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EVALUATION OF THE WATER RESOURCES OF LEMMON VALLEY, WASHOE COUNTY, NEVADA, WITH EMPHASIS ON EFFECTS OF GROUND-WATER DEVELOPMENT TO 1971

By

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EVALUATION OF THE WATER RESOURCES OF LEMMON VALLEY, WASHOE COUNTY, NEVADA, WITH EMPHASIS ON EFFECTS OF GROUND-WATER DEVELOPMENT TO 1971

By James R. Harrill

SUMMARY AND CONCLUSIONS

This study, made in cooperation with Washoe County, City of Reno, and Nevada Department of Conservation and Natural Resources, reappraises the water resources of Lemmon Valley, a small valley of about 93 square miles some 8 miles north of Reno, Nevada. The water-resources reconnaissance (Rush and Glancy, 1967) was too general to meet the needs of water planners, developers, and administrators in this rapidly growing suburban area.

This more detailed study was designed to reevaluate ground-water recharge, discharge, and yield; to inventory ground-water pumpage, imported water, and water use; to describe the geologic framework as it controls the hydrology; the define the extent and magnitude of ground-water storage changes; to delineate the extent of poor-quality water; and to explore the possibilities of artificial recharge and the potential affects of sewage effluent on ground water. Table 1 summarizes the principal quantitative estimates developed during this study. The principal conclusions regarding the ground-water system in Lemmon Valley are as follows:

1. Intense faulting and fracturing associated with the Walker Lane fault zone have formed barriers to ground-water movement in the valley-fill reservoir and have created permeable zones in consolidated rocks which not only store water but also probably transmit some water out of the valley. Fault barriers identified in this study have necessitated division of the valley for hydrologic studies into two major subareas, Silver Lake and East Lemmon, and a further division of East Lemmon subarea into a Central area, Black Springs area, and Golden Valley. Additional subdivision may be required if development demonstrates the existence of additional fault barriers. Ground-water flow within compartments formed by barriers is complex and well yields are adversely affected. The barriers also complicate any plans for the orderly development and management of the valley-fill reservoir.

2. Under natural conditions, recharge and discharge averaged about 1,400 acre-feet per year--about 900 in Silver Lake subarea and 500 in East Lemmon subarea. Perennial yields of the two sub-

Table 1.--Summary of hydrologic estimates

(Water estimates, in acre-feet per year, except as indicated)

Item	Silver Lake subarea	East Lemmon subarea	Lemmon Valley (rounded)
Area (square miles)	53	40	93
Summary of natural conditions			
PRECIPITATION	29,000	21,000	50,000
RUNOFF	2,200	1,200	3,400
GROUND-WATER INFLOW			
Recharge	1,000	500	1,500
Possible subsurface inflow	minor	--	minor
Underflow from Silver Lake subarea to East Lemmon subarea	--	minor	--
GROUND-WATER OUTFLOW			
Evapotranspiration	760	420	1,200
Probable subsurface outflow	--	200	200
Underflow to East Lemmon subarea	minor	--	--
VALUE SELECTED TO REPRESENT NATURAL GROUND-WATER INFLOW AND OUTFLOW	900	500	1,400
PERENNIAL YIELD	900	400	1,300
Summary of conditions as of 1971			
IMPORTED WATER			
Stead Facility	500	400	1,000
Raleigh Heights	--	a 150	
GROUND-WATER INFLOW			
Natural recharge	1,000	500	1,500
Recharge from imported water	100	b 250	350
GROUND-WATER OUTFLOW			
Evapotranspiration	810	580	1,400
Probable subsurface outflow	--	220	220
Annual pumpage (1971)			
Withdrawn	320	600	920
Consumed	200	190	390
Net increase in ground-water storage, natural to 1971 conditions (acre-feet)	2,200	3,000	5,200
AUGMENTED YIELD	1,000	b 600	1,600
TRANSITIONAL STORAGE RESERVE (acre-feet)	90,000	50,000	140,000

a. About 60 acre-feet exported as sewage not indicated in total.

b. Includes 140 acre-feet recharged sewer effluent.

areas are about 900 and 400 acre-feet, respectively.

3. Water has been imported to Lemmon Valley for use at Stead Facility (formerly Stead Air Force Base) since 1944. Since 1966, water has also been imported to Raleigh Heights. During 1971 about 900 acre-feet of imported water was used by about 2,700 persons living at Stead Facility, including industrial use. About 150 acre-feet was used by about 700 persons living in that part of Raleigh Heights within the study area; however, about 60 acre-feet of this water was returned to the Truckee Meadows as sewage. Over the 27-year period 1944-71 about 15,000 acre-feet of water has been imported for use at Stead. Because part of this water becomes secondary recharge, ground water in storage has increased by about 5,000 acre-feet. Consequently, as of 1971 evapotranspiration had increased to about 1,400 acre-feet. The augmented yield (perennial yield plus secondary recharge from imported water) was about 1,000 acre-feet per year in Silver Lake subarea and about 600 acre-feet per year in East Lemmon subarea.

4. As of September 1971, the State Engineer had issued permits to pump about 15,500 acre-feet per year in Lemmon Valley. If all permits to pump water were exercised, a significant valley-wide overdraft would develop. Annual pumpage in 1971 was only about 900 acre-feet withdrawn with only 400 acre-feet consumed. Water not consumed, about 500 acre-feet, was returned to the ground-water reservoir slightly degraded in quality. No overdraft on the ground-water reservoir had occurred as of 1971, but significant declines had occurred in localized areas.

5. If pumping is not strategically distributed with respect to the supply, local overdraft may develop even though no valley-wide overdraft exists. Optimum areal distribution of pumping is difficult to predict, because of inferred fault barriers and resulting compartmentation of the valley-fill reservoir. However, chances of local overdraft in Silver Lake subarea would be reduced if net pumpage south of Silver Lake were about 300 acre-feet per year or less and net pumpage north of Silver Lake were about 700 acre-feet per year or less. In East Lemmon subarea, chances of local overdraft would be reduced if net pumpage were about 400 acre-feet per year or less in the Central area, about 170 acre-feet per year or less in Black Springs area, and 30 acre-feet per year or less in Golden Valley. These estimates should be refined as more data concerning cause and effect relationships are developed.

6. In 1971 the chemical quality of ground water, as indicated by available samples, generally was acceptable for most uses. Exceptions to this are accumulations of naturally salty water beneath the playas in both subareas and some wells affected by local conditions. Because salty water in the fine-

grained deposits beneath the playas probably will drain slowly in response to pumping, no short-term problem is expected from this source, particularly in deep wells.

7. Future plans for ground-water development will be affected principally by the quantity of water available on an annual basis (augmented yield), water-quality changes caused by recycling of ground water, hydraulic barriers caused by faults in the valley-fill reservoir, and areal distribution of pumping.

8. An average of 400 to 500 acre-feet per year of streamflow reaches Silver Lake where it is lost by evaporation. Off-channel spreading of the streamflow in the area between U. S. Highway 395 and the area of natural discharge might increase ground-water recharge. Pumping in this area would salvage the water for beneficial use.

9. Examples of several intensities of water use are presented. These range from one-time use to recycling water to the maximum extent possible. Generally, use on a one-time basis results in minimal water-quality problems and is less expensive; however, return flows potentially available for reuse would not be utilized. Maximum reuse would completely utilize all water possible, but treatment to maintain acceptable quality would substantially increase the cost of water. The amount of reuse feasible depends on economic factors and is between the two extremes cited. If imports were to remain the same as in 1971 and if water were used on a one-time-only basis, Lemmon Valley could support a population of slightly more than 10,000 persons indefinitely (this assumes an average use of about 200 gallons per day per person). If this same supply were reused to the maximum extent possible and if adequate treatment were provided, the valley could support about 24,000 persons indefinitely.

Examples are also given whereby the local supply could be augmented by imported water from the Truckee River in conjunction with a planned return flow. One example shows that with careful water management and treatment, importation of 3,100 acre-feet per year plus local ground-water supply and reuse would also supply a population of about 24,000. Return flow to the Truckee River would be about 2,200 acre-feet per year; a net diversion from the Truckee of only about 900 acre-feet per year. Legal and other aspects would have to be resolved.

10. The cause and effect relations described in this report are first approximations based on data available as of 1971. To make future refinements in cause and effect relations, reasonably detailed records of pumpage, periodic measurements in selected observation wells (preferably in the spring before large-scale

pumping begins), and periodic samples of pumped water to monitor the quality would provide much of the needed information. Extensive drilling and testing might be required to evaluate conditions in areas of compartmented valley fill, and to evaluate more accurately the areas and amounts of subsurface outflow.

INTRODUCTION

Purpose and Scope

This is the second report on the hydrology of the Lemmon Valley area prepared by the U. S. Geological Survey; it was prepared in cooperation with the City of Reno, Washoe County, and Nevada Department of Conservation and Natural Resources. The first report (Rush and Glancy, 1967), was a reconnaissance of 11 valleys in western Nevada. It included preliminary estimates of the water supply of Lemmon Valley.

The need for this study arose from concern that residential and industrial development might result in an overdraft on the ground-water supply of Lemmon Valley. Estimates in the earlier study gave a wide range in the amount of water available (between 1,200 and 2,100 acre-feet per year) which does not provide specific enough information to meet present and future planning needs. Also, the reconnaissance study posed questions concerning the ground-water flow system and water quality which could not be resolved during the brief initial study.

Therefore, the principal objectives of this study are: (1) to reappraise natural recharge to, discharge from, and perennial yield of the ground-water system; (2) to describe the geologic framework as it controls the hydrologic system; (3) to describe the flow system and evaluate possible areas of interbasin flow; (4) to inventory development as of 1971 and to appraise effects of pumping and importing water on the hydrologic system; and (5) to appraise the chemical quality of the water to better define areas of poor water quality and provide a basis for comparison in the future.

Field work began in July 1971 and was completed in December 1971, and included: canvassing and measuring selected wells, collecting water samples, mapping areas of phreatophytes, making one pumping test, field checking data from published geologic maps, and drilling 27 small-diameter observation wells where additional data were needed. Surface-water runoff was estimated from discharge and channel-geometry measurements made at selected sites.

The estimates developed in this study are subject to some errors that are inherent in applying point data to large areas and in the simplifying assumptions made in order to evaluate natural conditions. Estimates derived for a complete hydrologic basin generally are considered to have errors of less than about 25 percent. However, additional specific data would be required to apply these generalized estimates to a part of a basin without risking increased error.

Location and General Features

Lemmon Valley is a small topographically closed basin about 8 miles northwest of Reno, in Washoe County, Nevada. Total area of the valley is about 93 square miles. Rush (1968) divided the valley into two parts, an eastern part and a western part. These subdivisions are used in this report and are shown in figure 1. Figure 1 also shows the principal features and locations of main roads and weather station.

The eastern part of Lemmon Valley contains about 40 square miles, and is referred to as the East Lemmon subarea. It is further subdivided into Golden Valley (4 square miles), Black Springs area (11 square miles), and the Central area (25 square miles), as shown in figure 1. Altitudes range from about 4,915 feet on a small playa near the center of the subarea to 8,266 feet on Peavine Mountain. Mountains along the east border generally have altitudes of less than 6,000 feet.

The western part of the valley covers about 53 square miles, and is referred to as the Silver Lake subarea. Silver Lake is an intermittent playa in the southern part of the subarea. Altitudes range from about 4,955 feet on Silver Lake to 8,266 feet on Peavine Mountain.

Acknowledgments

Acknowledgment is made of the cooperation of local residents of the valley in supplying data and permitting access to their wells for purposes of measuring water levels, collecting water samples, and obtaining discharge data during the course of this study. The Desert Research Institute of the University of Nevada supplied water-level measurements made in about 60 selected wells during March and June of 1971. Additional data on specific areas of the valley were provided by Leareno Inc., Mr. James Sweger of Silver Knolls Estates, the Lemmon Valley Land Company, and Mr. Keith Meador. Data on quantities of imported water and on power consumption of large wells were furnished by the Sierra Pacific Power Company. Wholehearted assistance was also received from Federal, State, and local governmental agencies. Copies of water-quality analyses of samples from wells were provided by the State Department of Environmental Health. Most of the drillers' logs and data on well construction used in this investigation were furnished by the State Engineer of Nevada.

DEVELOPMENT

Lemmon Valley is currently undergoing a period of rapid growth for residential and industrial purposes. This is largely because of its proximity to the City of Reno.

Prior to the 1940's the area was sparsely inhabited. Population was limited to several small farms in the valley and some houses along the Western Pacific Railroad. Industry consisted of mining and some cattle ranching. In the early 1940's, Stead Army Air Base was established. The initial water supply for the base was from wells 21/19-30ddda and 21/19-31ccccl (pl. 1) and a mine shaft on Peavine Mountain. Water from well 21/19-31ccccl and the mine shaft was of poor quality. Water from well 21/19-30ddda was of good quality, but the yield of the well was small.

To obtain a dependable supply, water was imported from the Truckee River. The initial pipeline was installed in 1944 and served the needs of the base until 1956 when a 14-inch line was installed which is still in use today. Stead Air Force Base remained the principal industry in the valley until it was closed in July 1966 and released to local interests. Currently, the City of Reno operates the airport and sewer facilities; about 650 houses are rented by commercial interests (Oasis Homes and Stead Park). The Stead Facility of the University of Nevada and several industries occupy most of the former military base, and Washoe County has expanded the 9-hole golf course to an 18-hole public course.

Population (excluding Stead Air Base) increased from about 75 in 1946 to about 550 in 1956 (both estimates from air photos); and about 2,000 in 1966 (Rush and Glancy, 1967, p. 39). Using an estimated population for the Stead Facility of about 2,500, the estimated total population of the valley in 1966 was about 4,500. Rapid growth has occurred since 1966, and in 1971 estimated total population was about 7,000. This includes about 2,700 persons living at Stead and about 700 persons living in that part of the Raleigh Heights subdivision (fig. 1) which extends into Lemmon Valley. These residents are supplied by imported water. The remaining 3,600 persons obtain water from ground-water supplies developed within the area. About 900 obtain water from individual domestic wells and 2,700 are supplied by water companies or privately owned systems, such as those which serve trailer courts.

As of 1971, large areas of additional land had been subdivided for future development, and the State Engineer had granted permits to pump about 15,500 acre-feet per year. Permits had also been granted to pump about 600 acre-feet of ground water from adjacent Cold Springs Valley for use in Lemmon Valley.

HYDROLOGIC ENVIRONMENT

Physiographic Features

Landforms in Lemmon Valley are typical of those in the Great Basin. The valley is a structural depression partially filled by unconsolidated and semiconsolidated lacustrine and subareal deposits. Physiographically the valley may be divided into three parts: mountains, alluvial aprons, and playas.

The mountains bordering Lemmon Valley consist of complexly faulted granitic, volcanic, and metavolcanic rocks. Their gross size, shape, and relief were controlled by faulting associated with large-scale regional deformation. Erosion and smaller structural features largely account for the present topography. The mountains are areas of active erosion and are the major source of both sediment and water that reach the valley.

The alluvial apron is the area of intermediate slope between mountains and the comparatively horizontal playas. Slopes on the apron range from about 800 feet per mile on the north flank of Peavine Mountain to several feet per mile near the playas. The apron generally is composed of coalescing alluvial fans but may also contain pediments, or areas where bedrock is covered by a thin sheet of alluvium. In some areas, such as parts of the north slope of Peavine Mountain, alluvial deposits have been uplifted by recent structural deformation. These areas are commonly deeply dissected, and older alluvial deposits are exposed at the surface. Local relief may be as much as 150 feet.

Playas occupy nearly horizontal areas near the centers of the two subareas. Each subarea is topographically closed and contains one or more playas, as shown on plate 1. Silver Lake subarea has one large playa, Silver Lake (area 430 acres) and three smaller playas (combined area about 70 acres). East Lemmon subarea contains one large playa (area about 800 acres). Playa altitudes in the Silver Lake subarea are 40 to 50 feet higher than the East Lemmon playa. This difference has hydrologic implications which are discussed in a later section of this report.

A Pleistocene lake occupied parts of both subareas. Shoreline features are prominently developed along the northeast side of East Lemmon subarea. The highest observed features were at an altitude of about 4,980 feet. Well-defined shoreline features were not observed in the Silver Lake subarea.

Lithologic Units

For the purposes of this report, the five major lithologic units in Lemmon Valley were divided into two major groups on the basis of their hydrologic properties: (1) unconsolidated deposits, which form the valley fill, are highly porous and commonly transmit water readily; and (2) consolidated rocks, which compose the mountains and underlie the valley fill, commonly have low porosity and permeability, and except where highly fractured, do not readily transmit water. The five lithologic units are described in table 2; descriptions are based on the work of Bonham (1969) and field observations. Areal distribution of these units is shown in figure 2.

Structural Features

Rocks in the study area are believed to have undergone two periods of structural deformation: one in late Mesozoic time and the other in late Tertiary and Quaternary time (Bonham, 1969, p. 42). The late Mesozoic period of deformation resulted in pre-Tertiary sedimentary and volcanic rocks being strongly faulted and folded and regionally metamorphosed prior to the intrusion of granitic rocks in the Cretaceous period. The second period of deformation began in the middle to late Tertiary and has continued to the present. It has formed the structural depression underlying Lemmon Valley and shaped many existing topographic features of the area.

The structural features formed during this last period of deformation have greatly affected the ground-water flow system in Lemmon Valley. The effects are mainly related to one of two conditions: (1) development of bedrock permeability by formation of highly fractured zones adjacent to faults, and (2) the formation of barriers to ground-water movement, probably resulting from poorly sorted material and cementation along fault surfaces in the valley fill.

The high degree of structural deformation in the area is due in part to its close proximity to the Walker Lane structural zone which is adjacent to the north part of the area. Bonham (1969, p. 44 and pl. 1) describes the zone in Washoe County as a number of prominent, en-echelon, northwest-trending faults in a zone approximately 20 miles wide extending from Wadsworth, Nev., northeast through Honey Lake Valley and the southern end of the Smoke Creek Desert. This same zone then extends northwestward into California. Long, large-scale faults associated with this structural zone may provide continuity to zones of fractured bedrock which would not be present in other areas. Maps by Rush and Glancy (1967, pl. 1) and Bonham (1969, pl. 1) show the extent of these features in areas adjacent to Lemmon Valley.

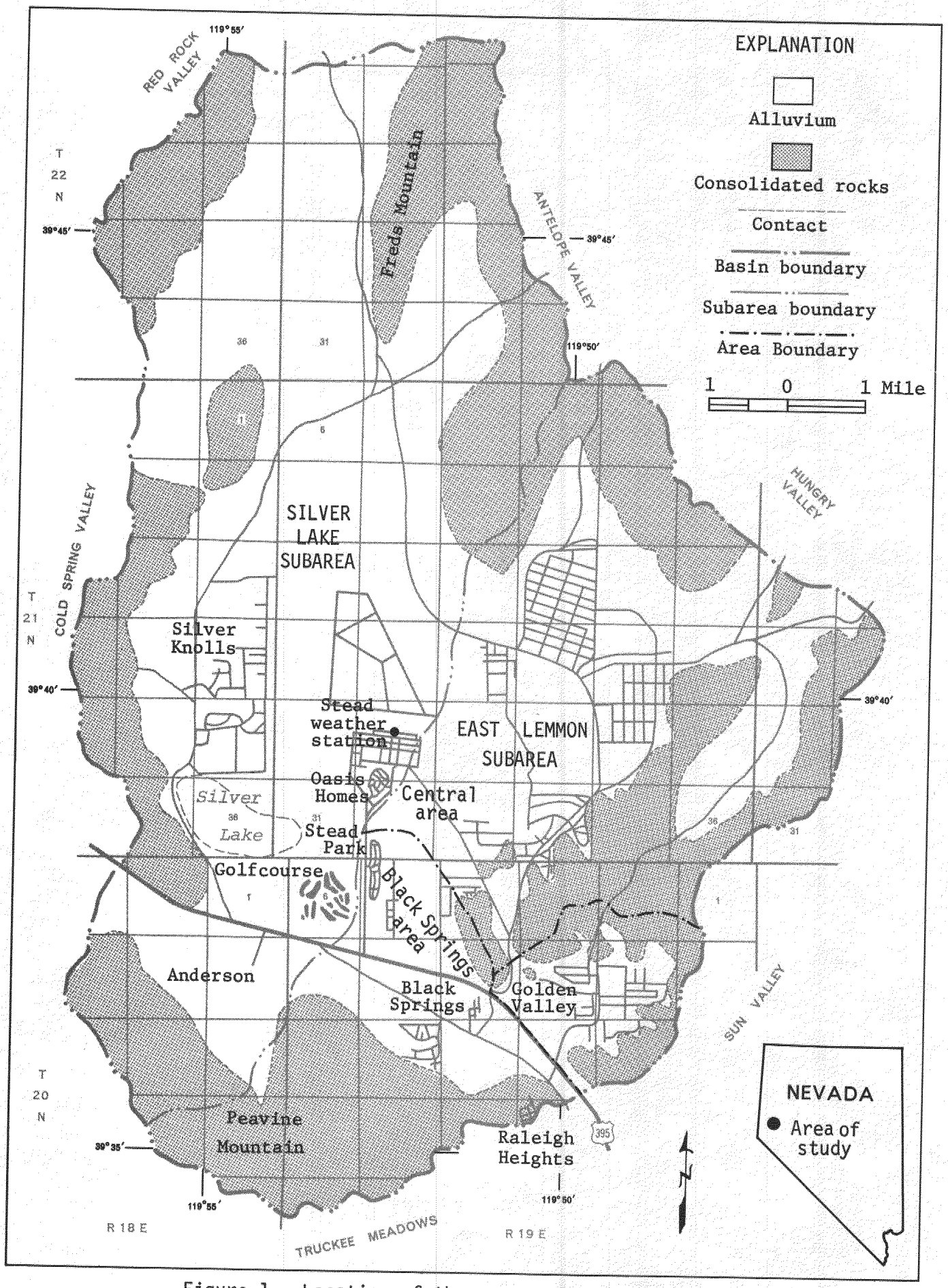

Figure 1.- Location of the area and general features

Table 2.—Principal lithologic units

Age			Unit designation	Estimated thickness (feet)	Lithology	Occurrence	General hydrologic properties
QUATERNARY	Pleistocene and Holocene	valley fill	Younger alluvium	0-300±	Unconsolidated alluvial and colluvial deposits of interbedded sand, gravel, silt, and clay. Materials generally moderately to well sorted and form lenticular bodies.	Occur as alluvial-fan deposits around margins of the valley and lakebed and playa deposits in central part of the valley.	Permeability ranges from low to high. Zones of high permeability generally are sand and gravel deposits.
	Pleistocene		Older alluvium	0-1200±	Alluvial and colluvial deposits of gravel, sand, silt, and clay. Partially consolidated (cemented) locally and at depth. Deposits at depth in central part of valley may contain slightly higher proportion of sand and gravel than overlying deposits.	Occur along margins of the valley primarily as alluvial-fan deposits and underlies younger alluvium. In many areas these deposits have been structurally deformed. Uplifted areas have generally been dissected by streams.	Permeability ranges from low to high. Low permeabilities generally associated with semiconsolidated deposits or deposits high in silt and clay. Faults may form barriers to ground-water movement. Deposits at depth near the centers of the valleys form the most productive known aquifers in the valley.
TERTIARY		consolidated rocks	Volcanic rocks	--	Flows of andesite, basalt, and rhyolite, flow breccia, mudflows, and associated sedimentary rocks. Include rocks from the Pyramid sequence, Hartford Hill Rhyolite tuff, Alta Formation, and an unnamed sequence of basalt and sedimentary rocks as mapped by Bonham (1967).	Occur as small outcrop at south end of Freds Mountain and around margins of Golden Valley. Large outcrops are present along east border of study area adjacent to Hungry Valley. Locally underlie valley fill.	Commonly have little or no interstitial porosity, except where highly vesicular. May transmit some water through joints and zones between flows.
CRETACEOUS			Granitic rocks	--	Principally granodiorite	Occur as faulted blocks which form the mountains north of Peavine Mountain. Have undergone several sequences of deformation and in local areas are highly faulted and fractured. Locally underlie valley fill.	Virtually no interstitial porosity and permeability; normally transmits small quantities of water through fractures and weathered zones. If highly fractured may be capable of transmitting moderate quantities of water.
TRIASSIC AND JURASSIC			Metavolcanic and metasedimentary rocks		Regionally and thermally metamorphosed volcanic flows, breccia, and pyroclastic and associated sedimentary deposits.	Occur on Peavine Mountain and as small outcrops along the west side of the valley. Locally underlie valley fill.	Low interstitial porosity and permeability. May transmit some water through fractures.

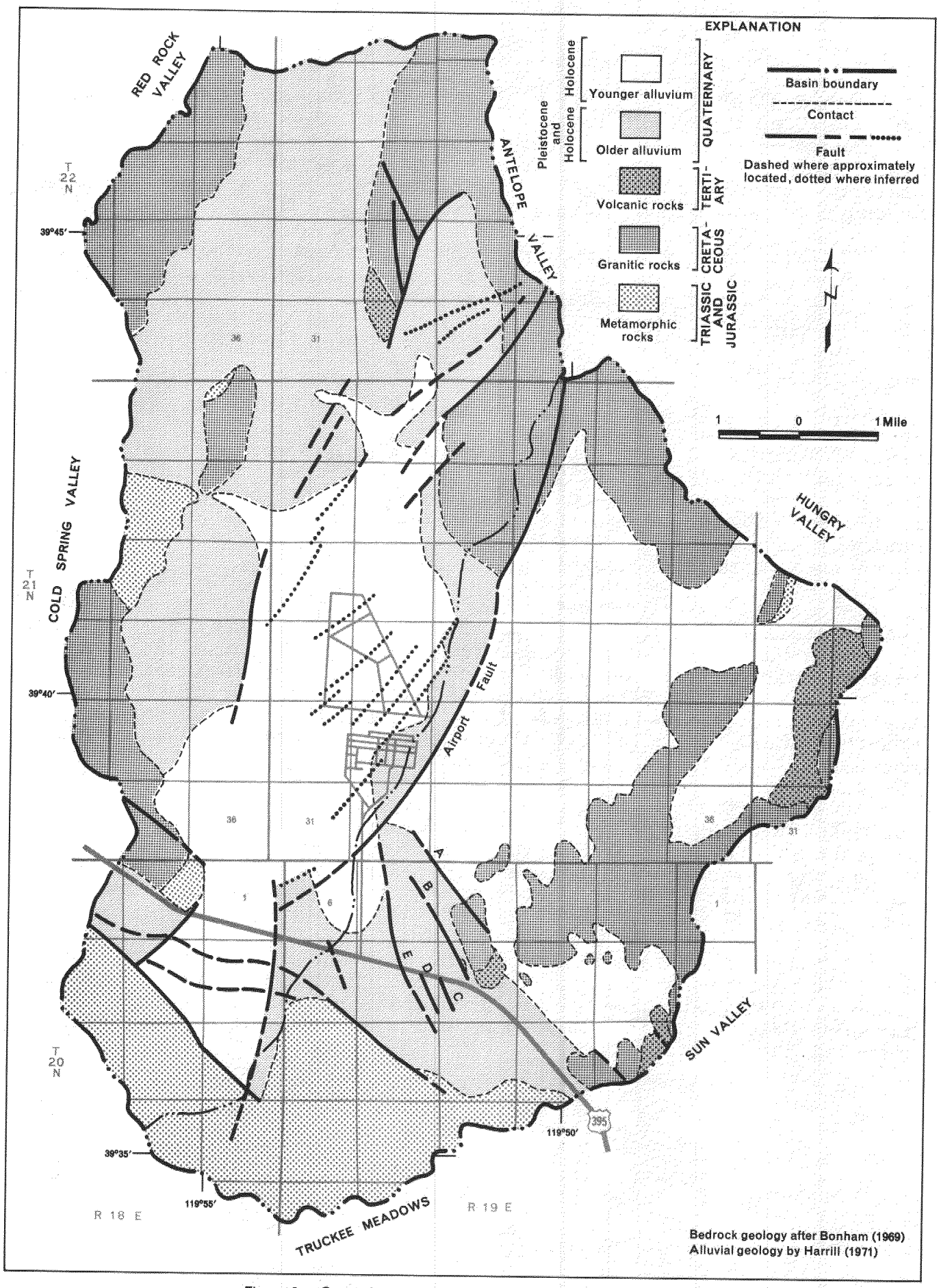

Figure 2.— Generalized geologic map of Lemmon Valley, Nevada

The faults shown on plate 1 are those mapped by Bonham (1969), Rush and Glancy (1967), and a few additional ones mapped during the course of this study. These represent only the most readily discernable faults. Examination of areal photographs and brief field observation suggest that other faults exist; however, it was beyond the scope of this study to properly map them.

The six faults that most discernably effect ground-water flow have been named or lettered so that they could be more easily referred to in later sections of this report. The name and the letters are shown in figure 2.

Climate

Climate in Lemmon Valley is similar to that of other valleys in western Nevada at comparable altitudes. Precipitation is controlled largely by topography. Air masses that move eastward over the State are generally deficient in moisture, and areas at low altitudes commonly receive less moisture than areas at higher altitudes. Winter precipitation generally falls as snow from regional storms, whereas summer precipitation is localized as thunderstorms of short duration and commonly of high intensity.

Records from one precipitation station in the valley and two nearby stations are listed in table 3. Average annual precipitation in Lemmon Valley probably ranges from slightly less than 8 inches on the lower part of the valley floor to more than 20 inches on the upper slopes of Peavine Mountain. Much of the precipitation at the south end of the valley falls on the north slope of Peavine Mountain where potential evapotranspiration is less than where the mountain slopes have a southerly exposure.

Rush and Glancy (1967, p. 7) summarized freeze data from published records of the U. S. Weather Bureau for six stations adjacent to the study area. These data suggest that in Lemmon Valley the summer period between 32°F frosts is usually about 100 to 130 days and the period between 28°F frosts is usually from about 130 to 170 days.

Precipitation records for nearby stations indicated that 1969 and 1970 were years of above-average precipitation at most stations. These two wet years immediately preceding this study probably have had some effect on water levels in wells and vegetation densities observed during this study.

Table 3.--Average monthly and annual precipitation, in inches, at three stations in or near Lemmon Valley

[From records of the National Weather Service]

Station[1/]	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Reno	1.27	0.91	0.71	0.45	0.61	0.41	0.28	0.20	0.26	0.42	0.65	1.05	7.22
Sand Pass	1.02	.83	.56	.44	.52	.53	.19	.12	.30	.47	.60	1.02	6.60
Stead AFB	1.3	1.28	.73	.51	1.18	.34	.31	.28	.31	.47	.64	1.07	a8.42

1. Information on station locations given below

Altitude	Station location	Period of record	Remarks
4,404	T.19 N., R.20 E., sec.18	34 years, 1937-70	About 10 miles south of study area.
4,198	T.28 N., R.20 E., sec.31	54 years, 1913-62, 1967-70	About 40 miles north of study area.
5,046	T.21 N., R.19 E., sec.29	13 years, 1952-66	Near center of study area. See figure 1.

a Computer printout of Stead AFB data showed average January precipitation of 3.98 inches and an average annual precipitation of 11.1 inches. Values shown in above table adjusted on basis of monthly distribution of precipitation at eight surrounding stations (Reno, Sand Pass, Doyle, Vinton, Portola, Sierraville RS, Doyle 5SSE, and Loyalton).

GROUND-WATER RESERVOIRS

Two ground-water reservoirs are recognized in the study area: (1) fractured consolidated rocks in the uplands adjacent to and at depth beneath valley fill, and (2) valley fill, which forms the principal water-bearing units.

Fractured Consolidated Rocks

Consolidated rocks of the types shown in figure 2 and described in table 2 are generally not capable of transmitting appreciable quantities of water, except where secondary permeability has developed as the result of structural deformation. Because of the high degree of structural deformation, bedrock in localized areas is capable of storing and transmitting enough water to be significant. For example, fractured granitic rocks in Golden Valley generally yield sufficient water to wells for domestic purposes. Also, public-supply well 20/19-4ddac, just downgradient from where Golden Valley drains to the Central Area, was drilled to a depth of 296 feet in bedrock and reportedly produces 440 gallons a minute from "hard rock with fractures." Fractured bedrock also appears to be transmitting water along a zone immediately east of the Airport Fault (pl. 1). This is inferred from water levels in nearby alluvium and is discussed further in a later part of this report.

Table 4 lists estimated transmissivities and average permeabilities for selected wells drilled in consolidated rocks.

Generally, the permeability of fractured consolidated rocks is not high, and the chance of developing a high-yield well in them is small. Consequently, fractured bedrock is generally less favorable for ground-water development than the valley-fill reservoir. However, zones of fractured bedrock associated with major faults may transmit intervalley ground-water flow.

Valley-Fill Reservoir

The valley-fill reservoir is composed of younger and older alluvium that partly fills the structural depression underlying Lemmon Valley. These deposits contain the most productive aquifers in the area and are considered the more feasible source for large-scale development of ground-water supplies. Consequently, elements of the hydrologic system are discussed in terms of their relation to the valley-fill reservoir.

Table 4.--Estimated transmissivity and average permeability of bedrock

[Based on data in drillers' logs]

Location	Depth (feet)	Estimated transmissivity (gpd/ft)	Open interval[1] From	To	Thickness	Type of rock	Average permeability for open interval[2] (gpd/ft^2)
20/19-10aa[3]	160	7,500	110	160	50	Granite	150
-10dabd1	150	1,000	90	150	60	Granite	17
-14abbc2	100	1,000	54	100	46	Fractured rhyolite	22
-14a[4]	135	2,800	68	135	67	Fractured rhyolite	42
-14a[5]	155	1,100	64	155	91	Fractured rhyolite	12
-15bcca	216	240	116	216	100	Granite	2

1. Either perforated casing or uncased hole in bedrock.
2. Average permeability for entire thickness of open interval. Water commonly produced from smaller interval of fractured rock.
3. State log number 6922, not shown on plate 1 or listed in table 24.
4. State log number 11726, not shown on plate 1.
5. State log number 11735, not shown on plate 1.

Extent and Boundaries

The valley-fill reservoir occupies the central parts of both Silver Lake and East Lemmon subareas. It has a surface area of about 50 square miles. Consolidated-rock surfaces of adjacent uplands and their subsurface extensions form lateral and bottom boundaries of the reservoir.

The configuration of the bottom surface cannot be determined from existing data. Figure 3 shows the approximate areal extent of the valley-fill reservoir and selected depths to consolidated rocks as reported in drillers' logs. Because the valley-fill reservoir, as defined for this report, does not include areas of thin or unsaturated alluvial deposits, the area of the valley-fill reservoir is slightly less than the area of valley fill shown on plate 1. Several generalizations may be made from the data shown in figure 3. Thickness of fill in the Silver Lake subarea is generally greater than that in the East Lemmon subarea. Maximum thickness in the Silver Lake subarea is not known but probably is greater than 1,000 feet. Bonham (1969, p. 53) states that the northwest-trending fault that bounds the steep northeast face of Peavine Mountain has over 2,000 feet of dip-slip displacement. Maximum thickness of fill probably does not exceed this amount. Comparatively thin accumulations of fill are present in Golden Valley where the thickness did not exceed 200 feet in any of the wells. Thicker accumulations occur in the Black Springs area and depths to consolidated rocks of more than 400 feet are probable. However, considerable variation in thickness may occur due to structural relief caused by the faults shown on plate 1. In the Central Area, depth to bedrock ranges from less than 100 feet along the southeast side of the valley to more than 600 feet near the Airport Fault.

Transmissivity and Storage Coefficients

The transmissivity and storage coefficient express certain water-bearing properties of the valley fill. Transmissivity is a measure of the ability of an aquifer or reservoir to transmit water. It is dependent on the permeability and the thickness of the aquifer. The coefficient of storage is a measure of the amount of water that will be released from storage, within a unit area, as water levels are lowered. These coefficients may be used for computing drawdowns and storage changes caused by pumping, or in the determination of subsurface flow.

Transmissivity may be estimated from specific capacities of wells, which are usually expressed as yield in gallons per minute per foot of drawdown. Properly designed wells in deposits with high transmissivities have higher specific capacities than wells tapping deposits with low transmissivities.

Transmissivities were determined from one pumping test made during this study and from reported specific capacities and pumping-test data for nine other wells. These estimates are shown in figure 4, and represent the ability of thick sections of valley fill to transmit water laterally. Insufficient data are available to delineate zones of different transmissivity. Point values shown range from less than 10,000 gpd (gallons per day) per foot of aquifer near Peavine Mountain to nearly 100,000 gpd per foot near the center of the Silver Lake subarea. Because estimates of transmissivity made from specific capacities are sometimes low, maximum transmissivity may exceed 100,000 gpd per foot. As previously mentioned, transmissivity is the product of the average permeability and thickness. Table 5 lists estimates of the average permeability of water-bearing materials described in drillers' logs. The most common water-bearing material is described as sand. Estimated average permeabilities range from about 12 to 360 gpd per square foot; however, because specific capacities locally may be affected by barriers, the lower values probably are correspondingly small.

A storage coefficient of 0.0003 was computed from the short-term pumping test run on well 20/19-15bbdc2. This value indicates that response to short-term pumping is artesian. Over the long-term, however, most alluvial deposits drain slowly in response to pumping, and the coefficient of storage usually will be nearly equal to the specific yield. Thus, in any analysis of long-term cause and effect relations, the valley-fill reservoir must be considered as a water-table system. Storage coefficients may be approximated from the specific-yield values discussed in the next section.

Specific Yield

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, usually expressed as a percentage (Meinzer, 1923, p. 26). Estimates of average specific yield of the upper 50 feet of saturated deposits (nonpumping water levels) were made from descriptions in drillers' logs. Deposits described were grouped into the five general lithologic categories listed in table 6. Specific-yield values were assigned to each category on the basis of values determined by Morris and Johnson (1966) for similar deposits. Observations made by the U. S. Geological Survey while drilling 27 small-diameter test holes in undeveloped parts of the valley were used to supplement information from drillers' logs.

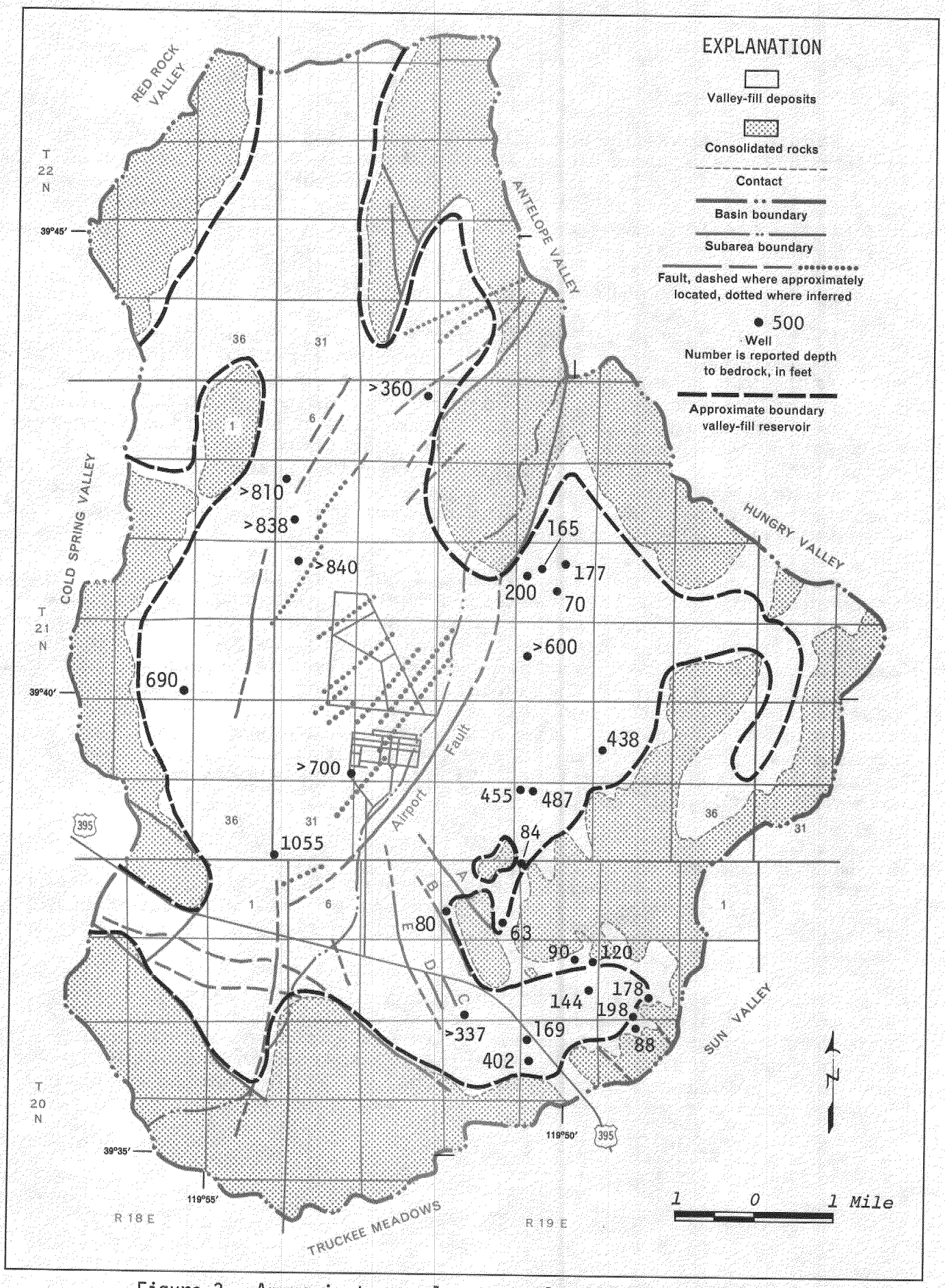

Figure 3.- Approximate areal extent of valley-fill reservoir and selected depths to bedrock at wells

Figure 5 shows the estimated distribution of specific yield in Lemmon Valley. Areas of lowest specific yield are associated with playa deposits in the Silver Lake and East Lemmon subareas. Weighted average specific yield of the valley fill is about 16 percent in the Silver Lake subarea and about 14 percent in the East Lemmon subarea.

Source, Occurrence, and Movement of Ground Water

Virtually all ground water in the valley, except that recharged from imported water, is derived from infiltration of precipitation that falls within the drainage basin. Most deep infiltration is from runoff and occurs on the upper slopes of the alluvial apron; however, some deep infiltration also occurs in the mountains where percolating water moves through bedrock fractures to the zone of saturation, then laterally to the valley-fill reservoir. During exceptionally wet years, significant amounts of moisture may also infiltrate to the zone of saturation from precipitation on the upper slopes of the alluvial apron.

Ground water occurs in saturated parts of the valley fill where it occupies intersticies present in the granular clastic deposits and chemical precipitates. It occurs under both water-table and artesian conditions. Artesian conditions occur where saturated permeable deposits are overlain by less permeable strata and where the water at the top of the aquifer is greater than atmospheric pressure. Water-table conditions exist where the saturated deposits are not confined by poorly permeable strata and where the water pressure at the top of the zone of saturation, the water table, is equal to atmospheric pressure. Figure 6 shows approximate depths to water in the fall of 1971.

Artesian conditions occur in secs. 1, 2, 11, and 12, T. 20 N., R. 18 E., and sec. 36, T. 21 N., R. 18 E. This area contains several springs and seepage areas and some flowing wells. Artesian conditions also occur at depth in the valley fill where lenticular deposits of silt and clay partially confine the water in underlying deposits.

Ground water moves along the paths of least resistance from areas of high hydraulic head to areas of low hydraulic head. The rate of movement depends on the hydraulic gradient and the permeability and porosity of the material through which the water is moving. Typical rates probably range from a few feet to several hundred feet per year.

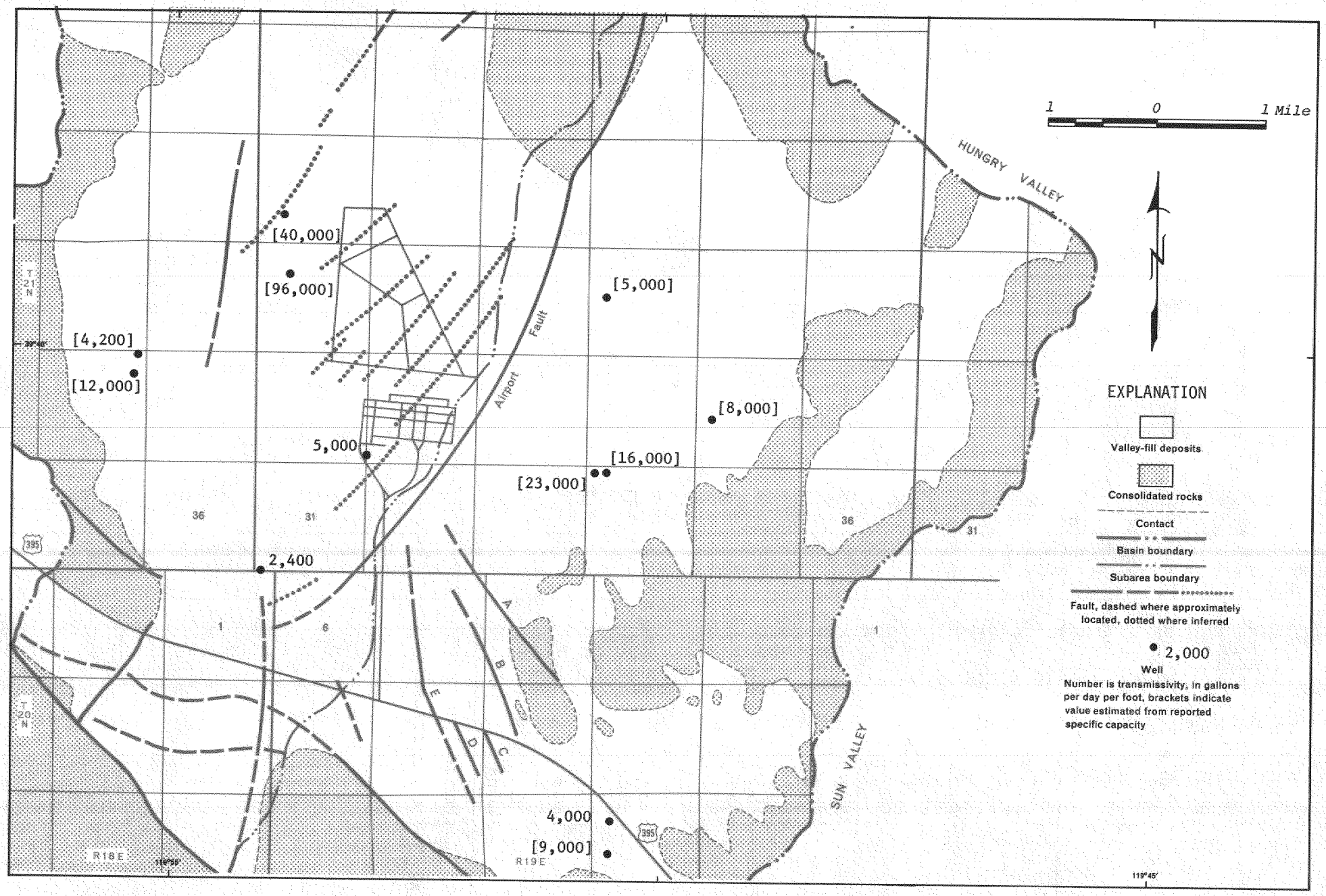

Figure 4.- Distribution of transmissivity values in the valley-fill reservoir

Table 5.--Estimated permeability of water-bearing material in the valley fill

[Based on data in drillers' logs]

Location	Transmissivity (gpd/ft)[1]	Thickness perforated interval (feet)	Water-bearing material: Description	Water-bearing material: Thickness in perforated interval	Water-bearing material: Average permeability (gpd/ft^2)
21/18-26aaab	4,200	62	sand	27	155
-26aadb	12,000	75	sand	33	360
20/19-11ddbc1	1,100	40	sand	21	52
-11ddbc2	800	40	sand	18	45
-11ddcb	800	40	sand	17	47
-15dbdc	4,000	135	sand, gravel, and rock	77	a 52
-15bcdc	11,400	200	sand	93	120
21/19-18cbdd	40,000	408	--	--	>100
-19bacc	96,000	336	sand, minor gravel	296	290
-22bcdc	5,000	400	sand, minor gravel	202	a 25
-26cbac	7,800	335	--	--	>23
-30ddda	5,000	483	sand, minor gravel	234	a 21
-31cccc1	2,400	1,012	sand, gravel	203	a 12
-34bbab	16,000	212	sand, some gravel and clay	98	160
-34bbba	23,000	268	sand	135	170

1. Estimated from reported specific capacities.

a. Value significantly lower than that expected from description of material.

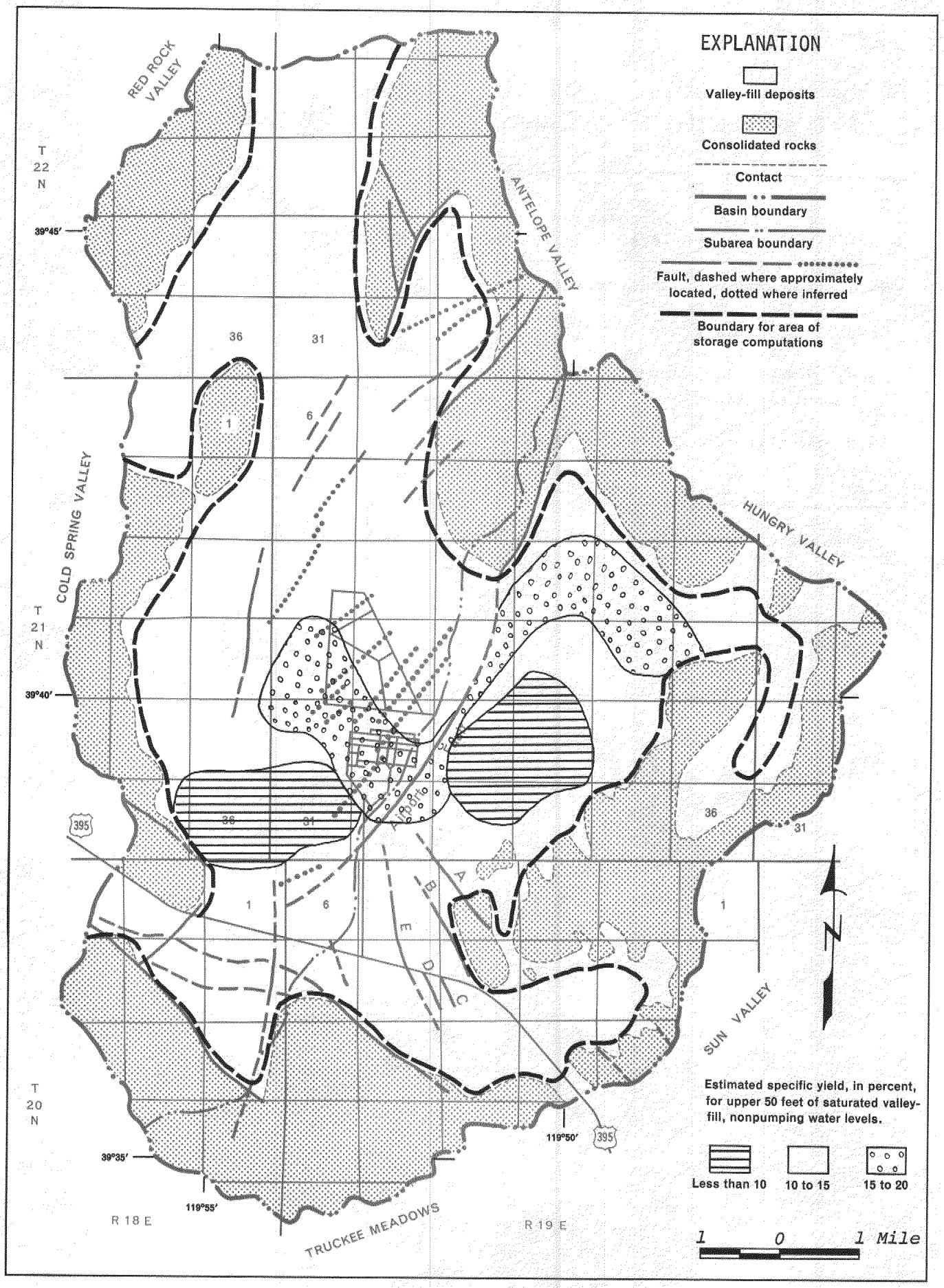

Figure 5.- Distribution of specific yield

Table 6.--Specific yields of materials described in drillers' logs

Lithologic category (based on drillers' description)	Assigned specific-yield value[1/] (percent)
Sand, fine, medium, and coarse	30
Gravel; sand and gravel	25
Sand, gravel, and clay; gravel and clay; cemented gravel	15
Sand and clay; sandy clay, silt, mud, muck	10
Clay	5+

1. Assigned specific-yield values based on Morris and Johnson (1966).

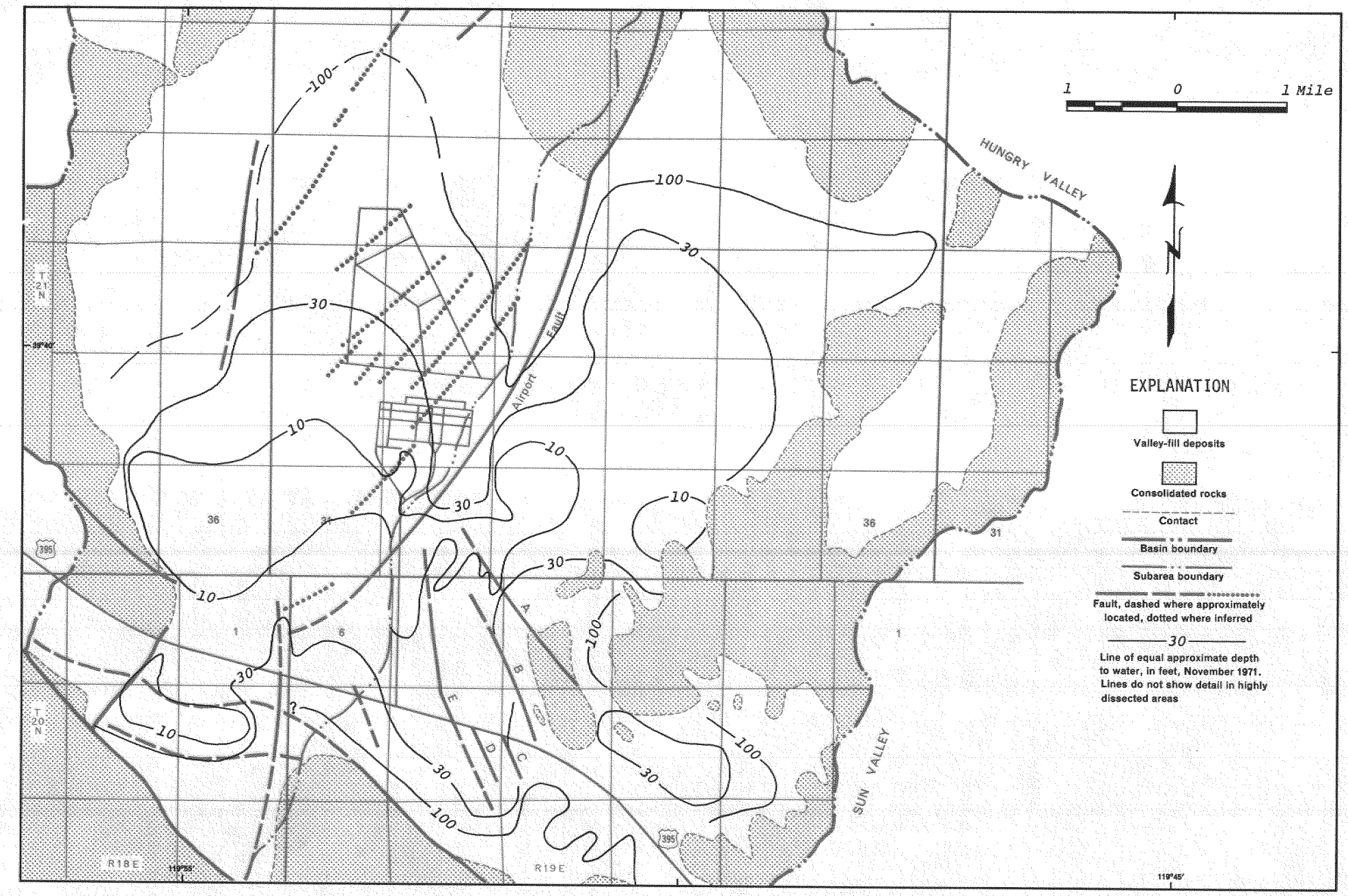

Figure 6.- Approximate depths to water, Fall 1971

The lateral movement of ground water in the valley fill generally is parallel to the slope of the water surface. A downward component of movement occurs in areas of recharge and an upward component occurs in areas of pumping and evapotranspiration. The slope of the water surface is shown in figure 7 which shows contours of approximate springtime water levels for natural conditions prior to any extensive withdrawal of ground water by pumping or any importation of water. Conditions for figure 7 were reconstructed from water-level measurements made in 1942 by the U. S. Army Corps of Engineers (table 25 at end of report), drillers' reports of water levels in older wells (table 24 at end of report), and some present-day water levels which are largely unaffected by development. These contours indicate the general direction of ground-water movement under natural conditions. The direction of movement is perpendicular to the contours.

Generally water moves from areas of recharge to areas of discharge in the central part of the valley. This pattern of flow is complicated by fault barriers (fig. 6). The principal effects of these barriers are (1) to restrict flow between the subareas, and (2) to compartmentalize parts of the valley-fill reservoir in the Black Springs area. These effects are evidenced by offsets of water levels on the opposite sides of faults. The most pronounced offset, about 100 feet, is across the Airport Fault.

A northeastward hydraulic gradient across faults A, B, C, D, and E is shown in figure 7. This probably is caused by the combined effects of localized recharge from streams which flow across the faults, ground-water spillover in topographically low areas, and possibly some subsurface leakage. Ground-water movement in this part of the valley is complex, but the contours as drawn suggest that there is very little flow between subareas.

Water-level contours in Golden Valley indicate that water moves from the low bordering mountains toward the center of the valley and then northwestward through a gap to the Central Area. Contours as drawn at the lower end of Golden Valley suggest that some ground water may flow through bedrock as it moves out of Golden Valley.

Ground water in the Central Area flows northwestward beneath areas of evapotranspiration in the center of the valley. Water not consumed by evapotranspiration flows to a linear ground-water sink immediately east of the Airport Fault. Ground-water levels along the linear sink are the lowest in Lemmon Valley. The area of lowest observed water levels is remote from pumping and the water-level configuration could not be explained by the distribution of phreatophytes. Therefore, it is concluded that ground water probably flows out of the area through fractured bedrock adjacent to and east of the Airport Fault. The direction of flow is probably to the north.

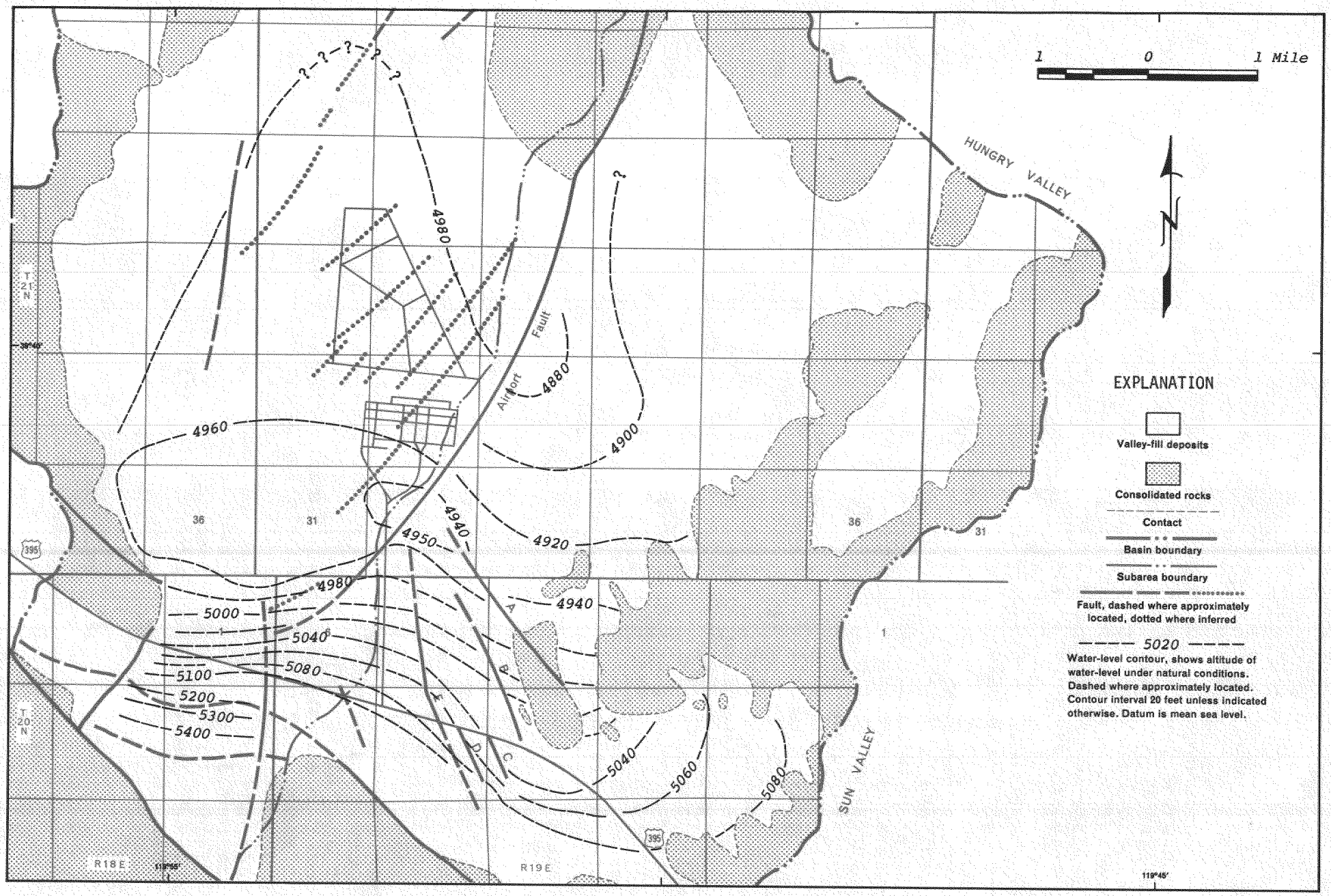

Figure 7.- Approximate water-level contours for natural conditions

Ground-water levels west of the Airport Fault are much higher than water levels east of the fault. Thus, the fault acts as a barrier to movement in the valley fill; however, fractured consolidated rocks adjacent to the fault may act as a ground-water drain. It was not determined why indications of subsurface drainage were observed only east of the fault. Adequate hydraulic continuity may be developed only along the east side of the fault.

Not shown in figure 7 are indications of the vertical movement of ground water. Three sets of paired wells (two adjacent wells of different depths) were drilled to obtain information on vertical movement of water. Wells 21/19-22bdab1 and 2, and 21/19-26 cccd1 and 2, in phreatophyte areas in the Central Area, exhibited differential heads which indicated upward movement of water. Under natural conditions upward movement also occurred in Silver Lake subarea near wells 21/18-36addb1 and 2. This natural gradient is reversed during summer months as a result of pumping nearby wells 21/19-31cccc2. The upward component of movement was noted in wells less than 150 feet deep. However, water levels in four deeper wells in the Silver Lake subarea, suggest downward leakage from the upper several hundred feet of valley fill to deeper valley-fill deposits. The U. S. Army Corps of Engineers (1943, p. 9) reported that in 1942 the water level in a shallow farm well, about 150 feet from well 21/19-31ccccl (total depth 1,170 feet and not perforated above 158 feet), was at an altitude about 12 feet higher than the water level in the deep well. Also, water levels in wells 21/19-18bada, 21/19-18cbdd, and 21/19-19bacc (all three wells deeper than 800 feet and not perforated above 300 feet) are significantly lower than water-level contours drawn using only nearby shallow wells.

A northward gradient is present from well 21/19-18cbdd to well 21/19-18bcba. The absolute difference in altitude is small, only about 2 feet, but was confirmed by instrumental leveling. (See water-level measurements and relative land-surface altitudes listed in table 24 at the end of the report.) Also, a northward gradient exists from well 21/18-24adac to wells 21/18-24aabc and 21/18-24aabd. Here the absolute minimum difference in water-level altitudes is about 10 feet which, even though not checked by instrumental leveling, probably is significant. These observations could be explained by poor hydraulic continuity between wells, different perforated intervals, or local affects of pumping. However, the explanation that best fits the above-inferred downward movement of ground water and localized northward hydraulic gradient is leakage into bedrock similar to that postulated adjacent to the Airport Fault in East Lemmon subarea. In this case, however, there is insufficient information to evaluate the possibility.

INFLOW TO THE VALLEY-FILL RESERVOIR

Precipitation

Precipitation is the source of virtually all the water naturally entering the hydrologic system in Lemmon Valley. Of the precipitation that falls on the basin, part is directly evaporated from vegetation or the ground surface, part runs off as surface flow, part infiltrates to shallow depths where it replenishes soil moisture, and part eventually infiltrates to the zone of saturation where it recharges the ground-water system. The total average annual precipitation in Lemmon Valley is about 50,000 acre-feet (table 8, later in report).

Surface Water

by D. O. Moore

General Conditions

Runoff in Lemmon Valley is generated by high intensity precipitation or rapid snowmelt, and is more frequent and more intense on the mountain blocks than on the lowlands. Minor amounts of surface-water flow from springs occur locally in stream channels on the northeastern flank of Peavine Mountain. One of the largest springs, in the east half of sec. 20, T. 20 N., R. 19 E. (pl. 1), had a flow of 0.3 cfs (cubic feet per second) in August 1971.

Occasional flow may occur locally on alluvial fans and playa areas. Although this type of streamflow is so erratic in frequency and duration that it is difficult to use directly, it may provide significant recharge to the ground-water system. Most runoff infiltrates or is lost by evapotranspiration as it moves downstream. During periods of exceptionally high intensity rainfall or during periods of rapid snowmelt, part of the flow reaches the lowlands. Runoff increases downstream within the mountain blocks and then decreases as it crosses valley fill after leaving the mountains.

Estimated Runoff

Runoff has not been recorded by gaging stations in Lemmon Valley; however, the characteristics of runoff are similar to the infrequent and short-duration flow at a nearby gaging station, Peavine Creek near Reno, Nev. Flows at this station are summarized in table 7. The relation between flow volume and flow duration is variable. The short-term record suggests that most runoff occurs during the winter months.

The amount of runoff from the mountains cannot be computed directly because of the absence of streamflow data. Therefore,

Table 7.--Discharge and duration of flow in Peavine Creek near Reno, Nev., January 1963-December 1970

Date	1963 Discharge (acre-ft)	1963 No. days of flow	1964 Discharge (acre-ft)	1964 No. days of flow	1965 Discharge (acre-ft)	1965 No. days of flow	1966 Discharge (acre-ft)	1966 No. days of flow
Jan.	14	1	0		55	15	0	
Feb.	59	11	0		10	22	0	
Mar.	0		0		0		0	
Apr.	0		0		0		0	
May	0		0		0		0	
June	0		0		0		0	
July	0		0		0		0	
Aug.	0		0		0		0	
Sept.	0		0		0		0	
Oct.	0		0		0		0	
Nov.	0		0		0		0	
Dec.	0		46	10	0		0	
Total	73	12	46	10	65	37	0	0

Date	1967 Discharge (acre-ft)	1967 No. days of flow	1968 Discharge (acre-ft)	1968 No. days of flow	1969 Discharge (acre-ft)	1969 No. days of flow	1970 Discharge (acre-ft)	1970 No. days of flow
Jan.	32	5	0		33	12	28	16
Feb.	8.5	24	0		22	28	0.4	2
Mar.	60	16	0		63	31	0	
Apr.	0.8	4	0		25	24	0	
May	0		0		0		0	
June	0		0		0		0	
July	0		0		0		0	
Aug.	0		0		0		0	
Sept.	0		0		0		0	
Oct.	0		0		0		0	
Nov.	0		0		0		0	
Dec.	0		0		0		0	
Total	101.3	49	0	0	143	95	28.4	18

methods described by Moore (1968) were used to estimate runoff and are based on use of altitude-runoff relations, which are adjusted for local differences in geology, precipitation, vegetation, and land slopes. These estimates in turn are corroborated by use of a channel geometry-runoff relation. Estimates at several sites within Lemmon Valley were made by using channel-geometry measurements.

Estimated mean annual runoff in Lemmon Valley totals about 3,400 acre-feet per year. Of this total, about 2,200 acre-feet is generated in the Silver Lake subarea and about 1,200 acre-feet is generated in the East Lemmon subarea. Areas contributing to runoff, its general distribution, and the estimated average annual runoff are shown in figure 8. Peavine Mountain, the highest and wettest part of the area, generates the largest amount of runoff per unit area of any runoff-producing area in the valley. About three-fourths of all the runoff in the East Lemmon subarea is generated on Peavine Mountain. In the Silver Lake subarea, however, only about 60 percent of the total runoff is generated on Peavine Mountains. The remainder is from large areas of lower-unit runoff production at the north end of the subarea, as shown in figure 8.

Playa Flooding

During periods of high winter and spring runoff in most years, Silver Lake playa is flooded by surface-water flow. This probably is due more to proximity to Peavine Mountain and the steep gradients on the fan than to excessively large runoff. Average annual surface-water runoff to Silver Lake playa is estimated to be 400 to 500 acre-feet per year on the basis of geometry measurements of channels which drain onto the playa. The other playas are flooded very infrequently, and the average quantity of streamflow reaching them is considered to be small.

Ground-Water Recharge

In this valley, as in many other valleys in the State, much of the ground-water recharge occurs on the alluvial apron and is derived principally from runoff generated in the adjacent mountains. Recharge also occurs in the mountains and moves as underflow across the bedrock-alluvial contact to the valley-fill reservoir. During wet years, additional recharge may be generated on the alluvial apron from high-intensity precipitation or snowmelt.

Table 8.--Estimated average annual precipitation and ground-water recharge from precipitation

Precipitation zone (altitude in feet)	Area (acres)	Estimated range (inches)	Annual precipitation: Average (feet)	Annual precipitation: Average (acre-feet)	Estimated recharge: Percentage of precipitation	Estimated recharge: Acre-feet per year
East Lemmon Subarea						
>8,000	30	>20	1.7	51	25	13
7,000-8,000	300	15-20	1.5	450	15	68
6,000-7,000	1,910	12-15	1.1	2,100	7	150
5,000-6,000						
(a)	9,520	8-12	.8	7,600	3	230
(b)	8,920	8-12	.8	7,100	1	71
<5,000	6,400	<8	.5	3,200	minor	--
Subtotal (rounded)	27,000			21,000	2+	500
Silver Lake Subarea						
>8,000	90	>20	1.7	150	25	38
7,000-8,000	650	15-20	1.5	980	15	150
6,000-7,000	3,730	12-15	1.1	4,100	7	290
5,000-6,000						
(a)	18,400	8-12	.8	14,700	3	440
(b)	8,820	8-12	.8	7,100	1	71
<5,000	3,300	<8	.5	1,600	minor	--
Subtotal (rounded)	35,000			29,000	3+	1,000
Total (rounded)	62,000			50,000	3	1,500

a. Areas of exposed bedrock or steeply sloping alluvial surfaces where runoff probably occurs.
b. Comparatively flat alluvial surfaces where little recharge occurs.

Average annual recharge may be estimated as a percentage of the average annual precipitation within the basin (Eakin and others, 1951, p. 79-81). Hardman (1965) demonstrated that in gross aspect, the average annual precipitation in Nevada is related closely to the altitude of the land surface and that it can be estimated with a reasonable degree of accuracy by assigning precipitation rates to altitude zones. Thus, recharge may be estimated as a percentage of the precipitation within each zone.

Estimates of recharge for Lemmon Valley are summarized in table 8. The various precipitation zones were approximated from a 1965 revision of the Nevada precipitation map (Hardman, 1936) and are similar to those used by Rush and Glancy (1967) in their reconnaissance study of the area. Total estimated recharge from precipitation within the basin is about 1,500 acre-feet per year, or only about 3 percent of the total precipitation. This includes about 1,000 acre-feet per year in the Silver Lake subarea and about 500 acre-feet per year in the East Lemmon subarea.

The annual estimate of recharge to Silver Lake subarea may be somewhat high, because during wet years some streamflow is rejected as recharge and flows onto Silver Lake playa, as previously described. However, the amount rejected is small and probably within the limits of error inherent in the crude method of estimating recharge.

This estimate of recharge for Lemmon Valley is about 20 percent less than that made by Rush and Glancy (1967). Different interpretations of the precipitation and recharge patterns can be expected to provide correspondingly different estimates of recharge.

The estimated average annual runoff of 3,400 acre-feet (fig. 8) for the entire valley is slightly more than twice the estimated recharge from precipitation of about 1,500 acre-feet per year. This ratio between recharge and runoff is in good agreement with results obtained from other areas in the State.

Subsurface Inflow

In order for intervalley flow to occur, two basic conditions must be met: (1) a hydraulic gradient must exist between the two areas, and (2) rocks separating the areas must be able to transmit water. Potential hydraulic gradients to Lemmon Valley from two adjacent valleys, Antelope Valley and Cold Spring Valley, are recognized on the basis of altitudes on U. S. Geological Survey topographic quadrangle maps and water-level data reported by Rush and Glancy (1967). Because of the high degree of structural deformation and resultant fracturing, consolidated rocks between both valleys and Lemmon Valley probably are able to transmit some water.

Water levels in the valley fill beneath the central part of Antelope Valley are about 200 feet higher than water levels in the East Lemmon subarea. However, Rush and Glancy (1967, p. 42) indicated that potential gradients from Antelope Valley also exist toward Bedell Flat and Warm Springs Valley to the north and northeast. They also reported that there was no observed evapotranspiration of ground water in the valley; thus, all discharge must be by subsurface outflow. If the conclusion regarding subsurface outflow from Lemmon Valley is valid, then subsurface outflow from Antelope Valley probably does not drain to Lemmon Valley.

Water levels beneath the playa in Cold Spring Valley are about 60 feet higher than ground-water levels beneath Silver Lake. Figure 2 shows several faults in the bedrock between the two valleys. One has a northwest orientation and terminates at the edge of the alluvium in the southwest corner of sec. 36, T. 21 N., R. 18 E., adjacent to a small spring and several flowing wells (pl. 1). Rush and Glancy (1967, p. 43) estimated that natural ground-water recharge to Cold Spring Valley exceeded the observed evapotranspiration by about 770 acre-feet per year. Therefore, ground water is potentially available to supply outflow from the valley. However, discharge from the spring and flowing wells adjacent to the fault are small. Thus, although some subsurface inflow from Cold Spring Valley is possible, the possible quantity (if any) is small and is believed to have little affect on the ground-water regimen of Lemmon Valley.

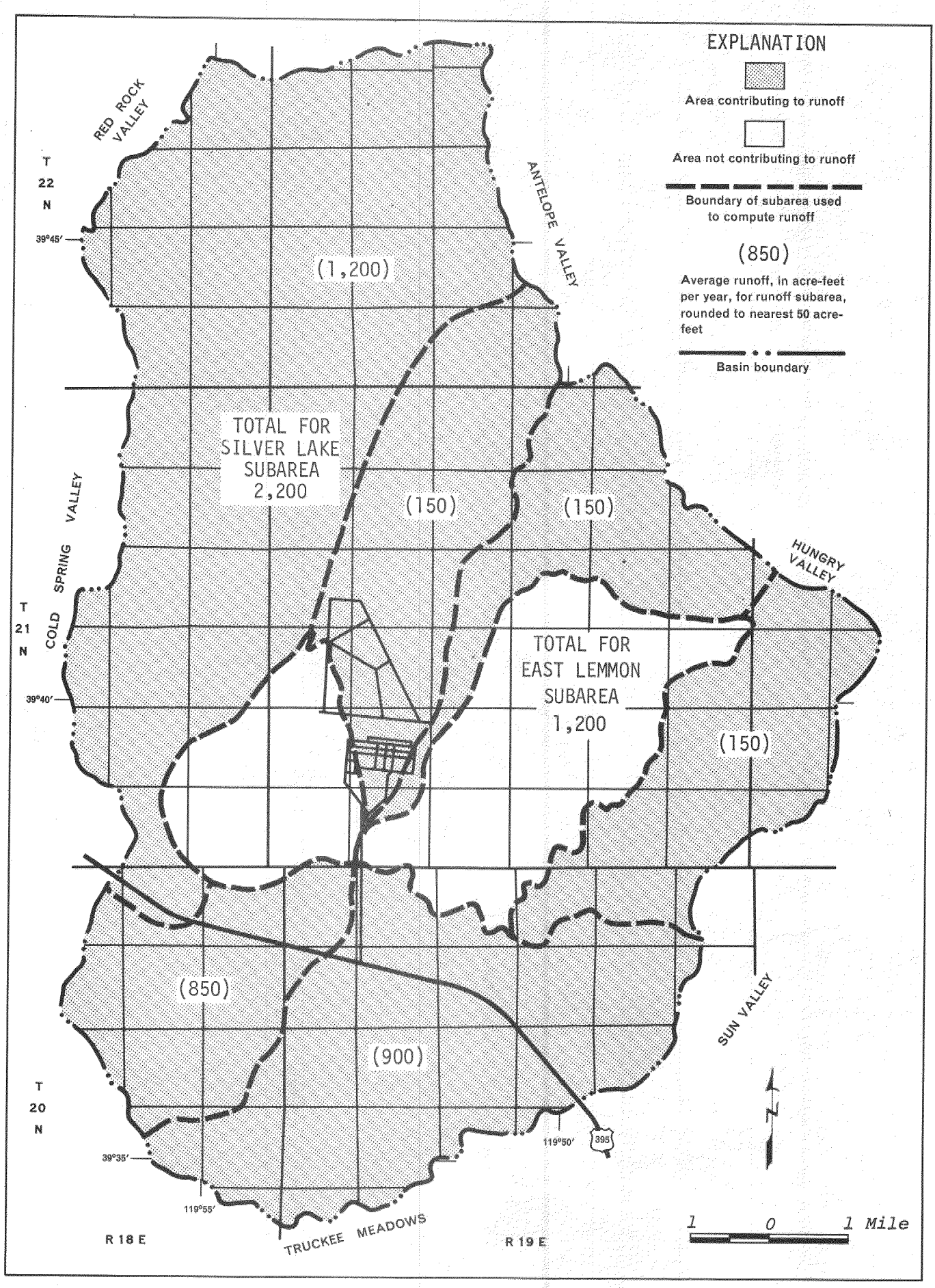

Figure 8.- Areas contributing to runoff and general distribution of runoff

NATURAL OUTFLOW

Natural outflow from the valley-fill reservoir occurs by evapotranspiration in areas of shallow ground water and by subsurface outflow from Lemmon Valley to other areas.

Evapotranspiration

Natural discharge of ground water occurs where the water level in the valley fill is at shallow depth. Natural discharge is accomplished principally in two ways: (1) by evapotranspiration in areas of phreatophytes; and (2) by direct evaporation from bare soil or where the capillary fringe extends to or near the land surface.

Plate 1 shows the distribution of phreatophytes in the summer of 1971. However, water has been imported to Lemmon Valley and used at the Stead Facility since the early 1940's, which has resulted in additional ground water being available for evapotranspiration near Stead. Consequently, some areas of vegetation mapped during this study are more dense and contain plants which use more ground water than the former natural assemblage. These areas are indicated on plate 1.

Estimates of the natural evapotranspiration of ground water are given in table 9. Where the vegetation has been affected by imported water, composition of the natural plant assemblage was estimated on the basis of adjacent areas not effected thereby and on water-level contours for natural conditions shown in figure 7. Estimates of evapotranspiration are based on rates of consumption of ground water as described by Lee (1912), White (1932), Houston (1950), and Robinson (1965). Estimated total evapotranspiration is about the same as estimated by Rush and Glancy (1967).

An attempt to measure the rate of upward leakage beneath two selected areas of phreatophytes by determining temperature gradients was made by Michael Sorey of the U. S. Geological Survey during July 1971. Small diameter wells 21/19-22bbab1 and 21/18-36addb1, each 150 feet deep, were drilled in June 1971. Well 21/18-36addb1 was drilled just north of Silver Lake in an area of low, stabilized sand dunes covered by a vigorous stand of greasewood and some sparse saltgrass; depth to water was about 11 feet. Well 21/19-22bbab1 was drilled north of the East Lemmon subarea playa in a healthy stand of greasewood and rabbitbrush; depth to water was about 20 feet. Temperature profiles measured in July were analyzed using a technique developed by Sorey (1971). The vertical flow of water in well 21/18-36 addb1 had apparently been effected by nearby well 21/19-31cccc2, which was being pumped to irrigate the Washoe County golf course, and a slight downward movement of water was indicated. A vertical upward flow of 0.85 acre-foot per acre per year was obtained from the data in well 21/19-22bbab1. The vigorous and healthy stand of

Table 9.--Estimated evapotranspiration of ground water (natural conditions)

Assemblage or type surface	Density	Depth to water (feet)	Area (acres)	Evapotranspiration (acre-feet per year)	Evapotranspiration (acre-feet)
Silver Lake Subarea					
Silver Lake playa[1]	--	0-5	430	a 0.5	220
Other playas[2]	--	5-10	170	.1	17
Greasewood and rabbitbrush	medium to low	10-35	870	.2	170
Greasewood and rabbitbrush[2]	medium	5-15	230	.5	120
Grass and spring-supported vegetation					
near Silver Lake playa	--	0-5	130	1.2	160
south of Highway 395	--	0-5	60	1.2	72
Subtotal (rounded)			1,900		760
East Lemmon Subarea					
Playa[2]	--	15-35	860	trace	small
Greasewood and rabbitbrush[2]	medium to low	10-40	2,000	.2	400
Channel-bottom vegetation[2] grass, willows, rabbitbrush	medium to high	0-15	40	.5	20
Subtotal (rounded)			2,900		420
Total (rounded)			4,800		1,200

1. Covered by water during part of some years.
2. Assemblage contains localized areas where natural evapotranspiration has been effected by imported water, and evapotranspiration rates in 1971 are significantly higher than the estimated natural rates shown in this table.

a. Evaporation of ground water only

rabbitbrush and greasewood near the well suggests this rate is probably near the maximum for greasewood and rabbitbrush in the East Lemmon subarea for growing-season conditions. Consequently, the average rate shown in table 9 is significantly less.

Use of temperature gradients to estimate upward leakage to phreatophytes is a promising technique. A practical application of the theory has been developed by Sorey (1971); however, field techniques regarding well construction, site selection, sampling densities, and other factors must be improved before this method can be utilized with full confidence.

Comparatively little is known about the rate at which ground water is evaporated from playa surfaces. An estimated average rate of 0.5 foot per year is used for Silver Lake and 0.1 foot per year is used for other playa surfaces in the Silver Lake subarea. These are rates which have been used in the study of similar areas of the State. Depth to water in the East Lemmon subarea playa exceeded 15 feet under natural conditions, and ground-water evaporation is considered to be small.

Subsurface Outflow

The probable subsurface outflow along the east side of the Airport Fault in the East Lemmon subarea under natural conditions can be estimated directly from water-level contours shown in figure 7 and transmissivity values shown in figure 4. A simple flow net was constructed, and flow toward the Airport Fault was estimated using the formula:

$$Q = 0.00112\ TIW$$

where Q is quantity of flow in acre-feet per year; 0.00112 is a constant to convert gallons per day to acre-feet per year; T is estimated transmissivity, in gallons per day per foot; I is hydraulic gradient, in feet per mile; and W is width of flow section, in miles. A transmissivity of 5,000 gpd per foot was used for flow sections (total width, 1.6 miles; average gradient, 15 feet per mile) adjacent to the fault. All other flow sections (total width, 1.45 miles; average gradient, 34 feet per mile) crossed the playa, and a transmissivity of 2,000 gpd per foot was used for less permeable playa deposits. By substituting these values in the above equation, total computed flow toward the Airport Fault was estimated to be about 250 acre-feet per year. Evapotranspiration from about 200 acres of greasewood along the west side of the playa is about 40 acre-feet per year. Thus, as computed by the flow-net analysis for natural conditions, about 200 acre-feet per year flowed into the sink along the west side of the Airport Fault.

Water-level contours on plate 1 indicate the direction of flow in the valley fill but do not indicate the direction of flow in bedrock along the linear sink area. Any nearby area where a potential gradient exists from East Lemmon subarea is a possible recipient of any subsurface outflow from the valley. However, the regional geologic structure associated with the Walker Lane fault zone strongly suggests that the outflow from Lemmon Valley probably is moving generally northward through highly fractured consolidated rocks to one or more valleys north of the area having lower water-level altitudes. These areas are included on the map prepared by Rush and Glancy (1967, pl. 1) and preliminary ground-water budgets prepared in that study suggest that some intervalley ground-water flow may occur. However, determination of this complex flow system could not be resolved with the meager data available in Lemmon Valley and adjacent areas.

GROUND-WATER BUDGET FOR NATURAL 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.

Table 10 is a ground-water budget which lists estimates of recharge to and discharge from the valley-fill reservoir under natural conditions. The budgets for both subareas and the total for Lemmon Valley show imbalances of between 5 and 20 percent of inflow and outflow values. The largest imbalance, 20 percent, is for Silver Lake subarea. As previously mentioned, the estimated recharge may be high (p. 37) and subsurface outflow may be low (p. 32). In addition, imbalances in general are due principally to the crude methods available to estimate most elements of inflow and outflow. Because a single value is needed to represent both inflow and outflow for computations of the available supply, rounded values were selected and are shown in table 10.

Table 10.--Ground-water budget for natural conditions in Lemmon Valley

[All estimates in acre-feet per year]

Budget item		Silver Lake subarea	East Lemmon subarea	Total for Lemmon Valley
NATURAL INFLOW				
Recharge from precipitation (table 6)		1,000	500	1,500
Possible inflow from Cold Spring Valley (p. 44)		minor	0	minor
Net inflow from Silver Lake subarea (p. 34)		--	minor	--
Total (rounded)	(1)	1,000	500	1,500
NATURAL OUTFLOW				
Evapotranspiration (table 9)		760	420	1,200
Net outflow from Silver Lake subarea (p. 34)		minor	--	--
Subsurface outflow (p. 48)		(a)	200	200
Total (rounded)	(2)	760	620	1,400
IMBALANCE (rounded) (1) - (2)		200	-100	100
Values selected to represent both inflow and outflow		900	500	1,400

a. Excludes possible subsurface outflow through fractured consolidated rocks.

CHEMICAL QUALITY OF WATER

Partial or detailed analyses of water samples from 23 wells and 1 spring were made during the course of this study to evaluate the quality of ground water as of 1971. These analyses are listed in tables 12 and 13 along with 46 other analyses made prior to this study. Specific-conductance determinations were made for 38 water samples from U. S. Geological Survey test wells and selected hydrologic points. These values are listed in table 14.

Variations in Water Quality

For purposes of this report, waters are classified on the basis of their predominant anion and cation. Calcium bicarbonate and sodium bicarbonate are the principal water types in the area. Detailed analyses of water beneath the playas were not made, but in other areas these waters are typically sodium chloride and sodium sulfate types.

The chemical quality of water changes as the water moves from areas of recharge near the mountains to areas of ground-water discharge near the center of the valley. Readily discernable changes do not occur until the water reaches discharge areas. Evapotranspiration causes residual salt to be concentrated in the discharge areas. This is illustrated by figure 9, which shows variations of dissolved-solids content of water samples in Lemmon Valley. Limited data from paired wells (a shallow well drilled next to a deeper one) indicate that beneath playas the quality of water improves with depth. For example, the estimated dissolved-solids content of water from well 21/18-36 addb2 (13.5 feet deep) is about 11,000 mg/l (milligrams per liter), whereas the estimated dissolved-solids content of water from well 21/18-36addbl (150 feet deep and about 10 feet from the shallow well) is only about 1,600 mg/l. Owing to lack of control points, the vertical extent of naturally salty water beneath the playas was not delineated in this study.

Suitability for Use

On the basis of the data in tables 12 and 13, virtually all water samples, except some from shallow wells on or near the playas, were of suitable chemical quality for irrigation and domestic purposes. One exception is water from deep well 21/19-31ccccl, which has a noticeable hydrogen-sulfide smell and required treatment before it was used as a supply at Stead Air Force Base prior to the time that water was imported to the valley. For more specific information regarding the suitability of water for use, the reader is referred to the following published references:

Type of use	Reference
Agricultural	Federal Water Pollution Control Administration (1968)
	McKee and Wolf (1963)
	U. S. Salinity Laboratory (1954)
Domestic	U. S. Public Health Service (1962)

Most water withdrawn for use in Lemmon Valley is for domestic purposes. The U. S. Public Health Service drinking water standards, which are generally accepted as standards for public supplies, are listed below as they apply to data in tables 12 and 13:

Constituent	Recommended maximum concentration (milligrams per liter)
Iron (Fe)	0.3
Sulfate (SO_4)	250
Chloride (Cl)	250
Fluoride (F)	a 0.9
Nitrate (NO_3)	45
Arsenic (As)	0.01
Total dissolved solids	500

a. The optimum concentration for average annual maximum daily temperature of 64-71 degrees.

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

Among the listed constituents, excessive iron causes staining of porcelain fixtures and clothes, large amounts of chloride and dissolved solids impart an unpleasant taste, and sulfate can have a laxative effect on persons who are drinking a water for the first time. Excessive fluoride tends to stain teeth, especially of children, and large amounts of nitrate are dangerous for infants and pregnant women because of the possibility of "blue-baby" disease.

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

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

The bacteriological quality of drinking water also is important but is outside the scope of this report. If any doubt exists regarding the acceptability of a drinking-water supply, contact the Nevada Bureau of Environmental Health, Carson City, Nev.

Table 12.--Partial chemical analyses of water from wells and springs

[Field-office analyses by the U.S. Geological Survey, except as indicated]

Location	Source	Date sampled	Temperature °F	Temperature °C	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) plus potassium (K)[3]	Bicarbonate (HCO_3)[4]	Sulfate (SO_4)	Chloride (Cl)	Hardness as $CaCO_3$	Specific conductance (micromhos per cm at 25°C)	pH (lab. determination)	Factors affecting suitability for irrigation[2]: Salinity hazard	Sodium hazard	Residual sodium carbonate (RSC)
					Milligrams per liter (upper number) and milliequivalents per liter (lower number)[1]											
20/18-1dddcd[6]	well	8-12-71	--	--	37 1.85	10 0.83	17 0.73	148 2.43	39 a 0.81	3 0.08	134 2.68	327	7.4	low	low	safe
-11aaca[6]	well	8-11-71	52	11.0	23 1.15	4 0.29	18 0.76	111 1.82	14 a 0.29	2 0.06	72 1.44	211	7.8	low	low	safe
-12bdaa[6]	spring	8- 6-71	--	--	24 1.20	7 0.56	12 0.53	109 1.79	21 a 0.44	1 0.03	88 1.76	222	7.8	low	low	safe
20/19-4ddac[6]	well[5]	11-18-69	--	--	29 1.45	13 1.04	15 0.64	132 2.16	21 0.44	12 0.34	124 2.48	--	7.4	low	low	safe
	(6)	8-11-71	61	16.0	24 1.20	14 1.14	20 0.88	107 1.75	55 a 1.14	7 0.20	117 2.34	320	7.4	low	low	safe
-3bcab[5 6]	well	7-27-65	--	--	24 1.20	14 1.12	14 0.61	137 2.24	10 0.21	8 0.23	116 2.32	--	7.6	low	low	safe
	(5 6)	11-18-69	--	--	29 1.45	12 0.96	20 0.85	142 2.33	20 0.42	13 0.37	120 2.40	--	7.5	low	low	safe
	(5 6)	11-16-70	--	--	27 1.35	13 1.07	23 1.00	149 2.44	27 0.56	8 0.23	120 2.40	--	7.9	low	low	safe
	(6)	8-11-71	63	17.0	24 1.20	14 1.12	23 0.99	127 2.08	41 a 0.85	8 0.23	116 2.32	328	7.5	low	low	safe
-4bbcc[6]	well	8-11-71	61	16.0	37 1.85	16 1.31	44 1.91	176 2.88	88 a 1.83	8 0.23	158 3.16	500	7.7	low	low	safe
-4ddac[5 6]	well	11-18-69	--	--	29 1.45	12 0.96	6 0.24	95 1.56	36 0.75	10 0.28	120 2.40	--	7.6	low	low	safe
	(5 6)	11-16-70	--	--	32 1.60	15 1.23	16 0.70	151 2.48	28 0.58	9 0.25	140 2.80	--	7.5	low	low	safe
	(5 6)	12- 4-70	--	--	29 1.45	12 0.99	17 0.74	122 2.00	36 0.75	8 0.23	120 2.40	--	7.4	low	low	safe
-8baaa[6]	well	8-11-71	61	16.0	120 5.99	63 5.18	58 2.53	314 5.15	360 a 7.50	21 0.59	559 11.17	1,210	7.9	medium	low	safe
-8caad[5 6]	well	6-10-61	--	--	54 2.70	74 6.07	325 14.12	217 3.56	907 18.88	9 0.25	440 8.79	--	7.1	high	medium	safe
-8ddbd[5 6]	well	5-23-67	--	--	35 1.75	12 0.96	12 0.51	120 1.97	14 0.29	14 0.40	136 2.72	--	7.0	low	low	safe
-9cdcc[5 6]	well	1-13-70	--	--	32 1.60	6 0.48	56 2.44	146 2.39	94 1.96	5 0.14	104 2.08	--	7.8	low	low	safe
-10cabb[6]	well	8-11-71	58	14.5	42 2.10	18 1.50	33 1.44	142 2.33	54 a 1.12	44 1.24	180 3.60	523	7.2	low	low	safe
-11bdba[5 6]	well	7-14-67	--	--	32 1.60	21 1.76	31 1.35	212 3.48	14 0.29	18 0.51	168 3.36	--	7.4	low	low	safe
	(5 6)	2-15-68	--	--	32 1.60	29 2.40	40 1.74	244 4.00	34 0.71	13 0.37	200 4.00	--	7.6	low	low	safe
	(5 6)	2-24-69	--	--	32 1.60	29 2.40	30 1.31	232 3.80	16 0.33	9 0.25	200 4.00	--	7.4	low	low	safe
	(5 6)	6- 3-69	--	--	34 1.70	25 2.08	23 0.99	229 3.75	12 0.25	13 0.37	188 3.76	--	7.9	low	low	safe
	(5 6)	10- 8-69	--	--	32 1.60	28 2.32	21 0.93	234 3.84	13 0.27	16 0.45	196 3.92	--	7.6	low	low	safe
	(5 6)	4-15-70	--	--	32 1.60	29 2.38	23 1.00	239 3.92	17 0.35	15 0.42	200 4.00	--	7.7	low	low	safe
	(5 6)	11-18-70	--	--	37 1.85	32 2.63	31 1.35	251 4.11	21 0.44	21 0.59	224 4.48	--	7.6	low	low	safe
-11caac[5 6]	well	12- 8-70	--	--	38 1.90	14 1.15	22 0.96	176 2.88	17 0.35	17 0.48	152 3.04	--	7.6	low	low	safe
-11dbdd[6]	well	8-11-71	61	16.0	49 2.44	31 2.53	22 0.97	244 4.00	55 a 1.15	26 0.73	249 4.98	572	7.8	low	low	safe
-14abc[6]	well	8-11-71	62	16.5	71 3.54	27 2.25	34 1.47	216 3.54	150 a 3.12	20 0.56	290 5.79	698	7.9	low	low	safe
-15bbdc1[5 6]	well	6-38-71	--	--	24 1.20	10 0.82	23 1.00	112 1.84	46 0.96	4 0.11	100 2.00	--	7.4	low	low	safe
-15bcaa[5 6]	well	1-26-71	--	--	21 1.05	6 0.49	58 2.52	156 2.56	60 1.25	9 0.25	76 1.52	--	8.3	low	low	safe
-15bcdc[5 6]	well	11- 7-63	--	--	53 2.64	10 0.80	3 0.11	129 2.11	48 1.00	6 0.17	172 3.44	--	7.7	low	low	safe
-16badb	well	7-25-66	--	--	43 2.15	22 1.79	34 1.47	207 3.39	56 1.17	30 0.85	197 3.94	499	8.0	low	low	safe
1/18-24aabd[5 6]	well	6-16-66	--	--	24 1.20	9 0.72	66 2.87	205 3.36	34 0.71	23 0.65	96 1.92	--	9.3	low	low	unsuitable
-24acac[5 6]	well	4- 6-66	--	--	27 1.35	10 0.80	30 1.30	142 2.33	19 0.40	15 0.42	108 2.16	--	7.8	low	low	safe
	(5 6)	6- 9-70	--	--	29 1.45	11 0.90	17 0.74	129 2.11	18 0.38	18 0.51	116 2.40	--	8.0	low	low	safe
(6)	well	8-11-71	63	17.0	28 1.40	5 0.40	24 1.06	124 2.03	23 0.48	10 0.28	90 1.80	289	7.8	low	low	safe
-25adad	well	7-26-66	--	--	46 2.30	14 1.14	22 0.96	168 2.75	56 1.17	17 0.48	172 3.44	398	8.2	low	low	safe
-25adcd[6]	well	8-11-71	59	15.0	42 2.10	11 0.90	28 1.24	156 2.56	64 a 1.33	9 0.25	150 3.00	375	7.9	low	low	safe
-25bada[6]	well	8-11-71	59	15.0	35 1.75	7 0.57	27 1.18	144 2.36	35 a 0.73	10 0.28	116 2.32	344	7.6	low	low	safe
-25bbbb[5 6]	well	11-11-69	45	7.0	50 2.50	9 0.72	13 0.55	167 2.74	32 0.67	11 0.31	160 3.20	--	7.7	low	low	safe
-25bcab[5 6]	well	3-26-65	--	--	24 1.20	7 0.58	31 1.35	120 1.97	38 0.79	12 0.34	88 1.76	--	7.4	low	low	safe
-26aaab[5 6]	well	5- 3-66	--	--	48 2.40	13 1.04	24 1.03	171 2.80	58 1.21	13 0.37	172 3.44	--	8.1	low	low	safe
-26aadb[5 6]	well	5- 3-66	--	--	54 2.70	10 0.80	38 1.66	176 2.88	96 2.00	9 0.25	176 3.52	--	7.9	low	low	safe

Table 12.--Partial chemical analyses of water from wells and springs--Continued

Location	Source	Date sampled	Temperature °F	Temperature °C	Calcium (Ca)	Magnesium (Mg)	Sodium (Na) plus potassium (K)[3]	Bicarbonate (HCO_3)[4]	Sulfate (SO_4)	Chloride (Cl)	Hardness as $CaCO_3$	Specific conductance (micromhos per cm at 25°C)	pH (lab. determination)	Salinity hazard	Sodium hazard	Residual sodium carbonate (RSC)
					Milligrams per liter (upper number) and milliequivalents per liter (lower number)[1]									Factors affecting suitability for irrigation[2]		
21/19-7dcda[5 6]	well	9-20-62	48	9.0	40	18	19	144	67	12	172	--	8.0	low	low	safe
					2.00	1.44	0.83	2.36	1.40	0.34	3.44					
-15adaa[5 6]	well	4- 3-61	--	--	42	8	40	129	82	22	136	--	7.9	low	low	safe
					2.10	0.64	1.72	2.11	1.71	0.62	2.72					
-15cbad[5 6]	well	10- 2-69	--	--	34	6	23	129	32	11	108	--	7.8	low	low	safe
					1.70	0.48	1.02	2.11	0.67	0.31	2.16					
-15cbba[5 6]	well	4-26-71	--	--	34	19	34	193	30	20	160	--	8.2	low	low	safe
					1.70	1.56	1.48	3.16	0.62	0.56	3.20					
-15dbca[5 6]	well	1-26-71	--	--	18	5	38	107	45	7	64	--	8.1	low	low	safe
					0.90	0.41	1.65	1.75	0.94	0.20	1.28					
-15dbcb[6]	well	8-11-71	62	16.5	60	18	27	131	[a] 78	48	223	591	8.5	low	low	safe
					2.99	1.47	1.16	2.15	1.62	1.35	4.46					
-19bacc[5 6]	well	11-14-68	--	--	29	10	32	167	28	8	112	--	7.9	low	low	safe
					1.45	0.80	1.40	2.74	0.58	0.23	2.24					
-21daac[6]	well	8-11-71	57	14.0	20	6	45	137	[a] 46	6	74	343	8.1	low	low	safe
					1.00	0.48	1.96	2.24	0.96	0.17	1.48					
-22baac[6]	well	8-11-71	59	15.0	--	--	--	--	[a] 52	5	--	271	--	low	--	--
									1.08	0.14						
		12- 8-71	--	--	31	5	--	83	--	--	97	282	9.0	low	--	safe
					1.55	0.39		1.36			1.94					
-22badb[5 6]	well	5-10-71	--	--	30	8	11	112	[a] 35	3	108	--	7.8	low	low	safe
					1.50	0.66	0.48	1.84	0.73	0.08	2.16					
-22bcdc[5 6]	well	2-17-71	--	--	27	6	38	142	39	11	92	--	8.1	low	low	safe
					1.35	0.49	1.65	2.33	0.81	0.31	1.84					
-23aaac	well	7-26-66	58	14.5	42	13	42	220	33	25	160	450	8.1	low	low	safe
					2.10	1.10	1.81	3.61	0.69	0.70	3.20					
-23addb2[5 6]	well	4- 1-70	--	--	32	6	41	188	13	16	104	--	7.8	low	low	safe
					1.60	0.49	1.78	3.08	0.27	0.45	2.08					
-23caab[6]	well	8-11-71	61	16.0	29	7	32	156	16	10	102	340	7.5	low	low	safe
					1.45	0.59	1.38	2.56	0.33	0.28	2.04					
-24badd[6]	well	8-11-71	68	20.0	33	9	54	195	36	24	120	465	7.8	low	low	safe
					1.65	0.75	2.35	3.20	0.75	0.68	2.40					
-24dab[5 6]	well	8-30-65	--	--	26	14	32	195	6	10	120	--	7.2	low	low	safe
					1.30	1.12	1.41	3.20	0.12	0.28	2.40					
-30ddda[6]	well a	12- 4-57	60	15.5	6	0	(b)	86	34	8	16	282	8.4	low	--	safe
					0.30	0.02		1.41	0.71	0.23	0.32					
		7-25-66	62	16.5	9	1	58	112	36	17	28	273	7.9	low	low	marginal
					0.45	0.11	2.51	1.84	0.75	0.48	0.56					
	(5 6)	3-24-71	--	--	13	2	39	100	32	7	40	--	8.4	low	low	safe
					0.65	0.16	1.70	1.64	0.67	0.20	0.80					
-31cccc1	well	12- 5-57	68	20.0	4	0	(c)	212	21	2	9	381	7.5	low	--	unsuitable
					0.20	0.00		3.48	0.44	0.06	0.18					
-31cccc2[6]	well	8-12-71	68	20.0	3	1	129	320	[a] 12	2	12	626	8.6	low	high	unsuitable
					0.15	0.09	5.62	5.24	0.25	0.06	0.24					
-34bbah[5 6]	well	11-16-70	--	--	26	2	51	156	32	14	72	--	8.1	low	low	safe
					1.30	0.16	2.22	2.56	0.67	0.40	1.44					
-34bbba[5 6]	well	9- 9-70	--	--	24	4	42	142	36	8	76	--	8.0	low	low	safe
					1.20	0.33	1.83	2.33	0.75	0.23	1.52					
	(5 6)	11-16-70	--	--	27	4	38	149	31	6	84	--	7.8	low	low	safe
					1.35	0.33	1.65	2.44	0.64	0.17	1.68					
-34cccd[5 6]	well	4-18-63	--	--	16	15	17	110	14	6	100	--	7.5	low	low	safe
					0.80	1.20	0.75	1.80	0.29	0.17	2.00					

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

2. Salinity hazard is based on specific conductance (in micromhos) as follows: 0-750, low hazard (water suitable for almost all applications); 750-1,500, medium (can be detrimental to sensitive crops); 1,500-3,000, high (can be detrimental to many crops); 3,000-7,500, very high (should be used only for tolerant plants on permeable soils); >7,500, unsuitable. Sodium hazard is based on an empirical relation between salinity hazard and sodium-adsorption ratio. Residual sodium carbonate (expressed in milliequivalents per liter) is tentatively related to suitability for irrigation as follows: safe, 0-125; marginal, 1.26-2.50; unsuitable, >2.50. The several factors should be used as general indicators only, because the suitability of water for irrigation also depends on climate, type of soil, drainage characteristics, plant type, and amount of water applied. These and other aspects of water quality for irrigation are discussed by the National Technical Advisory Committee (1968, p. 143-177), and the U.S. Salinity Laboratory Staff (1954).

3. Computed as the milliequivalent-per-liter difference between the determined negative and positive ions; expressed as sodium. Computation assumes that concentrations of undetermined ions are small.

4. All carbonate values 0 mg/l except: 21/18-24aabd, 50 mg/l; 21/19-15dbcb, 4 mg/l.

5. Analysis by Nevada Health Division.

6. Additional determinations from detailed analyses in table 13.

a. Laboratory analysis by the U.S. Geological Survey.

b. Na, 51 mg/l, 2.20 me/l; K, 1.6 mg/l, .04 me/l.

c. Na, 86 mg/l, 3.74 me/l; K, 1.6 mg/l, .04 me/l.

Table 13.--Additional constituents determined from water from wells and springs

[Laboratory analyses by the U.S. Geological Survey, except as indicated]

Location	Date	Milligrams per liter (upper number) and milliequivalents per liter (lower number)[1]: Silica (SiO_2)	Fluoride (F)	Nitrate (NO_3)	Ortho-phosphate (PO_4)	Arsenic (As)	Iron (Fe)[2]	Dissolved-solids content
20/18-1ddcd	8-12-71	41	--	5.3 0.09	0.15	--	0.02	a 225
-11aaca	8-11-71	23	--	1.8 0.03	0.37	--	--	a 141
-12bdaa	8- 6-71	37	--	2.0 0.03	0.25	--	--	a 158
20/19-4ddac[3]	11-18-69	--	0.1 0.00	11 0.18	--	0.00	0.05	b 230
	8-11-71	43	--	8.0 0.13	0.21	--	0.03	a 224
-3bcab[3]	7-27-65	--	0.0 0.00	17 0.27	--	--	0.10	b 213
[3]	11-18-69	--	0.1 0.00	9.4 0.15	--	0.00	0.04	b 230
[3]	11-16-70	--	0.2 0.01	10 0.16	--	0.00	0.03	b 197
	8-11-71	42	--	9.3 0.15	0.25	--	0.56	a 223
-4bbcc	8-11-71	46	--	8.0 0.13	0.25	--	0.06	a 334
-4ddac[3]	11-18-69	--	0.1 0.00	7.3 0.12	--	0.00	1.8	b 204
[3]	11-16-70	--	0.2 0.01	11 0.18	--	0.00	0.03	b 230
[3]	12- 4-70	--	0.2 0.01	9.6 0.16	--	0.00	0.0	b 216
-8baaa	8-11-71	47	--	28 0.45	0.09	--	0.02	a 851
-8caad[3]	6-10-61	--	--	12 0.19	--	--	0.0	b 606
-8ddbd[3]	5-23-67	--	--	35 0.56	--	--	0.15	b 271
-9cdcc[3]	11-13-70	--	0.1 0.00	2.8 0.04	--	0.00	0.02	b 294
-10cabb	8-11-71	45	--	22 0.35	0.34	--	0.04	a 328
-11bdba[3]	7-14-67	--	--	27 0.44	--	--	0.58	b 582
[3]	2-15-68	--	--	42 0.68	--	--	0.15	b 287
[3]	2-24-69	--	--	58 0.94	--	--	0.20	b 272
[3]	6- 3-69	--	0.2 0.01	23 0.37	--	0.00	0.06	b 194
[3]	10- 8-69	--	0.3 0.02	18 0.29	--	0.00	0.10	b 287
[3]	4-15-70	--	0.3 0.02	20 0.32	--	0.00	0.34	b 273
[3]	11-18-70	--	0.3 0.02	41 0.66	--	0.00	0.16	b 315
-11caac[3]	12- 8-70	--	0.0 0.00	18 0.29	--	0.00	0.02	b 230
-11dbdd	8-11-71	35	--	4.4 0.07	0.21	--	0.08	a 342
-14abc	8-11-71	23	--	2.5 0.04	0.03	--	0.02	a 434
-15bbdc1[3]	6-28-71	--	0.2 0.01	4.6 0.07	--	0.00	0.17	b 204
-15bcaa[3]	1-26-71	--	0.2 0.01	0.1 0.00	--	0.00	0.14	b 235
-15bcdc[3]	11- 7-63	--	--	17 0.27	--	--	0.28	b 338
21/18-24aabd[3]	6-16-66	--	--	5.9 0.10	--	--	0.36	b 151
[3]	6-24-66	--	--	--	--	--	0.34	b 172
-24acac[3]	4- 6-66	--	--	20 0.32	--	--	0.41	b 242
[3]	6- 9-70	--	0.2 0.01	5.4 0.08	--	trace	0.69	b 210
	8-11-71	48	--	4.4 0.07	0.09	--	0.02	a 203
-25adcd	8-11-71	51	--	6.2 0.10	0.18	--	0.10	a 288
-25bada	8-11-71	51	--	8.0 0.13	0.12	--	0.01	a 244
-25bbbb[3]	11-11-69	--	0.2 0.01	0.9 0.01	--	trace	0.36	b 251
-25bcab[3]	3-26-65	--	0.2 0.01	0.0 0.00	--	--	0.26	b 195
-26aaab[3]	5- 3-66	--	--	6.5 0.10	--	--	0.08	b 297
-26aadb[3]	5- 3-66	--	--	3.0 0.05	--	--	0.10	b 270
21/19-7dcda[3]	9-20-62	--	--	12 0.19	--	--	0.72	b 218
-15adaa[3]	4- 3-61	--	--	1.7 0.03	--	--	0.0	b 245
-15cbad[3]	10- 2-69	--	0.7 0.04	4.7 0.08	--	trace	0.04	b 224
-15cbba[3]	4-26-71	--	0.2 0.01	21 0.34	--	0.00	0.03	b 283
-15dbca[3]	1-26-71	--	0.2 0.01	2.5 0.04	--	trace	0.19	b 171
-15dbcb	8-11-71	43	--	23 0.37	0.12	--	0.07	a 365
-19bacc[3]	11-14-68	--	--	3.3 0.05	--	--	0.06	b 228
-21daac	8-11-71	53	--	4.2 0.07	0.12	--	0.04	a 247
-22baac	8-11-71	41	--	4.0 0.06	0.06	--	0.18	--
-22badb[3]	5-10-71	--	0.1 0.00	1.0 0.02	--	0.00	0.30	b 197
-22bcdc[3]	2-17-71	--	0.2 0.01	2.9 0.05	--	trace	0.04	b 220
-23addb2[3]	4- 1-70	--	0.1 0.00	11 0.18	--	trace	0.06	b 230
-23caab	8-11-71	59	--	15 0.24	0.49	--	0.02	a 246
-24badd	8-11-71	38	--	7.5 0.12	0.15	--	1.7	a 298
-24dab[3]	8-30-65	--	--	14 0.23	--	--	1.1	b 231
[3]	9-12-65	--	--	--	--	--	0.72	--
-30ddda	12- 4-57	29	0.6 0.03	0.0 0.00	--	--	0.01	a 179
[3]	3-24-71	--	0.5 0.03	0.7 0.01	--	trace	0.09	b 157
-31cccc1	12- 5-57	42	0.8 0.04	2.0 0.03	--	--	0.02	a 264
-31cccc2	8-12-71	50	--	2.7 0.04	0.77	--	0.02	a 365
-34bbab[3]	11-16-70	--	0.1 0.00	3.1 0.05	--	trace	0.14	b 233
-34bbba[3]	9- 9-70	--	0.2 0.01	4.3 0.07	--	trace	0.04	b 228
[3]	11-16-70	--	0.2 0.01	4.7 0.08	--	trace	0.04	b 233
-34cccd[3]	4-18-63	--	--	30 0.48	--	--	0.04	b 174

1. See footnote 1, table 12. Where only one number is shown, it is milligrams per liter.

2. Total iron; some high values may be due to impurities in unfiltered samples.

3. Analysis by Nevada Department of Environmental Health.

a. Calculated with HCO_3 multiplied by 0.492 to make results comparable with "residue on evaporation" value

b. Residue on evaporation at 110°C.

Table 14.--Specific conductance and estimated dissolved-solids content of 38 supplemental water samples

Location	Source	Well depth (feet)	Date sampled	Specific conductance[1]	Estimated total dissolved solids[2] (mg/l)
20/19-5baab	USGS test no. 14	27	12- 1-71	450	450
-6aabc	USGS test no. 8	27	12- 1-71	395	260
21/18-36addb1	USGS test no. 2	150	12- 1-71	2,470	1,600
-36addb2	USGS test no. 3	13.5	12- 1-71	16,200	11,000
-36ccd	Spring	--	12- 1-71	418	280
-36cdcd	Well	75	12- 1-71	275	180
21/19-19cada	USGS test no. 6	42	11-24-71	424	280
-20bdcd	USGS test no. 4	67	11-24-71	325	220
-20dbda	USGS test no. 5	87	11-24-71	446	300
-21dcdb	USGS test no. 21	77	12- 8-71	828	550
-22bdab1	USGS test no. 1	150	11-18-71	314	210
-22bdab2	USGS test no. 19	26	11-18-71	635	420
-26cccd1	USGS test no. 26a	62	11-18-71	287	190
-26cccd2	USGS test no. 26b	23	12- 8-71	650	430
-27bcbc	USGS test no. 18	70	11-18-71	26,900	18,000
-27dcaa	USGS test no. 17	42	11-24-71	7,450	5,000
-28aabd	USGS test no. 22	50	11-18-71	21,800	15,000
-28bada	USGS test no. 10	82	12- 8-71	715	480
-28cada	USGS test no. 9	52	11-18-71	37,400	25,000
-28cbcc	USGS test no. 11	53	12- 8-71	607	400
-29	Imported water	--	10- 5-71	110	75
			11-24-71	128	85
-29caab	USGS test no. 13	32	12- 1-71	a1,660	a1,100
-29dacb	USGS test no. 12	84	11-24-71	440	290
-30cabc	USGS test no. 7	22	11-24-71	1,920	1,300

Table 14.--Specific conductance and estimated dissolved-solids content of 38 supplemental water samples--Continued

Location	Source	Well depth (feet)	Date sampled	Specific conductance[1]	Estimated total dissolved solids[2] (mg/l)
21/19-32acaa	USGS test no. 25	62	11-24-71	323	210
-32acdd1	Sewer plant effluent	--	12- 1-71	635	420
-32acdd2	Drainage ditch from Silver Lake Subarea	--	12- 1-71	746	500
-32baad	USGS test no. 23	64	12- 8-71	562	370
-32ddbd	USGS test no. 15	37	12- 1-71	512	340
-33cbaa	Settling pond	--	11-24-71	635	420
-33cbab	Silver Lake Subarea drainage plus sewer plant effluent	--	10- 5-71	576	380
			11-24-71	625	420
-33ccbc	USGS test no. 16	22	12- 1-71	417	280
-34acdc	Drainage ditch along Lemmon Drive	--	11- 9-71	1,180	780
			11-24-71	935	620
-34badb	USGS test no. 20	32	11-24-71	2,710	1,800
-34bdad	Sump pump (drainage well)	--	11-24-71	887	590

1. Micromhos per cm at 25°C.
2. Estimated at about two-thirds of specific conductance. These values should be revised when more detailed analyses are available.

a. Well may not have been bailed sufficiently to obtain a representative sample.

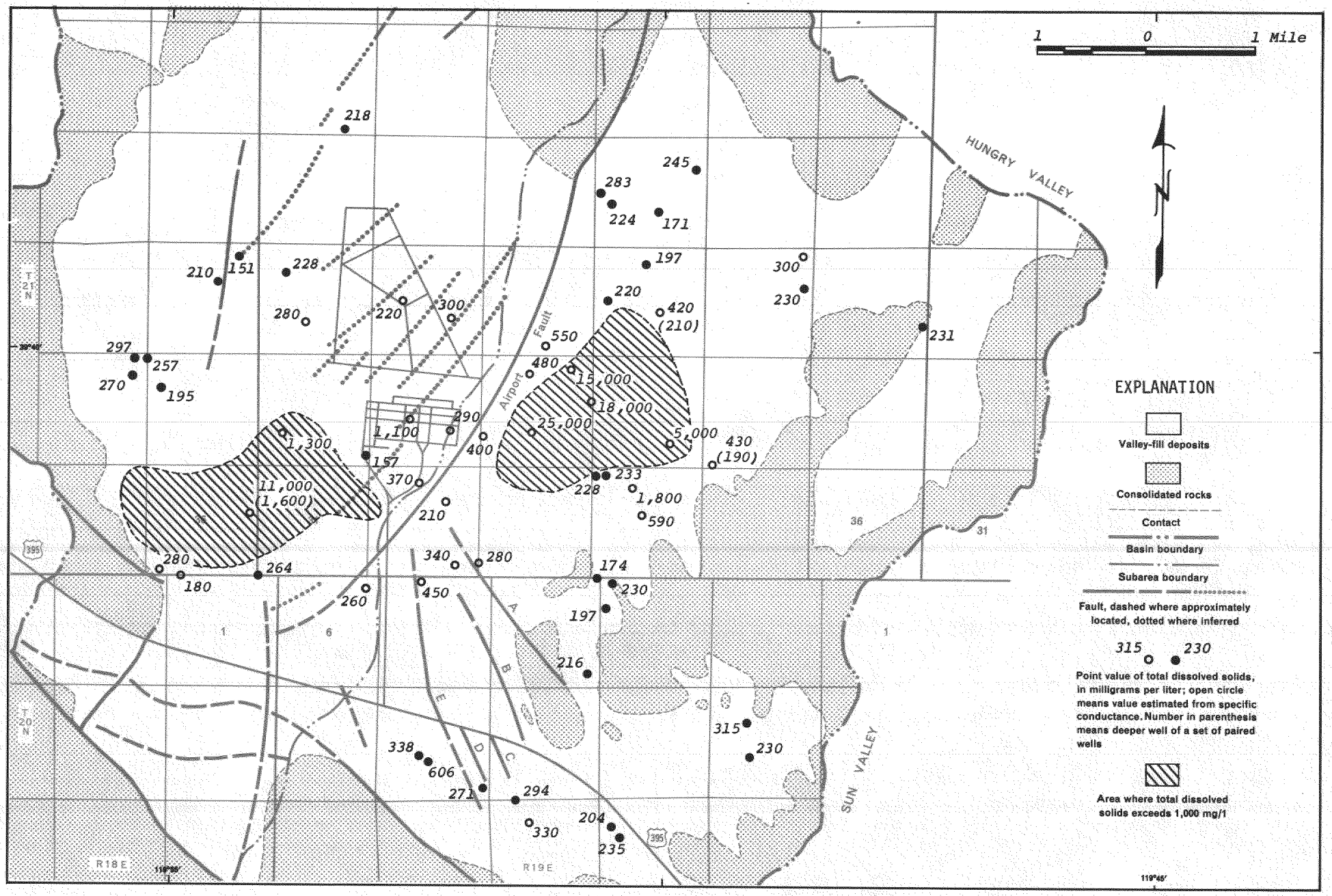

Figure 9.- Distribution of total dissolved solids concentrations

IMPORTED WATER

Water has been imported to Lemmon Valley from Truckee Meadows since 1944. Prior to 1966, the Stead Facility was the only area in the valley using imported water. In early 1966 the Raleigh Heights subdivision was completed and also began receiving imported water. As of 1971, one additional small industrial development in the southwest quarter of sec. 15, T. 20 N., R. 19 E., was supplied with imported water. Use in this area was small because the development was new and not all sites had been leased by users.

Table 15 lists the available information on water imported to Lemmon Valley for use at the Stead Facility. Records are not available prior to 1956. There was no military dependent-family housing in use during this early period, and imported water was supplemented by a small number of wells. Moreover, the base was shut down for a short period during the 1950's. These factors suggest that the average quantity of water imported during this period was comparatively low, possibly averaging about 300 acre-feet per year. Over the 27-year period 1944-71, an estimated 15,000 acre-feet of water was imported for use at the Stead Facility.

During 1970, about 860 acre-feet of water was used by about 2,700 persons living at Stead and by the industrial facilities there. If water used for industrial purposes is included with the requirements of the persons living there, average per capita importation for the year is about 280 gpd. An estimate of the water used within households at Stead may be obtained by examining the seasonal distribution of the imported water. Figure 10 shows seasonal distribution of imported water and flow through the sewer plant for parts of 1969, 1970, and 1971. During winter months most of the water imported is discharged through the sewer plant and probably is a fair estimate of the water actually used for in-house purposes. Per capita use during the period November 1970 through March 1971 was computed to be about 140 gpd. Because of the included industrial use, the actual in-house use was somewhat lower. Table 16 lists estimates of the disposition of imported water at Stead under 1971 conditions.

Water has been imported to Raleigh Heights since 1966 to serve about 700 persons living in Lemmon Valley. Water is not metered and there is no industrial use in the development. Using a per capita rate of 200 gpd, somewhat less than that at Stead, about 150 acre-feet per year is imported into Lemmon Valley. However, part of this water is exported back to the Truckee Meadows as sewage. As shown in tabel 16, an estimated 40 percent of the water imported to Stead flows through the Stead Sewer Plant (1971 conditions). If the same return is assumed at Raleigh Heights, about 60 acre-feet per year is exported as sewage. The remaining 90 acre-feet per year is partly consumed by lawn evapotranspiration and part infiltrates to recharge ground water. Based on the estimates in table 16, recharge from imported water in Raleigh Heights may be about 30 acre-feet per year. If only the net imported water to the valley is considered, then about 630 acre-feet have been imported to the Raleigh Heights area since 1966.

Table 15.--Water imported to Lemmon Valley for use at Stead Facility

Year	Imported (acre-feet)	Flow through sewer plant (acre-feet)	Flow through sewer plant (percentage of import)
1944-1955	a 3,300	--	--
1956	260	--	--
1957	290	--	--
1958	500	--	--
1959	940	390	42
1960	1,080	400	37
1961	1,060	400	38
1962	1,130	370	33
1963	1,140	380	33
1964	1,280	260	20
1965	1,110	440	40
1966	510	--	--
1967	220	--	--
1968	500	--	--
1969	710	--	--
1970	860	371	43
1971	b 420	--	--
Total	a 15,000	--	--

a. Estimated; records not available.
b. First 7 months.

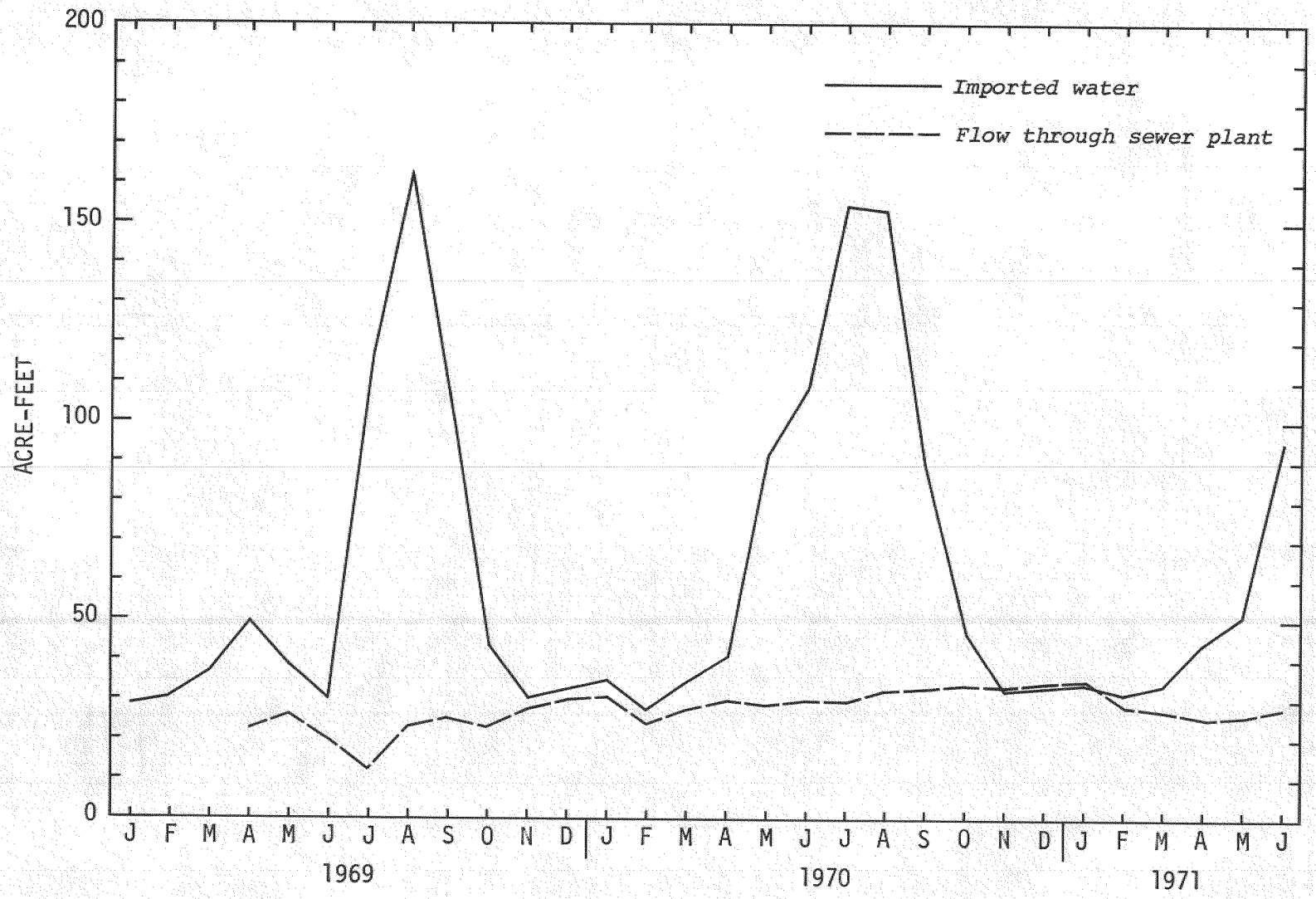

Figure 10.- Monthly values of water imported to Stead and flow through sewer plant

Table 16.--Estimated disposition of imported water at Stead Facility, 1971 conditions

a. Disposition in percent

Inflow = 100 percent

Flow to sewer plant = 40 percent of inflow (table 15)

Evapotranspiration of effluent = 60 percent flow to sewer plant, or 24 percent of inflow

Recharge from effluent = 40 percent of effluent, or 16 percent of inflow

Lawn irrigation = 60 percent of inflow

Evapotranspiration of lawn water = two-thirds of lawn irrigation, or 40 percent of inflow

Recharge from lawn water = one-third of lawn irrigation, or 20 percent of inflow

Total secondary recharge[1/] = 36 percent of inflow

b. Disposition by subareas, in acre-feet per year, 1971 conditions

Item	Silver Lake subarea	East Lemmon subarea
Inflow	500	400
Flow to sewer plant	a 200	160
Evapotranspiration of effluent	--	220
Recharge from effluent	--	140
Lawn irrigation	300	240
Evapotranspiration of lawn water	200	160
Recharge from lawn water	100	80
Total secondary recharge[1/]	100	220

1. Recharge derived from man's activities is herein termed secondary recharge to distinguish it from "primary" or natural recharge.

a. Flows to East Lemmon subarea.

PUMPAGE

Table 17 lists estimates of ground-water pumpage in Lemmon Valley. Part A lists estimated pumpage for the entire valley for the selected years 1956, 1966, and 1971. The 1956 pumpage estimate is based on information from Stead Air Force Base and population estimates made from numbers of dwellings counted on aerial photographs taken during that year. The 1966 estimate is based on information reported by Rush and Glancy (1967) and on aerial photographs flown during 1966. Estimated pumpage for 1971 was based on power consumption data for large-capacity wells used for irrigation and public supply and on population estimates, per capita use rates, and estimated lawn-water requirements for areas served by individual wells or small public-supply systems, such as those serving trailer courts.

The following factors, based largely on field observation, were generally used to obtain indirect estimates of domestic use:

1. On an average basis, one house represents 3.5 persons.
2. On an average basis, one trailer represents 3 persons.
3. Average household use (not including lawn water requirements) is about 100 gpd per capita. Of this, only 10 gpd or less is consumed.
4. An average-size lawn requires application of about 0.25 acre-foot of water per year. Of this, about 0.17 acre-foot is consumed. Adjustments were made for larger-than-average and smaller-than-average sized lawns.

Separate estimates were made of in-house use and lawn-water requirements so that the large variation of water supplied to lawns could be taken into account.

Part B of table 17 lists the various categories of use in 1971 and also indicates the distribution of pumpage. Water withdrawn is the gross pumpage; the amount consumed is called the net pumpage. The difference between the two is considered to be returned to the ground-water system. Withdrawal in the East Lemmon subarea is about twice that in Silver Lake subarea; however, consumption in both areas is about the same. This is due primarily to the comparatively high consumptive-use rate of water pumped to irrigate the Washoe County Golf Course.

Table 17.--Estimated ground-water pumpage in Lemmon Valley

[All estimates in acre-feet per year]

A. Estimated total pumpage during three selected years[1]

Year	Withdrawn	Consumed (net pumpage)
1956	90	20
1966	430	110
1971	920	390

B. Estimated distribution of pumpage during 1971

Location	Irrigation[2]		Public supply		Domestic		Total (rounded)	
	Withdrawn	Consumed	Withdrawn	Consumed	Withdrawn	Consumed	Withdrawn	Consumed
Silver Lake Subarea	280	190	13	2	30	9	320	200
East Lemmon Subarea								
Central area	0	0	a 430	150	35	10	470	160
Black Springs area	0	0	67	14	28	7	95	21
Golden Valley	0	0			42	11	42	11
Subtotal (rounded)	0	0	500	160	100	28	600	190
Total (rounded)	280	190	510	160	130	37	920	390

a. Includes 30 to 40 acre-feet used for industrial purposes, primarily road construction and dust control.

1. Water withdrawn and not consumed returns to ground water. For example, the amount returned in 1971 was about 500 acre-feet.

2. Golf-course irrigation.

EFFECTS OF DEVELOPMENT

Nonequilibrium Conditions

Prior to development, a ground-water system, over the long term, is in a state of dynamic equilibrium: Recharge equals discharge, and the quantity of water in storage remains constant over periods of several years. Development creates an imbalance in the system. In the case of pumping, total discharge (natural discharge plus net pumpage) exceeds the recharge. Consequently, water is pumped from storage and water levels decline until natural discharge is reduced sufficiently to bring the system to a new equilibrium, where recharge equals a reduced natural discharge (sometimes to zero) plus net pumpage. If net pumpage exceeds the predevelopment natural discharge, water levels will decline indefinitely, and a new equilibrium will never be reached. In the case of imported water, the opposite situation occurs. An imbalance is caused by increased recharge, water is added to storage and water levels rise until natural ground-water discharge is increased sufficiently to bring the system to a new equilibrium. Finally, if both pumping and importation occur, as in Lemmon Valley, no new equilibrium is possible until natural recharge augmented by recharge from imported water equals a new natural discharge (may be more, less, or equal to the old natural discharge) plus net pumpage.

Water-Level Changes

Water-level changes due to development are of two general types: (1) seasonal, or short-term, fluctuations caused by cyclic variations in water use, and (2) long-term changes associated with permanent changes in ground-water storage as the system adjusts toward a new equilibrium.

Short-Term Changes

The most common short-term changes are seasonal fluctuations due to large summer pumping. Highest water levels generally occur in the spring, and the lowest water levels in the late summer. In areas developed by individual domestic wells or small public-supply wells, the magnitude of the fluctuations probably has ranged from several feet to possibly as much as 30 feet. In the vicinity of heavily pumped large-capacity wells, much larger drawdowns and recoveries occurred. Spring and fall water-level measurements in well 20/19-3bbba (table 24) indicate that water levels near wells 20/19-3bcab and 20/19-4ddac fluctuated in excess of 80 feet. Water-level measurements in wells 21/19-31cccc1 and 21/19-31cccc2 suggest seasonal fluctuations of similar magnitude near these two wells. Fluctuations of this magnitude probably are due to combined effects of hydraulic barriers, low transmissivity, and large-scale pumping.

Imported water also has affected seasonal water-level fluctuations adjacent to the Stead Facility. Summer lawn watering has resulted in the ground-water reservoir being locally recharged. Consequently, annual high water levels in these areas occur during the late summer, and the annual lows during late winter or early spring. This is converse to the fluctuations experienced under natural conditions.

Long-Term Changes

As of 1971, no discernable widespread decline in water levels had occurred in Lemmon Valley due to long-term pumping. This probably is due to combined affects of (1) a comparatively low consumption of pumped water, as indicated in table 17; (2) a high percentage of recirculated water, plus the widespread use of septic tanks; (3) a broad areal distribution of pumping; and (4) above average precipitation and recharge during several years prior to this study. However, local declines due to pumping were noted in four areas. The areas are indicated in figure 11, which shows the approximate net change in water levels between natural conditions (fig. 7) and spring 1971 (fig. 12).

Declines near wells 21/19-31cccc1 and 21/19-31cccc2 are the result of at least 10 years of pumping water to irrigate the adjacent golf course. The extent of the decline is not known, because no deep wells were near enough to monitor areal effects of pumping. Figure 11 also indicates water-level rises beneath the area of the golf course which probably are due to return flow from the pumped irrigation water.

The decline in the vicinity of Black Springs is due primarily to years of sustained pumping; however, the extent of the decline is complicated by the fault barriers. Although data are insufficient to determine the magnitude of decline, limited information collected during the course of this study suggests that declines in this area have been comparatively small.

Significant local declines were noted in the west half of sec. 15, T. 20 N., R. 19 E. Data in table 24 suggest that water levels in this area are declining at rates of 4 to 5 feet per year. The most probable reason for this is that water pumped for a trailer court in the area of maximum decline is not returned to ground water locally, but is piped northward beneath U. S. Highway 395 to oxidation ponds. This practice greatly reduces the amount of return flow available for reuse in the immediate area of pumping, but may be desirable for maintaining good water quality.

The largest observed water-level declines are near wells 20/19-3bcab and 20/19-4ddac (fig. 11 and pl. 1). These wells are pumped intermittently throughout the year, and a moderate drawdown is maintained most of the time.

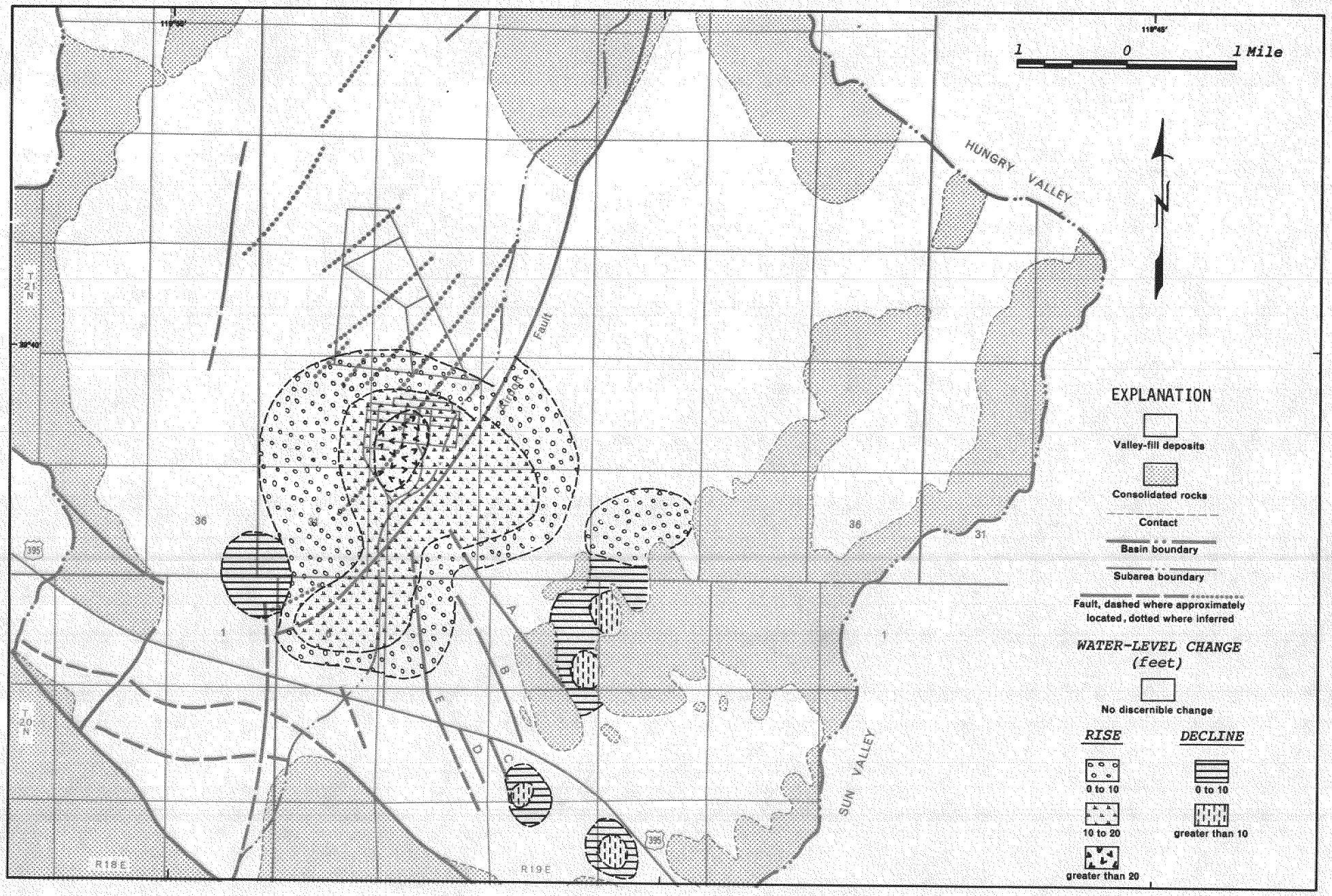

Figure 11.- Approximate net change in water levels, natural conditions to spring, 1971

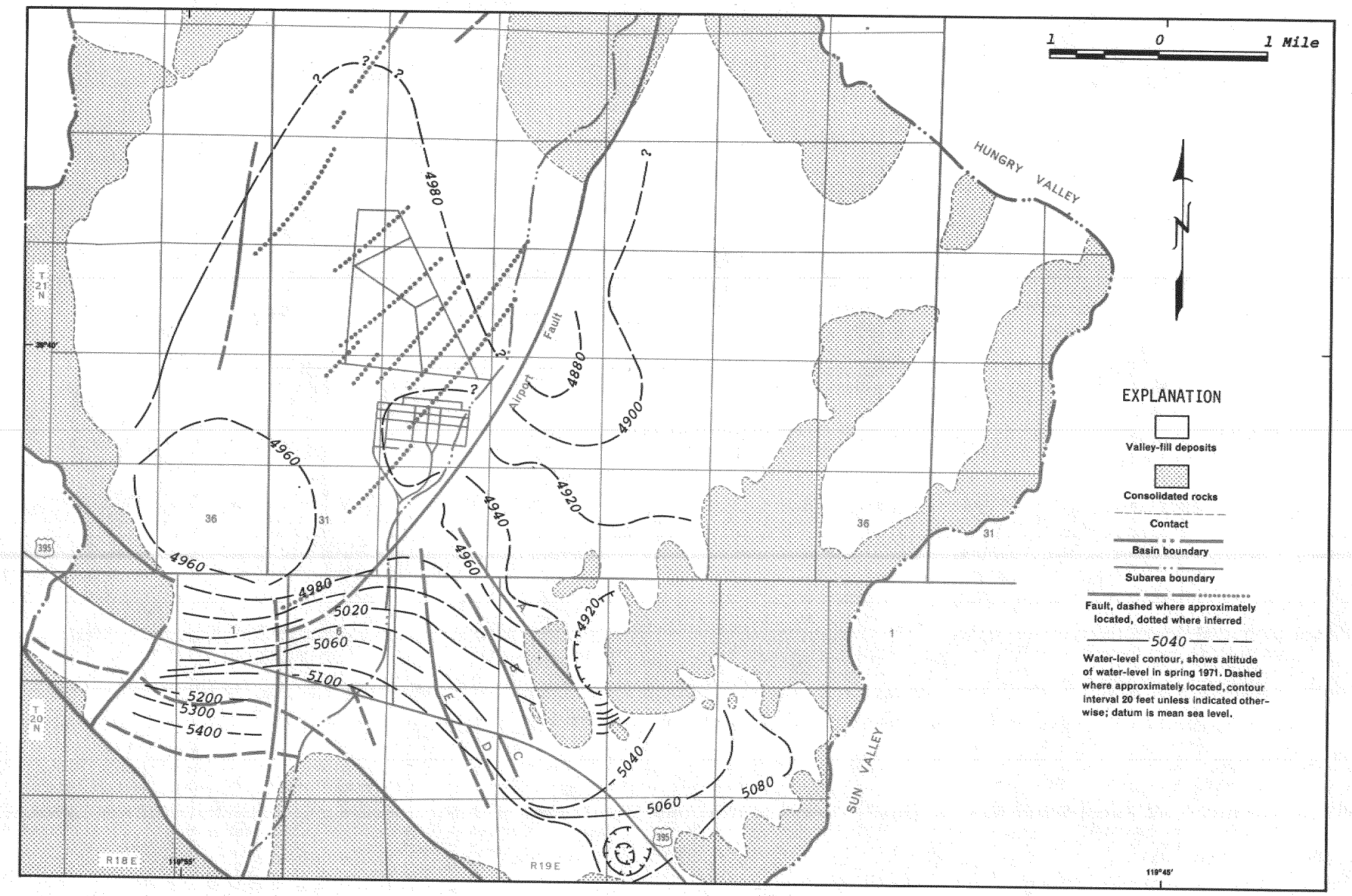

Figure 12.- Approximate water-level contours, spring 1971

Much of the water pumped from these wells is distributed to houses more than half a mile to the north. Consequently, recirculated water has had little affect in reducing water-level declines near the wells. The net affect has been that, though declines have occurred near the wells, water levels to the north, in the vicinity of Lemmon Valley school, have risen 10 feet or more. In November 1971, the levels were within several feet of the land surface.

Long-term changes in water levels have also occurred in response to recharge from imported water. Water levels in the vicinity of Stead Facility have risen as much as 20 feet (fig. 11). Some recharge from imported water also has occurred in the vicinity of Raleigh Heights; however, the amount of net change in water levels in this area could not be determined.

Ground-Water Storage Changes

The water-level changes shown in figure 11 have resulted in a net change of ground water in storage. This change in storage may be estimated from the thicknesses and areas watered or dewatered shown in figure 11 and the specific-yield values shown in figure 5. Computation of the net change in storage is summarized in table 18, which shows that an estimated net increase in ground-water storage of some 5,000 acre-feet has occurred. For about the 25 years of development and imported water, the average annual net increase in storage was on the order of 200 acre-feet per year. The bulk of the increase probably occurred during the 7 years, 1959-65, of large imports (table 15). Thus, recharge from imported water, including sewage effluent, has exceeded estimated depletions due to pumping.

Changes in Evapotranspiration of Ground Water

Development has also affected natural evapotranspiration of ground water. Near most areas supplied by imported and pumped water, ground-water levels have risen to within several feet of the land surface. Consequently, plants, such as grasses and tules, which consume comparatively large quantities of ground water have become established locally. Adjacent to these areas, natural assemblages of rabbitbrush and greasewood have become more dense and a sparse undergrowth of saltgrass has appeared. Plate 1 shows the general areas where the natural ground-water discharge has been affected by imported water. Increased discharge in the Silver Lake subarea is supplied principally from recharge derived from lawn irrigation. Increased discharge in East Lemmon subarea is supplied principally from the recharge of sewage effluent. In 1971, shallow water levels near Stead Facility appeared relatively stable, which suggests that increased recharge from imported water has been nearly offset by increased natural evapotranspiration and that locally the ground-water system is approaching equilibrium.

Table 18.--Net change in storage from natural conditions to spring 1971

Net water-level rise (+) or decline (-) (feet) Range	Average (1)	Area (acres) (2)	Volume of material (acre-feet) (1)x(2)=(3)	Average specific yield (percentage) (4)	Net storage increase (+) or decrease (-) (acre-feet) (3)x(4)
			Silver Lake subarea		
0 to +10	+5	460	2,300	7	+160
	+5	380	1,900	12.5	+240
	+5	280	1,400	18	+250
+10 to +20	+15	57	860	7	+60
	+15	76	1,100	12.5	+140
	+15	290	4,400	18	+790
greater than 20	+22	160	3,500	18	+630
Subtotal[1] (rounded)		1,700	15,000		+2,270
0 to -10[2]	-5	250	1,200	18	-220
Net increase, Silver Lake subarea (rounded)					+2,000
			East Lemmon subarea		
0 to +10	+5	340	1,700	7	+120
	+5	530	2,600	12.5	+320
	+5	52	260	18	+470
+10 to +20	+15	130	2,000	7	+140
	+15	650	9,800	12.5	+1,200
	+15	340	5,100	18	+920
Subtotal[1] (rounded)		2,050	21,000		+3,200
0 to +10	+5	280	1,400	12.5	+180
0 to -10	-5	430	2,200	12.5	-280
greater than 10	-15	60	900	12.5	-110
	-15	85	1,300	a 1±	-13
Subtotal[2] (rounded)		860	6,000		-220
Net increase, East Lemmon subarea (rounded)					+3,000
Net increase, Lemmon Valley (rounded)					+5,000

1. For areas responding to imported water.
2. For areas responding to pumping.
a. Estimated for fractured consolidated rocks.

Other development has tended to reduce natural discharge of ground water. The longest sustained high rate of pumping has been in the Silver Lake subarea, where water has been pumped to irrigate the golf course for more than 10 years. As of 1971, only a slight water-level decline had occurred in the vicinity of the pumped wells. Consequently, pumping may have caused some reduction in natural evapotranspiration. Pumping apparently has had little effect on natural ground-water discharge in other parts of the area.

Reductions in natural discharge have also been caused by land clearing connected with development. In Silver Lake subarea, about 250 acres of greasewood and rabbitbrush were cleared several years ago. In 1971, some phreatophytes were reestablished on this land, but evapotranspiration of ground water had been reduced from about 50 acre-feet per year under natural conditions to possibly only 10 acre-feet per year. This salvaged discharge is readily available for use by domestic-well owners and may explain in part why there had been no discernable decline in water levels in the Silver Knolls subdivision. About 100 acres of land in the Central Area has also been cleared to make way for roads and houses. Natural discharge probably has been reduced by about 20 acre-feet per year.

Table 19 summarizes estimates of ground-water evapotranspiration in Lemmon Valley as of 1971. Consumptive-use rates used are based on the same sources as used earlier in this report. Although the total area was about 200 acres less, the estimated evapotranspiration of ground water in 1971 was about 200 acre-feet per year more than under natural conditions. (See table 9.)

Changes in Chemical Quality

Over a period of time, the chemical quality of pumped ground water may slowly deteriorate. One process that may cause such a deterioration is migration of naturally occurring poor-quality water stored beneath playas in both the Silver Lake subarea and East Lemmon subareas (fig. 9) toward wells. The degree to which this process will occur depends upon the location, transmissivity, and the rate at which a well is pumped. Heavily pumped wells near playas should be the first affected. However, even in these areas, poor-quality water would be mixed with good quality water moving toward the well from other directions and possibly from at depth beneath the playas. This mixing will tend greatly to decrease adverse effects of the poor-quality water.

Another process that acts to change the quality of pumped water is a combination of deterioration in water quality with use and recycling of water. Deterioration of water quality with use, in turn, can generally be attributed to either concentration or loading, which is the addition of salts to the water as it is used. When water is

Table 19.--Estimated evapotranspiration of ground water in 1971

Assemblage or type of surface	Density	Depth to water (feet)	Area (acres)	Evapotranspiration (acre-feet per year)	Evapotranspiration (acre-feet)
		SILVER LAKE SUBAREA			
Silver Lake playa[1]	--	0-5	430	0.5	220
Other playas	--	0-10	40	.2	8
Cleared land (formerly greasewood)	--	15-35	250	<.1	10
Greasewood and rabbitbrush	medium to low	10-35	620	.2	120
Greasewood, rabbitbrush, and some saltgrass	high to medium	5-15	300	.5	150
Grass and spring-supported vegetation					
near Silver Lake	--	0-5	130	1.2	160
south of Highway 395	--	0-5	60	1.2	72
Tules	--	0-5	20	3	60
Subtotal (rounded)			1,800		810
		EAST LEMMON SUBAREA			
Playa	--	10-35	800	trace	small
Grass-covered playa	--	0-10	60	0.5	30
Greasewood and rabbitbrush	medium to low	10-40	1,700	.2	340
Grasses	--	0-5	60	2	120
Rabbitbrush, greasewood, and grass	high to medium	0-15	130	.5	65
Channel bottom vegetation	medium to high	0-20	30	.5	15
Channel bottom vegetation	high	0-5	10	1	10
Subtotal (rounded)			2,800		580
Total (rounded)			4,600		1,400

1. Covered by water during part of some years.

partly consumed by evapotranspiration, the salt left behind usually remains dissolved in the residual water and increases the dissolved-solids concentration of the return flow. If there is no loading, dissolved-solids content of return flow can be estimated by dividing the original dissolved-solids content of the water by the percentage of return flow. The data in table 14 suggest that total dissolved-solids content of the imported Truckee River water is only about 80 mg/l. If about two-thirds of the water applied to lawns is consumed and one-third recirculated and if no salts are precipitated or otherwise consumed, then the dissolved-solids content of the return flow should be about three times the original, or 250 mg/l. This is in reasonable agreement with the estimated dissolved-solids content of five of the six shallow well waters near Stead Facility (fig. 9). Water from all these wells probably is derived from infiltration of imported water.

When water is used for irrigation, loading can occur as a result of salt being leached from soil or fertilizer; loading also occurs as the result of domestic use. In Lemmon Valley, loading probably will be the most significant factor affecting future quality of ground water. Data in table 14 suggest that dissolved-solids content of the Stead Facility sewage effluent is about 340 mg/l higher than that of the imported water. If the flow through the Stead sewage-treatment plant in 1970 of 370 acre-feet is used as an estimate of the average flow, then a chemical load of about 170 tons of dissolved salts was added to the hydrologic system as a result of public-supply and domestic use. The estimated per capita load resulting from this use is about 120 pounds of dissolved salts per person per year. Most of this salt eventually reaches the ground-water system.

The Stead Facility is used to illustrate that the processes of concentration and loading are operating in Lemmon Valley. More significantly, however, these same processes are also operating in areas where the 3,600 persons served by local ground-water supplies live. Most of these persons dispose of wastes through septic tanks; therefore, the entire chemical load is returned to the ground-water system. In most cases, recycled water will mix with native water of better quality, and thus, the deterioration in the quality of the pumped water is expected to proceed slowly. Once a significant deterioration in the quality of pumped water has occurred, any corrective measures taken to improve the quality would require a long period of time to become effective.

Increased Subsurface Outflow

Rising water levels in central East Lemmon subarea have resulted in an increased hydraulic gradient toward the ground-water sink along the east side of the Airport Fault. The probable amount of subsurface flow toward this area was estimated in the same manner as the amount of subsurface flow under natural conditions (p. 43). The only change was that average gradient near the fault, where estimated transmissivity was 5,000 gpd per foot, had increased by about 20 percent. Thus, estimated subsurface outflow in 1971 was about 220 acre-feet per year.

GROUND-WATER BUDGET, 1971 CONDITIONS

Table 20 is a ground-water budget for conditions in Lemmon Valley as of 1971. The estimated inflow to the ground-water system of 1,900 acre-feet is 400 acre-feet higher than that estimated under natural conditions (table 10). This is due to secondary recharge from imported water. The imbalance between inflow and outflow probably is due largely to errors in the estimates. An estimate of the annual depletion of storage could not be made during the course of this 6-month study; however, if most of the net pumpage indicated in table 17 were considered derived from storage, much of the imbalance could be accounted for.

Table 20 shows that for all of Lemmon Valley, outflow exceeded inflow by about 100 acre-feet. However, an estimated average net increase in storage of some 200 acre-feet a year is suggested for the past 25 years or so (p. 70), which is converse to the decrease calculated for 1971 in table 20.

Table 20.--Ground-water budget, 1971 conditions
[All estimates in acre-feet per year]

Budget item	Silver Lake subarea	East Lemmon subarea	Total for Lemmon Valley
INFLOW:			
Recharge from precipitation (table 8)	1,000	500	1,500
Possible inflow from Cold Spring Valley (p.38)	minor	--	minor
Net inflow from Silver Lake subarea (p. 30)	--	minor	--
Secondary recharge from imported water			
Stead (table 16)	100	a 220	a 320
Raleigh Heights (p.59)	--	30	30
Total (rounded) (1)	1,100	800	1,900
OUTFLOW:			
Evapotranspiration (table 19)	810	580	1,400
Subsurface outflow (p. 74)	(b)	220	220
Net outflow from Silver Lake subarea (p.30)	minor	--	--
Net pumpage (table 17)	200	190	390
Total (rounded) (2)	1,000	1,000	2,000
IMBALANCE (rounded): (1)-(2)	+100	-200	-100

a. Includes 140 acre-feet recharge from sewage effluent.
b. Excludes possible subsurface outflow through fractured consolidated rocks.

THE AVAILABLE WATER SUPPLY

The available water supply in Lemmon Valley is discussed in the following sections in terms of: (1) the perennial yield, or the maximum amount of salvable natural discharge; (2) an augmented yield where the natural ground-water supply is supplemented by imported water; (3) storage depletion, which is sometimes referred to as the "one-time reserve" and is evaluated in terms of a transitional storage reserve; (4) reuse of water; and (5) imported water.

Perennial Yield

The perennial yield of a ground-water reservoir may be defined as the maximum amount of water of usable chemical quality that can be withdrawn and consumed economically each year for an indefinite period of time. If the perennial yield is continually exceeded, water levels will decline until the ground-water reservoir is depleted of water of usable chemical quality or until pumping lifts become uneconomical to maintain. Perennial yield cannot exceed the natural recharge to or discharge from the ground-water reservoir. Moreover, perennial yield ultimately is limited to the maximum amount of natural discharge that can be economically salvaged for beneficial use.

Table 10 shows that the estimated natural recharge to and discharge from the ground-water system in Lemmon Valley is about 1,400 acre-feet per year. However, about 200 acre-feet per year of the discharge might be subsurface outflow to adjacent valleys. The amount of this outflow that can be salvaged by pumping is not known. If water is leaking downward into fractured consolidated rocks beneath the valley fill and then laterally out of the area, probably only a small part of the outflow could be salvaged by pumping from the valley-fill reservoir. On the other hand, if water is moving laterally into fractured bedrock, water levels might be drawn down below a barrier by pumping and most subsurface outflow could be salvaged. For purposes of this report it is assumed that about half of the 200 acre-feet per year of probable subsurface could be economically salvaged by pumping from the valley-fill reservoir. If it is assumed that virtually all evapotranspiration could be salvaged, then perennial yield for Lemmon Valley totals about 1,300 acre-feet. Perennial yield of the Silver Lake subarea is about 900 acre-feet, and perennial yield of East Lemmon subarea is about 400 acre-feet. Any significant flow between the two subareas would change the natural yields accordingly.

Augmented Yield

The water resources of Lemmon Valley have been supplemented by imported water since the early 1940's. Importation probably will continue at least at the same level as in 1971. In this report the term augmented yield is used to describe the total amount of ground

water available: the perennial yield plus salvable secondary recharge resulting from use of imported water. Augmented yield remains constant only as long as the amount of imported water and the manner in which it is used remain constant. Consequently, if the amount or disposition of imported water changes, augmented yields and predictions or plans based thereon also must be revised. Augmented yield of Lemmon Valley is estimated for 1971 conditions of water use and disposition. Table 21 summarizes estimates used to

Table 21.--Estimated augmented yield, 1971 conditions

[All estimates in acre-feet per year]

Item	Silver Lake subarea	East Lemmon subarea	Total for Lemmon Valley
Perennial yield	900	400	1,300
Secondary recharge from imported water:			
Stead Facility	100	a 220	320
Raleigh Heights	0	30	30
Augmented yield (rounded)	1,000	600	1,600
Imported-water use resulting in augmented yield:			
Stead Facility	500	400	1,000
Raleigh Heights	0	b 150	

a. Includes 140 acre-feet recharge from sewage effluent.

b. About 60 acre-feet per year of sewage exported from the valley.

compute the augmented yield of about 1,600 acre-feet. This amount of ground water is available for development and use whenever an additional 1,000 acre-feet per year of imported water is used and the same proportion infiltrates to ground water.

Storage Depletion

No ground-water source can be developed by pumping without causing some storage depletion. The magnitude of depletion varies with the amount of pumpage, the hydraulic properties of the system, and the distance of development from any recharge and discharge boundaries in the ground-water system. Few desert valleys have well-defined recharge boundaries, such as live stream or lakes; however, most have well-defined discharge boundaries, such as areas of evapotranspiration.

Transitional storage reserve has been defined by Worts (1967, p. 50) as the quantity of water in storage in a ground-water reservoir that can be extracted and beneficially used during the transition period between equilibrium conditions in a state of nature and the new equilibrium conditions under the perennial yield concept of ground-water development. Thus, transitional storage reserve is a specific amount of the total ground water in storage; it is water in addition to and developed along with the long-term amount provided by recharge.

To develop the transitional storage reserve, several assumptions are made: (1) wells would be strategically situated in, near, and around areas of natural discharge so that these natural losses could be reduced (subsurface outflow) or stopped (evapotranspiration losses) with a minimum of water-level drawdown in the pumped wells; (2) a perennial water level 50 feet below the land surface would curtail virtually all losses from ground water; (3) over the long term, pumping would cause a moderately uniform depletion of storage throughout most of the valley fill (excluding some remote tributary areas); (4) the average specific yield would be approximately equal to that indicated in table 11; (5) the water levels are within the range of economic pumping lift for the intended use; (6) the development would have little or no effect on adjacent valleys or areas; and (7) the water is of suitable chemical quality for the intended use.

Table 22 lists the estimates of transitional storage reserve for Silver Lake and East Lemmon subareas. Although nearly the entire perennial yield of East Lemmon subarea probably could be salvaged by pumping only in the Central Area, the Black Springs area and Golden Valley are included because the development is significant. Also, some of the natural discharge in these two tributary areas could be salvaged by pumping from wells. If most of the faults shown on plate 1 are effective barriers to flow and if the valley fill in the Black Springs area is compartmentalized as a result of this faulting, outflow could be salvaged with comparatively small water-level declines, providing pumping is stragetically distributed.

Considerable time will be required to salvage the natural discharge and approach a new equilibrium in the ground-water system. Assuming uniform rates of storage depletion and salvage of natural discharge, the annual pumpage (Q) and the time in years (t) during which depletion would take place can be approximated from the following equation:

$$Q = \frac{\text{Storage depletion}}{t} + \frac{\text{Natural discharge}}{2}$$

Using (1) the equation and estimated transitional storage reserves of 90,000 acre-feet in Silver Lake subarea and 50,000 acre-feet in East Lemmon subarea, (2) estimated increased salvable discharge (augmented yields) in 1971 of 1,000 acre-feet per year for Silver Lake subarea and 600 acre-feet per year in East Lemmon subarea (assuming these

Table 22.--Estimated transitional storage reserve

Subdivision	Area subject to depletion[1] (acres) (1)	Thickness to be dewatered (feet) (2)	Average specific yield (percentage) (3)	Transitional storage reserve (acre-feet) (1)x(2)x(3)
Silver Lake subarea	a 14,000	40	16	90,000
East Lemmon subarea				
Central Area	b 7,000	30	13	27,000
Black Springs area	2,900	50±	12	c 17,000
Golden Valley	860	50±	12	c 5,200
Subtotal (rounded)	11,000	35±	13	50,000
Total (rounded)	25,000	38±	15	140,000

1. Shown in figure 5.

a. Does not include remote alluvial area northwest of sec. 6, T. 21 N., R. 19 E., or area secs. 2 and 3, T. 20 N., R. 18 E.

b. Does not include remote alluvial area in sec. 19, T. 21 N., R. 20 E., and area to the south.

c. Recovery of all stored water indicated would be complicated by barrier affects.

values would remain constant in the future), and (3) a pumping rate (Q) equal in quantity to the augmented yield, in accordance with the general intent of Nevada water law, the time (t) to deplete the transitional storage reserve is computed to be about 180 years in Silver Lake subarea and 170 years in East Lemmon subarea. In actual practice, the transitional storage reserve probably will not drain uniformly from the valley-fill reservoir because of the fault barriers and the irregular distribution of pumping. Consequently, less water would be withdrawn from storage and equilibrium may be approached significantly sooner than indicated by these rough computations. In the event that pumping is not strategically located (that is, becomes too concentrated in one or more local areas), conditions of local overdraft could occur, and no new equilibrium could be attained before conditions unfavorable to local pumping occurred.

Reuse of Water

When water is pumped from the ground-water reservoir, usually only part is consumed. The remainder may be returned to the ground-water system and become available for reuse in a manner similar to imported water. However, as previously described, most uses result in some deterioration in water quality, and recirculation may eventually lead to a serious deterioration in the quality of pumped water. In arid areas, where demand for water exceeds the readily available perennial supply, one alternative is to reuse water as much as possible and attempt to maintain satisfactory chemical quality by water treatment. Advances in water-treatment technology have made this alternative more attractive than it was several years ago.

The maximum sustained withdrawal from a ground-water basin developed under the perennial- or augmented-yield concepts may be estimated by multiplying the yield by a reuse factor. (For a detailed explanation, see appendix I.) Briefly, the reuse factor is defined as $\frac{1}{1-R}$, where R is the part of the water that is recirculated. These computations assume that all the water available on a perennial basis would be reused repeatedly until entirely consumed and that suitable water quality could be maintained by some type of advanced water treatment. Tables 16 and 21 indicate that about 35 percent of the water used at the Stead Facility is recycled. Recirculation by houses with lawns that dispose of waste water through septic tanks probably is almost twice this amount. Houses without lawns, apartment houses, and trailer courts probably recycle even a larger precentage of withdrawn water.

A recirculation of 35 percent is used for the following example; in this case the reuse factor is about 1.5. Table 21 shows the augmented yield for Lemmon Valley under 1971 conditions to be about 1,600 acre-feet per year, which when multiplied by a reuse factor of 1.5, provides a maximum sustained withdrawal, under this condition, of about 2,400 acre-feet per year. In 1971, much of the total sewage-

plant effluent was lost to evapotranspiration. If most of the sewage-plant effluent were recirculated, the maximum sustained withdrawal for Lemmon Valley can be computed to be roughly 4,500 acre-feet per year. This figure approaches the theoretical maximum. The amount of use that could be practically achieved would be between 2,400 and 4,500 acre-feet per year. The above computations serve to illustrate how recycled water is a means of extending the usefulness of a limited water supply. There also would be the very substantial problem of disposal of salts removed during advanced treatment, which could adversely affect the desirability of this alternative.

Imported Water

As mentioned before, water has been imported to Lemmon Valley since the early 1940's. In the event that previously listed estimates of yield are insufficient to meet water requirements for planned future developments, importation of additional water is an alternative that may be considered. However, there is also a high demand for water in the Truckee River Basin and significantly increased importation of water into Lemmon Valley may not be possible until legal and social questions beyond the scope of this study are resolved. Consequently, no estimates of future quantities of imported Truckee River water are included in this section. As of September 1971, permits had been issued by the State Engineer to pump about 600 acre-feet per year of ground water from adjacent Cold Springs Valley for use in Lemmon Valley.

FUTURE DEVELOPMENT

Location of the area adjacent to Reno, quick access to Reno by way of U. S. Highway 395, and the presence of tracts of land which have been subdivided but not yet occupied suggest that the population of Lemmon Valley will continue to grow at a rapid rate. However, future development will ultimately be limited by the quantity of water available on a perennial basis, by probable changes in chemical quality of pumped water, and by features of the ground-water flow system, such as hydraulic barriers in the valley fill and the areal of distribution of water. Options concerning water quantity are simple; either future development will be limited by the supply currently available or additional water will be obtained from outside the valley. The following sections discuss future development in relation to constraints imposed by the ground-water flow system, future water-level declines, water-quality changes, and availability of storage facilities.

Strategic Distribution of Pumping

A previous section indicated that for 1971 conditions augmented yield was about 1,000 acre-feet per year in Silver Lake subarea and about 600 acre-feet per year in East Lemmon subarea. These estimates tell how much water may be withdrawn and consumed annually for an indefinite period of time, using 1971 supply as the criterion. However, if development is not strategically distributed with respect to the ground-water flow system, part of the ground-water reservoir may be pumped so intensively that a local overdraft could develop even though augmented yield of the area had not been exceeded. On the other hand, if pumping is distributed in roughly the same proportion as ground-water recharge, discharge, and storage and wells are properly spaced near areas of discharge, then natural discharge could be salvaged with minimum water-level declines. The following paragraphs give preliminary estimates of distributions of pumping which would reduce the probability of local overdraft. However, local problems can be expected to develop in areas of compartmented valley fill where cause and effect relations are difficult to predict.

A strategic distribution of pumping in Silver Lake subarea could be attained by proportioning pumping between the north and south parts of the subarea and making sure that withdrawals were not too concentrated in any one area. The pattern of ground-water flow suggested by contours on plate 1, disposition of imported water listed in table 16, and estimates of ground-water evapotranspiration listed in table 19 suggest that if net pumpage south of Silver Lake were about 300 acre-feet per year or less and net pumpage north of Silver Lake were about 700 acre-feet per year or less, pumping would be reasonably distributed with respect to the ground-water flow system.

In the section on storage depletion it was indicated that augmented yield in East Lemmon subarea could be most readily salvaged by pumping in the Central Area. However, considerable development has already occurred in Black Springs area and Golden Valley; estimates

for these areas are included. The quantity of water that can be readily salvaged by pumping from these two areas is difficult to evaluate because they both drain to the Central Area and salvage would probably be accomplished by decreased transmissivity caused by lowered water levels or by drawing water levels down below hydraulic barriers. For purposes of obtaining a preliminary estimate, about half of the recharge generated from the drainage areas of Black Springs area and Golden Valley was assumed salvable by local pumping. The estimated recharge generated in the two tributary areas, the pattern of ground-water flow suggested by contours on plate 1, the distribution of imported water listed in table 16, and estimated evapotranspiration of ground water shown in table 19 suggest that if net pumpage in the Central area was about 400 acre-feet per year or less, if net pumpage in Black Springs area was about 170 acre-feet per year or less, and if net pumpage in Golden Valley was about 30 acre-feet per year or less, pumping would be reasonably distributed with respect to the ground-water flow system. Any water exported from Black Springs area or Golden Valley as sewage should be considered part of the local net pumpage, because there would be no local return flow to ground water.

Changes in Distribution of Water

Water-level changes resulting from the existing development have been described in the preceding sections. It was pointed out that as of 1971 the most significant water-level declines were in areas where water had been transported away from where it was pumped. Consequently, recirculated water had little stabilizing effect on water levels in the pumped areas. Water levels declined as though all pumped water were consumed, whereas at the same time, water levels where the water was used rose in response to induced local recharge.

If future developments include placing houses, which are currently supplied by locally derived ground water and which currently dispose of wastes through septic tanks, on a public sewer system, significant declines in local ground-water levels may occur. For example, if the community of Black Springs were to be placed on a public sewer system and if the sewage were to be transported to the Stead sewage plant, the ground-water reservoir would no longer be locally recharged by septic-tank effluent; consequently, some decline in ground-water levels would be expected. Moreover, much of the treated effluent from the Stead sewer plant is consumed by evapotranspiration and only part recharges the ground-water system. Thus, total draft on the hydrologic system would be increased even though the rate of withdrawal remained the same.

Future Water-Level Declines

One of the findings of this report is that as of 1971 no discernible widespread decline in ground-water levels had occurred due to pumping. However, in the future, as net pumpage approaches the augmented yield, either because of increased development or increased con-

sumption of existing withdrawals, ground-water levels will decline as the ground-water system adjusts toward a new equilibrium. Accordingly, it would be advisable to drill new wells deep enough to allow for a reasonable amount of water-level decline (several tens of feet) or to construct them so they may be deepened in the future.

Maintaining Acceptable Water Quality

Lemmon Valley is a topographically closed basin with only a small amount of possible subsurface outflow. Consequently, problems of maintaining satisfactory chemical quality of pumped ground water can be expected to develop in the future. The following paragraphs describe several patterns of development whereby quality problems would be reduced.

One means of maintaining satisfactory chemical quality would be to minimize reuse of water by limiting ground-water withdrawals to the perennial or augmented yield. Not all water pumped would be consumed and some water would still drain to areas of natural discharge. If pumping were strategically located, much of the return flow would eventually move to areas of natural discharge, carrying dissolved salts with it. For example, in 1971 the augmented yield for the entire valley was 1,600 acre-feet per year. If withdrawal by pumping were to be increased to this amount and used largely for domestic purposes, only about 40 percent of the pumpage (table 16) would be immediately consumed by evapotranspiration. The remaining 1,000 acre-feet of return flow (sewage plus recharge from lawn water) could carry dissolved salts to areas of natural discharge near the center of the valley. Salt could continue to accumulate in these areas as it had under natural conditions. Total water supplied each year would be 900 acre-feet of imported water plus 1,600 acre-feet of pumped ground water. On the basis of an average demand of about 200 gpd per capita, about 10,000 persons, or the equivalent in other uses, could be supplied.

If the above quantity were insufficient to satisfy future demands for growth, one alternative would be to increase imported water and maintain drainage toward natural discharge areas by keeping pumping withdrawals at or below the augmented yield. If additional sites served by imported water and pumping were both strategically distributed, a significant increase in use might be realized without any significant deterioration in water quality. The amount of increase probably would be limited by ability of the discharge area to handle the increased drainage. Because subsurface outflow is believed to be small, it is doubtful whether much water of poor quality could be drained in this manner. Table 9 shows that there are more than 1,200 acres of playa in the low parts of Lemmon Valley. If a net rate of evaporation of 3.3 feet per year is assumed (Kohler, 1959, pl. 2), these areas should be capable of consuming nearly 4,000 acre-feet per year of water by evaporation, less any natural runoff that reaches

these areas. This alternative, although simple in principal, is also a comparatively inefficient "use" of water. Much imported water would be used only once and then lost by evaporation.

A more efficient alternative is to reuse the water. The amount of water that can be reused ranges from a small amount when withdrawals are near the perennial yield to a substantial part of the pumpage when the maximum sustained withdrawal rate is attained. The rate of deterioration in quality of pumped water increases in proportion to the degree of reuse. If about 900 acre-feet per year of imported water and the perennial yield of 1,300 acre-feet were reused to the maximum extent possible, the maximum sustained withdrawal would be about 5,400 acre-feet per year (900 acre-feet per year imported water and about 4,500 acre-feet per year pumpage, p. 82). Using a per capita withdrawal of 200 gpd per person, about 24,000 persons could be served. However, reused water would have to undergo advanced treatment to maintain satisfactory quality, salts removed by treatment would have to be disposed of, pumping would have to be strategically distributed so that necessary recycling would occur in spite of barriers, and techniques would have to be devised to recharge treated effluent to the ground-water reservoir. Thus, substantial reuse of water would be an efficient but costly alternative.

Still another alternative would be to import water, combine imported water with ground water withdrawn at the maximum possible rate, and maintain a satisfactory chemical quality by exporting highly treated effluent back to the Truckee River Basin. This alternative offers a means of maintaining satisfactory chemical quality without the extensive treatment necessary for recycling and also avoids problems of salt disposal and artificially recharging the ground-water reservoir. Moreover, ground-water withdrawals from Lemmon Valley would make up part of the exported effluent, thus helping to reduce the net loss to the Truckee River system. There would be some reduction in chemical quality of the return flow but probably not much more than if the same water were withdrawn and used within the Truckee River Basin. The problem aspects of this alternative would be the legality of increasing imports, if needed, the cost of constructing export facilities, and of treating and pumping effluent out of the area.

Table 23 summarizes the preceding alternative in terms of estimates of imported water, ground-water pumpage, consumption, recycled water, return flow to the Truckee River system, and estimated population served for specified levels of net loss to the Truckee River system. These estimates were computed from relations described in Appendix II and the distribution of imported water given in table 16. Estimates in table 23 are based on average conditions and do not take into account factors such as peak demand and reservoir storage. Also, pumping and high density areas served by imported water would have to be strategically located with respect to the hydrologic system. Table

Table 23.--Summary of estimated import-export values for specified levels of net diversion from the Truckee River system

[Water values in acre-feet per year]

Imported water (1)	+	Ground-water pumpage[1]	=	Total	=	Water consumed	+	Amount recycled[2]	+	Return flow to Truckee River system (2)	Net diversion from Truckee River system (1)-(2)	Estimated population served[3]
1,300		1,900		3,200		1,300		600		1,300	0	14,000
3,100		2,400		5,500		2,200		1,100		2,200	a 900	24,000
4,760 b		2,800		7,560		3,030		1,500		3,030	1,760	34,000

1. Pumpage at maximum sustained rate permitted by augmented yield and reuse factor.

2. Includes recharge from imported water and recycled ground-water pumpage.

3. Based on per-capita withdrawal of 200 gpd.

a. Approximate net diversion in 1971.

b. Maximum rate of import to Stead quthorized by the Public Service Commission of Nevada.

23 indicates that with an importation of 3,100 acre-feet per year and ground-water pumpage of 2,400 acre-feet per year, a population of about 24,000 could be served. The return flow to the Truckee River system would be about 2,200 acre-feet per year with a net diversion of only 900 acre-feet per year.

Examples of possible schemes of future development listed in the preceding paragraphs have been presented in terms of general conditions for the entire basin. The examples given illustrate that development will be constrained by quantity and quality considerations and that any plan for future development should take both into consideration. Implementation of any specific scheme of development will also be hampered by the fault barriers and compartments identified in this study and probably by additional ones that will be discovered as development proceeds. Any valley-wide plan for substantial ground-water development would have to take these geologic constraints into account.

Temporary Ground-Water Storage

Figure 10 showed that demand for water during summer months greatly exceeded the demand during winter months. In the event increased import of Truckee River water were feasible, the potential population served would be limited by ability of the pipeline to supply peak demands. If adequate storage were available, water imported during periods of low demand could be temporarily stored and then used to meet peak demands during the summer. Storage could be accomplished by constructing a surface reservoir; however, another alternative would be to temporarily store imported water in the ground-water reservoir. For example, if water imported and not used during winter months were injected into large-capacity wells, such as wells 21/19-18cbdd or well 21/19-19bacc, then these same wells could be pumped during summer months to meet peak demands. Additional testing would be required to evaluate the feasibility of this alternative.

NUMBERING SYSTEM FOR HYDROLOGIC SITES

The numbering system for hydrologic sites in this report is based on the rectangular subdivision of the public lands, referenced to the Mount Diablo base line and meridian. It consists of three units: The first is the township north (N) of the base line; the second unit, separated from the first by a slant, is the range east (E) of the meridian; the third unit, separated from the second by a dash, designates the section number. The section number is followed by a letter that indicates the quarter section and quarter-quarter-quarter section where applicable, the letters a, b, c, and d designate the northeast, northwest, southwest, and southeast quarters, respectively. For example, well 21/19-15bbbb is the well recorded in the NW¼NW¼NW¼NW¼ section 15, T. 21 N., R. 19 E., Mount Diablo base line and meridian. Township and range numbers are shown along the margins of plate 1, and section numbers are shown on the topographic base. Because of limitation of space, wells are identified on plate 1 only by quarter section letters.

SELECTED WELL DATA AND WELL LOGS

Selected well data are listed in tables 24 and 25. Selected drillers' logs of wells are listed in table 26. Most of the well data and logs are from the files of the Nevada State Engineer. Table 27 lists generalized logs of U. S. Geological Survey test wells in Lemmon Valley.

Table 24.--Selected well data

Owner: USGS, U.S. Geological Survey, testhole
Use: D, domestic; I, irrigation; Ind, industrial; O, observation; PS, public supply; S, stock; T, testhole; U, unused; Dr, drainage

Yields in parenthesis reported from bailer test

Altitude: Determined from topographic maps
Water-level measurements: Depth, in feet, below land-surface datum; +, water stands above land surface, well may flow; R, reported by driller
Remarks: SLN, State log number, from the files of the State Engineer

Location	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) /drawdown (feet)	Land surface altitude (feet)	Water-level measurement Date	Water-level measurement Depth (feet)	Remarks
20/18-1abbc	Leareno	1968	1,155	8	T	--	4,970	9- -68	flowing	SLN 10280
-1cbcc	R. W. Watson	--	320	8	D	--	5,080	4-23-71	21.3	
-1cdad	T. Hackman	--	--	--	D	--	5,130	4-23-71	31.45	
-1dcbc	A. G. and R. M. Matts	--	--	6	D	--	5,165	4-12-71	10.39	
								6-11-71	16.59	
								11- 1-71	27.6	
-1dccc	T. J. Hoffman	--	140	--	D	--	5,215	4-23-71	60.33	
								8- 6-71	60.65	
-1dccd	V. and G. P. Della	1960	175	6	D	(20)/	5,220	1960	87 R	SLN 5383
								4-13-71	98.11	
								6-11-71	82.47	
								11- 1-71	82.94	
-1ddcd	Simenson	--	--	--	D	--	5,220	8-13-71	51.88	
								11- 1-71	52.29	
-2dddd	Anderson Fire Dept.	1963	170	6	--	(5)/115	5,222	1963	40 R	SLN 7073
								4-23-71	22.02	
								6-11-71	22.09	
								8- 6-71	27.89	
								11- 1-71	32.70	
-11aaca	E. D. Spurgeon	--	--	--	D	--	5,321	4-23-71	flowing	
								6-11-71	flowing	
								8- 6-71	flowing	
-11aadd	J. W. Bradley	1964	100	6	D	(5)/70	5,360	1964	flowing	SLN 8126
								4-23-71	flowing	
								6-11-71	flowing	
								8- 6-71	flowing	

Table 24.--Selected well data--Continued

Location	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) /drawdown (feet)	Land surface altitude (feet)	Water-level measurement Date	Water-level measurement Depth (feet)	Remarks
20/18-12abcc	P. Echevirria	1947	79	6	S	(8)/27	5,340	1947	6 R	SLN 114
								11- 1-71	2.08	
-12acba	P. Echevirria	1949	162	8	I	42/71	5,380	1949	11 R	SLN 1040
-12acbb	P. Echevirria	1947	79	6	S,D	--	5,380	1947	6 R	SLN 1040-A
-12acbc	P. Echevirria	1946	98	6	D,I	25/58	5,395	1946	0 R	SLN 3967
								1- 6-71	flowing	
-12bdaa	Trail	--	--	--	PS	--	5,370	--	--	
-13dcaa	W. W. Walters	1946	200	6	D	(20)/	6,115	1964	46 R	SLN 8174
								4-13-71	37.70	
								6-11-71	40.97	
20/19-3bbba	Lemmon Valley Land Co.	1962	280	8	Ind	75/	4,955	1962	28 R	SLN 6579
								4-23-71	17.73	
								6- 8-71	48.30	
								11- 3-71	97.83	
								11- 4-71	95.86	
								11- 5-71	94.32	
-3bcab	Lemmon Valley Land Co.	1957	375	14	PS	400±/	4,965	1957	36 R	SLN 4125
-3dbdb	R. W. Lambert	--	--	--	D	--	5,260	4-21-71	88.49	
								6-10-71	89.79	
-3dddc	G. Couch III	--	--	--	D	--	--	4-21-71	80.67	
-4bcab	S. L. Sappenfield	--	--	--	D	--	4,961	4-22-71	38.47	
								6-10-71	34.31	
								11- 3-71	38.93	
-4bbcc	C. and R. Hoover	1963	110	6	D	--	4,981	1963	35 R	SLN 7636
								4-22-71	33.19	
								6-10-71	38.81	
-4bcab	J. T. Greene	--	--	--	D	--	4,978	11- 3-71	39.05	
-4bcbd	--	--	--	--	D	--	4,992	11- 3-71	40.59	
-4bccb	D. Harvey	1964	122	6	D	(30)/70	5,005	1964	42 R	SLN 8159
								11- 3-71	44.18	
-4bdab	J. L. Newman	1959	114	6	D	(15)/50	4,970	1959	35 R	SLN 4712

Table 24.--Selected well data--Continued

Location	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) /drawdown (feet)	Land surface altitude (feet)	Water-level measurement Date	Water-level measurement Depth (feet)	Remarks
20/19-4bdad	--	--	--	--	D	--	4,975	11- 3-71	30.29	
-4bdbb	--	1970	150	6	D	(10)/11	4,972	1970	58 R	SLN 10980
-4cbac	--	1963	172	6	D	--	5,000	1963	30 R	SLN 7246
-4cbbd	G. A. Smith	--	--	--	D	--	5,010	4-22-71	33.8	
								6-10-71	26.25	
								11- 3-71	28.98	
-4cbca	G. Denson	--	165	--	D	--	5,018	11- 3-71	46.2	
-4cbcb	E. H. Marmerrihew	--	--	--	D	--	5,014	4-22-71	26.95	
								6-10-71	32.58	
								11- 3-71	36.35	
-4ddac	Lemmon Valley Land Co.	1963	296	8	PS	440/	4,982	1963	60 R	SLN 7830
-5baab	USGS no. 14	1971	27	1.0	O	--	5,001	10- 4-71	8.38	Testhole
								11- 2-71	8.68	
-5cdac	J. Cavanaugh	--	--	6	U	--	5,060	8- 6-71	17.90	
								11- 4-71	17.84	
-5daad	--	--	--	8	U	--	5,020	7-26-66	53.12	
								11- 3-71	43.46	
-6aabc	USGS no. 8	1971	27	1½	O	--	5,011	10- 4-71	16.20	Testhole
								11- 1-71	14.12	
-8accb	Town & Country Trailer Court	1971	34	8	PS	(5)/140	5,105	1971	34 R	SLN 11682
								11- 4-71	25.54	
-8baad	Western Capital Development Co.	1943	90	8	D	(10)/25	5,080	1943	13 R	SLN 125
								8- 6-71	16.54	
								11- 4-71	16.67	
-8bcda	J. L. Mathews	1950	110	5	D	(6)/18	5,138	1950	45 R	SLN 1487
								4-13-71	24.12	
								8- 6-71	37.21	
								11- 4-71	29.39	
-8caba	Town & Country Trailer Court	1970	292	6	PS	--	5,145	6-11-71	61.20	SLN 11231
								8- 6-71	58.01	
								11- 4-71	105.58	

Table 24.--Selected well data--Continued

Location	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) /drawdown (feet)	Land surface altitude (feet)	Water-level measurement Date	Water-level measurement Depth (feet)	Remarks
20/19-8caad	Town & Country Trailer Court	--	244	6	PS	--	5,145	11- 4-71	31.27	
-8cbcd	Foothill Trailer Court	--	--	6	PS	--	5,190	4-23-71	66.47	
								8- 6-71	85.1	
								11- 4-71	96.18	
-8cccb	G. Shelley	--	--	--	D,I	--	5,280	11- 4-71	125.82	
-8dbbb	--	--	--	8	U	--	5,130	11- 4-71	26.32	
-8ddbd	B. L. Kennington	1962	180	6	D	--	5,170	1962	22 R	
								6- 7-70	14.1 R	
-9adda	J. R. Brizendine	--	--	6	U	--	5,042	4-22-71	17.35	
								6-10-71	15.67	
								11- 4-71	19.44	
-9bbba	USGS no. 27	1971	42	1½	O	--	5,039	10- 4-71	20.35	Testhole
								11- 3-71	14.61	
-9cdcc	S. W. Sweatt	1967	337	8	PS	57	5,158	4-15-71	125.95	
								6-11-71	129.59	
								8- 6-71	133.23	
								11- 4-71	125.48	
-10aaaa	C. R. Wollard	1971	125	6	D	(10)/52	5,155	3- -71	75 R	SLN 11439
-10aaab	W. Ravenstein	1971	174	6	D	(5)/30	5,150	7- -71	104 R	SLN 11683
								4-21-71	76.08	
-10aaad	--	1971	124	6	D	(6)/23	5,145	4- -71	84 R	SLN 11467
								4-21-71	89.36	
-10aaac1	--	1971	120	6	D	(10-15)/18	5,140	2- -71	72 R	SLN 11383
-10aaac2	D. Cohen	1971	120	6	D	(5)/30	5,141	--	--	SLN 11386
-10aaba	J. McCullen	--	--	--	D	--	5,145	4-21-71	87.73	
-10aabb	R. Fellows	--	120	6	D,U	--	5,145	11- 3-71	90.80	
-10aabd	--	1971	121	6	D	(3-5)/42	5,130	4- -71	79 R	SLN 11485
-10aacc	--	1968	109	6	D	--	5,110	12- -68	40 R	SLN 10526
-10aadd	--	1971	130	6	D	(3-5)/	5,120	2- -71	78 R	SLN 11466
-10accd	--	1970	120	6	D	(10-12)/38	5,080	6- -70	35 R	SLN 11305
-10acdb	J. R. Bledsoe	1970	146	6	D	(10-12)/40	5,082	6- -70	36 R	SLN 11304
								9-14-71	35.73	

Table 24.--Selected well data--Continued

Location	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) /drawdown (feet)	Land surface altitude (feet)	Water-level measurement Date	Water-level measurement Depth (feet)	Remarks
20/19-10acda	W. W. Peterson	1970	100	6	D	(10-12)/40	5,080	6- -70	38 R	SLN 11303
								4-14-71	38.50	
-10adab	--	1971	120	6	D	(12)/20	5,117	5- -71	65 R	SLN 11562
-10adcc	L. Larson	1969	106	6	D	--	5,087	4-14-71	42.55	
								6-10-71	35.24	
								11- 3-71	40.75	
-10addd	J. F. Stewart	1968	80	6	D	--	5,093	12- -68	50 R	SLN 10525
								4-14-71	39.37	
-10bdac	--	1971	--	--	--	--	5,070	11- 5-71	35.00	
-10bdcd	--	--	37	6	U	--	5,060	11- 5-71	16.29	
-10cabb	J. D. Bass	--	36	--	D	--	5,061	11- 5-71	15.50	
-10dabd1	--	1970	150	6	D	10/20	5,082	7- -70	50 R	SLN 11144
-10dabd2	--	1965	112	6	D	--	5,080	4- -65	22 R	SLN 8701
-10dabd3	--	1965	90	6	D	--	5,079	4- -65	25 R	SLN 8700
-10dada	--	--	--	6	U	--	5,090	7-26-66	27.6	
								11- 5-71	26	
-10dadd	--	--	93	8	U	--	5,090	11- 5-71	23.90	
-10dddb	--	--	86	6	D	--	5,090	11- 3-71	24.40	
-11bdaa	J. Foster	--	--	6	D	--	5,178	8- 9-71	131.5	
-11bdba	H. O. Pepple	--	170	6	D	--	5,150	11- 3-71	72.86	
-11bddc	D. E. Brix	--	--	--	D	--	5,140	4-21-71	60.18	
-11caac	F. B. Gillespie	1970	100	6	D	(10)/20	5,122	4- -70	50 R	SLN 10120
								4-14-71	49.5	
-11cabc	D. Joseph	1971	103	6	D	--	5,115	11- 3-71	52.3	
-11cdab	C. D. Morris	1970	120	6	D	(8-10)/30	5,114	3- -70	51 R	SLN 10942
								4-15-71	40.97	
-11cdad	E. L. Piper	1969	100	6	D	(17)/	5,115	4-14-71	36.8	SLN 10913
-11cdbc	A. Giannotti	--	--	--	D	--	5,015	4-21-71	35.05	
-11cdca	--	1970	120	6	D	(10)/30	5,015	6- -70	40 R	SLN 11079
-11cdcb	M. R. Coleman	1970	103	6	D	(15)/18	5,016	6- -70	37 R	SLN 11078
								4-21-71	34.28	
-11dbcd	J. D. Wood	1971	131	6	D	--	5,130	11- 3-71	61.10	

Table 24.--Selected well data--Continued

Location	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) /drawdown (feet)	Land surface altitude (feet)	Water-level measurement Date	Water-level measurement Depth (feet)	Remarks
20/19-11dbdc	R. S. Rhodes	--	--	--	D	--	5,138	4-21-71	58.46	
								6-11-71	61.04	
-11dbdd	Philips	1971	135	6	D	(8)/30	5,145	2- -71	58 R	SLN 11370
								4-14-71	60.13	
								6-11-71	64.59	
-11ddbc1	--	1971	178	6	D	12/22	5,118	5- -71	81 R	SLN 11595
-11ddbc2	--	1971	168	6	D	12/31	5,118	4- -71	79 R	SLN 11596
-11ddcb	--	1971	200	6	D	12/31	5,119	4- -71	110 R	SLN 11594
-14abbc1	W. L. Prince	1971	90	6	D	(10)/28	5,135	2- -71	42 R	SLN 11460
-14abbc2	--	1971	100	6	D	15/30	5,140	8- -71	54 R	SLN 11736
-14abbd	K. L. Brackenbaugh	1971	87	6	D	--	5,140	11- 3-71	52.2	
-14abdc	--	1971	140	6	D,U	--	5,180	11- 3-71	91.25	
-14a	--	1971	155	6	D	20/36	--	7- -71	64 R	SLN 11735
-14a	--	1971	135	6	D	45/32	--	8- -71	68 R	SLN 11726
-15aaca	J. Hughes	1971	182	6	D	(7)/30	5,118	6- -71	95 R	SLN 11672
								11- 5-71	56.3	
-15aacc	J. Hughes	1971	143	6	D	(12)/	5,125	6- -71	98 R	SLN 11673
								11- 5-71	61.19	
-15bbdc1	North Park, Inc.	1971	220	12	PS	150/10	5,140	11- 5-71	64.62	SLN 11697
-15bbdc2	North Park, Inc.	1971	226	12	PS	160/77	5,140	11- 5-71	64.25	
-15bcaa	North Park, Inc.	1971	216	6	PS	10/84	5,160	1- -71	96 R	SLN 11368
								11- 5-71	107.90	
-15bcda	C-Mor Trailer Park	1961	217	8	PS	(60)/113	5,139	7- -61	67 R	SLN 6126
								11- 5-71	89.31	
-15bcdc	C-Mor Trailer Park	1963	408	10	PS	300/67	5,150	8- -63	125 R	SLN 7534
								4-13-71	160.88	
								6-11-71	164.90	
								8- 9-71	164.10	
								11- 4-71	166.19	
-15cbac	Nev. Propane	--	220	--	D	--	5,161	8- -70	170 R	
								11- 4-71	175.25	

Table 24.--Selected well data--Continued

Location	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) /drawdown (feet)	Land surface altitude (feet)	Water-level measurement Date	Water-level measurement Depth (feet)	Remarks
20/19-15cbbb	J. Streeter	--	--	--	D	--	5,190	4-15-71	166.31	
								8- 9-71	165.90	
								11- 5-71	163.69	
-15cdba	Atlas Propane	1959	159	6	D	--	5,180	2- -59	119 R	
								4-14-71	85.80	
								6-11-71	84.35	
								8- 9-71	83.24	
								11- 4-71	81.68	
-16aaab	Fitzgerald	1949±	81	6	S,U	--	5,125	11- 4-71	66.3	
-16baa	P. E. Galagher	--	--	6	D	--	5,179	8-10-71	146.85	
								11- 4-71	144.66	
-16badb	Black Spring Bar and Grocery	1949	300	6	D	--	5,212	5- -49	125 R	SLN 951
								8- 9-71	124.7	
-16dbaa	R. W. Jeakins	--	--	--	D	--	5,225	4-15-71	36.90	
								6-11-71	41.12	
-21aaac	Nevada Forest Service	1965	200	8	D	(15)/13	5,290	3- -65	172 R	SLN 8419
21/18-13acdc	--	1971	149	6	D	--	5,130	11- 1-71	118.32	
-23ddac	J. Sweger	1972	690	--	PS	--	5,085	2-25-72	87 R	
-24aabc	T. L. Schriber	1971	180	8	D	(15)/	5,055	7- -71	110 R	SLN 11685
-24aabd	C. Hymes	1966	150	6	D	(20)/	5,035	3- -66	86 R	SLN 8947
								11- 1-71	107.03	
-24addc	A. Yates	1971	135	6	D	(20)/	5,018	7- -71	60 R	SLN 11688
								11- 1-71	53.6	
-24acac	R. Payne	--	210	6	D	--	5,076	11- 1-71	118	
-24acbc	R. Stewart	--	180	6	D	--	5,090	11- 1-71	121.02	
-24ccdc	J. F. Carter	--	--	6	D	--	5,050	11- 1-71	90.7	
-24cdaa	J. E. Lovitt	1968	140	8	D	(25)/	5,052	11- -68	78 R	SLN 10488
-24cdbd	J. Hanson	--	--	8	D	--	5,061	11- 1-71	116.55	
-24cdcd	J. Wise	1969	120	6	D	(15)/	5,040	4- -68	73 R	SLN 10576
								11- 1-71	83.41	
-24dacc	J. Greenwell	--	141	6	D	--	4,998	11- -71	33 R	

Table 24.--Selected well data--Continued

Location	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) /drawdown (feet)	Land surface altitude (feet)	Water-level measurement Date	Water-level measurement Depth (feet)	Remarks
21/18-24dcdb	--	--	--	8	D	--	5,030	11- 1-71	73.07	
-25aaac	E. A. Dinan	1967	91	6	D	--	4,979	7- -67	30 R	SLN 9653
								4-14-71	20.68	
-25aabc	D. Greco	1969	120	6	D	(15)/	4,979	2- -69	14 R	SLN 10487
								4-15-71	16.82	
								6-11-71	17.83	
-25aaca	R. E. Dinan	--	--	--	D	--	4,979	11- 2-71	18.95	
-25abcc	--	1971	100	--	D	--	4,995	11- 2-71	40.78	
-25abdd	C. Lovelace	1967	96	6	D	(20)/	4,979	8- -67	18 R	SLN 9961
-25accb	--	1971	--	--	D	--	4,979	11- 2-71	19.83	
-25adab	Mooney	--	--	--	D	--	4,978	11- 2-71	17.4	
-25adad	--	--	74	6	D	--	4,978	7-26-66	16.78	
-25adba	--	1970	90	6	D	(10)/30	4,978	8- -70	15 R	SLN 11156
-25adcd	R. C. Lannon	--	--	--	D	--	4,975	11- 1-71	16.04	
-25baba	J. E. Dickens	1963	141	8	D	(20)/10	5,030	8- -63	70 R	SLN 7496
-25bacc	A. J. Foster	1965	103	6	D	10/	5,010	11- -65	58 R	
								4-16-71	49.35	
								6-11-71	58.84	
-25bacd	R. Clark	1965	150	6	D	15/	5,009	10- -65	56 R	SLN 8761
								11- 2-71	49.50	
-25bada	R. H. Marvin	1965	83	6	D	(32)/	4,998	4- -65	36 R	SLN 8450
								4-15-71	38.76	
-25bbbb	--	1964	135	6	D	(15)/20	5,070	4- -64	75 R	SLN 7846
-25bbbc	D. Dean	1963	175	6	D	(15-20)/	5,070	10- -64	73 R	SLN 7547
								4-16-71	74.3	
								11- 2-71	74.19	
-25bbdd	C. F. Clifford	1965	177	6	D	--	5,010	4-16-71	46.27	SLN 8489
-25bcab	D. S. York	1965	170	8	D	(20)/85	5,010	1- -65	55 R	SLN 8311
								4-16-71	54.30	
-25bcac	Bartholomans	1969	150	6	D	(25)/	4,999	3- -68	42 R	SLN 10486
-25bcca	F. G. Trujillo	1965	105	8	D	(20)/	5,007	11- -65	38 R	SLN 8766
								4-16-71	45.83	
								6-11-71	47.25	
								11- 2-71	45.45	

Table 24.--Selected well data--Continued

Location	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) /drawdown (feet)	Land surface altitude (feet)	Water-level measurement Date	Water-level measurement Depth (feet)	Remarks
21/18-25bcda	--	1965	127	8	D	(20)/55	4,997	2- -65	35 R	SLN 8370
-25bdda	--	1966	175	6	D	(20)/	4,985	3- -66	22 R	SLN 8905
-26aaab	J. Sweager	1953	154	6	D	30/16	5,095	12- -53	80 R	SLN 2447
-26aadb	J. Sweager	1959	160	8	I	105/21	5,080	4- -59	66 R	SLN 4587
-26daad	C. W. Shepard	--	31	--	--	--	4,985	11- 3-71	18.12	
-36addb1	USGS no. 2	1971	150	1½	O	--	4,968	7-21-71	1.99	Testhole
								9-.9-71	17.08	
								10- 4-71	25.0	
								11- 1-71	2.50	
-36addb2	USGS no. 3	1971	13½	3/4	O	--	4,968	9- 9-71	11.92	Testhole
								10- 4-71	11.42	
								11- 1-71	11.51	
-36ccda	P. Echeverria	1946	115	8	I	30/21	4,972	10- -46	6 R	SLN 127
								4-22-71	1.07	
								6-11-71	.8	
-36cdcc	P. Echeverria	--	60	4	I	--	4,979	6-11-71	flowing	
-36cdcd	P. Echeverria	--	75	4	I	--	4,979	6-11-71	flowing	
-36dcbc	P. Echeverria	--	160	4	I	--	4,961	6-11-71	flowing	
-36dccb	P. Echeverria	--	20	6	I	--	4,970	6-11-71	flowing	
-36ddcb	P. Echeverria	--	40	8	I,S	--	4,957	4-13-71	4.05	
								6-11-71	3.93	
21/19-5aadc	C. Dickenson	1944	300	6	S	--	5,131	8- -44	220 R	SLN 124, well des-
								7-26-66	123.22	troyed in 1967
-7dcda	Lemmon Valley Drag Strip	--	142	6	D	--	5,038	4-22-71	69.40	11-2-71 well filled
								6- 8-71	68.95	with dirt to above
								8-21-71	68.9	water level
-15aacc	D. S. Hass	--	165	6	D	--	5,020	4-22-71	119.6	
								6- 8-71	114.04	
								11- 3-71	114.10	
-15acdd	Brock	--	175	6	D	--	5,015	9- 9-71	122.53	
-15adaa	--	1960	170	6	D	(10)/16	5,010	5- -60	122 R	SLN 5193
-15adad	M. Lowe	--	152	6	D	--	5,015	11- 2-71	101.20	
-15adbc	--	1971	176	6	D	(35)/	5,009	--	--	SLN 11686

Table 24.--Selected well data--Continued

Location	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) /drawdown (feet)	Land surface altitude (feet)	Water-level measurement Date	Water-level measurement Depth (feet)	Remarks
21/19-15adcc	M. Shelton	--	142	6	D	--	4,980	11- 2-71	79.85	
-15bacb	--	--	--	6	D,U	--	5,025	11- 3-71	135.75	
-15bbdb	Grant	1971	--	6	D	--	5,120	10- 6-71	223.1	
								11- 3-71	222.40	
-15bcdb	M. W. Hansen	1969	240	6	D	(20)/70	5,000	5- -69	140 R	SLN 10632
								11- 3-71	116.55	
-15bdba	--	1962	237	6	D	(11)/	5,020	11- -62	110 R	SLN 6920
								4-22-71	113.75	
								6- 8-71	113.04	
-15bdcc	J. J. Seeman	--	180	6	D	--	4978	4-22-71	102.03	
								6- 8-71	97.67	
								11- 3-71	77.29	
-15caca	E. Vieira	--	--	--	D	--	4,948	11- 3-71	43.75	
-15ccda	--	1962	105	6	D	(20)/5	4,950	9- -62	50 R	SLN 6912
-15cbad	--	1963	150	6	D	--	4,959	9- -63	65 R	SLN 7385
								11- 3-71	59.09	
-15cbba	Allen Wilcox	--	150	6	D	--	4,990	11- 2-71	96.1	
-15cbbc	J. Decker	--	--	6	D	--	4,970	11- 5-71	71.18	
-15cbdd	--	1971	133	6	D	--	4,948	4- -71	58 R	SLN 11587
-15ccccl	P. Hanson	1966	111	6	D	(20)/22	4,945	8- -66	52 R	SLN 9187
-15cccc2	P. Hanson	1967	176	6	D	(10)/25	4,945	8- -67	45 R	SLN 9960
-15cccd	--	1971	105	6	D	12/9	4,938	7- -71	50 R	SLN 11601
-15ccdd	R. Hall	1971	100	6	D	(20)/60	4,930	7- -71	30 R	SLN 11615
								11- 2-71	25.73	
-15cdba	--	1970	123	6	D	(55)/22	4,939	11- -70	38 R	SLN 11300
-15cdbb	--	1962	125	6	D	(14)/51	4,939	4- -62	38 R	SLN 8192
-15cdccl	--	1971	110	6	D	(15)/15	4,928	6- -71	26 R	SLN 11614
-15cdcc2	P. Fanlo	1971	106	6	D	(15)/15	4,929	5- -71	25 R	SLN 11541
-15cdcd	A. J. Clanton	1962	102	6	D	(25)/45	4,928	8- -62	22 R	SLN 6904
-15dbbd	J. Powers	1961	108	6	D	(15)/30	4,957	7- -61	48 R	SLN 6223
-15dbca	J. W. Ferran	--	200	6	D	--	4,949	11- 2-71	47.80	
-15dbdbl	D. L. McFarland	1961	104	6	D	(15)/22	4,962	5- -61	64 R	SLN 6215
-15dbdb2	D. L. McFarland	1962	94	6	D	(20)/25	4,962	9- -62	40 R	SLN 6910

Table 24.--Selected well data--Continued

Location	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) /drawdown (feet)	Land surface altitude (feet)	Water-level measurement Date	Water-level measurement Depth (feet)	Remarks
21/19-15dccd	--	1969	120	6	D	(12)/30	4,934	6- -69	40 R	SLN 10639
-18bcda	Leareno	1968	810	12	I,D	--	5,040.7	8-17-71	87.36	
								9- 9-71	88.94	
								10- 4-71	90.06	
								11- 1-71	89.70	
								11- 9-71	89.29	
-18cbdd	Leareno	1968	838	12	I,D	1,000/52	5,017.9	1- -69	60 R	
								8-17-71	62.50	
								9- 9-71	63.85	
								10- 4-71	64.74	
								11- 1-71	64.50	
								11- 9-71	64.05	
-19bacc	Leareno	1968	840	12	I,D	1,200/25	5,002	11- -68	44 R	SLN 10319
								8-17-71	47.46	
								9- 9-71	48.88	
								10- 4-71	49.88	
								11- 1-71	49.68	
								11- 9-71	49.24	
-19cada	USGS no. 6	1971	42	1½	O	--	4,991	10- 4-71	28.42	Testhole
								11- 1-71	28.49	
-20bdcd	USGS no. 4	1971	67	1½	O	--	5,025	10- 4-71	56.99	Testhole
								11- 1-71	56.92	
-20dbda	USGS no. 5	1971	87	1½	O	--	5,040	10- 4-71	62.4	Testhole
								11- 1-71	62.3	
-21adab	B. J. Mudge	1970	106	8	D	(40)/10	4,945	--	--	SLN 11181
-21daac	R. C. Pompe	--	--	6	D	--	4,927	11- 2-71	25.28	
-21dacd	D. Cunningham	1970	275	8	D	(20)/78	4,922	11- -70	22 R	SLN 11302
								4-15-71	29.36	
								6- 8-71	24.61	
								11- 2-71	26.78	
-21dcdb	USGS no. 21	1971	77	1½	O	--	4,942	10- 4-71	70.98	Testhole
								11- 2-71	70.61	

Table 24.--Selected well data--Continued

Location	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) /drawdown (feet)	Land surface altitude (feet)	Water-level measurement Date	Water-level measurement Depth (feet)	Remarks
21/19-22abcc	--	1971	100	6	D	(20)/20	4,925	5- -71	20 R	SLN 11542
-22badb	R. W. Christenson	1971	108	6	D	(10)/40	4,925	1- -71	27 R	SLN 11358
-22bada	J. Gaston	1970	112	6	D	(10)/70	4,925	11- -70	30 R	SLN 11312
								11- 2-71	21.10	
-22badd	--	1971	95	6	D	(15)/	4,925	6- -71	35 R	SLN 11602
-22bbbc	R. Addams	--	160	6	D	--	4,938	11- 3-71	41.78	
-22bcdc	Lemmon Valley Land Co.	1970	600	26	PS	400/157	4,920	10- -70	18 R	SLN 11290
								9-23-71	13.72	
								6- 8-71	11.68	
								11- 2-71	18.65	
-22bdab1	USGS no. 1	1971	150	1½	O	--	4,919	7-27-71	17.98	Testhole
								10- 4-71	17.43	
								11- 3-71	20.07	
-22bdab2	USGS no. 19	1971	26	1½	O	--	4,919	10- 4-71	19.84	Testhole
								11- 3-71	19.73	
-22bddb	--	1971	--	6	D	--	4,920	11- 3-71	19.14	
-23aaac	Lemmon Valley Land Co.	--	275	8	Ind	--	4,975	4-23-71	79.3	
								6- 8-71	69.18	
								11- 2-71	71.50	
-23addb1	L. A. Youngberg	--	--	--	U	--	4,960	4-22-71	56.14	Dug well
								6- 8-71	58.60	
								11- 2-71	56.42	
-23addb2	L. A. Youngberg	1968	130	6	D	(10)/50	4,960	5- -68	50 R	SLN 10097
								11- 2-71	61.10	
-23caab	P. Bingham	1961	90	6	D	(20-25)/20	4,933	9- -61	43 R	SLN 8054
								11- 3-71	31.20	
-23daba	H. B. Suter	1960	96	6	D	(10)/10	4,950	6- -60	24 R	SLN 5267
								4-22-71	42.35	
								6- 8-71	41.83	
								11- 2-71	41.75	
-23ddbb	R. Taylor	1969	110	6	D	(15)/	4,940	9- -69	48 R	SLN 10736
								11- 2-71	40.26	

Table 24.--Selected well data--Continued

Location	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) /drawdown (feet)	Land surface altitude (feet)	Water-level measurement Date	Water-level measurement Depth (feet)	Remarks
21/19-24abcc	USGS no. 27	1971	80	--	--	--	--	--	--	Testhole - dry hole
-24badd	KCRL	--	--	--	--	--	4,983	4-22-71	76.92	
								6- 8-71	75.93	
								11- 2-71	76.88	
-24dadb	--	1969	202	6	PS	15	5,100	1- -69	181 R	SLN 10392
-26abbd	--	--	--	6	D	--	4,935	11- 2-71	31.20	
-26cbac	Lemmon Valley Land co.	--	446	12	PS,U	346/88	4,919	4-23-71	12.18	
								6- 8-71	10.18	
								11- 2-71	12.98	
-26cccd1	USGS no. 26a	1971	62	1½	O	--	4,919	10- 4-71	14.34	Testhole
								11- 2-71	16.85	
-26cccd2	USGS no. 26b	1971	23	1¼	O	--	4,919	10- 4-71	14.94	Testhole
								11- 2-71	14.48	
-27bcbc	USGS no. 18	1971	70	1¼	O	--	4,915	10- 4-71	24.86	Testhole
								11- 2-71	24.91	
-27dcaa	USGS no. 17	1971	42	1½	O	--	4,918	10- 4-71	8.48	Testhole
								11- 2-71	5.26	
-28aabd	USGS no. 22	1971	50	1½	O	--	4,916	10- 4-71	34.87	Testhole
								11- 2-71	31.23	
-28bada	USGS no. 10	1971	82	1½	O	--	4,933	10- 4-71	67.21	Testhole
								11- 2-71	67.22	
-28cada	USGS no. 9	1971	52	1½	O	--	4,915	10- 4-71	17.05	Testhole. Flooded
								11- 2-71	--	with effluent
								12- 8-71	16.59	11-2-71
-28cbcc	USGS no. 11	1971	53	1½	O	--	4,930	10- 4-71	14.34	Testhole
								11- 2-71	14.37	
-29bccc	Titanium West	--	18	12	Dr	--	4,992	8-17-71	14.44	
								11- 1-71	14.86	
-29caab	USGS no. 13	1971	32	1	O	--	5,012	10- 4-71	27.69	Testhole
								11- 1-71	27.79	
-29dacb	USGS no. 12	1971	84	1½	O	--	5,035	10- 4-71	48.16	Testhole
								11- 1-71	46.69	

Table 24.--Selected well data--Continued

Location	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) /drawdown (feet)	Land surface altitude (feet)	Water-level measurement Date	Water-level measurement Depth (feet)	Remarks
21/19-30cabc	USGS no. 7	1971	22	1½	O	--	4,970	10- 4-71	7.34	Testhole
								11- 1-71	7.30	
-30ddda	Sierra Pacific	1942	706	12	PS,U	--	4,989	1942	35 R	
								11- 9-71	11.57	
-31ccccl	City of Reno	1942	1,170	12	I	--	4,971	12-22-42	22.25	
								11- 1-71	70.70	
-31cccc2	City of Reno	1971	1,000	12	I	--	4,967	10- 5-71	116.0	Recovered for at least 12 hours
								11- 1-71	66.0	Recovering for about one week
-32acaa	USGS no. 25	1971	62	1½	O	--	5,001	10- 4-71	46.10	Testhole
								11- 1-71	45.94	
-32baad	USGS no. 23	1971	64	1½	O	--	5,032	10- 4-71	57.90	Testhole
								11- 1-71	52.72	
-32ddbd	USGS no. 15	1971	37	1½	O	--	4,980	10- 4-71	19.53	Testhole
								11- 1-71	19.85	
-33bbcd	--	1957	165	8	U,O	--	4,940	6- -57	22 R	SLN 3969
								8-22-66	11.02	
								3-18-68	9.55	
								4- 8-69	9.65	
								3-10-70	8.30	
								3-30-71	9.82	
								11- 2-71	9.96	
-33ccbc	USGS no. 16	1971	22	1½	O	--	4,960	10- 4-71	8.81	Testhole
								11- 2-71	7.98	
-33cccb	J. Cavanaugh	--	--	6	D	--	4,965	10- 4-71	9.05	
								11- 2-71	9.93	
-34badbl	USGS no. 20	1971	32	1½	O	--	4,919	10- 4-71	27.12	Testhole
								11- 3-71	23.73	
-34bbab	Lemmon Valley Land Co.	1970	457	14	PS	425/54	4,919	4-23-71	12.94	

Table 24.--Selected well data--Continued

Location	Owner or name	Year drilled	Depth (feet)	Diameter (inches)	Use	Yield (gpm) /drawdown (feet)	Land surface altitude (feet)	Water-level measurement Date	Water-level measurement Depth (feet)	Remarks
21/19-34bbba	Lemmon Valley Land Co.	1970	488	8	PS	423/37	4,919	4- -70	11 R	
								4-23-71	13.92	
								6- 8-71	12.85	
								11- 3-71	17.29	
-34cccd	LeCaer	1963	254	8	D	--	4,950	1- -63	19 R	SLN 7075
-34ccdc	LeCaer	--	--	8	PS	--	4,950	11- 4-71	56.35	
22/19-18dddd	C. Dickenson	1941	265	6	S	--	5,550	1941	230 R	

Table 25--Approximate location, altitude, and depth to water of seven wells in Lemmon Valley on July 18, 1942

[Data from U.S. Army Corps of Engineers, 1943, p. 6]

Location	Altitude land surface or top casing	Depth to water	Altitude water surface
21/18-36ddd	4,969.31	9.73	4,959.58
21/19-31cdc1	4,967.15	7.00	4,960.15
-31cdc2	4,961.91	2.70	4,959.21
-31dbc1	4,970.72	13.45	4,957.27
-31dbc2	4,969.02	15.83	4,953.19
-32cdb	4,986.61	22.00	4,964.61
-33ccc	4,968.02	17.60	4,950.42

Table 26.--Selected drillers' logs of wells

Material	Thickness (feet)	Depth (feet)
20/18-1dccd		
Topsoil	3	3
Boulders	22	25
Clay	65	90
Gravel, small, some water	20	110
Clay	9	119
Water gravel	19	138
Clay, sandy, and small gravel	29	167
Sand, coarse, and small gravel	6	173
Clay, sandy, and small gravel	2	175
20/18-2dddd		
Topsoil and rock	6	6
Boulders and clay	108	114
Clay and broken rock	56	170
20/18-11aadd		
Rocks, coarse sand and gravel with soil	8	8
Clay, yellow with coarse sand and gravel, rock, hard. First water. Water level 6 ft 8 inches. Very little water	29	37
Sand and gravel, fine to coarse with yellow clay. Rocks, hard. Second water. Water level 23 feet 8 inches. Very little water	9	46
Sand and rocks. Very hard	7	53
Clay, yellow, soft	10	63
Sand and rocks. Third water. Water level 23 feet. Very little water	5	68
Clay, yellow with fine to coarse sand and gravel with yellow clay, rocks, hard. Has trickle of artesian flow. Probably seep from Anderson's Springs above WPRR tracks	5	73
20/18-11ad (continued)		
Sand and gravel, fine to coarse with yellow clay, rocks, hard. Fifth water, very little water	7	80
Sand, fine to medium, with yellow clay, rocks, hard. Sixth water, very little water	20	100
20/18-12abcc		
Soil, black loam	10	10
Clay, yellow	9	19
Gravel strata with water, rocks, sandy yellow clay mixed	21	40
Clay, yellow, sand and small rocks	13	53
Clay, yellow, with sand	9	62
Rocks and sand	2	64
Clay, yellow, with sand	4	68
Rocks and sand	1	69
Clay silt formation	5	74
Sand and gravel	5	79
20/18-13dcaa		
Clay and broken rock	3	3
Rock, weathered, broken	16	19
Clay and rock	10	29
Rock	7	36
Rock and clay	10	46
Clay, brown	22	68
Clay, gray	36	104
Sand and rock	16	120
Clay, sandy	8	128
Sand and rock, water-bearing	14	142
Sandstone	4	146
Shale, blue and sand, water-bearing	8	154
Shale, some water	24	178
Shale, gray, some water	22	200

Table 26.--Selected drillers' logs of wells (continued)

Material	Thickness (feet)	Depth (feet)
20/19-3bcab		
Topsoil, water-bearing	36	36
Gravel	24	60
Gravel, water-bearing	8	68
Gravel	11	79
Sand, water-bearing	1	80
Granite, decomposed	4	84
Granite, decomposed, water-bearing	26	110
Granite, decomposed	146	256
Granite, decomposed, with water-bearing strata	80	336
Granite	39	375
20/19-4bdab		
Topsoil, sandy	22	22
Clay, sandy, hard	19	41
Clay, sandy	31	72
Clay, sandy, and rock	26	98
Granite to hard granite	16	114
20/19-4ddac		
Sand	63	63
Rock, hard, with fractures	124	187
Soft spot	1	188
Rock, hard, with fractures	108	296
20/19-8bcba		
Clay, sticky, red, with fine to coarse sand and gravel	35	35
Clay, red, with fine to coarse sand and gravel, few stones, soft and solid	24	59
Sand, medium to coarse, large gravel, stony, loose. First water. Water level 45 feet	3	62
Clay, red, with fine to coarse sand and gravel	2	64
Sand, medium to coarse, and large gravel, loose. Second water. Little water	2	66
20/19-8bcba (continued)		
Clay, red, with fine to coarse sand and gravel. Soft	6	72
Sand, coarse, and coarse gravel, stony, loose. Third water, little water	3	75
Clay, red, with medium to coarse sand and gravel. Soft. Fourth water. Water level 57 feet 6 inches. Little water	10	85
Clay, red, with medium to coarse sand and gravel, soft. Fifth water. Water level 55 feet 6 inches. Little water	15	100
Clay, red, with medium to coarse sand and gravel, soft. Sixth water. Water level 47 feet 10 inches. Little water	10	110
20/19-8caac		
Soil	2	2
Clay and rock	54	56
Sand	2	58
Clay and rock	22	80
Sand	4	84
Clay and boulders	28	112
Sand	6	118
Clay and rock	62	180
Sand	7	187
Clay and rock	35	222
Sand	6	228
Clay and rock	34	262
Sand	4	266
Clay	5	271
Sand	7	278
Clay and rock	6	284
Sand and boulders	8	292

Table 26.—Selected drillers' logs of wells (continued)

Material	Thickness (feet)	Depth (feet)
20/15-8ddbd		
Clay, yellow, soft	38	38
Sand and gravel, fine to coarse, with clay. First water, water level 22 feet	7	45
Clay, yellow	5	50
Sand and gravel, fine to coarse, with clay, stony. Second water, water level 24 feet	5	55
Clay, yellow	10	65
Sand and gravel, fine to coarse, with clay. Third water	7	72
Clay, yellow	5	77
Sand and gravel, fine to coarse, with clay. Fourth water	13	90
Clay, yellow	5	95
Sand and gravel, fine to coarse, loose. Fifth water, water level 27 feet	5	100
Clay, yellow, with fine to coarse sand and gravel. Sixth water, water level 23 feet 6 inches	15	115
Clay, yellow, hard and sticky	30	145
Sand and gravel, fine to coarse, with clay. Seventh water	15	160
Clay, yellow	25	185
Sand and gravel, fine to coarse, loose. Eighth water	2	187
20/19-10aaacl		
Soil	3	3
Granite, decomposed, and clay	79	82
Granite, decomposed	6	88
Sand, dry	1	89
Granite, decomposed, hard	29	118
Granite, decomposed, and sand	2	120
20/19-11cdab		
Soil	2	2
Clay	73	75
Sand	2	77
Clay, yellow	14	91
Granite, decomposed	4	95
Clay, yellow	13	108
Sand, hard	7	115
Boulders and clay	3	118
Clay	2	120
20/19-14abbc		
Topsoil	2	2
Clay, yellow, sandy, with small gravel to 2 inches	4	6
Clay, brown, sandy	7	13
Clay, brown, sandy, with small gravel to ¼ inch	19	32
Clay, yellow, hard, with gravel to ¼ inch mixed	11	43
Clay, yellow, sandy, soft	3	46
Sand, coarse, with gravel to 3/8 inch mixed with yellow clay	40	86
Sand, coarse, with small gravel to ¼ inch	2	88
Granite, weathered, becoming harder	2	90

Table 26.--Selected drillers' logs of wells (continued)

Material	Thickness (feet)	Depth (feet)
20/19-15aaca		
Granite, broken	3	3
Granite, gray	52	55
Basalt, black	17	72
Clay seam	8	80
Granite, gray	12	92
Clay, sandy	18	110
Granite, rotten	5	115
Granite, gray	30	145
Clay crevice, sandy	5	150
Granite, gray, hard	32	182
20/19-15bcdc		
Topsoil	4	4
Clay, heavy, and sand	34	38
Clay, sand, and broken rock formation	88	126
Clay, sand, gravel, and broken rock (some water)	32	158
Clay, hard, dry, and shale	49	207
Clay, sand, and broken rock formation	153	360
Water-bearing	42	402
Rock, hard	6	408
21/18-24aabd		
Soil	4	4
Granite, decomposed	8	12
Clay, sandy	82	94
Sand	1	95
Clay, sandy	33	128
Sand	1	129
Clay	9	138
Sand	10	148
Clay	2	150
21/18-25abdd		
Clay and shale	55	55
Sand, fine, water-bearing	27	82
Sand, coarse, water-bearing	11	93
21/18-25bbbc		
Topsoil	1	1
Clay	79	80
Sand, coarse to fine, water	13	93
Clay, brown	12	105
Sand, coarse to fine, water	15	120
Clay, brown	43	163
Gravel, medium, main water	10	173
Clay, brown	2	175
21/18-26aadb		
Sandy loam	15	15
Clay, yellow	45	60
Clay, blue	15	75
Clay, blue, with fine to coarse sand, fine mica. First water, water level 63 feet 6 inches. Little water	10	85
Sand, fine to coarse with blue clay. Second water, little water	10	95
Sand, fine to coarse with blue clay. Third water, water level 64 feet	10	105
Sand, fine to coarse with blue clay, a little gravel. Fourth water, water level 64 feet 6 inches	10	115
Clay, blue with fine to coarse sand. Fifth water	10	125
Clay, blue, hard, sticky	5	130
Clay, blue with fine to coarse sand. Sixth water, water level 64 feet	15	145
Clay, blue, hard, sticky	5	150
Sand, fine to coarse, a little gravel with blue clay, fine mica. Seventh water	10	160
Sand, fine to coarse, a little gravel with blue clay, fine mica. Water	10	170

Table 26.—Selected drillers' logs of wells (continued)

Material	Thickness (feet)	Depth (feet)
21/18-36ccda		
Soil, black loam	5	5
Clay, yellow	22	27
Sand, water strata	.4	27.4
Clay, yellow with sand	29.6	57
Sandy formation with some yellow clay	28	85
Clay, blue	10	95
Sand, fine with blue clay formation	15	110
Clay, blue	5	115
21/19-5aad		
Soil, sandy loam	2	2
Granite sand, fine mixed with a little yellow clay	30	32
Clay, yellow with sand	138	170
Gravel strata (seepage water 6 inches) at 170 feet. Yellow clay with dand. Gravel strata (seepage water at 292 feet)	122	292
Clay, yellow with sand	8	300
Sand gravel strata, black, almost like the Truckee River sand		300
21/19-15bcdb		
Clay, sandy	140	140
Sand, loose	6	146
Clay, sandy	52	198
Rock, yellow, hard	7	205
Rock, white, soft	15	220
Crevice	2	222
Rock, hard	6	228
Crevice	1	229
Rock, solid	11	240
21/19-15cbad		
Sand	30	30
Sand and boulders	20	50
Sand and small boulders	30	80
Sand	20	100
Sand with small streaks of gravel	20	120
21/19-15cbad (continued)		
Sand, fine, and streaks of water sand	20	140
Water sand, coarse	10	150
21/19-19bacc		
Clay, sandy	16	16
Sand	8	24
Clay, dry	6	30
Sand	40	70
Clay	20	90
Sand	20	110
Sand and clay lense	135	245
Sand	15	260
Clay, sandy	45	305
Sand	15	320
Clay, sandy	20	340
Sand	20	360
Clay, sandy	45	405
Clay	10	415
Sand and "pea" gravel	45	460
Clay	5	465
Sand, coarse	20	485
Clay, sandy	30	515
Sand and "pea" gravel	100	615
Clay	12	627
Sand and "pea" gravel	213	840
21/19-21dacd		
Clay	12	12
Gravel and clay streaks	26	38
Cobbles and clay	6	44
Clay	7	51
Sand	2	53
Clay	12	65
Gravel	2	67
Clay	45	112
Clay with thin layer of sand	91	203
Sand rock	72	275

Table 26.--Selected drillers' logs of wells (continued)

Material	Thickness (feet)	Depth (feet)
21/19-22bcdc		
Clay	16	16
Sand	1	17
Clay	3	20
Sand	3	23
Clay	17	40
Sand	2	42
Clay	34	76
Sand and clay layers	36	112
Clay	55	167
Sand	8	175
Sand, gravel, and clay layers	17	192
Sand	23	215
Clay	3	218
Sand and clay layers	150	368
Clay, sticky	10	378
Sand	2	380
Clay, sticky, hard	10	390
Sand	17	407
Sand, gravel, and clay layers	115	522
Boulders	3	525
Sand and gravel	75	600
21/19-23adbb		
Sand, loose	14	14
Sand and clay	46	60
Sand, coarse	10	70
Clay, sandy	13	83
Sand and gravel	12	95
Clay, sandy	15	110
Sand, coarse	18	128
Clay	2	130
21/19-30ddda		
Clay and gravel	15	15
Granite sand	130	145
Clay	11	156
Granite sand	24	180
Cemented	7	187
Clay and sand	43	230
Cemented, hard	16	246
Clay	10	256
Cemented, hard	7	263
Medium hard	5	268
21/19-30ddda (continued)		
Clay, hard streaks	14	282
Granite, tight, medium-hard	34	316
Cemented, hard	18	334
Gravel, fair	3	337
Clay, tough	8	345
Gravel, fair	3	348
Clay, tough	8	356
Gravel, no good	7	363
Clay, tough	14	377
Gravel, fair condition	10	387
Clay, tough	3	390
Gravel	4	394
Clay, tough	11	405
Gravel, loose	7	412
Clay	2	414
Gravel	4	418
Gravel, cemented 418-420	9	427
Clay, tough	4	431
Gravel, loose	4	435
Clay, good	11	446
Gravel	11	457
Clay	5	462
Gravel and clay streaks, blue clay	20	482
Gravel, loose	8	490
Clay	10	500
Gravel, hard streaks	6	506
Gravel, loose	10	516
Gravel, tight, medium	10	526
Shale	5	531
Gravel, hard streaks	25	556
Gravel, loose	5	561
Gravel and clay streaks	10	571
Shale, clay	5	576
Gravel, hard streaks	25	601
Clay	2	603
Gravel, tight	23	626
Gravel and clay	5	631
Clay	10	641
Gravel, hard streaks	30	671
Clay	5	676
Gravel, tight	5	681
Gravel, loose	5	686
Gravel, tight	15	701
Clay	5	706

Table 26.--Selected drillers' logs of wells (continued)

Material	Thickness (feet)	Depth (feet)
21/19-31cccc		
Clay, sandy	22	22
Clay, sticky	24	46
Clay, brittle (ash)	2	48
Clay, sticky	53	101
Clay, blue, tough	51	152
Clay with brittle streaks of clay	84	236
Clay, tough, with soft spots	89	325
Clay, tough	27	352
Gravel	28	380
Clay	7	387
Packed hard, not water-bearing	5	392
Clay, brittle (soft shale)	7	399
Clay, soft	50	449
Granite sand, loose, not good aquifer	18	467
Clay	3	470
Sand and gravel, loose	17	487
Clay	19	506
Sand	4	510
Clay, hard	20	530
Clay, soft	20	550
Clay, hard	53	603
Gravel, loose	24	627
Clay, firm	11	638
Gravel, small and fair condition	12	650
Clay	44	694
Clay, brittle (shale in clay)	10	704
Clay	20	724
Sand and gravel, loose	52	776
Clay	7	783
Sand and gravel, loose	18	801
Clay, tough	5	806
Clay, medium hard	44	850
Clay, sandy, soft	18	868
Clay with some sand streaks	20	888
Clay	26	914
Gravel, loose	8	922
Clay	8	930
Gravel, loose	7	937
Clay	28	965
21/19-31cccc (continued)		
Shale, medium hard	20	985
Gravel, loose	11	996
Gravel, tight	7	1,003
Clay	2	1,005
Gravel, loose	15	1,020
Clay, tough	35	1,055
Shale, hard	115	1,170
21/19-34bbab		
Clay, sandy	5	5
Clay, hard	3	8
Sand	1	9
Clay, brown	19	28
Sand	1	29
Clay, brown	13	42
Sand and clay layers	24	66
Clay	4	70
Sand	2	72
Clay	18	90
Clay, gray, soft	22	112
Clay, brown, sticky	45	157
Sand and clay layers	23	180
Clay, light gray	12	192
Sand and clay streaks	10	202
Clay, brown	14	216
Sand with thin clay layers	32	248
Clay, brown, sticky	4	252
Sand and gravel	16	268
Sand, gravel, and clay streaks	29	297
Clay	7	304
Sand and clay streaks	78	382
Cobbles	1	383
Sand, gravel, and clay streaks	29	412
Boulders	2	414
Sand, gravel, and clay streaks	41	455
Granite	3	458
22/19-18dd		
Soil, sandy loam	3	3
Sand mixed with yellow clay	77	80
Clay, yellow	100	180
Clay, blue	85	265

Table 27.--Generalized logs of U.S. Geological Survey test wells

(Numbers in parentheses are U.S. Geological Survey field numbers)

Material	Thickness (feet)	Depth (feet)
20/19-5bbab (14)		
Silt and sand	7	7
Clay, sandy, brown, drilling cased at 16 feet	10	17
Clay, sandy, wet	10	27
20/19-6aabc (8)		
Topsoil and gravel	7	7
Sand, clayey, some gravel	20	27
20/19-9bbba (27)		
Gravel and sand	7	7
Silt and clay, red-brown, drilling cased at 15 feet	15	22
Sand and clay, red-brown	20	42
21/18-36addb1 (2)		
Clay and silt, dry	6	6
Sand, damp, wet at 12 feet	14	20
Clay, brown	85	105
Clay	45	150
21/18-36addb2 (3)		
Silt	8	8
Sand	5.5	13.5
21/19-19cada (6)		
Silt and sand, drilling cased at 10 feet	10	10
Silt, sand, some gravel	1	11
Sand and clay, interbedded	31	42
21/19-20bdcd (4)		
Sand, some silt, hard drilling	32	32
Sand and silt	15	47
Clay and sand, soft drilling at 50 feet	20	67
21/19-20dbda (5)		
Sand	7	7
Sand and gravel	15	22
Sand, damp, brown	10	32
Sand and silt	5	37
Sand and clay	35	72
Sand and gravel	5	77
Sand, clayey	10	87
21/19-21dcdb (21)		
Sand, tan	7	7
Sand and gravel, tan	20	27
Sand	10	37
Sand, cemented with clay	9	46
Sand and clay	6	52
Clay, sandy, drilling cased at 68 feet	20	72
Clay, sandy, and sand, red	5	77
21/19-22bdab1 (1)		
Clay, dry	10	10
Clay, damp	15	25
Sand and clay, interbedded	125	150
21/19-22badb2 (19)		
Clay, dry	7	7
Clay, damp	15	22
Clay and sand	4	26
21/19-24abcc (24)		
Sand, silty, tan	40	40
Gravel	1	41
Clay, sandy, dark brown	19	60
Rock	1	61
Clay, sandy, brown	14	75
Gravel, rock at 80 feet, dry hole	5	80

Material	Thickness (feet)	Depth (feet)
21/19-26cccd (26a and b)		
Silt and clay, tan	12	12
Silt and clay, sandy	5	17
Sand and silt, grayish-tan, interbedded	45	62
21/19-27bcbc (18)		
Clay, silty, brown	27	27
Clay, silty, tanish-green	10	37
Clay, blue-gray	20	57
Clay, greenish-gray	20	77
Clay, red, tight, sticky	8	85
21/19-27dcaa (17)		
Silt, clayey, brown	17	17
Silt, drilling cased at 20 feet	5	22
Clay, brown	15	37
Clay, blue	5	42
21/19-28aabd (22)		
Silt and clay, tan	17	17
Clay, brown	20	37
Clay, gray-green	5	42
Clay, gray-brown	8	50
21/19-28bada (10)		
Sand	7	7
Clay, sandy, brown	10	17
Clay, sandy, light brown	5	22
Clay, sandy, tan	20	42
Clay, silty	30	72
Clay	7	79
Sand	3	82
21/19-28cada (9)		
Silt and clay, brown	17	17
Clay, brown	28	45
Clay, gray	7	52
21/19-28cbcc (11)		
Sand, clay, and silt	7	7
Clay, sandy, brown	15	22
Sand and clay, light brown	15	37
Clay, sandy	15	52
Sand	1	53
21/19-29caab (13)		
Silt and clay, some sand	7	7
Clay, brown, sandy, some gravel	5	12
Clay, sandy, brown	30	42
21/19-29daab (12)		
Clay, sandy, brown	7	7
Sand and gravel	5	12
Sand, brown	5	17
Sand and clay	20	37
Clay, sandy, red-brown	5	42
Gravel, clay	10	52
Gravel, rocks, and clay	10	62
Clay, drilling cased at 70 feet	8	70
Sand and clay	14	84
21/19-30cacb (7)		
Silt, sand, and clay	12	12
Sand and clay	10	22
21/19-32acaa (25)		
Sand, tan	17	17
Sand, brown, clayey	15	32
Sand, silty, brown	28	60
Sand, red	2	62
21/19-32baad (23)		
Sand	17	17
Sand and gravel	15	32
Sand and large gravel	5	37
Sand, damp	10	47
Clay, sandy, drilling at 47 feet	17	64

Material	Thickness (feet)	Depth (feet)
21/19-32ddbd (15)		
Clay and silt	6	6
Gravel	1	7
Clay, sandy	30	37
21/19-33ccbc (16)		
Soil, sandy	7	7
Clay, sandy	15	22
21/19-34badb (20)		
Clay, silty, and sand	7	7
Clay, silty, brown	5	12
Silt, clay, and sand	5	17
Clay, brown, silty	10	27
Clay, gray-green	5	32

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A P P E N D I X I

APPENDIX I

This appendix presents a method for estimating maximum sustained withdrawals in ground-water basins developed under a perennial-yield concept. The perennial yield of a ground-water reservoir has been defined as the maximum amount of water of usable chemical quality that can be withdrawn and consumed legally and economically each year for an indefinite period of time. Generally, only part of the water pumped is consumed in use; the remainder may be returned to the ground-water reservoir and is available for reuse. However, most uses result in some deterioration in water quality, and recirculation eventually leads to a deterioration in quality of pumped water. In arid areas, such as Nevada, demand for water commonly exceeds the readily available perennial supply. Consequently, one alternative receiving increased consideration is to reuse water as much as possible and maintain satisfactory chemical quality by water treatment. This appendix develops a method of estimating the maximum rate at which water (including recirculated water) might be withdrawn from a ground-water reservoir without exceeding the perennial yield.

The following terms and symbols are used:

PY=perennial yield

R=part of withdrawn water that is recirculated, expressed as a decimal fraction

Q_{max}= maximum annual rate of withdrawal without exceeding perennial yield

F= a reuse factor

C=part of withdrawn water that is consumed, expressed as a decimal fraction

When water is used, a certain part, R, is not consumed and returns to the ground-water system. If the quantity withdrawn equals the perennial yield, the amount returned to the ground-water system equals R(PY). When the quantity R(PY) is withdrawn for reuse, the amount returned equals only $R^2(PY)$. When the quantity $R^2(PY)$ is withdrawn to be used a third time the amount returned is only equal to $R^3(PY)$. This process can continue indefinitely with an ever smaller quantity of return flow available for reuse. The maximum possible rate of sustained pumping should equal the perennial yield plus the total quantity of return flow. This relation may be stated mathematically as follows:

$$Q_{max} = PY + R(PY) + R^2(PY) + R^3(PY) + \ldots\ldots R^{oo}(PY).$$

This simplifies to:

$$Q_{max} = PY(1 + R + R^2 + R^3 + \ldots\ldots R^{oo}).$$

However, $R + R^2 + R^3 + \ldots\ldots R^{oo}$ is a geometrical progression whose sum equals $\frac{R}{1 - R}$.

Therefore: $Q_{max} = PY\ (1 + \frac{R}{1 - R}) = \frac{PY}{1-R}$ (1)

If the following substitution is made: $F = \frac{1}{1 - R}$ then $Q_{max} = F\ (PY)$. (2)

If it is desired to use consumption instead of recirculation, $1 - C = R$ may be substituted in equation (1) which then simplifies to:

$$Q_{max} = \frac{PY}{C}$$

Equation 2 is a simplified form of equation 1 designed to be used with figure A1-1. Figure A1-1 shows the relation between the part of withdrawn water that is recirculated, R, and the reuse factor, F. For example, if a basin is to be developed for agricultural purposes, perhaps one-third (33 percent) of withdrawn water is expected to be recirculated. Figure A1-1 indicates a reuse factor of 1.5. If the perennial yield of the basin was about 1,000 acre-feet per year, then the maximum sustained withdrawal under a perennial-yield concept would be about 1,500 acre-feet per year. If the same basin were developed for municipal purposes, perhaps 60 percent of the withdrawn water would be recirculated (this assumes that sewage could be satisfactorily treated and the effluent returned to the ground-water system). In this case, the reuse factor is 2.5, and the maximum sustained withdrawal would be about 2,500 acre-feet per year.

The relation shown in figure A1-1 has a limit in practical application. The mathematically computed reuse factor approaches infinity as the percentage of recirculated water approaches 100. In actuality, time lag and local overdraft would prevent the theoretically possible reuse from being attained under conditions of high recirculation. The limit of practical application is not known, but effective application above 80 percent recirculation is doubtful.

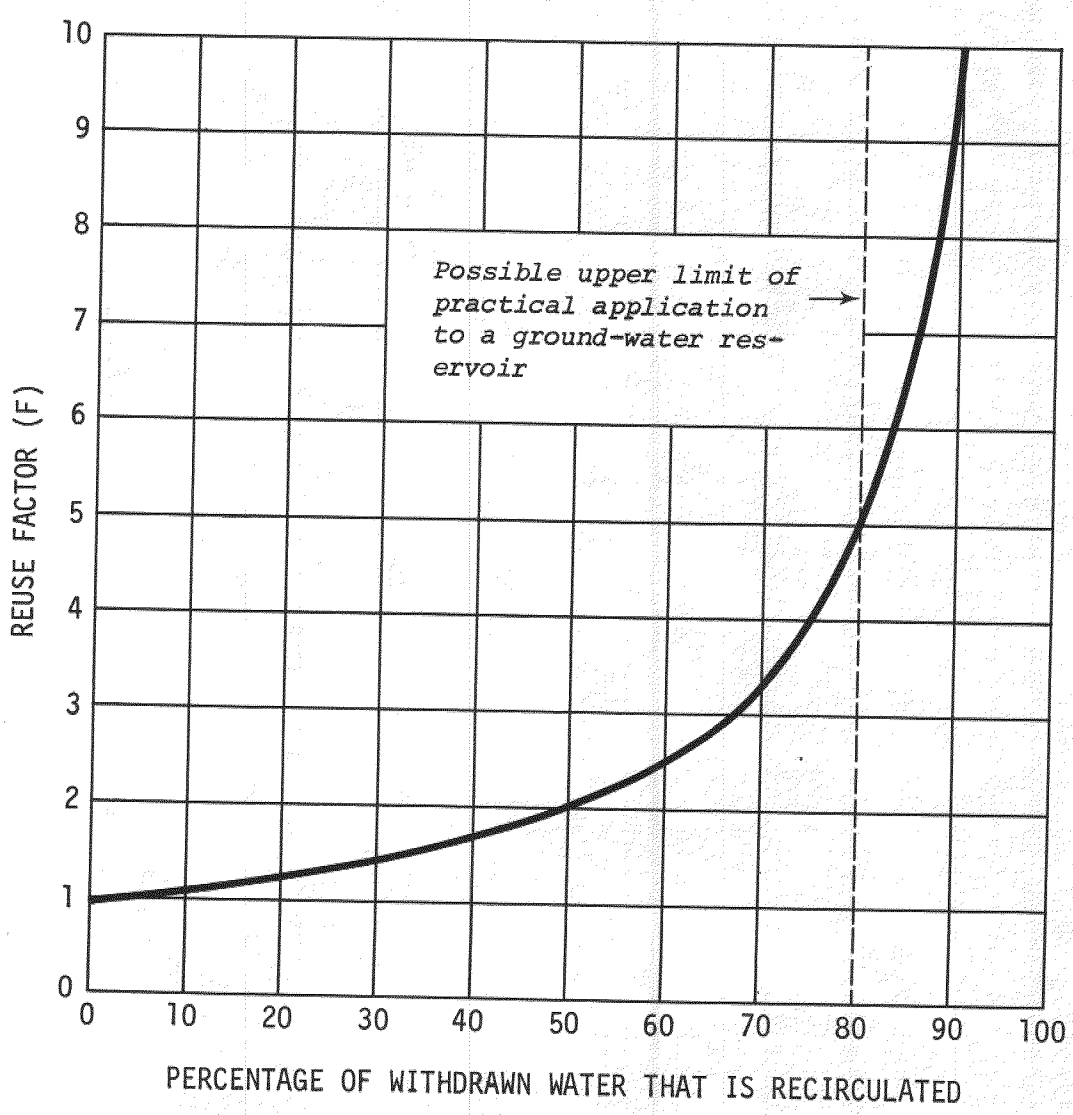

Figure AI-1 Relation between reuse factor and percentage of withdrawn water that is recirculated

A P P E N D I X I I

APPENDIX II

This appendix describes a method of evaluating the net diversion from the Truckee River system, if imported water were used conjunctively with ground water and if treated sewage effluent were returned to the Truckee River system. In this situation, water imported into Lemmon Valley would be supplemented by ground water, pumped at the maximum possible sustained rate, to provide the water supply for the area. A single sewer system would serve the entire area. Part of the total water supplied would flow to the sewage-treatment plant, be treated, and returned to the Truckee River system. The remaining part of the water supplied would be used outside of houses, primarily to irrigate lawns, part of which would infiltrate to recharge the ground-water system. Recharge from imported water would augment the perennial yield. Ground water would be withdrawn from the valley-fill reservoir at the maximum sustained rate permitted by the augmented yield and the amount of recirculation.

The following terms are used:

I = imported water

E = Exported water

PY = Perennial yield

R = part of imported plus pumped water that is recirculated, expressed as a decimal fraction.

C = part of imported plus pumped water that is consumed, expressed as a decimal fraction.

ND = Net diversion from the Truckee River system; also equals I - E

AY = Augmented yield = PY + RI

F = Reuse factor for recirculation of R (see Appendix I)

Q_{max} = Maximum possible sustained rate of ground-water pumpage equals.

$$F(PY + RI); \text{ (see Appendix I)}$$

S = part of imported plus pumped water that is exported, expressed as a decimal fraction.

An expression for the amount of exported water may be written as that part of the imported water plus that part of the pumped

ground water that is exported as effluent. This is written in terms of the above symbols as follows:

$$E = SI + SQ_{max}.$$

Substituting the equalities listed above gives:

$$I - ND = SI + SF(PY + RI) \qquad (1)$$

Equation 1 is the generalized expression which describes net diversion from the Truckee River system under the conditions indicated. Disposition of withdrawn water is assumed to be the same as that given for imported water at Stead Facility in table 16 in the main part of the report. It is summarized as follows:

40 percent flows to the sewage-treatment plant (exported in this case)

40 percent consumed

20 percent recirculated.

Under these conditions S = .4; C = .4; and R = .2; perennial yield is 1,300 acre-feet per year; and F = 1.25 where R = .2 (appendix I). Substituting these values in equation 1 gives:

$$I - ND = .4I + .4(1.25)\ (1{,}300 + .2I).$$

This simplifies to:

$$I = \frac{650 + ND}{.5} \qquad (2)$$

Equation 2 was used to compute inflow values listed in table 23 in the main part of the report for specified values of net loss to the Truckee River system. Pumpage was computed as 1.25 (PY + .2I). Water consumed was computed as PY + ND. Recycled water was computed as .21 + .25[PY + .2I]. Return flow to the Truckee River system was computed as I - ND. In the event that the disposition of water changes, revised values would have to be substituted in equation 1 to obtain reasonably accurate estimates.

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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

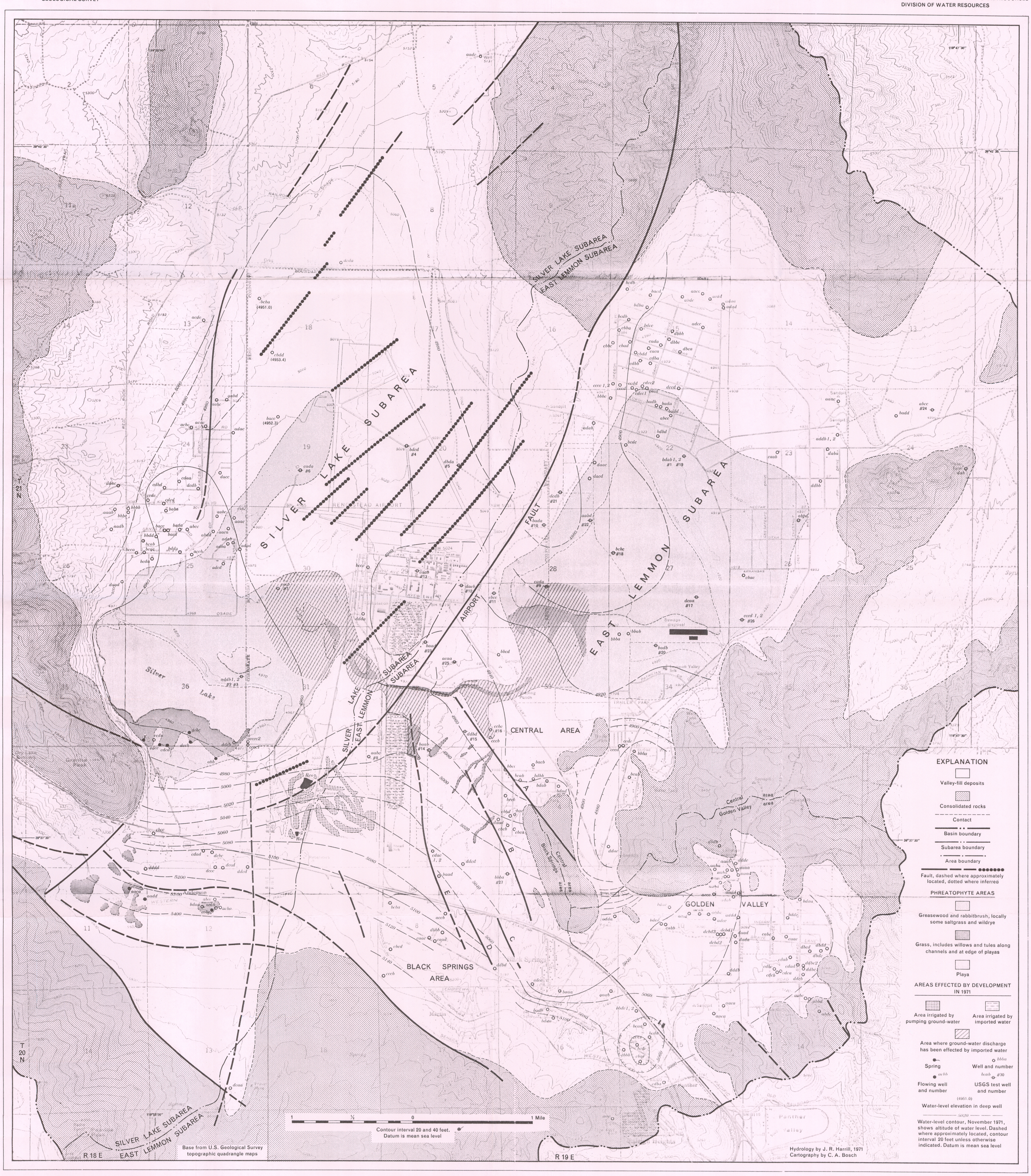

PLATE 1.-HYDROLOGIC MAP OF LEMMON VALLEY, NEVADA