DESERT RESEARCH INSTITUTE
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ABSTRACT

There are approximately 400 homes in the Golden Valley area, all of which are served by individual domestic wells and septic tanks. Water levels in some wells have been declining by as much as 10 ft/yr. In recent years several wells have had to be deepened to maintain a water supply. Also, water quality in many wells has shown signs of deterioration, presumably as a result of septic tank return flows. Nitrate concentrations in excess of 70 mg/ℓ have been measured. Preliminary water budget calculations for Golden Valley indicate an annual groundwater storage depletion of about 185 acre-feet. Septic tank return flow represents about 2/3 of the estimated 150 acre-feet/yr groundwater replenishment. Groundwater withdrawal is currently estimated at 335 acre-ft/yr.

Opportunities for new replacement water supplies are limited. One option is to salvage runoff from nearby Peavine Mountain which is currently being lost by evaporation from two large playas. Estimated average annual evaporation loss from Silver Lake Playa is 400-500 acre-ft. If this excess runoff can be captured and recharged into the Golden Valley aquifers, decline in water levels would be abated and general quality of water would be enhanced. Preliminary hydrologic analysis indicates that it may be possible to divert up to 400 acre-ft/yr before the water reaches the playa. Diversion elevation would be near 6000 ft with delivery to Golden Valley at approximately 5,300 ft. Geologic conditions in Golden Valley appear favorable for recharge either through infiltration basins or injection wells.

Preliminary cost estimates for this harvest/recharge system range from $962,000 to $1,290,000 depending upon design criteria. Equivalent annual cost would range from $360 to $435 per acre-foot for delivery of 400 acre-feet/yr. These costs are not too dissimilar from those paid by other residential water users in the Reno area.

INTRODUCTION

Harvest of winter and spring-time flows from Peavine Mountain is technically feasible from an engineering perspective. Diversion structures and pipelines can be built and the water can be transported to Golden Valley for injection and/or infiltration. Whether such an undertaking makes sense, however, is largely a question of economics, both at the private and public levels. Economic feasibility will, in large measure, be determined by the long-term average yield of the harvest/recharge system. Studies are currently in progress that address four major aspects of this water salvaging scheme: 1) yield of the watersheds on Peavine Mountain's north and east faces; 2) hydrogeologic characterization and modelling of the Golden Valley groundwater reservoir; 3) analysis and characterization of water chemistry of Peavine runoff and Golden Valley groundwater; and 4) preliminary design and construction aspects of the scheme-particularly pipeline routes, land ownership, pipeline characteristics, recharge sites and construction costs.

PRELIMINARY GOLDEN VALLEY WATER BUDGET

The southern portion of Lemmon Valley Hydrographic area can logically be subdivided into two sub-units, the Black Springs area and the Golden Valley area. Harrill (1973) showed groundwater from both areas moving through the "Lemmon Valley Drive Canyon" into Lemmon Valley proper (see Figure 1). Surface water draining from the two areas is carried through the same canyon via the major drainage that approximately follows the old railroad grade. For purposes of this study, this latter drainage is being used as the divide between the Black Springs and the Golden Valley area, at least in terms of precipitation and surface runoff. Harrill (1973) used Highway 395 as the dividing line between these two sub-areas.

PRECIPITATION AND NATURAL RECHARGE

Golden Valley encompasses a topographic drainage area of approximately 2,300 acres and ranges in elevation from about 5000 ft. at its distal end to more than 5,850 ft. at the highest point. As indicated in Figure 2, precipitation in the valley is estimated to range from about 10 inches per year on the valley floor to over 14 inches per year on the northeast peaks.

Based on Figure 2, it is estimated that the Valley receives an average annual total precipitation of about 2,300 acre-feet (AF). Because of the favorable geologic conditions it is realistic to expect that a portion of the precipitation which infiltrates the soil eventually reaches the water table to become natural recharge. While as much as 1 to 3 inches of precipitation may actually be infiltrated, it is unlikely that more than 1/4 to 1/2 inch actually reach the water table. The balance of the infiltrated water is retained in the unsaturated zone and is subsequently lost to evapotranspiration by native vegetation and soils. Based on this assumption (1/4 to 1/2 inch) the total average annual recharge would be about 50 to 100 AF.

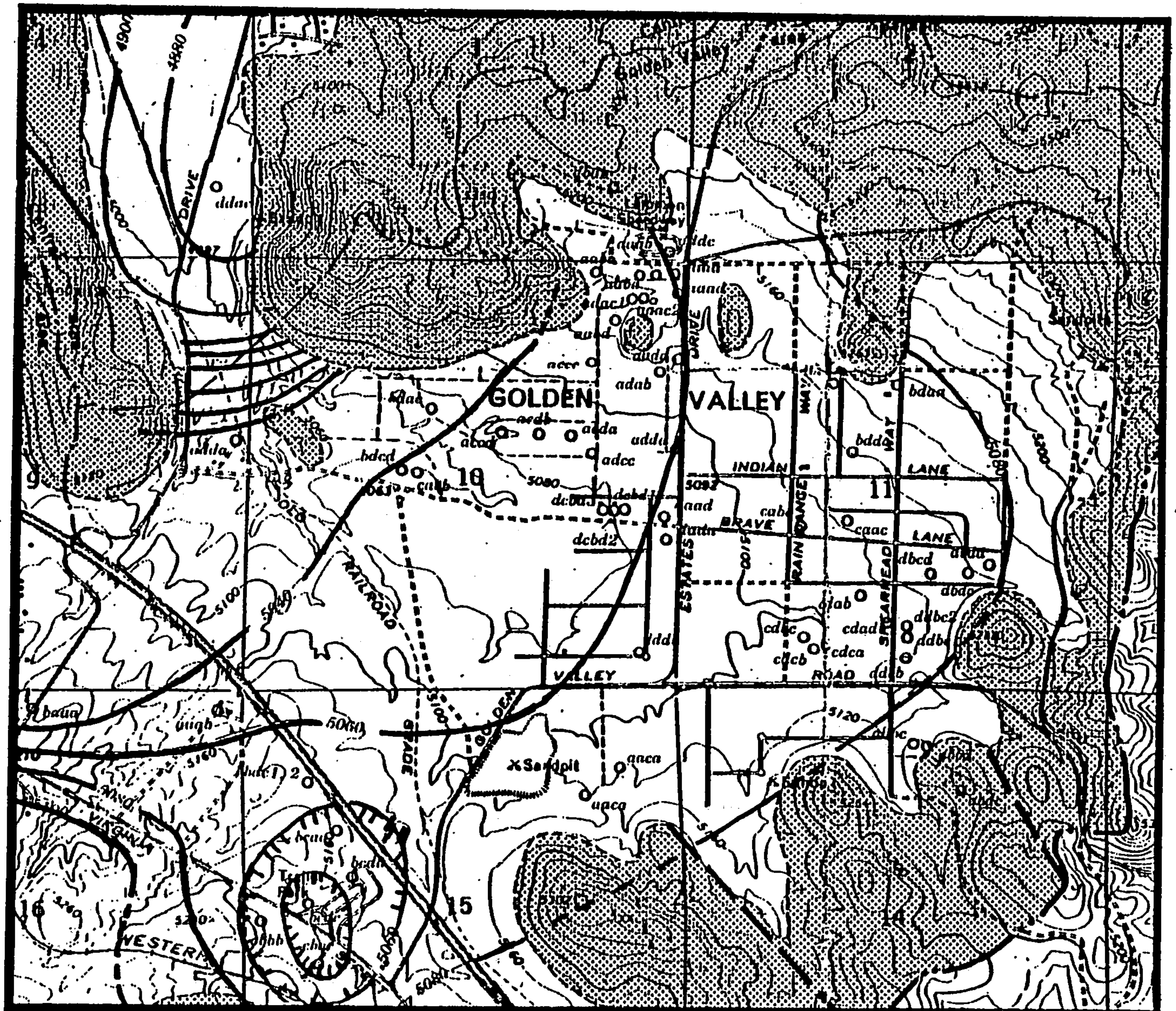

FIGURE 1. Golden Valley groundwater levels in Nov. 1971 (after Harrill, 1973).

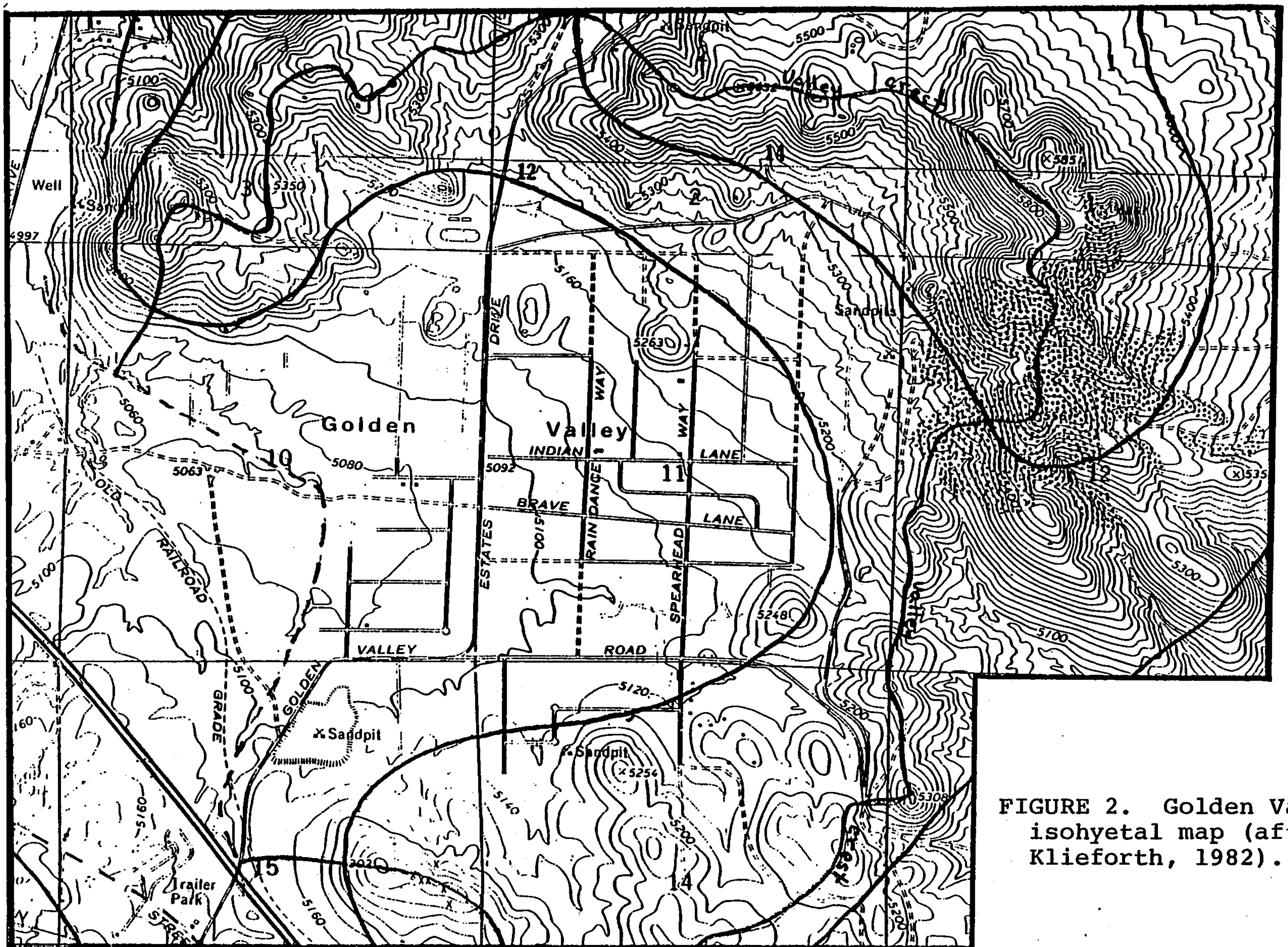

FIGURE 2. Golden Valley isohyetal map (after Klieforth, 1982).

Another approach to estimating recharge is that which has been extensively used in Nevada by the U.S. Geological Survey (USGS). The USGS, or Maxey-Eakin, method is based on area, elevation and precipitation. The Maxey-Eakin method was developed for large basins and thus its application to such a small area may indeed be questionable. However, application of the method to Golden Valley yields an average annual natural recharge of about 120 AF. For purposes of this study and until such time as more reliable data are developed it is being assumed that Golden Valley's average annual natural recharge is only 50 AF.

Much of the effective infiltration (recharge) probably occurs in the eastern and northeastern portions of the valley along the weathered granitic outcrops. The surficial deposits in the central portions of the valley are also described as decomposed granite, but contain a higher percentage of fines and thus are less permeable. Along the margins, however, there may be ready access by infiltrated water to the fractured and weathered granitic aquifer that underlies most of the valley.

GROUNDWATER PUMPAGE AND RETURN FLOW RECHARGE

There are currently about 400 single family residences in Golden Valley, all of which are served by individual domestic wells and septic tanks. The home lots are all large (ranging from 1 to 3 acres) and many residents maintain horses (and other stock) with associated corrals and pastures.

In 1973 the estimated population was 530 (Lemmon Valley Study Group), which has grown to the current estimate of about 1,320 people. At an average water use rate of 200 gallons per person per day (gpcd), the annual groundwater pumpage in Golden Valley would be about 300 AF. This use rate may be conservative, but has commonly been used for Regional Planning estimates. A rate of 250 gpcd, which was found for the Hidden Valley metered system (Blue Ribbon Task Force, 1973), yields a groundwater pumpage of about 370 acre-feet per year (AF/y).

The pumpage question can be checked from a slightly different perspective. Several studies, both local and national, have found that average per capita in-door water use is about 75 gal. This rate yields an in-house use of about 110 AF/y. To this figure must be added outdoor use for irrigation and miscellaneous purposes. Virtually all homes in the area have some ornamental vegetation and many have both lawns and some pasture. It is estimated that the combined irrigated acreage (ornamentals, lawns and pasture) is about 75 acres and thus the aggragate pumpage is about 225 AF/y. This assumes an average application rate of 3 acre-feet per acre (AF/A). The in-door and out-door pumpage would thus be about 335 AF/y. This latter number falls midway between the estimates based on average use rates, and will be used in this study until such time as a more refined estimate can be made.

Return flows from groundwater pumpage can occur via two pathways: 1) irrigation; and 2) septic tank wastewater treatment. At the assumed irrigation application rate of 3 AF/A there is likely little irrigation return flow recharge. Fordham (1982) found agricultural and urban landscape irrigation application rates of 4.6 and 6.2 AF/A respectively for the Truckee Meadows. Complementarily he found evapotranspiration rates of 2.4 and 3.2 AF/A respectively. The 3 AF/A rate used here, is thus considered to be the net irrigation pumpage rate with no returns from out-door water use.

Return flow from septic tanks probably represents most of the indoor water usage. A small percentage of domestic use is lost to direct evaporation (cooking, laundry, etc.) and a portion is lost to evapotranspiration in the leach fields. For purposes at this time it is being estimated that 90 percent, about 100 AF/y, of indoor water use becomes groundwater recharge.

GOLDEN VALLEY WATER BUDGET

The foregoing discussion can be summarized as a first approximation of Golden Valley water budget as follows (Table 1):

TABLE 1. PRELIMINARY GOLDEN VALLEY WATER BUDGETS FOR 1983 AND 1973.

	1983	1973
Direct Precipitation	2,300 AF/y	2,300
Losses to Run-off and ET	-2,250 AF/y	-2,250
Natural Recharge	50	50
Groundwater Pumpage		
Indoor Use	- 110 AF/y	- 45
Outdoor Use	- 225 AF/y	- 90
Gross Storage Change	- 285 AF/y	- 85
Septic Tank Recharge	+ 100 AF/y	+ 40
Net Storage Change	- 185 AF/y	- 45

Assuming an average porosity of 15 percent for the alluvial aquifer, this current groundwater storage depletion rate (185 AF/y) would represent an average water level decline over the entire Golden Valley reservoir of about 1 ft/y. Storage depletion, however, is not uniformly distributed, but is concentrated near the center of pumpage and in pumped areas of low transmissivity. Observed water level declines have ranged from less than 1 ft/y to in excess of 10 ft/y.

Based on the foregoing water budget parameters, since 1973 a total of approximately 1,150 AF have been pumped from Golden Valley groundwater storage. However, data compiled by the Washoe County Regional Administrative Planning Agency (RAPA) tend to indicate that this estimated storage depletion may be somewhat conservative. Figure 3 shows groundwater level fluctuations in the western portion of the valley. These data indicate that for the periods 1972-75 and 1978-80 the average decline rate of about 1.4 ft/yr. However, because of the 1976-77 drought the average decline from 1972 to 1982 was nearly 2.8 ft/yr. RAPA's schematic representation of water level declines (Figures 4, 5 and 6) indicate even greater storage depletion and water level decline rates. Interpretation of these RAPA data imply that from 1971 to 1982 between 3,500 and 6,300 AF of groundwater were removed from storage. The respective annual depletion rates of 320 to 570 AF/y are nearly 2 to 3 times greater than the rate estimated by the water budget process.

Data are currently being collected to allow development and calibration of a groundwater simulation model of Golden Valley. The model will enable more precise definition of water budget parameters and storage depletion rates. However, regardless of whether actual storage depletion is nearer the 1,150 or 6,300 AF estimate, these depletions have created a substantial subsurface storage space that can be manipulated to salvage lost Peavine runoff. At this time it is believed that the current storage depletion rate is closer to the 185 AF/y figure than higher estimates.

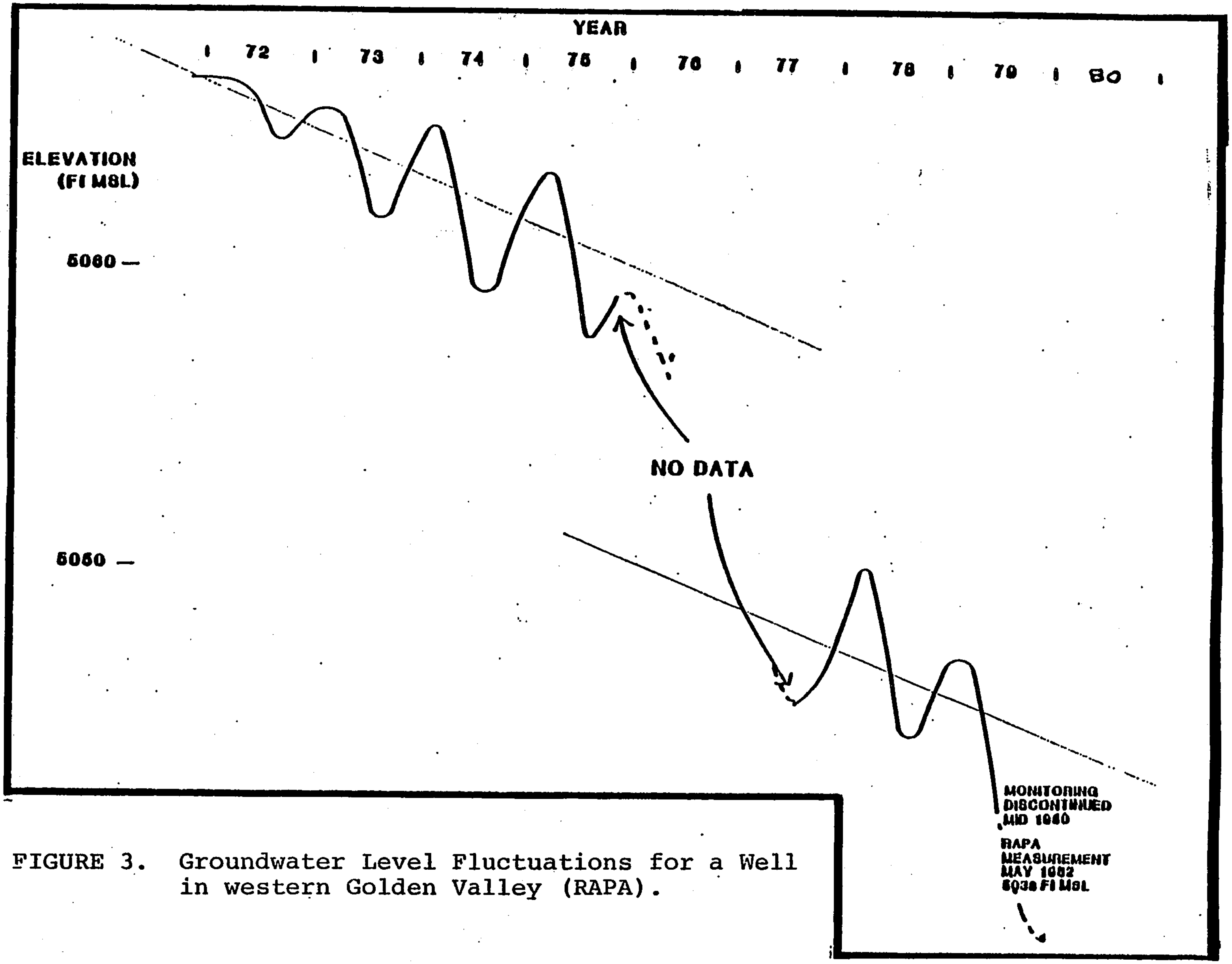

FIGURE 3. Groundwater Level Fluctuations for a Well in western Golden Valley (RAPA).

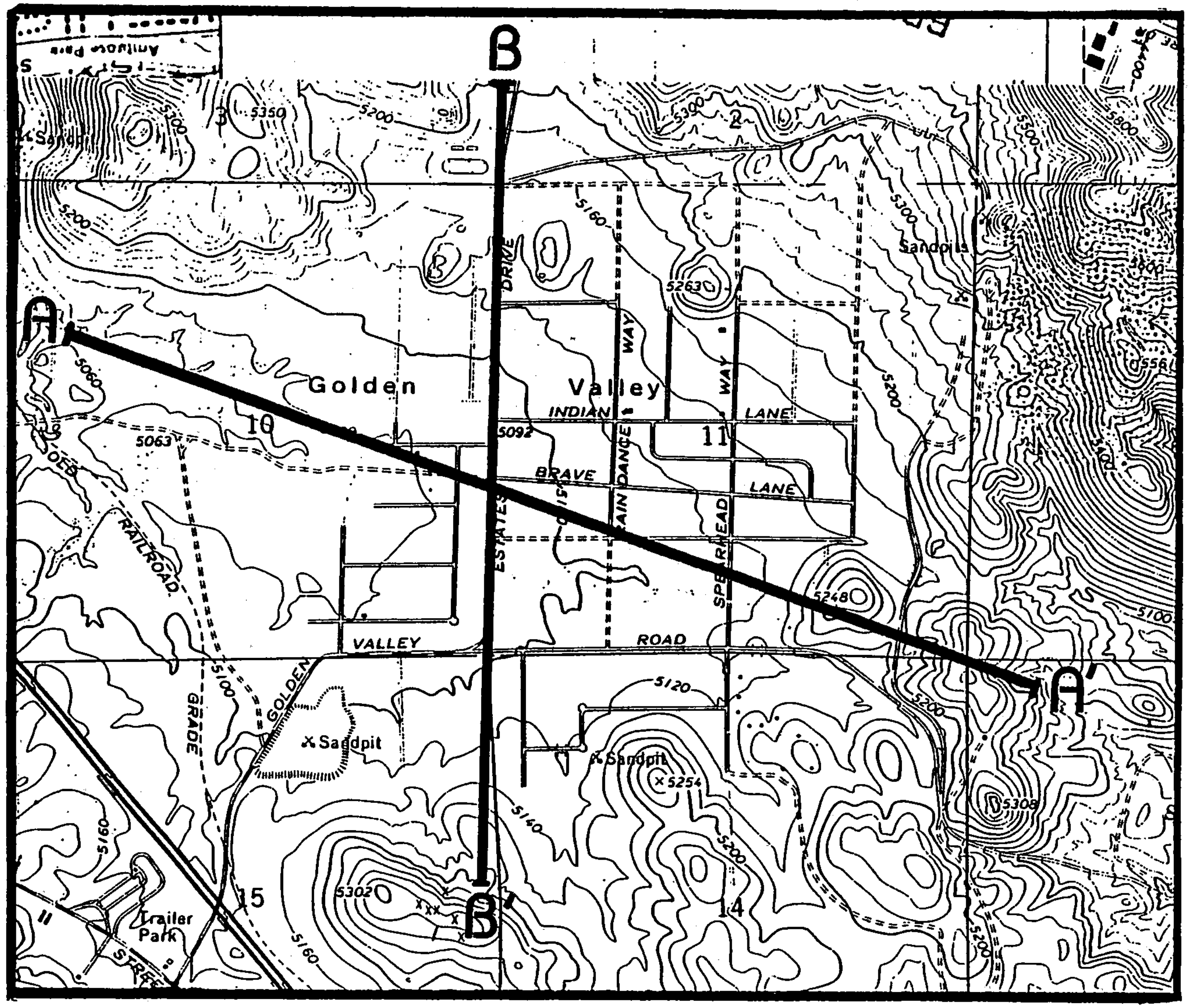

FIGURE 4. Location of RAPA cross-sections shown in Figures 5 and 6.

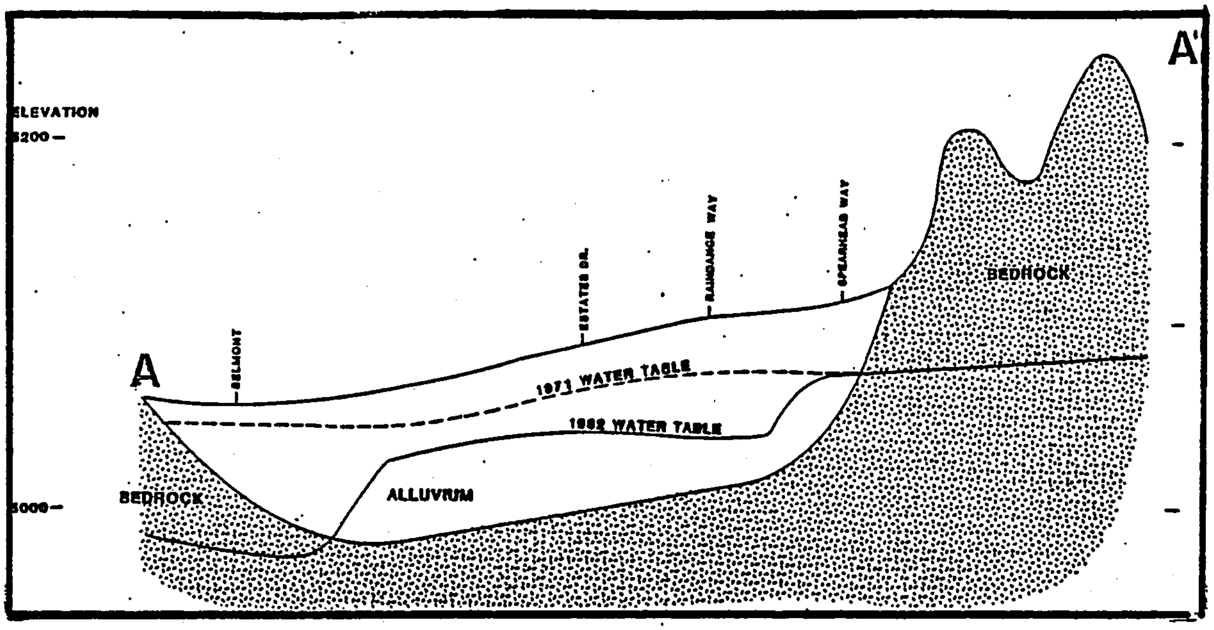

FIGURE 5. RAPA East-West Golden Valley Cross-section.

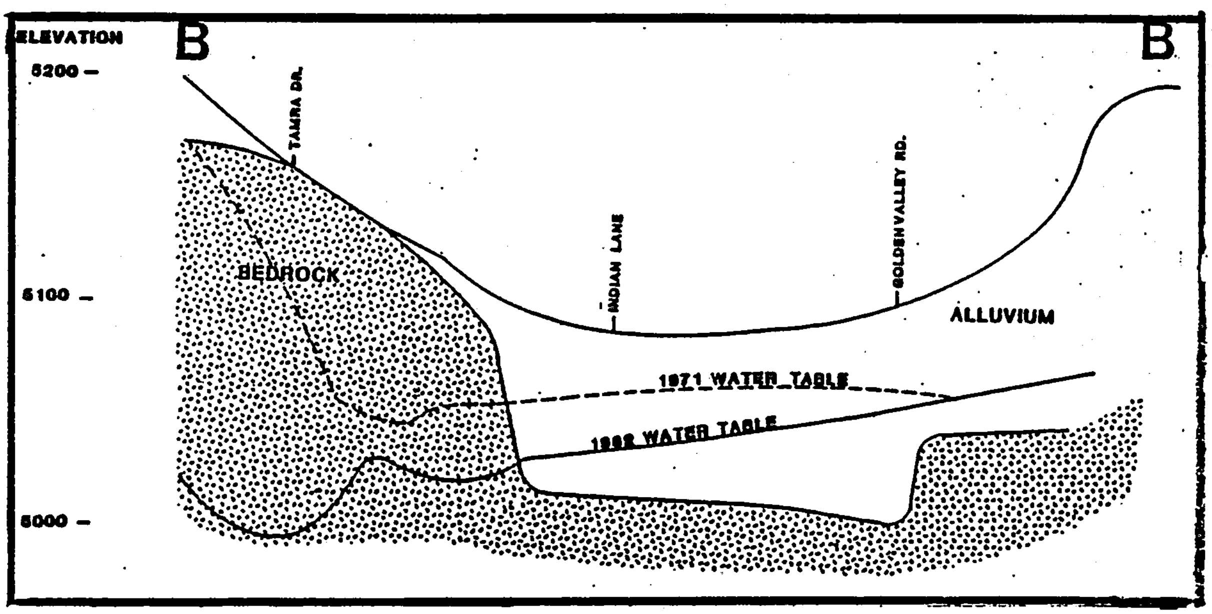

FIGURE 6. RAPA North-South Golden Valley Cross-section.

GOLDEN VALLEY GEOLOGY AND HYDROGEOLOGY

GEOLOGY

Golden Valley is enclosed to the north, east and south by gently to moderately steep sloped mesozoic to tertiary calc-alkalic igneous rocks. The valley's western-most extent is marked by an indefinite contact between Quaternary alluvial fan deposits of Peavine Mountain and the valley's indigeneous detritus (Figure 7).

The steeper slopes are along the valley's northeastern boundary and, locally, rise above the valley plain approximately 740 ft. Differences in elevation between the valley and its boundaries (i.e., crestline), however, generally range between 200 to 300 feet.

The dominant igneous rock is a coarse grained hornblende-biotite granodiorite. Lesser amounts of a coarse grained, deeply weathered quartz monzonite, rhyolitic ash flow tuff and rhyolitic breccia, and a metamorphosed andesitic flow can be found along the valley's eastern and southern boundaries (Figure 7).

The Mesozoic grandioritic and monzonitic intrusives, and metamorphosed andesitic flows share an unconformable relationship with the overlying tertiary rhyolites. These rhyolites, in turn, share an unconformable relationship with the Golden Valley detritus and alluvial fan deposits from Peavine Mountain.

The granodiorite can easily be identified by its minerology (e.g., hornblende plus biotite) and by its tendency to form bold outcrops. Within Golden Valley the quartz monzonite has a distinctly friable characteristic as well as a lighter color and coarser texture than the granodiorite. The rhyolites are white to cream to pinkish volcanic rocks which have been divided into: 1) an older crystal-poor, ash flow tuff with sparse quartz and feldspar crystals in a moderately welded matrix of ash and pumice, and 2) a younger epiclastic volcanic breccia containing primarily

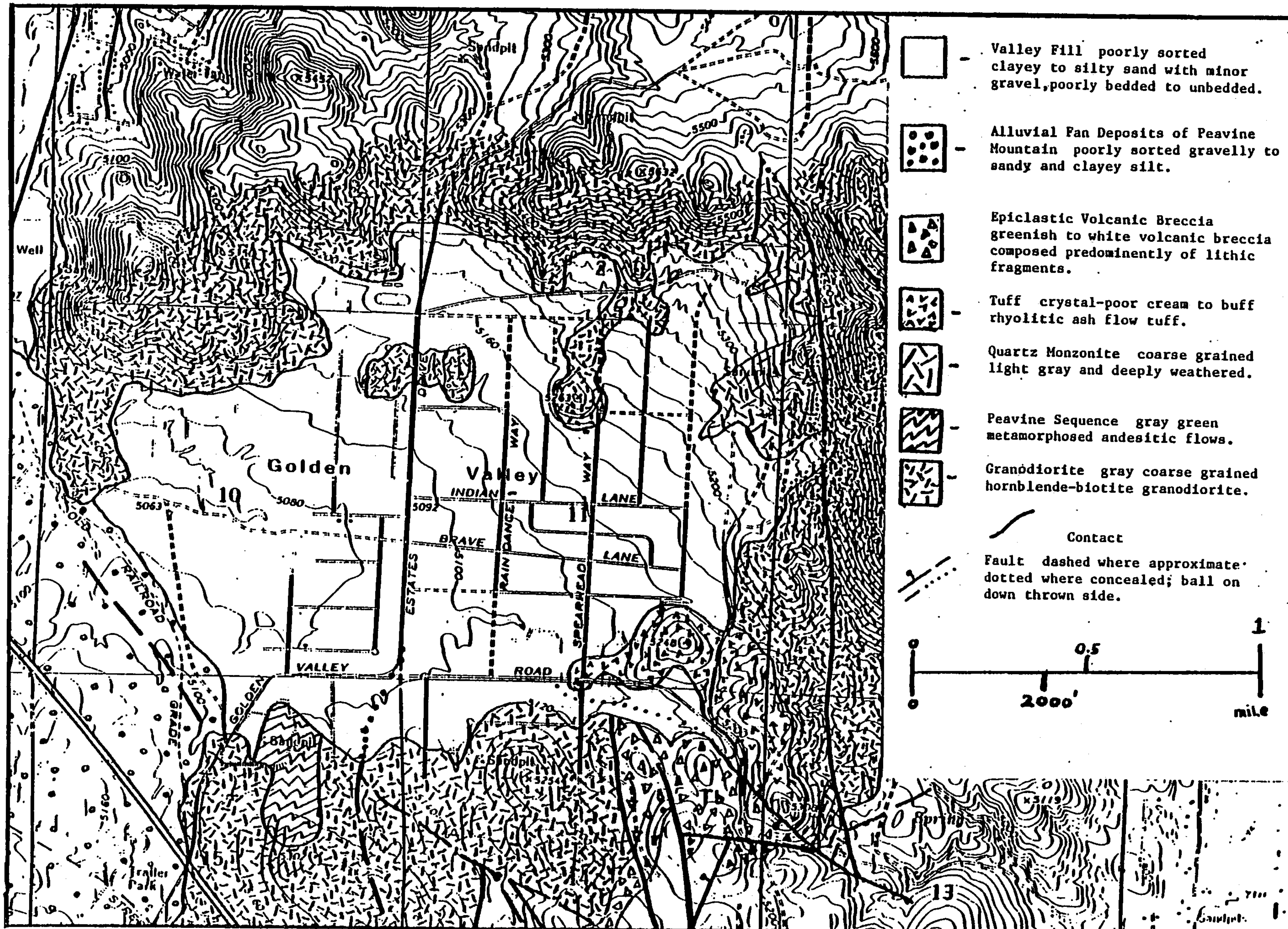

FIGURE 7. Geology of Golden Valley (after Bonham and Bingler, 1973).

lithic fragments of older rhyolitic tuffs and flows (Bonham and Bingler, 1973). The metamorphosed andesite which outcrops along the valley's southwestern boundary appears as a dark greenish, fine grained rock.

There are numerous faults in the rocks forming the valley's southern boundary. Most of these faults dip westward and appear to be reversed. From well log data, one fault which enters Golden Valley from its southwestern corner is believed to continue at least 100 to 200 ft. north beyond Golden Valley Road and along Estates Drive.

One fault, which trends north-northwest, runs along the entire eastern boundary of Golden Valley. This fault appears to have some minor right lateral strike-slip movement, but it is uncertain if there exists a dip-slip component.

A fault is inferred to be present approximately one-third of a mile northwest of Route 395 just beyond the western extent of Golden Valley. Along the valley's northern boundary no faults were located.

Depth to bedrock estimations were made using nearly 400 driller's logs. Figure 8 is an isopach map constructed from a compilation of these data. From Figure 8 the bedrock appears to dip gently in an eastward direction from the vicinity of Estates Drive, reaching its maximum depth in the area between Spearhead and Wigwam.

Drainage ditches and road cuts have permitted an examination of the upper one to six meters of the valley fill. The detritus is a reddish brown, medium to coarse sand, containing primarily quartz grains with minor feldspar, mafic minerals and gravels of granitic composition. The silt and clay fration within the detritus is estimated to comprise 5 to 10 percent of the valley fill.

Figure 9 is a west to east cross-section of Golden Valley constructed from driller's logs. Construction of this and other cross-sections were made in an attempt to identify, where possible, potential aquifers and aquicludes. However, after a detailed construction of these cross-sections no clearly identifiable aquifer(s) or aquiclude(s) was recognized within the valley fill.

PERCENT SAND, CLAY AND GRAVEL

Calculations for sand, clay and gravel percentages were made for over ninety well logs throughout Golden Valley. A table of sediment descriptions was devised to accommodate a wide range of sedimentary characteristics. In

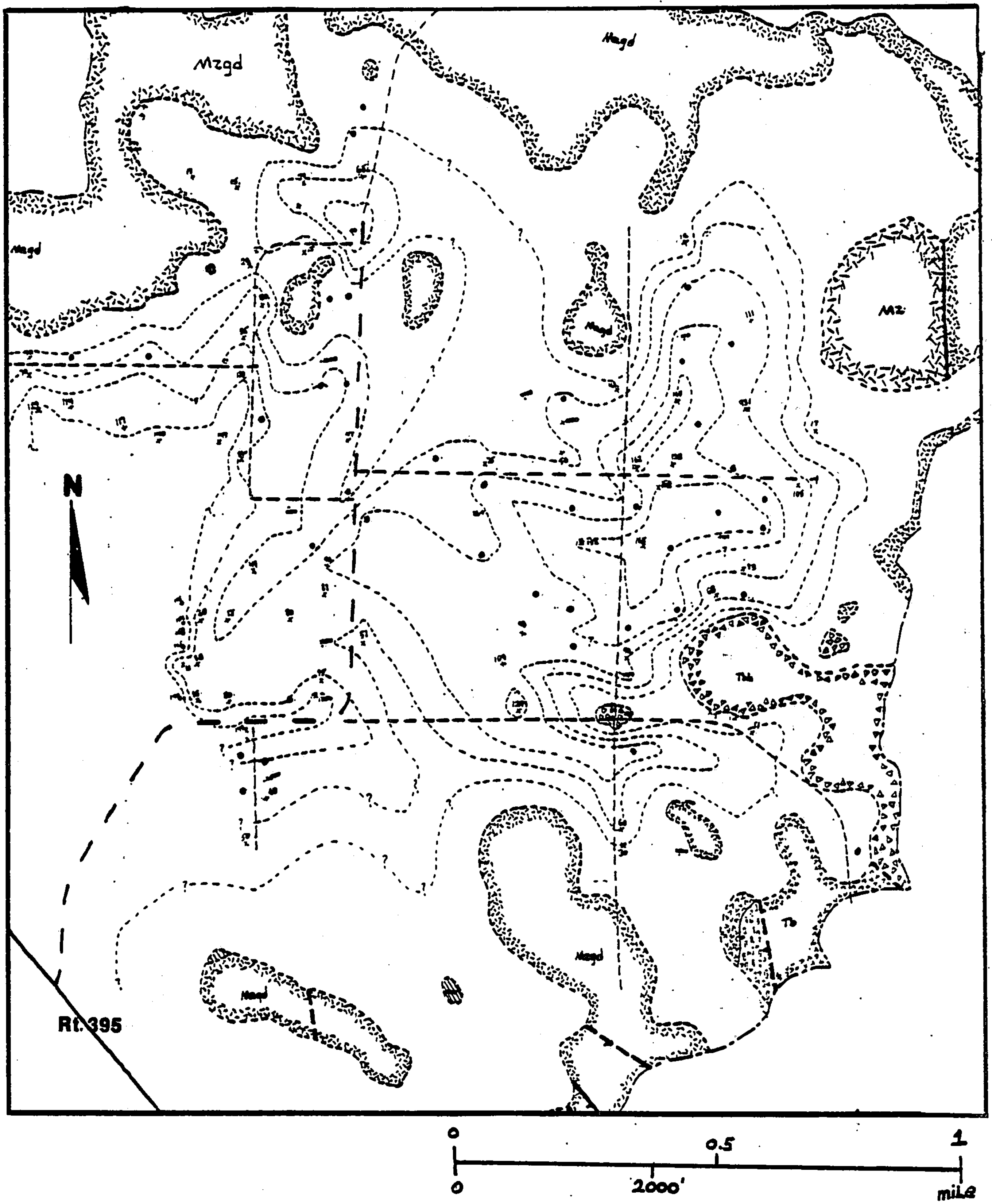

FIGURE 8. Isopach map of depth to fractured bedrock 30 ft. contour interval.

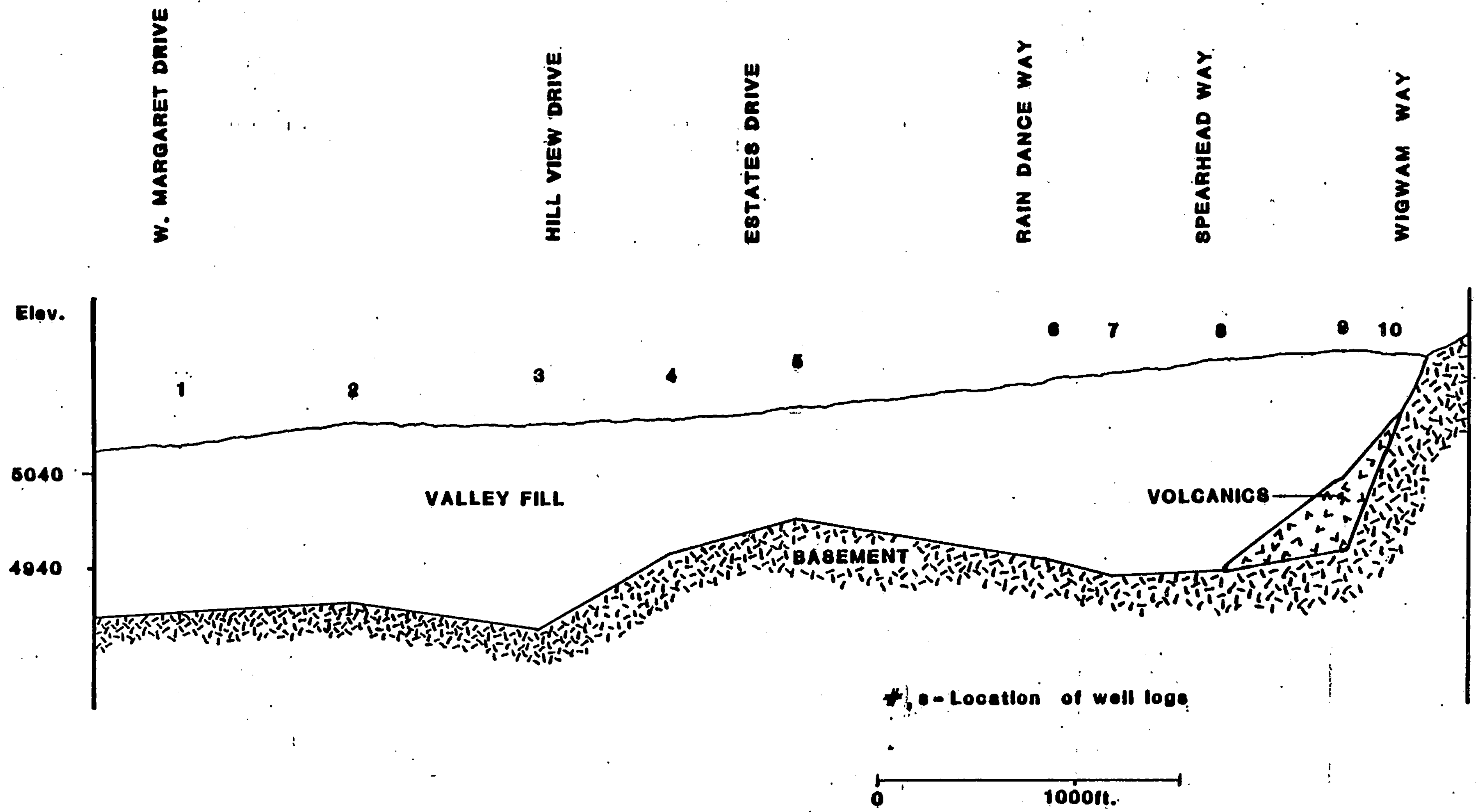

FIGURE 9. Golden Valley west-east cross-section.

all, seventeen different descriptions were used. These descriptions were then distilled to three major headings: 1) sand and/or gravel; 2) clay; and 3) sand/clay/gravel.

Results showed that those areas of the valley nearest to its borders (e.g., Sec's. 15, 14 and 3) contained primarily decomposed granite sand, as under heading #1 above, with subequal amounts of a mixture of sand, clay and gravel, as under heading #3 above, and only minor amounts of clay. As for sections 10 and 11, which make up the bulk of Golden Valley proper, there was a slight but noticeable increase in clay content.

TRANSMISSIVITY

Transmissivity (T) estimates were made for 100 wells on the basis of well pump test data in the well logs. Equations used for these calculations were as follows:

$$\bar{\bar{K}} = \frac{1750Q}{b_s \, S}$$

where:

$\bar{K}$ = effective hydraulic conductivity (gpd/ft^2)
Q = discharge from the well, (gpm)
b_s = the screened interval of the well (ft.)
S = the drawdown in the well (ft.)
T = the transmissivity in (gpd/ft)
$T = Kb_s$

The calculated values ranged from a low of 90 gpd/ft to a high of 5,700 gpd/ft. However, approximately 55 percent of all transmissivity values were less than or equal to 500 gpd/ft, while over 75 percent of all transmissivity values were at or below 1,000 gpd/ft.

From a detailed analysis of these data along with their respective well log descriptions it has been determined that the highest transmissivity values come from those zones where the driller encountered fractured granite. It was also determined that, in general, the lowest transmissivity values were found when the well penetrated only as far as the valley fill and did not reach the granite below. However, a few relatively high transmissivity values were encountered for wells completed in the valley fill. Figure 10 is a map of the transmissivity variations within Golden Valley. These findings thus indicate two hydrogeologic units must be dealt with: 1) the valley fill alluvial aquifer: and 2) the weathered/fractured granitic aquifer.

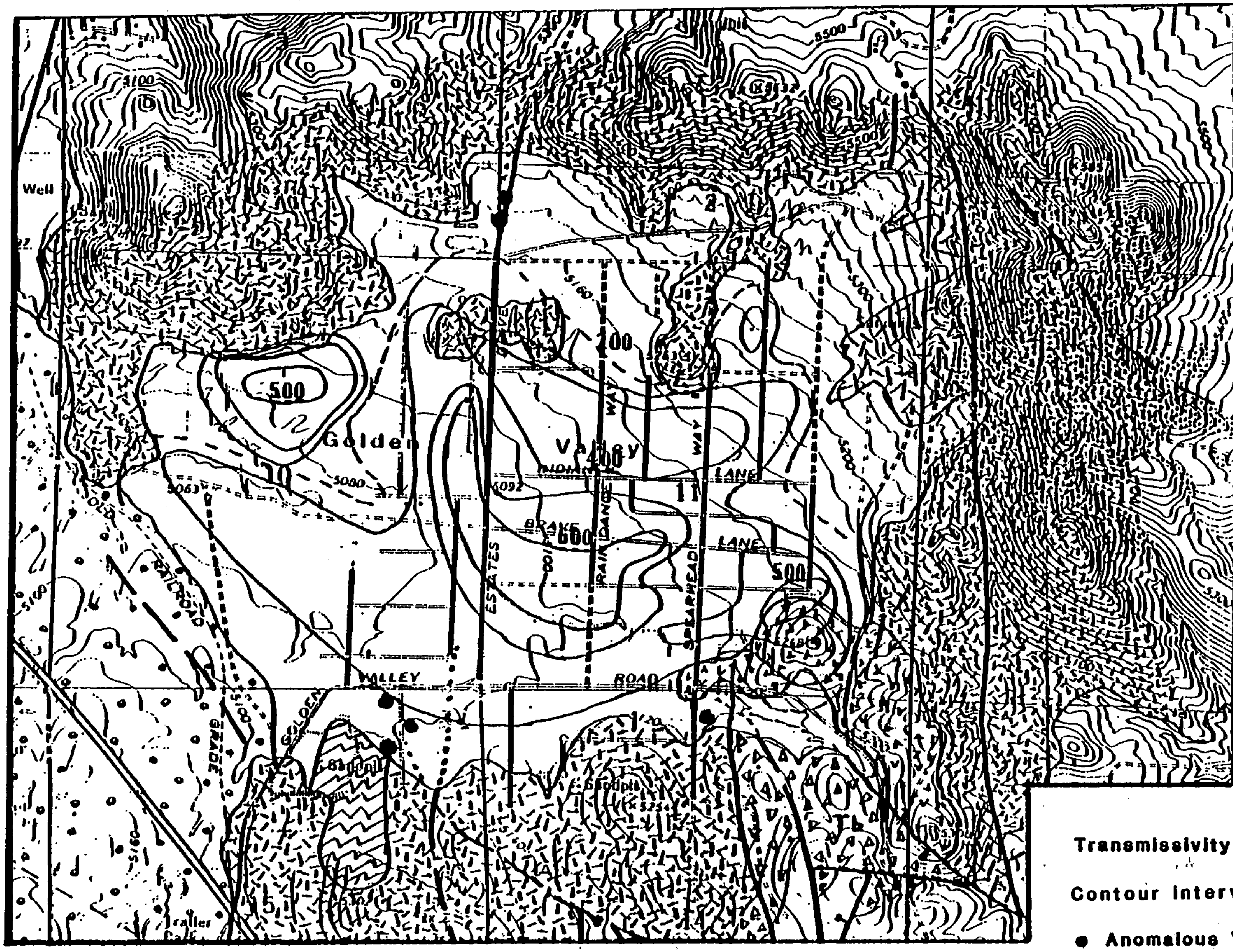

FIGURE 10. Estimated distribution of Golden Valley transmissivities.

HYDROGEOCHEMISTRY

Historical water quality data from Golden Valley were obtained from the State Health Office in Carson City. The majority of the analyses were done to fulfill loan requirements and the samples were collected either by agency personnel or by the homeowner.

Table 2 contains data for mean concentrations of constituents based on data from 1980 to present. The historical data and personal interviews with homeowners indicate that some wells contain high concentrations of iron and manganese. Iron buildup and poor taste are common complaints. Many of the wells in the valley do not show this problem which indicates a heterogenous system. Presently, historical data are being correlated to distinguish analogous localities and lithologic controls.

The historical data indicate that the groundwater within the area is of fairly good chemical quality with mean total dissolved solids (TDS) of 291ppm. Of the 60 samples examined, most dissolved constituents fell consistently within the Nevada State water quality standards with the exception of Iron and Manganese which exceeded the standards 16 times. Further sampling is necessary to determine the validity of the data and trend deliniation. Table 2 also indicates that the concentrations of each constituent exhibit large variances, which can be seen when comparing data from nearby wells. Some of these variances may be explained by wells penetrating different lithologies; i.e., valley fill vs. bedrock, and structural controls such as faulting.

TABLE 2. GOLDEN VALLEY WATER CHEMISTRY STATISTICS, 1980-1983.

	Concentration, ppm	
Constituent	Mean	Std. Dev.
TDS	291.5	96.51
Ca	41.8	16.6
Mg	17.7	7.33
Na	26.9	8.20
K	3.67	1.54
Fe	.292	.469
Mn	.11	.299
SO_4	48.1	55.9
Cl	17.6	12.5
NO_3	10.7	9.25
HCO_3	193.5	46.6
F	.203	.078
As	.001	.004
Ph	7.61	.287

Water quality data from wells drilled since the late 1960's compared briefly to determine the extent to which nitrate contributions from septic tanks had dispersed through the groundwater reservoir over the time period. No significant increases could be seen. At this time, nitrate dispersion appears to be of limited extent though there are exceptions. Further sampling is necessary to confirm this and a sampling program has been initiated. These results will be compared to the historical data in order to determine changes with time which will aid in understanding the present geochemistry as well as the interactions associated with mixing of recharge waters with in-situ groundwater.

PEAVINE MOUNTAIN RUNOFF

Study of Peavine Mountain watersheds is directed at two major questions: 1) potential average annual and peak year surface runoff; and 2) stream channel infiltration losses to the Lemmon Valley groundwater reservoir. To be legally viable, any Peavine Mountain runoff diversions for use in Golden Valley must be those flows in excess of what might become recharge to the over-appropriated Silver Lake and East Lemmon sub-basins. Coincident with examining the water production zone (Peavine Mountain), the major water loss zone (Silver Lake Playa) is being examined. It is from Silver Lake that the flows in excess of recharge are evaporated.

PEAVINE MOUNTAIN WATERSHEDS

The Peavine Mountain drainage area includes 17 sub-watersheds that drain into the Lemmon Valley Hydrographic Basin. Watersheds 5 through 17 are shown in Figure 11. To date, work has taken place in three of the 17 drainages and along the Western Pacific Railroad Company's culverts at the base of Peavine Mountain.

As indicated in Figure 12 precipitation on Peavine Mountain averages from 36 inches per year (in/y) on the summit to 8 in/y on the playas. Watershed 9 has a precipitation ranging from 28 in/y to 12 in/y, watershed 12 has precipitation ranging from 26 in/y to 12 in/y and watershed 16 has precipitation from 34 in/y to 12 in/y. These precipitation data are based on a recent isohyetal map of the area prepared by Harold Klieforth of the DRI for the Washoe County Regional Administrative Planning Agency. In Klieforth's work precipitation distribution is a function of elevation modified to reflect prevailing wind direction. Klieforth's precipitation estimates are considerably greater than those used in earlier studies of the Lemmon Valley area. Area, elevation and precipitation data for the 17 watersheds are given in Table 3.

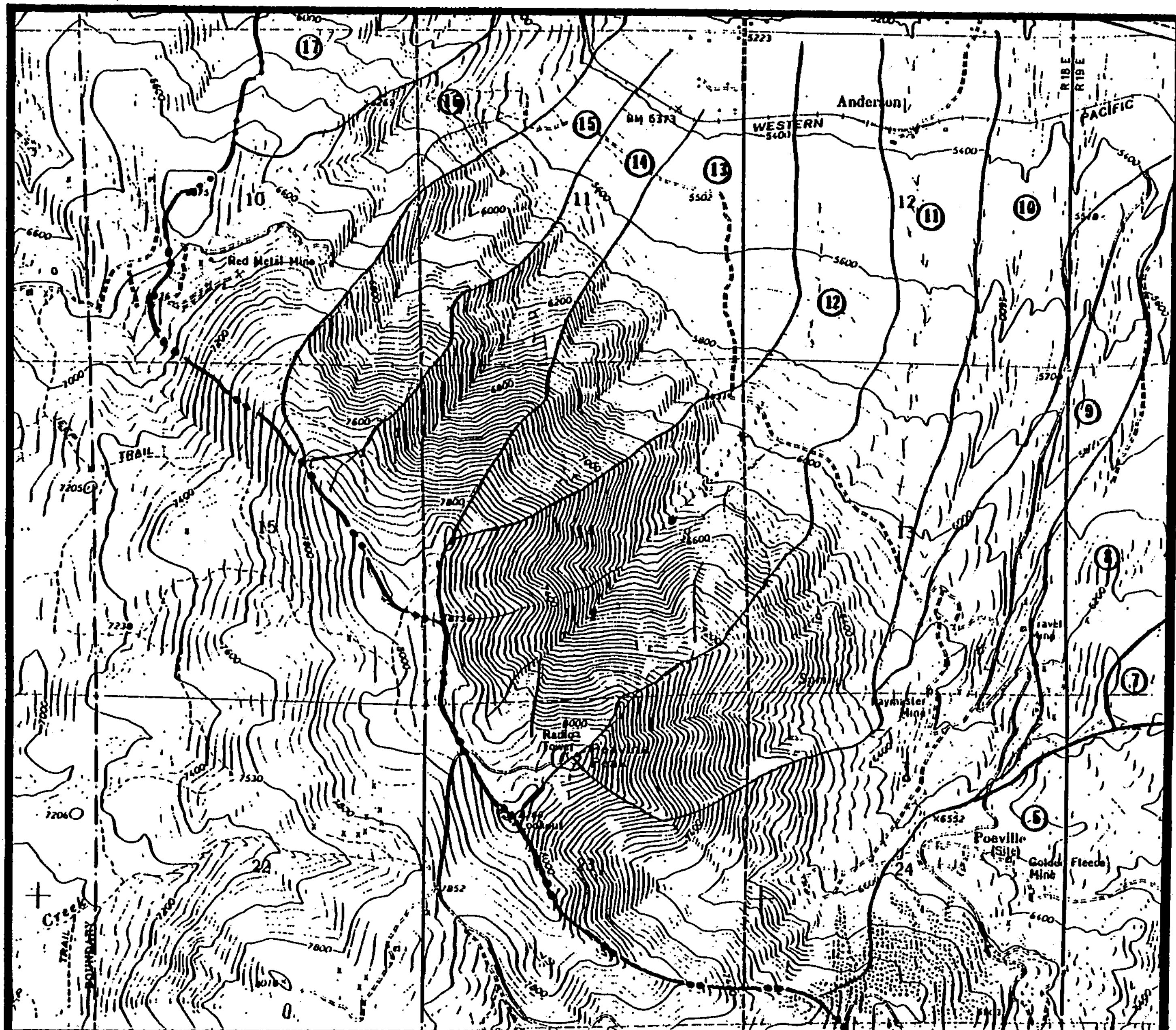

FIGURE 11. Peavine Mountain north slope watersheds.

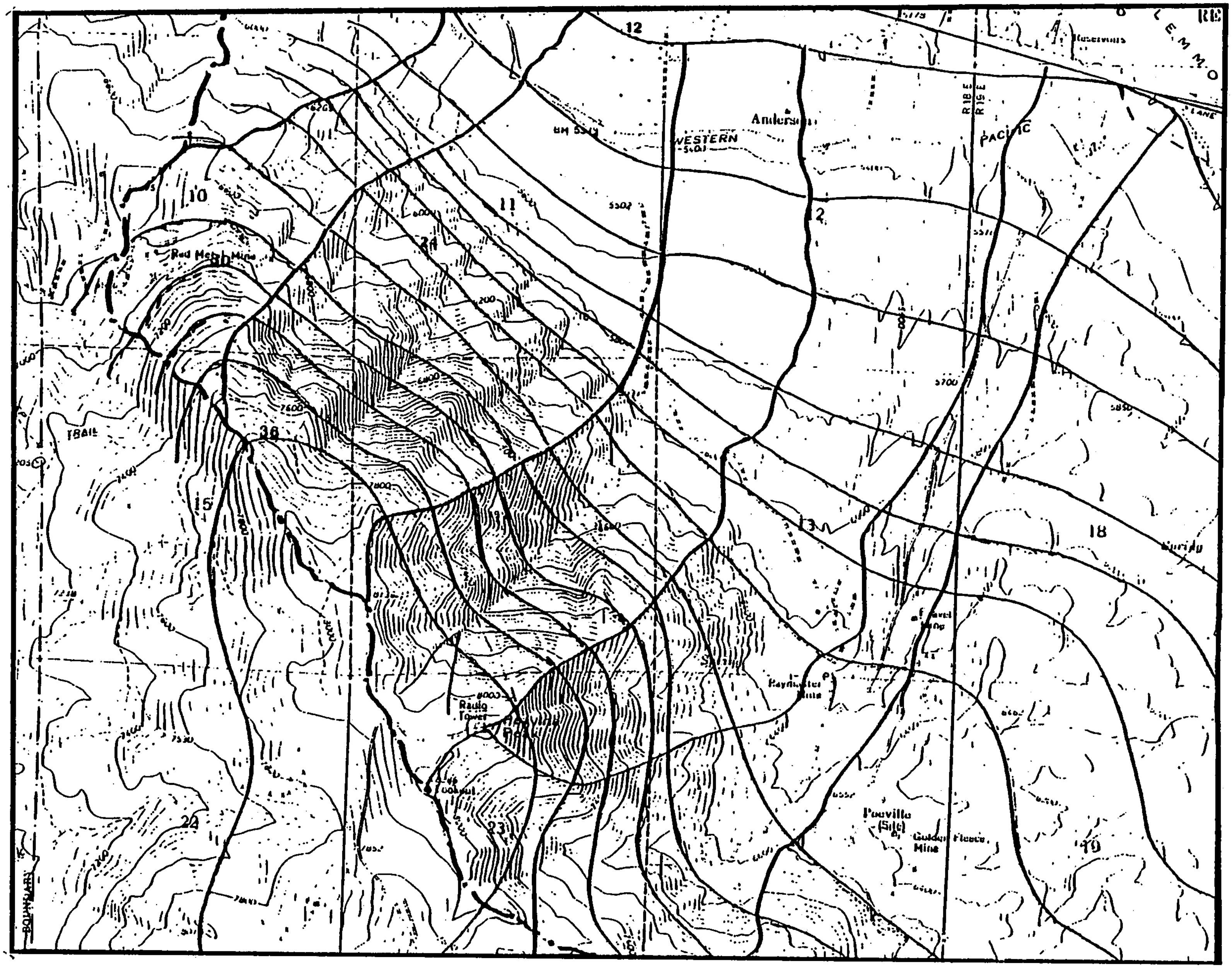

FIGURE 12. Peavine Mountain isohyetal map (after Klieforth, 1982).

TABLE 3. PEAVINE MOUNTAIN WATERSHED AREAS AND ESTIMATED ANNUAL PRECIPITATION.

Watershed No.	Area Above 12" Isohyet, Acres	Average Annual Precip. AF	AF/A
1	80	90	1.13
2	110	120	1.09
3	90	90	1.0
4	750	1,000	1.33
5	1,670	2,810	1.68
6	620	790	1.27
7	200	320	1.6
8	770	1,060	1.38
9	790	1,680	2.13
10	440	550	1.25
11	560	1,130	2.02
12	770	1,590	2.06
13	450	740	1.64
14	410	710	1.73
15	310	590	1.9
16	460	830	1.8
17	630	820	1.3
Totals	9,110	14,920	1.66

To date, field work has been confined to collecting a baseline sample for water quality, measurement of discharge in the canyons, and measurement of discharge along the Western Pacific Railroad tracks.

The three watersheds originally selected for sampling were chosen on the basis of the extent of vegetative cover and location, with the intent of using them to characterize all 18 watersheds. Field work has revealed major differences in each watershed that are fundamental to the observed discharges and these differences may preclude effective extrapolation.

Watershed 9

This stream flows through the active Peavine Mining district. Outcrops, other than the mine openings, indicate the bedrock to be volcanic rock, in an area of small dry, hillslopes. The stream flows off of Peavine onto a well developed alluvial fan. Structural geologic relations of this area to the rest of Peavine are not known.

In late November and early December (1983) the upper watershed had two (2) springs near the 7,000 ft. level. These springs issued from fractured bedrock and quickly "sunk".

Surface water heads from a discharge point near elevation 6,280 ft. This flow is seepage from an apparent fill of younger age than the underlying material. This stream flows among mining waste piles that consist of a pale, yellowish pulverized rock. Flow is persistant, being observed at elevation 5,328 ft., which is a Western Pacific railroad culvert.

Several open and partially caved mine adits and prospects are situated within watershed 9. No seepage of water was observed from any of the adits or drifts during the Fall of 1983.

Watershed 12

This watershed is morphologically different from watershed 9. The watershed is quite steep, with side slopes approaching 60 percent. A soil zone is not developed, instead the side slopes are extensive areas of talus (more properly angular boulders of bedrock). Precipitation falls directly upon the talus and infiltrates with very little, if any, lateral overland flow. During the Fall of 1983 no evidence of flood, or heavy surface flow was observed in this watershed.

Watershed 12 is more accurately described as a steep "hollow" with two small streams draining the canyon bottom fill. Seepage zones and the gaining-losing reaches of each stream have been mapped for watershed 12. The canyon bottom aquifer is made up of large angular metavolcanic rocks, the void spaces being filled by finer grained soil. This fill is suggestive of a debris flow. Evidence, for a debris flow includes a large treeless area near the top of the hollow and an abrupt steep face before the flow spilled out onto the alluvial fan. Neither of the surface flows is persistant for a very long distance down the fan.

Discharge monitoring and a quality baseline have been established for both streams in watershed 12. Results of these water quality analyses are shown in Table 4. The water quality baseline indicates a good quality of water. pH readings indicate that the groundwater seepage is almost neutral (pH 7.31 and 7.49 respectively) with low specific conductance (97.0 and 95.3 μMhos/cm). The dominant anion is bicarbonate, amounting to approximately 85 percent of the constituent anions. Nitrates and various nitrogen compounds were not detected in the baseline samples.

Calcium is the dominant cation, amounting to 14 ppm and 13.6 ppm in the headwaters of each subdrainage. This amounts to approximately 70 percent of the observed cations in each sample.

TABLE 4. WATER CHEMISTRY ANALYSES FOR WATERSHED NO. 12.

Sample Date Sample Point	8-Nov-83 Peavine 12 Str.I L		8-Nov-83 Peavine 12 Str.I U		17-Nov-83 Peavine 12 Str.II	
Lab Number	7385		7383		7384	
pH	7.56		7.31		7.49	
TDS by Evaporation	ND		ND		ND	
Sp. Cond. (U-MHOS/CM)	86.50		97.00		95.30	
Constituents	PPM	EPM	PPM	EPM	PPM	EPM
HCO_3	46.90	0.769	52.30	0.857	51.30	0.841
CO_3	ND	0.000	ND	0.000	ND	0.000
CL	0.80	0.023	0.70	0.020	0.80	0.023
SO_4	3.90	0.081	4.60	0.096	4.30	0.090
F	ND	0.000	ND	0.000	ND	0.000
NO_3	<0.40	0.000	<0.40	0.000	<0.40	0.000
NO_2	ND	0.000	ND	0.000	ND	0.000
Total Anions	51.60	0.872	57.60	0.973	56.40	0.953
NA	4.07	0.177	4.13	0.180	4.10	0.178
K	1.35	0.035	1.30	0.033	1.48	0.038
CA	11.80	0.589	14.00	0.699	13.60	0.679
MG	1.46	0.120	1.31	0.108	1.34	0.110
NH_4	ND	0.000	ND	0.000	ND	0.000
Total Cations	18.68	0.920	20.74	1.019	20.52	1.005
Anions/Cations (EPM)		0.948		0.954		0.948
SIO_2	15.00		15.00		15.00	

Discharge monitoring records indicate a rapid response of the canyon bottom groundwater reservoir to a snowfall and melt event. On November 8, 1983 the observed discharge at station 1 of subdrainage 1 was 7.5 gpm. After an approximate 4" snowfall and subsequent melting, the flow on November 15 was 10.7 gpm. Similar increases were noted along each of the sampling stations.

Watershed 16

This watershed is morphologically and hydrologically distinct from both watersheds 9 and 12. The stream discharges onto the Peavine Mountain alluvial fan, where flow again becomes subsurface. Water is diverted from this drainage through an old pipe system. Flow during the autumn of 1983 was persistant, although flow was not directly measured.

The bedrock is of a different type, being a highly jointed fine grained, volcanic rock. This watershed does have a soil cover which is supporting vegetation distinct from watersheds 9 and 12. However, many reasons can be put forth to explain the different plant types including physical aspects, different soils, different logging or fire history.

RUNOFF CONCENTRATION

There are two significant cultural features in Lemmon Valley that serve to concentrate all diffuse and stream channel flow from Peavine Mountain. These are the Western Pacific Railroad and U.S. Highway 395, both of which traverse the base of the mountain at elevations approximately below 5,400 ft. and 5,200 ft. respectively. All water from Peavine not lost to infiltration or evapotranspiration above these elevations is collected and directed through a series of culverts. The Western Pacific Railroad track, and its drainage system is being used to measure total discharge from Peavine Mountain. Seven culverts have been mapped, classified and the discharge measured. All surface flow to Silver Lake playa from Peavine Mountain must be directed through the railroad's drainage controls. The discharge through this system is the residual flow that is not utilized by the mountain front ecosystem, or infiltrated to recharge the groundwater reservoir. On December 6, 1983 the aggragate flow through the culverts to Silver Lake Playa was measured at 395 gpm.

SILVER LAKE PLAYA

As indicated in Figure 13, Silver Lake Playa is actually a group of 4 playas, the largest of which is called

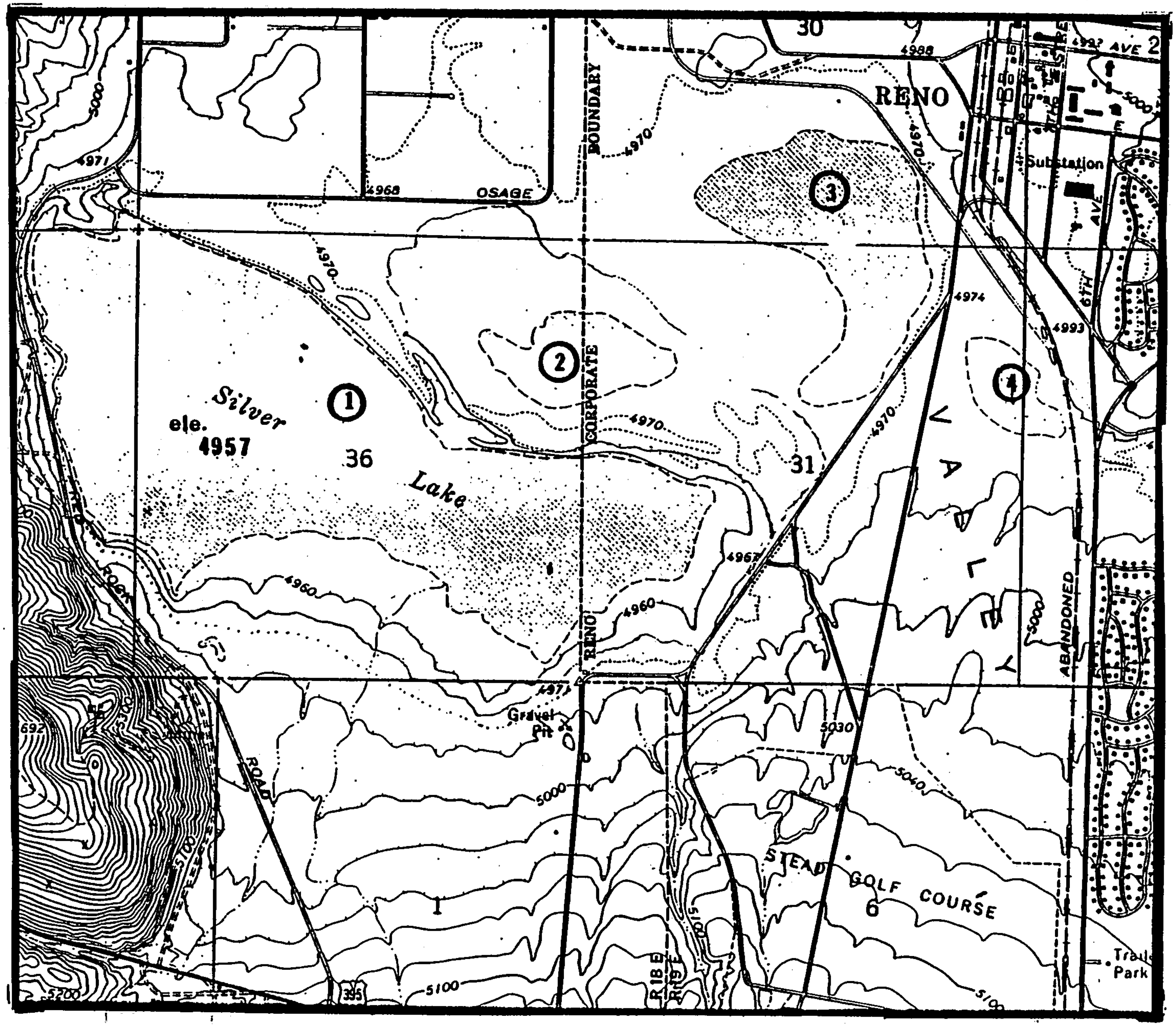

FIGURE 13. Silver Lake playas.

"Silver Lake". Playa No. 4 has recently been modified by development activities and no longer exists as shown. The three remaining playas all lie within the 4,970 elevation contour. The mapped playa area of Silver Lake is at a surface elevation of 4,957± feet. The playas are separated by low divides at approximate elevation of 4,965 ft. Maximum elevation on the low ridge separating Silver Lake and Playa No. 2 is 4,972. Under normal annual precipitation conditions the 3 playas are separate, but for a period in summer 1983 they were all interconnected, indicating a maximum water surface elevation of about 4,965± ft.

Silver Lake receives most of its runoff from Peavine Mountain, with only a minor contribution from the range bordering it to the west. Playas 2 and 3 receive most of their water from the area to the north and west, with only a minor contribution from Peavine.

Topography of the playas below elevation 4,957 is not defined, but for Silver Lake the maximum depth probably is above elevation 4,950 ft. and occurs near the northern shore. Silver Lake "bathymetry" will be defined under the next phase of this study. Based on the known topography and approximated Silver Lake "bathymetry", area-elevation and elevation-volume curves have been constructed for the playa area as shown in Figure 14. Two alternative configurations below elevation 4957 were postulated, one with minimum elevation of 4950 ft and the other at a more conservative 4953 ft.

Silver Lake is both a groundwater and surface water discharge area for the Silver Lake sub-basin of Lemmon Valley. The groundwater discharge nature of the playa was documented by Harrill (1973) on the basis of groundwater elevations and water chemistry as shown in Figures 15 and 16. Harrill estimated groundwater discharge from the playa to be about 220 AF/y during those years when surface water does not cover the playa. Even if groundwater levels in the Silver Lake sub-basin are greatly lowered, the playa will not serve as a significant recharge area. The playa sediments are extremely fine-grained and thus very impermeable. This low permeability will severely restrict downward movement of water and thus limit any potential recharge.

Moore (in Harrill, 1973) estimated, on the basis of stream channel geometry, that average annual surface water runoff to Silver Lake is 400 to 500 AF. As previously discussed, most, but not all, of this runoff is derived from Peavine Mountain. Runoff during spring 1982 and 1983 was considerably greater than this estimated average. The playa has remained flooded since the spring 1982 runoff period. Based on the interconnection of the playa areas in spring 1983, and using Figure 14, the peak volume in the "lake"

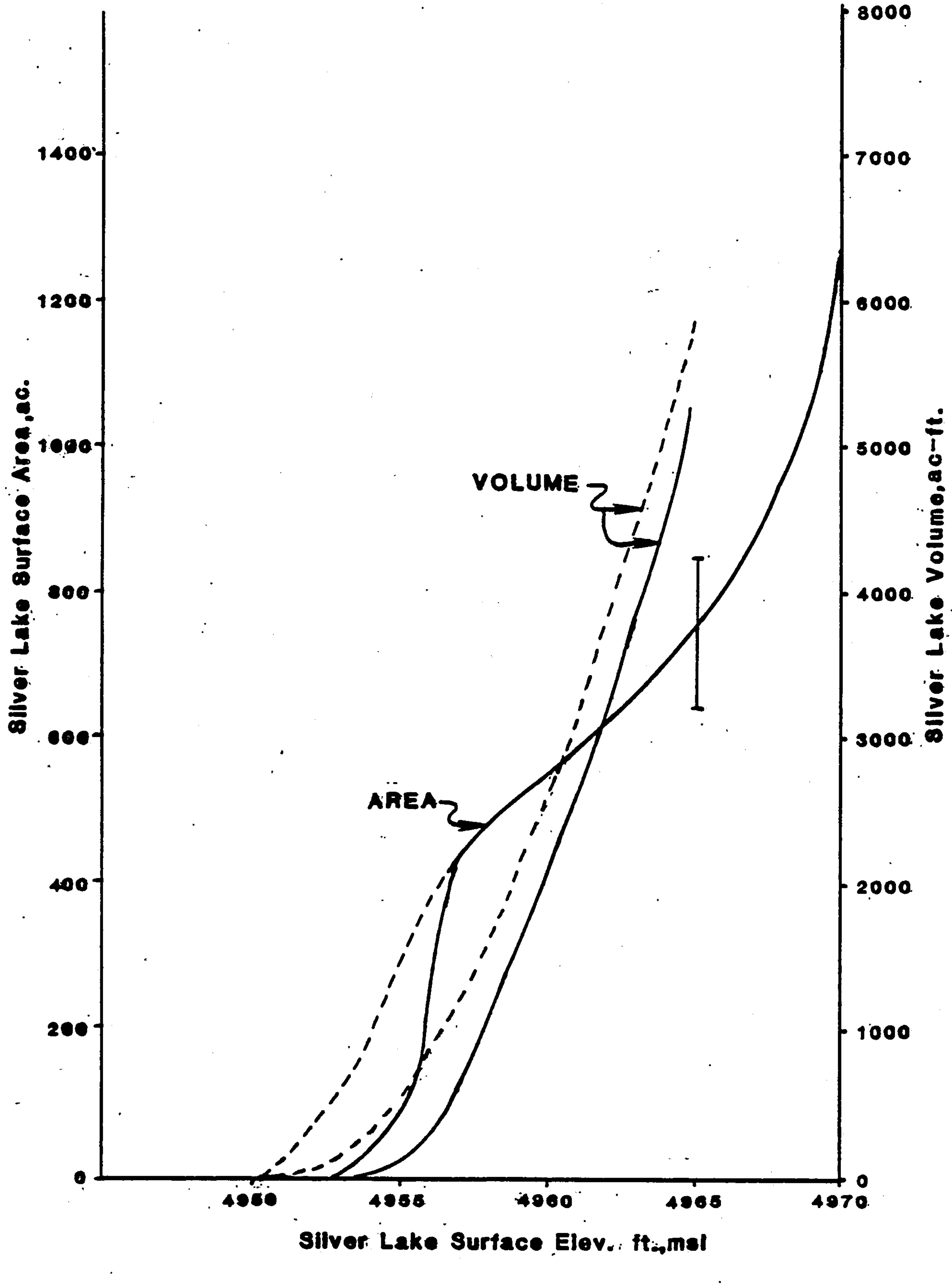

FIGURE 14. Area-elevation and volume-elevation curves for Silver Lake.

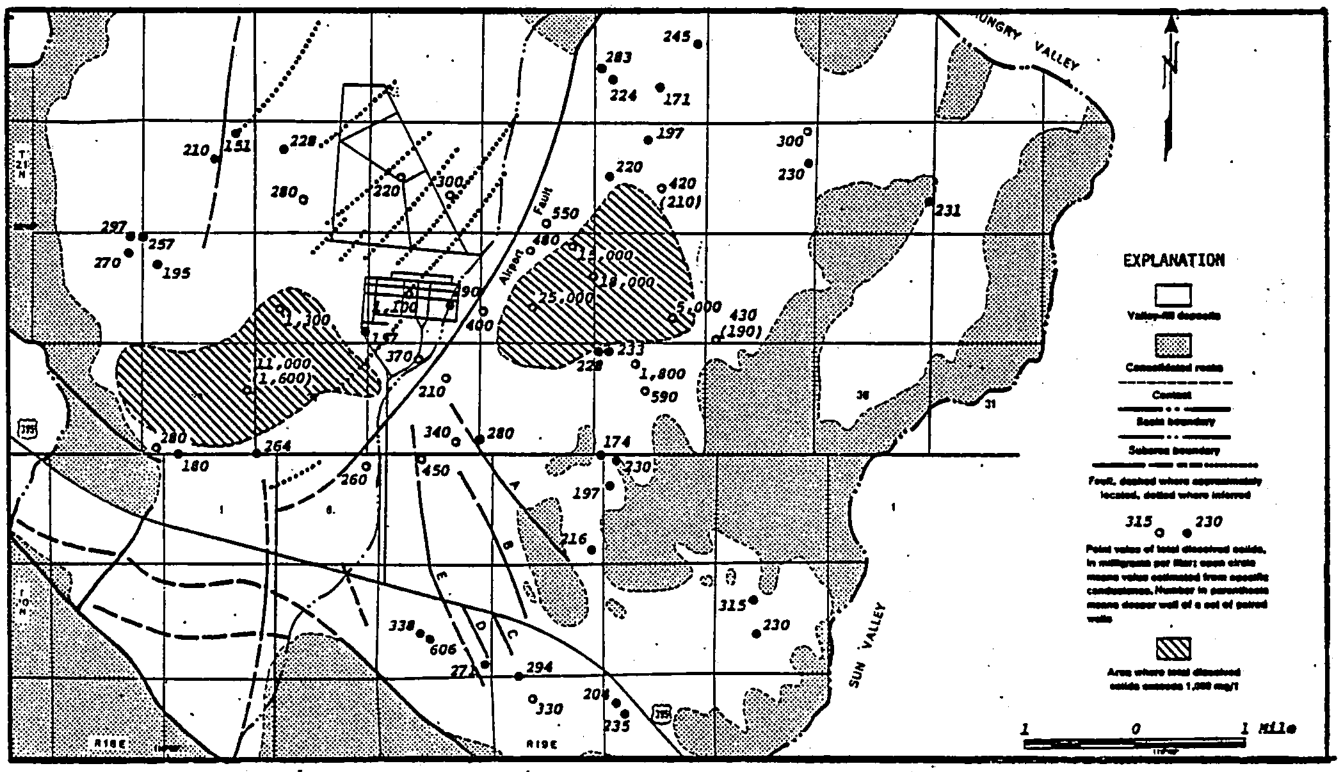

FIGURE 15. Distribution of total dissolved solids in Lemmon Valley, 1971 (from Harrill, 1973).

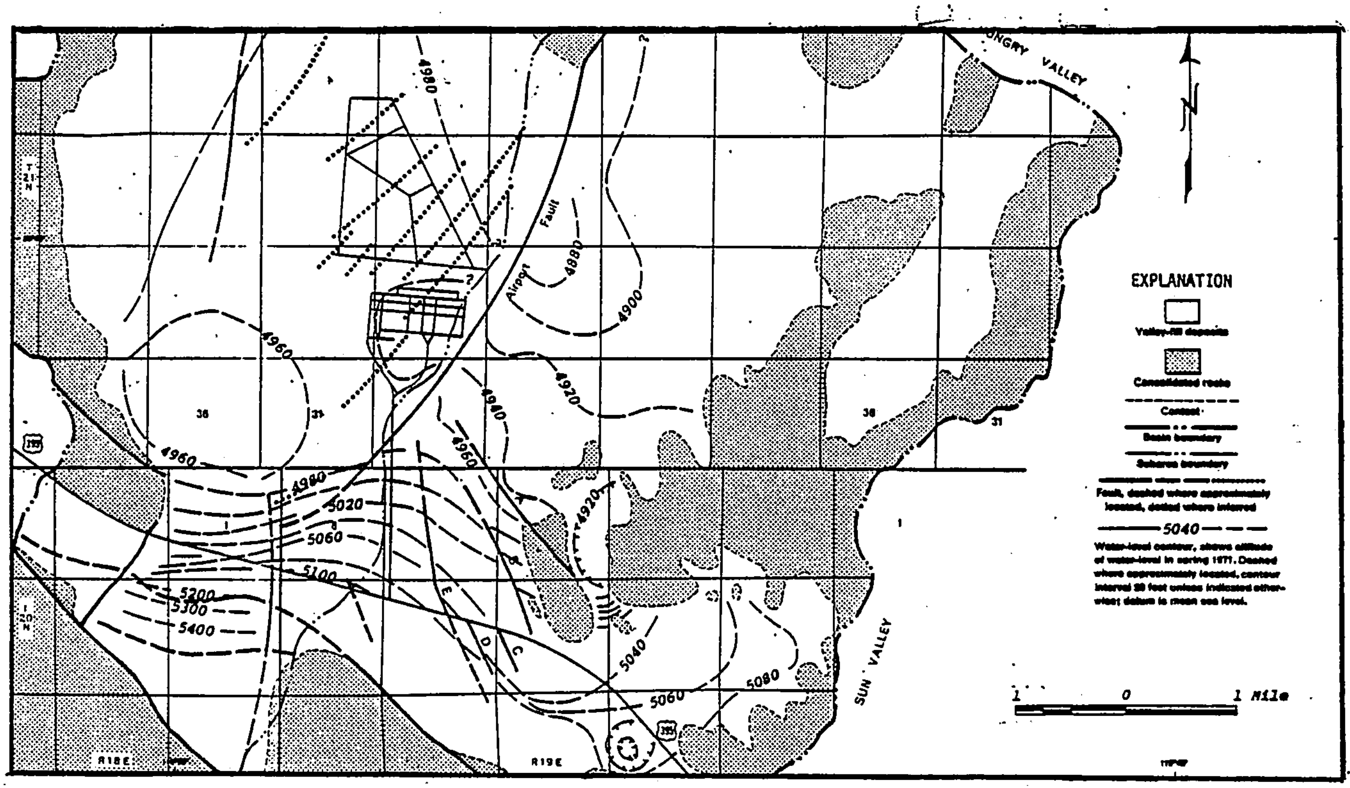

FIGURE 16. Approximate Lemmon Valley groundwater-level contours, Spring, 1971 (from Harrill, 1973).

during 1983 could have been nearly 5300 AF. Considering that the playa was dry to start the 1981-82 runoff period and that the average water surface area during the past two years has been at least 600 acres, the total 2-year inflow to the playas may have been in excess of 6400 AF. This estimate assumes an annual evaporation rate of 3 ft. Even if the above estimates are in error by 50 percent, the annual runoff for the past two years has been in excess of 1600 AF. This conservative excess flow is greater than 8 years of the current Golden Valley groundwater storage depletion rate.

A major uncertainity at this point is the relative productivity of the many Peavine watersheds and how many of them would have to be developed to capture a significant portion of this runoff. A second set of uncertainties consists of the duration of flow in more nearly normal years and the peak flow to be expected.

The only flow records for any Peavine Mountain streams were collected by the USGS on Peavine Creek during the 11 year period Jan. 1963 through Sept. 1974. These records are of little use, however, because the Peavine Creek watershed is south facing, it has only a very small catchment above 6600 ft and it is very windswept. As a consequence of these factors the Peavine Creek catchment accumulates relatively little snow, and that snow experiences early season melt. In contrast, the drainages feeding Silver Lake have catchment area above 7,800 ft., are all north to northeast facing and they tend to accumulate snow drifted over the ridgetop from the windward side. As a consequence, the north drainages receive more snow and it melts over a longer period of time.

Streamflow data will be collected during Spring 1984 to reduce some of the uncertainty about runoff duration, runoff volumes and peak flows - at least for good water year conditions.

PRELIMINARY DIVERSION AND RECHARGE FACILITY CONCEPTS

Recharge facilities represent a major constraint to the design of diversion and transmission facilities. Ideally the recharge facility would be designed to accept a constant and fairly low flow rate without need for regulating storage. Unfortunately the supply will not be available under those conditions, but rather will be available for about a 3 to 4 month period and be highly variable during that period. Flows in excess of the recharge rate will be lost unless a portion of the peak flow can be attenuated with a regulating reservoir. Significant reservoir sites are not available, and furthermore construction of a reservoir would be an expensive propositon. Selection of recharge mode must, therefore, attempt to balance the need for regulating storage against the water to be lost without such storage.

RECHARGE FACILITIES

To be effective, recharge operations must take place up-gradient from, or within, the cone of depression resulting from storage depletion. At this time it appears there are two areas that should be considered as potential recharge sites: 1) the SE and SW corners of Sec's. 3 and 2 respectively; and 2) the E 1/2 of the E 1/2 of Sec. 11. Recharge at both these locations would be up-gradient from most existing pumpage in the valley, thus maximizing distribution of recharged water and minimizing loss due to outflow.

Two methods of recharge should be considered: 1) injection wells, and 2) infiltration basins. Each method will have its advantages and disadvantages.

The two primary advantages to injection wells are that they require minimal land and they provide excellent control both as to point of implacement and injected volumes. The major disadvantage is the tendency to clog and loose capacity if the injected water is not free from suspended material. Capacity can be restored through surging and "re-development".

Primary advantages of spreading basins are the ease of maintenance and the lack of hardware installation. Major disadvantages are the significant land area required and lack of control over the point of implacement. With an injection well, the zone of recharge can be selected, but with infiltration, recharged water may flow laterally on top of zones of less permeable materials and thus not efficiently get to the intended production zones.

Rates of artificial recharge will dictate the extent and cost of the recharge facilities. At this point in time, there are no actual data for Golden Valley on potential rates either for injection wells or infiltration basins. However, well test data in Sec. 3 for example, indicate hydraulic conductivities ranging from about 0.1 to 4 ft/day (1± to 30 gpd/ft^2) and transmissivities ranging from about 12 to 94 ft^2/day (90 to 700 gpd/ft).

If 12 to 16 inch recharge wells are used it should be possible to achieve injection rates of 100 to 200 gpm (0.2-0.4 cfs) with injection pressures of 50 to 100 feet (22 to 44 psi). Under these assumptions, 5 recharge wells could handle a peak flow of between 1 and 2 cfs, however, it is believed that these are conservative capacity estimates. Recent drilling experience by DRI indicates that completed 16" wells will cost on the order of $50/ft. Figuring 5-16" wells each 200 ft deep, the capitol cost would be about $50,000. Apurtenant structures, control valves and transmission lines would probably equal that figure, for a total cost of about $100,000.

If infiltration basins are considered, the most logical location at this time would appear to be in the vicinity of the sand and gravel pit located in Sec. 11 at an elevation of about 5,300 ft. This location would provide ready access by infiltrated water to the weathered granite aquifer zone. The materials in this area should be highly permeable, with conductivity approaching that estimated from the well tests. Conservatively an infiltration rate of 1 ft/day might be expected, or about 0.5 cfs per acre of infiltration basin. Unimproved 1-acre lots in Golden Valley currently are selling for about $25,000 to $30,000. Thus 1 cfs of infiltration capacity (2 acres) might be purchased for about $60,000. Improvements may cost an equal amount for a total cost of about $120,000 for 1 cfs capacity.

As a first approximation it appears that infiltration would be the more costly approach. However, some sort of settling basin/regulating reservoir will be required in Golden Valley. An infiltration basin could serve this purpose. Thus, a combined approach using both recharge wells and an infiltration basin may be desirable. A 1-acre basin designed for a maximum operating water level of 5 ft. could handle a one-day peak inflow rate of 3 cfs if operated in conjunction with 4 injection wells each capable of handling 0.25 cfs. The cost for such a system would be on the order of $140,000.

Thus for planning purposes at this time the peak diversion design rate is being considered to be 3 cfs with a delivery elevation of 5,300 ft.

DIVERSION AND TRANSMISSION FACILITY

A total of five watersheds have tentatively been identified as potential diversion sites. These are watersheds No's 9, 11, 12, 14 and 16. Streamflow from these drainages rapidly infiltrates into the fan area after the streams leave the mountainfront. Much of this infiltrated water reappears as spring and marshy areas lower down on the fan. Because of this rapid infiltration loss, diversion will have to be made at a relatively high elevation. For preliminary planning purposes the 6,000 ft. elevation contour was selected as the common elevation. Area and precipitation data for these watersheds above the 6000 ft. elevation are given in Table 5. This diversion elevation would provide a maximum head difference with the recharge facilities of about 700 ft. This large head difference may present some difficulties in energy dissipation and also increase the cost of pipeline construction.

Watersheds 11, 12, 14 and 16 are all tributary to Silver Lake and are believed to be prime runoff producers. Watershed 9 is tributary to East Lemmon Valley and based on

TABLE 5. AREA AND PRECIPITATION FOR WATERSHEDS 9, 11, 12, 14 AND 16 ABOVE ELEVATION 6000'.

Watershed No.	Area Above 6000', AC	Average Annual Precipitation, AF	Average Precip. in/y
9	610	1440	28.3
11	330	740	26.9
12	490	1150	28.2
14	240	570	28.5
16	270	590	26.2
Totals	1940	4490	27.8

observations in Fall 1983 is a fair producer. As previously noted, runoff from these north slope watersheds is significantly different from that of Peavine Creek. In order to characterize the seasonal north slope hydrograph Dog Creek at Verdi was chosen as being fairly representative of the exposure conditions. Based on the Dog Creek runoff characteristics (Schroer and Mooseburner, 1978) a seasonal hydrograph for Peavine northslope runoff was developed assuming Moore's (in Harrill, 1973) 400 AF/y average Silver Lake runoff. This appoximate seasonal hydrograph is shown in Figure 17.

Based on this hydrograph and assuming equal productivity from the 5 watersheds, a preliminary collection and transmission system was laid out as shown in Figure 18. Two alternative designs were considered, both based on peak collector flows of 0.6 cfs (~270gpm) per watershed. The first alternative attempts to minimize peak flow head loss and the second to minimize construction costs. Cost estimates are based on a "rule of thumb" of $1.50 per inch diameter per foot of pipe. These alternative designs are summarized in Table 6. Under alternative No. 1 total head loss is about 200 ft as opposed to about 500 ft for Alternative 2.

One option for energy dissipation might be a turbine for electrical energy generation. With a net head difference of 500 ft and peak flow of 3 cfs, maximum generating capacity would be about 100Kw and average production about 70 KW. Over a 3-4 month operating season a total of about 144,000 KWH would be produced at a value of nearly $7,500. Cost of the turbine generator would be about $120,000. Economics of such an operation will warrant further consideration in later phases of this project.

RIGHTS-OF-WAY

The proposed routes for the collectors and transmission line are predominantly over private property until the transmission line reaches old highway 395, which is owned by Washoe County. Property ownership is shown in Figure 18. Once the alignment reaches the old highway it would remain within that County right-of-way to Golden Valley Road. It would then cross US 395 and follow Golden Valley Road to Spearhead Drive, turning north on Spearhead to Deer Foot, thence east on Deer Foot to Bull Way and finally north on Bull Way to the gravel pit area.

Except for the segments shown in Figure 18, the alignment would be within the rights-of-way of dedicated streets. Private property easements can be obtained, but costs and potential agreements have not yet been explored. If

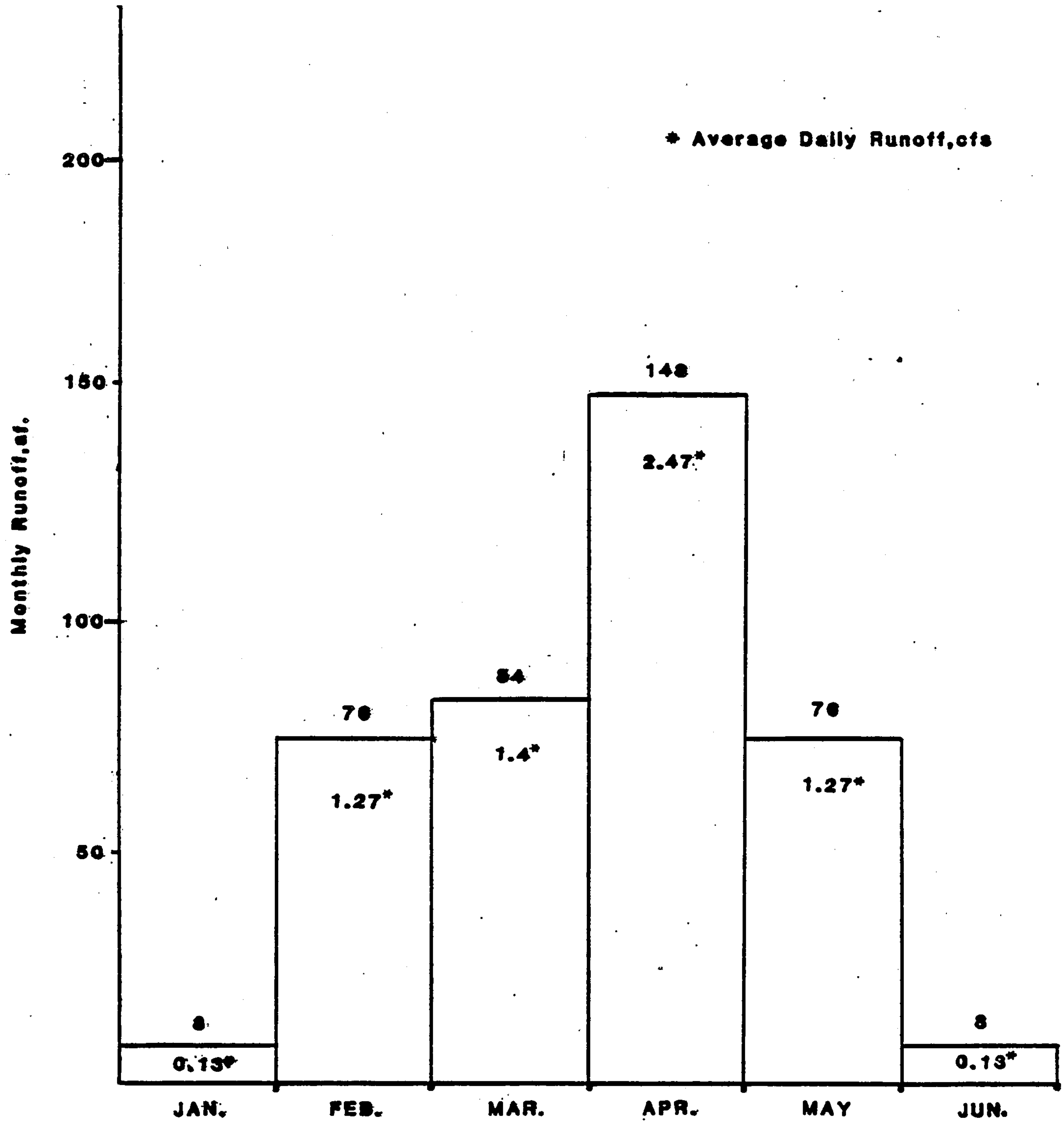

FIGURE 17. Peavine Mountain northslope watersheds aggrate runoff hydrograph.

TABLE 6. PRELIMINARY ALTERNATIVE COLLECTION AND TRANSMISSION SYSTEM DESIGNS

Reach	Length ft.	Max. Discharge cfs	Alternative 1		Alternative 2	
			Diam. inches	Cost $	Diam. inches	Cost $
A	3,800	0.6	6	34,000	4	23,000
B	1,600	0.6	6	14,000	4	10,000
D	3,200	0.6	6	29,000	4	19,000
F	6,600	0.6	8	79,000	6	59,000
H	13,200	0.6	8	158,000	6	119,000
C	3,500	1.2	8	42,000	6	32,000
E	5,000	1.8	10	75,000	8	60,000
G	11,500	2.4	12	207,000	10	173,000
I	21,800	3.0	12	392,000	10	327,000
Totals	70,200	-	-	$1,030,000	-	$822,000

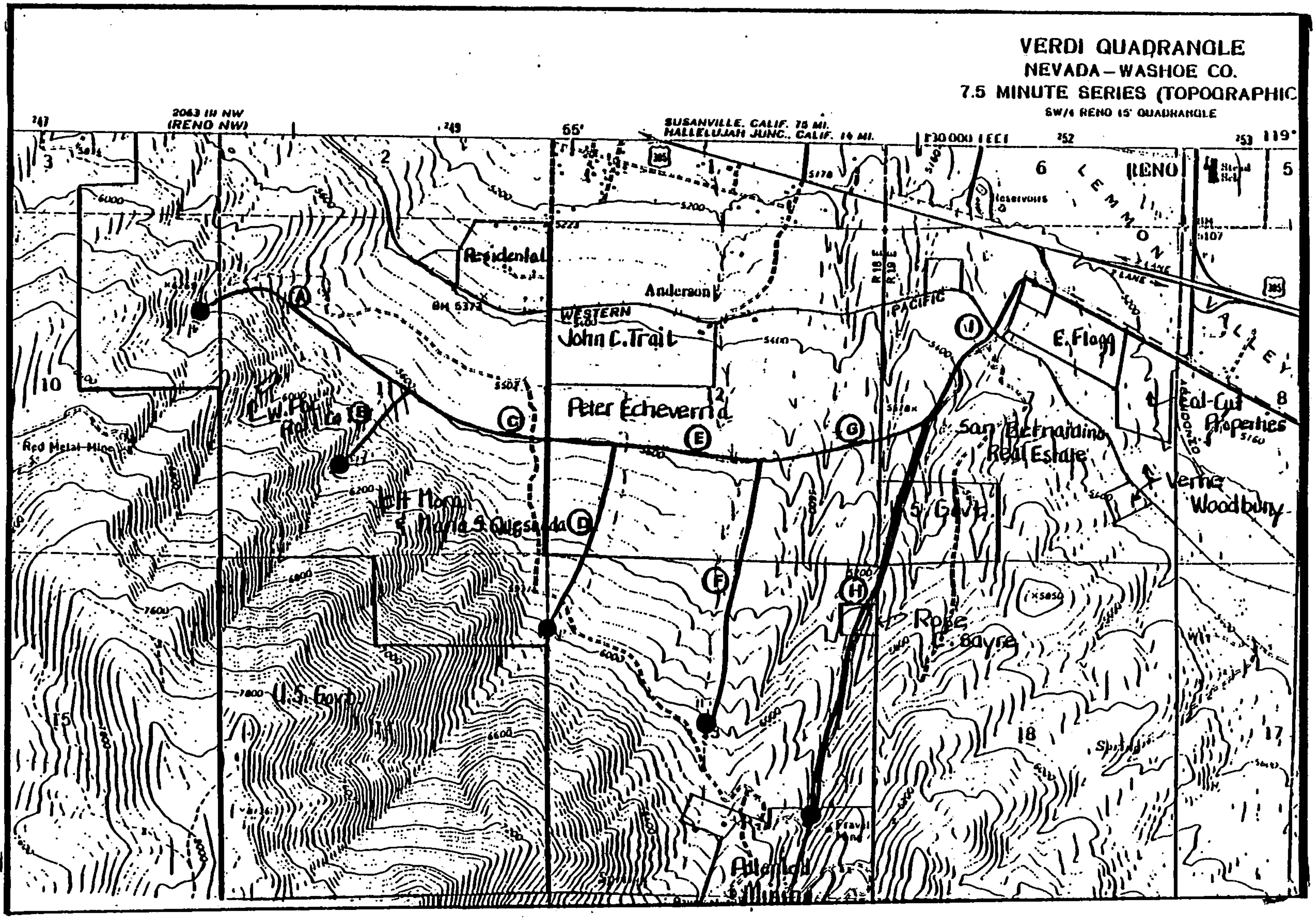

FIGURE 18. Preliminary Runoff Collection and Transmissions System Location and Property Ownership.

necessary the easements could be obtained through comdemnation under NRS 533.050 or through the County's ordinary police powers.

Except for pipeline reaches G and H few construction difficulties should be experienced.

SUMMARY

Golden Valley groundwater storage reserves currently are being depleted at an estimated rate of about 185 AF/y. Since 1973 a minimum of 1150 AF is estimated to have been withdrawn from storage. As further development in the valley continues, the rate of storage depletion will accelerate. This depletion has created a subsurface storage space which can be used to salvage currently lost runoff from Peavine Mountain. Geologic and hydrologic conditions appear favorable to artificial recharge by injection wells or infiltration basins. A combined injection well/infiltration basin recharge system capable of handling a one-day peak inflow of 3 cfs is estimated to cost on the order of $140,000.

Average annual runoff from Peavine Mountain's north slope drainages to the Silver Lake playa is estimated to be about 400 AF. Most of this runoff occurs during the months of February, March, April and May, with peak runoff occurring in April. Five canyons have tentatatively been identified for diversion of this runoff at an elevation of about 6000 ft. The collector and transmission system is estimated to cost between $1,030,000 and $822,000 for delivery of peak flows of 3 cfs to Golden Valley. The Golden Valley delivery elevation would be about 5300 ft.

The higher cost system would deliver water with a total head loss of about 200 ft, leaving an operating head in Golden Valley of 500 ft. The less expensive system would result in about 500 ft of head loss leaving a working head of 200 ft. With the more expensive system it would be possible to incorporate a turbine to generate about 100 KW of electric power. The incremental cost for the turbine/ generator would be about $120,000 and produce an estimated $7,500 worth of electricity per year.

This harvest/recharge system should be capable of salvaging an average of 300 AF/y of water that is currently being evaporated from Silver Lake playa. During this past

year (1983) as much as 1400 AF could have been salvaged. During very dry years (1976-77 for example) as little as 50 to 100 AF would have been saved.

Since the system would be idle for about 6 months of each year and would be entirely gravity operated, the operation and maintenance costs would be minimal. Maintenance activities would include periodic cleaning of diversion structures and the infiltration facility. Operations during the runoff period would include monitoring of water levels and regulating inflow and distribution. If hydropower were included, a portion of the O&M costs would be offset by power revenues.

Table 7 summarizes preliminary estimates of costs for implementing this system. The equivalent annual unit costs for water salvaged with this system ($360-$580/AF) are of the same order of magnitude as costs paid for water by Sierra Pacific Power Co. residential customers. The equivalent cost to Golden Valley residents would be about $360 to $435 per residence per year. Benefits of this harvest/recharge scheme, beyond firming up of the long-term water supply, would include a reduction in the cost of pumping (between $5 and $10 per year savings per residence) and long term improvement in water quality through dilution with the high quality Peavine Mountain water.

If no actions are taken, Golden Valley residents will be faced with a continuing deterioration in water quality due to the septic tank recharge, and the need to deepen existing wells. The deteriorating water quality may force installation of sewers. However, sewers will accelerate the need for deepening of wells because septic tank recharge represents a substantial portion of the annual water supply. Thus, sewering to protect water quality would be a "Catch-22" temporary "solution" because there is a limit to which deepening of wells will be effective. Analysis of valley well logs indicates that only the upper few 10's of feet of the underlying granitic rock are fractured and weathered enough to serve as an aquifer.

Thus, eventually a new source of water is going to be necessary if the current life-style is to be continued. The alternative to a new supply is severe curtailment of water use, both for indoor and outdoor purposes.

The only alternative source of supply is to purchase an existing water right in another valley, Truckee Meadows being the most logical. Once such a supply is secured, there would be two choices as to how it should be delivered to the homeowners: 1) recharge the groundwater reservoir; or 2) build a distribution system. Construction cost for a distribution system would be of the order of $0.5 to 1

TABLE 7. ESTIMATED HARVEST/RECHARGE SYSTEM CONSTRUCTION COSTS.

System Component	Estimated Cost Alternative No. 1	Estimated Cost Alternative No. 2
Recharge Facilites	$ 140,000	$140,000
Collector & Transmission Lines	1,030,000	822,000
Sub-totals	$1,170,000	$962,000
Turbine/Generator	120,000	-
	$1,290,000	$962,000
Equiv. Annual cost, 20 yrs @ 10%	$151,500	$113,100
O&M Costs	30,000	30,000
Power Revenue $/yr	<7,500>	-
Net Equiv. Annual Cost	$174,000	$143,000
Cost per AF @ 300 AF/yr	$580	$480
Cost per AF @ 400 AF/yr	$435	$360

million. A distribution would, however, mean abandoning the $2 to $3 million dollars already invested by the homeowners in their wells and pressure tanks. Recharging the alternative supply would be less costly because the groundwater reservoir would serve as the distribution system to the individual wells. To the costs of either distribution method must be added the cost of purchasing the water rights and transporting the water to Golden Valley. These costs will likely be of the same magnitude as those for a Peavine/Mountain water harvest system. Purchase of existing water rights will not add to the region's useable water supply, but result only in a redistribution of that which is already available.

In summary this preliminary investigation indicates that a harvest/recharge system is economically and technically feasible.

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