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GROUND-WATER RECONNAISSANCE OF THE SMOKE CREEK DESERT BASIN, WASHOE COUNTY, NEVADA AND ADJACENT PARTS OF CALIFORNIA

By J. K. Sales

ABSTRACT

The Smoke Creek Desert Basin, an intermontane basin in northwestern Nevada, has a northeast-south west trend. It is bounded on the east and south by eastward tilted, north-south trending fault block ranges and on the north and west by a high volcanic plateau.

Drainage into the basin is asymmetrical, streams entering from the east and south being short and steep while those on the north and west are longer and have more gentle gradients. A partially buried block of bedrock allows surface flow from the Granite Creek Desert basin to enter the Smoke Creek Desert basin at its eastern end. This block may act as a subsurface dam, diverting the underflow from the Granite Creek Desert basin into the Black Rock Desert basin to the east.

In the center of the basin playa deposits cover nearly three hundred square miles and are probably thousands of feet deep. These interfinger at depth with alluvial slope deposits deposited at the base of the ranges.

Lake Lahontan deposited a well developed set of beaches, bars and spits which are perched upon the alluvial slopes. This lake was continuous at high water level between the Smoke Creek and Pyramid basins through Emmons Pass. Northward drainage through this pass during the retreats of the glacial lake may have flushed the Pyramid basin and caused deposition of excessive salt in the Smoke Creek basin.

Granitic and metamorphic rocks of the mountain blocks are largely impermeable except in local fracture zones. Tertiary and Quaternery volcanics in places contain tuffaceous and scoraceous interbeds which may yield good amounts of water.

Permeability of the alluvial slope material is influenced by the characteristics of the streams which have built them, the parent rock of the mountain block, and previous differences in climate and vegetation. Alluvial slopes below the volcanic plateau should have more favorable ground water conditions. Playa deposits are impermeable and contain highly mineralized water.

The ground water increment is between fifty and one hundred thousand acre feet per year. Dominant recharge occurs as runoff and under flow from the volcanic plateau, dominant discharge as evaporation from the playa.

Water quality varies greatly in the area and also at different horizons within a specific alluvial slope. Overpumping of well may result in in flow of saline water from the playa deposit. Water quality appears best below the lava plateau. Methods of improving ground water are discussed.

INTRODUCTION

Scope and Acknowledgements

This report was completed as a term project for the Ground Water Class at the Mackay School of Mines. A field reconnaissance was conducted over one weekend. The author wishes to thank Mr. William Sinclair of the Ground Water Branch of the United States Geological Survey in Carson City for information gained in discussing the area with him and for aerial photographs that he made available. Mr. Lloyd Whalen, Jr., of the State Department of Health ran the chemical analysis of water samples taken in connection with this report. Mr. Ray Paskall of Empire furnished information about the Empire water supply and ranchers throughout the valley were very cooperative in giving water samples and information concerning their water supplies.

The general format which has been adopted by the United States Geological Survey for their water reports has been followed in this report since it is concise and standard. Work accomplished by Zones (1961) in the Winnemucca Valley has been extensively referred to because of the proximity and similarity of the two basins. The general geology was taken from the Geologic Map of the State of Nevada compiled by Stephenson, and from field observations.

Location

The Smoke Creek Desert Basin is located in west-central Nevada in central Washoe County. Approximately 160 square miles of the western part of the basin is located in adjacent parts of California. The flat playa filled valley trends north east-south west and is approximately 40 miles long and 8 miles wide and has an area of about 300 square miles. The area of the drainage basin as a whole is roughly 1,100 square miles. Another subsidiary basin, the Granite Creek Desert Basin, contributes its surface runoff and an undetermined part of its under flow to the Smoke Creek Basin. This basin, at the edge of which Empire is located, covers an area of about 250 square miles.

The Smoke Creek Desert itself, is bounded on the north-west by the high volcanic flows of Northern Washoe County and on the north-east by the precipitous western scarp of the Granite Range. At its eastern extremity it is partially separated from the Black Rock Desert and Granite Creek Desert Basins by a narrow, nearly buried, bedrock dam which projects south west from the southern end of the Granite Range. The northward extension of the Lake Range, (in this report called the Pah Rum Range), constitutes the south-eastern boundary of the drainage basin. The southern end of the Smoke Creek Desert is separated from Pyramid Lake by the Terraced Hills, through which there is a low gap called Emmon's Pass. It is connected with the Honey Lake Basin by Sand Pass, also at the southern end of the playa.

Access to the valley is by Nevada Highway 81 from Gerlach, a partially paved road, and by dirt road from the west side of Pyramid Lake through Sand Pass. The road along the western side of the valley is graveled and well maintained. In contrast, the one on the eastern side of the valley, which follows the railroad, is unmaintained and passable only with difficulty.

There are several ranches located around the edge of the valley floor. The nearest towns are Gerlach and Empire which are situated 3 and 10 miles respectively from the eastern end of the valley, and have a combined population of a few hundred people. Gerlach is a ranching center and is on the Western Pacific Rail Road. Many of its residents are employed by the railroad. The United States Gypsum Company has a plant at Empire at which nearly all of the residents are employed.

Previous Investigations

A reconnaissance of portions of the area was made by the Fortieth Parallel Survey (King, 1878). Russell (1885) and Jones (1925) surveyed the area in connection with their studies of Lake Lahonton and Quaternery climates. Hardman (1936) gives data on rainfall within the area. Hardman and Venstrom (1941) have studied historical fluctuations in rainfall as they relate to the Pyramid and Winnemucca Basins to the south.

The Ground Water Branch of the United States Geological Survey, in conjunction with the Nevada Department of Conservation and Resources is in the process of making systematic surveys of ground water basins in the north-western part of the state. A survey of the Winnemucca Valley to the south has recently been accomplished (Zones, 1961). Work is in progress on the Granite Creek Basin north-east of Gerlach (not to be confused with the Granite Creek Desert Basin south of Gerlach). The Granite Creek Basin is between the Granite Range and the Calico Mountains and is bounded on its western side by the Smoke Creek Desert Basin. Since these surveys are progressing southward in a systematic manner from the northern border of the state, it is likely that the Smoke Creek Desert Basin will come under study in the near future.

CLIMATE

Long term temperature and precipitation records, available for Sand Pass at the western end of the valley and for Empire at the eastern end of the valley are taken from Zones (1961), and given in the accompanying tables. Both of these stations are at elevations only slightly above the valley floor (3,800), and are representative of conditions on it. These records are quite unrepresentative of the surrounding ranges, some of which rise more than 5,000 feet above the valley floor. The following quotation from the Winnemucca report is probably equally, if not more, applicable to the present study, since the stations that are used are found at either end of the Smoke Creek Valley.

> "The annual precipitation recorded at Sand Pass is 6.53 inches, and at Empire, 5.25 inches. Most of the precipitation occurs during the winter months, largely as snow. At higher elevations the snow cover may last for several weeks or months. Precipitation during the summer months is very slight. During August, the driest month, the normal amount of precipitation recorded at Sand Pass is only 0.07 inch, and at Empire, only 0.13 inch. According to local residents, much of the summer precipitation...occurs as cloud bursts...
>
> "Although no data are available concerning the rate of evaporation..., the rate is probably comparable to that at Lahontan Reservoir.... The United States Bureau of Reclamation estimated that

Table 1.

Normal monthly and annual precipitation at Empire, Washoe county, Nev. (From records of the U.S. Weather Bureau; length of record, 43 years through 1957)

Month	Precipitation (inches)	Month	Precipitation (inches)
January........	0.62	August........	0.13
February.......	.68	September.....	.25
March..........	.45	October.......	.45
April..........	.35	November......	.48
May............	.56	December......	.65
June...........	.46		
July...........	.17	Annual.....	5.25

Normal monthlu and annual precipitation at Sand Pass, Washoe County, Nev. (From records of U.S. Weather Bureau; length of record, 43 years through 1958)

Month	Precipitation (inches)	Month	Precipitation (inches)
January........	1.01	August........	0.07
February.......	.80	September.....	.19
March..........	.53	October.......	.45
April..........	.47	November......	.61
May............	.50	December......	1.23
June...........	.49		
July...........	.18	Annual....	6.53

Normal monthly and annual temperature at Empire, washoe County, Nev. (From records of U.S. Weather Rureau; length of record, 41 years through 1956)

Month	Temperature (°F)	Month	Temperature (°F)
January........	28.3	August........	73.1
February.......	34.8	September.....	63.9
March..........	42.2	October.......	52.1
April..........	50.0	November......	39.7
May............	58.0	December......	31.4
June...........	66.1		
July...........	75.5	Annual	51.3

Normal monthlu and annual temperature at Sand Pass, Washoe County, Nev. (From records of U.S. Weather Bureau; length of record, 38 years through 1957)

Month	Temperature (°F)	Month	Temperature (°F)
January........	29.8	August.......	72.0
February.......	36.0	September....	63.6
March..........	43.0	October......	53.0
April..........	50.5	November.....	40.3
May............	58.4	December.....	32.6
June...........	65.9		
July...........	74.5	Annual....	51.6

(After Zones, 1961, p. 4-5)

the average annual evaporation from the surface of Lahontan Reservoir is about 54 inches.

"The normal annual temperature is 51.6° F at Sand Pass and 51.3° F at Empire. The lowest normal monthly temperatures are recorded in January (29.8° F at Sand Pass and 28.3° F at Empire); the highest in July (74.5° F and Sand Pass and 75.5° F at Empire). Temperatures of 100° F or higher are common in the summer months, but in the winter the temperature may drop below 0° F, although such low temperatures ordinarily are recorded only a few days each year. Daily fluctuations in temperature are as much as 50° F during the summer, but more commonly range from 30° to 40° F. The daily fluctuations generally range from about 20° to 30° F during the winter."

LANDFORMS AND DRAINAGE

The Smoke Creek Desert is situated in a rather complex structural setting which includes elements of basin and range and volcanic plateau topography. To the south and east tilted north-south trending eastward tilted fault block ranges with deeply alluviated valleys are the dominant feature. To the north and west high, rolling volcanic plateaus which are an east and southward extension of the Modoc lava fields of northeastern California border on the Smoke Creek Desert. The Granite Range directly north of Gerlach, which is over 9,000 feet high, seems to be the most northerly extension of the fault block topography in this general area. It is probable that basin and range structure is buried under the more recent Modoc flows and "islands" or steptoes of older rocks protrude through these later flows in northern Washoe County (Gianella, 1962). It is interesting to note that toward the west on the Modoc flows the topographic high points which to the east were fault block steptoes become volcanic cones associated with the flows.

The north east-south west trending Smoke Creek and Black

Rock Desert Basins are transverse structural features with regard to basin and range alignments which tend to be nearly north-south. These depressions may represent a large right lateral wrench zone associated with the Walker Lane wrench zone that passes through Pyramid Lake. Even the topography might appear to suggest right lateral movement on opposite sides of the basin. The question might be asked, is the western scarp of the Granite Range an extension of the western scarp of the Selinite Range, or is it to be correlated with the eastern slope of the Smoke Creek Basin, or are they unrelated. This type of conjecture is not within the scope of a practical ground water report but it emphasizes the fact that minor features of practical interest such as flows, faults, springs, valleys, and dip of strata are controlled by, and a result of, large scale, more elusive structures which are likely present in the area.

A low, nearly buried block of volcanics separates the Smoke Creek Basin from the Black Rock Basin just to the west of Gerlach. At the south end of this barrier it is completely buried, forming a narrow gap through which the valley bottoms of the two basins are continuous.

Alluvial or piedmont slopes lie between the flat playa bottom and the steep scarps that bound the ranges. These commonly have a slope of about 100 feet per mile toward the playa and are well developed though not large. The break between these slopes and the range front is quite sharp, especially at the base of the Granite Range where recent faulting may be indicated. Recent fault traces show clearly on aerial photographs in other areas around the valley. In some areas along the north west side of the valley as in the vicinity of Smoke and Buffalo Creeks the break is less distinct and the piedmont slopes are longer, less well defined and project farther upward onto the mountain slope. The alluvial slopes are composed of rubble eroded from the range above. This material reflects the composition of the mountain block behind them. Those at the base of the Granite Range are composed chiefly of granite and weathering products of the granite as are those at the base of the Pah Rum Range along the sough eastern side of the playa. An area of Triassic-Jurassic metamorphic rocks found in the northern tip of the Pah Rum Range may provide metamorphic debris to the fans in this small area. Except for the above, the remainder of the basin is surrounded by tertiary and quaternery volcanics which are reflected in the alluvial slopes below them.

Superimposed upon the alluvial slopes and the lower portions of the ranges are a well defined set of shore line features developed by Lake Lahontan which filled the basin in glacial times. These take the form of benches, beaches, bars and spits and are made up of gravels and sand of the alluvial slopes which has been reworked by the lake.

Pediments beneath the alluvial slopes are either only primitively developed or non-existant since no well records indicate bed rock at shallow depth and there is no noticeable linear set of springs anywhere on the valley floor. It is likely that the rapid and deep accumulation of playa deposits on the valley floor would have deeply buried any pediment that had developed at an early time. These same playa deposits have likely also buried a great succession of alluvial slope material along the margins of the valleys with which they probably interfinger. In the Black Rock Desert to the east over 2,000 feet of successive playa deposits were intersected by a well along the valley border according to Sinclair (oral communication).

The floor of the Smoke Creek Desert itself is a large, nearly featureless and level alkali flat.

Drainage within the Smoke Creek Basin is centripetal as is characteristic of the Great Basin. No through streams pass through the basin. All stream courses are ephemeral, flowing only in the periods of high spring snow melt and very briefly during local convectional thunder storms during the summer months. Drainage into the basin is asymmetrical, the eastern side being drained by short streams with steep gradients on the steep scarps that bound that side of the valley. It is generally less than three miles, and sometimes less than one mile, from the crests of the ranges to the playa floor in this area. The streams on the north and west sides of the drainage basin that flow off of the more level Modoc Volcanic Plateau are much longer and the drainage divide that limits the basin lies from 10 to 20 miles from the edge of the playa bottom.

A subsidiary drainage basin, the Granite Creek Desert Basin contributes its surface flow to the Smoke Creek Desert playa through the narrow gap in the bed rock dam to the west of Gerlach. The eastern slope of this basin is a large Bahada or alluvial slope which sits at the foot of the Selenite Range. The bottom of this drainage basin contains playas which are nearly continuous with that of the Black Rock Desert and with that of the Smoke Dreek through the bed rock gap.

FEATURES OF LAKE LAHONTON

The highest shoreline features of Lake Lahontan indicate that at that stage the waters in the Smoke Creek Basin were continuous with those of the Pyramid Lake Basin through a narrow straight which occupied Emmons Pass at the north east corner of Pyramid Lake. Jones (1925, p 40) gives a detailed description of features found in the pass and concludes that there was no drainage from the Pyramid Basin into the Smoke Creek Basin during the waning stages of the glacial lake. An inspection of aerial photographs seems to indicate, however, that possible a channel was eroded during at least one of the retreats of lake level and that it has since been obscured by alluvium shed into it from the walls of the pass. If this does represent an erosional channel it would be required that the level of the waters in the Smoke Creek-Black Rock Basin be lowered by evaporation while those on the Pyramid side were overflowing through the pass since inflow still exceeded evaporation. This might be explained by the fact that the Truckee Basin includes a large portion of the higher Sierras which received heavier precipitation, accumulated valley glaciers and even developed an icecap in glacial times. In contrast the Smoke Creek-Black Rock Basins lie entirely within a much lower, drier, unglaciated set of ranges which are located in the rain shadow of the Sierras to the west.

If this drainage prevailed it may have had a significant effect on the salinity of these adjacent basins. Pyramid Lake would be kept flushed clean, while the Smoke Creek-Black Rock area acted as an evaporating dish, concentrating the salts from both of the basins in their playa deposits. Though Jones came to the opposite conclusion many feel that Pyramid Lake is deficient in salts and the above considerations might be a factor. They would also point up the possibility of higher than average concentrations of salt in the ground water supply of the Smoke Creek Basin.

GEOLOGIC FORMATIONS AND THEIR WATER-BEARING CHARACTER

Lithified Rocks

The three basic types of lithified rock within the drainage basin are granite, metamorphosed sediments and volcanics, and the younger unmetamorphosed volcanic flows. The granite and metamorphic rocks are unporous and impermeable and will transmit significant amounts of water only along fracture zones. It is possible that highly brecciated zones may yeld an appreciable amount of water. The volcanic flows contain scoraceous and tuffaceous layers and may be good aquifers.

Alluvial Slope Material

The alluvial slopes consist of series of coalescing alluvial fans composed of erosion debris brought down canyons and deposited on the flat valley floors because of a decrease in gradient. In detail the material of the fans may show very complex characteristics. (1) The streams that flow over the fan usually migrate, diverge and coalesce back and forth across each individual fan. (2) There is a coalescing of water courses between adjacent fans. (3) The surface of the fan lifts vertically with time as the valley is filled, burying a great succession of channels and intra channel deposits. (4) As the valley is filled there may be many inter fingerings of playa and slope deposits as the boundary between the two oscillates inward and outward from the valley wall.

The materials of the fan are subject to many variations. (1) The flow of water out of the canyon greatly affects the degree of sorting. A high sustained flow will tend to deposit coarse, openwork, highly permeable gravels on the alluvial slope, flushing the fines out into the playa. A flash flood will indiscriminately dump both coarse and fine material together on the slope, leading to less permeable deposits. A very low sustained flow may deposit fines along the stream course, decreasing the permeability of its bed. (2) The size and length of the drainage basin has an effect on the sorting of materials on the fans. The extremely short, steep canyons on the bordering Granite and Pah Rum ranges should tend to be covered completely by even a very local cloudburst. This combined with their steep gradients would cause the entire canyon to be flushed at once, leading to poorly sorted and relatively impermeable deposits on the fan below. Longer streams with larger drainage basins and lower gradients tend to yield more sustained flow. It is not probable that a cloudburst of the type common in the Great Basin would cover the entire drainage basin at one time. It is less probable that the crests of floods from many tributaries would reach the mouth of the canyon at the same time, swell the flood greatly and then dissipate all at once. With the same type of reasoning it is likely that precipitation will occur in at least a part of the drainage area more frequently. The streams on the western side of the valley are of this type and they should build fans that are better aquifers and generally produce more dependable ground water conditions. (3) Composition of the parent rock plays a part in the permeability of the fan material. The feldspars of the granitic material tend to weather to clay products which decrease permeability. In contrast the fine grained or glassy volcanics tend to break down mechanically into discreet particles, a process less deletereous to permeability according to Sinclair (oral communication). (4) More lush vegetation which probably grew on the alluvial slopes during more moist past climates may affect both the quality of the water and the permeability of the material. Heavy vegetation and moist climate tend to accelerate chemical decomposition and develop thick, dense residual soils. A well drilled at Empire produced good water for a time but upon extensive pumping it became highly mineralized and produced fragments of leaves and wood from a depth of approximately 300 feet below the surface of the fan. Much of the mineralization that frequently occurs in wells drilled near the valley bottom may result from this organic decomposition.

Deposits of Lake Lahontan

Most of the material in the beaches, bars and spits deposited by Lake Lahontan is reworked alluvial slope material. Permeability may be good since much of the finer material may have been winnowed out by water and wind action. However, these deposits are perched upon the alluvial slopes and therefore seldom intersect the water table. They do constitute good areas for recharge.

Playa Deposits

With the possible exception of material right at the outlet of the larger streams the playa deposits, which are likely to be thousands of feet thick, are largely impermeable. Though the playa was entirely inaccessable at the time field work was done, due to water and mud covering it, it is likely that deposits in its center are largely clay. These may grade into silts and fine sand toward the valley walls.

GROUND WATER

Occurence and Movement

Ground water occurs in the lithified rocks of the mountain blocks, on the alluvial slopes and in the playa deposits. The thin Lake Lahontan deposits and sand dunes are almost always situated above the water table. Likewise, only the deeper portions of the alluvial slopes lie below the water table and the depth to water may be as much as 300 to 500 feet. In the mountain blocks depth to water may be very great if water is found at all. The granitic rocks can be expected to contain very little water except in localized shattered zones. Area of permeable beds within the volcanics and below the water table may produce significant aquifers. Permeable stream courses within the alluvial fan deposits are erratic in that they lie at varying depths and in any position upon the fan. These stream courses slope from the mountains and are commonly surrounded by less permeable material, often resulting in artesian flow when they are tapped. The playa deposits will produce very little water due to their impermeability and water that is obtained will be highly mineralized. The slope of the water table is away from the mountains and toward the valley floor. It is generally much subdued compared with the topography above it, lying very close or at the surface in the center of the playa and at considerable depth at higher surrounding elevations.

One of the significant problems concerned with ground water in this basin is whether there is under flow from the Granite Creek Desert Basin into the Smoke Creek Basin and if so, how much. The structural setting around the bed rock barrier west of Gerlach indicates that underflow might be largely diverted into the Black Rock Basin, even though surface runoff passes through the gap and into the Smoke Creek Basin. Much more detailed work must be done to solve this question. The present author submits that ion analysis work such as has been conducted by the United States Geological survey in the Truckee Meadows are (, 1962) may discern this. A limited attempt at this, made in conjunction with this report, though inconclusive pointed to great differences in ion content in various areas of the drainage basin. As can be seen from table number 2, samples taken in the Black Rock-Granite Creek Desert Basins (samples 1 and 3) have a much higher total hardness and calcium content than those obtained in the Smoke Creek Basin. Sample 3 also has a magnesium content four times as great as any of the other samples. These four samples indicate that more detailed work of this type might be fruitful.

Recharge

Methods used in computing recharge and discharge in this report have been adapted from Zones (1961).

There is a pronounced increase in precipitation with elevation in the basin and therefore the dominant recharge occurs as precipitation on the higher elevations.

The records at Sand Pass and Empire indicate an average annual precipitation of about 6 inches per year for the valley floor and lower elevation of the alluvial slopes. Studies in the Paradise Valley some 100 miles to the east (Loeltz, et. al., 1949) indicate that approximately 9 inches of precipitation per year are required to satisfy evapotranspiration requirements. It is unlikely therefore that any significant amount of the precipitation at these lower elevations reaches the water table. Within the drainage divide approximately 500 square miles lie within the 8-12 inch zone, 200 square miles within the 12-15 inch zone and 100 square miles in the 15-20 inch zone. The precipitation in excess of the evapotranspiration requirement (9 inches) amounts to 27,000 acre feet in the 8-12 inch zone, 53,000 acre feet in the 12-15 inch zone, and 48,000 acre feet in the 15-20 inch zone. This gives a total of 128,000 acre feet that either soaks into the water table or runs off onto the valley floor. Approximately three inches of runoff per year are required to supplement precipitation on the valley floor to meet evapotranspiration requirements. Therefore approximately 19,000 acre feet must be subtracted to meet this requirement, leaving 119,000 acre feet of runoff. If the figure determined in the Paradise Valley study (Loeltz, et. al., 1949) of 40% of the runoff recharging the ground water supply is valid then approximately 75,000 acre feet are annually available for recharge within the Smoke Creek Basin proper. Possibly 1000 acre feet of surface runoff may reach the Smoke Creek from the Granite Creek Drainage Basin. It should be stressed that the above method and the figures used are subject to many inaccuracies and therefore the figure of 75,000 acre feet is at best only approximate.

Discharge

Ground water is discharged from the valley by direct evaporation where the water table is very close to the surface, by evaporation from the capillary fringe where it is near the surface, by transpiration from phreatophytes and by springs.

Evaporation from the playa: Since the playa is inaccessable during the spring of the year no detailed information is known about it. It is likely that conditions here are very similar to those of the Winnemucca Valley Playa. The watertable is believed to be at or within a few feet of the surface over most of the area. Where it lies below the surface the associated capillary fringe usually intersects the surface. A layer of salt crystals is likely to be present over most of the surface as it is in the Winnemucca Valley (Zones 1961, p. 13).

Taking mean figures for water table depth from Winnemucca Valley and using the reasoning of Zones (1961, pp. 13-14) a crude quantitative estimate might be made. During the spring and at times of heavy rainfall the surface of the playa is largely covered with water. If 100 square miles of the playa meet these conditions between 50,000 and 70,000 acre feet of water might be evaporated annually. In fringe areas of the playa and on the lower parts of the slopes 5,000 to 1,000 acre feet of evaporation per year would seem reasonable considering the size of the area and the rates as determined by Zones.

Phreatophytes: The area in which there is appreciable transpiration by phreatophytes is restricted to a narrow band between one half and one mile wide around the edge of the valley. Below this zone on the playa nothing grows and above this zone on the higher parts of the alluvial slopes the water table and the capillary fringe are so far below the ground surface that even the sturdier phreatophytes cannot reach them. Using quantities based on the studies of White (1932) and applying these to a ring one half to one mile wide around the edge of the playa a figure of between 5,000 and 10,000 acre feet might prevail, assuming an effecive density of phreatophytes throughout this belt.

Springs and wells: Numerous springs are located around the perimeter of the valley, mostly at the upper or lower ends of the alluvial slopes. It was not possible to determine the number of springs or the quantity of their flow. Assuming a frequency and size of springs similar to those in the Winnemucca Lake Valley a figure of from 2,000 to 5,000 acre feet of evaporation per year would probably satisfy both spring requirements and those of the limited ranches in the valley.

GROUND WATER INVENTORY

In a closed desert basin such as the Smoke Creek the annual recharge must equal the annual discharge. If recharge were greater a lake would form and out flow from the basin would occur. If recharge were less, the water table would lower in the central part of the basin until equilibrium was attained by the decrease in evaporation. The total computed discharge is roughly between 60,000 and 90,000 acre feet. The computed recharge is approximately 75,000 acre feet, giving the same order of magnitude for both.

CHEMICAL QUALITY OF WATER

The limited chemical analysis made of samples from four locations within the area show a wide range of ion content as shown in table number 2 . Sample 3, taken from the Empire domestic water supply which comes from a well situated up slope from the town, contains a relatively high total hardness and a magnesium content greater than any of the other samples. Sample 4, from an artesian stock well at the Deep Hole Ranch on the alluvial slope at the base of the Granite Range contains the most alkaline water. Sample 2 from a domestic artesian well at the Parker Ranch at the foot of the lava plateau contains water low in ion content though it flows nearly luke warm. Sample 1 from the hot springs at Gerlach is low in magnesium and high in calcium. The water from one well which was not sampled at the Lingfelter Ranch emitted a very strong sulfur smell.

DEVELOPMENT OF GROUND WATER

Ground water underlying the playa generally cannot be utilized both because it is highly mineralized and because the impermeability of the playa deposits would not permit significant flow into wells.

Ground water potential in the alluvial slope areas is a result of some confined buried stream courses that slope

Table 2. - Chemical analyses of water in the Smoke Creek Desert Basin and adjacent areas.

(Analyses by the Nevada State Department of Health, Lloyd Whalen, Jr. - Chemist)

Locality number	Location	Date collected	Constituents (ppm): Alkalinity (as $CaCo_3$)	Bicarbonate (as $CaCo_3$)	Calcium	Magnesium	Total Hardness (as $CaCo_3$)	Remarks
1.	T.32 N. R 23 E. Gerlach Hot springs	5-6-62	84.0	102.0	76.88	3.01	204.0	1 mi north of Gerlach. Temp near boiling
2.	T.32 N. R.21 E. Parker Ranch	5-6-62	78.0	95.0	16.02	4.87	60.0	Artesian flow. Water luke warm
3.	T.31 N. R.23 E. Empire water supply	5-6-62	156.0	190.0	44.84	20.46	196.0	Welldepth 550', 15' perf. Pressure surface 315' Continuous pumping of 550 gpm dropped water level 20'.
4.	T.33 N. R.22 E. Deephole Ranch	5-6-62	188.0	229.0	24.02	5.85	84.0	Artesian flow stock well. Water cold.

toward the valley. These aquifers must be below the water table which also slopes toward the valley. The sloping and semi-confined nature of these aquifers frequently will produce a positive artesian head and not infrequently artesian surface flow. Over pumping of wells, especially those low on the slope or deep, may reverse the hydraulic gradient and cause saline water to flow into them from the valley floor. This has happened to wells previously used for the town water supply at Empire. Wells tapping aquifers at different horizons in the fans may produce widely differing quality of water, partially due to areas of buried organic matter and partially due to interfingering of playa deposits in the lower areas of the fans.

Alluvial slopes on the north and west side of the valley should be superior to those on the eastern and south eastern side of the valley for the following reasons: The parent rock material should produce greater permeability since the volcanics do not weather to clay products as easily as the granitic rocks do. The longer water shed should produce higher and more sustained flow causing better sorting and greater permeability of the slope material. This higher flow should also cause a relatively higher water table and decrease the possibility of saline contamination due to reversal in hydraulic gradient.

The ground water available for development in the basin consists of a wedge shaped body lying within the alluvial slope. It is limited on top by the water table, at its upper end by the impermeable rocks of the mountain blocks and on the bottom by a horizon below which pumping would bring in salt water from the valley floor. If this wedge shaped mass is over drawn it will thin until nothing but saline water is available to the pumps.

Since recharge and discharge must balance, the only way to increase available water is to decrease the discharge in some manner, thus salvaging a portion of the water normally evaporated or transpired for economic use. Elimination of phreatophytes would be of only limited value since transpiration from them probably accounts for less than 10% of the discharge from the valley. By far the greatest percentage of water loss occurs by evaporation from the playa where the water table is everywhere quite close to the surface. A lowering of the water table would decrease evaporation and salvage water. However, water pumped from the playa, to accomplish this, would be too saline to be useable. Water pumping on the alluvial slope to lower the level under the playa would contaminate the alluvial slope aquifers. Finally there is no place to put the quantities of saline water necessary to lower the playa water table effectively.

Perhaps an answer may be had in a process which is already going on. It is known that films of salt deposited on the surface of playas by evaporation decrease the rate of evaporation from that surface. Without considering the economic feasibility of the project, let us consider what would happen if the surface of the Smoke Creek playa were rendered impermeable to evaporation by the application of some substance highly more efficient than salt (a minute film of plastic for instance). The greatest source of water discharge would be halted and indications are that this might amount to over 50,000 acre feet per year. Since out flow by evaporation from the playa would be halted, under flow from the alluvial slopes into the playa would like wise hault and the water in the slope would increase. In effect the wedge of useable water within the alluvial slope would thicken and the water table would rise, coming closer to the surface of the slope. Hydraulic gradients would increase and the pressure surface of the confined aquifers would rise causing greater artesian and natural spring flow. The increased slope of the water table would eliminate or reduce the possibility of reversal of flow and saline contamination from the valley.

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FIGURE 1

Looking south east from Lava plateau across the Smoke Creek Basin, Granite Range - left, Smoke Creek Playa - center right, Bedrock dam + gap - center, Selinite Range - right background.

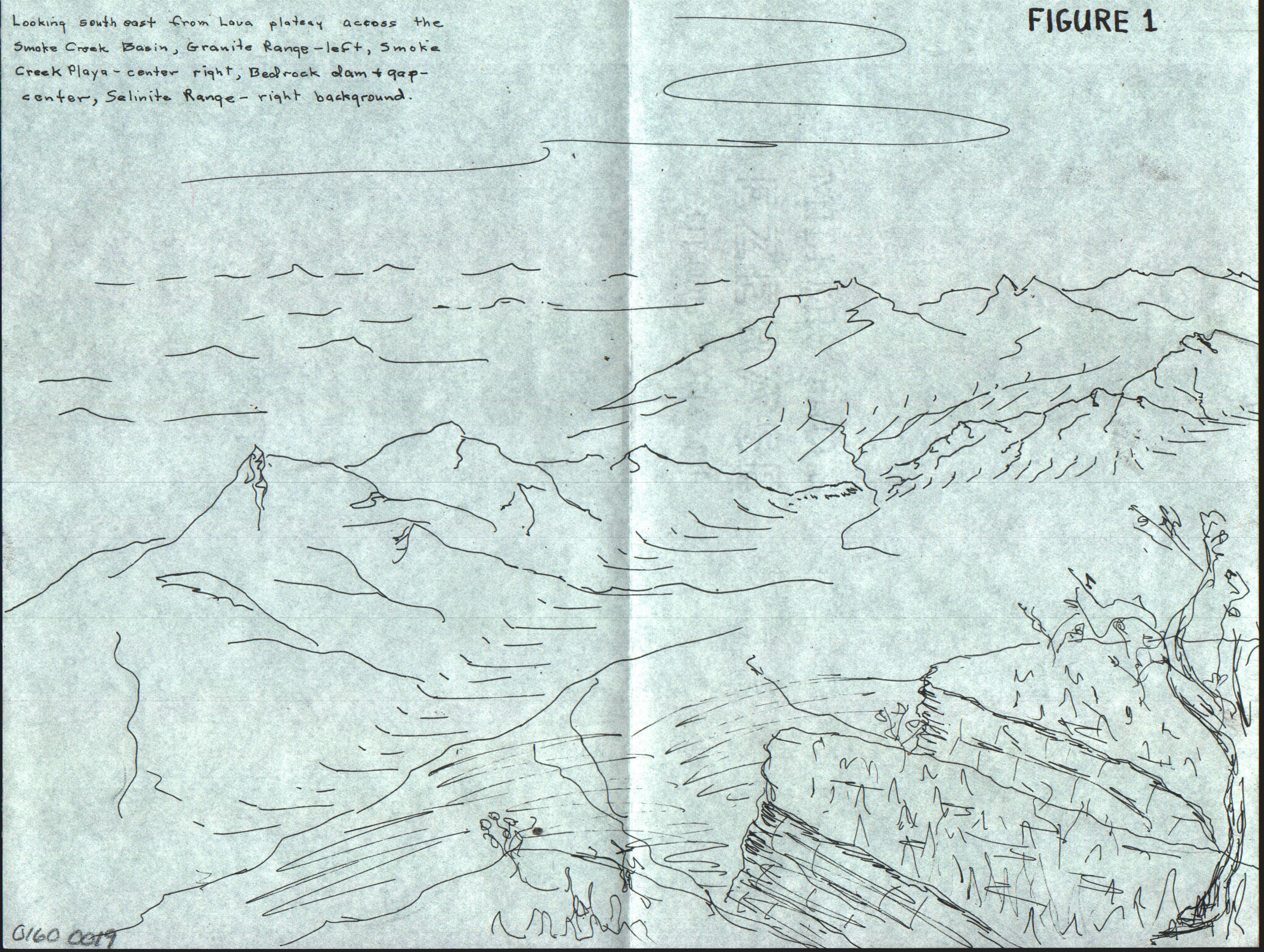
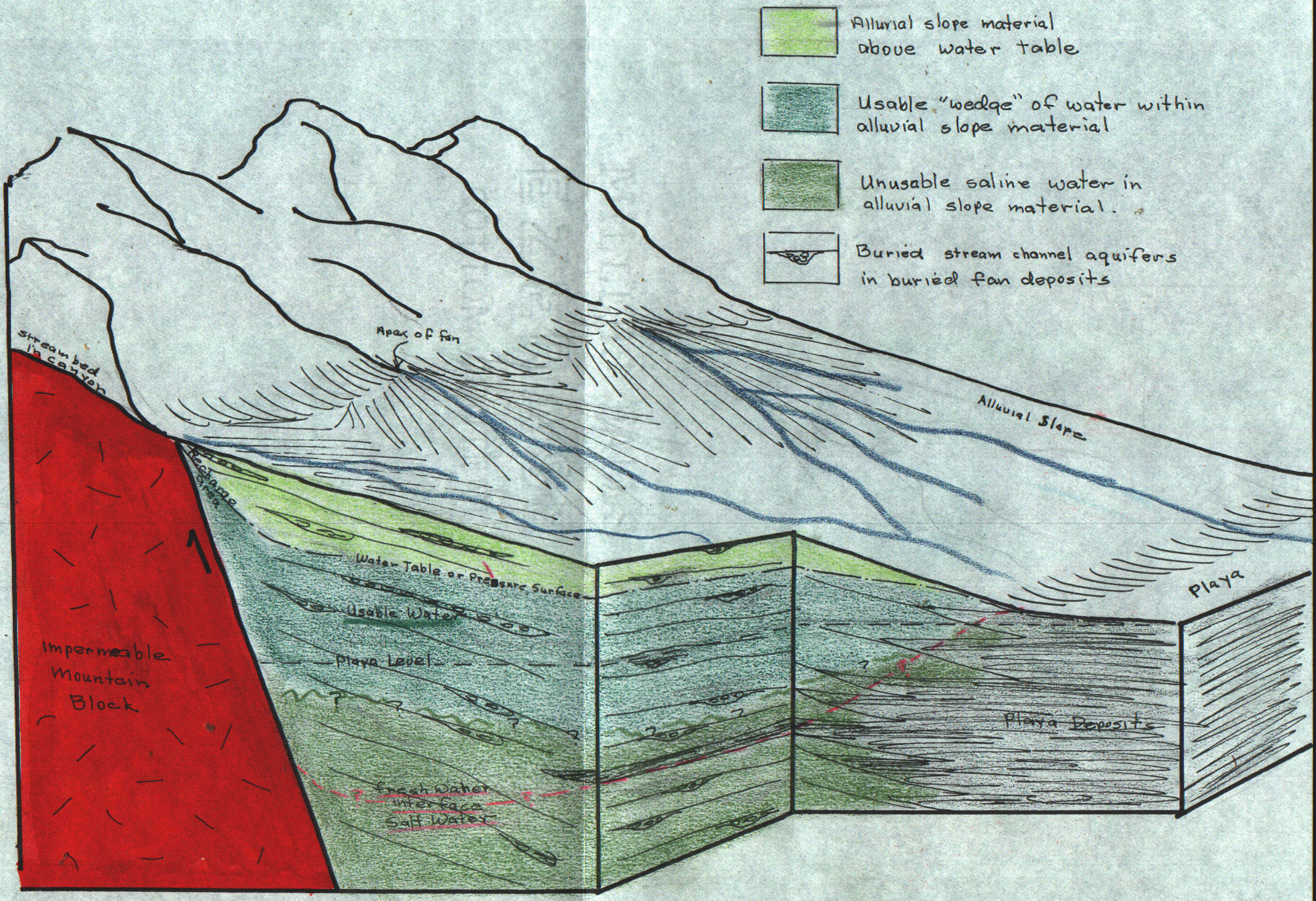


FIGURE 2.



GENERALIZED CONDITIONS IN THE SMOKE CREEK BASIN

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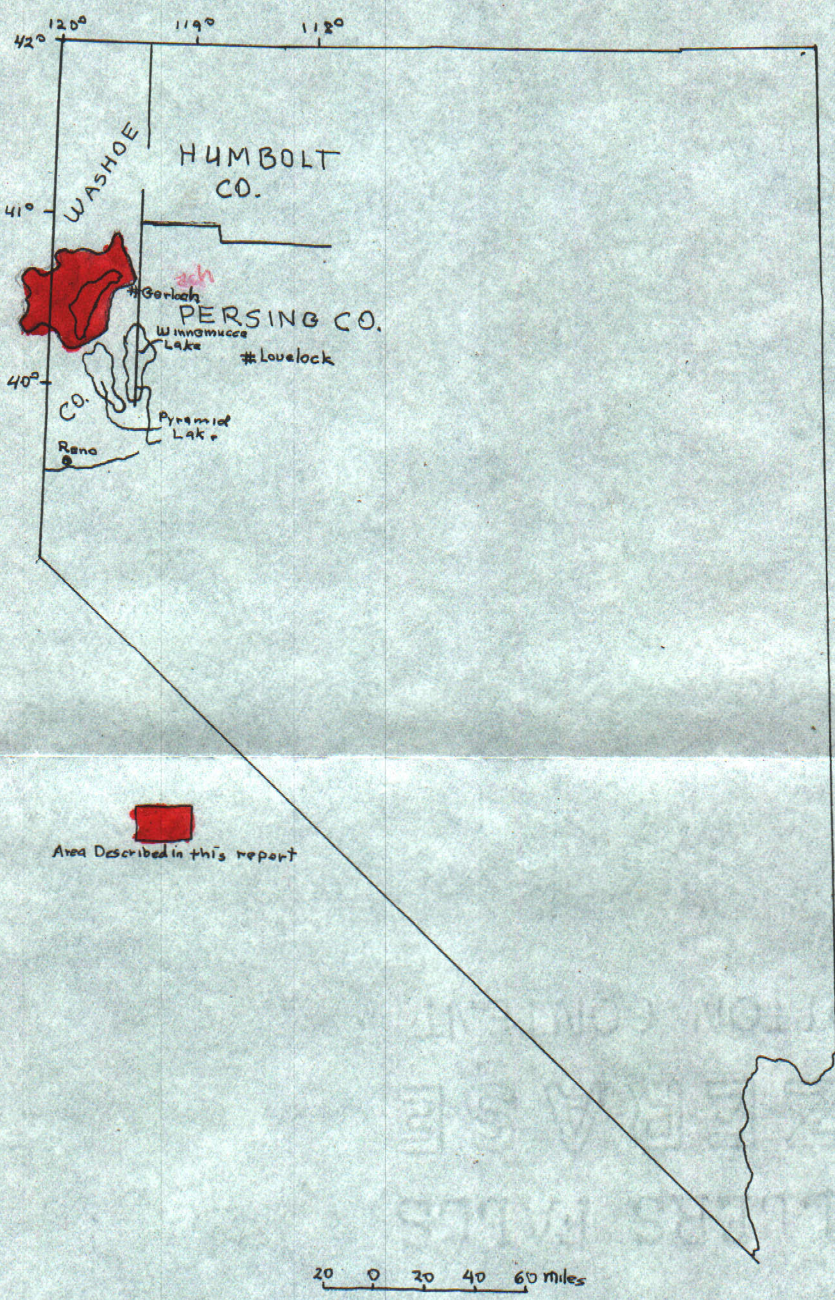
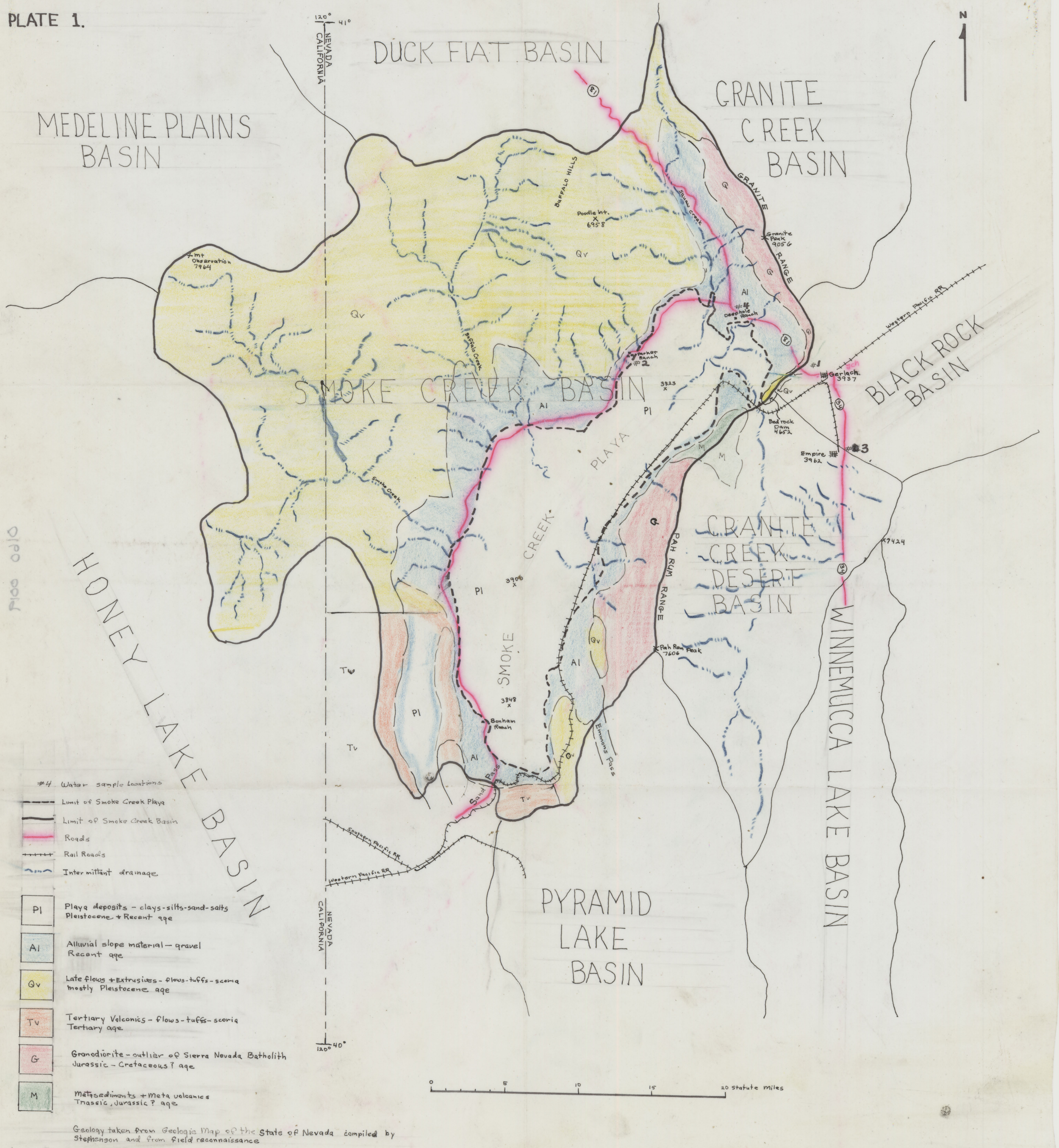
FIGURE 3.



120°
119°
118°
42°
41°
40°
WASHOE
CO.
HUMBOLT
CO.
#Gerlach
PERSING CO.
Winnemucca
Lake
#Lovelock
Pyramid
Lake
Reno
Area Described in this report
20 0 20 40 60 miles

PLATE 1.



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