SOME ASPECTS OF THE
HYDROGEOLOGY OF THE SPRING MOUNTAINS
AND PAHRUMP VALLEY, NEVADA, AND ENVIRONS,
AS DETERMINED BY SPRING EVALUATION

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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. ABSTRACT</td>
<td>18</td>
</tr>
<tr>
<td>II. INTRODUCTION Scope and Purpose</td>
<td>17</td>
</tr>
<tr>
<td>III. PHYSIOGRAPHIC FEATURES</td>
<td>16</td>
</tr>
<tr>
<td>IV. VEGETATION</td>
<td>15</td>
</tr>
<tr>
<td>V. GENERAL GEOLOGY AND HYDROLOGIC PROPERTIES</td>
<td>14</td>
</tr>
<tr>
<td>VI. GROUND-WATER SYSTEMS IN ARID ZONES</td>
<td>13</td>
</tr>
<tr>
<td>VII. RECOMMENDATIONS</td>
<td>12</td>
</tr>
<tr>
<td>VIII. WELL AND SPRING DESIGNATION</td>
<td>11</td>
</tr>
<tr>
<td>APPENDICES</td>
<td>10</td>
</tr>
<tr>
<td>Key to Classification of Springs</td>
<td>9</td>
</tr>
<tr>
<td>Index to Springs</td>
<td>8</td>
</tr>
<tr>
<td>Spring Descriptions</td>
<td>7</td>
</tr>
<tr>
<td>Approved by Director of Thesis</td>
<td>6</td>
</tr>
<tr>
<td>Approved by Department Head</td>
<td>5</td>
</tr>
<tr>
<td>Approved by Dean of Graduate School</td>
<td>4</td>
</tr>
<tr>
<td>Approved by</td>
<td>3</td>
</tr>
</tbody>
</table>

Approved by George B. Whitney

Approved by

Approved by

Approved by
## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. ABSTRACT</td>
<td>1</td>
</tr>
<tr>
<td>II. INTRODUCTION</td>
<td></td>
</tr>
<tr>
<td>Scope and Purpose</td>
<td>3</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>4</td>
</tr>
<tr>
<td>Location and Extent of Area</td>
<td>5</td>
</tr>
<tr>
<td>Climate</td>
<td>5</td>
</tr>
<tr>
<td>III. PHYSIOGRAPHIC FEATURES</td>
<td>7</td>
</tr>
<tr>
<td>IV. VEGETATION</td>
<td>10</td>
</tr>
<tr>
<td>Phreatophytes</td>
<td>12</td>
</tr>
<tr>
<td>V. GENERAL GEOLOGY AND RELATED HYDROLOGIC PROPERTIES</td>
<td>16</td>
</tr>
<tr>
<td>Aquifers</td>
<td>16</td>
</tr>
<tr>
<td>Aquitards</td>
<td>20</td>
</tr>
<tr>
<td>VI. GROUND-WATER SYSTEMS IN ARID ZONES</td>
<td>23</td>
</tr>
<tr>
<td>General</td>
<td></td>
</tr>
<tr>
<td>Regional Ground-water Systems in Area Studied</td>
<td>25</td>
</tr>
<tr>
<td>Local Ground-water Systems in Area Studied</td>
<td>31</td>
</tr>
<tr>
<td>VII. RECOMMENDATIONS</td>
<td>35</td>
</tr>
<tr>
<td>VIII. WELL AND SPRING DESIGNATION</td>
<td>35</td>
</tr>
<tr>
<td>APPENDICES</td>
<td></td>
</tr>
<tr>
<td>Key to Classification of Springs</td>
<td>44</td>
</tr>
<tr>
<td>Index to Springs</td>
<td>48a</td>
</tr>
<tr>
<td>Spring Descriptions</td>
<td>48</td>
</tr>
</tbody>
</table>
Instrumentation                            page 102

Chemical Analysis of Spring and Well Waters                            108

BIBLIOGRAPHY                                             113

1. Geologic Sections of Kupah and Roasting Springs Ranges, California and Spring Mountains, Nevada, Showing Approximate Thickness, Type of Rocks, and Geologic Ages of the Various Formations   18
2. Plotting of Spring and Well Water Analysis                     29
3. Cross-section of 'Y' Notch Wells                                105
4. Fischart Pliano                                                   105

Diagrams

1. Twenty Mile Spring                                                 49
2. Roasting Spring                                                    49
3. Vale Spring                                                        50
4. Ford Spring                                                        50
5. Rainbow Springs                                                    55
6. Cool Springs                                                       56
7. Crystal Springs                                                    50
8. Horsecreek and Mill Smith Springs                                 50
9. Sparrow Springs                                                    58
10. Jackrabbit Spring                                                  72
11. Girl Scout Spring                                                  96

Maps

1. Geologic Map                                                         In pocket
LIST OF ILLUSTRATIONS

Figures
1. Index Map ........................................... 6

2. Geologic Sections of Nopah and Resting Springs Ranges, California and Spring Mountains, Nevada, Showing Approximate Thicknesses, Type of Rocks, and Geologic Ages of the Various Formations .................. 18

3. Plotting of Spring and Well Water Analysis ........ 29

4. Cross-section of 'V' Notch Weir .................. 105

5. Parshall Flume ..................................... 105

Diagrams
1. Twelve Mile Spring .............................. 48

2. Resting Spring .................................. 49

3. Tule Spring .................................... 50

4. Ford Spring ..................................... 53

5. Rainbow Spring ................................. 55

6. Coal Spring ................................... 56

7. Crystal Springs ................................. 57

8. Horseshutem and Bill Smith Springs ......... 58

9. Grapevine Springs .............................. 58

10. Jackrabbit Spring ............................... 72

11. Girl Scout Spring ............................... 84

Maps
1. Geologic Map ..................................... in pocket

iv
ABSTRACT

All available data pertaining to springs in the Spring Mountains and environs have been obtained and evaluated. Included are August discharge measurements, water quality and temperatures, and geology.

Analysis of geology indicates that nearly all springs are controlled by impermeable fault contacts or exposure of cavernous systems in limestone due to faulting or erosion. Spring discharge nearly always resulted from a 'perched' or elevated water table.

It was possible to define the lower and middle Paleozoic carbonates as the principal transmitters of ground water.

Observation of plant growth, particularly the phreatophytes, indicate areas of alluvial drainage. Both well and spring data offer evidence of the existence of such buried stream gravels.

Subsurface movement of water is toward California with Spring Mountains acting as the principal recharge area and Amargosa River area, Tecopa and Shoshone, California as discharge zones of the interbasin system. Northward movement from Pahrump Valley into Ash Meadows is believed to be small.
even though the quartzite barrier is highly fractured and a differential head exists to allow extensive movement. The Bonanza King formation, a cavernous carbonate, could act as a conduit supplying water to Ash Meadows springs from Pahrump Valley.

It has been concluded from this investigation that nearly all springs discharge from a local groundwater system.
INTRODUCTION

Scope and Purpose

Springs in southwest Nevada have long been a focus of interest since water is of primary concern in this arid region. Early settlements were first based upon utilization of discharge from springs, and even today, some springs still supply the only water to small farms and range cattle.

Because water is of utmost importance to this area, this investigation was undertaken with the purpose of appraising both mountain and valley hydrogeology.

Of primary concern was an understanding of springs and their role in evaluating mountain hydrology. This entailed compiling data on geology, discharge, quality, and any other pertinent data that might assist such an evaluation.
ACKNOWLEDGMENTS

In connection with this report, invaluable assistance from many sources is gratefully acknowledged. For providing the original suggestions as to the path this study was to follow, this writer is indebted to Dr. G. B. Maxey, Research Professor of Hydrogeology and Geology, Mackay School of Mines and Desert Research Institute, University of Nevada, and to Isaac J. Winograd, United States Geological Survey. Additional appreciation is expressed to Dr. Maxey for editing of this report and for arranging financial aid during the course of fieldwork.

Special thanks are also due members of the United States Geological Survey, Carson City, for information and suggestions concerning the hydrogeology in Pahrump Valley, and to individuals at the Water Resources Division of the Nevada State Engineer's Office, Las Vegas, for help in locating unmapped springs.
LOCATION AND EXTENT OF AREA

The area of this report covers some 2400 square miles and includes Spring Mountains, Ash Meadows, and Pahrump Valley, Nevada. It also includes Nopah Range, Chicago and California Valleys of California (figure 1).

The mountains and valleys have a north-northwest trend and are in the southern part of the Basin and Range Physiographic Province (Nolan, 1943, pp. 142).

The principal areas of concentration are Spring Mountains and Pahrump Valley, Nevada, covering approximately 1700 square miles, or three quarters of the total area.

The largest basin, Pahrump Valley, totals approximately 400 square miles and extends across the California-Nevada border; that portion of the basin which extends into California includes an area of about 150 square miles and is located in the southeast corner of Inyo County. The remaining areas are within Clark and Nye Counties, Nevada.

CLIMATE

The areas included in this report display a wide range of temperature and precipitation. Climatically, the valleys are considered arid with less than 10 inches of rainfall annually. The mountainous areas are much more temperate and the annual precipitation may exceed 20 inches (Malmberg, 1961, pp. 4).
Figure 1

Nahrop Valley, in typical of many of the large playa lakes. The southern portion of the valley splits westward into two of the playa lakes, one of which is Stewart Lake. This lake is the lowest point in the valley with an elevation of 2,487 feet. The southern part drains towards the playas at the base of the eastern slope of the Nopah Range, about 10 miles southwest of the Nye Ranch. The valley has an average elevation of 3,000 feet (all elevations are with respect to mean sea level).

California and Chicago Valleys have an average elevation of 2,600 and 2,300 feet, respectively. Drainage from California Valley is to the west and joins the southerly directed drainage of Chicago Valley in the vicinity of Tecopa. Tecopa, California, is at an elevation of 2,000 feet. California Valley is separated from the southern portion of Nahrop Valley by very slight change in topography between Nopah and Kingston Ranges.

From the typical intermittent valley of the Basin and Range that they are not topographically shown. All areas shown are correspondently to the Amargosa River.
PHYSIOGRAPHIC FEATURES

Pahrump Valley is typical of Basin and Range topography in that it is internally drained and exhibits three large playa lakes. The northern portion of the valley drains westward into two of the playas, one of which is Stewart Lake. This lake is the lowest point in the valley with an elevation of 2457 feet. The southern part drains towards the playa at the base of the eastern slope of the Nopah Range, about 12 miles southwest of the Manse Ranch. The valley has an average elevation of 3000 feet (all elevations are with respect to mean sea level).

California and Chicago Valleys have an average elevation of 2600 and 2300 feet, respectively. Drainage from California Valley is to the west and joins the southerly directed drainage of Chicago Valley in the vicinity of Tecopa Pass, California, at an elevation of 2000 feet. California Valley is separated from the southern portion of Pahrump Valley, by a very slight change in topographic relief between Nopah and Kingston Ranges.

Ash Meadows, Chicago, and California Valleys, differ from the typical intermontane valleys of the Basin and Range Province, in that they are not topographically closed. All three drain intermittently to the Amargosa River.
With few exceptions, all surface drainage is intermittent with water running only during the infrequent, and short lived, violent storms. Even the large springs only flow for very short distances before the water infiltrates the alluvium or is lost to evaporation.

Each of the valleys is composed of two locally defined unified geomorphic provinces: the alluvial apron and the basin lowlands (Maxey and Jameson, 1948, pp. 26). The alluvial apron borders the steeper and more pronounced mountains, but is less distinct where it interfingers with the relief of the basin lowlands. The alluvium is easily distinguished from the deposits of the lower valley in that it is made up of poorly sorted gravels, sand, silt, clay, and caliche. In many places the valleys feature a coalescing of the piedmonts, thus eliminating the basin lowland.

Because of the lack of vegetation on the alluvial apron, deposition is basically in the basin lowlands. The aprons display a high degree of dissection. According to Maxey and Jameson (1948, pp. 57-58) the alluvial sediments of these slopes are late Tertiary and Quaternary, Pliocene (?), and Pleistocene (?).
In Ash Meadows the playa lakes occupying the basin lowlands are presently being eroded (Walker and Eakin, 1963, pp. 5) and any current deposition is in the Amargosa River basin.

Eolian deposits, chiefly sand dunes and spring mounds, may also be found in the basin lowlands. The spring mounds indicate an area of spring emission where a concentration of vegetation occurs thereby aiding the accumulation of loess. Spring mounds are prominent in the vicinities of Twelve Mile Springs (Chicago Valley), and Mound and Bennett's Springs (Pahrump Valley).

The mountains bordering each of the valleys have considerably greater relief than the adjacent alluvial deposits and in the case of Mt. Charleston (Spring Mountains) rises to an elevation of 11,910 feet. Spring Mountains trend in a northwesterly direction, except in the northernmost portion where they swing westward, separating the Pahrump Valley from Ash Meadows.

Spring Mountains exhibit a series of canyons, most of which are filled by alluvium and are a result of structural displacements. They are: Wheeler, Walker, Lovell and Trout Canyons on Pahrump Valley side, and Kyle, Lee, La Madre, Red Rock, Deer Creek Canyons on the Las Vegas side of Spring
Mountains. Mountain Springs Pass connects the two valleys. Comparatively, the Nopah Range does not have the deep structural canyons that are present in Spring Mountains. The Nopah Range has an asymmetric profile and parallels the trend of Spring Mountains.

Spring Mountains, Nopah, Resting Springs, and Kingston Ranges are all composed of Precambrian (?) sediments and meta-sediments, Paleozoic metasediments and non-clastics, and in the southern portion of Spring Mountains, Mesozoic clastics and non-clastics crop out. (Hazzard, Hewett, Longwell, Nolan, in Maxey and Jameson, 1948, pp. 43)

VEGETATION

Most of the information included herein concerning the general occurrence, description, and locations of arid vegetation, especially the phreatophytes, is taken from reports by T. W. Robinson (1958), W. White (1932), O. E. Meinzer (1927), G. B. Maxey and C. H. Jameson (1948), C. H. Lee (1912), and G. E. Walker and T. E. Eakin (1963). Each of these articles may be referred to for a more detailed description of the individual types of flora. The information taken from these articles has been used in relation to specific springs at or near which that plant was observed, and its significance to the determination of that spring's possible origin.
The vegetation ranges from the characteristic desert plants, mesquite and sagebrush, to the higher elevation and colder climate vegetation, such as pines.

Creosote bush, saltbrush, arrowweed, picklewood, saltgrass, greasewood, rabbit-brush, sacaton, are all characteristic of the lower areas and grade into joshua tree, blackbrush and spanish bayonet. The higher elevations display juniper, white fir, and the pines: Piñon and Ponderosa.

Cottonwood and willow trees occurred in a wide range of elevations. Grapevines and aspens also are found to have a wide range of growth.

In areas of domestic cultivation, crops are raised. They are mostly cotton, alfalfa, and various cash crops.
Phreatophytes

Phreatophytes are a type of vegetation whose roots extend down to zones of capillarity and saturation. Because phreatophytes require water in order to survive, they can be used as an indicator of near surface water supply, possible shallow ground water flow, and areas where the capillary zone is near enough to the surface to sustain discharge. The depth of root growth is usually not more than 15 feet. Fourwing saltbrush is an excellent example of such a phreatophyte (*Atripex canescens*). Desert willow (*Chilopsis linearis*) and big greasewood (*Sarcobatus vermiculatus*) (Robinson, 1958, pp. 32-40) have roots extending down to depth of 60 ft.

Phreatophytes are very useful in locating springs and in determining such features as: effluent seepage and associated evaporation, contacts of the less permeable with the more transmissive stratigraphic units (ex. the clay-alluvium contacts of the lower valleys), areas where direction of drainage in the alluvium may have been in previous periods of erosion (since later deposition in these areas of erosion would be more coarse and thereby an avenue of important shallow ground water flow and possibly a cause for spring locations).
Density of phreatophytic growth assists in determination of near surface water and direction of flow. The calculation of the amounts of water wasted by the plants is also a function of density. According to Robinson (1958, pp. 3-7)

"The yearly use of water by phreatophytes ranges from a few tenths of an acre foot per acre to more than 7 acre feet per acre."

In the study of the Ash Meadows area, Nevada, Walker and Eakin (1963, pp. 21-24) estimated that mesquite, saltgrass, rabbit brush, meadow grass, willow and saltcedar, transpired 11500 acre feet of ground water annually for an area of 6200 acres.

The most common phreatophytes encountered in the area were the saltcedar (Tamarix gallica and T. aphylla), mesquite (Prosopis juliflora, P. velutina and P. pubescens), saltgrass (Distichlis stricta), rabbit brush (Chrysothamnus nauseasus gravelolens), pickleweed (Allenrolfea occidentalis), greasewood (Sarcobatus vermiculatus), saltbush (Atriplex lentiformis), arrowweed (Pluchea sericea), reedgrass (Phragmites communis), quaking aspens (Populus gremuloides aurea), and willows (Salix).
Of the phreatophytes most commonly observed, the two most frequent and useful were saltgrass and mesquite. Saltgrass, having a root depth of much less than 8 feet and nearly always in the zone of saturation (Shantz and Piemeisel, 1940, pp. 37), is observed at many of the springs where the near-surface soil is saturated by infiltration of spring water or where the water table is believed to be at the surface. According to Robinson, 1958, pp. 56:

"In much of the area of saltgrass growth, the capillary fringe extends to the land surface so that ground water evaporates directly from the soil."

Twelve Mile Spring, Lost Cabin Springs, Horse Thief Springs, Gold Spring, Cottonwood Spring, the 'spring line' and nearly all springs in Ash Meadows, display an abundance of this particular phreatophyte.

The other phreatophyte most frequently encountered is mesquite. This transpiring plant is observed over a wide range of elevation. As a result it is useful in evaluation of shallow and saturated ground water flow. In the lower areas, Stewart Lake and Chicago Valley, mesquite grows abundantly and possibly indicates areas of ground water discharge. Elsewhere, mesquite flourishes on the alluvial fans and in the high canyons where deposition of sediments produced an aquifer for drainage of the higher and intermediate elevations. In the
areas of Red Rock Canyon and Blue Diamond the water supply derived from two wells drilled at a location of dense mesquite growth on the alluvium (especially the Blue Diamond wells), has implied that this plant, when used with caution, can be a valuable aid in determining areas of alluvial drainage. It is believed that with careful aerial studies of this phreatophyte and others associated with it, pickleweed, rabbit-brush, and greasewood, could supply valuable assistance in determination in previous surface drainage in alluvium.

Mesquite flourishes along the clay-alluvium contacts in the Pahrump Valley where water is flowing in a shallow perched drainage.

Individual spring descriptions (appendix, pp. 48) list those plants common to each of the springs and their relationship to that spring.
The regional geology compiled for this report and the geologic map (in folder), are a result of previous surveys. The geology related directly to the area immediately surrounding and fixing the position of the springs as presented in the appendix, is original.

Throughout the area investigated numerous geologic formations ranging in age from PreCambrian to Recent and of varied lithology can be recognized (figure 3). In addition to the analysis of the complicated structural history, the geology has been investigated with respect to the hydrology or transmissive characters of the formation units and associated structure.

**Aquifers**

The principal aquifers of the region are the Paleozoic carbonate formations and the Quaternary-Tertiary valley fill. The carbonates and valley fill have the largest distribution in both aerial and subsurface extent. The valley fill is the primary geologic unit used in the Las Vegas and Pahrump Valleys for water supply. According to Winograd (1963, pp. 207) the transmissibility
of the valley fill ranges from 200-310,000 gallons per day per foot, with a median value of 4000 gallons per day per foot. The large variation in transmissive values results from the extreme diversity of stratification produced by admixtures of clay, gravels, sands, and silts; this interfingerling and lithologic differentiation is the result of several episodes of faulting and volcanism, which in turn gave way to erosion of assorted bedrock types, and created a wide vertical and horizontal fluctuation in transmissibility. The figures for specific capacity, 5-100 gallons per day per foot of drawdown, as reported by Winograd (1964, pp. 207), would further verify this.

Many of the springs discharge as a result of interstratification of the clays and gravels, as for example, those issuing from the shallow alluvial gravels overlying the lake bed clays along lower Pahrump Valley. Stump, Brown, and those unnamed springs of the same locale, are of this type. Twelve Mile, Mound, Resting Spring, Valley, and some Ash Meadows Springs are also in part related to this type of contact, although it is strongly believed that their discharge results from association
Figure 2 - Geologic sections of Nopah and Resting Springs Ranges, California, and Spring Mountains, Nevada, showing approximate thicknesses, type of rocks, and geologic ages of the various formations.
with faulting. The contact springs have a very small discharge, whereas the contact-structure springs have a relatively large discharge.

Several wells were examined in the mountain areas, Kyle and Lee Canyons, but these wells were shallow and did not extend into the underlying carbonate rocks. The underlying Paleozoic carbonates are next in importance to the Quaternary-Tertiary valley fill as aquifers. These non-clastics are massive and highly fractured. The Kaibab limestone is more massive and less permeable. The Bird Spring, Monte Cristo, Sultan limestones, Devils Gate, Ely Springs dolomite, Nevada formation, and undifferentiated Silurian carbonates, are the more permeable due to fractures, which in turn produced some prominent solution cavities.

Pumping tests at the Nevada Test Site in nine wells north of the area investigated have supplied hydrologic data relating to the Paleozoic carbonates. The apparent transmissibility was determined at a median value of about 10,000 gallons per day per foot. The coefficient of storage for the carbonates was determined not by pumping
tests, but by "examination of outcrops, cores, and preliminary interpretation of geophysical logs" (Winograd, 1963, pp. 206). This method suggested a range of about 0.01 to 0.03 for water table conditions and 0.1 to 0.2 for valley fill.

In addition to the valley fill and Paleozoic carbonates, Tertiary ignimbrites and undifferentiated clastic deposits may be considered as aquifers. But because of their limited aerial extent, they are not considered as primary aquifers.

Winograd (1963, pp. 208) reports that five wells have supplied data on the welded tuffs. The transmissibility figures are in the range of 280-120,000 gallons per day per foot with a median of 3700 gallons per day per foot. These values are based primarily on fractures, and not interstices.

No values have been obtained for the Aztec sandstone since this formation is void of wells, but "interstitial permeability of these rocks may be as high as 0.5 to 2.0 gallons per day per square foot". (Winograd, 1963, pp. 208)

**Aquitards**

Those units found in the area which have relatively insignificant permeability are: PreCambrian (?) - Cambrian crystalline rocks, Johnnie formation and Stirling quartzite,
lower and upper Paleozoic clastic, which includes the Wood Canyon, Carrara and Supai formations. As mentioned previously, the upper Paleozoic nonclastic unit, Kaibab limestone, may also be considered as an aquitard. Although these units have low transmissive values, they may be very significant in regional movement of ground water. Because under conditions of differential head, these rocks may transmit relatively large quantities of water.

The Mesozoic clastic sequences which may be of little value as water bearing units are the Moenkopi, Shinarump, and Chinle formations. No well evidence has supported this, but these clastics are generally impermeable and too well consolidated to act as aquifers (Maxey and Jameson, 1948, pp. 39).

Those units of the Cenozoic which may be considered as aquitards are the lake beds, playa deposits, welded tuffs, and volcanic extrusives occurring throughout the area, principally in the southwest. These volcanics range in composition from basalts through andesites. Mesozoic granitic intrusives are also present.

*For a more complete presentation of the stratigraphy, geology and structural history of the area briefly covered here, refer to:


The concept of an ideal groundwater system was developed by LeRoy (1940) and more recently by Folk (1948, 1961). It has been found that certain data in this area is applicable to such a system.

The essential components of the system are the boundaries, which are defined by hydrologic, geologic, geomorphic, and climatic controls. These limits consist of a recharge area, or topographic high, under which groundwater discharge normally occurs; the water table; primarily a zone of relatively impermeable rock which acts to impede flow along the lower part of the system; and the discharge areas which occur in the topographic low.

Components to the recharge and discharge areas is a system of lateral flow where groundwater seepages between recharge or discharge potential.

Diagramming thin concepts, in mountainous areas where precipitation is high enough to constitute recharge, water infiltrates and enters the system. Responding to this continuous replenishment, water moves downward and eventually to the area of discharge. Recharge potential
General

The concept of an ideal ground-water system was developed by Hubbert (1940) and more recently by Toth (1962, 1963). It has been found that certain data in this area is applicable to such a system.

The essential components of the system are the boundaries, which are defined by hydrologic, geologic, physiographic, and climatic controls. These limits consist of a recharge area, or topographic high, under which a ground-water divide normally occurs; the water table; possibly a zone of relatively impermeable rock which acts to impede flow along the lower part of the system; and the discharge areas which occur in the topographic lows. Intermediate to the recharge and discharge areas is a region of lateral flow where ground-water demonstrates neither recharge or discharge potential.

Diagramming this concept, in mountainous areas where precipitation is high enough to constitute recharge, water infiltrates and enters the system. Responding to this continuous replenishment, water moves downward and laterally to the area of discharge. Because potential
energy is required for ground-water movement beneath the ground-water table, there is a constant loss of potential with depth in the recharge area and the equipotential lines assume an almost horizontal configuration.

When potential lines assume an almost vertical configuration, the resulting flow lines, which are drawn perpendicular to potential lines, are horizontal and remain so over relatively large areas. In this area of lateral flow, the potential is constant with depth. In the discharge zone, the flow lines curve upward and approach vertical positions. The potential lines thereby become nearly horizontal and increase in potential with depth.

The foregoing discussion describes a regional system of ground-water flow in the zone of saturation. Due to the nature of this system, it is characterized by large drainage areas which encompass several basins, long flow paths and accordingly regional boundary conditions. Another system common to arid zones is local flow. This system involves waters that have been controlled largely by lithologic and structural boundaries which have prevented downward movement to the water table. According to Maxey and Mifflin (in press), local ground-water systems are characterized by:
1. "Small drainage areas and relatively short paths of flow.

2. Boundary controls consisting of local lithologic, tectonic, and topographic features.

3. Spring discharge points with waters of relatively low temperature that often fluctuate considerably and with discharges that vary broadly both seasonally and even with local storms.

4. Many involve little or no interbasin transfer of ground-water.

5. They may or may not be a part of a larger regional system, that is, they do not necessarily contribute water to a system where water motion may encompass a broad area."  

Chemically, the waters derived from the two systems differ in total dissolved solids, temperature, and often volume of flow. The regional system has a high concentration in contrast to the local system. Also, temperatures of the regional system will be high and fluctuate very little, whereas temperatures of the local system will fluctuate with respect to fluctuating air temperatures.

The Regional Ground-water System in Area Studied

Topography is a significant control on the regional ground-water system. The Spring Mountains attain elevations in excess of 11,000 feet and are known to receive 20 or more inches of rainfall annually.
That this lofty range is a recharge area is indicated by its contrasting topography and by well drilling attempts. Static levels measured in wells (e.g. Boy Scout well, 23S/58 - 4) have shown decreasing potential with depth. As indicated by the earlier discussion of the regional flow system, there is a decreasing potential in recharge areas and loss of head with depth is characteristic (Toth, 1963, pp. 4810).

Discharge areas within this system are the topographic lows at Ash Meadows, Tecopa Springs area, and Pahrump Valley.

In Pahrump Valley several large springs indicate the discharge area. Bennetts and Manse Ranch Springs (refer to spring index, appendix) have a total discharge of approximately 3,000 gallons per minute. These springs are known to have very little fluctuation and demonstrate water temperatures of about 75°F. Numerous wells indicate that ground-water levels in this area are near the surface. Further evidence of discharge is indicated by dense phreatophytes and large areas of spring mounds.

Tecopa Springs area is located at the lowest topographic position within this system. Water levels in this area are at or above the surface in numerous wells and
the Amargosa River exhibits intermittent flow as a result of near surface saturation. This is also an area of multiple types of large water using phreatophytes. Tecopa Spring is only one of a cluster of constant and relatively large discharging springs. The temperature of Tecopa Spring is in the range of 108°F.

In this regional system of varying ground-water potential, from mountainous areas to the topographic lows, regional systems can be mixed where waters moving from a single recharge area can have one or more sites of discharge. Likewise, an area of discharge can have multiple recharge areas. Ash Meadows is a topographically low area of very high discharge. Numerous springs in this locale discharge individually in the range of 50 to 2824 gallons per minute (Crystal Spring). Phreatophytes in this area are also very dense and constitute a large total consumptive use. Ash Meadows is a discharge area which probably receives recharge from several sources. It has been demonstrated that the range of mountains separating Pahrump Valley from Ash Meadows is principally a highly fractured and relatively impermeable quartzite. The Bonanza King, a highly cavernous limestone, also exists in this section. If water does
move into Ash Meadows from Pahrump Valley and the Spring Mountains, it would have to do so by either moving along the Bonanza King formation and using this unit as a sort of intra-valley conduit, or by forcing water along the fractures in the quartzite. A favorable head differential exists so that flow from Pahrump Valley to Ash Meadows could occur.

It has been estimated (Maxey and Jameson, 1948, pp. 117) that the Spring Mountains serves to recharge approximately 23,000 acre feet annually to the Pahrump Valley system. Malmberg (in press) has estimated that discharge in Pahrump Valley is in the range of 10,000 acre feet. Considering the relative volume of spring discharge and potential evapotranspiration at Tecopa and along the Amargosa River drainage, an equivalent 10,000 acre feet could be reasonably estimated for discharge from this area. This totals some 20,000 acre feet of discharge which leaves 3,000 acre feet for discharge in Ash Meadows. Walker and Eakin (1963, pp. 27) estimated 20,000 acre feet of total discharge in the Ash Meadows area, most of which, then, must be derived from sources other than Pahrump Valley.

In conclusion, Ash Meadows derives a small amount of water from the Spring Mountain recharge and has
Figure 3.

TOTAL DISSOLVED SOLIDS (TDS)

DISTANCE (miles)

Cl\(^{-}\) + SO\(_4^{2-}\) (ppm)

1. ROGERS SPRING (175/50-15)
2. DEVIL'S HOLE NAT'L MONT. (175/50-35)
3. POINT OF ROCKS SPRINGS (185/51-7)
4. BIG SPRING (185/51-19)
5. TECOPA HOT SPRING (205/57-33)
6. MANSE RANCH SPRINGS (215/54-3)
7. WHISKEY AND MACPHERSON SPRING (185/56-13)
8. STANLEY B SPRING (195/56-25)
9. SIX MILE SPRING (205/52-1)
10. WELL (195/57-31)
11. SPRING (195/56-36)
12. INTERMITTENT SPRING (205/56-31)
as its primary source the large drainage system to the
north and northeast.

Discussion of water quality has been postponed
in this report until now so as to give a final element of
supporting data to the regional flow system, in contrast
to the local system. Maxey and Mifflin (in press) have
demonstrated that an analysis of spring water could indicate
the position within the system and the kind of system in
which a spring occurs. First, the position of the spring
in the system is determined with respect to geology,
topographic location, and other data that might delineate
the system.

Since concentration of ions increase with
distance of ground-water flow in a carbonate terrane, a
plot of distance to anions, and total dissolved solids,
(refer to figure 3) indicates support of such an hypothesis.
It is to be noted that springs in Pahrump Valley and Ash
Meadows fall in the middle of the graph, Tecopa springs at
a much higher level, and those springs believed to be
entirely local, at the base of the graph. Plotting tem­
peratures for similar springs would also indicate the same
distribution. Local springs have temperatures in the range
of 40° to 60°F, and regional springs such as Ash Meadows and
The Local Ground-water Systems in Area Studied

As outlined earlier, a local ground-water system has several distinct characteristics: small drainage areas and relatively short flow paths; boundary conditions which are principally lithologic, structural and topographic; and distinct temperature, chemical and discharge properties.

This localized flow system has been demonstrated by spring studies of the area studied. The following discussion of springs indicates that nearly all springs in this area are of the local type.

The majority of the springs were localized as a result of a combination of factors, with the exception of the cavernous springs whose large discharge and distinct orifice character made possible a definite control. The Bryan's tubular springs (refer to Kirk's classification of springs, appendix) were always found to be in highly fractured carbonate host rocks, where large to small cavities were able to form as a result of solution of limestone due to ground-water movement along fractures. Exposure of the
orifices were made possible by either folding, assisted by erosion, or by faulting, leaving the portal at the surface. Trout, Lee, and Willow springs are examples of this type of occurrence.

The extent of this type of solution channel may be in some cases intra-valley. Examples of this are: Lee and Trout Springs, and as mentioned previously, the possibility of a hydraulic connection of Six Mile Spring and the Ash Meadows spring line, via the Bonanza King formation. On the same approximate scale of occurrence are those classified as fault dam springs. Although smaller in discharge, these springs are far more abundant. Geological evidence indicates that the faults are usually perpendicular to the gradient of ground-water flow and have a permeability value that is much less than the displaced rocks, thereby 'damming' or elevation the potentiometric surface so that any additional topographic or geologic irregularities would result in surface discharge. Excellent examples of this are Grapevine, Crystal, and Horseshutem Springs, Coal Spring, Buck and Rosebud Springs (refer to spring index). At each of these springs small
to large erosional draws have cut into the fault plane and thereby exposed the elevated or 'perched' water table mound.

This same erosional draw concept of spring discharge occurs where an impermeable strata underlies a more transmissive unit, the impermeable strata usually dipping into the mountain, or essentially away from the direction of ground-water flow. This is illustrated by Rock, C. C., Cane, Mule, and many other springs (refer to page index of springs, appendix).

Springs located along the sandstone bluffs and in the vicinity of Blue Diamond, and Red Rock have, as their mode of occurrence, the same erosional intersection principle outline above. Refer to Willow Spring for additional explanation, page 78, appendix.

Girl Scout Spring is a perfect example of the high elevation exposure of a well jointed, gently dipping limestone that is underlain by a less fractured, impermeable unit. In this case, the water issues from a series of joints and is localized by the impervious unit. This type of spring is usually found to have no single site of discharge and relatively small in the same respect. Due
to its shallow nature, this class of spring dries up rapidly during seasons of little runoff, as in the case of the falls in Kyle Canyon (see Little, Mary Jane, and Big Falls, spring index, appendix).

This same principle of an underlying impermeable unit, with an overlying or interbedded highly pervious strata, or better named, a 'contact spring', is common to the lower valleys. Here the interfingering of the valley fill, clay and alluvial gravels, give rise to issuing water where the clays have an irregular contour and results in shallow ponding of ground-water and overflows where it is laterally exposed. Tule Spring (Pahrump Valley) diagrammatically illustrates this principle.

In several instances, this form was coupled with a contact of an additional impervious unit, which in turn deflected ground-water movement and cause further saturation of the more permeable unit (refer to Resting Spring, pp. 49, diagrammed).
RECOMMENDATIONS

Since this is a pilot study in spring evaluation as a means of determining ground-water conditions in mountainous areas, it is recommended that further data be obtained on seasonal spring discharge and precipitation. This data would then supply comparative hydrographs from which possible interpretations of spring fluctuations could be made.

It is also recommended that additional work be undertaken to determine the extent of interbasin movement of ground-water. This could be accomplished through deep drilling and/or geophysical investigations.

WELL AND SPRING DESIGNATION

Wells and springs are located according to the standard method used by the U. S. Geological Survey. For example: 20S/18 - 23aad indicates Township 20 South, Range 18 East, section 23, SE% of NE% of NE%.

Explanation of spring data abbreviations are: Sp. Cond. and Q, are specific conductance and discharge, respectively.
KEY TO CLASSIFICATION OF SPRINGS

after Bryan, 1919

1. Springs due to deep-seated waters, juvenile and connate, admixed with deeper meteoric water, does not flow under hydrostatic head and is not subject to seasonal fluctuation.

A. Voleanic Springs. Associated with volcanism or volcanic rocks; water normally hot, highly mineralized and containing gases. Springs from geyser vents into surface of nearest water body those due to other causes.

B. Fissure Springs. Due to fractures extending into deeper parts of the crust; water usually highly mineralized and commonly warm or hot.

1. Fault Springs. Associated with recent faults or great magnitude.

2. Fissural Springs. No direct structural evidence as to origin, but because of temperature and steady flow believed to have deep origin.

II. Springs due to incipient and occasionally active moving under hydrostatic head; illustrates with rainfall.

A. Depression Springs. Due to land surface cutting water table in porous rocks.

1. Dimple Springs. Due to depressions in hillside.

2. Valley Springs. Due to abrupt change in slope at edge of flood plain.

3. Channel Springs. Due to depressions in flood plain or alluvial plain caused by channel cutting of streams.
KEY TO CLASSIFICATION OF SPRINGS

after Bryan, 1919

I. Springs due to deep-seated waters, juvenile and connate, admixed with deeper meteoric water; does not flow under hydrostatic head and is not subject to seasonal fluctuation.

A. Volcanic Springs. Associated with volcanism or volcanic rocks; water commonly hot, highly mineralized and containing gases. Grades from gas vents into springs of normal temperature indistinguishable from those due to other causes.

B. Fissure Springs. Due to fractures extending into deeper parts of the crust; water usually highly mineralized and commonly warm or hot.

1. Fault Springs. Associated with recent faults of great magnitude.

2. Fissure Springs. No direct structural evidence as to origin, but because of temperature and steady flow believed to have deep origin.

II. Springs due to meteoric and occasionally others moving under hydrostatic head; fluctuates with rainfall.

A. Depression Springs. Due to land surface cutting water table in porous rocks.

1. Dimple Springs. Due to depressions in hillsides.

2. Valley Springs. Due to abrupt change in slope at edge of flood plain.

3. Channel Springs. Due to depressions in flood plains or alluvial plains caused by channel cutting of stream.
4. Border Springs. Due to change in slope at border between alluvial plains and playas, lake beds, or river bottoms; relative impermeability of central clay deposits assists flow.

B. Contact Springs. Due to porous rock overlying impervious rock.

1. Impervious rock has a horizontal and regular surface.
   a) Underlying bed is of large extent; common in consolidated sedimentary rock.
      1) Gravity Springs. Overlying material is soft.
      2) Mesa Springs. The overlying material is hard, usually sandstone or lava flow; water contained in pores and joints of the rock.
   b) Underlying bed is of small extent; common in unconsolidated alluvium; impervious bed is usually clay, cemented gravel, "mortar bed", caliche, or hardpan.
      1) Hardpan Springs

2. Impervious bed has an inclined and regular surface; all springs on the low side unless the overlying bed is very thick and the dip low.
   a) Underlying bed is of large extent.
      1) Inclined Gravity Springs. The overlying material is soft.
      2) Questa Springs. The overlying material is hard; of some character as Mesa Springs.
b) Underlying bed is of small extent; as in Hardpan Springs.

1) Impervious layer dips away from hill; spring possible.
2) Impervious layer dips into hill; spring possible only in ravines.

3. Impervious bed has irregular surface.

a) Overlying porous material is thick and of wide extent; contact is unconformable. Gravity, Inclined Gravity, Mesa, and Cuesta Springs may occur, but springs will be sharply localized at lowest parts of contact.

b) Pocket Springs. Overlying porous material is unconsolidated and more or less discontinuous, residual soil, talus, landslide debris, alluvium, till, stratified drift, wind-blown sand, or volcanic ash.

c) Overflow Springs. Irregular floor is not continuous, but porous bed is saturated and overflows at lateral contacts; common at receiving end of artesian systems.

d) Rock Dam Springs. Irregularities of the rock floor under an alluvial plain force the water to the surface; these may be projections of partly consolidated older alluvium, igneous dikes, or volcanic plugs.

e) Fault Dam Springs. Damming of ground water by faulting.

C. Artesian Springs. Due to pervious bed between impervious materials.

1. Fracture Artesian Springs. All the conditions
above, except that lower end of porous bed does not crop out but an opening allows water to escape.

D. Springs in Impervious Rock.

1. Tubular Springs. Due to more or less rounded channels in impervious rocks.
   a) Solution Tubular or Cavern Springs. Due to solution channels in limestones, calcareous sandstones, gypsum, and/or salt.
   b) Lava Tubular Springs. Due to caverns and tunnels in lava flows.
   c) Minor Tubular Springs. Due to channels made by movement of water, decay of tree roots, sand streaks, or shrinkage cracks, usually in unconsolidated sediments.

2. Fracture Springs. Due to fractures consisting of joints, openings due to cleavage, fissility, schistosity, cross-bedding planes, and faults in impervious sedimentary, igneous, and metamorphic rocks.

3. Siphon Springs. (refer to page 38)
<table>
<thead>
<tr>
<th>Name</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feuille miller Springs</td>
<td>65</td>
</tr>
<tr>
<td>Belling Spring</td>
<td>49</td>
</tr>
<tr>
<td>Tallie Spring</td>
<td>59</td>
</tr>
<tr>
<td>Neck Spring</td>
<td>91</td>
</tr>
<tr>
<td>Ribbon and Rosewood Springs</td>
<td>52</td>
</tr>
<tr>
<td>Wine Spring</td>
<td>72</td>
</tr>
<tr>
<td>Shay Spring</td>
<td>92</td>
</tr>
<tr>
<td>Ford Spring</td>
<td>30</td>
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<tr>
<td>Poule Spring</td>
<td>53</td>
</tr>
<tr>
<td>Boxesley Spring</td>
<td>54</td>
</tr>
<tr>
<td>Rosect and Rainbow Springs</td>
<td>56</td>
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<td>56</td>
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<td>Coal Spring</td>
<td>56</td>
</tr>
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<td>Cave Spring</td>
<td>56</td>
</tr>
<tr>
<td>Bookleggs Whitey</td>
<td>57</td>
</tr>
<tr>
<td>Cephal Spring</td>
<td>57</td>
</tr>
<tr>
<td>Vignon and St. Margaret Springs</td>
<td>57</td>
</tr>
<tr>
<td>Hill Castle Springs</td>
<td>57</td>
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<td>Hopkins Spring</td>
<td>57</td>
</tr>
<tr>
<td>Hay Spring</td>
<td>57</td>
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<tr>
<td>Newtontown Spring</td>
<td>57</td>
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<td>E. Han Springs</td>
<td>57</td>
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<td>57</td>
</tr>
</tbody>
</table>

**SPRING DESCRIPTIONS AND INDEX**
<table>
<thead>
<tr>
<th>Name</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twelve Mile Springs</td>
<td>48</td>
</tr>
<tr>
<td>Resting Spring</td>
<td>49</td>
</tr>
<tr>
<td>Tule Spring</td>
<td>50</td>
</tr>
<tr>
<td>Buck Spring</td>
<td>51</td>
</tr>
<tr>
<td>Pinon and Rosebud Springs</td>
<td>51</td>
</tr>
<tr>
<td>Mule Spring</td>
<td>52</td>
</tr>
<tr>
<td>Klup Spring</td>
<td>52</td>
</tr>
<tr>
<td>Ford Spring</td>
<td>53</td>
</tr>
<tr>
<td>Trout Spring</td>
<td>53</td>
</tr>
<tr>
<td>Bootleg and Rainbow Spring</td>
<td>54</td>
</tr>
<tr>
<td>Lost Cabin Spring</td>
<td>55</td>
</tr>
<tr>
<td>Coal Spring</td>
<td>56</td>
</tr>
<tr>
<td>Cave Spring</td>
<td>56</td>
</tr>
<tr>
<td>Bootlegger Spring</td>
<td>57</td>
</tr>
<tr>
<td>Crystal Spring</td>
<td>57</td>
</tr>
<tr>
<td>Horseshutem Spring</td>
<td>59</td>
</tr>
<tr>
<td>Bill Smith Springs</td>
<td>59</td>
</tr>
<tr>
<td>Grapevine Springs</td>
<td>60</td>
</tr>
<tr>
<td>Kwichup Spring</td>
<td>61</td>
</tr>
<tr>
<td>C C Spring</td>
<td>61</td>
</tr>
<tr>
<td>Lower Center Spring</td>
<td>61</td>
</tr>
<tr>
<td>Jody Spring</td>
<td>62</td>
</tr>
<tr>
<td>The Narrows Springs</td>
<td>62</td>
</tr>
<tr>
<td>Switchback Springs</td>
<td>63</td>
</tr>
<tr>
<td>La Madre Springs</td>
<td>63</td>
</tr>
<tr>
<td>Sheep Springs</td>
<td>64</td>
</tr>
<tr>
<td>East Spring</td>
<td>64</td>
</tr>
<tr>
<td>Claybank Spring</td>
<td>64</td>
</tr>
<tr>
<td>Wheeler Well and Spring</td>
<td>64</td>
</tr>
<tr>
<td>Trough Spring</td>
<td>65</td>
</tr>
<tr>
<td>Clark Springs</td>
<td>65</td>
</tr>
<tr>
<td>Cane Springs</td>
<td>66</td>
</tr>
<tr>
<td>Lee Springs</td>
<td>66</td>
</tr>
<tr>
<td>Spring (Hidden Hills Ranch)</td>
<td>67</td>
</tr>
<tr>
<td>Stump Spring</td>
<td>67</td>
</tr>
<tr>
<td>Browns Spring</td>
<td>68</td>
</tr>
<tr>
<td>Spring (no name)</td>
<td>68</td>
</tr>
<tr>
<td>Alma Spring</td>
<td>68</td>
</tr>
<tr>
<td>Mound Spring</td>
<td>68</td>
</tr>
<tr>
<td>Spring (no name)</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>Name</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>41</td>
<td>Bennetts Springs</td>
</tr>
<tr>
<td>42</td>
<td>Manse Ranch Springs</td>
</tr>
<tr>
<td>43</td>
<td>Six Mile Springs</td>
</tr>
<tr>
<td>44</td>
<td>Point of Rocks Springs</td>
</tr>
<tr>
<td>45</td>
<td>Jackrabbit Spring</td>
</tr>
<tr>
<td>46</td>
<td>Big Spring</td>
</tr>
<tr>
<td>47</td>
<td>Bole Spring</td>
</tr>
<tr>
<td>48</td>
<td>Spring (no name)</td>
</tr>
<tr>
<td>49</td>
<td>Last Chance Spring</td>
</tr>
<tr>
<td>50</td>
<td>Springs (no name)</td>
</tr>
<tr>
<td>51</td>
<td>Springs (no name)</td>
</tr>
<tr>
<td>52</td>
<td>Crystal Spring</td>
</tr>
<tr>
<td>53</td>
<td>Corky Spring</td>
</tr>
<tr>
<td>54</td>
<td>Button Springs</td>
</tr>
<tr>
<td>55</td>
<td>Springs (no name)</td>
</tr>
<tr>
<td>56</td>
<td>Parent Springs</td>
</tr>
<tr>
<td>57</td>
<td>Longstreet Spring</td>
</tr>
<tr>
<td>58</td>
<td>Rogers Spring</td>
</tr>
<tr>
<td>59</td>
<td>Bell-Soda Spring</td>
</tr>
<tr>
<td>60</td>
<td>Fairbanks Spring</td>
</tr>
<tr>
<td>61</td>
<td>Ash Tree Spring</td>
</tr>
<tr>
<td>62</td>
<td>Davis Ranch Springs</td>
</tr>
<tr>
<td>63</td>
<td>Willow Spring</td>
</tr>
<tr>
<td>64</td>
<td>Bird Spring</td>
</tr>
<tr>
<td>65</td>
<td>Cold Creek Spring</td>
</tr>
<tr>
<td>66</td>
<td>Whiskey Spring</td>
</tr>
<tr>
<td>67</td>
<td>MacFarland Spring</td>
</tr>
<tr>
<td>68</td>
<td>Mud Spring</td>
</tr>
<tr>
<td>69</td>
<td>West Rosebud</td>
</tr>
<tr>
<td>70</td>
<td>East Rosebud Spring</td>
</tr>
<tr>
<td>71</td>
<td>Jaybird Spring</td>
</tr>
<tr>
<td>72</td>
<td>Rock Spring</td>
</tr>
<tr>
<td>73</td>
<td>Gold Spring</td>
</tr>
<tr>
<td>74</td>
<td>Big Timber Spring</td>
</tr>
<tr>
<td>75</td>
<td>Girl Scout Spring</td>
</tr>
<tr>
<td>76</td>
<td>Spring (no name)</td>
</tr>
<tr>
<td>77</td>
<td>CCC Spring</td>
</tr>
<tr>
<td>78</td>
<td>Upper Macks Canyon Springs</td>
</tr>
<tr>
<td>79</td>
<td>Middle Macks Canyon Springs</td>
</tr>
<tr>
<td>80</td>
<td>Lower Macks Canyon Springs</td>
</tr>
<tr>
<td>81</td>
<td>Mofford Spring</td>
</tr>
<tr>
<td>82</td>
<td>McWilliams Springs</td>
</tr>
<tr>
<td>83</td>
<td>Cold Water Springs</td>
</tr>
<tr>
<td>84</td>
<td>Deer Creek Springs</td>
</tr>
<tr>
<td>85</td>
<td>Sawmill Spring</td>
</tr>
<tr>
<td>86</td>
<td>S. B. Spring</td>
</tr>
<tr>
<td>87</td>
<td>Mary Jane Falls</td>
</tr>
</tbody>
</table>
88. Big Falls ........................................ 89
89. Little Falls ...................................... 89
90. Stanley B Springs ............................... 90
91. Harris Springs .................................. 90
92. Prospect Springs ............................... 91
93. Spring (no name) .............................. 91
94. Cabin Springs .................................. 91
95. Grapevine Spring .............................. 91
96. Willow Spring .................................. 92
97. Spring (no name) .............................. 93
98. White Rock Spring ............................ 93
99. Pine Creek Spring ............................. 93
100. Oak Creek Spring ............................. 93
101. First Creek Spring ........................... 94
102. Sandstone Spring (Heart Spring) .......... 94
103. Bonnie Springs ............................... 94
104. Point Spring .................................. 95
105. Lone Willow Spring ........................... 95
106. Wheeler Camp Spring ......................... 95
107. Cottonwood Spring ........................... 96
108. Mormon Green Springs ....................... 96
109. Indian Springs ................................ 96
110. Mud Spring .................................... 96
111. Spring (no name) ............................. 97
112. Spring (no name) ............................. 97
113. Spring (no name) ............................. 97
114. Ash Creek Spring ............................. 97
115. Spring (no name) ............................. 98
116. Calico Spring ................................ 98
117. Red Spring ................................... 98
118. Mountain Springs ............................ 99
119. Tecopa Hot Springs ......................... 100
120. Beck Springs .................................. 100
121. Horse Thief Springs ......................... 100
122. Crystal Springs ............................... 100
Twelve Mile Springs (2)

22N/8 - 17bb and 22N/8 - 7da
Q = 0 gpm
Temp. = 74.5°

Located two water seeps in Chicago Valley, California - Nevada. Neither spring was flowing, although the second spring, located approximately N50E of the first, had standing, stagnant water.

Both springs are a result of seepage from an alluvial fan which overlies a white, impermeable, calcareous clay (lacustrine). The alluvium is made up of Cambrian-Devonian limestone derived from the Nopah Range to the east.

This is a contact spring, classified as II2bl.

Vegetation was relatively sparse throughout the valley, with the exception of the fan-clay contact zone and a series of dome-like structures which were throughly covered by mesquite. These forms are called spring mounds (surface seepage of water from artesian or any other media of natural discharge around which vegetation has grown and has acted as a collecting place for wind-blown sand). Several cottonwoods indicated the presence of the second spring.
Resting Spring

21N/8 - 31db
Q = 151.8 gpm
Temp. = 78.5°
Sp. Cond. = 860

The spring is discharging from a flat-lying formation of non-calcareous, interstratified clay and alluvium, and a contact of highly fractured and jointed Cambrian quartzite. The quartzite is well banded, varied colored and strikes N30W and dips 57-61°W.

This spring would be classified as IIC4, IIB3d.

The water is derived from the valley fill and forced to the surface by the quartzite as a result of damming, deflection of ground water flow, or terminal contact of an artesian bed with the impermeable quartzite. Anyone, or a combination of these have to be correct, since to the east of the spring and at a lower elevation, deep erosional cuts into the valley fill are dry.

Vegetation at the spring is mostly saltgrass, cattails, and cottonwoods. To the east, in the dry wash of the valley fill, mesquite is very dense.
Tule Spring

20N/9 - 18c
Q = 0.1 gpm
Temp. = 63°
Sp. Cond. = 840

This spring is very similar to Resting Spring in its geologic situation, with the exception of the quartzite not having the principal ground water movement control. The main drainage is to the south and not into the quartzite outcropping to the west of this spring.

Nearby, the quartzite may slightly deflect water in the alluvium and clay, and cause confinement and thereby increase the volume in a small area, which in turn would give rise to saturation of a shallow system and discharge in the form of a spring.

Classified IIB3b. Refer to diagram for explanation.

The valley fill is typically the interstratified, white, calcareous, clay and gravel. This gravel was observed in several shallow, hand dug wells to the east, as being caliche.

Tule Spring is most likely a result of such a condition of clay acting as an impermeable boundary to downward circulation of recharge and the water thereby moving through the coarser material to an area of surface exposure of the lower portion of the clay.

Diagram 3
Buck Spring

18S/53 - 35cb
Q = 2.3 gpm
Temp. = 49.5°
Sp. Cond. = 640

This spring and two others, Rosebud and Pinon, occur in a dry creek bed. Along this dry wash, the lithology is primarily a dark gray, highly brecciated, dolomitic limestone, dipping 35°N and striking nearly E-W. This unit is believed to be part of the Bird Spring formation. On the west side of the wash, there is a light brown limestone with interbeds of shale (Sultan limestone?), which is emplaced as a result of normal faulting. This breccia zone has a N45°E strike and contains fragments of gray limestone, dark gray dolomitic limestone, and siltstone, well cemented by a dense, highly calcareous, light gray cement.

The Spring (Buck) is a result of ground water seepage along fractures and small cavernous zones in the Bird Spring formation, and is structurally controlled by the faulted zone being relatively well cemented and thereby impervious.

Classified as either IID2 or IIB3e.

Vegetation was primarily pine, with small grass areas located at the springs.

Pinon and Rosebud Springs

18S/53 - 35bd
Q = 0.34 gpm
Temp. = 50.5°

Same as Buck Spring. These springs were located one-quarter mile, N25E of Buck Spring. Smaller discharge may be a result of higher elevation or a less developed fracture system.

Buck, Rosebud, and Pinon Springs are all reported to fluctuate with respect to seasons of greater precipitation. This may be a result of their relatively shallow nature and recharge occurring from local, direct infiltration. Cold temperatures (water), altitude, and structural control would support this.
Mule Spring

22S/57 - 15cb
Q = 0.5 gpm
Sp. Cond. = 440

The spring is located at the end of an eroded canyon of light-gray to blue-gray, well jointed limestone. This non-clastic sequence is part of the Kaibab limestone and locally has a dip of 15-20°W, striking N-S. A basal unit of buff colored, sandy limestone, about 30 feet thick, was located west of the spring.

The spring is a result of several seeps that discharge from fractures in the apparently impermeable limestone overlying the buff colored unit.

Classified IID2.

Kiup Spring

20S/56 - 31da
Q = 7.71 gpm
Temp. = 62.5°
Sp. Cond. = 725

Kiup Spring is located in a highly brecciated, light-gray limestone of the Bird Spring formation. The brecciation is a result of normal and thrust faulting. The upper plate of the thrust is mostly a blue-gray dolomitic limestone, with lenses of white quartzite. Both formations, the Cambrian dolomite and Bird Spring formation are relatively impermeable. The fault zones are believed to be impermeable. The faulting and associated erosion may also have exposed a small cavern.

Classified IIB3e or IID1a.
Ford Spring

20S/56 - 31da
Q = 2.21 gpm
Temp. = 63°
Sp. Cond. = 778

Same as Kiup Spring.

Trout Spring

20S/56 - 10ca
Q = 328 gpm
Temp. = 45.5°
Sp. Cond. = 302

The spring emerges from a large cavern in a highly fractured and jointed gray, medium to coarse grained limestone. Directly overlying this unit is a more massive, dark colored medium grained limestone. This unit is less fractured. Beneath the spring occurs a very massive, impermeable, blue-black dolomite. This lower section
contains classic, bedded black chert. A 6 foot thick quartzite bed, striking N23W and dipping 15W, was located about 200 feet up section from the spring. This quartzite unit was part of a section of gray-black, very fossiliferous limestone. The fossils were corals, but further examination of the paleontology was not made.

This spring is typical of those classified as IID1a, a tubular spring, with a large discharge. Unlike most of the springs, this spring was not controlled by faulting. Erosion most likely exposed the portal of the cavern.

A local resident stated that discharge increases almost to the point of flooding down canyon areas in recharge seasons. The fluctuation responding rapidly with recharge.

Vegetation above the spring is a very dense, well developed manzanita. Below the spring, cottonwoods, mesquite, and large phreatophytic cacti grow. The latter flora may be strictly a result of re-infiltration of the spring discharge into the alluvium of the dry wash starting at the spring and continuing down into the Pahrump Valley.

**Bootleg Spring**

22S/58 - 7bd  
Q = dry

**Rainbow Spring**

22S/58 - 6db  
Q = dry

Both springs above were located in a buff colored to gray (on fresh fracture) dolomitic limestone. This unit lies on top and conformable to a darker, almost blue-gray dolomite, which is more massive and less fractured. This sequence is the Goodsprings dolomite which has thrusted (Keystone) Cambrian upon the Jurassic, Aztec sandstone. Both springs discharge from the lighter colored non-clastic, but their aquifer may be the overlying, thrusted sandstone, with the water leaving the clastic and following the fractures and joints of the
upper plate to a place of discharge. This movement from sandstone to dolomite to surface, may adhere to the principles of a siphon.

Lost Cabin Springs

21S/56 - 36bc
Q = 0.1 gpm
Temp. = 62°

Located in the Moenkopi formation, the lithologic sequence hosting the spring is a gray, medium to coarse grained limestone. The unit above the host rock is a dark gray, fine grained, shaley limestone. Below the host rock is a light brown, sandy limestone. This unit grades into sandstone down section, and is likely to be well cemented and thereby probably impermeable except along fractures and joints. The overlying shaley limestone appeared to be more of an aquifer. This shaley unit is fairly abundant in lower Triassic Pelecypods.

The attitude of local strata indicates that this spring is located in a syncline. This structure could explain its almost cliff-face location, in that water moves down dip and discharges at the lowest outcrop of the already described, underlying sandy limestone.

Classified IIIBla2.
Coal Spring

20S/57 - 31da
Q = 1.33 gpm
Temp. = 52.5°
Sp. Cond. = 590

Coal Spring is the result of a small, impermeable fault that strikes N-S and is perpendicular to the E-W canyon that drains this area. The fault displaces a massive, shaley, fine grained, gray limestone. This unit of the Bird Spring formation contains bedded cherts (Trout Spring, pp. 53). Cavernous conditions may assist the discharge.

Classified IIB3e and IID1a.

Cave Spring

20S/57 - 33cb
No Measurements

Same structural situation as described for Coal spring. Lithology is a massive, blue-black limestone unit of the Late Paleozoic, Kaibab limestone. Drainage is to the east.

Classified IIB3e and IID1a.

Vegetation is principally grass and pine.
Bootlegger Spring

208/57 - 33ca
Q = 0.3 gpm
Temp. = 67°
Sp. Cond. = 580

Same structural situation as described for Coal and Cave springs. The host rock is a fault contact of light red sandstone and a buff to blue-gray limestone. Some light brown shale was also noted in the vicinity of the spring. This sequence is probably the lower section of the Triassic Moenkopi formation. Drainage is to the east.

Crystal Springs

178/53 - 36 (6 springs)
Total Q = 1.6 gpm
Temp. = 59.5°
Sp. Cond. = 250

A maroon, well fractured quartzite hosts all six springs. Interbeds of micaeous, brown shale persists throughout the area. The section is upper Johnnie formation, and lower Mt. Stirling quartzite.

Referring to the diagram on the following page, two normal faults structually control the ground water movement, and are the principal factors effecting the location of all springs.

Classified IIB3e and IID2.

The only significant vegetation were willows and dense growths of grapevine.
Spring Cross-sections - starting with Crystal Springs and moving north to Horseshutem Springs. Kwichup Spring is located on the northwest, and controlled by the same fault indicated by (1).

Each of the springs located on this normal fault (1) are at a lower elevation, moving north. The gradient of the potentiometric surface is also to the north.

Diagram 7

Crystal Springs

Diagram 8

Bill Smith Sprs.

Diagram 9

W - E cross-section

W - NE cross-section

W - E cross-section
Geologic conditions controlling location of springs are like those described for Crystal Springs (page 74). Two normal faults displacing the Johnnie formation, which is a sequence of white to maroon quartzites, with interbeds of brown and green shales.

Spring number 4 was located in a small cave which had for its back, the lower normal fault (refer to cross-section, pp. 58). Ground water was discharging through the impermeable gouge along small fractures. Water at this spring was probably a result of re-infiltration of the discharge of the upper spring, number 5.

Classified IIB3e and IID2.

Cottonwoods, grapevines, and willows, were dense around the springs.
Springs 1 and 2, are located on a N-S, NE-SW pair of normal faults. Both faults expose a green-brown chloritic shale, this shale, along with a coarse grained, gray quartzite, hosts both springs. These units are a lower section of the Mt. Stirling quartzite. Below the lower spring, a brown-maroon quartzite dominates, the Johnnie formation.

(For further explanation refer to description of Horse-shutem Springs, pp. 59, and diagrams showing spring crossections, pp. 58).

Classified IIB3e and IID2.

Grapevine Springs

17S/53 - 21c
total Q = 17.6 gpm
Temp. = 67°
Sp. Cond. = 825-840

The geology fixing the springs is more complex than illustrated in the crosssection, pp. 58, all being lithologically the quartzite of the Mt. Stirling formation. From discontinuity of like colored quartzite beds, and shale units, there is a large normal fault, trending almost N-S. The fault caused an uplifted section that is lithologically white quartzite and is highly brecciation. The material to the east and west of this prominent outcrop is void of brecciation.

The principal source of discharge were two addits driven to the fault. Each had a flow of about 8.0 gpm. The fault, as observed in the crosscuts, had visible brecciation, and is most likely impermeable due to cementation, the faults perching the water in order that discharge can occur.

The only spring located in the area was found at the surface exposure of the displacement encountered by the addits. This spring was controlled by both faulting and a relatively impermeable, green-brown chloritic shale.
Classified IIB3e and IID2.
Vegetation was confined to a sparse growth of mesquite and salt grass.

Kwichup Spring

17S/53 - 8 (approximately)
Q = negligible
Temp. = 70° (may be high due to lack of circulation)
Stagnant water

Similar structural conditions as encountered at Grapevine Springs. Hosted by a brown siltstone - shale containing limonite after pyrite. This shale is joined on both sides by a medium grained, white - dark gray quartzite (Mt. Stirling quartzite), that is highly fractured, almost to the point of being shaley. The dark gray quartzite contains chalcopyrite (?)

C C Spring

21S/57 - 9ba
Q - dry

Refer to Lost Cabin Spring, pp. 55, for explanation of structural control and physiographic situation of this spring. No faulting was recognized locally.

Stratigraphically the spring is hosted by the lower Permian, Kaibab limestone. This blue-gray limestone is wavy, massive with sandstone-shaley interbeds. Vertical fracturing is characteristic of this lower unit. Directly beneath this formation is a red sandstone (Supai formation). This clastic is massive and well consolidated in upper sections, grading downward into shale.

Classified IIB1a2.

Lower Center Spring

20S/57 - 28ab
Q = 1.6 gpm
Temp. = 53°
Sp. Cond. = 560
This spring is hosted by a gray limestone that changes from shaley to a massive unit regularly. Here the Moenkopi formation is highly fractured and is likely the structural control of this spring. The deep erosion causing Lovell Canyon may also assist in the location.

 Classified IID2 and IIB2b2.

Jody Spring

Located in an exposure of the Bird Spring formation. The host unit being a dark gray, well fractured limestone.

A large normal fault striking northwest may be the controlling factor in this spring's location, but circumstances observed at the spring, in addition to its negligent rate of discharge, indicates that this is hardly a spring, but more of a seep. The seep results almost entirely from local rainfall surfacing immediately via fractures.

 Classified IID2 or IIB2b2.

The Narrows Spring

(1) 20S/57 - 27ba
Q = 3.05 gpm
Temp. = 51.5°
Sp. Cond. = 610

(2) 20S/57 - 27cb
Q = 2.7 gpm
Temp. = 53°

The springs are situated on the faulted contact of lower Moenkopi and Bird Spring formations. The highly brecciated Bird Spring formation, on the footwall, hosts both springs.
Topographic and structural relief is towards the fault, away from the axis of an anticline to the east. The nature of discharge indicates conditions similar to those described diagrammatically for the springs: Crystal, Grapevine, and Horseshute, pages 57-59. The potentiometric surface being elevated due to the impermeable nature of the normal, westerly dipping fault.

Classified IIB3e and/or IID2.

Vegetation was entirely a dense undergrowth of mesquite.

Switchback Springs

218/58 - 7bc
Q = 0 gpm

Both springs are located in the Goodsprings dolomite, along a north to south trending fault of small displacement. The fault is parallel to and probably intersects the Keystone trust at depth (?). Refer to Rainbow and Bootlegger Springs and diagram, pages 53-54, for a detailed description of discharge control.

This spring is dry, as were Rainbow and Bootlegger Springs, and is probably a result of lowering water table conditions.

La Madre Springs

208/58 - 29bd
Q = 4.5 gpm
Temp. = 57°
Sp. Cond. = 785

Hosted by the Goodsprings dolomite, the springs (3) were all observed to discharge from vertical bedding joints in the dark-gray nonclastic. The spring control is definitely the fault damming that has resulted from the intersection of a north-west striking normal fault which displaces the low angle Keystone trust, which has a north-east trace in this vicinity. This normal fault probably has greater control on ground water movement, in that it deflects movement to the south and causes saturation of fractures.
Because the springs are located near the Keystone thrust, the siphon effect described earlier (Rainbow Spring, pp. 54) does not take place, on the contrary, water is most likely lost downward through the fault and contributes to the discharge at Willow Spring (to be described).

Cottonwoods, and grapevines were observed at the spring, with mesquite growing in down canyon areas.

Sheep Spring

20S/57 - 36cc
Temp. = 51°
Sp. Cond. = 560

East Spring

20S/57 - 35ab

Claybank Spring

20S/57 - 35ac

Each of the last three springs were indicated by presence of salt grass and other characteristic spring vegetation. Local geology was omitted because of doubtful locations.

Wheeler Well and Spring

18S/55 - 20ca
Q = 0.4 gpm
Temp. = 55.5°
Sp. Cond. = 500

The spring is hosted by an alluvium which has followed deep local erosion and recent down-faulting. The graben truncates the Wheeler Pass thrust and a northeast plunging syncline. A northeast-southwest crossectional projection places the
spring in alluvium overlying the Sultan limestone (Vincellette, 1964, geologic map). A well banded, maroon quartzite, brown siltstone and light gray to black dolomite outcrops are exposed laterally from the spring.

Discharge is a result of fault damming with the elevated water table reflecting the impermeable fault zones.

Classified XIB3e.

**Trough Spring**

18S/55 - 23bb  
Q = 0.2 gpm  
Temp. = 52.5°  
Sp. Cond. = 565

The host rock is the limestone of the Bird Spring formation. This limestone is dark-gray at the spring and contains numerous bedded cherts and thin interbeds of tan, shaley, fossiliferous limestone. The entire unit conformably overlies the Monte Cristo limestone.

The spring sets unusually high above and at the beginning of a deep canyon. It was obvious that saturated conditions did not exist and that the spring is most likely a result of seepage along the well developed bedding joints and filling a low point in the limestone that dips gently back into the mountain, and discharges when the depression fills. Similar in structure to Lost Cabin Spring, page 55, and Tule Spring, page 50.

Classified IIB3a.

No significant vegetation at or below the spring.

**Clark Springs**

19S/56 - 7ba  
Q = 25.9 gpm  
Temp. = 46°  
Sp. Cond. = 500
This series of springs occur along a fault which dis­
places a Cambrian, massive-shaley, dark blue dolomite.
It appears as though this fault functions as an avenue of
discharge rather than an impermeable barrier to ground
water movement, similar to fracture controlled springs.

The springs increase in discharge as elevation decreases
and thereby would imply a possible saturated condition.
The fault disappears under alluvium directly below the
last spring and prevents any further investigation. The
presence of phreatophytic vegetation in the alluvium might
support this theory.

Classified IID2.

Cane Springs

Located respectfully:
21S/57 - 16bb
21S/57 - 8dd

Structurally identical to the explanation of C C Spring,
page 61 . The springs are hosted by a upper unit of the
Supai formation. The vertical joints in the overlying
Moenkopi limestone functioning as the channels of water
supply and the apparently impermeable sandstone discharg­
ing it accordingly.

Classified IIBla2.

Lee Springs

20S/56 - 8ac
Q = 227.0 gpm
Temp. = 45°
Sp. Cond. = 300

The spring emerges from a small cavern in a medium grained,
gray limestone. This limestone is exceptionally well joint­
ed along bedding planes and exhibits a well developed
cavernous structure. Bedded cherts and fossils are also
present in this steeply dipping unit of the Bird Spring
formation. The strata around the springs are highly folded
and possibly overturned.
Unlike nearly all other springs visited, the water discharging from the springs does not immediately re-infiltrate even though it passes over considerable jointing along its one and one-half mile run to alluvium.

This spring is similar to Trout Spring, page 53, in almost every respect, and it is believed that the two springs are part of the same cavernous system. Each occur in like units of the Bird Spring formation, with a large orifice discharge, underlain by an impermeable, well-jointed limestone, specific conductance being 300 and 302, temperatures are 45° and 45.5°, respectively. Lee Spring having a slightly higher elevation, which might account for its smaller discharge, 227 gallons per minute, as compared to 328 gallons per minute.

Classified IIDla.

Spring (Hidden Hills Ranch)

22S/54 - 24a
Q = dry

Hosted by valley fill. Spring occurs at the contact of relatively coarse alluvial material and an impermeable lacustrine deposit.

This type of contact spring is explained and diagrammed in more detail on page 50, Tule Spring.

Classified IIB3a,b.

Stump Spring

22S/55 - 5ba
Q = standing water
Temp. = 85° (air temperature - ?)

Located at the contact of alluvium and white, calcareous lake deposits, with this impermeable clay being exposed on the face of a small eroded cliff. Because of its shallow nature, this type of spring dries up early in periods of less precipitation.
Vegetation is typically saltgrass, cottonwoods, and large mesquite.

Refer to Tule Spring, page 50.

Classified IIB3a,b.

Vegetation is typically saltgrass, cottonwoods, and large mesquite.

Browns Spring

22S/54 - 15da
Q = 0.2 gpm
Temp. = 75°
Sp. Cond. = 460

Typically an alluvium-clay contact spring. Refer to Stump Spring, above.

Spring (no name)

22S/54 - 15ba
Q = standing water
Temp. = 81° (air temperature -?)

Refer to Stump Spring, above.

Spring (no name)

21S/54 - 33ba
Q = dry

Refer to Stump Spring, above.

Vegetation consists of sagebrush, large mesquite, and cottonwoods.

Mound Spring

21S/54 - 28bed
Q = dry

A typical spring mound hosts this spring. Source of water adheres to the definition of a 'spring mound'.
"Windblown dust is deposited in the moist area around the spring and is held in position by surrounding vegetation. The mound may be built up to elevation of the artesian head of the spring water. If the spring finds a lower exit, the mound may be abandoned..." (Tolman, 1937, pp. 436-437)

Vegetation consisted of cottonwoods, mesquite, and saltgrass.

Classified IIC4.

Spring (no name)

21S/51 - 15ad
Q = dry

Refer to Stump Spring, page 67.

Bennetts Springs

20S/54 - 14dd
Q = dry

Measured by the Nevada State Engineer's Office, July 18, 1943, at a discharge of 2520 gallons per minute. The spring was reportedly destroyed during the drilling of a nearby well. The spring emerges from the valley fill, but the controlling structure is most likely faulted or exposed cavernous limestone bedrock. It is also possible that the spring source be the alluvial fan, and the aquifer a very coarse gravel feed from higher elevations. This water in turn being forced to the surface by either faulting in the alluvium or a less permeable interstratified valley fill.

This type of spring, with its high degree of discharge could possibly function in the same manner as a pumped
well, the orifice acting as the loci of pressure release over the entire gravel, or hydraulically connected series of gravels in an alluvial fan. The result is a drawdown in the direction of the spring and likewise a potentiometric gradient.

**Classified IIB3e, IIC4 and/or IIDla.**

**Manse Ranch Springs**

21S/54 - 3ad  
Q = 605 gpm  
Temp. = 75.5°  
Sp. Cond. = 430

This spring may be controlled in the same manner as described for Bennetts Spring, page 69. The latter theory being supported by two wells drilled into the alluvial fan, directly above the springs, and a large discharging artesian condition resulting.

**Classified IIB3e, IIC4 and/or IIDla.**

**Six Mile Springs**

20S/52 - 1bd  
Q = dry

Hosted by valley fill and the cavernous Bonanza King formation. The spring results from either water transported by the cavernous non-clastic, or forced to the surface in the same manner as described for Resting Spring, page 49.

**Classified IID1c, LLB3d and/or IIC4.**

Vegetation consisted of willows, cottonwoods, and dense growths of a very large mesquite. Saltgrass was also abundant.
Point of Rocks Springs

18S/51 - 7db
(King Springs, 18S/50 - 17da)
Q = 1078 gpm
Temp. = 89.5°
Sp. Cond. = 675

Both springs are hosted by valley fill, with local deposits of calcareous sinter. Outcropping nearby is the Bonanza King formation. Locally, the non-clastic is medium to coarse grained and gray to black in color.

The structural control is very likely cavernous. Exposure of the caverns beneath the valley fill may have either resulted from faulting or folding. Evidence is in favor of faulting and may be illustrated by examination of Devils Hole and the 'spring line' extending from Fairbanks to Bole Springs (geologic map, folder). This implied fault is supported by geophysical data (Moench, oral communication) and excessive, parallel faulting in the outcropping Bonanza King formation.

Classified IIDla.

Vegetation consists of cottonwoods, willows, and dense, large growths of mesquite. Saltgrass, reedgrass and rabbit-brush are all well displayed throughout this area, especially at and below the springs.

Jackrabbit Spring

18S/51 - 18bd
Q = 587 gpm
Temp. = 82°
Sp. Cond. = 675

Hosted by the valley fill, and located along the Ash Meadows 'spring line'. Refer to Point of Rocks Springs for additional explanation, page 71.

Like many of the large springs located in the Ash Meadows...
area, hosted by valley fill, the water can be seen entering the large circular pool at the bottom through an orifice. This type of crystal blue pool has been called 'ojo de aqua', eye of water.

Classified IIDla.

This spring is hosted by valley fill and even though its direct age may be less than other springs along this type of topography, it is one of the more recent discharge ojo de aqua springs. Refer to Hole Spring, page 72.

Spring (no name)

Big Spring

An 'ojo de aqua' spring with similar conditions of structural control as described for Point of Rocks Springs, page 71, and Jackrabbit Spring, page 71.

Vegetation and classification are also the same.
Bole Spring

18S/51 - 30ab
Q = 11.0 gpm
Temp. = 72°
Sp. Cond. = 665

This spring is hosted by valley fill and even though its discharge may be less than other springs along this 'spring line', it is believed that its mode of discharge is the same as that described for Point of Rocks Springs, page 71.

Spring (no name)

18S/51 - 29bb
Q = 1 gpm
Temp. = 72°
Sp. Cond. = 790

Refer to Bole Spring, page 73.

Last Chance Spring

18S/51 - 30bd
Q = 1 gpm
Temp. = 67°
Sp. Cond. = 575

Hosted by valley fill, but located near Tertiary volcanics.

This spring, like Bole Spring, may be associated with the cavernous system outlined in the explanation of Point of Rocks Springs, page 71. The rate of discharge results from the volcanic activity decreasing the cavernous permeability of the underlying limestone.

Classified IID1a (?).
Springs (no name, 3)

18S/50 - ldb
\( Q = 9.3 \text{ gpm} \)
Temp. = 78.5°

These springs also lie on the 'spring line', but it is very possible that their discharge may impart result from shallow alluvial percolation. Since the springs lie on a contact of alluvium and clay, refer to Tule Spring, page 50.

Classified IIDla, IIB3a,b.

Springs (no name, 2)

18S/50 - lb
\( Q = 3.76 \text{ gpm} \)
Temp. = 84°
Sp. Cond. = 665

Refer to last nameless spring discussed, above.

Crystal Spring

18S/50 - 3ac
\( Q = 2824.0 \text{ gpm} \)
Temp. = 89°
Sp. Cond. = 650

This spring is very characteristic of the larger springs in that it occurs as an 'ojo de aqua' and is feed by a large cavity, at or near the bottom.

Structural control is similar to the theory outlined for Point of Rocks Spring, page 71, and Jackrabbit Spring, page 71.

Classified IIDla.

Vegetation is typically saltgrass and mesquite, sparse.
Corky Springs
17S/50 - 35ac
Q = 149 gpm
Temp. = 49°
Sp. Cond. = 640

Refer to Point of Rocks Spring for explanation, page 71.

Button Springs
17S/50 - 35da
Q = 7.2 gpm
Temp. = 93°
Sp. Cond. = 620

Hosted by valley fill with structural control similar to that outlined in the explanation of Point of Rocks Springs, page 71.

Vegetation is sparse, and consists of cottonwoods, and saltgrass.

Spring (no name)
17S/50 - 35ab
Q = 17.0 gpm
Temp. = 82.5°
Sp. Cond. = 620

The spring discharges from a pool, an 'ojo de aqua', like those of larger discharge. Refer to Jackrabbit Spring, page 71. It is hosted by the valley fill and is near the undefined contact of a coarse gravel and an extremely fine clay. Because of the characteristic appearance of the spring, and its location along the 'spring line', its structural control is attributed to the explanation given for Point of Rocks Springs, page 71.

Classified IIDla.
Parent Springs

17S/50 - 23bb
Q = 177 gpm
Temp. = 93°
Sp. Cond. = 650

All three springs are hosted by a contact of alluvium and clay with a volcanic ash.

Structural description and control similar to Point of Rocks Springs, page 71. Classification same.

Vegetation consists almost entirely of grapevines and cottonwoods.

Longstreet Spring

17S/50 - 22ab
Q = 1042 gpm
Temp. = 81°
Sp. Cond. = 640

Hosted by a white, calcareous clay, this spring has the characteristic appearance of the large alluvial springs located in the Ash Meadows area, with the water being supplied through an orifice at the bottom of a large, circular, clear pool (Jackrabbit Spring, page 71).

Its appearance and location with respect to the 'spring line', classifies it IIDla. Refer to Point of Rocks Springs, page 71.

Rogers Spring

17S/50 - 15ab
Q = 736 gpm
Temp. = 82°
Sp. Cond. = 650

A visual description of this spring is like that of most large springs in this area, an 'ojo de aqua'. Refer to Jackrabbit Spring, page 71, and Point of Rocks Springs, page 71, for a detailed description.
Bell-Soda Spring
17S/50 - 10db
Q = 75 gpm
Temp. = 72°
Sp. Cond. = 725

Hosted by a white, calcareous clay. This spring is structurally controlled in the same manner as described for Point of Rocks Spring, page 71. The lower temperature might be explained by larger quantities of meteoric, shallow, valley fill water joining the discharge from the exposed cavernous system.

Classified IIDla.

Fairbanks Spring
17S/50 - 9ad
Q = 1715 gpm
Temp. = 80°
Sp. Cond. = 650

An 'ojo de aqua' spring located on the 'spring line', and hosted by valley fill.

Refer to Point of Rocks Spring, page 71, and Jackrabbit Spring, page 71.

Vegetation consisted of reedgrass, cottonwoods, and very large, dense growths of mesquite.

Ash Tree Spring
17S/49 - 35dd
Q = 8.7 gpm
Temp. = 75°
Sp. Cond. = 350

Hosted by a calcareous clay, the spring may be a result of saturation of this valley fill by re-infiltration of water discharging from the springs back to the east;
Longstreet, Rogers, etc. The saturation and associated discharge may be assisted by local Tertiary volcanics being even less permeable than the very fine clay.

Classified IIB3c and IIB3d.

Vegetation was confined to the spring local and consisted of saltgrass and mesquite.

Davis Ranch Springs
17S/50 - 11da
17S/50 - 12cb
Total Q = 443 gpm
Average Temp. = 76°
Sp. Cond. = 760

Several springs make up this cluster with only one having the typical appearance of a large spring of this area. This spring makes up 397 gallons per minute of the total 443 gallons per minute recorded. The structure controlling its location is believed to be similar to that described for Point of Rocks Springs, page 77. It is also an 'ojo de agua', that is a large, deep, circular pool with an orifice feeder at its bottom. Refer to Jackrabbit Spring, page 77.

The other springs, making up the smaller sum of the total discharge, may adhere to the explanation given for Ash Tree Spring, page 77, with local saturation being the contributing factor in their occurrence.

The average temperature is a comparatively low, 76° (the large spring described here having a temperature of 80°). Refer to Bell-Soda Spring, page 77, for possible explanation of this irregularity.

Willow Spring
18S/55 - 2ac
Q = 225 gpm
Temp. = 54°
Sp. Cond. = 405
Hosted by alluvium, the spring is located in an area of extreme faulting and brecciation. The Wheeler Pass thrust fault being exposed to the west with the upper plate showing a series of normal faults perpendicular to the thrust. The Wood Canyon formation, Bonanza King, and Mt. Stirling quartzite forming the principal formations offset. The Bird Spring formation outcrops nearest to the spring and is believed to be the source of the spring.

Defining the structural control of this spring is difficult since its situation with respect to faulting and geologic column makes possible several theories, each discussed previously. Theoretically, either fault damming or exposure of a cavernous system would explain its location. Because the discharge is relatively large, previous examinations of large springs and associated formations, indicate that this spring is similar to Trout and Lee Springs, pages 53 and 66, respectively, each a cavernous system located in the Bird Spring formation.

Classified IIDla.

**Bird Spring**

17S/55 - 36ca
Q = standing water

On the north side of the spring, an outcrop of a well brecciated dolomite is exposed through the hosting alluvium. This dolomite contains fragments of a light brown siltstone, and is stratigraphically the Lone Mountain dolomite.

This spring is believed to be a result of fault damming with the brecciation acting as an impermeable barrier to ground water movement through fractures or small solution cavities in the dolomite.

Classified IIB3d.

Vegetation is sparse and consists mainly of pines, cottonwoods, and mesquite.
Cold Creek Spring

18S/55 - 1da
Q = 230 gpm
Temp. = 51.5°
Sp. Cond. = 420

This spring is hosted by alluvium of what appears to be an uplifted pediment surface. The erosional cuts are relatively deep. The spring occurs above such a cut, therefore proving the impossibility of an erosional intersection with the ground water table.

Recalling that a pediment is a "gently inclined planate erosion surface carved in bedrock and generally veneered with fluvial gravels..." (Childs, O. E., 1948, A. C. I Glossary, 1960, pp. 214), indicates the possibility of erosional exposure of a cavernous system which would explain the large discharge from a non-saturated system.

Refer to Trout Spring, page 53, Lee Spring, page 66, and the springs located in Ash Meadows, pages 71-78, for additional explanations.

Whiskey Spring

18S/56 - 13db
Q = 0.5 gpm
Temp. = 50.50

MacFarland Spring

18S/56 - 13dc
Q = 1.7 gpm
Temp. = 47.5°
Sp. Cond. = 360

The above springs are hosted directly by an alluvium, but indirectly by an underlying dark gray, well fractured dolomitic limestone, that has been exposed due to a northwest striking normal fault. The hanging wall contains the well bedded black cherts describing the Bird Spring formation.
Classified IIB3e, springs resulting from damming of ground water movement due to the impermeability of fault planes.

Mud Spring

18S/55 - 21bc
Q = 3.0 gpm
Temp. = 49°
Sp. Cond. = 478

The spring is hosted by a brecciated fault zone that trends in an east-west direction. This fault displaces a dark gray limestone containing bedded cherts and a series of inter-bedded light gray and tan siltstones; the Bird Spring formation and Monte Cristo limestone.

The spring is physiographically located in an erosional cut which is perpendicular to the fault. Diagrammatically illustrated on page 56 (Coal Spring).

Classified IIB3e.

The spring is part of a meadow consisting entirely of reedgrass.

West Rosebud Spring

18S/55 - 22bc
Q = standing water
Temp. = 60°

Located on same fault described for Mud Spring, page 81. Lithology is also repetitious.

East Rosebud Spring

18S/55 - 22bc
Q = 0.6 gpm
Temp. = 46°
Sp. Cond. = not taken

Refer to West Rosebud Spring, above.
Jaybird Spring

17S/53 - 11db
Q = dry

The spring is hosted by the jointed quartzite of the Mt. Stirling. This quartzite is varied colored: green-white-blue-maroon. Some green to brown, sericitic shale occurs locally. The seep is located on the conformable contact of the Mt. Stirling and the Johnnie formation, with a fault displacing both formations and located east of the spring. The fault is the impermeable structure controlling the springs location. Refer to diagrams and associated explanation for Crystal, Grapevine, and Horseshutem Springs, pages 57-60.

Classified IIB3e and IID2.

Topographically located on the side of a hill with a deep erosional canyon below making any possible intersection with the ground water table impossible.

Rock Spring

17S/53 - 12cbd
Q = standing water
Temp. = 67°

Topographically located in a draw exposing the Mt. Stirling quartzite. The water was observed to discharge from bedding joints at the base of a large unit of white quartzite. This dense, highly fractured clastic is underlain by a dark brown shale that dips opposite to drainage. This shale halting downward movement of ground water and producing saturation in the quartzite. Similar to the diagram illustrating Coal Spring, with the shale instead of a fault plane.

Classified IIB2b2.

Vegetation was very dense and consisted almost entirely of mesquite.

82
Gold Spring

17S/53 - 24acc
Q = 0.1 gpm

This spring is hosted by Mt. Stirling quartzite and is structurally controlled in the same manner as described for Jaybird Spring, page 82.

Big Timber Springs

17S/54 - 29a
Q = 0.5 gpm
Temp. = 58°
Sp. Cond. = 590

The springs are a result of an elevated zone of saturation caused by a brown to green, impermeable shale dipping back into the mountain, overlying this unit is a well fractured, buff-colored limestone. The springs are located in a dry wash draining a high-level sloping area. The Carrera formation hosts the springs.

Refer to Rock Spring, page 82.

Classified IIBb2.

Vegetation was high elevation reedgrass, pines, and an occasional cottonwood.

Girl Scout Spring

19S/56 - 14cb
Q = 0.9 gpm
Temp. = 39.5°
Sp. Cond. = 310

Located in a very gently dipping, cliff forming, gray limestone which exhibits jointing perpendicular to and along bedding planes. The water follows these fractures and discharges above a ledge of less vertically jointed limestone. The Bird Spring is the hosting formation.
Classified IIB2.

Diagram 11

Spring (no name)

19S/56 - 3dc
Q = dry

Stratigraphically located in Cambrian dolomitic limestone that weathers to a light brown, buff color.

Circumstances at the spring indicate a similarity to Jody Spring, page 62.

Classified IID2 and/or IIB2b2.

No significant vegetation at, or below the spring.

CCC Camp Spring

19S/56 - 3c
Q = dry

Reported to have 1 gallon per minute discharge during spring months. The spring is hosted by a gray, massive to well jointed limestone. Topographically and structurally located similar to the nameless spring above.
Upper Macks Canyon Springs

18S/56 - 33db
Q = 9.2 gpm
Temp. = 46.5°
Sp. Cond. = 480

Measurement of discharge was taken below the third spring in this series. The total individual spring discharges did not total 9.2 gallons per minute, therefore indicating that the stream connecting the springs is part of the spring cluster.

Located on the east side of an erosional canyon in the Lone Mountain dolomite (?) - Sultan limestone (?), the hosting dark, massive carbonate is extremely brecciated along the wash. Detailed geology indicates that the brecciation is a result of fault displacement with the darker non-clastic being thrown against a buff colored limestone containing white, well bedded interbeds of quartzite. This fault follows the compass direction of the canyon and accounts for all springs located in Macks Canyon.

Classified IIIB3e.

Vegetation consists of local spring growths of grass, and cottonwoods.

Middle Macks Canyons Springs

18S/56 - 27cd
Q = 2.1 gpm
Temp. = 44°
Sp. Cond. = 483

Refer to Upper Macks Canyon Springs, page 85.

Lower Macks Canyon Springs

18S/56 - 27ca
Q = dry
The spring is hosted by alluvium, but lithology and structural sequence outcropping laterally is similar to previously described springs in this canyon. Refer to Upper Macks Canyon Springs.

Lack of discharge may be a result of alluvium being capable of transmitting the summer discharge, whereas during months of greater precipitation and discharge of upper spring, would cause this spring to flow.

**Mofford Spring**

18S/56 - 35cc  
Q = 0.7 gpm  
Temp. 49°

The spring is situated in a small draw trending east-west that intersects a north-south striking normal fault that places the spring on the hanging wall. The downdropped block consists of a Cambrian dark gray, massive limestone, with a conformable contact of Lone Mountain dolomite overlying. The footwall exposes in its entirety, the Cambrian.

Perpendicular erosion to a possibly impermeable fault indicates a structural situation similar to that diagrammed for Coal Spring, page 56, the water table being elevated as a result of faulting and sharp canyon downcutting which exposed the suspended water level.

*Classified IIIB3e.*

**McWilliams Springs**

19S/56 - 15c  
Q = 34.0 gpm  
Temp. = 43.5°  
Sp. Cond. = 315

These springs are all hosted by a massive-well bedded, fine grained limestone. This limestone varies in color from buff to gray to dark gray. Water comes from the limestone.
There is some increase in flow along the wash, but this ceased about 100 yards down from the top spring. Below this point, the limestone is less defined, and water that discharges from bedding joints at higher elevations probably joins the alluvium filling the lower part of the draw.

Chert is frequently found bedded in the buff colored limestone. This sequence of carbonates are in part, the Bird Spring formation.

McWilliams Springs are structurally similar to that type described for Girl Scout Spring, page 83, with the larger discharge occurring as a result of the jointed units having a lower elevation and likewise a larger area of recharge, Mt. Charleston. Girl Scout Spring was located near the crest of its zone of recharge.

Classified IID2.

Aspens, pine and grass make up the vegetation, with cottonwoods becoming more frequent at lower elevations.

Cold Water Springs

19S/57 - 6bb
Spring 1) \( Q = 1.7 \) gpm
Temp. = 44°
2) \( Q = 3.4 \) gpm
Temp. = 43°
Sp. Cond. = 458

Both springs are hosted by an uplifted alluvium giving way to deep erosion. Laterally from the spring area a gray-white sandy limestone outcrops, overlain by a well jointed, dark gray limestone. Both units are a part of the Ordovician sequence described in this area.

The uplift causing the deep erosion results in part from a large fault that locally, defines the boundary between the pediment and the outcropping bedrock of the Spring Mountains. This fault may also have exposed small caverns and water transmitting bedding planes in the limestone.

Classified IIDlc and/or IIDe (?).

Vegetation consists of aspens and large growths of mesquite.
Deer Creek Springs

Spring 1) 19S/57 - 7cd
Temp. = 43°
2) 19S/51 - 18bc
Q = 115 gpm
Temp. = 44°
3) 19S/56 - 12db
Q = 24.9 gpm
Temp. = 42.5°

An east-west normal fault that follows the deep erosional cut in which the springs occur, is the primary structure causing their discharge. The springs are hosted by two formations, a Cambrian limestone and dolomite, buff colored (Cold Water Springs, page 87). This Ordovician limestone comprises the entire hanging wall in this locale.

The springs are a result of exposure of bedding fractures and associated solution cavities.

Classified IID1c and IID2.

Sawmill Spring

19S/57 - 18cd
Q = 1.3 gpm
Temp. = 42.5°
Sp. Cond. = 320

Hosted by Ordovician limestone. Structurally identical to Girl Scout Spring, page 83.

S. B. Spring

19S/56 - 13cc
Q = 0.1 gpm
Temp. = 47.5°

Situated on the contact of a light gray, sandy limestone and a dark gray dolomite, the Monte Cristo and Lone Mountain formations. The Monte Cristo limestone exhibiting small solution cavities where water has moved along considerable
bedding and vertical jointing. This spring occurs in the same structural and topographic situation as diagrammed for Girl Scout Spring, page 83.

Classified IID2 and IIDc.

Mary Jane Falls
19S/56 - 27db
Q = negligible
Temp. = 41°

Big Falls
19S/56 - 27cb
Q = negligible

Mary Jane Falls and Big Falls are both hosted by cliff-forming, gently dipping, gray limestone. The springs discharge along well developed bedding joints with some water being added to the flow by alluvium overlying the bedrock. The Bird Spring formation hosts both falls-springs.

Refer to Girl Scout Springs, page 83.
Classified IID2.

Aspens are common throughout this area where alluvium is relatively shallow and sufficient water occurs near the surface.

Little Falls
19S/56 - 35d
Q = 4.0 gpm
Temp. = 52°

Refer to description of Mary Jane and Big Falls, page 89.
Stanley B Springs

19S/56 - 25ac
Q = 5.3 gpm
Temp. = 50°
Sp. Cond. = 500

Most of the flow is through gravel located in a stream bed that drains the north side of the Kyle Canyon area. Water is originally derived from a limestone that strikes N10W and dips 35°W. The limestone is fractured by vertical joints spaced from 1 to 6 inches apart.

Local faulting may assist the jointing in the location of these springs.

Classified IID2 and IIB3e (?).

Harris Springs

20S/57 - 1bd
Q = 3.0 gpm
Temp. = 60.5°

Structurally situated in a sequence of repetitious red sandstone overlain by well fractured, medium grained limestones. The Permian stratigraphy repeats as a result of two normal, north-south striking faults.

A combination of factors assists in the location of these springs. First, the red sandstone is relatively impermeable when compared to the well jointed limestone. Secondly, the faults are believed to be impermeable and in turn elevates the potentiometric gradient, which in this area is perpendicular and opposite to the westerly dip of the fault planes.

In addition to Harris Springs, Prospect and Cabin Springs are also located in this sequence and likewise adhere to the combination of spring controls outlined above.

Classified IIB1a2 (C C Spring, page 61) and IIB3e.

Vegetation was primarily scrub oak and cottonwoods. Large patches of grass encompasses the springs.
Prospect Springs

20S/58 - 6da
Q = 4.0 gpm
Temp. = 57°
Sp. Cond. = 710

Refer to Harris Springs, page 90, for explanation of geology and spring classification.

Spring (no name)

20S/57 - 1dac
Q = standing water
Temp. = 65°

Refer to Harris Springs, page 90.

Cabin Springs

20S/58 - 6bd
Q = 0.1 gpm
Temp. = 60°

Same structural situation as described for Harris Spring, page 90. Stratigraphy and vegetation is also identical.

Classified IIB1a2 and IIB3e.

Grapevine Spring

19S/58 - 16bc
Q = dry

Hosted by shallow alluvium which is directly underlain by a brown and yellow siltstone. This clastic strikes perpendicular to and opposite to the alluvial drainage. During periods of runoff and heavy rainfall, the siltstone would serve to dam shallow water and cause discharge.

Classified IIB2b2.
Willow Spring

20X/58 - 33cc  
Q = 1.1 gpm  
Temp. = 66.5°  
Sp. Cond. = 320

Typical of many springs located in this area, Willow Spring is hosted by the Aztec sandstone, which differs from the underlying Chinle sandstone, only in that it is in its entirety a sandstone and is capable of transmitting relatively abundant quantities of water, both by interstitial permeability and along its well developed, three directional jointing. The Chinle sandstone grades into shale in basal sections, and like the conformable underlying formations, the Shinarump conglomerate, and Moenkopi formation, are far less transmissive.

Because of the unusual character of the topography in this location (the sandstone bluffs), and the structural thrusting (Keystone) of the Goodsprings dolomite upon this Jurassic sandstone, a slightly asymmetric water table mound is believed to have resulted. This mound has formed due to the Aztec sandstone and upper Chinle, having to act as an aquifer between two aquitards, with its only form of discharge being through downward seepage into and along the Chinle shale, and by spring occurrence. This is evident since at nearly every location where erosion has cut back into the sandstone bluffs and intersection with the Jurassic and upper Triassic, a spring of relatively constant discharge forms. An illustration of this principal is on page 54, (Rainbow Spring) this diagram picturing idealistically the Keystone thrust, the water table mound, and spring locations.

Willow, Pine Creek, Oak Creek, First Creek, Sandstone, etc., and other nameless springs in the area are similarly formed.

Classified IIA2, and IIB2b2.

Abundant phreatophytic vegetation is consistently located at the springs: grapevines, willows, cottonwoods, aethel trees, with rabbit brush, and mesquite flourishing in surrounding areas.
Spring (no name)

198/58 - 4bb
Q = 18.7 gpm
Temp. = 59°
Sp. Cond. = 533

This spring is hosted by Triassic-Jurassic, red and white sandstone. Refer to Willow Spring, page 92, for detailed description of geology, spring occurrence, and vegetation.

White Rock Spring

208/58 - 33aa
Q = 0.3 gpm
Temp. = 78°
Sp. Cond. = 690

All criteria similar to Willow Spring. Refer to page 92.

Pine Creek Spring

218/58 - 16bd
Q = 12.8 gpm
Temp. = 68.5°
Sp. Cond. = 505

Vegetation at the spring is very dense and thins out downwash. Consists of grapevines, tree mesquite and cottonwoods. Stratigraphic, and structural control of spring occurrence similar to Willow Spring, page 92.

Oak Creek Spring

218/58 - 21dd
Q = 14.2 gpm
Temp. = 64°
Sp. Cond. = 579

Refer to Willow Spring, page 92.
First Creek Spring

21S/58 - 33ac
Q = 1.3 gpm
Temp. = 61°
Sp. Cond. = 240

Refer to Willow Spring, page 92.

Sandstone Spring (Heart Spring)

22S/58 - 3bc
Q = 188 gpm (upper)
Q = 4.6 gpm (lower, Heart Spring)
Temp. = 62°
Sp. Cond. = 496

Refer to Willow Spring, page 92, for explanation of spring control.

Bonnie Springs

22S/58 - 3 dd, 2cc
Q = 61 gpm
Temp. = 67°
Sp. Cond. = 660

These springs conform to the structural control outlined for Willow Spring, page 92. The erosional cut which assists the location of this type of classified spring, occurs from Blue Diamond westward. The erosional draw localizing Lone Willow, Mormon Green Springs, Cottonwood, and Wheeler Camp Springs. There may be additional elevating of the water table mound in this particular locale by the reversal of relief by westerly dipping hogbacks-cuestas (?) of conformable lying basal and upper sections of the Moenkopi limestones, and the Kaibab limesone, respectively.

The exposure of these formations result from a thrust fault of relatively small throw occurring to the east of Blue Diamond and striking northsouth.
Vegetation is consistent with that described for Willow Spring, page 92, and is a dense growth of cottonwoods, mesquite, and willow trees, and large patches of meadow grass.

Point Spring

22S/58 - 10bb
Q = 0.1 gpm
Temp. = 69°

Refer to explanation given for Bonnie Springs, above.

Lone Willow Spring

22S/58 - 2ac
Q = dry

Refer to explanation given for Bonnie Springs, above.

Wheeler Camp Spring

22S/59 - 7bca
Q = standing water in a large cement reservoir.
Temp. = 68°

Vegetation is very lush and consists of cottonwoods, aspens, willows, mesquite trees, and grass (salt?).

For structural and stratigraphic situation, refer to Bonnie Springs, page 94, and Willow Spring, page 92.

Classified IIA2 and IIB2b2.
Cottonwood Spring

22S/59 - 7cb
Q = 4 gpm
Temp. = 69°

Refer to Bonnie Springs Explanation, page 94.

Norman Green Springs

spring 1) 22S/58 - 12bb
Q = 0.5 gpm
Temp. = 69.5°
2) 22S/58 - lcca
Q = dry, with standing water in some areas.

Refer to explanation cited for Bonnie Springs, page 94, and Willow Spring, page 92.

Indian Springs

22S/58 - lca
Q = 1.0 gpm
Temp. = 65°
Sp. Cond. = 755

Refer to Bonnie Springs, page 94.

Mud Spring

22S/58 - 14ca
Q = 0.3 gpm
Temp. = 67.5°
Sp. Cond. = 910

Hosted by alluvium, this spring has stratigraphic and structural control similar to that outlined for Bonnie Springs, page 94.
Spring (no name)

22S/58 - 23bca
Q = dry
Refer to Bonnie Springs, page 94.

Spring (no name)

22S/58 - 22ca
Q = standing water

Refer to Willow Spring, page 92. This spring is hosted by the red-white sandstone of the upper Triassic, with the well jointed Aztec formation exposed above.

Spring (no name)

22S/58 - 22ba
Q = 0.7 gpm
Temp. = 66.5°

Refer to Willow Spring, page 92.

Classified IIA2 and IIB2b2.

Ash Creek Spring

21S/58 - 1ab
Q = 1.9 gpm
Temp. = 70.7°
Sp. Cond. = 510

The spring is hosted by a red sandstone of Triassic age. Above or interbedded with this red sandstone is a tan to light gray sandstone. This clastic bed exhibits excellent examples of festoon crossbedding.

The spring occurs in an erosional draw and has a condition of discharge similar to that described for Willow Spring, page 97.
A normal fault located below the spring and striking north-south is believed to have very little effect on spring occurrence. It is suspected that faulting in this type of lithology does not prevent ground water movement, as in the case of impermeable fault planes described in the carbonates, but functions more as an avenue of discharge along which water would move.

Classified IIA2 and IIB2b2.

Spring (no name)

21S/58 - lac
Q = standing water

Refer to Ash Creek Spring for explanation, page 97.

Calico Spring

21S/58 - lac
Q = standing water

Same circumstance of discharge as outlined for Ash Creek Spring, page 97.

Red Spring

21S/58 - 7bb
Q = 11.6 gpm
Temp. = 68°
Sp. Cond. = 441

Conditions describing the control of spring occurrence for Ash Creek Spring, page 97, remains valid for this spring, with the larger discharge being accounted for by the potentiometric surface being slightly asymmetric in a southerly direction. This resulting from the topographic drainage of the area to the north, northwest and assistance offered by the fault described for Ash Creek Spring.

Classified IIA2 and IIB2b2.
Vegetation consisted of large willows, cottonwoods, and dense growths of mesquite and grass.

Mountain Springs

228/58 - 20 (west of half section)
springs 1) Q = 0.7 gpm  
Temp. = 67°
2) Q = 0.2 gpm  
Temp. = 63.5°
3) Standing Water
4) Q = 1.5 gpm  
Temp. = 60.5°
5) Q = 0.6 gpm  
Temp. = 67.5°
6) Q = 1.8 gpm  
Temp. = 63.5°
Sp. Cond. = 581

All the springs comprising this cluster are hosted directly by a small erosional depression filled by alluvium. Indirectly, the springs have as their source, the nonconformable contact of Goodsprings dolomite and Sultan limestone, the Ordovician and Silurian missing in the southern part of the Spring Mountains' stratigraphic column.

Structurally, the springs are located on a series of east-west striking normal faults and in the upper plate of the Keystone thrust. Two of the normal faults are older than the thrust, and are only exposed in the Jurassic and Triassic sandstone bluffs to the east. The other fault is younger and displaces the thrust.

The location of these springs is in essence a short summary of some of the theories put forth by this paper to explain spring occurrence. First, the springs are situated in an erosional depression which intersects an elevated water table band. Referring to the explanation given for Rainbow and Bootlegger Springs, page 54, the Goodsprings dolomite and underlying Keystone thrust is an ideal lithologic-structure combination for spring discharge, the siphon theory. In addition to this, the two normal faults, below the thrust would function to elevate the ground water mound by acting as aquifers (Ash Creek Spring, page 97), with
the fault displacing the Cambrian dolomite and serving to dam any ground water movement due to its impermeable nature (common occurrence in carbonates).

Classified IIB3a, IIB3e and IID2.

NOTE: Springs located in the southwestern portion of the area investigated were visited only in order to obtain chemical and discharge data. Because of time limitation, no geological information was obtained.

Tecopa Hot Springs

20N/7 - 33cd
Q = 170 gpm
Temp. = 108°
Sp. Cond. = 2600

Chemical analysis, page 106.

Beck Springs

20N/10 - 31ad
Q = 0.7 gpm
Temp. = 62°
Sp. Cond. = 521

Chemical analysis, page 106.

Horse Thief Springs

19N/10 - 6a
Q = 8.0 gpm
Temp. = 58°

Chemical analysis, page 106.

Crystal Springs

20N/10 - 24c
Q = 3.8 gpm
Temp. = 58°
Sp. Cond. = 591

Chemical analysis, page 106.
INSTRUMENTATION

METHODS, INSTRUMENTATION, AND RELATED THEORY

Three instruments were used to measure spring discharge:

1. The 'U' Notch Weir
2. Parshall Flume
3. Containers of known water volume or weight

The 'U' Notch Weir

A weir may be described as a structure that permits the flow of water over a contraction or notch (see figure 34) of known dimensions, and whose contraction adheres to a contingent formulated theory, that is, the contracting structure is a 90° notch cut into the downstream section, whose sides and bottom are steeper than the stream channel and whose downstream edges on each side of the crest and sides of the notch are beveled to a 45° angle. (refer to figure 4) This allows the water to spring clear of the downstream side.

Two sizes of 'U' notch weir were employed: One with a maximum crest height of 5", and the other, 12". With a maximum head, the 8" weir was capable of measuring approximately 400 gpm or 0.9 cfs. Under similar circumstances, the 12" weir had a measurement potential of approximately 900 gpm or 2.44 cfs.

For additional information of the theory of instrumentation, refer to King and Krater (1963). For a complete description of procedure of installation, other types of measuring devices, and complete tables of head-corrections, use the 1953 publication of the Nevada State Engineer's office.
INSTRUMENTATION

METHODS, INSTRUMENTATION, AND RELATED THEORY.*

Three instruments were used to measure spring discharge:

1. The 'V' Notch Weir
2. Parshall Flume
3. Containers of known water volume or weight.

The 'V' Notch Weir

A weir may be described as a structure that permits the flow of water through a contraction or notch (see figure 3), of known dimensions, and whose contraction adheres to a contingent formulated theory, that is, the contracting structure is a 90° notch cut into the damming edifice, whose sides and bottom are smaller than the stream channel and whose downstream edges on both the crest and sides of the notch are beveled to a 45° angle. (refer to figure 4) This allows the water to spring clear of the downstream side.

Two sizes of 'V' notch weir were employed. One with a maximum crest height of 8'', and the other, 12''. With a maximum head, the 8'' weir was capable of measuring approximately 400 gpm or 0.9 cfs. Under similar circumstances, the 12'' weir had a measurement potential of 1,118 gpm or 2.49 cfs.

* For additional information of the theory of instrumentation, refer to King and Brater (1963). For a complete description of procedure of installation, other types of measuring devices, and complete tables of head conversions, use the 1952 publication of the Nevada State Engineer's Office, H. Shamberger.
There are several formulae relating to the 'V' notch weir, all are a result of variations in the computation of the value of 'C' in the formula, $Q = CH^{5/2}$. This variable is the coefficient of contraction. (King, Brater, 1963, pp. 5-4)

The value of 'C' used in the measurement of the spring discharge was, 2.54, thereby resolving a formula for the sharp-crested, 90° notch weirs used:

$$Q = 2.5 H^{2.47}$$

or

$$Q = 2.5 H^{5/2}$$

**Parshall Flume**

The Parshall Flume is an instrument which uses the basic principle of the Venturi for free surface flow in open channels (see figure 5). This free flow condition exists when the elevation of the water surface near the downstream end of the throat section is not high enough to cause any retardation of flow due to backwater. The flume, in other words, is a trough with a free drop at the end and back into head. This is accomplished by allowing the water to flow up an inclined plane, the velocity being expended in the actual lifting of the water mass to a higher elevation. The effect of the converging sides of
the trough section is to increase the velocity through the narrow section, thus insuring over a greater range, velocities higher than the critical value, and therefore, a flow through the opening independent of back-water conditions. (Parshall, R. L., 1926, pp. 841)

The Parshall Flumes used to measure the southern Nevada spring discharge were of the 9 inch throat type, and were previously implanted at Big Spring and Manse Ranch.

The empirical formula for the flume is

\[ Q = 3.9WH_a^{1.58} \]

\( H_a \) is the head measured at the upper stilling well. When the ratio of the \( H_a:H_b \), (\( H_b \), the lower head) exceeds 60\%, a correction for submergence must be made, this correction of the computed discharge being graphically obtained from the Nevada State Engineer's Office Publication, H. Shamberger, pp. 55-59.

Containers of known water volume or weight

This was the most widely used media, principally because of its simplicity and accuracy in measuring small discharges.

A five gallon container, when timed, produced the following results:

\[ \frac{5 \text{ gal}}{60 \text{ sec}} = \frac{x \text{ gal}}{x \text{ sec}} \]

ex. If it required 6 sec. to fill the 5 gal. container, then the resultant discharge would be on the order of 50 gpm.
The other device employed, used the principal of known water weight:

\[
\frac{\text{lb/sec}}{62.4} = \text{cfs} \times 440 = \text{gpm}
\]

ex. The known water weight for this smaller container was 6.4 lbs. Therefore, if it required 6 sec. to fill the receptacle, then the computed discharge was 7.7 gpm.
### CHEMICAL ANALYSIS OF SPRINGS AND WELLS

<table>
<thead>
<tr>
<th>Sample</th>
<th>pH</th>
<th>Ca</th>
<th>Mg</th>
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<th>Fe</th>
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<th>Cl</th>
<th>SO₄</th>
<th>NO₃</th>
<th>PO₄</th>
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*Note: Data represents various chemical compositions of springs and wells.*
Table

CHEMICAL ANALYSIS OF SPRINGS AND WELLS

(Analyses were done by varied sources.)

Refer to Maxey and Jameson, 1948, Walker and Eakin, 1963

<table>
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<tr>
<th>Well or Spring location</th>
<th>Name of spring or well</th>
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<th>TDS</th>
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<th>Fe</th>
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* All specific conductance values calculated during 1964, J.L.H.
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