201
63	378	1,161
64	472	1,451
1965	a 521	a 1,600

a. From Carson Water Co.

Table 10a.--Net water use for public and rural supplies, 1965

(Most values estimated, as described in text)

Item	Amount (acre-feet)
Sources of water:	
Imported water (table 5)	425
Spring and stream diversions for public supply (table 6)	1,300
Pumpage for public and rural supply (table 7).	950
Total (rounded): (1)	2,700
Disposition of water:	
Public supply: conveyance losses and deep percolation (p. 30)	500
Sewage effluent: Carson City and Stewart (p. 26)	1,370
Percolation to ground water from rural use (p. 26)	300
Total (rounded): (2)	2,200
Net use (amount consumed in Eagle Valley): (1) - (2)	a 500

a. Largely, water evaporated and transpired in watering lawns, shrubs, and trees, and not accounted for in table 8.

WATER BUDGETS FOR NATURAL AND 1965 CONDITIONS

Over the long term and for natural conditions inflow to and outflow from an area are equal. Accordingly, a water budget for natural conditions expresses the quantity of water flowing in a hydrologic system under equilibrium conditions. A water budget generally is designed to bring together and compare the several estimates of inflow and outflow and to ascertain the magnitude of error in the estimates. A budget that balances reasonably well also lends confidence to the reliability of the individual elements of inflow and outflow; the gross quantities in turn are depended upon by those concerned with water development and management.

For Eagle Valley equilibrium conditions existed up to the time that man began to develop the area for industries related to mining at Virginia City and agriculture. Surface-water diversions from the principal streams probably began 100 years ago and have continued to date. Diversions and importation of water for public supply also have modified the natural condition. Total pumpage in 1965 was about 1,000 acre-feet, which was nearly equal to the estimated percolation to ground water from pumpage, stream diversions, and imported water. Therefore, the net result has been virtually no change of stored water up to 1965. A minor depletion probably has occurred in the rural areas but may have been compensated for by a minor increase in storage within and east of the city limits.

Table 11 summarizes the several estimates of inflow and outflow made in the preceding sections of the report for natural and 1965 conditions, shows the water balance achieved, and compares the effect of water development on the natural flow system. The water budgets for natural and 1965 conditions lack closure by 300 to 400 acre-feet, or errors of less than 5 percent. Such close coincidence should not be taken to imply comparable accuracy of the several items of the budget. There are undoubtedly compensating errors on both the inflow and outflow sides that result from the assumptions and estimates made in deriving the estimates.

Table 11--Water budgets for Eagle Valley under natural and 1965 conditions

(Most values estimated, as described in text)

Budget item	1965 conditions (acre-feet)	Natural conditions (ac-ft/yr.)
ESTIMATED INFLOW:		
Surface water (table 4).	13,000	13,000
Ground-water inflow across bedrock-alluvial contact (p.16)	1,000	1,000
Precipitation: valley floor (table 2).	400	400
Imported water (table 5)	425	0
Total (rounded): (1).	14,800	14,400
ESTIMATED OUTFLOW:		
Surface water (table 4).	6,500	a 8,800
Evapotranspiration (table 8) . . .	4,000	4,000
Subsurface outflow (table 9) . . .	2,000	2,000
Springs (p.30)	(b)	(b)
Public and rural supply: net use (table 10a)	500	0
Sewage effluent: Carson City and Stewart (p. 26)	1,370	0
Consumptive use: surface water diverted for irrigation (p.24).	700	0
Total (rounded): (2).	15,100	14,800
DIFFERENCE: (1) - (2)	-300	-400

a. Assumes that all surface-water diversions in Eagle Valley (1,300 acre-feet for public supply, table 6, and 1,000 acre-feet for irrigation, p. 24) would have been surface-water outflow under natural conditions.

b. The estimated 200 acre-feet per year (p.30) included with evapotranspiration.

CHEMICAL QUALITY OF WATER

As part of the present study, 22 water samples were field analyzed and 4 samples were analyzed in more detail to make a general appraisal of the suitability of the water for domestic and agricultural use and to help define potential water-quality problems. Sampling sites were chosen to achieve a modest areal representation of conditions throughout the valley. The field and detailed analyses are shown in tables 12 and 12a, respectively.

The field analyses include the principal anions and cations, except sodium and potassium, which were determined by difference (table 12). Boron, fluoride, iron, and nitrate were not determined. Locally, the shallow ground water reportedly contains iron in excess of 0.3 ppm (parts per million), which may cause laundry staining (U.S. Public Health Service, 1962). Most plants are sensitive to boron in excess of about 1 or 2 ppm; for human consumption the U.S. Public Health Service (1962) suggests that fluoride not be in excess of 1.7 ppm and nitrate not in excess of 45 ppm.

Except for the unknown content of minor constituents just described, the surface and ground waters generally are satisfactory for irrigation, domestic, and most common uses. Most of the water is soft (less than 60 ppm hardness). Salinity hazard, alkali hazard, RSC (residual sodium carbonate), and SAR (sodium adsorption ratio), as shown in table 12, are quality factors related to the suitability of water for irrigation (U.S. Department of Agriculture, 1954). Because most of the water is suitable for irrigation, further elaboration of these factors is not warranted in this reconnaissance.

The detailed analyses (table 12a) for public supply wells 15/19-12da, 15/20-8bb, 15/20-17bd, and 15/20-32dd2 (Carson Water Co. wells 1, 2, and 3, and Nevada Indian Agency well 2, respectively) suggest that the water at depths below 200 to 300 feet generally is of good chemical quality for municipal use.

Table 12.--Field chemical analyses of water from selected wells and springs in Eagle Valley

[Analyses by the U.S. Geological Survey]

Constituents, in parts per million

Location (name or number)	Date of collection	Temperature (°F)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) Potassium (K) (computed by difference)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: noncarbonate	Specific conductance (micromhos at 25°C)	pH	SAR	RSC	Salinity hazard	Alkalinity hazard
Wells																	
15/19-1dc	3-29-65	61	15	9.1	12	92	0	4.8	3.2	58	0	181	7.7	0.7	0.35	Low	Low
12cd2	3-29-65	49	14	2.7	10	72	0	6.0	2.6	46	0	119	7.4	0.7	0.26	Low	Low
15/20-3cd	3-26-65	52	40	8.8	40	208	0	28	17	136	0	394	8.1	1.5	0.69	Medium	Low
4bd	3-26-65	59	18	1.7	68	84	0	87	28	52	0	436	7.8	4.1	0.34	Medium	Low
5cd	3-26-65	54	21	3.8	17	116	0	4.8	3.1	68	0	185	7.8	0.9	0.54	Low	Low
6ab	3-26-65	46	22	5.6	17	120	0	7.6	6.2	78	0	232	7.4	0.8	0.41	Low	Low
7ca	3-29-65	48	21	3.8	12	103	0	5.2	2.2	68	0	169	7.5	0.6	0.33	Low	Low
8cc	3-25-65	56	23	5.7	14	119	3	4.4	4.0	81	0	205	8.4	0.7	0.43	Low	Low
9da	3-26-65	48	55	12	122	244	0	176	48	186	0	893	7.8	3.9	0.28	High	Low
10ad	3-26-65	48	49	9.4	52	184	0	89	21	161	10	531	7.1	1.8	0.00	Medium	Low
15bc	3-29-65	54	15	1.1	72	136	4	56	16	42	0	396	8.5	4.8	1.52	Medium	Low
16ca	3-26-65	50	20	3.2	25	102	0	26	5.4	63	0	217	7.7	1.4	0.41	Low	Low
18ba	3-25-65	60	22	5.4	10	112	0	4.4	2.1	77	0	181	8.2	0.5	0.30	Low	Low
21ca	3-26-65	51	25	6.2	20	146	0	6.0	4.7	88	0	223	7.6	0.9	0.63	Low	Low
26cd	3-26-65	44	19	5.0	21	116	0	12	5.0	68	0	194	7.2	1.1	0.54	Low	Low
29bc	3-26-65	--	15	4.0	12	80	0	6.4	6.4	54	0	178	8.0	0.7	0.23	Low	Low
32dd	3-26-65	56	27	5.7	23	144	0	12	7.0	91	0	247	7.3	1.0	0.54	Low	Low
16/20-32cc	3-26-65	68	23	4.7	24	128	0	14	6.3	77	0	229	8.1	1.2	0.56	Low	Low
Springs																	
Carson Hot Springs																	
15/20-5ad	3-30-65	120	2.6	0.4	96	36	28	96	29	8	0	506	9.3	15	1.36	Medium	High
Steinheimer Spring																	
15/20-8db	3-30-65	60	13	1.8	29	104	0	12	3.5	40	0	194	8.1	2.0	0.90	Low	Low

Table 12a.--Detailed chemical analyses of water from selected public supply wells in Eagle Valley

/Analyses by the U. S. Geological Survey/

Well number	15/19-12da	15/20-8bb	15/20-17bd	15/20-32dd2
Date of collection	5-25-66	5-25-66	5-25-66	5-25-66
Constituents in parts per million				
Silica (SiO_2)	25	34	25	31
Iron (Fe)	0.00	0.00	0.00	0.01
Calcium (Ca)	21	20	24	25
Magnesium (Mg)	4	1.5	5.4	4.7
Sodium (Na)	8.4	19	14	13
Potassium (K)	2.0	1.9	1.5	1.7
Bicarbonate (HCO_3)	102	114	136	127
Carbonate (CO_3)	0	0	0	0
Sulfate (SO_4)	3.0	2.0	1.0	7.0
Chloride (Cl)	0.6	1.2	1.2	2.0
Fluoride (F)	0.0	0.5	0.0	0.1
Nitrate (NO_3)	1.8	0.4	0.5	0.1
Boron (B)	0.0	0.0	0.0	0.0
Dissolved solids Calculated	116	136	140	148
Hardness as $CaCO_3$ Total	69	56	82	82
Noncarbonate	0	0	0	0
Percent sodium	21	42	27	25
Specific conductance (micromhos at 25°C)	170	189	214	210
pH	7.5	7.5	7.3	7.2
Temperature (°F)	50	67	56	55
Depth of well	470	431	535	508
Laboratory number	53071	53074	53075	53076

SYSTEM YIELD

Basic Concepts

The yield of a discrete hydrologic system is here defined as the maximum amount of surface and ground water of usable chemical quality that can be obtained economically each year from sources within the system for an indefinite period of time. The system yield can not be more than the natural inflow to or outflow from the system. Under practical conditions of development the yield is limited to the maximum amount of surface-water, ground-water, and water-vapor outflow that can be salvaged economically each year for beneficial use.

System yield is similar to the more restricted term perennial yield, which in common usage has been limited to the maximum amount of natural discharge (outflow) that can be salvaged by pumping from a ground-water reservoir. The concept of system yield in the development of a discrete hydrologic unit under conditions that generally prevail in the semiarid western States is three-fold: (1) In a state of nature before development begins, the hydrologic system is in an equilibrium condition, which means that over the long term inflow equals natural outflow and no change in stored water occurs either underground or on the surface in lakes and ponds; (2) after development starts, the system is in a nonequilibrium condition--natural discharge plus diversions (both surface and ground water) exceed recharge; the deficit over the years is made up principally by a substantial depletion of stored water; and (3) if the net diversions are finally held to a rate about equal to the salvable natural outflow, or system yield, and if the points of diversion and amount diverted are strategically situtated so as eventually to reduce the salvable outflow to zero, then the system attains a new equilibrium. If all natural outflow is salvable, inflow equals net diversions, natural outflow approaches zero, and over the long term no change in stored water occurs.

The amount of time that it takes to make the full transition from equilibrium under natural conditions to the new equilibrium under full development is largely a function of the annual diversion rate and the amount of stored water that must be removed to terminate the salvable natural outflow. For surface water the effect can be accomplished as rapidly as diversion works or other structures are built and placed into operation. On the other hand, for ground water the time involved commonly is measured in decades. If the net pumping draft is maintained at a rate roughly equal to the salvable outflow from the ground-water reservoir part of the system, a new equilibrium eventually will be established.

Diversions in 1965 in Eagle Valley were largely from streams and springs in the Sierra Nevada and to a small extent by pumping on the valley floor. Most of the available base flow of the streams and springs has been developed, whereas little of the available ground-water supply has been tapped.

Eagle Valley

For Eagle Valley, the estimated total outflow under natural conditions averaged 15,000 acre-feet per year (table 11). As mentioned, the system yield is limited to the maximum amount of natural outflow that can be economically salvaged. The table shows that in 1965 the surface-water outflow was 2,300 acre-feet less than for natural conditions, subject to the assumptions given in the footnote to table 11, which indicates that development thus far has salvaged about 15 percent of the total natural annual outflow.

The maximum salvage over the long term is limited to the additional diversions that can be made from surface-water and ground-water sources. Without the construction of major surface reservoirs, probably not more than 3,000 acre-feet per year of surface-water inflow could be salvaged, which is only about 500 acre-feet per year more than in 1965. Moreover, except possibly in Clear Creek, the steep canyons of the Sierra Nevada would not provide suitable reservoir sites.

The ground-water supply has been developed to a minor degree, amounting to only about 1,000 acre-feet in 1965 (table 7). Moreover, the diversions of surface water, although decreasing the downstream flow, are in the canyons and would not be affected by substantial ground-water development downstream in the valley. However, substantial ground-water development near streams would salvage a significant part of the surface-water outflow from the valley. The estimated maximum salvage of outflow by ground-water development over the long term would include most of the evapotranspiration losses from ground water (table 8), possibly half of the surface-water outflow at the 1965 rate, and part of the subsurface outflow (table 9). Thus, the estimated yield from ground-water sources alone probably is about 7,000 acre-feet per year.

The foregoing estimates and assumptions provide a preliminary value for the system yield of Eagle Valley of about 10,000 acre-feet per year, or about 70 percent of the natural supply. To attain a yield of this magnitude, wells would have to be placed in the areas of phreatophytes, near the principal streams, and near the areas of major subsurface outflow (fig. 7). As water levels are drawn down by pumping, much of the moderate to low flows of the streams would sink into the channels before leaving the valley, and evaporation and transpiration losses would decrease, or would stop entirely, if water levels were drawn down 50 feet or more below land surface. Moreover, the water stored in that part of the valley-fill reservoir which would be dewatered in lowering the water table 50 feet would provide an additional supply during this development process.

In terms of storage depletion, a water-level decline of this magnitude might represent 25,000 to 50,000 acre-feet. This depletion, sometimes referred to as the "permissive mining yield", would be necessary before a new equilibrium could be reached with a sustained draft on the system of 10,000 acre-feet per year. Once equilibrium is reached, further storage depletion over the long term would approach zero.

TOMORROW'S WATER

The preceding discussion dealt mainly with the hydrologic environment, the distribution of water quantities in the hydrologic system, and present water use in Eagle Valley. How will the future needs be met and what additional problems can be expected to accompany the expanding water use? These matters are discussed briefly in the following paragraphs.

Sources

Table 10 shows the rapid increase of water use by Carson City. Montgomery Engineers (1965) project the water needs for the entire valley as follows: 3,600 acre-feet in 1970, 10,000 acre-feet in 1980, 16,000 acre-feet by 1990, and 21,000 acre-feet in 2000. These projections suggest that in 1980 the water requirements of 10,000 acre-feet will be about equal to the preliminary estimate of the system yield of Eagle Valley, which was just described. Therefore, in time outside sources must be developed to augment the local supply. Moreover, economic or other considerations may dictate that an outside source of supply is more feasible than developing the total supply of Eagle Valley.

Possible sources of supply outside Eagle Valley include increased imports through the Marlette Water System, diversions from the Carson River, pumping from wells along the Carson River, and imports from Washoe Valley. Montgomery Engineers (1965) estimate that the potential yield of the Marlette Water System is somewhat more than 5,000 acre-feet per year. Over the years this water system has fallen into a state of disrepair, and Montgomery Engineers estimate that the cost of rehabilitating the system would be about $600,000.

The largest nearby source of water is the Carson River (pl. 1), which is east of the area and which has an average annual flow at the gaging station, Carson River near Carson City, of nearly 280,000 acre-feet per year (U.S. Geol. Survey, 1965). Most of this water is appropriated for agricultural use. Any development for public supply would require appropriate action to acquire existing rights or to establish new rights that might be made available in the future. Regulation of the Carson River by construction of Watasheamu Dam, upstream about 25 miles, is planned as part of the Washoe Project by the U.S. Bureau of Reclamation. It could provide additional water for Eagle Valley.

The ground-water sources along the Carson River include: east of Eagle Valley, the valley fill in secs.22, 23, and 26, T. 15 N., R. 20 E., which could be tested for yield, drawdown, and water quality; and south of Eagle Valley, near Stewart, the valley fill in sec. 9, T. 14 N., R. 20 E., within about half a mile of the river, which could be tested for yield, drawdown, and water quality. Any large-capacity wells in these areas ultimately would derive most of their water from the river. New wells at these locations also should be considered with due respect to water quality.

The estimated yield of Washoe Valley is 15,000 to 25,000 acre-feet (F. E. Rush, U.S. Geol. Survey, oral communication, 1966). If any of this water is considered excess to the needs of Washoe Valley, the surplus could be exported to Eagle Valley.

Problems

Water Quality

Potential water-quality problems exist near and downstream from the sewage disposal plants and in the rural areas where cesspools and domestic wells are used. The sewage disposal plant for Carson City is in sec. 15, T. 15 N., R. 20 E., adjacent to the combined channel of Kings Canyon and Ash Canyon Creeks (pl. 1). After treatment and aeration in ponds, the effluent flows eastward in the creek to Mexican Ditch, and discharges into the Carson River near the center of sec. 11. Similarly, for Stewart, the effluent from the sewage-oxidation lagoons discharges into Clear Creek. Effluent should be considered a pollution hazard to wells located downstream. The extent of the hazard would require special study.

In the rural areas where each home has its own well and septic tank, potential, and possibly actual, water-quality problems exist. Federal and State Public Health agencies can supply information on minimum distances that wells should be placed from any sewer line, septic tank, and leaching field. Wells usually should be upslope from possible sources of contamination to avoid having the ground-water flow move contaminants toward the wells. Also, perforations in wells should be at a prescribed distance below land surface, and obviously, no surface drain water should be allowed to collect around or seep down around the well casing. Where livestock, such as horses and cattle, are kept on the premises, wells should be fenced in, maintaining the minimum required distances from potential sources of contamination. These precautions will reduce to a minimum the possibility of transmitting bacteriological pollutants from sources on or near the land surface to the well water.

On the other hand, these precautions will not reduce the threat posed by the transmission of most chemicals from a source of contamination to the well. Chemicals can be carried miles in the underground-water flow system. Examples: (1) nitrate (NO_3) reaching the well water from septic tanks, fertilizers, and livestock in excess of 45 ppm can be injurious to babies, causing "methemoglobinemia," or "blue babies" disease; and (2) chemicals in household detergents will travel great distances, and a concentration of more than 0.5 ppm not only causes the water to foam when released from faucets but also causes disagreeable taste and may be injurious to health (U.S. Public Health Service, 1962).

As mentioned, information on these and other health hazards can be obtained from the U.S. Public Health Service (1962) or the Nevada Department of Health and Welfare, Bureau of Environmental Health, Reno. All persons living in rural areas who may have questions or doubts about the sanitary condition of their wells should contact one of these health agencies. Ultimately the rural areas of Eagle Valley may be included in valley-wide water-supply and sewage systems, thereby relieving the potential health hazard that now exists.

Water Salvage and Waterlogging

Figure 7 shows the areas of ground-water loss by evapotranspiration, and figure 5 shows the depth to water. Where the water level is less than about 5 feet below land surface, waterlogging may occur. As the two figures show, most of Carson City is in the areas of shallow water level and evapotranspiration losses. Wells drilled for public supply and other uses in secs. 4 to 10, 17 to 21, and 31 and 32, T. 15 N., R. 20 E., not only would salvage much of the water now wasting by evapotranspiration and surface-water outflow, but also in time would relieve substantially the problem of waterlogged lands within and near the city. Moreover, if properly distributed, the pumpage together with surface-water diversions would help resolve the problem of additional water supply needed for the future growth of the area.

Large-Capacity Wells

Moderately large-capacity wells yielding 500 gpm with water-level drawdowns of 50 feet or less, have been difficult to construct in Eagle Valley. The principal problems basically are that production is mainly from sand lenses in the valley-fill reservoir and that penetration of 400 feet or more of the valley fill is usually necessary to encounter enough sand lenses to obtain the desired yield without excessive drawdown.

Large-capacity wells that derive their supply from sand beds or lenses require scientific skill in design, construction, and development. Wells of this type commonly are gravel-packed; have both screen and gravel-pack sizes carefully selected and matched, based on mechanical analyses of the sand samples; and are carefully developed, sometimes using air-lift techniques in addition to surge blocks to wash down the mud cake, flush out the fines, and build up the natural pack outside the artificial pack. These and many other techniques are employed to engineer a successful well in sand.

The previously described range in transmissibility of 20,000 to 50,000 gpd per foot for the best producing wells in the valley strongly suggests that using proper techniques, yields of 500 gpm with drawdowns of 50 feet or less should be obtainable in Carson City and vicinity. Evaluation of existing well-log data and a modest test-drilling program should indicate the most suitable areas for drilling in and near the city--particularly in and near the waterlogged areas (fig. 5).

WELL RECORDS

Selected Data

A reconnaissance field inspection suggests that at least 300 wells are in Eagle Valley. Table 13 includes information on about 60 wells, which generally are representative of the other wells in the valley. Well locations are shown on plate 1. Drillers' logs for more than 100 wells are available. Table 14 includes 10 of these well logs selected to provide data on depth and areal coverage. Their locations also are shown on plate 1.

Well-Numbering System

The numbering system for wells and springs in this report is based on the rectangular subdivision of public lands, referenced to the Mount Diablo base line and meridian. The number consists of three units: the first is the township north of the base line; the second, separated from the first by a slant, is the range east of the meridian; and the third, separated from the second by a dash, designates the section number. The two letters following the section number indicate the quarter-quarter section (40-acres); the letters a, b, c, and d designate the northeast, northwest, southwest, and southeast quarters of each subdivision of the section. A number following the final letter indicates that more than one well was located in the quarter-quarter section. For example, well 15/19-12da, assigned to a Carson Water Co. well, designates that the well is the only well in the NE¼SE¼ sec. 12, T. 15 N., R. 19 E., Mount Diablo base line and meridian.

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

Table 13.--Records of selected wells and springs in Eagle Valley

Use: D, domestic; I, irrigation; PS, public supply; S, stock.
Yield: Gallons per minute (gpm).
Altitude: Land-surface datum interpolated from U.S. Geological Survey topographic maps.
Water-level measurement: Depth to water, in feet below land-surface datum; a few may be pumping levels. Measurements to whole feet are reported.
Log number: Number in files of the State Engineer.

Well number	Owner or lessee	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm)/drawdown (feet)	Approximate altitude (feet)	Water-level measurement Date	Water-level measurement Depth	State log number
14/20- 4bd	Nevada State Prison	1963	454	12	PS	100/240	4675	7-28-64	28.58	7310
5ad	Barry Meyer	1962	102	6	D,I	20/ 23	4685	8-20-64	38.52	--
6ca	Robert Grupe	1958	115	6	D	- -	4835	8-14-64	49.05	4178
15/19- 1dc	J. W. Cudworth	1963	350	8	D	30/250	5020	2-12-63	250	7015
12cd1	J. L. Bensinger	1961	-	8	D	- -	4980	7-28-64	133.27	--
12cd2	Steve Cogorno	1960	180	8	D	30/145	4980	3-24-60	143	5111
12da	Carson Water Co., well 3	1961	470	12	PS	920/ 36	4810	8- 5-64	33.09	6040
13cc	Max Faylor	1963	64	6	D	30/ -	5030	do	4.64	7160
23ab1	Douglas Miller	1960	200	10	D	127 /100	5300	7- -60	60	5840
23ab2	R. H. Schneider	1964	300	8	D	2/300	5300	8-13-64	63.10	--
15/20- 2cc	J. W. Buttner	1961	60	6	D	24/ -	4635	2-28-61	21	5741
3cd	Carl Jensen	1957	96	6	D	30/ -	4675	8- 7-64	34.32	--
4bd	Ormsby County	1964	155	6	D	12.5/ 94	4700	8-13-64	40.10	--
4da	Carson City Airport	1962	150	10	D,I	12.5/125	4685	8- 7-64	34.39	7016
5ba1	George Zappettini	1959	154	12	D,I	30/ 92	4740	9-30-65	19.55	4417
5ba2	A. W. Henderson	1948	87	8	D	- -	4730	7-29-64	6.48	--
5cd	Seventh Day Adventist Church	1962	75	6	D	15/ -	4710	4-17-62	6	6492
6ab	A. J. O'Connell	1958	104	8	D	25/ 80	4760	8-13-64	32.07	4045
7bc	Dr. W. R. King	1960	150	8	D	20/ -	4830	1- -60	50	5186
7bd	- - -	--	-	4	-	- -	4790	8-20-64	16.93	--

Table 13.--Continued

Well number	Owner or lessee	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm)/drawdown (feet)	Approximate altitude (feet)	Water-level measurement Date	Water-level measurement Depth	State log number
15/20- 7ca	Thomas Furlong	1958	92	6	D	30/ 20	4780	8- 4-64	6.55	4328
7cb	Michael Batesel	--	--	6	D	- -	4800	7-29-64	6.55	--
7cc	A. J. Palmer	--	--	6	D	- -	4765	do	5.48	--
8b10	Edith Waters	1945	31	5' x 5'	D,I	20/ --	4715	9-30-65	9.30	--
8bb	Carson Water Co., Well 2	1961	431	6	PS	285/178	4725	8-11-64	35	5638
8cc	J. W. Wagner	1940	125	2	D	- -	4710	2-15-66	Flowing	--
9bc	Milton Steinheimer Inc.	1961	--	3	D	- -	4675	8-18-64	14.40	--
9da	Miles Dewitt	1946	--	-	I	15/ 15	4640	8- 5-64	4.65	--
9d11	Everett Hamlin	1938	48	3	D	4/6.7		2-26-63	7.66	--
10ab	W. E. Blain	1959	66	6	D	- -	4645	2-18-66	6.27	--
10ad	Blake Darling	1960	360	8	D	20/ -	4610	8- 7-64	20.23	5125
10cb	Walter Schwartz	1956	70.5	8	D	30/ 40	4635	1- 9-56	6	3326
11bb	Seaforth Corporation	1962	200	8	D	30/168	4625	7-30-64	37.08	6826
15ac	Carson City Dog Pound	1960	116	6	D	20/ 35	4620	7-28-64	49.38	5589
16ca	Sam Lompa	1957	101	6	D	30/ 52	4635	7- -57	3	3841
16db	Nevada State Prison (Test hole)	1961	668	No casing	Test hole	- -	4630	--	--	--
17ab	Sam Lompa	--	-	-	I	- -	4660	8- 7-64	24.29	--
17bd	Carson Water Co., Well 1	--	-	12	PS	300/75?	4665	8-11-64	53.50	--
17c1	Nevada Children's Home	1929	600	18	PS	600/100	4670	9-30-65	11.63	--
17cd	"76" Hereford Ranch	1960	265	8	-	- -	4665	8-19-64	8.73	5603
18ba	John Winters	--	--	2	S	- -	4760	2-16-66	Flowing	--
18bc	W. H. Long	1960	120	12	D,I	100/160	4760	8- 4-64	6.19	5360
18ca	W. H. Campbell	1948	490	12	D,S,I	225/168	4740	8-11-64	16.59	568
18dc	Archie Pozzi, Jr.	1960	96	6	I,D	25/ 28	4740	2-13-60	8	5041
20bd	C. L. May	1958	72	6	D	-/ 12	4650	7-30-64	11.89	4292
20c1	Philip Harper	Dug	37.5	4' x 4'	I	- -	4685	9-30-65	27.50	--
20cc	Nevada National Guard	1958	252	8	PS	40/ 24	4685	5- -58	19	4066
21ca1	Nick Aragno	1964	68	6	D	24/ -	4675	--	--	6

Table 13.--Continued

Well number	Owner or lessee	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm)/ drawdown (feet)	Approximate altitude (feet)	Water-level measurement Date	Water-level measurement Depth	Well log number
15/20-21ca2	J. R. Gettys	1956	100	8	D,I	200/ 60	4675	8-17-64	43.06	--
22bd	C. R. Anderson	1958	35	6	D	- -	4620	8-18-64	22.87	--
23cc	Donald Anderson	1960	160	8	S,I	30/ 27	4605	do	14.85	5103
26bb	Silver Saddle Ranches	1959	136	8	I	220/ 60	4610	8-19-64	19.10	5040
28cd	Steven Griffith	1960	140	6	D	30/ 20	4750	8-11-64	68.76	--
29bb	Silver State Lanes	1960	235	8	D	350/ 74	4700	7-28-64	31.31	5558
29db	J. R. Urton	1962	128	6	D	- -	4710	3-14-62	38.90	--
30aa1	Harold Rupert	1949	88.5	6	D	-/ 15	4710	8- -49	30	1075
30aa2	Carson Indian Colony	1960	228	8	PS	50/ 3	4710	7-30-64	36.25	--
31ab	E. I. Hamlin	1963	--	6	D	- -	4900	8-11-64	170.79	--
31cd	Ormsby County Farm	1956	90	6	D	25/ -	4770	8- 4-64	32.38	3592
32db	Jim D. Wallace, Jr.	1960	101	6	D	28/ 75	4725	8- 5-64	31.28	5517
32dd1	Nevada Indian Agency, Well 1	1936	236	12	PS	200/140	4715	10- 4-44	13	--
32dd2	Do., Well 2	1960	508	12	PS	250/130	4720	- - 60	22	
16/20-31ca	A. D. Bunnell	1963	190	6	D	- -	4875	8-18-64	115.17	--
31cc	Eagle Valley Children Home	1963	91	8	D	25/ -	4840	8-21-63	20	7362
32cc1	J. A. Rankin	1965	180	6	D	14/ -	4820	3-14-65	140	8552
32cc2	Howard Sutherland	1964	115	6	D	- -	4760	8-12-64	31.07	--
32cd	D. R. Spurlock	1963	175	6	D	- -	4820	8-12-64	142.22	--
Springs	Name							Temperature		
15/20- 5ad	Carson Hot Springs				PS	60	4700	120°F		
8db	Steinheimer Springs				S	50	4700	60°F		

Table 14.--Selected drillers' logs of wells in Eagle Valley

Material	Thickness (feet)	Depth (feet)
15/19-1dc		
Topsoil	2	2
Sand boulders with clay streaks	178	180
Sand, fine; some water	2	182
Clay, yellow	68	250
Clay and boulders	60	310
Sand	40	350
15/19-12da		
Topsoil	9	9
Clay, yellow	29	38
Granite, decomposed, loose	87	125
Granite, solid	11	136
Granite, decomposed	154	290
Granite, white, solid	30	320
Fissure	2	322
Granite, white, solid	59	381
Rock, broken	19	400
Granite, blue, solid	27	427
Fissure in rock	24	451
Granite, blue, solid	19	470
15/20-4ba		
Sand and clay	131	131
Rock	19	150
15/20-5ba1		
Sand	2	2
Sand and clay	17	19
Sand and rock	86	105
Rock and clay	37	142
Clay, hard, compact	2	144
Rock and hard clay	11	155
15/20-8bb		
Topsoil	3	3
Hardpan	3	6
Sand and clay	7	13
Clay	2	15
Sand and clay	20	35
Clay	15	50
Sand	70	120
Sand, coarse	45	165

Table 14.--Selected drillers' logs--continued

Material	Thickness (feet)	Depth (feet)
15/20-8bb--continued		
Shale	17	182
Sand and gravel	16	198
Shale	12	210
Sand and gravel	18	228
Sand	42	270
Clay	37	307
Rock, hard	1	308
Sand	24	332
Shale	23	355
Rock, hard	4	359
Clay	12	371
Shale, hard	21	390
Shale, very hard	33	427
Granite, hard	6	431
15/20-10ad		
Soil and clay	8	8
Sand, fine	7	15
Sand and small boulders	11	26
Clay, hard, and boulders	60	86
Gravel, cemented, and clay, sand streaks	86	172
Clay, small sand streaks	173	345
Conglomerate rock	15	360
15/20-15ac		
Sand	3	3
Hardpan	8	11
Sand and clay, brown	14	25
Clay, blue, sandy	84	109
Sand, blue, and small gravel	7	116
15/20-16db		
Clay, black, and topsoil	30	30
Sand, gray, and clay	10	40
Sand and gravel	10	50
Clay, blue, and sand	10	60
Sand streaks of clay	30	90
Sand and gravel	10	100
Clay, blue, and sand	20	120
Sand streaks of blue clay	30	150
Clay, sandy	10	160
Sand streaks, blue clay	10	170
Clay, blue, and sand	10	180
Sand streaks, blue clay	10	190

Table 14.--Selected drillers' logs--continued

Material	Thickness (feet)	Depth (feet)
15/20-16db--continued		
Clay, blue, and sand	20	210
Sand	10	220
Sand streaks, blue clay	10	230
Sand	10	240
Sand and blue clay	30	270
Sand	10	280
Sand and blue clay	10	290
Sand with rough streaks	20	310
Sand	10	320
Sand streaks, blue clay	10	330
Sand and sandy shale	10	340
Sand and clay with rough streaks	10	350
Shale, sandy, and sand	10	360
Shale, sandy	10	370
Clay, blue, and sand	10	380
Sand	10	390
Sand with blue clay	8	398
Clay, blue, hard	270	668
15/20-17cl		
Soil	6	6
Gravel	9	15
Clay, sandy	2	17
Gravel	5	22
Sand and gravel, coarse	9	31
Gravel and boulders	59	90
Clay and gravel, sandy	5	95
Clay, blue	5	100
Clay, sandy, soft	4	104
Clay and gravel, hard	10	114
Sand and gravel	11	125
Clay, sandy, some gravel	66	191
Sand, fine, little gravel	8	199
Clay and gravel, sandy	14	213
Sand and gravel	5	218
Clay and gravel, sandy	70	288
Clay, blue	2	290
Clay, blue, sandy, some gravel	41	331
Sand and gravel	4	335
Clay, blue, and gravel	55	390
Clay, blue, sandy	46	436
Sand gravel, coarse	5	441
Clay and gravel, sandy	18	459
Sand and gravel, coarse	18	477
Clay and gravel, sandy	18	495
Clay, sandy	6	501

Table 14.--Selected drillers' logs--continued

Material	Thickness (feet)	Depth (feet)
15/20-18ca		
Topsoil	3	3
Clay, yellow, sandy, hard	17	20
Gravel, coarse, some water	4	24
Gravel and sand mixed, some water	8	32
Gravel, tight	3	35
Clay, brown, tight	4	39
Clay and gravel	6	45
Clay, sandy, with larger gravel	36	81
Sand and gravel	11	92
Sand	10	102
Gravel (conglomerate), water	13	115
Sand and clay	20	135
Clay, very hard	4	139
Clay, yellow mud, hard	10	149
Clay, yellow, hard	11	160
Gravel, very hard packed	5	165
Clay, yellow, hard	15	180
Clay, yellow, softer	8	188
Granite, hard, gravel	2	190
Clay, yellow, sandy, hard	4	194
Gravel, coarse	4	198
Clay, yellow, hard	56	254
Sand, hard, and rock	5	259
Clay, yellow, hard	41	300
Clay, yellow, cemented and gravel	8	308
Clay, yellow, hard	6	314
Sand, hard, and rock	2	316
Sand and rock	2	318
Clay, yellow, hard	6	324
Clay, yellow, hard, and sand	6	330
Clay, hard	10	340
Clay, sand pack (hard)	45	385
Gravel with clay	3	388
Sand	2	390
Clay, yellow, hard	14	404
Clay, white, hard	6	410
Clay, white, sandy and hard	10	420
Clay, brown; coarse sand	3	423
Clay, brown, some water	15	438
Clay, gray	6	444
Clay, brown, gravelly	6	450
Ledge rock, brown	2	452
Clay, brown, sandy	6	458
Clay, gravelly	17	475
Rock, brown	15	490

Table 14.--Selected drillers' logs--continued

Material	Thickness (feet)	Depth (feet)
15/20-20cc		
Topsoil, sandy	1	1
Clay, sandy	4	5
Hardpan	30	35
Sand	5	40
Clay, sandy	4	44
Clay	60	104
Clay, sandy	46	150
Clay, blue	4	154
Clay, sandy	22	176
Granite, decomposed	21	197
Granite, hard	37	234
Granite, blue	4	238
Clay and sand	10	248
Granite, blue	3	251
Clay, sandy	1	252
15/20-32dd2		
Soil and sand	27	27
Sand and clay	12	39
Sand, coarse	21	60
Sand and clay	90	150
Clay, sand, and boulders	195	345
Sand, heavy	99	444
Clay and sand	16	460
Sand, coarse	48	508
Sand and hard boulders	3	511
Sand	7	518
Rock	7	525

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8	Independence	
9	Gabbs	
10	Sarcobatus and Oasis	
11	Hualapai Flat	
12	Ralston and Stonecabin	
13	Cave	
14	Amargosa	
15	Long	Surprise
	Massacre Lake	Coleman
	Mosquito	Guano
	Boulder	
16	Dry Lake and Delamar	
17	Duck Lake	
18	Garden and Coal	
19	Middle Reese and Antelope	
20	Black Rock Desert	
	Granite Basin	
	High Rock Lake	
	Summit Lake	
21	Pahranagat and Pahroc	
22	Pueblo	Continental Lake
	Virgin	Gridley Lake
23	Dixie	Stingaree
	Fairview	Pleasant
	Eastgate	Jersey
	Cowkick	
24	Lake	

Report No.	Valley	
25	Coyote Spring	
	Kane Spring	
	Muddy River Springs	
26	Edwards Creek	
27	Lower Meadow	Patterson
	Spring (near Panaca)	Panaca
	Eagle	Clover
	Dry	
28	Smith Creek and Ione	
29	Grass (near Winnemucca)	
30	Monitor, Antelope, and Kobeh	
31	Upper Reese	
32	Lovelock	
33	Spring (near Ely) (out of print)	
34	Snake	
	Hamlin	
	Antelope	
	Pleasant	
	Ferguson Desert (out of print)	
35	Huntington	
	Dixie Flat	
	Whitesage Flat (out of print)	
36	Eldorado - Piute Valley (Nevada and California)	
37	Grass and Carico Lake (Lander and Eureka Co.)	
38	Hot Creek	
	Little Smoky	
	Little Fish Lake	

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
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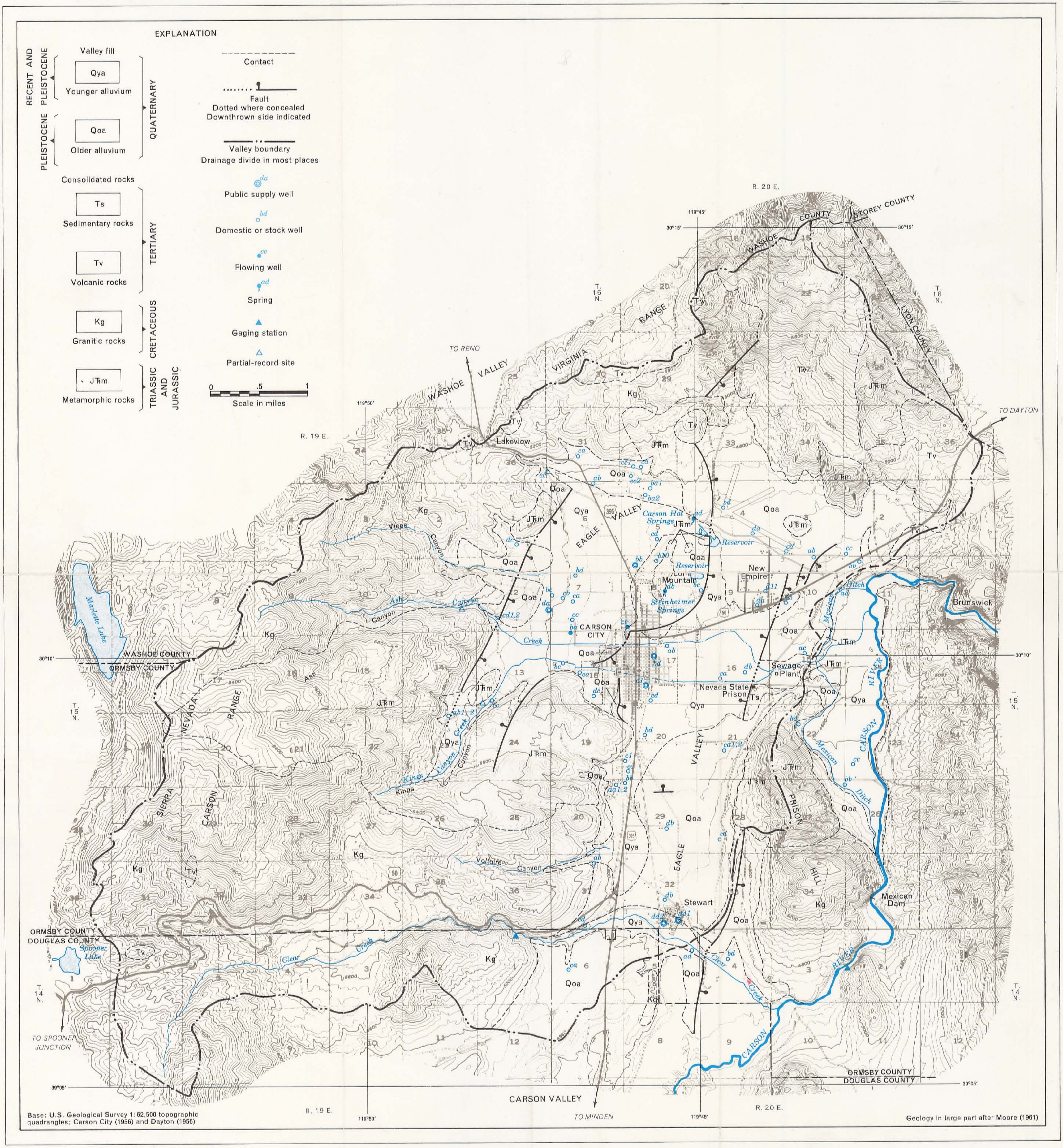

PLATE 1.—GENERALIZED GEOLOGIC MAP OF EAGLE VALLEY, ORMSBY COUNTY, NEVADA