RECONNAISSANCE GEOTHERMAL RESOURCE ASSESSMENT OF 40 SITES IN CALIFORNIA

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MASTER

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CALIFORNIA DEPARTMENT OF CONSERVATION DIVISION OF MINES AND GEOLOGY

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RECONNAISSANCE GEOTHERMAL RESOURCE ASSESSMENT
OF 40 SITES IN CALIFORNIA

Report of the Third Year, 1980-81 of the
U.S. Department of Energy--California State-Coupled Program

for

Reservoir Assessment and Confirmation

By

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Under the direction of
C. Forrest Bacon

1981

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INTRODUCTION

This report sets forth the results of the Phase I portion of the 1980-81 Geothermal Resource Assessment Program of the California Division of Mines and Geology. Phase I is a continuing reconnaissance-level assessment of promising geothermal sites scattered throughout California. Phase I studies involve acquisition of new data based upon field observations, compilation of data from published and unpublished sources, and evaluation of the data to identify areas suitable for more intensive area-specific Phase II studies.

The objective of the Phase I studies is to obtain and publish pertinent information on as many as possible of the known occurrences of natural hot springs and thermal wells in California, as well as on selected oil, gas, and water wells in the state that appear to have reasonable potential for development as a geothermal resource. The goal is to identify and evaluate those hot springs and wells that have a strong potential for development into significant sources of useable energy.

In general, the factors that indicate usefulness of a hydrogeothermal source are: temperature, flow rate, life expectancy of the source, chemical composition of the steam or water, accessibility to a viable market, cost of developing the source and delivery system for the steam or water, and environmental concerns. These and related factors need to be measured and evaluated for all of California's low and moderate temperature geothermal occurrences in order to provide an assessment of California's geothermal resources.

Detailed area investigations are conducted under Phase II studies. These investigations include geological, geohydrological, geochemical, and geophysical studies including deep resistivity, gravity, microacoustics, and heat flow. They also include analysis and interpretation of the findings of these studies for application by potential geothermal resource users. Aquifer testing studies may be conducted if deemed desirable by the Department of Conservation and Lawrence Berkeley Laboratories. Phase II investigations have been or are being conducted in Bridgeport, Paso Robles, San Bernardino, Los Angeles, Calistoga, and in areas of the Sonoma Valley.

This report presents the findings of the 1980-81 Phase I studies of 40 sites in California that were selected for evaluation of their potential for development into sources of useable energy. The following specific tasks were conducted for each of these sites:

1. Review of the literature for information concerning the stratigraphy, hydrology, structure, hydrothermal alteration, geothermal heat, and history of the site.
2. On-site evaluation of geology.
3. Springs or wells at each site were located on maps.
4. Measurement of well and spring water temperatures.
5. To the extent feasible, geothermal gradients of existing wells were measured.
6. Samples of water from a representative well or spring at the site were collected and sent to the University of Utah Research Institute for analysis.

SITE SELECTION CRITERIA

The 40 sites chosen for Phase I study during 1980-81 were selected on the basis of their relative potential for development as a significant resource. The following guidelines were used in determining this potential:

Principal Criteria.

- o Available information concerning temperature, purity of steam or water, rate of flow, areal extent of the resource, surface phenomena, subsurface phenomena, etc., indicates that the site may be developed into a relatively significant resource.
- o Site is close to a population center.
- o Site is close to an agricultural or industrial operation that could use the energy or there is evidence of commercial or other need for the energy in the area.
- o No recent or thorough studies of the site have been made that are available to the public.
- o The site is not within or near a Known Geothermal Resource Area (KGRA). However, if the site is in or peripheral to a KGRA that has not been adequately explored, or if the site shows potential only for direct heat use (rather than for the generation of electricity) then it will be considered.

Secondary Criteria.

- o The occurrence is of general scientific interest and study of it may improve our understanding of other geothermal occurrences.
- o The site's proximity to a major transportation facility could encourage the development of an industrial or agricultural plant. As a consequence energy demand could be relieved elsewhere.
- o The site is owned by the State and may be a source of energy that could be developed for State uses.
- o Local interest and support for development of the resource exists.
- o Local, state, or federal government interest in developing the resource exists.
- o Industry interest in developing the resource.

EXPLANATION OF SECTION HEADINGS AND DATA PRESENTED

Scope of Reports

SYNOPSIS: The purpose of the synopsis is to provide a brief abstract of the contents of the report.

GEOHERMAL FEATURES: The purpose of the geothermal features section of each report is to present what we know about the source of the hot water and the extent of the resource.

CHEMISTRY: In most of the site reports contained herein, the chemistry section consists solely of a table which presents the results of our water analyses. In a few cases, more complete explanations are attempted. The following discussion presents a more detailed explanation of the methods used in analysis of the water.

The tables provided in each of the reports show the elements and concentrations that were recorded for the indicated water sample. The element names are provided below. The elemental concentrations were measured in parts per million (ppm) of the total. Concentration values preceded by the "less than" symbol (<) indicate that the concentration is less than the lowest detectable concentration limits.

	<u>ELEMENT</u>	<u>CONCENTRATION (PPM)</u>
EXAMPLE 1:	Ni	<0.125
EXAMPLE 2:	Zn	45

Example 1 states that the nickel concentration is less than 0.125 ppm, which is the lowest detectable concentration of nickel possible by the methods used in this analysis. In fact, the nickel concentration may be zero or non-existent in this sample. A list of the lowest detectable elemental concentration limits is provided below. In example 2, the zinc concentration is 45 ppm.

The cation (positively charged ion) analyses were performed at the Earth Science Laboratory of the University of Utah Research Institute (UURI) in Salt Lake City. Cations include sodium (Na) to thorium (Th). The cation concentrations were measured on an Inductively Coupled Plasma Spectrometer. UURI also analyzed two anions (negatively charged ions): chloride (Cl) and fluoride (F). Chloride concentration was measured by the Mohr titration method; fluoride concentration was determined by a specific ion meter.

Carbonate (CO_3), bicarbonate (HCO_3), sulfate (SO_4), and Total Dissolved Solids (TDS) concentrations were determined at the Geochemical Laboratory of the California Division of Mines and Geology (CDMG) at San Francisco by standard geochemical laboratory techniques. The corrected TDS values are recalculations of the total dissolved solids values incorporating corrections based on the amount of bicarbonate present in the sample.

Temperature, pH value, salinity, and specific conductance measured in micromhos per centimeter ($\mu\text{mhos/cm}$) were measured in the field by CDMG staff using thermometers, a pH meter (Orion Instruments Ionalyser/model 407A), a Salinity-Conductivity-Temperature meter (Yellow Springs Instrument Co., model 33 S-C-T Meter). Sulfide and ammonia concentrations were measured in the field using a portable spectrophotometer (Bausch and Lomb Spectronic mini 20).

<u>ELEMENT SYMBOL</u>	<u>ELEMENT NAME</u>	<u>LOWEST DETECTABLE ELEMENTAL CONCENTRATION (PPM)</u>	<u>ELEMENT SYMBOL</u>	<u>ELEMENT NAME</u>	<u>LOWEST DETECTABLE ELEMENTAL CONCENTRATION (PPM)</u>
Na	Sodium	1.25	Ag	Silver	0.050
K	Potassium	2.50	Au	Gold	0.100
Ca	Calcium	0.25	As	Arsenic	0.625
Mg	Magnesium	0.500	Sb	Antimony	0.750
Fe	Iron	0.025	Bi	Bismuth	2.50
Al	Aluminum	0.625	U	Uranium	6.25
Si	Silicon	0.250	Te	Tellurium	1.25
Ti	Titanium	0.125	Sn	Tin	0.125
P	Phosphorus	0.625	W	Tungsten	0.125
Sr	Strontium	0.013	Li	Lithium	0.05
Ba	Barium	0.625	Be	Beryllium	0.005
V	Vanadium	1.25	B	Boron	0.125
Cr	Chromium	0.050	Zr	Zirconium	0.125
Mn	Manganese	0.250	La	Lanthanum	0.125
Co	Cobalt	0.025	Ce	Cerium	0.250
Ni	Nickel	0.125	Th	Thorium	2.50
Cu	Copper	0.063	Cl	Chloride	2.00
Mo	Molybdenum	1.25	F	Fluoride	0.10
Pb	Lead	0.250	CO_3	Carbonate	0.30
Zn	Zinc	0.125	HCO_3	Bicarbonate	0.10
Cd	Cadmium	0.063	SO_4	Sulfate	10.00

GEOLOGY: The purpose of the geology section is to discuss briefly the geology of the site. The discussions generally begin with a broad description of the regional geology, including the major fault features in the area, and then present a more site specific discussion of the geology that is present locally.

HISTORY: The purpose of the history section is to provide a brief description of the prior uses of the spring or well at this location. While it is not a complete history, it does serve the purpose of summarizing the prior uses of this resource.

RECOMMENDATIONS FOR MORE DETAILED STUDY

Based on 1980-81 Phase I investigations, the following areas, listed below, are recommended for more detailed Phase II type studies. These areas are not presented in any particular order of priority.

1. Elsinore - water temperatures range from 40°C to 56°C. Area of interest extends from Glen Ivy (RV-1) on the north to Murrieta Hot Springs (RV-25) on the south, a distance of some 40 km. Many faults, including the Elsinore fault zone, provide a likely conduit for upwardly migrating thermal water.
2. Tecopa - lots of warm water -- 32°C at Shoshone on the north to 48°C near Tecopa. This world famous hot spring area is being developed by a number of local entrepreneurs. The large number of tourists using the hot springs has created a demand in the area for more facilities. The geothermal resource should be

studied prior to full-scale development in order to provide an assessment of the geothermal-hydrologic resource potential for planning purposes.

3. Twentynine Palms - many warm water wells (53°C to 48°C from Geothermal Resource Map) indicate that an extensive warm water aquifer underlies the City of Twentynine Palms and an area to the north of the city between the Marine Corps base and the city.

The reader should note that the areas recommended for further study are selected from the group of geothermal sites presented in this report. These are not the only areas that may be suitable for further, more intensive, study. Under different economic and technological conditions, other areas may become favorable for geothermal development.

Additionally, it is not intended that study of geothermal sites not recommended herein be excluded. The recommended sites share common characteristics of:

1. Potential for use by a large number of consumers (district heating for example);
2. Large volume of water; and
3. The resource is believed to underlie a large area thus increasing the chance that a significant economic geothermal resource exists.

Smaller sites may lend themselves to very favorable economic development of the geothermal resource on a smaller scale such as for agricultural use or for space heating the facilities of a spa/resort.

ACKNOWLEDGMENTS

We wish to thank the owners and managers of the properties that we visited during this study. Their help and cooperation during the field phase of this investigation was a valuable asset to this project.

Special thanks are in order for Patty Gouvea and the staff of the Department of Conservation Word Processing Center for typing the manuscript, to Louise Huckaby who prepared the illustrations in this report, and to Emily Kishi, Geologic Aid, who assembled the tables, prepared some of the topographic profiles, and performed some of the very necessary, but time consuming, chores essential to this project.

SITE REPORTS

NAME: Agua Caliente Spring (RV-29)

LOCATION: 33°49.50'N; 116°32.68'W

T4S, R4E, Sec. 14 (SBB&M)

Riverside County; located in downtown Palm Springs.

QUADRANGLE: Palm Springs 7.5'

SYNOPSIS: Warm water at Agua Caliente Spring rises through more than 183 m of alluvium. An uncemented chimney composed of sandy silty clay provides a conduit for the 41°C water. Flow rate is unknown. These warm springs have been used for balneological purposes since prehistoric times. Currently the site, leased from the Agua Caliente Tribe, includes a large hotel and mineral bath resort (photo 1). The subsurface quantitative extent of the resource is not known but the low temperature of this spring and the lack of other warm springs in this area suggests that the geothermal resource may be relatively small.

GEOHERMAL FEATURES: Warm water at Agua Caliente Spring rises through more than 183 m of alluvium (Dutcher and Bader, 1963). The thermal property of the water is probably due to deep circulation of meteoric water. Rainfall on the eastern slopes of the San Jacinto Mountains very likely percolates, along fractures, toward the east. At depth the water intersects the Palm Canyon fault, which provides an easy access for warm water to rise. Although the fault trace is concealed at the surface by alluvium (figure 1), an uncemented chimney composed of sandy silty clay provides a conduit for the warm water through the alluvium (Dutcher and Bader, 1963).

The quantitative extent of the geothermal resource at Agua Caliente Spring is unknown. It is possible that the quantity of thermal water could be increased by drilling in the area of the

Photo 1. Agua Caliente Spring (Palm Springs). The hot spring is visible by looking into the cylindrical object in front of the stone wall in the center of the photo. The warm water is used in the Palm Springs Spa resort. All the buildings visible here are part of the resort complex. Photo by E. Leivas.

- Qa** Quaternary alluvium.
- Qc** Quaternary channel deposits.
- Qf** Quaternary alluvial fan deposits.
- bc** PreTertiary basement complex.
- Contact, approximately located.
- ... Fault, concealed trace.

Figure 1. Map and section showing geology around Agua Caliente Spring, Riverside County. Both figures from Dutcher and Bader (1963).

spring and pumping the water; however, this should be undertaken with a great amount of caution as the chimney deposit could be damaged (Dutcher and Bader, 1963), thus possibly depleting the resource at its present location.

CHEMISTRY: See table 1, page 14.

GEOLOGY: Agua Caliente Spring is located at the northeast edge of the Peninsular Ranges Geomorphic Province. The San Jacinto Mountains form an impressive backdrop to the city of Palm Springs, which is located on the desert floor east of San Jacinto Peak.

The active San Andreas fault system has greatly influenced the structural geology and topography of this region. In this area the San Andreas fault consists of several different faults. The Banning fault, part of the fault system, is located approximately 10 km north of this site. The Mission Creek fault, also a part of the San Andreas fault system, is located about 16 km to the north of this site. The town of Desert Hot Springs with its many thermal wells is located on the Mission Creek fault. Several other faults of Pre-Quaternary age occur in this area (Jennings 1975).

A granite-gneiss (Fraser, 1931) or Pre-Cretaceous metamorphic rock (Rogers, 1963) complex underlies the lower slopes of the San Jacinto Mountains west of the city of Palm Springs. San Jacinto Peak, further west, is composed of granite and granitic rocks.

Subsurface material in the immediate area of Agua Caliente Spring is Quaternary alluvium (figure 1). These sedimentary deposits were extensively studied by Dutcher and Bader (1963) in an investigation of the Agua Caliente Spring.

While there is general agreement as to the occurrence of the different rock types located on the surface, there are different

Table 1

SITE NAME: Agua Caliente Spring (RV-29)

LOCATION: 33° 49.50'N; 116° 32.68'W
T4S, R4E, Section 14 (SBB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>	
Element	Concentration (ppm)
Na	56
K	3
Ca	3
Mg	1
Fe	0.05
Al	< 0.625
Si (As SiO ₂)	37
Ti	< 0.125
P	< 0.625
Sr	< 0.013
Ba	< 0.625
V	< 1.25
Cr	< 0.050
Mn	< 0.250
Co	< 0.025
Ni	< 0.125
Cu	< 0.063
Mo	< 1.25
Pb	< 0.250
Zn	< 0.125
Cd	< 0.063
Ag	< 0.050
Au	< 0.100
As	< 0.625
Sb	< 0.750
Bi	< 2.50
U	< 6.25
Te	< 1.25
Sn	< 0.125
W	< 0.125
Li	< 0.050
Be	< 0.005
B	0.1
Zr	< 0.125
La	< 0.125
Ce	< 0.250
Th	< 2.50
Cl	26
F	2.2

<u>CDMG FIELD ANALYSIS</u>	
Chloride.....	< 139 ppm
Sulfate.....	_____ ppm
Sulfide.....	0.34 ppm
Nitrogen (Ammonia).....	1.4 ppm
Alkalinity (as CaCO ₃)....	_____ ppm
Salinity (percent).....	Trace
pH.....	9.1
Electrical Conductivity	
at _____ °C.....	310 µmho/cm

<u>CDMG LAB ANALYSIS</u>	
Carbonate.....	34.50 ppm
Bicarbonate.....	32.03 ppm
Sulfate.....	26.05 ppm
Corrected TDS.....	207 ppm

<u>OTHER DATA</u>	
Date of Site Visit.....	6-30-81
Ambient Temperature.....	38°C
Surface Temperature	
of Water.....	41°C
Flow Rate or Capacity....	
Field Investigator.....	Leivas

interpretations of the faulting along which the Agua Caliente Springs rise.

Fraser (1931) suggested that the Palm Canyon fault extends to the north along the eastern edge of the San Jacinto Mountains and provides the fracture along which the warm water rises.

Dutcher and Bader (1963) show a northwest-southeast trending fault across the northerly entrance to Palm Canyon. The fault is believed to offset the basement rocks which underlie the alluvium in this area (figure 1). The trace of the fault was arbitrarily placed under the location of the spring (Dutcher and Bader, 1963). They do not show a north-south trending fault in Palm Canyon on their geologic map.

Rogers (1965) shows the Palm Canyon fault trending north-south in Palm Canyon and continuing to the north concealed by the alluvium.

Jennings (1975) shows the trace of a north-south trending fault concealed under alluvium and located along the eastern side of the San Jacinto Mountains. This fault is shown as a thrust in Palm Canyon.

Locally the warm "spring water probably rises through a washed-sand conduit of its own making; the spring water in the sand-filled orifice is confined laterally by poorly permeable sandy silty clay that was also deposited or reworked by the spring water" (Dutcher and Bader, 1963). Dutcher and Bader (1963) also report that "the spring orifice is not surrounded near the surface by a cemented chimney of any type". Depth to the ground water table, in the surrounding area in 1958, was in excess of 61 m.

HISTORY: The following quote from a Riverside County Historical Marker, RIV-025, summarizes the history of Agua Caliente Spring: "Warm water here was the site of SE-KHE (boiling water), important village of the Kawasic Cahuilla Indians. The Spanish called it 'Aqua Caliente' (hot water). A stage station of that name operated here from 1862 to 1876. As early as 1871 the Indians operated a bath house for tourists and the site still is tribally owned. Because of the surrounding native palm trees, it was later called 'Palm Springs'."

Currently, Palm Springs Spa, Inc. leases the site from the Agua Caliente Tribe and operates a large resort including, hot mineral baths, swimming pool, and a large, modern hotel. The water is collected at the spring, then pumped to two 189,251 liter (50,000 gallon) storage tanks. All the spring water used by the resort comes from these tanks. There is no bypass for direct use of hot, spring water; therefore, prior to use in the hot mineral baths, the water must be reheated to 39°C. The resort management is investigating the use of heat pumps to capture and use heat from the water.

NAME: Agua Caliente Springs (SN-10)

LOCATION: 38°19.32'N; 122°29.26'W

T6N, R6W, Sec. 35 (MDB&M)

Sonoma County; 4.3 km northwest of Sonoma.

QUADRANGLE: Sonoma 7.5'

SYNOPSIS: Agua Caliente Springs resort, which currently consists of a swimming pool and picnic grounds, is supplied with water from two wells at Agua Caliente resort and from one well at Fetters Hot Springs resort. The wells at Agua Caliente are all about 91.4 m deep and provide 35°C water. Capacity of the sampled well is 1022 liters per minute. A warmer-than-normal geothermal gradient related to the fault postulated by Jennings (1975) is probably the source of heat for the water in this area.

The occurrence of other warm springs (wells) nearby, coupled with the proximity to a subsurface structural feature (fault?) along which the warm water sources align, suggests that a viable geothermal resource may exist. Further study is recommended.

GEOHERMAL FEATURES: Warm water at Agua Caliente Springs is pumped to the surface from a warm water aquifer bounded on the east by an unnamed fault. The fault acts as a groundwater barrier preventing the influx of percolating cooler surface runoff from the mountains on the eastern side of the valley. The source of heat for the water is probably related to deep seated circulation of percolating groundwater and upward migration of the warm water along a fault.

CHEMISTRY: See table 2, page 18.

GEOLOGY: Agua Caliente Springs is located in Sonoma Valley, which is within the Coast Ranges Geomorphic Province. Northwest-southeast trending Sonoma Valley is bounded on the east and west sides by

Table 2

SITE NAME: Agua Caliente Springs (SN-10)

LOCATION: 38° 19.32'N; 122° 29.26'W
T6N, R6W, Section 35 (MDB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	95	Chloride.....	< 139 ppm
K	9	Sulfate.....	_____ ppm
Ca	12	Sulfide.....	0.01 ppm
Mg	2	Nitrogen (Ammonia).....	1.6 ppm
Fe	0.45	Alkalinity (as CaCO ₃)....	_____ ppm
Al	< 0.625	Salinity (percent).....	0.2
Si (As SiO ₂)	68	pH.....	6.8
Ti	< 0.125	Electrical Conductivity	
P	< 0.625	at 31°C.....	750 µmho/cm
Sr	0.04		
Ba	< 0.625	<u>CDMG LAB ANALYSIS</u>	
V	< 1.25	Carbonate.....	- ppm
Cr	< 0.050	Bicarbonate.....	181.48 ppm
Mn	< 0.250	Sulfate.....	<10.00 ppm
Co	< 0.025	Corrected TDS.....	426 ppm
Ni	< 0.125		
Cu	< 0.063	<u>OTHER DATA</u>	
Mo	< 1.25	Date of Site Visit.....	7-21-81
Pb	< 0.250	Ambient Temperature.....	20°C
Zn	< 0.125	Surface Temperature	
Cd	< 0.063	of Water.....	35°C
Ag	< 0.050	Flow Rate or Capacity....	1022 l/m
Au	< 0.100	Field Investigator.....	Leivas
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sb	< 0.125		
W	< 0.125		
Li	0.42		
Be	< 0.005		
B	3.4		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	142		
F	2.8		

mountains underlain by rocks of the Pliocene Sonoma Volcanics (figure 2). Quaternary alluvium and older fan deposits underlie this portion of the valley. The Rogers Creek fault, part of the San Andreas transform fault system, is located 9 km to the west. Jennings (1975) shows several other faults in the area. Last movement on these faults is shown to be Pre-Quaternary.

Jennings (1975) and Huffman and Armstrong (1980) postulate the existence of a fault trending parallel to the valley and located approximately in this area (within tens of meters to the east). A more detailed investigation is needed to better define the hydrology and the location of the fault of this area.

HISTORY: Originally, the hot spring here was used by the Indians.

According to the present owner, Agua Caliente Springs has operated continuously since May 5, 1887. Waring (1915) reported that in 1909, Agua Caliente was a resort with hotel and cottages for about 300 people. Water from these wells was bottled and marketed. Water for the resort was supplied from "five flowing wells" about 91.4 m (300 feet) deep with temperatures ranging from 97°F (36°C) to 108°F (42°C). Hamilton (1915) noted that six wells had been drilled by 1914. Water temperature measured in the swimming pool was 102°F (39°C).

In 1950, the resort was purchased by the present owner. The grounds were cleared, trees planted, and the mud baths removed. Currently, the owners operate a day-use area and the original swimming pool, which is filled from three wells, on the Agua Caliente property. Water from Feters Hot Springs property, now owned by the same people who own Agua Caliente Springs, is also used to fill the swimming pool.

Figure 2. Map and section of geology around Agua Caliente Springs and Fethers Hot Springs, Sonoma County. Geologic map modified from Huffman and Armstrong (1980).

NAME: Avila Hot Springs (SL-12); formerly called Ontario Hot Springs

LOCATION: 35°10.85'N; 120°42.10'W

T31S, R12E, Sec. 32 (MDB&M)

San Luis Obispo County; 11 km south of San Luis Obispo.

QUADRANGLE: Pismo Beach 7.5'

SYNOPSIS: The warm water at Avila Hot Springs comes from one artesian well producing 189.3 liters per minute of 55°C water. The warm water is used for bathing and, by means of heat exchangers, for space heating. Natural gas, also produced from the same well, is separated and collected at the well head for use on the premises. The extent of the geothermal resource is not known, but the heat source may somehow be associated with the petroleum resources of this area.

GEOHERMAL FEATURES: An artesian well, flowing at 189.3 liters per minute, has produced 55°C water here since 1907. An oil exploration well drilled here in 1907 discovered hot "mineral" water at approximately 274 m depth. Drilling continued to 609 m. The artesian flow brings up occasional 2 mm diameter flakes of tar. The drill hole penetrates the south limb of an east-west trending syncline. Under favorable conditions, a synclinal structure produces an artesian water system. This may be the case here. The extent of the resource is not known; however, the geology of the area suggests that further investigation may be worthwhile.

CHEMISTRY: See table 3, page 22.

Table 3

SITE NAME: Avila Hot Springs (SL-12)

LOCATION: 35° 10.85'N; 120° 42.10'W
T31S, R12E, Section 32 (MDB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	170	Chloride.....	< 139 ppm
K	25	Sulfate.....	_____ ppm
Ca	31	Sulfide.....	_____ ppm
Mg	26	Nitrogen (Ammonia).....	_____ ppm
Fe	< 0.025	Alkalinity (as CaCO ₃)....	_____ ppm
Al	< 0.625	Salinity (percent).....	0.5
Si (As SiO ₂)	55	pH.....	7.2
Ti	< 0.125	Electrical Conductivity	
P	< 0.625	at 28°C.....	1450 µmho/cm
Sr	0.57		
Ba	< 0.625		
V	< 1.25		
Cr	< 0.050		
Mn	< 0.250		
Co	< 0.025		
Ni	< 0.125		
Cu	< 0.063		
Mo	< 1.25		
Pb	< 0.250		
Zn	< 0.125		
Cd	< 0.063		
Ag	< 0.050		
Au	< 0.100		
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sb	< 0.125		
W	< 0.125		
Li	< 0.050		
Be	< 0.005		
B	1.1		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	34		
F	0.7		

<u>CDMG LAB ANALYSIS</u>	
Carbonate.....	- ppm
Bicarbonate.....	706.08 ppm
Sulfate.....	<10.00 ppm
Corrected TDS.....	691 ppm

<u>OTHER DATA</u>	
Date of Site Visit.....	7-06-81
Ambient Temperature.....	22°C
Surface Temperature of Water.....	55°C
Flow Rate or Capacity....	189.3 l/m
Field Investigator.....	Leivas

GEOLOGY: Avila Hot Springs is located in the Coast Ranges Geomorphic Province. The geologic structure of this region has been strongly influenced by the tectonics associated with the northwesterly trending San Andreas fault system located 65 km to the northeast. Several other major faults located between this site and the San Andreas fault zone have also probably left their mark on the structural-geologic picture of this area. The Hosgri fault is located 15 km southwest of this site.

The fault nearest to this site is a reverse fault located about 0.5 km west of the site; relative movement is up on the west block (Hall, 1973).

Avila Hot springs well is located along San Luis Creek (photo 2) approximately 300 m from Highway 101 north of Pismo Beach. San Luis Creek is underlain by Quaternary alluvium which is in turn underlain by moderately dipping beds of the Miguelito Member of the Pismo Formation (figure 3). The well has been bored through beds of the south limb of an east-west trending syncline (Hall, 1973), to a depth of 609 m.

Interpretation of geologic map and section from Hall (1973), indicates that the bore hole passed through the Edna Member of the Pismo Formation, which locally contains clasts of oil-bearing vesicular dacite. Flakes of oil up to 2 mm in diameter contained in the hot water support this theory.

HISTORY: Avila Hot Springs began as an exploration well for oil, drilled in 1907. Hot "mineral" water was discovered at 274 m depth. According to a brochure available from the present resort

Photo 2. Avila Hot Springs. The well is located approximately under the small tower with the shuttered arches in the right center of the photo. The hillside on the left side of the photo (north) is underlain by the Pismo Formation. The flat area in front of the resort is underlain by Qal. At depth the well probably penetrates the Monterey Formation. Photo by E. Leivas.

Figure 3. Map and section of geology around Avila Hot Springs (Ontario Hot Springs), San Luis Obispo County. Generalized from Hall (1973).

owners, the well had an artesian flow of warm water at 130°F (55.5°C) in 1907. Laizure (1925) listed a temperature for the water as 178°F (81°C).

The original bath house and the 15.2 m by 30.5 m swimming pool, built circa 1908, are still in use. Additions to the facilities include a Recreational Vehicle (RV) Park and a 6.1 m by 6.1 m hot tub. The fresh swimming pool water is heated by the water from the well.

The warm water is also used for radiant heat in the shower/change rooms in the RV Park. Natural gas is separated and collected at the well head and used on the premises.

NAME: Bainter Spring (IN-14)

LOCATION: 35°50.57'N; 117°22.90'W

T24S, R43E, Sec. 18 (MDB&M)

Inyo County; 8 km north of Trona.

QUADRANGLE: Trona 15'

SYNOPSIS: Bainter Spring at 24°C is not a warm water spring! This site has been listed as having a water temperature of 33°C in 1955, but a temperature measurement one year later produced a value of 23°C. Most likely the first measurement was a typographical error since the CDMG measurement in 1981 gave a temperature of 24°C. Bainter Spring should be disregarded as a low-temperature geothermal site.

GEOHERMAL FEATURES: The temperature of the water at Bainter spring was 24°C with an ambient temperature of 27°C on the date of the site visit. Jennings (1975) shows a fault extending northwesterly from this site. Although there is no obvious evidence to indicate that this fault is active, the spring activity is most likely associated with the faulting.

CHEMISTRY: See table 4, page 28.

GEOLOGY: Bainter Spring is located in the Argus Range within the Basin and Ranges Geomorphic Province. The nearest fault that shows evidence of activity in the last two million years is the Wilson Canyon fault (Jennings, 1975) located approximately 4 km to the south. The well known east-west trending Garlock fault zone is located 35 km south of the site and the north-south trending

Table 4

SITE NAME: Bainter Spring (IN-14)

LOCATION: 35° 50.57'N; 117° 22.90'W
T24S, R43E, Section 18 (MDB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	30	Chloride.....	< 139 ppm
K	< 2.50	Sulfate.....	22 ppm
Ca	43	Sulfide.....	ppm
Mg	7	Nitrogen (Ammonia).....	0.35 ppm
Fe	0.06	Alkalinity (as CaCO ₃)....	80 ppm
Al	< 0.625	Salinity (percent).....	0
Si (As SiO ₂)	38	pH.....	6.0
Ti	< 0.125	Electrical Conductivity	
P	< 0.625	at 26°C.....	320 µmho/cm
Sr	0.30		
Ba	< 0.625		
V	< 1.25		
Cr	< 0.050		
Mn	< 0.250		
Co	< 0.025		
Ni	< 0.125		
Cu	< 0.063		
Mo	< 1.25		
Pb	< 0.250		
Zn	1.0		
Cd	< 0.063		
Ag	< 0.050		
Au	< 0.100		
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sb	< 0.125		
W	< 0.125		
Li	< 0.050		
Be	< 0.005		
B	0.4		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	44		
F	0.6		

<u>CDMG LAB ANALYSIS</u>	
Carbonate.....	- ppm
Bicarbonate.....	114.38 ppm
Sulfate	29.27 ppm
Corrected TDS.....	250 ppm

<u>OTHER DATA</u>	
Date of Site Visit.....	5-14-81
Ambient Temperature.....	27°C
Surface Temperature of Water.....	24°C
Flow Rate or Capacity....	0.8 l/m
Field Investigator.....	Leivas

Panamint Valley fault zone is located 18 km to the east. Locally, a northwest trending, unnamed fault is located close to the spring (Jennings and others, 1962).

Quartz-monzonite is the predominate rock type in this area (figure 4). The quartz-monzonite exhibits jointing which trends N48E. The immediate area of the spring is underlain by a greenish-grey, weathered diorite. The highly weathered diorite is fractured but does not exhibit any preferred jointing direction.

Faulting in the immediate area of the spring appears to be connected to the diorite intrusion; however, the exact relationship was not obvious from this brief visit. Bainter Spring issues in the diorite outcrop area; however, the spring is really more of a seep.

HISTORY: The water has probably been used to fill water tanks located at the canyon mouth 3.2 km to the east. Apparently, the water was conducted through an abandoned 5.1 cm iron pipe.

Directly downslope, about 50 meters, is an adit. The prospector(s) who dug the adit probably drank the water. Currently the Bureau of Land Management maintains the spring for watering of the resident fauna. The temperature recorded in 1955 was 33°C, in 1956 it was 23°C, and in 1981 it was 24°C.

The conclusion presented here, supported by discussions with local residents, is that this spring has been erroneously listed as warm on the Geothermal Resources Map of California from data found in California Department of Water Resources Bulletin 91-17.

EXPLANATION

- Qd Quaternary deposits composed of sand, silt, lake deposits.
- pTb PreTertiary basement composed of igneous, metamorphic, sedimentary and metavolcanic rocks.
- Contact, dashed and queried where inferred.
- Fault, dashed where inferred.

LOCATION MAP

Figure 4. Map and section of geology around Bainter Spring, Inyo County. Geologic map simplified from Moyle (1969).

NAME: Bassett Hot Springs (LS-4)

LOCATION: 41° 08.70'N; 121° 06.65'W

T38N, R7E, Sec. 12 (MDB&M)

Lassen County; 3 km northeast of Bieber.

QUADRANGLE: Bieber 15'

SYNOPSIS: The area that extends about a kilometer northwest from and including Bassett Hot Springs is underlain by an important resource. A flow rate of 200 liters per minute of 79°C water was measured. The temperature of the spring has been consistent during this century, although the flow rate may have decreased. Geothermometers suggest reservoir temperatures of about 90° to 100°C. The water quality of the spring is fair except for excessive concentrations of fluoride, boron, sodium, and sulfate. These elements may be detrimental to agricultural or domestic use of the water.

The resource is ideally situated for possible applications either at the site or in Bieber. The nearby lumber mill could make extensive use of the hot water. The location of the resource both astride State Route 299 and 7 km from the Western Pacific Railroad at Nubieber is excellent for transportation of any product from the site.

GEOHERMAL FEATURES: Bassett Hot Springs rises from several orifices along a vertical fracture about 10 m long in horizontal beds of moderately consolidated tuffaceous sandstone (photo 3). The fracture trends N2W and is in the northwest corner of a shallow pond, which is about 25 m by 30 m and occupies a small topographic

Photo 3. Bassett Hot Springs. Vertical fracture in flat-lying tuffaceous sandstone along which the spring discharges at several points (trend of fracture is N2W). At top of photo is intake pipe for pump, which supplies water for domestic use. Wash tub and gallon-size container for scale. Photo by C. Higgins.

Photo 4. Pool into which Bassett Hot Springs discharges. The spring rises near the pumphouse at the edge of the pool. Photo by C. Higgins.

depression (photo 4). A faint odor of H_2S is present, and gas bubbles rise from the orifices. Some of the sandstone is encrusted with white deposits that do not react with hydrochloric acid.

Table 5 presents various physical and chemical properties of the spring.

Two thermal wells are present along a line that trends approximately N22W from Bassett Hot Springs (figure 5). A shallow dug-well on the ranch across State Highway 299 to the north was reportedly as hot as Bassett Hot Springs; the current resident also reported a linear zone of snowmelt that coincides with this trend. Farther north (figure 5) is a 10 m deep, 15.2 cm (6 inch) casing that flows less than 4 liters per minute. The measured temperature at the bottom was 64°C (147°F).

CHEMISTRY: See table 5, page 34.

GEOLOGY: The sandstone through which Bassett Hot Springs rises is part of the Plio-Pleistocene Bieber Formation, which is composed largely of fluvial and lacustrine sediments (figure 5). The Bieber Formation probably overlies Tertiary volcanic and volcanoclastic rocks of intermediate to basic composition.

The spring is situated near the center of the Big Valley graben, which trends northwest. The valley bottom is thought to be broken up by concealed faults that trend dominantly northwest (California Department of Water Resources, 1963). Published maps do not show faults associated with Bassett Hot Springs; rather it is shown as rising near the center of a northwest trending, concealed horst, based on geophysical evidence (California

Table 5

SITE NAME: Bassett Hot Springs (LS-4)

LOCATION: 41° 08.70'N; 121° 06.65'W
T38N, R7E, Section 12 (MDB and M)WATER ANALYSIS AND SITE DATA

UURI ANALYSIS		CDMG FIELD ANALYSIS	
Element	Concentration (ppm)		
Na	200	Chloride.....	110 ppm
K	3	Sulfate.....	330 ppm
Ca	34	Sulfide.....	ppm
Mg	< 0.544	Nitrogen (Ammonia).....	1.1 ppm
Fe	0.12	Alkalinity (as CaCO ₃)....	ppm
Al	< 0.680	Salinity (percent).....	0.5
Si (As SiO ₂)	57	pH.....	9.11
Ti	< 0.136	Electrical Conductivity	
P	< 0.680	at 34 °C.....	1260 µmho/cm
Sr	0.20		
Ba	< 0.680		
V	< 1.36		
Cr	< 0.054		
Mn	< 0.272		
Co	< 0.027		
Ni	< 0.136		
Cu	< 0.068		
Mo	< 1.36		
Pb	< 0.272		
Zn	0.4		
Cd	< 0.068		
Ag	< 0.054		
Au	< 0.109		
As	< 0.680		
Sb	< 0.816		
Bi	< 2.72		
U	< 6.80		
Te	< 1.36		
Sn	< 0.136		
W	< 0.136		
Li	0.11		
Be	< 0.005		
B	2.7		
Zr	< 0.136		
La	< 0.136		
Ce	< 0.272		
Th	< 2.72		
Cl			
F	2.0		

CDMG LAB ANALYSIS	
Carbonate.....	9.00 ppm
Bicarbonate.....	5.34 ppm
Sulfate.....	313.50 ppm
Corrected TDS.....	735 ppm

OTHER DATA	
Date of Site Visit.....	10-06-81
Ambient Temperature.....	26°C
Surface Temperature of Water.....	79.5°C
Flow Rate or Capacity....	200 l/m
Field Investigator.....	Higgins

EXPLANATION

- Qb** Recent basin deposits.
- Qal** Quaternary intermediate alluvium.
- TQb** Plio-Pleistocene Bieber Formation (silt, sand, gravel of lacustrine origin).
- Contact (approximate)
- Fault (concealed), inferred from geophysical evidence.
- ...?... Fault (concealed), postulated from geothermal phenomena.

Cross Section A-A'
Horizontal Scale 1:62,500
Vertical exaggeration 20X

Figure 5. Geologic map showing geothermal features of the Bassett Hot Springs area, Big Valley, Lassen County. Geology modified from California Department of Water Resources, Bulletin 98 (1963).

Department of Water Resources, 1963). The alignment of thermal features discussed above, however, suggest an associated fault zone that trends north-northwest (figure 5). Of possible significance also is the approximately circular topographic high upon which the spring and the two wells are situated.

SETTING AND HISTORICAL USE OF THE SITE: Bassett Hot Springs is adjacent to State Route 299, the major east-west road that traverses Big Valley and the Modoc Plateau area in general. The climate of the valley is characterized by warm, dry summers and cold winters with some snow.

Cattle ranching and the associated production of alfalfa are the mainstays of the economy of Big Valley. Lumbering and tourism are also important; a large lumber mill is about 2-1/2 km southwest of the spring. The town of Bieber, with about 500 people, is the nearest population center. Many ranches and residences are scattered throughout the rest of the local area.

Waring (1915) reported that the spring was used for both bathing and irrigation of a vegetable garden in the early 1900s. Hannah (1975) reported that the swimming pool was once used commercially.

At the time of the site visit, the spring was owned by a family that resided on the property. The spring and its pond were capable of feeding into a large swimming pool and also into a row of old bathhouses on the south edge of the pool. A pump near the spring supplied domestic hot water to the owner's residence (photo 3). The unused spring water flowed into a channel that opened into pasture. The two thermal wells north of the spring were not in use when visited.

NAME: Byron Hot Springs (CC-5)

LOCATION: 37°50.83'N; 121°37.83'W

T1S, R3E, Sec. 15 (MDB&M)

Contra Costa County; approximately 3 km south of Byron. .

QUADRANGLE: Byron Hot Springs 7.5'

SYNOPSIS: Byron Hot Springs, the site of a once thriving balneological resort, is currently undeveloped. The natural hot springs are now dry due to lowered regional ground water levels, but a significant supply of water up to 55°C and approximately 1300 ppm total dissolved solids is available from wells 61 m to 91 m deep. The wells are believed capable of providing 600 liters per minute. The resource is currently being evaluated by the owner for beneficial development. He is considering further exploration at the site in hope of finding a higher temperature resource.

GEOHERMAL FEATURES: Byron Hot Springs is the site of a formerly large and luxurious health resort 70 km east of San Francisco. Early reports claimed the existence of 50 springs at the site, ranging in temperature from 10°C to 60°C (Anderson, 1890). Waring (1915) reported 8 thermal springs which were improved and in use. Their saline waters ranged from 21°C to 49°C. Currently the resort is decrepit and idle (photo 5). Surface hot spring activity has disappeared, but thermal water, up to 55°C is available in three recently drilled wells.

Thermal gradient measured in well number two is shown in figure 6. The highest temperature measured was 56°C. The gradient was measured on December 30, 1980.

Photo 5. View of well No. 2 at Byron Hot Springs. Dilapidated structure in background is the remains of the bath house. Photo by R.C. Martin.

Figure 6. Thermal gradient - Byron Hot Springs, Well #2.

CHEMISTRY: Approximately twenty chemical analyses of the thermal waters from Byron Hot Springs were found in this cursory study. Eleven analyses are stored in the U.S. Geological Survey's GEOTHERM computer storage; two of these are from a group of eleven older analyses performed between 1887 and 1911 which were published by Waring in 1915. The analyses are from different springs and show a wide variation in temperature (14.5°C to 50°C) and TDS content (11,900 to 101,000 mg/l) but all are characterized by dominant NaCl with relatively high Ca, HCO_3 and Mg content. One analysis (Waring, 1915) lists a TDS of 321,389 mg/l, but is it possible that the sample was atypical, or the analysis erroneous. Measured pH ranges from 6.9 to 7.7 with mean of 7.0. SiO_2 content does not vary with the TDS, but is close to 30 mg/l in most of the analyses. Table 6 shows our analysis.

GEOLOGY: Byron Hot Springs is located near the Coast Range-Great Valley boundary, on northeast dipping Tertiary strata. These strata include the Eocene Domengine sandstone, Kreyenhagen shale and younger Mio-Pliocene continental sediments which dip beneath the Quaternary fill of the Great Valley. West of Byron Hot Springs is the upland Diablo antiform from which Tertiary rocks have been eroded to expose a thick sequence of Cretaceous and older basement rocks (figure 7).

The Byron Hot Springs are situated in a low valley underlain by Quaternary clay and sand, extending into the Diablo Range foothills from the Great Valley (figure 7). The valley is longitudinal in nature, following a trough in the easily eroded Kreyenhagen

Table 6

SITE NAME: Byron Hot Springs (CC-5)

LOCATION: 37° 50.83'N; 121° 37.83'W
T1S, R3E, Section 15 (MDB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	3606	Chloride.....	ppm
K	47	Sulfate.....	5 ppm
Ca	415	Sulfide.....	0.49 ppm
Mg	135	Nitrogen (Ammonia).....	ppm
Fe	0.18	Alkalinity (as CaCO ₃)....	370 ppm
Al	< 0.625	Salinity (percent).....	18
Si (As SiO ₂)	13	pH.....	6
Ti	0.3	Electrical Conductivity	
P	< 0.625	< at 51°C.....	34,900 µmho/cm
Sr	17.11		
Ba	5.7	<u>CDMG LAB ANALYSIS</u>	
V	< 1.25	Carbonate.....	0.00 ppm
Cr	< 0.050	Bicarbonate.....	510.88 ppm
Mn	0.4	Sulfate.....	<10.00 ppm
Co	< 0.025	Corrected TDS.....	14,918 ppm
Ni	< 0.125		
Cu	< 0.063	<u>OTHER DATA</u>	
Mo	< 1.25	Date of Site Visit.....	3-23-81
Pb	< 0.250	Ambient Temperature.....	24°C
Zn	< 0.125	Surface Temperature	
Cd	< 0.063	of Water.....	51°C
Ag	< 0.050	Flow Rate or Capacity....	757 l/m
Au	< 0.100	Field Investigator.....	Martin
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	0.10		
Be	< 0.005		
B	25.7		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	10400		
F	0.6

Figure 7. Geologic map of area around Byron Hot Springs; after Ham (1952), Lawson (1914), Taff (1935), Weaver (1949), Division of Mines Bull. 154 (1951), and Davis and Goldman (1958).

(Eocene-Oligocene) shale formation. The Kreyenhagen is underlain by the Eocene Domengine formation, consisting largely of clean sand, locally mined for glass production. Upward moving waters would evidently find an easy path through the Domengine up to the overlying Kreyenhagen shale. Several factors appear to have contributed to the location of both hot and cold springs at this site: (1) low relief of the site (elevation about 10 m above sea level) due to erosion of the shale formation where it strikes into the Great Valley; (2) the artesian nature of the Domengine sandstone capped by shale, rising westward on the flank of the Diablo Range and dipping eastward beneath the Great Valley; (3) a northeast trending cross fault appears to fracture and displace the strata at the hot spring site; and (4) an apparent longitudinal (northwest) distribution of the subsurface reservoir may be due to sandstone dikes penetrating the shale from the underlying Domengine. Such dikes are characteristic of these formations in this region and may have contributed to part of the sand mentioned by Crawford (1894): "The valley is covered with adobe clay and fine white sand, through which the springs bubble."

Earliest reports (Anderson, 1890) mentioned more than 50 springs at the site, including both cold soda or carbonate springs, and hot sulfur springs in close proximity. Irelan (1888) reported 26 springs between 65°F (18.3°C) and 128°F (53.3°C). Waring (1915) reported that in 1908 eight springs were improved and used. The chief source of hot mineral waters for the hotel was a well in which the water level stood 2.4 m (8 feet) below the surface. An

unpublished DMG Mineral Property Report of March 23, 1978 reported that all the original hot springs were dry and water level standing 10 feet (3 m) below the surface. Currently (January, 1981) the water level is 3.6 meters below the surface. Data on nearby ground water levels have not been examined in this study, but it is reasonable to assume that accelerated pumping for agricultural purposes in the Great Valley has lowered the water table east of Byron Hot Springs and the subsurface thermal waters are draining in that direction.

The development of fresh water supplies has long been a problem at the resort. Watts (1892, p. 193) described an unsuccessful well drilling effort and the establishment of a pumping plant on the San Joaquin River, 4.4 km distant, and construction of a 15.2 cm pipeline to the resort.

No significant alteration of surface rocks at or near the site has been reported, but Irelan (1888) cited the presence of one foot (30 cm) of pyrite underlying forty feet (12.2 m) of clay at Byron Springs. A few miles to the southeast, downstrike of the site, drilling along the California Aqueduct encountered pyrite and marcosite in blue clayey material of probable hydrothermal origin. Groundwater here was warm to the touch and obviously mineralized (C.F. Bacon, person communication). A light blue, tasteless scale was encountered while changing pumps in two of the wells currently used at Byron Hot Springs. The low thermal area has been described as a "salt flat" because of the abundance of salt precipitated from the mineral springs.

HISTORY: The Spanish explorers found Indians camped near Byron Hot Springs to bathe in the sulfurous mud and drink the iron-bearing waters (Anderson, 1890). In 1861, R.O. Risdon, a San Francisco industrialist, gained control of the property and in 1868, established a health resort which became famous throughout the state for the curative power of its waters. The resort was destroyed by fire twice and rebuilt in 1903 and 1915. During World War II the property was used as an internment camp for high-ranking prisoners of war. As of June, 1958 (Davis and Goldman, 1958) and December, 1980, it was unoccupied except for a caretaker.

POSSIBLE APPLICATIONS: The owner is establishing residence at the site in early 1981 and is entertaining suggestions for development of the geothermal resource. County planners would like to see a recreational development, and restoration of the old hotel, built in 1914 to its former palacial grandeur. Such restoration could be prohibitively expensive however, and large scale health spas may never again achieve the popularity they once had earlier in this century.

Considering the mild Mediterranean climate and the geothermal temperature known to be available to Byron (55°C) appropriate applications might be fish and prawn farming, mushroom growing, greenhouse operation, and commercial/industrial operations involving biodegradation or fermentation.

Determination of the feasibility of specific applications is beyond the scope of this report. Experts in the specific application field, or an advisory group such as the Oregon Institute of Technology should be consulted to weigh such factors

as the suitability of the chemistry of the geothermal waters, the need and quantity of non-geothermal fresh water supplies, etc. Because of the salinity of the Byron waters, reinjection of waste waters is advised.

NAME: California Hot Springs (TU-6)

LOCATION: 35°52.77'N; 118°40.62'W

T23S, R31E, Sec. 31 (MDB&M)

Tulare County; 37 km southwest of Porterville.

QUADRANGLE: California Hot Springs 15'

SYNOPSIS: California Hot Springs is a significant low temperature resource in the Sierra Nevada foothills 63 km northeast of Bakersfield. Water from several springs 41°C to 50°C flow together and cascade at a volume on the order of 500 liters per minute into Deer Creek. The springs are virtually unused. The potential for future development as an energy source appears favorable.

GEOHERMAL FEATURES: California Hot Springs, as examined in March, 1981, consists of approximately 8 springs on the south bank of Deer Creek. The westernmost spring is directly opposite the present day post office, and 90 m upstream from the remains of a once well known resort hotel. Water from at least three of the major springs is collected by pipe and discharged from a ledge 9 m above the creek to produce an impressive cascade of hot water down a near vertical rock river bank. A crude dam of rocks and plastic sheet in the creek below the cascade provides an informal bathing area for residents. From the collection point above the cascade, hot water is piped to a few local residents for domestic use.

Temperatures of the springs ranged from 50°C to less than 41°C. Some of the springs were not accessible for individual measurement because of the pipe collector system, which in places was well sealed with cement, but the temperature of their combined

discharge above the cascade measured 50°C. Three springs occur in the bank beside the remains of a small gazebo type structure which once served as a bath house. Two of the springs had ornate masonry arch-topped openings which were later sealed during construction of the collector pipe system. One of these may be the "House Spring" for which a chemical analysis was published by Waring in 1915.

Nearly 85 m east of the spring discharge vent above the cascade, the bench on which the gazebo structure rests slopes toward creek level and the two easternmost springs are found flowing from the rocky north bank, 2 m and 5 m respectively, above creek level. The uppermost spring was sampled. It flows from an open joint in a massive granitic rock face, 1.5 m above talus and soil level. A north dipping (75°) broadly convex joint surface forms part of the rock face and provides a triangular shaped discharge surface across which the spring water flows in a sheet 2 mm to 4 mm thick at a rate estimated at 16 liters per minute and at 45°C. This spring is referred to as Triangle Face Spring.

The last and easternmost spring of the group is 3 m lower, on the east side of a small talus cone which rises to the Triangle Face Spring. It issues from beneath a massive boulder at the base of the bluff. The water, at 41°C, flows at approximately 15 liters per minute along a sandy water course to Deer Creek only 10 m away.

CHEMISTRY: Available data indicate that the water from at least some of the springs contains somewhat more than 200 ppm total dissolved solids and is suitable for most purposes. Waring (1915) published an analysis which showed a relatively high (1.7 ppm) content of

arsenate, but subsequent analyses indicate much lower levels of arsenic approximately 0.5 ppm. A high SiO_2 content, 54 ppm, is consistent with its probable origin as a deep circulating thermal water. Our analysis is presented on table 7, page 50.

GEOLOGY: The Deer Creek fault passes through California Hot Springs in a north-northeast trend roughly along the course of Deer Creek (figure 8). Joints in the massive granitic country rock are both parallel and normal to this trend. The north trending joints are dominant and locally occur in closely spaced zones. Thus, it appears that the hot spring waters are moving upward on conduits along the intersection of the Deer Creek fault and intersecting north-south joints.

The California Hot Springs are among a group of low temperature thermal springs in the southern portion of the Sierra Nevada Mountains. The mountains are composed dominantly of granitic rocks of the Sierra Nevada Batholith, intruded in Cretaceous time. Roof pendants of Pre-Cretaceous metasedimentary rocks are common, and are elongate northeastward in this part of the Sierra Nevada; layering, or foliation, in the metasedimentary rocks generally is near vertical and strikes parallel to the long axis of the pendants (Troxel and Morton, 1962).

Hot spring phenomena in this region appear anomalous, for elsewhere, the Sierra Nevada block is generally devoid of geothermal activity, and is part of a major low heat flow anomaly. Heat flow values range from 60 to as little as 19 milliwatts per square meter (Sass and Lachenbruch, 1978).

Table 7

SITE NAME: California Hot Springs (TU-6)

LOCATION: 35° 52.77'N; 118° 40.62'W
T23S, R31E, Section 31 (MDB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	47	Chloride.....	ppm
K	3	Sulfate.....	7.5 ppm
Ca	17	Sulfide.....	0.02 ppm
Mg	1	Nitrogen (Ammonia).....	ppm
Fe	0.05	Alkalinity (as CaCO ₃)....	80 ppm
Al	< 0.625	Salinity (percent).....	0
Si (As SiO ₂)	39	pH.....	8.0
Ti	0.2	Electrical Conductivity	
P	< 0.625	at 45°C.....	258 µmho/cm
Sr	< 0.013		
Ba	< 0.625		
V	< 1.25		
Cr	< 0.050		
Mn	< 0.250		
Co	< 0.025		
Ni	< 0.125		
Cu	< 0.063		
Mo	< 1.25		
Pb	< 0.250		
Zn	1.0		
Cd	< 0.063		
Ag	< 0.050		
Au	< 0.100		
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	0.06		
Be	< 0.005		
B	0.4		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	29		
F	1.9		

<u>CDMG LAB ANALYSIS</u>	
Carbonate.....	16.50 ppm
Bicarbonate.....	74.73 ppm
Sulfate.....	<10.00 ppm
Corrected TDS.....	193 ppm

<u>OTHER DATA</u>	
Date of Site Visit.....	3-17-81
Ambient Temperature.....	17°C
Surface Temperature of Water.....	45°C
Flow Rate or Capacity....	16 l/m
Field Investigator.....	Martin

EXPLANATION

Figure 8. Map and section of geology around California Hot Springs, Tulare County.

As in other granitic upland regions, subsurface waters occur in relatively low volume in joints and fractures, and to a lesser extent, in narrow alluvial bodies along well established drainage courses. Most of the southern Sierra hot springs occur along the course of the Kern River, near the base of a canyon 457 to 1,067 m below the surrounding mountain peaks. The California Hot Springs group is isolated from these, but like most of the others, it is situated low in a canyon, associated with a regional fault. According to Jennings (1975) none of the mapped faults associated with the hot springs are known to have been active during the past two million years.

No signs of significant rock alteration by hydrothermal activity are evident.

HISTORY: California Hot Springs was once known as Deer Creek Hot Springs (Waring, 1915). In 1908 a hotel and annex provided accommodations for 100 guests and several hundred more had been accommodated in cottages and tents near the hotel. The hotel, baths and plunge were operated as late as 1928 (Franke, 1930) before falling into disuse.

NAME: Delonegha Springs (KR-4)

LOCATION: 35°34.40'N; 118°36.77'W

T27S, R31E, Sec. 26 (MDB&M)

Kern County; approximately 48 km east of Bakersfield and
7 km west of Bodfish.

QUADRANGLE: Miracle Hot Springs 7.5'

SYNOPSIS: Delonegha Hot Springs appears to be a minor geothermal resource of 43°C and of low volume. Observable discharge is estimated to be 30 liters per minute, but greater flows may exist beneath the river, which is adjacent to the springs. The site is isolated, in a confined canyon, and unlikely to be developed for uses other than balneological.

GEOHERMAL FEATURES: The hot springs occur on the west bank of the Kern River between Democrat and Miracle Hot Springs, about 72.5 km northeast of Bakersfield. The water issues from crevices in a massive outcrop of layered granitic rock, at the base of the right abutment of a former footbridge. The water is caught in two stone and cement basins for bathing. Water flows from several points within a 4 m radius, accompanied by occasional bubbles of odorless gas.

Waring (1915) reported two springs leading into basins, and a third "too close to the river to be easily available". When examined during this study on March 19, 1981, the river level was high and the third spring may have been submerged.

CHEMISTRY: See table 8, page 54.

Table 8

SITE NAME: Delonegha Hot Springs (KR-4)

LOCATION: 35° 34.40'N; 118° 36.77'W
T27S, R31E, Section 26 (MDB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	74	Chloride.....	_____ ppm
K	4	Sulfate.....	4 ppm
Ca	14	Sulfide.....	0.39 ppm
Mg	< 0.500	Nitrogen (Ammonia).....	_____ ppm
Fe	< 0.025	Alkalinity (as CaCO ₃)....	50 ppm
Al	< 0.625	Salinity (percent).....	0
Si (As SiO ₂)	45	pH.....	8.9
Ti	0.2	Electrical Conductivity	
P	< 0.625	at 43°C.....	375 µmho/cm
Sr	< 0.013		
Ba	< 0.625	<u>CDMG LAB ANALYSIS</u>	
V	< 1.25	Carbonate.....	- ppm
Cr	< 0.050	Bicarbonate.....	- ppm
Mn	< 0.250	Sulfate.....	- ppm
Co	< 0.025	Corrected TDS.....	235* ppm
Ni	< 0.125		
Cu	< 0.063	<u>OTHER DATA</u>	
Mo	< 1.25	Date of Site Visit.....	3-19-81
Pb	< 0.250	Ambient Temperature.....	18°C
Zn	0.9	Surface Temperature	
Cd	< 0.063	of Water.....	43°C
Ag	< 0.050	Flow Rate or Capacity....	
Au	< 0.100	Field Investigator.....	Martin
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	< 0.050		
Be	< 0.005		
B	3.5		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	90		
F	3.2		

*No data on HCO₃, therefore this is a partial TDS

GEOLOGY: Delonegha Hot Springs are among a group of low temperature thermal springs in the southern portion of the Sierra Nevada Mountains. The mountains are composed dominantly of granitic rocks of the Sierra Nevada Batholith, intruded in Cretaceous time. Roof pendants of Pre-Cretaceous metasedimentary rocks are common, and are elongate northeastward in this part of the Sierra Nevada; layering, or foliation, in the metasedimentary rocks generally is near vertical and strikes parallel to the long axis of the pendants (Troxel and Morton, 1962).

Hot spring phenomena in this region appears anomalous, for elsewhere, the Sierra Nevada block is generally devoid of geothermal activity, and is part of a major low heat flow anomaly. Heat flow values range from 60 to as little as 19 milliwatts per square meter (Sass and Lachenbruch, 1978).

As in other granitic upland regions, subsurface waters occur in relatively low volume in joints and fractures, and to a lesser extent, in narrow alluvial bodies along well established drainage courses. Most of the southern Sierra hot springs occur along the course of the Kern River, near the base of a canyon 457 to 1,067 m below the surrounding mountain peaks. The three northernmost hot springs occur on or close to well recognized faults. The Kernville Hot Springs are located on the Goat Ranch Fault, a branch of the Kern Canyon fault. California Hot Springs lies on the Deer Creek fault. Scovern Hot Springs issue from an alluviated valley on the Kern Canyon fault. Downstream from Scovern, major faults are unknown. The course of the southwest trending alignment of hot

springs is unknown, but they are obviously related to local fractures and joint concentrations seen surfacing in the relatively low elevations of the Kern River gorge or associated valley. According to Jennings (1975) none of the mapped faults associated with the hot springs are known to have been active during the past two million years.

Outcroppings in the canyon at Delonegha are coarsely layered dioritic and granitic rock (figure 9), locally with conspicuous lenticular basic inclusions oriented north-south, parallel to the layering. The site has not been mapped in detail and no significant fault is known at the site, but a possible splinter of the Breckenridge fault strikes toward the hot springs site from a tonalite/diorite on the southeast side of the Kern River. No signs of rock alteration by hydrothermal activity are evident.

HISTORY: Delonegha Hot Springs was the site of a hotel and resort in the period 1898 to 1910. It was bypassed by a new road constructed in 1905, and business declined to the extent the site was nearly deserted in 1912. Today no buildings remain. Cemented iron work remains of an old footbridge are seen on rocky prominences on each side of the river.

Waring (1915) believed that the springs were named after a prospector named Delonegha, but Powers (1979) reports that two gold miners from Georgia named it after the gold rush town of Dahlonegha, Georgia. That name was derived from the Cherokee word "taulonika," meaning "yellow metal".

NAME: Democrat Hot Springs (KR-6)

LOCATION: 35°31.73'N; 118°40.01'W

T28S, R31E, Sec. 5 (MDB&M)

Kern County; 38 km east of Bakersfield, 17 km west of
Bodfish.

QUADRANGLE: Democrat Hot Springs 7.5'

SYNOPSIS: Democrat Hot Springs issues from a moderately jointed,
fresh granodiorite, overlain by weathered granodiorite. Flow rate
of the spring sampled in this study was approximately 56.8 liters
per minute of 39°C water. The property is used intermittently by
the owners.

The extent of the geothermal resource is probably large enough
to supply a portion of the space/water heating energy requirements
of the resort.

GEOTHERMAL FEATURES: Democrat Springs is the westernmost of several
warm springs located along this portion of the Kern River.
Hydrothermal alteration or mineral deposits were not observed. The
water flows through a 7.6 cm plastic pipe after being collected at
the mouth of a "cave" (photos 6 and 7). The "cave" was constructed
by closing off a v-shaped cut with concrete blocks. Waring (1915)
reports that the main spring ceased to flow following the 1906
earthquake and an excavation was made "about 8 feet below the
former point of issuance of the spring". Sometime in the early
1970s the concrete block wall was erected forming a small cave.
The water drips onto the bottom of the cave from the walls and
flows into the "cave" from the rear. The cave walls are

Photo 6. Democrat Hot Springs. Kern River flowing toward upper right in the photo. The swimming pool in center of the photo is part of the resort facilities. The warm water flows in a pipe along the trench shown extending from the lower left to the center of the photo. Photo by E. Leivas.

Photo 7. Democrat Hot Springs. Warm water issues from the joints in the rocks within the blocked-off "cave" shown here. Photo by E. Leivas.

granodiorite; total length of the cave is about 13.7 m. The hot water enters through a small opening approximately 0.3-0.6 m in diameter. Width of the cave is about 1.2 m at the entrance and narrows to about 0.45 m in the rear. Height is about 1.52 m at the entrance and drops to about 0.9 m in the back at which point the cave becomes severely restricted in size. Depth of water is about 0.23 m from the front all the way to the rear.

Waring (1915) reports that in 1908, the water temperature was 115°F (46°C) and the flow rate 20 gallons per minute (75.7 liters per minute). Brown (1915) reports a water temperature of 115°F (46°C); no flow data are given. Waring (1965) gives a range of water temperatures from 100°F to 115°F (38°C to 46°C) and flow rate of 25 gallons per minute (94.6 liters per minute). On the date of the site visit the flow rate of the main spring was 56.8 liters per minute (visual estimate) and the water temperature was 39°C.

CHEMISTRY: See table 9, page 61.

GEOLOGY: Democrat Hot Springs is located near the southern end of the Sierra Nevada Geomorphic Province. The Kern Canyon fault is located approximately 14 km to the east. Smith (1964) shows no faults in the area of the hot springs. Morton and Troxel (1962) summarized mining activity in this area (Kern River Canyon District). Locally the geomorphology of the area which includes Democrat Hot Springs is that of a broad, dissected bench, cut into granodiorite. The granodiorite is weathered to "dg". The warm spring measured in this study occurs in moderately jointed, fresh granodiorite (figure 10). Preferred orientation for the joints was not observed; obvious evidence of faulting was also not observed.

Table 9

SITE NAME: Democrat Hot Springs (KR-6)

LOCATION: 35° 31.73'N; 118° 40.01'W
T28S, R31E, Section 5 (MDB and M)WATER ANALYSIS AND SITE DATAUURI ANALYSIS

Element Concentration (ppm)

Na	71
K	4
Ca	2
Mg	1
Fe	< 0.025
Al	< 0.625
Si (As SiO ₂)	56
Ti	0.2
P	< 0.625
Sr	< 0.013
Ba	< 0.625
V	< 1.25
Cr	< 0.050
Mn	< 0.250
Co	< 0.025
Ni	< 0.125
Cu	< 0.063
Mo	< 1.25
Pb	< 0.250
Zn	< 0.125
Cd	< 0.063
Ag	< 0.050
Au	< 0.100
As	< 0.625
Sb	< 0.750
Bi	< 2.50
U	< 6.25
Te	< 1.25
Sn	< 0.125
W	< 0.125
Li	< 0.050
Be	< 0.005
B	3.8
Zr	< 0.125
La	< 0.125
Ce	< 0.250
Th	< 2.50
Cl	64
F	2.2

CDMG FIELD ANALYSIS

Chloride.....	< 139 ppm
Sulfate.....	12 ppm
Sulfide.....	0.49 ppm
Nitrogen (Ammonia).....	ppm
Alkalinity (as CaCO ₃)....	0 ppm
Salinity (percent).....	0.1
pH.....	8.05
Electrical Conductivity at 29°C.....	343 µmho/cm

CDMG LAB ANALYSIS

Carbonate.....	42.00 ppm
Bicarbonate.....	62.53 ppm
Sulfate.....	< 10.00 ppm
Corrected TDS.....	278 ppm

OTHER DATA

Date of Site Visit.....	3-30-81
Ambient Temperature.....	13°C
Surface Temperature of Water.....	39°C
Flow Rate or Capacity....	56.8 l/m
Field Investigator.....	Leivas

gr Mesozoic granodiorite.

LOCATION MAP

Figure 10. Geologic Map and section of the area around Democrat Hot Springs. Geology adopted from Smith (1964).

HISTORY: Waring (1915) reports that "in 1908 there was a substantial hotel, having accomodations for 100 people". Brown (1915) reports that there were several buildings with accomodations for a number of people. Currently (1981) the resort is used intermittently by the Kern Recreation Association (private).

NAME: Elsinore Hot Springs (RV-14)

LOCATION: 33°40.17'N; 117°19.72'W

T6S, R4W, Sec. 7 (SBB&M)

Riverside County; located within the city of Elsinore.

QUADRANGLE: Elsinore 7 1/2'

SYNOPSIS: A history of once thriving balneological activity using natural hot springs, then shallow wells, indicate that a substantial resource of 50°C water underlies the downtown portion of Elsinore. The waters range from about 300 to 400 mg/l total dissolved solids, with low boron content; thus, appear suitable for many commercial uses. High fluoride and H₂S content limit their usefulness for potable applications. The heat resource is currently unused except by three operating balneological establishments and a few homes with wells for space heating.

A relatively large supply of thermal water of 42°C exists beneath the north part of the City of Elsinore. The water is of excellent quality for most commercial uses. It was once aerated and used for the municipal potable water supply, but this use has been discontinued because of the sulfurous odor and high fluoride content (5 mg/l). Presently the water is virtually unused and awaits a commercial application. Two municipal wells 0.3 m in diameter are capable of pumping the thermal water at 1850 liters per minute (500 gallons per minute) each.*

*Technical data on the Elsinore thermal wells and distribution of local geothermal activity, courtesy of Joe Kiezack, City Engineer, and Jim Blackford, Superintendent of Public Works.

GEOHERMAL FEATURES: Early reports (Waring, 1915) indicate that numerous hot springs once issued in the lowland which is now occupied by the downtown or oldest part of the City of Elsinore. Numerous spas developed in this area but only three remain in business today. A few wells are used by private owners for space heating.

Two municipal and a few other private wells tap thermal waters of up to 42.2°C in the northern part of Elsinore. The waters occur in fractured crystalline rock in wells that were set at 53 m depth; dynamic water level is about 43 m. In the 1890s natural hot springs were found near the lake, but these dried up when a drainage channel was deepened. Numerous spas flourished in the southern lake area, but thermal waters were unknown in the north area until discovered by well drilling.

This geothermal anomaly is one of several fault related features of the Elsinore fault zone. Other thermal anomalies in this zone (Higgins, 1980) are: Glen Eden, Temecula, and Murrieta Hot Springs, a subsurface warm water zone at Wildermar, Agua Tibia and Agua Caliente Springs, and a large group of thermal wells at Ocotillo. The Elsinore fault zone extends southward into Mexico as the Laguna Salada fault zone, which is associated with the well known Cerro Prieto geothermal field.

CHEMISTRY: The Elsinore Geothermal Zone thermal waters have a TDS of 268-400 mg/l. When wells were drilled in 1926, the water was used for drinking and balneological purposes, but this use was discontinued due to the sulfurous odor and high fluoride content.

The high pH (9.7 in Elsinore north area) and high bicarbonate and carbonate contents of wells formerly analyzed in the zone indicate mixing of deep geothermal waters with near surface ground water. See table 10, page 67, for our analysis of Elsinore Hot Springs water.

GEOLOGY: The thermal waters of Elsinore are present along the northeast edge of the Elsinore trough (figure 11). This trough is a complex, northwest trending graben separating the Santa Ana Mountains on the southwest and the Perris Block on the northeast. The Elsinore fault group constitutes one of the major components of the San Andreas system in southern California. It can be traced from the Los Angeles Basin, southeastward through the Peninsular Ranges province into Baja California.

Elsinore lies near the northwest extremity of the Peninsular Ranges province, a highland region between the Pacific Coast and the Colorado Desert, underlain dominantly by granodiorite intruded during lower Cretaceous time. Older rocks, intruded by the granodiorite, include Triassic metamorphic rocks of volcanic and sedimentary origin, (the Santa Ana formation) and other igneous rocks of pre-Cretaceous age, mainly porphyry and andesite. These constitute a crystalline basement mass on which thin and scattered remnants of younger sedimentary rocks such as the Chico and Martinez formations lie. Valleys and low basin areas are filled partially by Quaternary fan conglomerate terrace and alluvial sediments, which form important water bearing formations.

Table 10

SITE NAME: Elsinore Hot Springs (RV-14)

LOCATION: 33° 40.17'N; 117° 19.72'W
T6S, R4W, Section 6 (SBB and M)WATER ANALYSIS AND SITE DATAUURI ANALYSIS

Element	Concentration (ppm)
Na	75
K	4
Ca	3
Mg	1
Fe	0.04
Al	< 0.625
Si (As SiO ₂)	54
Ti	< 0.125
P	< 0.625
Sr	< 0.013
Ba	< 0.625
V	< 1.25
Cr	< 0.050
Mn	< 0.250
Co	< 0.025
Ni	< 0.125
Cu	< 0.063
Mo	< 1.25
Pb	< 0.250
Zn	< 0.125
Cd	< 0.063
Ag	< 0.050
Au	< 0.100
As	< 0.625
Sb	< 0.750
Bi	< 2.50
U	< 6.25
Te	< 1.25
Sn	< 0.125
W	< 0.125
Li	< 0.050
Be	< 0.005
B	0.8
Zr	< 0.125
La	< 0.125
Ce	< 0.250
Th	< 2.50
Cl	21
F	4.9

CDMG FIELD ANALYSIS

Chloride.....	< 139 ppm
Sulfate.....	_____ ppm
Sulfide.....	_____ ppm
Nitrogen (Ammonia).....	4.65 ppm
Alkalinity (as CaCO ₃)....	_____ ppm
Salinity (percent).....	Trace
pH.....	10.1

Electrical Conductivity	
at 33°C.....	590 µmho/cm

CDMG LAB ANALYSIS

Carbonate.....	67.74 ppm
Bicarbonate.....	0 ppm
Sulfate.....	16.74 ppm
Corrected TDS.....	254 ppm

OTHER DATA

Date of Site Visit.....	7-02-81
Ambient Temperature.....	31°C
Surface Temperature of Water.....	45°C
Flow Rate or Capacity....	7.6 l/m
Field Investigator.....	Leivas

EXPLANATION

Figure 11. Map and section of geology in the area around Elsinore Hot Springs, Riverside County. Geologic map and section taken from Engel and others (1959).

Lake Elsinore occupies a low part of the Elsinore complex graben, into which the San Jacinto River drains. The San Jacinto basin and the Elsinore Lake area constitute what is nearly a closed hydrologic basin, for only in years of exceptionally high rainfall does the lake rise high enough for exterior surface drainage to occur. Then it overflows through a channel on its northeastern side, through the town of Elsinore and down Temescal Wash to the Santa Ana River.

The Glen Ivy fault underlies the northeast side of the lake separating Triassic sediments, on which the town of Elsinore is built, basic igneous rocks of the deep part of the Elsinore graben, where Quaternary and older sediments extend to depths of 430 m and more. The latter area, under the lake and outwards along the graben length, is an important ground water basin for this region (Bean, 1959). The Glen Ivy fault serves as a ground water barrier; water levels have historically been higher on the northeast side of the fault. It also serves as an effective barrier between the zone of thermal water and the normal temperature waters of the principal ground water basin (Engel, Gay, and Rogers, 1959). Although ground water temperatures in the deep graben are considered normal, thermal gradients are twice the normal continental gradient. Four wells beneath Lake Elsinore have E-log bottom hole temperatures from 31.7°C to 35.6°C at depths of about 550 m. The maximum calculated geothermal gradient is 34.6°C/km. Near Wildemar, 7.2 km to the southeast, the gradient in a 794 m deep well is 28.6°C/km. These gradients are typical of tectonically active areas, especially a zone of active faulting, such as the Elsinore fault zone.

According to local information, thermal waters are known to underlie two areas of Elsinore: 1) the area of original hot spring activity near the lake and the Glen Ivy fault; and 2) at the northeast side of town where the city's municipal water supply wells were drilled. These thermal areas may be connected, but no intermediately placed wells are known which could prove their contiguance.

The thermal zone lies on a structural terrace, or step between the Glen Ivy and North Elsinore faults, on the north side of the graben. This area has a hilly topography developed on Triassic metasediments (Santa Ana formation) and diorite/gabbro of later Mesozoic age. The drainage channel of Lake Elsinore courses along this structural terrace and is covered thinly with alluvium. Two municipal wells were drilled along this alluvial channel.

The wells reportedly penetrate 9.1 m of alluvium, then fractured granitic rock for the remainder of their length. The wells are 1.4 km from the Glen Ivy fault to the southwest, and 0.9 km from the North Elsinore fault to the northeast. No evidence of a cross fault connecting the two thermal zones is known as yet.

HISTORY: According to Waring (1915), many small hot springs formerly issued in the lowland along the lake outlet through the city of Elsinore. In the early 1890s, when a canal was cut past the springs and the lake water was taken northward to irrigate citrus groves near Corona, it is said that most of the springs ceased to flow, but hot sulfurous water is still obtained from shallow wells. In 1888, a large bath house was built near the railroad depot and in 1915 these baths, known as Elsinore Hot

Springs, were still supplied by water pumped from three wells that were formerly springs. The Elsinore Hot Springs were later renamed Lakeview Inn Hot Springs (Engel and others, 1959). By 1945, the Inn was using three shallow wells in mud and tub baths. The wells have since been abandoned and the Inn building converted to an antique shop.

Bundy's Elsinore Hot Springs was another resort, a few blocks to the north where a shallow well supplied warm sulfur water for drinking and bathing and a hotel and several cottages provided accommodations for guests. Bundy's Elsinore Hot Springs were later known as Wrenden Hot Spring. By 1915, the original spring had failed and had been replaced by a shallow well. After 1926, water for the establishment was obtained direct from a hot pump line from city of Elsinore wells.

In 1926, the city of Elsinore drilled two 137 m wells near the north end of Langstaff Street in the northern end of town. Later a third well was added. They supplied a number of spas with mineral water for many years. One of the wells is still capable of operation but it and the supplemental water system is not in use.

NAME: Fales Hot Springs (MO-4)

LOCATION: 38°21.03'N; 119°24.02'W

T6N, R23E, Sec. 24 (MDB&M)

Mono County; 21 km northwest of Bridgeport.

QUADRANGLE: Fales Hot Springs 15'

SYNOPSIS: Fales Hot Springs produces 61°C water at more than 1000 liters per minute. The hot water appears to be restricted to a narrow zone. The geothermal well drilled by Magma Power Company indicates that a shallow hot water reservoir does not exist at Fales Hot Springs. Further shallow drilling is not likely to increase the geothermal resource available at Fales Hot Springs.

GEOHERMAL FEATURES: The springs issue from a concrete rimmed basin (photo 8) at a temperature of 61°C. The flow rate is reported to be greater than 1,000 liters per minute. The surface of the spring is kept in a state of constant ebullition by gas (predominantly CO₂) escaping to the surface. No mineral deposits are being formed by the present spring.

A wildcat geothermal well was drilled east of the springs by Magma Power Company in 1962. The bottom-hole temperature at 126 m depth is 38°C which is 23°C lower than the temperature of the springs.

CHEMISTRY: Chemical analyses indicate that the water is a sodium bicarbonate type with 2,356 mg/l total dissolved solids.

Geothermometry indicates a maximum subsurface temperature of about 150°C or more based on silica in equilibrium with quartz (145°C) and the Na-K-Ca cation ratio (174°C) (Mariner and others, 1977).

See our analysis on table 11, page 75.

Figure 12. Map of the Fales Hot Springs area. Geology from Koenig, 1963.

EXPLANATION

- Qg Glacial deposits.
- Qt Travertine deposits.
- Pv Pliocene volcanics.
- gr Mesozoic granitic rocks.

Contact, dotted where uncertain, dashed where approximately located.

Fault, dashed where inferred, dotted where concealed.

Photo 8. View of Fales Hot Springs. The springs issue from the pool in the foreground. New spas under construction are seen just behind the springs. An old bath house is to the right and a cold water spring issues just to the right of the spas. Photo by S. Bezore.

GEOLOGY: The spring issues from glacial deposits which overlies Pliocene volcanic andesites (figure 12). Columnar jointed hornblende andesite crops out to the west of the spring. North and east of the spring, tufa deposits overlie the glacial material. According to Koenig (1963) there is an east-west trending fault along the stream valley in which the hot spring lies.

Both hot and cold springs issue on the Fales Hot Springs property. One cold spring lies less than 20 m from the hot springs, and 2 m lower in elevation. The glacial deposit in the floor of the valley is the most likely aquifer to supply the cold springs. The hot springs appear to be derived from a fault controlled aquifer in the underlying volcanics which is isolated from the cold water aquifer.

HISTORY AND USE OF THE SITE: At present the area around the hot springs is under development to be a ski resort. The spring level will be raised to supply water to a swimming pool and spas by gravity flow. The pool and spas are under construction with completion anticipated by early 1981. A ski lift is to be built on the mountainside south of the springs.

Table 11

SITE NAME: Fales Hot Springs (M0-4)

LOCATION: 38° 21.03'N; 119° 24.02'W
T6N, R23E, Section 24 (MDB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	514	Chloride.....	182 ppm
K	33	Sulfate.....	295 ppm
Ca	34	Sulfide.....	ppm
Mg	8	Nitrogen (Ammonia).....	ppm
Fe	0.04	Alkalinity (as CaCO ₃)....	ppm
Al	< 0.625	Salinity (percent).....	1.7
Si (As SiO ₂)	77	pH.....	
Ti	< 0.125	Electrical Conductivity	
P	< 0.625	at 22°C.....	2690 µmho/cm
Sr	1.34		
Ba	< 0.625		
V	< 1.25		
Cr	< 0.050		
Mn	< 0.250		
Co	< 0.025		
Ni	< 0.125		
Cu	< 0.063		
Mo	< 1.25		
Pb	< 0.250		
Zn	< 0.125		
Cd	< 0.063		
Ag	< 0.050		
Au	< 0.100		
As	1.0		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	1.11		
Be	< 0.005		
B	7.1		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	161		
F	53		

<u>CDMG LAB ANALYSIS</u>	
Carbonate.....	0 ppm
Bicarbonate.....	1061.0 ppm
Sulfate.....	238.0 ppm
Corrected TDS.....	1651 ppm

<u>OTHER DATA</u>	
Date of Site Visit.....	9-24-80
Ambient Temperature.....	20°C
Surface Temperature of Water.....	61°C
Flow Rate or Capacity....	1000 l/m
Field Investigator.....	Bezore

NAME: Fetters Hot Springs (SN-11)

LOCATION: 38°19.32'N; 122°29.26'W

T6N, R6W, Sec. 35 (MDB&M)

Sonoma County; 4.3 km northwest of Sonoma.

QUADRANGLE: Sonoma 7.5'

SYNOPSIS: Fetters Hot Springs Resort is owned by the owners of the nearby Agua Caliente Springs and is currently closed. Many of the facilities in use during the resort's heyday are still on the property, but are in advanced stages of dilapidation. Water from one 50.3 m deep well at Fetters is sometimes used to help fill the swimming pool at Agua Caliente Springs, a resort located approximately 70 m to the west of the well. Capacity of the sampled well was 291 liters per minute of 29°C water.

The heat source for the water in this area is probably related to a steeper than normal geothermal gradient possibly associated faulting. The occurrence of other warm springs (wells) nearby, coupled with the proximity to a subsurface structural feature (fault?) along which the warm water sources align, suggests that a viable geothermal resource may exist. Further study is recommended.

GEOHERMAL FEATURES: Warm water at Fetters Hot Springs is supplied by a 50.3 m deep well. The water comes from an aquifer which appears to be bounded on the west by a fault. The relatively cooler temperature of the water in this zone may be the result of the water being withdrawn from a cooler, shallower aquifer than the aquifer which supplies the wells at Agua Caliente Springs (SN-10).

The source of heat for the waters is probably related to a warmer-than-normal geothermal gradient along the fault postulated by Jennings (1975).

CHEMISTRY: See table 12, page 78.

GEOLOGY: Fetters Hot Springs is located in the Sonoma Valley, within the Coast Ranges Geomorphic Province. Northwest-southeast trending Sonoma Valley is bounded on the east and west sides by mountains underlain by rocks of the Pliocene Sonoma Volcanics. Quaternary alluvium and older fan deposits underlie this portion of the valley. The Rogers Creek fault, part of the San Andreas transform fault system, is located 9 km to the west. Jennings (1975) shows several other faults (last movement--Pre-Quaternary) in the area.

Jennings (1975) and Huffman and Armstrong (1980) postulate the existence of a fault trending parallel to the valley and located approximately in this area (within tens of meters) (figure 13). A more detailed investigation is needed to better define the hydrology and the location of the fault of this area.

HISTORY: Fetters Hot Springs was originally called Eleda Hot Springs. The first warm water well at Eleda Hot Springs was drilled in 1908. Bradley (1915) reported that "the warm water was struck at a depth of 300 feet."

In 1909 a "bathing establishment" was opened, followed in 1910 by the opening of a hotel.

The property is currently owned by the owners of the nearby Agua Caliente Springs (SN-10) who use water from Fetters Hot Springs in conjunction with the water from Agua Caliente Springs in the swimming pool at Agua Caliente Springs.

Table 12

SITE NAME: Fethers Hot Springs (well) (SN-11)

LOCATION: 38° 19.32'N; 122° 29.26'W
T6N, R6W, Section 35 (MDB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	53	Chloride.....	< 139 ppm
K	5	Sulfate.....	_____ ppm
Ca	4	Sulfide.....	0.03 ppm
Mg	1	Nitrogen (Ammonia).....	1.25 ppm
Fe	0.21	Alkalinity (as CaCO ₃)....	_____ ppm
Al	< 0.625	Salinity (percent).....	Trace
Si (As SiO ₂)	67	pH.....	7.1
Ti	< 0.125	Electrical Conductivity	
P	< 0.625	at 30°C.....	375 µmho/cm
Sr	0.01		
Ba	< 0.625		
V	< 1.25		
Cr	< 0.050		
Mn	< 0.250		
Co	< 0.025		
Ni	< 0.125		
Cu	< 0.063		
Mo	< 1.25		
Pb	< 0.250		
Zn	< 0.125		
Cd	< 0.063		
Ag	< 0.050		
Au	< 0.100		
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	0.20		
Be	< 0.005		
B	2.1		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	46		
F	2.5		

<u>CDMG LAB ANALYSIS</u>	
Carbonate.....	- ppm
Bicarbonate.....	120.48 ppm
Sulfate.....	43.59 ppm
Corrected TDS.....	286 ppm

<u>OTHER DATA</u>	
Date of Site Visit.....	7-21-81
Ambient Temperature.....	20°C
Surface Temperature of Water.....	29°C
Flow Rate or Capacity....	291 l/m
Field Investigator.....	Leivas

EXPLANATION

- Qd Quaternary deposits (sand, gravel, alluvium).
- Tsvg Tertiary Sonoma Volcanics Group.
- Contact, dashed and queried where inferred.
- Fault, dashed where inferred, dotted where concealed, query indicates additional uncertainty.

Figure 13. Map and section of geology around Fetter's Hot Springs and Agua Caliente Springs, Sonoma County. Geologic map modified from Huffman and Armstrong (1980).

NAME: Grapevine Spring (IN-3)

LOCATION: 37°01.48'N; 117°23.06'W

T11S, R42E, Sec. 3 (MDB&M)

Inyo County; approximately 75 km northwest of Park Service Visitor Center, Death Valley.

QUADRANGLE: Ubehebe Crater 15'

SYNOPSIS: Grapevine Spring provides a steady supply of 37°C water at a rate greater than 115 liters per minute. This spring is one of several springs in the area, which are collectively known as Grapevine Springs. The warm water probably rises along faults which are part of the Furnace Creek Fault Zone.

The extent of the geothermal resource is unknown; however, the location of this site within a National Park currently would preclude development of the resource if it were to exist in a high enough volume to make it economic.

GEOHERMAL FEATURES: Grapevine Spring is only one of several springs which are collectively known as Grapevine Springs. Several of the springs are warm, most are cold. Warm water from Grapevine Springs rises in a shallow, sand-filled wash. The resultant stream flows for about 100 m and then percolates back into the subsurface. The area around the springs is overgrown with grapevines (photo 9), hence the name. All the springs in this area rise on the northeast side of the Furnace Creek Fault Zone. The warm waters probably rise along fractures or lesser fault strands of this fault zone. The extent of the geothermal resource is unknown.

CHEMISTRY: See table 13, page 82.

Photo 9. Grapevine Spring. Vegetation is mostly wild grapevines with some palm and mesquite trees. The spring location is marked by the arrow. View is to the east; the Grapevine Mountains are in the background. Photo by E. Leivas.

Table 13

SITE NAME: Grapevine Spring (IN-3)

LOCATION: 37° 01.48'N; 117° 23.06'W
T11S, R42E, Section 3 (MDB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	145	Chloride.....	< 139 ppm
K	15	Sulfate.....	_____ ppm
Ca	53	Sulfide.....	0.02 ppm
Mg	20	Nitrogen (Ammonia).....	0.96 ppm
Fe	< 0.025	Alkalinity (as CaCO ₃)....	300 ppm
Al	< 0.625	Salinity (percent).....	0.25
Si (As SiO ₂)	34	pH.....	6.0
Ti	0.3	Electrical Conductivity	
P	< 0.625	at 25°C.....	1100 µmho/cm
Sr	0.61		
Ba	< 0.625		
V	< 1.25		
Cr	< 0.050		
Mn	< 0.250		
Co	< 0.025		
Ni	< 0.125		
Cu	< 0.063		
Mo	< 1.25		
Pb	< 0.250		
Zn	< 0.125		
Cd	< 0.063		
Ag	< 0.050		
Au	< 0.100		
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	0.18		
Be	< 0.005		
B	1.1		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	59		
F	3.0		

<u>CDMG LAB ANALYSIS</u>	
Carbonate.....	- ppm
Bicarbonate.....	449.88 ppm
Sulfate.....	80.15 ppm
Corrected TDS.....	634 ppm

<u>OTHER DATA</u>	
Date of Site Visit.....	5-08-81
Ambient Temperature.....	28°C
Surface Temperature of Water.....	37°C
Flow Rate or Capacity....	113.6 l/m
Field Investigator.....	Leivas

GEOLOGY: Grapevine Spring is located in the Basin and Ranges Province near the northeastern border of Death Valley National Monument. Generally, the Grapevine Mountains are composed of Paleozoic marine rocks in unconformable contact with Tertiary volcanics. The nearest fault is the Furnace Creek Fault Zone, which in this area trends northwest-southeast. In this area, the Furnace Creek Fault Zone is composed of several shorter fault segments. A locally extensive tufa and Quaternary alluvium deposit covers the northeastern projection of one of these fault strands (Strand, 1967) and underlies many of the springs (figure 14). The tufa is generally tan or buff colored (generally associated with sulfate anions) with local deposits of white colored tufa (generally associated with carbonate anions).

The warm water at Grapevine Springs probably rises along one or several of the local faults.

HISTORY: Grapevine Spring, the one sampled for this report, has been used only for drinking by local wildlife. A spring located about 250 m north of Scotty's Ranch has been the domestic water supply at the Ranch. It is unlikely that the water from the lower (elevation) spring is in hydrologic continuity with the water at Grapevine Spring.

117°25'

EXPLANATION

Qal
and
Qp

Plio-Pleistocene
alluvial and fan
deposits.

TUFA

Quaternary mineral
spring deposits.

Tv

Tertiary volcanic
deposits.

IP

Paleozoic marine
deposits.

Fault, dashed where
inferred, dotted where
concealed, query indicates
additional uncertainty.

Contact, queried
where uncertain.

LOCATION MAP

Figure 14. Map and section of the geology around Grapevine Springs. Geology adapted from Strand (1964).

NAME: Indian Wells - well 5S/6E24N2S (RV-32)

LOCATION: 33°43.06'N; 116°18.99'W

T5S, R6E, Sec. 24 (SBB&M)

Riverside County; 27 km east of Palm Springs, 10 km west of
Indio, in the town of Indian Wells.

QUADRANGLE: La Quinta 7.5'

SYNOPSIS: The water from this well is not hot. Due to a typographical error in Moyle (1974), the water temperature was reported as 182°F (83°C); it should have been 82°F (27.7°C) (personal communication, Ron Freer, Coachella Valley Water District, June 30, 1981).

NAME: Jewell Well

LOCATION: 34°10.79'N; 116°03.89'W

T1N, R9E, Sec. 8 (SBB&M)

San Bernardino County, approximately 3.5 km north of the city of Twentynine Palms.

QUADRANGLE: Twentynine Palms 15'

SYNOPSIS: The Jewell Well (figure 15) lies in the north-central part of the low temperature geothermal zone. It produces water of 32°C from a depth of 36 m. Pumping capacity is estimated to be on the order of 500 liters per minute. Water quality is below average for the geothermal zone. TDS exceeds 600 ppm and the water leaving the top is visibly cloudy and orange with precipitated iron oxides. The heat energy of the Jewell well water is unused except as an aid to the domestic hot water heating system. The low temperature resource is considered fairly large and is practically unused.

GEOHERMAL FEATURES: The thermal anomaly at Twentynine Palms occurs as a warm ground water zone beneath the city, extending northwestward about 8 km, and eastward perhaps 4 km. The boundaries and temperature variations of this body are known only imperfectly. Numerous private wells in the area draw the thermal water for domestic consumption. To many, the heat and mineralized nature of the water is a disadvantage. Some residents have installed heat pumps which utilize the geothermal heat for energy saving space heating.

The Jewell well is less than 2 km west of the Mesquite Lake Fault and is one of a cluster of more than 15 wells in the

EXPLANATION

Surficial deposits
sand, alluvium, and clay

Older alluvium
Older gravel

Biotite-rich quartz monzonite

Contact, dashed where
approximately located.

Fault, dashed where
indefinite, dotted
where concealed.

Figure 15. Map and section of geology in the vicinity of Twentynine Palms, San Bernardino County. SB-15, SB-16, and SB-17 are the locations of wells noted in Higgins (1980); the locations of the Jewell and Zuncich wells are shown. Geologic map and section from Dibblee (1968).

southeast quarter of the section. It is 36 m deep with static water level 19.7 m deep. It has 20.3 cm (8 inch) casing, perforated between 18 m and 36 m depth. Wells in this locality are typically 33 m deep, $\pm$ 8 m, and water quality is lower than in the western part of the thermal zone. Drillers log's show alternating layers of sand, clay and gravel in beds up to 6.5 m thick.

CHEMISTRY: See table 14, page 89.

GEOLOGY: The Twentynine Palms area lies on the southern boundary of the Mojave Desert, just north of the Little San Bernardino Mountains. This is a desert area of Quaternary fanglomerate and alluvial sediments (figure 15) sloping gently northward from the mountain range. The local elevation varies from 548.7 m to 609.6 m except where isolated hills rise to moderate heights.

The mountains and scattered desert outliers are made up of Precambrian gneissic rocks and granitic intrusives of Mesozoic age (Dibblee, 1967). The basin areas are covered with Quaternary alluvium--mainly sand and gravel with minor clays and fanglomerate. Some 13 km west of the area are outcrops of Tertiary nonmarine sandstone and Pliocene basalt.

The area is one of interior drainage with no perennial streams. The major water-bearing units in the area are the unconsolidated sediments which underlie alluvial fans and fill local structural depressions to varying depths. The water-bearing deposits consist generally of lenticular beds of sand, gravel, silt, and clay, except near the mountains where they consist principally of coarse-grained angular rock detritus.

Table 14

SITE NAME: Jewell Well

LOCATION: 34° 10.79'N; 116° 03.89'W
T1N, R9E, Section 8 (SBB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	365	Chloride.....	_____ ppm
K	5	Sulfate.....	_____ ppm
Ca	23	Sulfide.....	_____ ppm
Mg	1	Nitrogen (Ammonia).....	_____ ppm
Fe	0.11	Alkalinity (as CaCO ₃)....	_____ ppm
Al	< 0.625	Salinity (percent).....	_____
Si (As SiO ₂)	26	pH.....	_____
Ti	0.2	Electrical Conductivity	
P	< 0.625	at _____ °C.....	_____ µmho/cm
Sr	0.57		
Ba	< 0.625		
V	< 1.25		
Cr	< 0.050		
Mn	< 0.250		
Co	< 0.025		
Ni	< 0.125		
Cu	0.1		
Mo	< 1.25		
Pb	< 0.250		
Zn	0.3		
Cd	< 0.063		
Ag	< 0.050		
Au	< 0.100		
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	0.10		
Be	< 0.005		
B	1.5		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	221		
F	10.8		

<u>CDMG LAB ANALYSIS</u>	
Carbonate.....	<u>0.00</u> ppm
Bicarbonate.....	<u>64.05</u> ppm
Sulfate.....	<u>418.00</u> ppm
Corrected TDS.....	<u>1104</u> ppm

<u>OTHER DATA</u>	
Date of Site Visit.....	1-25-81
Ambient Temperature.....	18°C
Surface Temperature of Water.....	°C
Flow Rate or Capacity....	500 l/m
Field Investigator.....	Martin

Water levels in wells in the Yucca Valley-Twenty-nine Palms area range from near land surface to more than 152 m below the land surface (Bader & Moyle, 1960). Near Mesquite Lake, north of Twenty-nine Palms, and at the Oasis of Mara, just south of Twenty-nine Palms, a few wells flow continuously or intermittently. Mesquite Spring is one manifestation of the pressurized aquifer condition. Thompson (1929) described large areas of alkali efflorescence on the ground surface due to evaporation of rising ground water. Moyle (personal communication) attributes to the rising water an elongate mass of sand dunes west and south of Mesquite Lake; the wind blown sand being stopped by the ground moisture and more dense vegetation, and permanently anchored by continued growth of vegetation over the pressured seepage area. The sand dunes extend southward into the presumed geothermal zone (figure 15), but it is not known if rising thermal waters have taken part in the anchoring of the sand dunes.

Low temperature geothermal zone: Based upon the meager evidence provided by five known thermal wells in the area, and a cursory study of water resource tables, it appears that the thermal zone may extend for about 15 km in an east-west direction, and as much as 6 km north-south. It appears that deep seated hot waters are rising along two or three known faults, the Mesquite Lake fault, the Pinto Mountain fault, and an unnamed fault extending northwestward from the center of Twenty-nine Palms.

The Mesquite Lake fault parallels the sand dune area and forms a pronounced barrier to ground water movement. On the west side of

the fault, water levels are generally less than 32 m below the surface. East of the fault water levels are abruptly lower, on the order of 70 m. According to Moyle (personal communication) temperatures are also higher on the east side of the fault. At present, however, this observation is supported only by temperature data from one well east of the fault and meager information on temperature/depth relations on the opposite side of the fault.

HISTORY: Unlike many geothermal areas in California, there has been no natural hot spring activity nor has there been a history of spas in the area. The first documentation of thermal wells here was by Moyle (1973).

NAME: Kellog Hot Springs (LS-3)

LOCATION: 41°07.65'N; 121°01.50'W

T38N, R8E, Sec. 14 (MDB&M)

Lassen County; 10 km east of Bieber.

QUADRANGLE: Beiber 15'

SYNOPSIS: The abundance of thermal springs and their high

temperatures suggest that Kellog Hot Springs have the potential to be an important resource locally. The temperature of the hottest spring (89.5°C) and the flow rate of the group as a whole (on the order of several hundred liters per minute) appear to have been consistent since the early 1900s. Reservoir temperatures may be about 110°C according to geothermometry. The water quality of the hottest spring is fair except for high concentrations of boron, fluoride, sodium, and sulfate, which may be detrimental to agricultural or domestic uses of the water. The water quality of the other springs is probably very similar to that of the hottest spring.

The site is adjacent to a county-maintained highway, which provides excellent access and could serve as a means of transportation of products to and from the area. Because the site is isolated from population centers, agricultural and industrial processing activities would probably be the most favorable applications.

GEOHERMAL FEATURES: Kellog Hot Springs include at least six distinct springs as shown in figure 16; measured temperatures are shown for all, with a chemical analysis (table 15) performed on the hottest

EXPLANATION

- Qal Quaternary intermediate alluvium.
- Qv Pleistocene basalt.
- Tqb Plio-Pleistocene Bieber Formation (diatomite, silt, sand, some gravel).
- Tv Tertiary volcanic and volcanoclastic rocks, undifferentiated.
- Contact, approximate.
- Fault
- Fault (concealed)
- ...?... Fault (postulated)

Cross Section A-A'
Scale 1:62,500
Vertical exaggeration 10X

Figure 16. Geologic map showing thermal springs of the Kellogg Hot Springs area, Big Valley, Lassen County. Geology modified from California Department of Water Resources, Bulletin 98 (1963).

Table 15

SITE NAME: Kellog Hot Spring (LS-3)

LOCATION: 41° 07.65'N; 121° 01.50'W
T38N, R8E, Section 14 (MDB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	227	Chloride.....	134 ppm
K	5	Sulfate.....	360 ppm
Ca	28	Sulfide.....	ppm
Mg	< 0.544	Nitrogen (Ammonia).....	1.1 ppm
Fe	< 0.27	Alkalinity (as CaCO ₃)....	ppm
Al	< 0.680	Salinity (percent).....	0.5
Si (As SiO ₂)	67	pH.....	8.6
Ti	< 0.136	Electrical Conductivity	
P	< 0.680	at 36 °C.....	1640 µmho/cm
Sr	0.28		
Ba	< 0.680		
V	< 1.36		
Cr	< 0.054		
Mn	< 0.272		
Co	< 0.027		
Ni	< 0.136		
Cu	< 0.068		
Mo	< 1.36		
Pb	< 0.272		
Zn	< 0.136		
Cd	< 0.068		
Ag	< 0.054		
Au	< 0.109		
As	< 0.680		
Sb	< 0.816		
Bi	< 2.72		
U	< 6.80		
Te	< 1.36		
Sn	< 0.136		
W	< 0.136		
Li	0.14		
Be	< 0.005		
B	3.4		
Zr	< 0.136		
La	< 0.136		
Ce	< 0.272		
Th	< 2.72		
Cl	134		
F	2.5		

<u>CDMG LAB ANALYSIS</u>	
Carbonate.....	3.75 ppm
Bicarbonate.....	23.10 ppm
Sulfate.....	340.50 ppm
Corrected TDS.....	823 ppm

<u>OTHER DATA</u>	
Date of Site Visit.....	10-04-80
Ambient Temperature.....	30°C
Surface Temperature of Water.....	89.5°C
Flow Rate or Capacity....	17 l/m
Field Investigator.....	Higgins

Photo 10. Concrete basin into which the hottest spring (89.5°C) of the Kellog group rises. Sunglasses on rim for scale. Photo by C. Higgins.

Photo 11. One of the eastern thermal springs of the Kellog group, looking north. Gas bubbles can be seen in the left side of the pool. Photo by C. Higgins.

of the group (photo 10). It is possible that there are other springs that were not recognized.

The springs rise in a flat, grassy field. Several springs form pools (photo 11). All contain gas bubbles and deposit white, non-CaCO₃ precipitates. The hottest spring (89.5°C) rises in a circular concrete pool, about 3 m in diameter, and emits a faint odor of H₂S. The aggregate rate of flow from the group is probably on the order of several hundred liters per minute.

A hot well (state well number 38N/8E-14P1) was reported just east of the springs many years ago (California Department of Water Resources, 1964), but a field check failed to find it.

CHEMISTRY: See table 15, page 94.

GEOLOGY: Kellog Hot Springs rise near the southern edge of Big Valley, a complexly-faulted, northwest-trending graben situated between two horsts, the Big Valley Mountains on the west and the Adin Mountains on the east. The oldest rocks are volcanic flows and sediments that form the mountains south of the springs. These range from Miocene to Pleistocene in age and from basalt to rhyolite in composition. The springs are within a tongue of Quaternary alluvium, which is surrounded by hillocks composed of fluvial and lacustrine sediments of the Plio-Pleistocene Bieber Formation (figure 16).

The springs are not shown to be associated with faults on published geologic maps, but considering the regional association of thermal springs with faults, it is probable that faulting is responsible for the origin of the springs. A postulated set of

faults, based on orientation of the springs and regional structural trends is shown in figure 16.

SETTING AND HISTORICAL USE OF THE SITE: Kellog Hot Springs are adjacent to county road A2, an excellent, two-lane paved road. The site is in a flat portion of the valley that is easily accessible. The climate is characterized by warm, dry summers and cold winters with some snow.

The economy of Big Valley is based mostly on cattle ranching and associated production of alfalfa. Lumbering and tourism are also important industries. The nearest population centers are Bieber and Adin, each with about 500 people and each about 10 km away. Many ranches and residences are scattered throughout the rest of the valley.

At the time of the site visit, the springs were unused except as a source of water for flooding pasture. A few abandoned bathhouses remained at two springs, but the site is uninhabited. At the turn of the century, the springs were used variously for bathing, scalding of hogs, and irrigation of gardens (Waring, 1915).

NAME: Keough Hot Springs (IN-1)

LOCATION: 35°15.23'N; 118°22.59'W

T8S, R33E, Sec. 17 (MDB&M)

Inyo County; 12 km south of Bishop.

QUADRANGLE: Bishop 15'

SYNOPSIS: There is no evidence that a significantly larger geothermal resource exists at Keough Hot Springs than is present at the surface--water temperature is 58°C and flow rate is reported to be 2,000 liters per minute. Furthermore, geothermometry indicates that the reservoir temperature is not much higher than the surface temperature of the springs. Any further or future development of the geothermal resource will depend upon the willingness of the City of Los Angeles to allow the springs to be developed. It seems unlikely that any development which might increase water consumption in the Owens Valley would be allowed.

GEOHERMAL FEATURES: The springs issue from three rock lined basins (photo 12) and are channeled underground to the cooling tower and swimming pool. The water temperature is 58°C with a flow rate reported at 2,000 liters per minute. No other expression of the thermal phenomena is evident. The area is undeveloped so no wells other than the domestic well for the trailer court have been drilled.

CHEMISTRY: According to Mariner and others (1977) Keough Hot Springs is a fresh water spring with 512 mg/l TDS. The dominant cation is Na⁺ (160 mg/l) and Cl⁻ is the most abundant anion (180 mg/l--Mariner, 210 mg/l--this report, table 16). A low temperature reservoir is indicated by the silica geothermometer (52°C in

Figure 17. Map of the Keough Hot Springs area, Inyo County. Geology from Bateman, 1965.

Photo 12. View of Keough Hot Springs. The springs issue from the stone basins in the foreground. The old bath house, no longer used, lies behind the motor home. Photo by S. Bezore.

EXPLANATION

Qal	Alluvium.
Qyf	Younger alluvial fan deposits.
Qof	Older alluvial fan deposits.
Qt	Talus.
gr	Mesozoic granitic rocks.
	Contact, dotted where uncertain.
	Fault, dashed where inferred.

Table 16

SITE NAME: Keough Hot Springs (IN-1)

LOCATION: 35° 15.23'N; 118° 22.59'W
T8S, R33E, Section 17 (MDB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	145	Chloride.....	ppm
K	< 2.50	Sulfate.....	72 ppm
Ca	13	Sulfide.....	ppm
Mg	< 0.500	Nitrogen (Ammonia).....	ppm
Fe	0.06	Alkalinity (as CaCO ₃)....	ppm
Al	< 0.625	Salinity (percent).....	0.6
Si (As SiO ₂)	30	pH.....	
Ti	< 0.125	Electrical Conductivity	
P	< 0.625	at ____ °C.....	1090 µmho/cm
Sr	0.31		
Ba	< 0.625		
V	< 1.25		
Cr	< 0.050		
Mn	< 0.250		
Co	< 0.025		
Ni	< 0.125		
Cu	< 0.063		
Mo	< 1.25		
Pb	< 0.250		
Zn	0.3		
Cd	< 0.063		
Ag	< 0.050		
Au	< 0.100		
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	0.34		
Be	< 0.005		
B	0.7		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	181		
F	8.1		

<u>CDMG LAB ANALYSIS</u>	
Carbonate.....	0.00 ppm
Bicarbonate.....	28.00 ppm
Sulfate.....	60.00 ppm
Corrected TDS.....	453 ppm

<u>OTHER DATA</u>	
Date of Site Visit.....	
Ambient Temperature.....	14.4°C
Surface Temperature of Water.....	51°C
Flow Rate or Capacity.....	2000 l/m
Field Investigator.....	Bezore

equilibrium with chalcedony) and the Na-K-Ca cation geothermometer (75°C).

GEOLOGY: The springs issue at the base of an east facing fault scarp.

The fault, part of the Sierra Nevada frontal fault system, is a normal, east dipping fault with Cretaceous intrusive rocks on the upthrown side and Quaternary alluvium on the downthrown side.

South of Keough Hot Springs the fault can be traced through the alluvium.

Alluvial fan deposits (figure 17) are the principal aquifers for the areas around Keough Hot Springs. A well drilled in alluvium near the springs provides cold water for domestic uses. Deep circulation of ground water in the frontal fault zone is the most likely source of heat for the thermal water. Recharge is mainly from runoff on the east slope of the Sierra Nevada.

HISTORY: Water from the springs is presently used to warm a swimming pool. The pool is open to the public in the summer and is used by residents of the adjacent trailer court in the winter. An old bath house on the premises is no longer in use.

NAME: Kernville Hot Springs (KR-1)--Meadow Hot Spring site

LOCATION: 35°43.74'N; 118°24.67'W

T25S, R33E, Sec. 26 (MDB&M)

Kern County; 3.2 km south of Kernville.

QUADRANGLE: Lake Isabella North 7.5'

SYNOPSIS: Low temperature water of approximately 40°C is available in low quantity flowing at less than 15 liters per minute. This flow rate could probably be increased five or tenfold by drilling into the granite terrain. The water quality appears good, even potable, based upon partial field analysis. These warm springs are currently unused.

GEOHERMAL FEATURES: A group of about 21 springs occurs in a small valley extending eastward from the northern end of Isabella Reservoir (figure 18). Many of the springs are tepid, i.e., approximately 20°C. They occur on an east-west alignment 1.7 km long. The hottest of the springs, which include Meadow Hot Spring (41°C), lie near the center of the alignment. Four low volume springs are found here at the base of a granitic (gneiss) knoll.

The warmest water and highest in volume of flow is from the most northerly of the group (figure 18) called Meadow Hot Spring, for it occurs at the upper end of a locally boggy meadow area. The meadow is streaked with belts of coarse grass and sedges growing in wide drainage paths from the warm and tepid springs. Meadow Hot Spring occurs in a subdued amphitheater weathered into the base of the granitic knoll. The spring issues from a bath tub size hole excavated in mud. The water at 42°C has a pH of 6.6 and is

EXPLANATION

- Qal Quaternary alluvium.
- Qc Pleistocene nonmarine.
- gr Mesozoic granitic rocks.
- bi Mesozoic basic intrusive rocks.
- ms Pre-Cretaceous metamorphic and metasedimentary rocks.

- Contact, dashed where approximately located.
- Fault, dashed where approximately located, dotted where concealed.

Figure 18. Map and section of geology around Meadow Hot Spring, Kern County. Geology from Smith (1964).

partially covered by a thick mat of olive green algae. Outflow from the hole was subsurface, hence no flow measurement was made. Four small vent areas were indicated by rising bubbles of odorless gas.

A neighboring spring, 5 m distant, was less conspicuous but had a surface runoff of about 1 liter per minute.

Higher on the knoll and 30 m to 50 m south of Meadow Hot Spring are two other springs. These issue from fractures in gneissose bedrock and produce similar boggy vegetation belts as the discharge reaches the lower gradient of the valley meadow. The southernmost spring produces about 26.5°C water with a pH of 7.7 flowing at 2 liters per minute. Pink, white, and some green algae grow in the water at its surface origin. The more northerly spring produces about the same volume of water at 28°C, with a pH of 7.1 from a .3 m diameter hole on the knoll. Gray and greenish-gray algae grow in the vent area of this spring.

No significant rock alteration is evident at the warm spring sites.

CHEMISTRY: See table 17, page 105.

GEOLOGY: The Kernville Hot Springs are among a group of low temperature thermal springs located in the southern portion of the Sierra Nevada Mountains. The mountains are composed dominantly of granitic rocks of the Sierra Nevada Batholith, intruded in Cretaceous time. Roof pendants of Pre-Cretaceous metasedimentary rocks are common, and are elongate northeastward in this part of

Table 17

SITE NAME: Kernville Hot Springs - Meadow Site (KR-1)

LOCATION: 35° 43.74'N; 118° 24.67'W
T25S, R33E, Section 26 (MDB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	63	Chloride.....	ppm
K	4	Sulfate.....	80+ ppm
Ca	2	Sulfide.....	0 ppm
Mg	< 0.500	Nitrogen (Ammonia).....	ppm
Fe	< 0.025	Alkalinity (as CaCO ₃)....	60 ppm
Al	< 0.625	Salinity (percent).....	
Si (As SiO ₂)	42	pH.....	6.6
Ti	0.2	Electrical Conductivity	
P	< 0.625	at 41 °C.....	310 umho/cm
Sr	< 0.013	<u>CDMG LAB ANALYSIS</u>	
Ba	< 0.625	Carbonate.....	- ppm
V	< 1.25	Bicarbonate.....	39 ppm
Cr	< 0.050	Sulfate.....	- ppm
Mn	< 0.250	Corrected TDS.....	127* ppm
Co	< 0.025	<u>OTHER DATA</u>	
Ni	< 0.125	Date of Site Visit.....	3-18-81
Cu	< 0.063	Ambient Temperature.....	22°C
Mo	< 1.25	Surface Temperature	
Pb	< 0.250	of Water.....	41°C
Zn	< 0.125	Flow Rate or Capacity....	15 l/m
Cd	< 0.063	Field Investigator.....	Martin
Ag	< 0.050		
Au	< 0.100		
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	0.06		
Be	< 0.005		
B	< 0.125		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	11		
F	4.2		

*No data on HCO₃, therefore this is a partial TDS.

the Sierra Nevada; layering or foliation, in the metasedimentary rocks generally is near vertical and strikes parallel to the long axis of the pendants (Troxel and Morton, 1962).

Hot spring phenomena in this region appears anomalous, for the Sierra Nevada block elsewhere is generally devoid of geothermal activity and is part of a major low heat flow anomaly in which heat flow values range from 60 to a little as 19 milliwatts per square meter (Sass and Lachenbruch, 1978).

As in other granitic upland regions, subsurface waters occur in relatively low volume in joints and fractures, and to a lesser extent, in narrow alluvial bodies along well established drainage courses. Most of the southern Sierra Nevada hot springs occur along the course of the Kern River, near the base of a canyon 457 m to 1,067 m below the surrounding mountain peaks.

The three northernmost hot springs occur on or close to well recognized faults: the Kernville Hot Springs are related to the Kern Canyon fault and its branch, the Goat Ranch fault; California Hot Springs lies on the Deer Creek fault; and Scovern Hot Springs issue from a narrow alluviated valley on the Kern Canyon fault. Downstream from Scovern, major faults are unknown. The cause of the southwest trending alignment of hot springs is unknown, but they are obviously related to local fractures and joint concentrations observed in the relatively low elevations of the Kern River gorge. According to Jennings (1975) none of the mapped faults associated with the hot springs are known to have been active during the past two million years.

The Kernville Hot Springs and associated springs exhibit a remarkable alignment on two apparent faults striking eastward from the northern end of Lake Isabella (figure 18). On the main northern alignment are approximately 17 springs of which the hottest are in the middle part of the alignment. The southern alignment is parallel, but is shorter and contains only four recognizable spring loci which form boggy patches on the valley floor and produce very little runoff. In the brief field examination time available for this investigation, no hot or truly warm springs were identified on this second alignment.

Temperatures of saturated soil in two of the bogs were 19°C to 20°C, which is only a few degrees warmer than ambient air temperature.

HISTORY: A small concrete walled bathhouse containing 4 bath tubs stands abandoned and decrepit, indicating past appreciation, but current indifference of residents to the warm spring waters. These springs have gone unnamed in the literature and topographic maps, but have been referred to as the "Kernville Hot Springs" in a report of the State Mineralogist (Tucker, 1929). The term "Meadow Hot Spring" is applied in this report to the hottest spring, which issues from a cove at the base of the bedrock knoll described above.

NAME: Kernville Hot Springs (KR-1)--Spring No. 6 site

LOCATION: 35°43.74'N; 118°24.90'W

T25S, R33E, Sec. 26 (MDB&M)

Kern County; 3.2 km south of Kernville.

QUADRANGLE: Lake Isabella North 7.5'

SYNOPSIS: This spring is believed to be representative of some 11 springs issuing from the rocky hillside above the western half of the valley containing the Kernville Hot Springs. Temperatures measured range from 19°C to 22°C with pH from 6.2 to 6.8.

Flows of the order of 4 liters per minute issue from the springs, both from well-defined vents and from ill-defined seepage zones. Two of the springs are utilized for domestic water supply. The thermal energy of the springs is insignificant by current economic and state-of-the-art engineering standards.

GEOTHERMAL FEATURES: A group of about 21 springs occurs in a small valley extending eastward from the northern end of Isabella Reservoir (figure 19). On the north flank of the valley at its western end, is an alignment of 10 springs issuing from fractures in the bedrock and flowing southward across the valley floor. These flow paths form conspicuous bands of boggy soil with characteristic grass and sedge floral associations. Counting from the most westerly spring, no. 1 and 2 are piped to a tank for a domestic water supply. Spring no. 6 was judged representative of the group and sampled for chemical analysis.

At spring no. 6, water issues from an open joint in gneissic granodiorite at 19.5°C at an estimated rate of about 3 liters per

EXPLANATION

- Qal Quaternary alluvium.
- Qc Pleistocene nonmarine.
- gr Mesozoic granitic rocks.
- bi Mesozoic basic intrusive rocks.
- ms Pre-Cretaceous metamorphic and metasedimentary rocks.

- Contact, dashed where approximately located.
- Fault, dashed where approximately located, dotted where concealed.

Figure 19. Map and section of geology around Spring No. 6, Kern County. Geology from Smith (1964).

minute. For 14 m along the course of the runoff stream, more water is contributed from other spring vents or seepages, to produce surface runoff of perhaps 25 liters per minute. The water is potable and has a pH of 6.8.

Springs 1 through 6 were also measured for temperatures and pH. Temperatures were in the narrow range of 19°C to 22°C and pH values from 6.2 to 6.8.

The east-west alignment of the springs indicates a fault covered by soil and slope wash material, but no more direct evidence was seen on the north flank of the valley. Here the dominant structural features seen are north-south joints and foliation planes which are nearly regional in extent. On the rock knoll 500 m to the east, are east trending fractures on joints suggesting of a nearly east trending fault. Foliation of the gneiss on the knoll retains its steep dipping north-south regional strike.

CHEMISTRY: See table 18, page 111.

GEOLOGY: The Kernville Hot Springs are among a group of low temperature thermal springs occurring in the southern portion of the Sierra Nevada Mountains which are composed dominantly of granitic rocks of the Sierra Nevada Batholith intruded in Cretaceous time. Roof pendants of Pre-Cretaceous metasedimentary rocks are common, and are elongate northeastward in this part of the Sierra Nevada; layering, or foliation, in the metasedimentary rocks generally is near vertical and strikes parallel to the long axis of the pendants (Troxel and Morton, 1962).

Table 18

SITE NAME: Kernville Hot Springs--Spring No. 6 (KR-1)

LOCATION: 35° 43.74'N; 118° 24.90'W
T25S, R33E, Section 26 (MDB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	60	Chloride.....	ppm
K	4	Sulfate.....	76 ppm
Ca	5	Sulfide.....	0 ppm
Mg	< 0.500	Nitrogen (Ammonia).....	ppm
Fe	0.09	Alkalinity (as CaCO ₃)....	60 ppm
Al	< 0.625	Salinity (percent).....	0
Si (As SiO ₂)	40	pH.....	6.8
Ti	0.2	Electrical Conductivity	
P	< 0.625	at ____ °C.....	335 µmho/cm
Sr	< 0.013	<u>CDMG LAB ANALYSIS</u>	
Ba	< 0.625	Carbonate.....	- ppm
V	< 1.25	Bicarbonate.....	- ppm
Cr	< 0.050	Sulfate.....	- ppm
Mn	< 0.250	Corrected TDS.....	124* ppm
Co	< 0.025	<u>OTHER DATA</u>	
Ni	< 0.125	Date of Site Visit.....	3-18-81
Cu	< 0.063	Ambient Temperature.....	18°C
Mo	< 1.25	Surface Temperature	
Pb	< 0.250	of Water.....	19.5°C
Zn	0.5	Flow Rate or Capacity....	3 l/m
Cd	< 0.063	Field Investigator.....	Martin
Ag	< 0.050		
Au	< 0.100		
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	0.05		
Be	< 0.005		
B	< 0.125		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	10		
F	4.4		

*No data on HCO₃, therefore this is a partial TDS.

Hot spring phenomena in this region appears anomalous, for the Sierra Nevada block elsewhere is generally devoid of geothermal activity in other regions, and is part of a major low heat flow anomaly in which heat flow values range from 60 to as little as 19 milliwatts per square meter (Sass and Lachenbruch, 1978).

Similar to other granitic upland regions, subsurface waters occur in relatively low volume in joints and fractures, and to a lesser extent, in narrow alluvial bodies along well established drainage courses. Most of the southern Sierra Nevada hot springs occur along the course of the Kern River, near the base of a canyon 457 m to 1,067 m below the surrounding mountain peaks. The three of the northernmost hot springs occur on or close to well recognized faults. For example, the Kernville Hot Springs are related to the Kern Canyon fault and its branch, the Goat Ranch fault; California Hot Springs lies on the Deer Creek fault; and Scovern Hot Springs issue from a narrow alluviated valley on the Kern Canyon fault.

The Kernville Hot Springs apparently are the result of deep circulating waters rising along the intersection of an unnamed east-west trending fault, underlying the local valley, with the Goat Ranch fault (figure 19). The Goat Ranch Fault, according to Engle (1963) is a normal fault which crosses the east area of Isabella Reservoir and extends north through the Kernville Hot Springs area to merge with the Kern Canyon fault north of Kernville.

Major faults are unknown downstream from Scovern Hot Springs. The cause of the southwest trending alignment of hot springs is

unknown, but they are obviously related to local fractures and joint concentrations observed in the relatively low elevations of the Kern River gorge. According to Jennings (1975) none of the mapped faults associated with the hot springs are known to have been active during the past two million years.

The Kernville Hot Springs and associated springs exhibit a remarkable alignment on two apparent faults striking eastward from the northern end of Lake Isabella (figure 19). The main northern alignment has approximately 17 springs--the hottest being in the middle part of the alignment. The southern alignment is parallel to the northern, but is shorter and contains only four recognizable spring loci. These form boggy patches on the valley floor and produce very little runoff. In the brief field examination time that was available for this investigation, no hot or truly warm springs were identified on this second alignment. Temperatures of the saturated soil in two of the bogs were 19°C to 20°C, only a few degrees warmer than ambient air temperature.

HISTORY: In the technical literature these springs have been described but not named. Tucker (1929) refers to two hot springs 3.2 km northeast of Kernville as the "Kernville Hot Springs". These are very likely to be the present hot springs near the base of the rocky knoll 450 m east of spring no. 6. Because of the tepid nature and co-linearity of spring no. 6 and its neighboring springs with the hotter springs, they are considered here part of the Kernville Hot Springs group, in which substantial mixing of hot deep-seated water with cold near surface water is taking place.

The owners live on the opposite side of the highway and obtain their domestic water supply from springs no. 1 and 2.

NAME: Little Hot Spring (MD-34)

LOCATION: 41°13.83'N; 121°24.20'W

T39N, R5E, Sec. 9 (MDB&M)

Modoc County; 3 km northwest of Day.

QUADRANGLE: Fall River Mills 15'

SYNOPSIS: Evidence suggests that a small resource is present along much of the north-east side of Little Hot Spring Valley. A flow rate of 300 liters per minute of 73°C water was measured. The temperature and possibly the flow rate appear to have been consistent throughout this century. Geothermometers indicate a reservoir temperature on the order of about 100-110°C. Water quality is fair except that high concentrations of boron, sodium, sulfate, and fluoride may cause problems if the water is used for agricultural or domestic purposes.

The valley's isolation is probably the most important factor that will affect use of the resource. Agriculture and residential space heating are uses perhaps most compatible with the sparse population and pristine environment of the area.

GEOHERMAL FEATURES: Little Hot Spring rises from several orifices in a pool about 3 m by 10 m at the base of a gentle colluvial slope (photo 13). The pool is about 2 m deep maximum and covered with green algae on the bottom; gas bubbles rise from the orifices. Analytical data for the spring are shown in table 19. A 10 m well drilled on adjacent property just north of the spring produced 57°C water according to the driller. The owner of this property reported a narrow band of anomalous snowmelt that extends from the

Photo 13. Little Hot Spring, northwest of Day. Several orifices discharge into the pool. View south with gallon-sized container for scale. Photo by C. Higgins.

Photo 14. View northeast from Day Road. Little Hot Spring is about halfway between the first and second outbuildings. A postulated fault zone parallels the base of the slope behind the outbuildings. Photo by C. Higgins.

Table 19

SITE NAME: Little Hot Spring (MD-34)

LOCATION: 41° 13.83'N; 121° 24.20'W
T39N, R5E, Section 9 (MDB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	223	Chloride.....	<u>141</u> ppm
K	5	Sulfate.....	<u>270</u> ppm
Ca	78	Sulfide.....	_____ ppm
Mg	1	Nitrogen (Ammonia).....	<u>1.2</u> ppm
Fe	0.28	Alkalinity (as CaCO ₃)....	_____ ppm
Al	< 0.680	Salinity (percent).....	<u>0.7</u>
Si (As SiO ₂)	68	pH.....	<u>7.7</u>
Ti	< 0.136	Electrical Conductivity	
P	< 0.680	at <u>34</u> °C.....	<u>1625</u> µmho/cm
Sr	0.71		
Ba	< 0.680		
V	< 1.36		
Cr	< 0.054		
Mn	< 0.272		
Co	< 0.027		
Ni	< 0.136		
Cu	< 0.068		
Mo	< 1.36		
Pb	< 0.272		
Zn	1.4		
Cd	< 0.068		
Ag	< 0.054		
Au	< 0.109		
As	< 0.680		
Sb	< 0.816		
Bi	< 2.72		
U	< 6.80		
Te	< 1.36		
Sn	< 0.136		
W	< 0.136		
Li	0.18		
Be	< 0.005		
B	4.3		
Zr	< 0.136		
La	< 0.136		
Ce	< 0.272		
Th	< 2.72		
Cl	141		
F	1.9		

<u>CDMG LAB ANALYSIS</u>	
Carbonate.....	<u>0.00</u> ppm
Bicarbonate.....	<u>48.04</u> ppm
Sulfate.....	<u>365.00</u> ppm
Corrected TDS.....	<u>913</u> ppm

<u>OTHER DATA</u>	
Date of Site Visit.....	10-03-80
Ambient Temperature.....	20°C
Surface Temperature of Water.....	73.5°C
Flow Rate or Capacity....	300 l/m
Field Investigator.....	Higgins

hot spring north beyond the boundary of Shasta National Forest (figure 20). Two wells (about 50 m and 60 m deep), just west of the house (A) shown in figure 20, were reported to be cold. A group of springs (B) are reportedly mildly warm. At site C, a well was drilled to at least 50 m depth and produced about 60°C water at the time of drilling, according to local residents. A temperature probe of this well, did not indicate anomalously warm temperatures. The Lorensen well (D) is about 140 m deep and ranges from 50°C to 57°C. In spring of 1980, it was 51°C according to the owner.

CHEMISTRY: See table 19, page 116.

GEOLOGY: The geology of the Little Hot Spring area has been mapped in reconnaissance only; therefore, the detailed local stratigraphy and structure is not established. The oldest rocks in the area are the Tertiary volcanic rocks (Tva) that form the Big Valley Mountains (figure 20). These range from basalt to andesite; the former is typically gray, olivine-bearing, and diktytaxitic in texture. The next oldest rocks are the dark gray, vesicular olivine basalts (Qrvb) that form the extensive lava field southwest of the spring. A narrow strip of gentle slope just east of the spring is composed of slope wash and boulders (Qfc) from the volcanic rocks higher up. The spring rises through Quaternary alluvium (Qal) that covers the flat bottom of the valley.

Little Hot Spring is situated along the northeast boundary of the Fall River Valley graben, which trends approximately N30W. Postulated faults in the Little Hot Spring area are shown in figure 20; brief field reconnaissance did not reveal conclusive evidence

TOPOGRAPHIC BASE BY USGS.

FALL RIVER MILLS 15' QUADRANGLE (1961)

EXPLANATION

- Qfc Recent fan deposits and colluvium.
- Qal Recent alluvium.
- Qrvb Recent basalt.
- Qbo Quaternary older basin deposits.
- Tvb Tertiary volcanic rocks (mostly basalt)
- Contact
- Fault
- Postulated fault
- Concealed fault

Cross Section A-A'
Scale 1:62,500
No vertical exaggeration

Figure 20. Geologic map showing geothermal features of the Little Hot Spring area, Modoc County.

of these faults. Little Hot Spring almost certainly rises along a fault as evidenced by the linear snowmelt zone mentioned above. It is not known how the Lorensen well relates to the other thermal phenomena, but it probably taps thermal water that rises along a concealed fault.

SETTING AND HISTORICAL USE OF THE SITE: Little Hot Spring is reached via a county road that branches from State Highway 299 to the south. The 16 km to Day is excellent two-lane paved surface, while the 3 km from Day to the spring is well-graded dirt.

The spring is at the west base of the Big Valley Mountains, some parts of which rise to over 1,850 m (photo 14). A broad, timbered lava field of fairly uniform elevation is to the southwest. Summers are warm and dry, while winters are cold and snowy.

The area's economy is based mainly on ranching and tourism (hunting and fishing) with some lumbering. The main population centers are Fall River Mills and MacArthur (total about 1,000 people), about 20-25 km south of Day. The area around the spring is sparsely populated.

As of late 1980, the spring was undeveloped except for a drainage ditch that carried the spring water to flood-irrigate nearby pasture. In the early 1900s the spring was used to supply a hotbed for vegetables and prior to that was used extensively by Native Americans for sundry purposes.

NAME: Matilija Hot Springs (VN-7)

LOCATION: 34°29.05'N; 119°18.43'W

T5N, R23W, Sec. 29 (SBB&M)

Ventura County; 11.3 km northwest of Ojai.

QUADRANGLE: Matilija 7.5'

SYNOPSIS: The warm water sampled at Matilija Hot Springs came from a single well located on the north side of Matilija Creek. Water temperature was 43°C; the flow rate is reported to be 284 liters per minute. Multiple hot spring locations in northwest trending Matilija Creek and another at nearby Wheeler Hot Springs suggest a larger than average hot spring resource in the Matilija region. A feasibility study is recommended for possible applications of the low energy water at population centers of Meiners Oaks and Ojai, 8 km to 16 km distant. Inhibitions to geothermal development are: (1) high relief with limited space for agriculture; (2) USFS ownership (access to most of the valley is restricted in summers due to classification as a hazardous fire area); and (3) location remote from population and industrial centers.

GEOHERMAL FEATURES: Source of the spa's thermal water is a single well or cistern on the north side of Matilija Creek at the base of a steep walled gorge. The well is about 150 m from the base of Matilija Dam, to the northwest, and the same distance from the spa, to the southeast. The well is a 1.3 m square, concrete lined shaft 5 m deep. At the time of the visit, water level was 3.2 m below ground surface and was being pumped by a 1 hp pump with bypass pressure regulating system to the spa, downstream. Hot spring

water is not used in the swimming pool because the Department of Health requires chlorination. Chlorination of the Matilija mineralized water causes clouding which results in another safety hazard in the pool, hence, cold non-mineralized water is used.

Downhole temperature was measured with a maximum reading thermometer. The quantitative flow capacity of the spring is unknown according to the spa operator. The 1 hp pump drives through a 5.1 cm pipe and operates continuously to supply several baths and jacuzzi pools, but apparently, neither the pump nor the spring cistern have been taxed for maximum yield. Berkstresser (1968) reported a flow rate of 284 liters per minute 75 gallons per minute (284 liters per minute) which seems reasonable in light of the plumbing system and flows observed.

CHEMISTRY: See table 20, page 122.

GEOLOGY: The Matilija Hot Springs occur in nearly vertically oriented sandstone beds on the south flank of the Santa Ynez Range (figure 21). This is a very youthful range, consisting of a thick sequence of Cretaceous and Tertiary sediments complexly folded and faulted along an east-west axis. Compressive stresses shown by Holocene reverse faulting and terrace uplift are currently active, and no doubt relate to the trend of several hot springs along this range front.

The spring occurs at the base of the canyon, in the Eocene Matilija Sandstone Formation (this is the type section). Fracture permeability of the massive, thick-bedded sandstone accounts partially for the local upward mobility of the thermal waters.

Table 20

SITE NAME: Matilija Hot Springs (VN-7)

LOCATION: 34° 29.05'N; 119° 18.43'W
T5N, R23W, Section 29 (SBB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	90	Chloride.....	_____ ppm
K	< 2.50	Sulfate.....	<u>15.0</u> ppm
Ca	7	Sulfide.....	_____ ppm
Mg	< 0.500	Nitrogen (Ammonia).....	<u>1.0</u> ppm
Fe	0.05	Alkalinity (as CaCO ₃)....	_____ ppm
Al	< 0.625	Salinity (percent).....	_____
Si (As SiO ₂)	39	pH.....	<u>8.3</u>
Ti	0.2	Electrical Conductivity	
P	< 0.625	at <u>34</u> °C.....	<u>405</u> µmho/cm
Sr	0.12	<u>CDMG LAB ANALYSIS</u>	
Ba	< 0.625	Carbonate.....	<u>0.00</u> ppm
V	< 1.25	Bicarbonate.....	<u>151.00</u> ppm
Cr	< 0.050	Sulfate.....	<u>39.00</u> ppm
Mn	< 0.250	Corrected TDS.....	<u>272</u> ppm
Co	< 0.025	<u>OTHER DATA</u>	
Ni	< 0.125	Date of Site Visit.....	10-29-80
Cu	< 0.063	Ambient Temperature.....	24°C
Mo	< 1.25	Surface Temperature	
Pb	< 0.250	of Water.....	<u>43.50</u> °C
Zn	0.3	Flow Rate or Capacity....	250 l/m
Cd	< 0.063	Field Investigator.....	Martin
Ag	< 0.050		
Au	< 0.100		
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	< 0.050		
Be	< 0.005		
B	0.3		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	19		
F	1.8

E Eocene marine

Fault, dashed and queried where uncertain.

Figure 21. Map and conceptualized section of geology around Matilija Hot Springs, Ventura County.

Alignment of other hot springs in Matilija Creek Canyon and the straightness of the canyon suggest the presence of a major fracture zone trending west-northwest and crossing, far to the northwest, the Santa Ynez fault at a low angle. Topography suggests that this fracture zone may be offset in a left lateral sense by the Santa Ynez fault.

HISTORY: Currently the site is a public county park, operated under lease by a legitimate massage and health bathing business. In addition to the bathing facility, there are accessory buildings and a large swimming plunge. There has been a resort at the springs since about 1890 and in 1908 there were accommodations for 200 guests (Waring, 1915). The hotel has since been destroyed by fire and smaller cottages have been lost in floods.

Clarke (1914) mentioned the existence of three spring locations and presented chemical analyses for four, Hot Sulphur, Fountain of Life, Mother Eve, and Lithia. Only one, Hot Sulphur, is recognizable today. The others have been obliterated or covered by flood deposits. According to the spa operator, the existence of Mother Eve, near the swimming pool, but on the opposite side of the creek, is occasionally evident by the smell of sulphurous gas. The site of the Fountain of Life spring is believed to be close to the snack bar of the spa, on the same side of the creek. Hot Sulphur is the currently developed spring, 150 m upstream from the spa. The location of Lithia spring is unknown today.

At Matilija Hot Springs proper, it is likely that the county will continue to encourage the recreational aspect of the site.

Use of the hot spring for the large swimming plunge has been restricted by Ventura County health regulations which require chlorination and clarity of public swimming pool waters. The swimming pool has been using only fresh (cold) water since the present operator arrived in 1965. This resource is plainly underutilized.

In upper Matilija Canyon are Vickers and Stingley hot springs, with reported temperatures of 51°C. The canyon is narrow and steep sided, with little space for most agricultural applications of the geothermal energy. Access to this area is restricted by the USFS during fire season. A likely application for the thermal water of Matilija Canyon is for fish and prawn culture. More data on the chemistry of the upper canyon waters is needed.

NAME: Miracle Hot Springs (KR-3)

LOCATION: 35°34.57'N; 118°31.98'W

T27S, R32E, Sec. 15 (MDB&M)

Kern County; 4 km west of Bodfish, 50 km east of Bakersfield.

QUADRANGLE: Miracle Hot Springs 7.5'

SYNOPSIS: Miracle Hot Springs flows in excess of 49 liters per minute; water temperature at sample point is 50°C. Some water is pumped upslope to a residence and a small general store. Access is very good. The extent of the geothermal resource is probably small--probably only large enough to supply the existing facilities, which include the store and trailer park.

GEOHERMAL FEATURES: Miracle Hot Springs is one of several warm springs located along this portion of the Kern River. On the date of the site visit, the springs consisted of 2 tubs for bathing and an enclosed collection basin (see photos 15, 16, and 17) that provided water to a pump which in turn supplied water for a residence and small general store. Inscription on the concrete tub indicates that the tubs were made on March 10, 1914.

CHEMISTRY: See table 21, page 128.

GEOLOGY: Miracle Hot Springs is located near the southern end of the Sierra Nevada Geomorphic Province. The Kern Canyon fault is located approximately 3 km to the east. Smith (1964) shows two unnamed faults trending N73E located near the hot springs (figure 22). Morton and Troxel (1962) do not show these two faults. Faulting was not obvious to the investigators during the brief field visit. Intersecting joints without a distinct trend were observed. The joints may provide the conduits along which upwardly

Photo 15. Miracle Hot Springs. Collection boxes, baths, and pump used for transferring warm water upslope to a residence and small general store. Photo by E. Leivas.

Photo 16. Miracle Hot Springs. Small spring which feeds bath shown in photo 17. Photo by E. Leivas.

Photo 17. Miracle Hot Springs. Rock and cement tub fed by warm water from spring shown in photo 16. This tub is also shown on photo 15 (extreme left-center). Photo by E. Leivas.

Table 21

SITE NAME: Miracle Hot Springs (KR-3)

LOCATION: 35° 34.57'N; 118° 31.98'W
T27S, R32E, Section 15 (MDB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	56	Chloride.....	55 ppm
K	4	Sulfate.....	5 ppm
Ca	4	Sulfide.....	0.235 ppm
Mg	1	Nitrogen (Ammonia).....	ppm
Fe	< 0.025	Alkalinity (as CaCO ₃)....	ppm
Al	< 0.625	Salinity (percent).....	0
Si (As SiO ₂)	36	pH.....	8.3
Ti	0.2	Electrical Conductivity	
P	< 0.625	at _____ °C.....	308 µmho/cm
Sr	0.01		
Ba	< 0.625		
V	< 1.25		
Cr	< 0.050		
Mn	< 0.250		
Co	< 0.025		
Ni	< 0.125		
Cu	< 0.063		
Mo	< 1.25		
Pb	< 0.250		
Zn	< 0.125		
Cd	< 0.063		
Ag	< 0.050		
Au	< 0.100		
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	0.08		
Be	< 0.005		
B	1.7		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	44		
F	5.0		

<u>CDMG LAB ANALYSIS</u>	
Carbonate.....	21.00 ppm
Bicarbonate.....	62.52 ppm
Sulfate.....	<10.00 ppm
Corrected TDS.....	204 ppm

<u>OTHER DATA</u>	
Date of Site Visit.....	3-30-81
Ambient Temperature.....	14°C
Surface Temperature of Water.....	50°C
Flow Rate or Capacity....	49 l/m
Field Investigator.....	Martin

Figure 22. Map and section of the geology around Miracle Hot Springs, Kern County. Geology adapted from Smith (1964).

migrating thermal waters may flow. The basement rocks at the spring's site are granodiorite with 1 to 2% xenoliths. The springs occur within 9 m of the Kern River (3-30-81). Hydrothermal alteration of rocks was not observed. The only water deposits observed were white encrustations which formed a "bathtub ring" in one of the source pools (see photo 16). Gas bubbles and a small amount of green algae were observed in this pool. Only 2 springs were observed on this field visit.

HISTORY: The area of the hot springs is located within the Sequoia National Forest. The trailer park immediately to the south is under lease from the USFS. Conveniences include a small general store, restroom and shower facilities, and full RV hookups.

Brown (1915) listed this spring as Air Compressor Springs and indicated that they were also known as Hobo Springs. The water temperature was listed at 60°C (140°F). Waring (1915) called this place Clear Creek Hot Springs and also indicated that the springs were known locally as the Hobo Springs. Both references indicate that the water was "sulphurated". Waring (1965) lists the water temperature at 48°C (119°F). The springs are currently used for bathing purposes and as a water supply for a residence and a small general store.

NAME: Montecito Hot Springs (SA-10)

LOCATION: 34°27.75'N; 119°38.28'W

T4N, R26W, Sections 5 & 6 (SBB&M)

Santa Barbara County; 4 km north of the center of the city of Montecito.

QUADRANGLE: Santa Barbara 7.5'

SYNOPSIS: Water of 44°C to 48°C issues from several points at the head of Hot Springs Canyon. Most of the total flow, 300 liters per minute, is collected by 5.1 cm (2 inch) collection pipes, and constitutes the entire water supply of the private Montecito Water Company. The resource is owned by the company and used for domestic water supply. Currently, the heat content is wasted. The site is in an area of high relief. Access is by Southern California Edison powerline access road, through locked gates, or by hiking up Hot Springs Canyon 1.7 km from residential development.

GEOTHERMAL FEATURES: Montecito Hot Springs consists of 4 individual springs near the head of Hot Springs Canyon, 4 km north of the center of Montecito (figure 23). These have been tapped by the water company, which has constructed a simple, gravity feed collection system with 5.1 cm and 7.6 cm pipe. The only runoff seen other than leakage from pipes, was at a crude bath site (photo 18), high on the northeast side of the cluster, above the ruins of a former spa. A large banana tree and several castor bean trees, 20 m below the bath site indicate a mild microclimate has been produced by the geothermal anomaly. This bath site is the highest and most northeasterly spring observed. Water issues from joints in clean outcrops of sandstone

EXPLANATION

QUATERNARY	Recent	Qal	Alluvium.
		Qfg	Fanglomerate.
		Qc	Casitas Formation.
TERTIARY	Pleistocene	Tm	Monterey Shale-upper.
		Tml	Monterey Shale-lower.
	Miocene	Tr	Rincon Shale.
		Ts	Sespe Formation.
	Oligocene	Tcw	Coldwater Sandstone.
		Tcd	Cozy Dell Shale.
	Eocene	Tma	Matilija Sandstone.
		Tj	Juncal Formation.
			Contact.
			Fault, dashed where approxi- mately located, queried where inferred, dotted where concealed.

Figure 23. Map and section of geology around Montecito Hot Springs, Santa Barbara County. Taken from Dibblee (1966). (Line of cross section is located approximately 2 miles to the west of Montecito Hot Springs.)

Photo 18. Montecito Hot Springs. Springs issue from joints in sandstone member of the Cozy Dell Shale. The thermal water (44°C) flows into an improvised bathing pool at right. Photo by R.C. Martin.

and flows as a thin sheet down the joint surface into a crude tub constructed of angular sandstone blocks and soil.

CHEMISTRY: The first analysis published in 1915 (Waring) shows the water to be essentially a NaSO_4 type with high Ca and Mg content. Waring describes it as a "laxative class medicinal water". That analysis showed a TDS of about 627 ppm. Our analysis is presented on table 22, page 135.

GEOLOGY: The Montecito Hot Springs are among several thermal springs on the south flank and central portions of the Santa Ynez mountain range (figure 23). This is the westernmost and perhaps the most tectonically active portion of the Transverse Ranges, an east-west trending mass of folded and faulted rocks uplifted by compressive forces. Exposed in the Santa Ynez range is a thick sequence of Cretaceous, Eocene, Oligocene and lower Miocene sediments. On the south flank of the range, these generally south dipping strata are exposed almost continuously for approximately 80.5 km.

At Montecito Hot Springs, Eocene marine sediments forming the south limb of an east-west trending anticline are overturned and dip northward 60° . The springs occur in the Cozy Dell shale formation. Longitudinal or bedding plane faults probably provide the upward conduits for the deep seated waters, but at the springs observed, thermal waters are issuing from joints within sandstone members of the shale.

No significant rock alteration was seen. Where the thermal waters were seen, the sandstone joint surfaces appeared fresh. Traces of sulfur are found on rock surfaces above the vents, and

Table 22

SITE NAME: Montecito Hot Springs (SA-10)

LOCATION: 34° 27.75'N; 119° 38.28'W
T4N, R26W, Sections 5 and 6 (SBB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	128	Chloride.....	63 ppm
K	< 2.50	Sulfate.....	18 ppm
Ca	5	Sulfide.....	ppm
Mg	1	Nitrogen (Ammonia).....	1.8 ppm
Fe	0.04	Alkalinity (as CaCO ₃)....	ppm
Al	< 0.625	Salinity (percent).....	0.025
Si (As SiO ₂)	29	pH.....	8.0
Ti	0.2	Electrical Conductivity	
P	< 0.625	at _____ °C.....	540 µmho/cm
Sr	0.25		
Ba	< 0.625		
V	< 1.25		
Cr	< 0.050		
Mn	< 0.250		
Co	< 0.025		
Ni	< 0.125		
Cu	< 0.063		
Mo	< 1.25		
Pb	< 0.250		
Zn	< 0.125		
Cd	< 0.063		
Ag	< 0.050		
Au	< 0.100		
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	< 0.050		
Be	< 0.005		
B	1.3		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	50		
F	3.6		

<u>CDMG LAB ANALYSIS</u>	
Carbonate.....	- ppm
Bicarbonate.....	234.90 ppm
Sulfate.....	14.00 ppm
Corrected TDS.....	350 ppm

<u>OTHER DATA</u>	
Date of Site Visit.....	10-31-81
Ambient Temperature.....	24°C
Surface Temperature of Water.....	44°C
Flow Rate or Capacity....	
Field Investigator.....	Martin

three or four types of algae are seen in a zoned configuration in the flowing waters. The zones, locally 1 mm to 3 mm thick were marked by black, dark green, and white algae.

HISTORY: Montecito Hot Springs was once the site of a resort hotel or spa. Only a few scattered ruins remain. Now the significant springs are no longer free flowing, but are "developed" to feed into the Montecito Creek Water Company system. Much of the 44°C heat is lost during the transport of the water to the residential area at the mouth of the canyon. Because the water is used for domestic washing and drinking purposes, use of the heat content would presumably require the use of heat exchangers in order to avoid adversely affecting or polluting it. At the low temperatures involved it would seem that any industrial or aquacultural use of the waters would be uneconomic at the current engineering state-of-the-art, and cost of alternative energy. For marginal energy sources as this, a broad scope feasibility analysis is called for.

NAME: Murrieta Hot Springs (RV-25)

LOCATION: 33°33.53'N; 117°09.43'W

T7S, R3W, Sec. 14 (SBB&M)

Riverside County; 21 km southeast of Elsinore, 50 km north
of Escondido, CA.

QUADRANGLE: Murrieta 7.5'

SYNOPSIS: Murrieta Hot Springs produces water at 54°C. The flow rate was not determined because there were several seepages and flows going in a variety of directions. Murrieta Hot Springs rises along the Murrieta Hot Springs fault. At least 2 other smaller faults intersect the Murrieta Hot Springs fault in the immediate area of the hot springs and probably account for the presence of the springs at that particular place as well as the high water temperature. While the extent of the geothermal resource was not determined during this study, it appears that an extensive ground water resource recharges the hot water system which produces the flow at Murrieta Hot Springs.

The resort has operated from the early 1900s to 1977. It is currently closed and up for sale.

GEOHERMAL FEATURES: Thermal water at a temperature of 54°C rises along the Murrieta Hot Springs fault at Murrieta Hot Springs (photo 19). Kennedy (1977) shows two unnamed faults branching to the northwest off the Murrieta Hot Springs fault within about 180 m of the point where the main hot springs issue. Another feature mapped as a fault on the basis of linear topography and a lithologic boundary (Kennedy, 1977), can be projected to intersect the

Photo 19. Murrieta Hot Springs resort. The warm water issues within the white walled area in the center of the photo (arrow). Photo by E. Leivas.

Murrieta Hot Springs fault under the hot springs (figure 24). The intersection of 2 or 3 faults in this small area probably accounts for the occurrence of the springs at this place and for the high temperature of the water.

Temecula Hot Springs is located about 1.2 km to the southwest. The water there is considerably cooler and, according to a resident, must be pumped for several days before warm water flows from the wells.

Based on interpretation of data presented by Kennedy (figure 6, 1977), there is probably an extensive ground water resource that recharges the hot water flow which issues at Murrieta Hot Springs.

CHEMISTRY: See table 23, page 141.

GEOLOGY: Murrieta Hot Springs is located in the Peninsular Ranges Geomorphic Province. The northwest trending Elsinore Fault Zone is approximately 4 km to the southwest. The northwest trending San Jacinto Fault Zone is approximately 33 km to the northeast. Both of these faults have been classified as active during the Quaternary (Jennings, 1975).

Murrieta Hot Springs is located either directly on the trace of the Murrieta Hot Springs fault or very close to it (figure 24). An unnamed fault intersects with or branches from the Murrieta Hot Springs fault in this immediate area (Kennedy, 1977). The geology of this area has been mapped in detail by Kennedy (1977) and his description should be read in detail for a more thorough discussion of the geology of the area. The following paragraph from Kennedy (1977) applies specifically to this area.

EXPLANATION

Figure 24. Geologic map and section of area around Murrieta Hot Springs, Riverside County (modified from Kennedy, 1977).

Table 23

SITE NAME: Murrieta Hot Springs (RV-25)

LOCATION: 33° 33.53'N; 117° 09.43'W
T7S, R3W, Section 14 (SBB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	214	Chloride.....	330 ppm
K	6	Sulfate.....	ppm
Ca	17	Sulfide.....	0.025 ppm
Mg	1	Nitrogen (Ammonia).....	1.4 ppm
Fe	0.14	Alkalinity (as CaCO ₃)....	ppm
Al	< 0.625	Salinity (percent).....	0.6
Si (As SiO ₂)	40	pH.....	8.9
Ti	< 0.125	Electrical Conductivity	
P	< 0.625	at 35 °C.....	1580 µmho/cm
Sr	0.04		
Ba	< 0.625		
V	< 1.25		
Cr	< 0.050		
Mn	< 0.250		
Co	< 0.025		
Ni	< 0.125		
Cu	< 0.063		
Mo	< 1.25		
Pb	< 0.250		
Zn	0.8		
Cd	< 0.063		
Ag	< 0.050		
Au	< 0.100		
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	0.09		
Be	< 0.005		
B	3.3		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	355		
F	4.1		

<u>CDMG LAB ANALYSIS</u>	
Carbonate.....	25.50 ppm
Bicarbonate.....	9.15 ppm
Sulfate.....	<10.00 ppm
Corrected TDS.....	673 ppm

<u>OTHER DATA</u>	
Date of Site Visit.....	7-04-81
Ambient Temperature.....	33°C
Surface Temperature of Water.....	54°C
Flow Rate or Capacity....	
Field Investigator.....	Leivas

"Supplementary to the prominent northwest-trending faults that define the Elsinore trough are several east-striking faults that constitute a discontinuous zone of faulting between Murrietta and Buck Mesa (plate 1). The most prominent of these faults is the Murrieta Hot Springs fault zone. The Murrieta Hot Springs fault zone intersects and is either cut off by, or is an eastern branch of, the Wildomar fault zone at Murrieta. It is composed of several faults that have an average strike of N 75°W and a dip of 80°S. The Murrieta Hot Springs fault can be mapped continuously from Murrieta to Murrieta Hot Springs, approximately 5 km. Immediately east of Murrieta, the fault trace is partly masked by cultivation. However, in the vicinity of Warm Springs Creek (plate 1), the fault is well exposed and forms a ground water barrier along which artesian warm water rises. The fault extends southeast from Murrieta Hot Springs to Buck Mesa, approximately 10 km, based on well data (Giessner and others, 1971) that defines a ground water barrier similar to, and along strike with, the one at Warm Springs Creek. Rocks of the Mesozoic basement complex crop out discontinuously along the northern side of the fault between Warm Springs Creek and Tocalota Creek, a distance of approximately 3 km (plate 1). Quaternary and questionable upper Tertiary sandstone crops out and extends to a subsurface depth of more than 849 m along the southern side of the fault near Murrieta Hot Springs (plate 1)."

HISTORY: Waring (1915) reported that in 1908 there was a hotel with accommodations for about 75 people and that the hot baths were mostly used "for their efficiency in cleansing the system from alcoholic poisoning". Over the years since 1908, the resort had been a family owned balneological business.

In 1969 new owners took over and extensively enlarged the resort. In 1977 the resort closed because of bankruptcy.

Foreclosure and bankruptcy proceedings have kept the resort from being sold, but as of the date of the site visit, the resort was up for sale.

NAME: Nevares Springs (IN-26)

LOCATION: 36°30.73'N; 116°47.40'W

T38N, R1E, Sec. 36 (SBB&M)

Inyo County; 8 km northeast of Park Service Visitor

Center, Death Valley.

QUADRANGLE: Chloride Cliff 15'

SYNOPSIS: A large supply of 40°C water is available for use. Currently the water is circulated through a cooling tower prior to use for domestic purposes at the National Park Service employees' residence. The warm water apparently rises along a fault which appears to be a strand of the Furnace Creek Fault Zone. A study to determine the feasibility of using the geothermal resource here should be conducted.

GEOHERMAL FEATURES: At least 6 separate springs furnish warm water to a central collection basin (photo 20) from which water is piped to storage tanks. Water temperature at the collection basin and sample point was 40°C. The springs are located on top of a mound of tan colored tufa approximately 300 m in diameter. The 40°C water probably rises along a fault located near the springs (Hunt and Mabey, 1966). This fault is one of the various parallel and subparallel faults which constitute the Furnace Creek Fault Zone in this area. The large volume of water collected by the National Park Service for domestic use and the large size of the tufa deposits (photo 21) suggests that a large reliable supply of warm water is located here.

CHEMISTRY: See table 24, page 147.

Photo 20. Nevares springs, Death Valley. This concrete box is the collection point for waters from several springs within about 200 feet of here. The water is piped by gravity flow to storage tanks and then from there to the National Park Service employees residences. The material here is composed of tufa. Nevares peak is in the background; view is easterly. Photo by E. Leivas.

Photo 21. Tufa mound upon which the Nevares springs issue. Peak in the background is Nevares Peak; view is easterly. Photo by E. Leivas.

Table 24

SITE NAME: Nevares Springs (IN-26)

LOCATION: 36° 30.73'N; 116° 47.40'W
T38N, R1E, Section 36 (SBB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	120	Chloride.....	< 139 ppm
K	11	Sulfate.....	_____ ppm
Ca	42	Sulfide.....	0.016 ppm
Mg	21	Nitrogen (Ammonia).....	0.65 ppm
Fe	< 0.025	Alkalinity (as CaCO ₃)....	240 ppm
Al	< 0.625	Salinity (percent).....	0.3
Si (As SiO ₂)	22	pH.....	6.7
Ti	0.3	Electrical Conductivity	
P	< 0.625	at 28 °C.....	1025 µmho/cm
Sr	1.13	<u>CDMG LAB ANALYSIS</u>	
Ba	< 0.625	Carbonate.....	- ppm
V	< 1.25	Bicarbonate.....	340.08 ppm
Cr	< 0.050	Sulfate.....	223.70 ppm
Mn	< 0.250	Corrected TDS.....	652 ppm
Co	< 0.025	<u>OTHER DATA</u>	
Ni	< 0.125	Date of Site Visit.....	5-11-81
Cu	< 0.063	Ambient Temperature.....	34°C
Mo	< 1.25	Surface Temperature	
Pb	< 0.250	of Water.....	40°C
Zn	< 0.125	Flow Rate or Capacity....	
Cd	< 0.063	Field Investigator.....	Leivas
Ag	< 0.050		
Au	< 0.100		
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	0.13		
Be	< 0.005		
B	0.9		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	38		
F	3.5		

GEOLOGY: Nevares Springs occurs on the east side of Death Valley, which is within the Basin and Ranges Geomorphic Province. Nevares Springs is located near the base of Nevares Peak, which is mostly composed of the Cambrian Bonanza King Formation. Sedimentary deposits which underlie the springs include a large deposit of tufa, underlain by fan gravel and floodplain deposits (figure 25) described by Hunt and Mabey (1966).

The nearest major fault is the northwest-southeast trending Furnace Creek Fault Zone, shown by Jennings (1975) to have been active in the last 2 million years. Hunt and Mabey (1966) show several faults, which cut Quaternary deposits in the area south of Nevares Springs. These faults are probably lesser strands of the larger Furnace Creek Fault Zone. One of these strands is located immediately downslope of the springs (Hunt and Mabey, 1966). This fault probably acts as a ground water barrier and a conduit for subsurface waters to migrate upward.

HISTORY: Nevares Springs was first used by Indians. Later, prospectors and settlers passing through the region used the springs.

Currently the National Park Service uses the water at the Park employees' residences--Park Village, for all domestic purposes. The water system includes collection basins at the springs, a pipeline to carry the water to a cooling tower, chlorinators, and then into a 500,000-gallon (1,892,706 liter) storage tank. From the storage tank the water is piped to the Park Village.

EXPLANATION

Figure 25. Generalized map and section showing geology around Nevares Springs, Inyo County. The map is simplified from Hunt and Mabey (1966).

NAME: Newsom Springs (SL-13)

LOCATION: 35°07.35'N; 120°32.58'W

T32S, R13E, Sec. 23 (MDB&M)

San Luis Obispo County; 4 km east of Arroyo Grande.

QUADRANGLE: Oceano 7.5'

SYNOPSIS: Two warm water springs located approximately 10 m apart produce a combined flow of about 56.8 liters per minute at a temperature of 36°C. The quantitative extent of the resource is not known; however, reports suggest that the springs have flowed at 56.8 liters per minute since at least 1864.

GEOHERMAL FEATURES: Two springs approximately 10 m apart (photo 22) produce a combined flow of about 56.8 liters per minute. The warm water is currently used only for bathing by the residents of the property. Hydrothermal alteration of rocks in the immediate area was not obvious. Waring (1915) observed small amounts of sulfur deposited downstream of the springs; however, these or similar deposits were not observed during this visit. Three other cold water springs occur in the area, one is only about 5 m from each of the two warm springs. The warm springs have been artificially confined and the water is clear; however, there is green to green-grey algae growing on the basin sides.

The warm waters probably rise along the contact between the opaline/cherty shale and claystone/siltstone members of the Monterey Formation as mapped by Hall (1973). The heat source for the geothermal waters at Newsom Springs is unknown; however, the

Photo 22. Newsom Springs. Two warm springs occur here. One is to the left of the wheelbarrow and the other occurs at the location indicated by the arrow. The materials underlying the site are Quaternary alluvium underlain by the Monterey Formation (shale). Photo by E. Leivas.

occurrence of thermal springs has been related to synclines in some areas. The existence of a syncline 0.6 km to the east (Hall, 1973) may have some relationship to the thermal properties of the water.

The quantitative extent of the resource is not known; however, reports (Laizure, 1925) indicate that these springs have flowed at 56.8 liters per minute and a temperature of about 38°C since at least 1864.

CHEMISTRY: See table 25, page 153.

GEOLOGY: Newsom Springs is located in the Coast Ranges Geomorphic Province. The geologic structure of this area has been strongly influenced by the tectonics associated with the northwesterly trending San Andreas fault system located 60 km to the northeast. Locally the springs issue in Newsom Canyon (figure 26) which is underlain by Quaternary colluvium. Under the thin covering of colluvium is the Monterey Formation. The axis of an east-west trending syncline is located 0.6 km to the east, and the beds in the area of the spring dip to the east. The fault nearest to the site is an unnamed reverse fault located 2.2 km to the northeast (Hall, 1973). The Edna fault, located 5.6 km to the northeast, has been active during the Quaternary (Jennings, 1975). The Hosgri fault zone is located 24 km southwest. It is unlikely that the warm water is associated with any of these faults.

HISTORY: The property upon which the warm springs are located was owned by the Newsom family since 1864 (Laizure, 1925). Waring (1915) reported the presence of a hotel and small cottages, tub baths, and

Table 25

SITE NAME: Newsom Springs (SL-13)

LOCATION: 35° 07.35'N; 120° 32.58'W
T32S, R13E, Section 23 (MDB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	51	Chloride.....	< 139 ppm
K	13	Sulfate.....	_____ ppm
Ca	60	Sulfide.....	_____ ppm
Mg	37	Nitrogen (Ammonia).....	8.4 ppm
Fe	0.08	Alkalinity (as CaCO ₃)....	_____ ppm
Al	< 0.625	Salinity (percent).....	2.0
Si (As SiO ₂)	29	pH.....	6.6
Ti	< 0.125	Electrical Conductivity	
P	< 0.625	at 28 °C.....	950 µmho/cm
Sr	0.33		
Ba	< 0.625		
V	< 1.25		
Cr	< 0.050		
Mn	< 0.250		
Co	< 0.025		
Ni	< 0.125		
Cu	< 0.063		
Mo	< 1.25		
Pb	< 0.250		
Zn	< 0.125		
Cd	< 0.063		
Ag	< 0.050		
Au	< 0.100		
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	< 0.050		
Be	< 0.005		
B	< 0.125		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	43		
F	0.5		

<u>CDMG LAB ANALYSIS</u>	
Carbonate.....	- ppm
Bicarbonate.....	483.43 ppm
Sulfate.....	<10.00 ppm
Corrected TDS.....	482 ppm

<u>OTHER DATA</u>	
Date of Site Visit.....	7-05-81
Ambient Temperature.....	24°C
Surface Temperature of Water.....	36°C
Flow Rate or Capacity....	56.7 l/m
Field Investigator.....	Leivas

Figure 26. Map and section of geology near Newsom Springs, San Luis Obispo County. Generalized from Hall (1973).

a swimming pool. Waring also reported that the water had "been carbonated and bottled by the local soda works."

In 1981, there were two mobile homes, two cottages, and a large building, presumably once the hotel. The current leasee has cleared the area around the springs of underbrush and cleaned out the springs for bathing.

NAME: Pan Hot Spring (SB-19)

LOCATION: 34°16.30'N; 116°50.25'E

T2N, R1E, Sec. 12 (SBB&M)

San Bernardino County; in the town of Big Bear City.

QUADRANGLE: Lucerne Valley 15'

SNYOPSIS: Pan Hot Spring supplies a commercial swimming pool and plunge with water of 32°C temperature and of fairly good quality. It is situated at the edge of a mountain community, but is practically unused during the cold winter season. The resource may be large enough that possible additional uses for this resource would be aquaculture and space heating with heat pumps for a high density residential development or winter sports resort.

DESCRIPTION: Pan Hot Spring occurs at the western edge of the ephemeral Baldwin Lake, in the northern part of the Big Bear City (figure 27). There is no natural surface flow but a well and hexagonal cistern mark the former spring site, about 100 m south of Highway 18. The water is pumped through 7.6 cm plastic pipe nearly 200 m to a commercial swimming pool and private home. Remnants of an older pipeline of wire-bound wood-slat pipe testify to a fairly long history of use of the spring. A hexagon sump house holds water about 1 m deep at and below ground level.

GEOHERMAL FEATURES: The site was visited on November 14, 1980. Air temperature changed from 18°C at 1415 hours to 3°C at 1800 hours. The sump contained water at 24°C to 27.5°C. A maximum temperature of 32°C was obtained by discharging a pipe from the well. This is consistent with Waring's (1915) report of 88°F (31.5°C) for the natural spring.

Figure 27. Map and section of geology around Pan Hot Springs, San Bernardino County. Geology adapted from Dibblee (1964).

CHEMISTRY: The water is of the NaSO_4 type with TDS of 450 ppm. It is of good quality for most uses. Only the fluoride content, 10 ppm, makes it undesirable for long term human consumption. See our analysis on table 26, page 159.

GEOLOGY: The hot spring lies on the northern edge of Bear Valley, an east-west intermountain trough containing Big Bear and Baldwin Lakes, high in the San Bernardino Mountains. Elevation of the site is 2,050 m. The hot spring is an isolated one, located on the fault bounding the northern side of the valley.

The mountain range consists largely of batholith rocks of Jura/Cretaceous age which intruded and metamorphosed sedimentary and volcanic rocks. Bear Valley is covered with Quaternary terrace, conglomerate and other alluvial sediments (figure 27) (Dibblee, 1964).

According to Richmond (1960) the mountains were uplifted in Miocene/Pliocene time chiefly along low and high-angle reverse faults trending east-west. Later the range front was further elevated along northwest trending reverse faults, some of which cut Quaternary terrace deposits. Depression of the south part of the mountain block along normal faults produced the Bear and Holcom Valleys and the west-trending ridge that separates them. Along the north front of the range and the north side of Bear Valley, the faults are in most places, covered by older alluvium, but locally they cut the alluvium.

Table 26

SITE NAME: Pan Hot Springs (SB-19)

LOCATION: 34° 16.30'N; 116° 50.25'W
T2N, R1E, Section 12 (SBB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	122	Chloride.....	_____ ppm
K	< 2.50	Sulfate.....	<u>207</u> ppm
Ca	5	Sulfide.....	_____ ppm
Mg	< 0.500	Nitrogen (Ammonia).....	<u>1.0</u> ppm
Fe	< 0.025	Alkalinity (as CaCO ₃)....	_____ ppm
Al	< 0.625	Salinity (percent).....	<u>0.2</u>
Si (As SiO ₂)	27	pH.....	<u>8.7</u>
Ti	0.1	Electrical Conductivity	
P	< 0.625	at <u>17</u> °C.....	<u>600</u> µmho/cm
Sr	0.04	<u>CDMG LAB ANALYSIS</u>	
Ba	< 0.625	Carbonate.....	<u>21.00</u> ppm
V	< 1.25	Bicarbonate.....	<u>213.50</u> ppm
Cr	< 0.050	Sulfate.....	<u>29.80</u> ppm
Mn	< 0.250	Corrected TDS.....	<u>337</u> ppm
Co	< 0.025	<u>OTHER DATA</u>	
Ni	< 0.125	Date of Site Visit.....	11-14-80
Cu	< 0.063	Ambient Temperature.....	18°C
Mo	< 1.25	Surface Temperature	
Pb	< 0.250	of Water.....	32°C
Zn	< 0.125	Flow Rate or Capacity....	
Cd	< 0.063	Field Investigator.....	Martin
Ag	< 0.050		
Au	< 0.100		
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	< 0.050		
Be	< 0.005		
B	< 0.125		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	12		
F	13.8		

The latest volcanism in the Bear Valley area is believed to be Triassic, thus the thermal water is not likely to have been heated by warm or hot rocks.

HISTORY AND USES: The earliest reference to the spring is by Waring (1915) who described it as the "warm spring at Baldwin Lake", consisting of a pool 6.1 m in diameter in a marsh at the western end of the lake. It was undeveloped until after 1920, when purchased by E.C. Jessurun. In 1926 it was named "Pan Hot Springs" after the wood nymph by Jessurun's daughter, Estelle Spradlin. By 1929 a well was under construction, 24.4 m indoor and outdoor pools, a dance hall, and the nucleus of a 24 room hotel had been completed. The name of the establishment was changed to "Mountain Springs Rancho", but the name "Pan" persists today as the name of the spring. The hotel was destroyed by fire in 1933 but the indoor pool is still in use commercially during the summer season.

Energy saving applications for 32°C water present problems of economic feasibility in California at today's energy costs. Obvious uses are aquaculture; space heating (with heat pumps); and possibly mushroom growing. The water is pure enough (TDS of 492 ppm) with Fe and Mn low enough for nearly all industrial applications. The only drawback in regard to water quality is the high fluoride content (10 ppm) which would be undesirable for consumption by humans and some other animal life.

NAME: Paso Robles Well 26S/12E 29C

LOCATION: 35°38.68'N; 120°42.21'W

T26S, R12E, Sec. 29 (MDB&M)

San Luis Obispo County; approximately 200 m west of Paso Robles city limits.

QUADRANGLE: Paso Robles 7.5'

SYNOPSIS: Water in well 26S/12E 29C comes from the Santa Margarita Formation. Bottomhole temperature of the water was measured at 32.7°C while the surface temperature was 21.5°C. Flow rate or capacity is unknown. The high boron level of the water from this well has caused use of the water for irrigation purposes to be discontinued.

GEOHERMAL FEATURES: The potential for Paso Robles well 26S/12E29C to produce geothermal fluids seems low. A more promising geothermal zone appears to be associated with the north trending concealed fault that branches from the Rinconada fault and passes 0.8 km to the east (figure 28). Water in well 26S/12E 29C is a very low-temperature geothermal fluid at best. The warm water is most likely the result of mixing of percolating groundwater with warm water moving upward along a northwest trending fault located within 10s of meters to the east (figure 28). The warmest waters (springs and wells) in the Paso Robles area appear to be associated with the north trending concealed fault that branches from the Rinconada fault.

Figure 29 is a presentation of the data from a downhole temperature log. Bottomhole water temperature was 32.7°C on July 6, 1981.

EXPLANATION

- Qal Quaternary alluvium.
- pr Plio-Pleistocene Paso Robles Formation.
- Tm Tertiary Monterey Shale.
- gr Mesozoic granitics.
- Contact.
- - - Fault, dashed where approximately located, dotted where concealed.
- Hot spring.

LOCATION MAP

GENERALIZED GEOLOGIC SECTION WEST OF THE CITY OF PASO ROBLES

Figure 28. Map and section of geology around Paso Robles well 26S/12E-29C, San Luis Obispo County. Geologic map modified from Dibblee (1976), section modified from Johanson (1981).

Figure 29. Downhole temperature log - Paso Robles Well 26S/12E29C.

CHEMISTRY: See table 27, page 165.

GEOLOGY: The Paso Robles area is located on the eastern margin of the Santa Lucia Range, which is part of the Coast Ranges Geomorphic Province. The northwest trending Rinconada fault is located 1 km to the southwest. Dibblee (1976) shows a concealed fault trending north through the city of Paso Robles and passing approximately 0.8 km to the east of well 26S/12E 29C (figure 28). This fault is shown as a minor branch of the Rinconada fault. The well known Paso Robles Mineral Hot Springs occur along the trend of this concealed fault. Locally, a northwest trending fault passes within 10s of feet to the east of the sampled well (figure 28).

The well penetrates a thin covering of Paso Robles Formation (less than 10 feet thick; oral communication, Stig Johanson, DWR, 1981) underlain by Santa Margarita Formation. More detail is presented in Johanson (1981), particularly with respect to groundwater quality.

HISTORY: Well 26S/12E 29C was drilled in 1964. The boring was developed into a well and the water used on the adjacent almond orchard (photo 23). Subsequently, the trees showed that something was damaging them, so an analysis was performed on the water; the relatively high boron level was suspected of causing the damage. Following the analysis, the use of the well for irrigation was discontinued. The well currently is cased and open to at least 600 feet in depth; the collar is set in concrete and the well itself is located within a fenced area. The water is unused.

Table 27

SITE NAME: Paso Robles (well 26S/12E 29C)

LOCATION: 35° 38.68'N; 120° 42.21'W
T26S, R12E, Section 29 (MDB and M)WATER ANALYSIS AND SITE DATA

CA DEPT OF WATER RESOURCES		DWR ANALYSIS	
Element	Concentration (ppm)		
Na	490	Chloride.....	ppm
K	9.3	Sulfate.....	ppm
Ca	5	Sulfide.....	ppm
Mg	1	Nitrogen (Ammonia).....	ppm
Fe		Alkalinity (as CaCO ₃)....	ppm
Al		Salinity (percent).....	
Si (As SiO ₂)		pH.....	8.7
Ti		Electrical Conductivity	
P		at 25°C.....	2470 µmho/cm
Sr			
Ba			
V			
Cr			
Mn			
Co			
Ni			
Cu			
Mo			
Pb			
Zn			
Cd			
Ag			
Au			
As			
Sb			
Bi			
U			
Te			
Sn			
W			
Li			
Be			
B	6.8		
Zr			
La			
Ce			
Th	16		
Cl	675		
F	3.4		

DWR ANALYSIS	
Carbonate.....	ppm
Bicarbonate.....	194 ppm
Sulfate.....	0 ppm
TDS.....	1310 ppm

OTHER DATA	
Date of Site Visit.....	7-06-81
Ambient Temperature.....	27.5°C
Surface Temperature of Water.....	21.5°C
Flow Rate or Capacity....	
Field Investigator.....	Leivas

Photo 23. Paso Robles Well 26S/12E29C. View is to the west. The site is in an almond orchard. Boron levels in the water from this well were too high for irrigation use. The famed Paso Robles hot spring resorts are located to the east (behind viewer) of here in the town of Paso Robles. Photo by E. Leivas.

NAME: Placer Claim Springs

LOCATION: 35°34.66'N; 118°32.96'W

T27S, R32E, Sec. 16 (MDB&M)

Kern County; approximately 5.5 km west of Bodfish and 48 km east of Bakersfield.

QUADRANGLE: Miracle Hot Springs 7.5'

SYNOPSIS: Placer Claim Springs total flow is in excess of 11.4 liters per minute; surface temperature of the water is 40°C. Springs are located in granodiorite, access is severely restricted by the topography. Current use is for bathing.

GEOTHERMAL FEATURES: Placer Claim Springs is one of several warm springs located along this portion of the Kern River. These springs are not shown on the USGS Miracle Hot Springs 7.5' quadrangle nor on the map of Geothermal Resources of California (Higgins, 1980).

The springs consist of several warm seeps at the river level, 2 springs up-slope from the main spring, and the main spring (photos 24 and 25). The warm water rises into the bottom of a rock and cement basin, which was constructed in 1956 (photo 24).

CHEMISTRY: See table 28, page 169.

GEOLOGY: Placer Claim Springs is located near the southern end of the Sierra Nevada Geomorphic Province. The Kern Canyon fault is located approximately 4 km to the east. Smith (1964) shows an unnamed fault with a northwest-southeast trend which could be

Photo 24. Placer Claim Springs. Warm water rises into the rock and cement tub shown here. Two other springs, with lesser flow, issue approximately 20 m upslope from here. Photo by E. Leivas.

Photo 25. Placer Claim Springs. View is to north, Kern River flowing from right (east) to left (west). The springs issue in jointed tonalite with elongated xenoliths as shown here cropping out on the other side of the river. Photo by E. Leivas.

Table 28

SITE NAME: Placer Claim Springs

LOCATION: 35° 34.66'N; 118° 32.96'W
T27S, R32E, Section 16 (MDB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	54	Chloride.....	< 139 ppm
K	4	Sulfate.....	8 ppm
Ca	13	Sulfide.....	2 ppm
Mg	1	Nitrogen (Ammonia).....	ppm
Fe	< 0.025	Alkalinity (as CaCO ₃)....	60 ppm
Al	< 0.625	Salinity (percent).....	0
Si (As SiO ₂)	38	pH.....	8.1
Ti	0.2	Electrical Conductivity	
P	< 0.625	at 30 °C.....	352 µmho/cm
Sr	0.02		
Ba	< 0.625	<u>CDMG LAB ANALYSIS</u>	
V	< 1.25	Carbonate.....	21.00 ppm
Cr	< 0.050	Bicarbonate.....	594.75 ppm
Mn	< 0.250	Sulfate.....	<10.00 ppm
Co	< 0.025	Corrected TDS.....	479 ppm
Ni	< 0.125		
Cu	< 0.063	<u>OTHER DATA</u>	
Mo	< 1.25	Date of Site Visit.....	3-31-81
Pb	< 0.250	Ambient Temperature.....	19°C
Zn	0.3	Surface Temperature	
Cd	< 0.063	of Water.....	40°C
Ag	< 0.050	Flow Rate or Capacity....	9.5 l/m
Au	< 0.100	Field Investigator.....	Leivas
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	0.09		
Be	< 0.005		
B	1.2		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	47		
F	4.0		

projected to the site of the springs (figure 30). Morton and Troxel (1962) do not show this fault. Evidence of faulting in the immediate area of the springs was not observed during the brief field reconnaissance. Photo 25 shows the main spring in the foreground with jointed granodiorite across the river. Elongated xenoliths are oriented parallel to the predominant direction of jointing, which strikes north-south. The warm water most likely migrates upward along the joint system. Evidence of hydrothermal alteration of the rocks was not observed.

HISTORY: The Placer Claim Springs have not been previously described in the literature and are not shown on the USGS topographic map of this area. The land is owned by the U.S. Forest Service. Access is by way of a steep trail from a turnout located on the old Highway 178. The springs were used for washing and bathing by prospectors and miners at least to 1956. The remains of an old car, the lower portions of rock walls for a rock cabin, and other debris are scattered about the up-slope area. Current use (bathing) is by a few local inhabitants of this region who happen to know the location of this spring.

NAME: Ridgecrest Well #9 (26S/40E-30K2)

LOCATION: 35°38.60'N; 117°42.79'W

T26S, R40E, Sec. 30 (MDB&M)

Kern County; 4.8 km northwest of Ridgecrest.

QUADRANGLE: Ridgecrest 15'; Ridgecrest North 7.5'

SYNOPSIS: Indian Wells Valley Water District well #9 is a 243.8 m deep water well which produces 30°C water at 4,921 liters per minute (1300 gpm). A northwest-southeast trending fault located 0.5 km to the northeast is related to the occurrence of warm water in this area. The volume of warm water produced, together with the consistency of the water temperature, suggests that this area may have potential as a geothermal resource.

GEOHERMAL FEATURES: Indian Wells Valley Water District well #9 is a 243.8 m (800 feet) deep water well which produces 30°C water year round. This well is one of 3 wells located within 150 m of each other; the other 2 wells also produce warm water of 30°C. A northwest-southeast trending fault located 0.5 km to the northeast (figure 31) is related to the occurrence of warm water in this area. Data from Department of Water Resources Bulletin 91-17 suggests that water from wells on the southwest side of the fault tends to be a little warmer (27°C - 31°C) than water from wells on the northeast side (23°C). Also the water on the southeast gets cooler with increasing distance from the fault. It seems likely that the occurrence of the warm water is somehow related to this fault. The source of the heat could be due to aseismic movement along the fault at depth, or to upward convective movement of the water along the fault from a deeper heat source such as heated rock.

EXPLANATION

Qya Quaternary younger alluvium.

Qoa Quaternary older alluvium.

Contact, dashed where approximately located.

Fault, dashed where inferred, dotted where concealed.

LOCATION MAP

Figure 31. Map and section of the area around Ridgecrest Well #9 (26S/40E-30K2), Kern County. Map and section from Moyle (1963).

The volume of warm water and the consistency of water temperature suggests that this area may have potential for a low-temperature geothermal resource. The region should be studied for its geothermal potential.

CHEMISTRY: See table 29, page 175.

GEOLOGY: Indian Wells Valley is located in the Basin and Ranges

Geomorphic Province. The Sierra Nevada Geomorphic Province is located 16 km to the west. The northeast trending, left-lateral Garlock fault is located approximately 23 km to the south. Indian Wells Valley is internally drained and has no perennial streams.

Rocks of this area include plutonic and metamorphic rocks of pre-Tertiary age, and sedimentary deposits that include alluvium, fan deposits, lake deposits, and windblown sand (figure 31) (Moyle, 1963). The following is a description of the sedimentary deposits from Moyle (1963):

"The older alluvium of Quaternary age is composed of unconsolidated weathered gravel, sand, silt, and clay....This material underlies parts of the younger alluvial deposits in Indian Wells Valley and is the principal source of ground water...."

The older fan deposits are composed of boulders, gravel, sand and silt. Again from Moyle (1963):

"The old lacustrine deposits of Quaternary age are subdivided into two units, both of which are composed of silt, sand, clay, and freshwater marl, cemented with calcareous tufa cement. These units

Table 29

SITE NAME: Ridgecrest Well 26S/40E-30K2

LOCATION: 35° 38.60'N; 117° 42.79'W
T26S, R40E, Section 30 (MDB and M)

WATER ANALYSIS AND SITE DATA

UURI ANALYSIS		CDMG FIELD ANALYSIS	
Element	Concentration (ppm)		
Na	56	Chloride.....	< 139 ppm
K	< 2.50		
Ca	14	Sulfate.....	34 ppm
Mg	4		
Fe	< 0.025	Sulfide.....	0.01 ppm
Al	< 0.625		
Si (As SiO ₂)	29	Nitrogen (Ammonia).....	0.84 ppm
Ti	< 0.125		
P	< 0.625	Alkalinity (as CaCO ₃)....	80 ppm
Sr	0.35		
Ba	< 0.625	Salinity (percent).....	Trace
V	< 1.25		
Cr	< 0.050	pH.....	6.7
Mn	< 0.250		
Co	< 0.025	Electrical Conductivity	
Ni	< 0.125	at 30 °C.....	435 µmho/cm
Cu	< 0.063		
Mo	< 1.25		
Pb	< 0.250	CDMG LAB ANALYSIS	
Zn	< 0.125	Carbonate.....	- ppm
Cd	< 0.063		
Ag	< 0.050	Bicarbonate.....	132.68 ppm
Au	< 0.100		
As	< 0.625	Sulfate.....	68.53 ppm
Sb	< 0.750		
Bi	< 2.50	Corrected TDS.....	277 ppm
U	< 6.25		
Te	< 1.25	OTHER DATA	
Sn	< 0.125	Date of Site Visit.....	5-13-81
W	< 0.125		
Li	0.06	Ambient Temperature.....	28°C
Be	< 0.005		
B	0.6	Surface Temperature	
Zr	< 0.125	of Water.....	30°C
La	< 0.125		
Ce	< 0.250	Flow Rate or Capacity....	4921 l/m
Th	< 2.50		
Cl	37	Field Investigator.....	Leivas
F	1.1		

are separated by an ancient shoreline of calcareous tufa at an altitude of 2,200 feet above mean sea level. The older lower unit (1) is also separated from the younger unit (2) by an angular unconformity....The younger alluvium of Recent age is unconsolidated, moderately to well-sorted sand, clay, and gravel....The younger fan deposits of Recent age are unconsolidated, poorly to moderately-sorted gravel, sand, and silt, with some mudflow debris...The playa deposits of Recent age...consist mainly of silt and clay and are of low permeability....The dune sand of Recent age is composed of windblown sand."

There are several northwest trending faults in the valley. The fault nearest to well 26S/40E-30K2 is located 0.5 km to the northeast (figure 31). Jennings (1975) shows this fault to have been active during the last 2 million years. Moyle (1963) shows an area of older alluvium (Pleistocene) which has been cut by the fault. The fault is depicted by Moyle to be near vertical to steeply northeast dipping. Ground water in the area surrounding the fault is warmer on the southwest side than on the northeast side (Moyle, 1963; oral communication J. Mont-Eton, Superintendent, Indian Wells Valley Water District, 1981).

HISTORY: This and numerous other wells in Indian Wells Valley have been drilled for water. Many wells, including this one, were inherited by the Water District and no geological logs are available. This well, and the 2 others located within 150 m of this one, have each consistently produced $30^{\circ}\text{C} \pm 1^{\circ}\text{C}$ water at the rate of 4,921 liters per minute for a number of years.

NAME: Scovern Hot Springs (KR-2)

LOCATION: 35°37.23'N; 118°28.38'W

T26S, R33E, Sec. 31 (MDB&M)

Kern County; in the town of Lake Isabella.

QUADRANGLE: Lake Isabella South 7.5'

SYNOPSIS: Scovern Hot Springs is a relatively large low-temperature geothermal resource. 54°C to 55°C water flows from the springs at 415 liters per second combined flow. The site is in a populated valley and appears to have good potential for geothermal development. It is a former resort/hotel/plunge site, but the resource is currently unused. Located in the town of Lake Isabella, its development potential appears to be favorable.

GEOHERMAL FEATURES: Scovern Hot Springs consists of three readily identified hot springs in a relatively wide alluviated valley containing the town of Lake Isabella. Scovern is the hottest and most voluminous of the hot spring groups of the southern Sierra Nevada. Flow from the three springs has been enhanced by shallow drilling and installation of large diameter standpipes (photo 26).

The site was visited on 3/20/81 and 3/31/81. Spring no. 1 discharges 55°C water at a height of 1.7 m above ground level from a 42 cm (16-1/2 inch) thin-walled standpipe. The flow rate measured with a 90° V notch weir was 333 liters per minute.

Spring no. 2 discharges 54°C to 55°C water through a 26.7 cm (10-1/2 inch) standpipe through openings 0.3 m and 1.0 m above ground level. Flow rate measured with the portable V-notch weir was 75.7 liters per minute. This spring is 75 m N78°E of spring no. 1.

Photo 26. View of spring no. 1 at Scovern Hot Springs. Water temperature is 55°C and flow rate is approximately 330 liters per minute. The framework in the background is the remains of the resort which once existed at this site. Photo by R.C. Martin.

Spring no. 3 discharges 47°C water from a 20.3 cm (8 inch) standpipe, 3.1 m above ground level. Its flow rate was estimated at 3 liters per minute. It is 90 m S15°W of spring no. 1.

Local residents report that other minor hot springs issue from a boggy field across the highway (west) from these springs. This was briefly field checked, but only cold springs, and the steaming runoff stream from the Scovern springs were found.

CHEMISTRY: Based on analysis of water from spring no. 2 (table 30), the Scovern waters are only slightly mineralized, with TDS of the order of 400 ppm. However, high fluoride content (8.5 ppm) discourages its use for human consumption.

GEOLOGY: Scovern Hot Springs occur near the middle of a flat alluvial valley surface in Hot Springs Valley (figure 32). Treasher (1948) suggested that the valley is the result of reverse faulting on the Kern Canyon fault. It is filled with as much as 70 m of detritus, principally from the Cook Peak area. Alvarez (1962) has suggested that the hot springs may mark the position of fracturing on the Kern Canyon fault, or a parallel extension of the Erskine Creek fault.

The occurrence of thermal waters of different temperatures in wells elsewhere in Hot Springs Valley indicates mixing of deep seated hot waters with near surface ground waters and lateral movement beneath Hot Springs Valley.

The Scovern Hot Springs are among a group of low temperature thermal springs in the southern portion of the Sierra Nevada Mountains. The mountains are composed dominantly of granitic rocks

Table 30

SITE NAME: Scovern Hot Springs (KR-2)

LOCATION: 35° 37.23'N; 118° 28.38'W
T26S, R33E, Section 31 (MDB and M)WATER ANALYSIS AND SITE DATA

UURI ANALYSIS		CDMG FIELD ANALYSIS	
Element	Concentration (ppm)		
Na	111	Chloride.....	_____ ppm
K	5	Sulfate.....	_____ ppm
Ca	7	Sulfide.....	_____ 1.8 ppm
Mg	1	Nitrogen (Ammonia).....	_____ ppm
Fe	< 0.025	Alkalinity (as CaCO ₃)....	_____ 200 ppm
Al	< 0.625	Salinity (percent).....	_____ 0.1
Si (As SiO ₂)	48	pH.....	_____ 7.6
Ti	0.2	Electrical Conductivity	
P	< 0.625	at 25 °C.....	_____ 540 µmho/cm
Sr	0.12		
Ba	< 0.625		
V	< 1.25		
Cr	< 0.050		
Mn	< 0.250		
Co	< 0.025		
Ni	< 0.125		
Cu	< 0.063		
Mo	< 1.25		
Pb	< 0.250		
Zn	< 0.125		
Cd	< 0.063		
Ag	< 0.050		
Au	< 0.100		
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	0.15		
Be	< 0.005		
B	2.1		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	41		
F	8.0		

CDMG LAB ANALYSIS

Carbonate.....	_____ - ppm
Bicarbonate.....	_____ - ppm
Sulfate.....	_____ - ppm
Corrected TDS.....	_____ 225* ppm

OTHER DATA

Date of Site Visit.....	3-20-81
Ambient Temperature.....	18°C
Surface Temperature of Water.....	54°C
Flow Rate or Capacity....	
Field Investigator.....	Martin

*No data on HCO₃, therefore, this
is a partial TDS value.

of the Sierra Nevada Batholith, intruded in Cretaceous time. Roof pendants of Pre-Cretaceous metasedimentary rocks are common, and are elongate northeastward in this part of the Sierra Nevada; layering, or foliation, in the metasedimentary rocks generally is near vertical and strikes parallel to the long axis of the pendants (Troxel and Morton, 1962).

Hot spring phenomena in this region appears anomalous, for elsewhere, the Sierra Nevada block is generally devoid of geothermal activity, and is part of a major low heat flow anomaly, in which heat flow values range from 60 to as little as 19 milliwatts per square meter (Sass and Lachenbruch, 1978).

As in other granitic upland regions, subsurface waters occur in relatively low volume in joints and fractures, and to a lesser extent, in narrow alluvial bodies along well established drainage courses. Most of the southern Sierra hot springs occur along the course of the Kern River, near the base of a canyon 457 m to 1,067 m below the surrounding mountain peaks. The three northernmost hot springs occur on or close to well recognized faults. The Kernville hot springs are located on the Goat Ranch Fault, a branch of the Kern Canyon fault. California Hot Springs lies on the Deer Creek Fault. Scovern Hot Springs issue from an alluviated valley on the Kern Canyon Fault. Downstream from Scovern, major faults are unknown. The cause of the southwest trending alignment of hot springs is unknown, but they are obviously related to local fractures and joint concentrations observed in the relatively low elevations of the Kern River gorge or associated valley. According

Figure 32. Map and section of geology around Scovern Hot Springs, Kern County. Compiled from Smith (1964).

to Jennings (1975) none of the mapped faults associated with the hot springs are known to have been active during the past two million years.

Bedrock is not exposed at Scovern and evidence of rock alteration by hydrothermal activity was not observed.

HISTORY: Scovern was formerly referred to as Neills Hot Spring and Waring (1915) reported that it was called Agua Caliente, like several hot springs in the state, by the Spanish settlers. He noted that just prior to 1915, the spring was developed by installing about 40 feet (12 m) of well casing, and that the entire hot spring flow was from that one vent.

Since 1915, a resort with a swimming pool and baths was constructed, but this has been destroyed and the hot springs are currently unused.

NAME: Sierra East Mobile Home Park Well (MO-2)

LOCATION: 38°31.50'N; 119°28.50'W

T8N, R23E, Sec. 19 (MDB&M)

Mono County; just east of Highway 395, north of the
community of Walker.

QUADRANGLE: Desert Creek Peak, Nev.-Calif. 15'

SYNOPSIS: A warm water aquifer with a temperature of at least 41°C

lies beneath southwestern Antelope Valley. The areal extent of this aquifer is unknown as there are few deep wells drilled in the valley. As a hot spring is reported north of Topaz, the warm water aquifer may extend along the west side of the valley a distance of at least 13 km. A likely source for the geothermal water is the fault on the west side of the valley.

The well supplies domestic water for the mobile home park. The owner is building a spa and plans to pump directly from the well into the spa (photo 27). Surface temperature of the water pumped from the well is reported to be 35°C.

GEOTHERMAL FEATURES: The well at the mobile home park was drilled to a depth of 39 m. The bottom-hole temperature measured by the driller was 41°C. According to Mr. Stout the well produces from both a cold water aquifer above 30 m and a hot water aquifer below 30 m.

The water pumped from the well is reportedly 35°C. It was not possible to measure water flowing directly from the well at the time of the visit but water from the insulated storage tank flowed at 25°C.

Figure 33. Map of southern Antelope Valley showing the location of the Sierra East Mobil Home Park warm water well. Geology from Koenig, 1963.

Photo 27. View of the Sierra East Mobile Home Park well (foreground). The building in the background contains a spa to be heated by the well water. A fault scarp formed by the fault on the west side of the valley is seen on the right side of the picture behind the trees. Photo by S. Bezore.

EXPLANATION

- Qal Alluvium.
- gr-m Pre-Cenozoic granitic and metamorphic rocks.
- Qg Glacial deposits.
- Contact, dotted where uncertain.
- Fault, dashed where inferred, dotted where concealed.

There are no known geothermal springs in the immediate area. A warm spring about 11 km to the north in T9N, R23E, Sec. 13 is reported. Mr. Stout reports that a warm spring exists on Spring Ranch on Cunningham Lane about 5 km to the northeast of the mobile home park, but this has not been confirmed. To the south, in Walker, shallow wells (less than 33.5 m) produce warm water (approximately 20°C). A well about 2 km to the northeast which was drilled to a depth of 97.9 m (MO-3) also produces warm water.

CHEMISTRY: See table 31, page 187.

GEOLOGY: Antelope Valley is an alluviated, fault bounded valley (figure 33). On the west side Mesozoic granitic rocks and undifferentiated metamorphic rocks have been uplifted along a north-south trending fault. The youthfulness of the fault is evidenced by the vertical offset of alluvium between Little Antelope Valley and Antelope Valley 1-1/2 km northwest of the mobile home park.

The principal aquifers are in alluvial valley fill. Possible recharge is by runoff from Mill Canyon to the south and from Little Antelope Valley to the west. The West Walker River enters Antelope Valley at the south-east corner and flows north through the length of the valley.

Table 31

SITE NAME: Sierra East Mobile Home Park (MO-2)

LOCATION: 38° 31.50'N; 119° 28.50'W
T8N, R23E, Section 19 (MDB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	33	Chloride.....	89 ppm
K	3		
Ca	10	Sulfate.....	20 ppm
Mg	4		
Fe	0.10	Sulfide.....	ppm
Al	< 0.625		
Si (As SiO ₂)	28	Nitrogen (Ammonia).....	ppm
Ti	< 0.125		
P	< 0.625	Alkalinity (as CaCO ₃)....	ppm
Sr	0.26		
Ba	< 0.625	Salinity (percent).....	0
V	< 1.25		
Cr	< 0.050	pH.....	6.7
Mn	< 0.250		
Co	< 0.025	Electrical Conductivity	
Ni	< 0.125	at 25 °C.....	360 µmho/cm
Cu	< 0.063		
Mo	< 1.25		
Pb	< 0.250		
Zn	0.4		
Cd	< 0.063		
Ag	< 0.050	Carbonate.....	0.00 ppm
Au	< 0.100	Bicarbonate.....	60.00 ppm
As	< 0.625		
Sb	< 0.750	Sulfate.....	15.00 ppm
Bi	< 2.50		
U	< 6.25	Corrected TDS.....	191 ppm
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	0.06		
Be	< 0.005	Date of Site Visit.....	9-27-80
B	1.9	Ambient Temperature.....	°C
Zr	< 0.125		
La	< 0.125	Surface Temperature	
Ce	< 0.250	of Water.....	25°C
Th	< 2.50		
Cl	57	Flow Rate or Capacity....	
F	0.8	Field Investigator.....	Bezore

CDMG LAB ANALYSISOTHER DATA

NAME: Soboba Hot Springs (RV-10); also called Ritchey Hot Springs

LOCATION: 33°48.05'N; 116°55.60'W

T4S, R1E, Sec. 30 (SBB&M)

Riverside County; approximately 3.5 km northwest of the
City of San Jacinto.

QUADRANGLE: San Jacinto 7.5'

SYNOPSIS: Soboba Hot Springs is the site of a once large and luxurious balneological resort. It now lies unused, devastated by a mudslide and an extensive fire. Water of 40°C still flows from the natural springs at a rate on the order of 40 liters per minute. It is believed that this flow could be at least tripled by well development.

GEOTHERMAL FEATURES: Soboba Hot Springs is situated at the foot of the San Jacinto Mountains 4 km northeast of San Jacinto. Six thermal springs ranging from 21°C to 48°C have been reported, (Waring, 1915, Tucker and Sampson, 1945). The springs once supported a luxurious resort hotel with multiple buildings, swimming pool and baths.

Currently three springs are identifiable in the ravine behind the resort buildings and warm seepages are evident in a few locations higher on the sides of the ravine. These locations are marked by clusters of palm trees (photo 28). The recent mudflow deposit covers the lower part of the ravine and may be covering one or more of the pre-existing spring sites. The mudflow has also shifted part of the drainage of the springs from the ravine's natural course northward onto the ground of the resort, where it flows across paved roads.

Photo 28. Soboba Hot Springs. The trace of the Hot Springs fault is shown. The circles indicate the locations of springs. Photo by R.C. Martin.

The springs were visited on January 27, 1981 in 18°C weather. The uppermost spring was sampled. Water at 40°C flowed from a leaky pipe projecting from a gully in colluvial sand at a pronounced break in slope in the hot spring ravine 61 m above the resort. Lower in the ravine, springs of 40°C and 31°C were measured. Total flow from the springs is estimated to be 40 liters per minute. Much of the runoff is lost by seepage into the recent mudflow a short distance from their points of discharge.

CHEMISTRY: Considering the long history of balneological use at Soboba, relatively little chemical data is available. A 1910 analysis indicates a NaHCO_3 water of 431 ppm TDS and another analysis of unknown age, indicates a NaSO_4 water of 815 ppm TDS. Our analysis (table 32) shows that TDS is acceptable for most direct use purposes, and that boron and other trace elements are sufficiently low that disposal is no problem.

GEOLOGY: Soboba Hot Springs lies on the southeastern edge of the San Jacinto Mountain block, a recently elevated mass that is probably still rising. The range front in this area has been uplifted along the active San Jacinto and associated branch faults. Aligned in this fault zone for 31 km are at least three known thermal wells (Higgins, 1980) and four or more thermal springs, including Soboba, Gilman, Indian, and Eden Hot Springs.

Soboba lies near the junction of the San Jacinto fault with one of its branches, the Hot Springs fault (figure 34). Here the Hot Springs fault forms a prominent south facing scarp where it displaces crystalline metamorphic rocks on the north from poorly

Table 32

SITE NAME: Soboba Hot Springs (RV-10)

LOCATION: 33° 48.05'N; 116° 55.60'W
T4S, R1E, Section 30 (SBB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	62	Chloride.....	_____ ppm
K	< 2.50	Sulfate.....	_____ ppm
Ca	1	Sulfide.....	_____ ppm
Mg	< 0.500	Nitrogen (Ammonia).....	_____ ppm
Fe	< 0.025	Alkalinity (as CaCO ₃)....	_____ ppm
Al	< 0.625	Salinity (percent).....	_____
Si (As SiO ₂)	40	pH.....	_____
Ti	0.1	Electrical Conductivity	
P	< 0.625	at _____ °C.....	_____ µmho/cm
Sr	< 0.013		
Ba	< 0.625		
V	< 1.25		
Cr	< 0.050		
Mn	< 0.250		
Co	< 0.025		
Ni	< 0.125		
Cu	< 0.063		
Mo	< 1.25		
Pb	< 0.250		
Zn	< 0.125		
Cd	< 0.063		
Ag	< 0.050		
Au	< 0.100		
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	< 0.50		
Be	< 0.005		
B	< 0.125		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	19		
F	1.6		

<u>CDMG LAB ANALYSIS</u>	
Carbonate.....	<u>37.50</u> ppm
Bicarbonate.....	<u>47.28</u> ppm
Sulfate.....	<u><10.00</u> ppm
Corrected TDS.....	<u>185</u> ppm

<u>OTHER DATA</u>	
Date of Site Visit.....	1-27-81
Ambient Temperature.....	18°C
Surface Temperature of Water.....	40°C
Flow Rate or Capacity....	
Field Investigator.....	Martin

Figure 34. Map and section of the geology around Soboba Hot Springs, Riverside County (adapted from Bean, 1959).

consolidated Pleistocene clastic sediments on the south. The crystalline rocks here are dominantly quartz-mica schist and gneiss considered Paleozoic by Larsen (1948). The Pleistocene sediments, where exposed in the upper hot spring ravine, are poorly sorted, gray sands called the Bautista formation by Frick (1921). This formation is similar to and may be contiguous with the Mt. Eden and San Timoteo formations, which mantle the uneven eroded surface of the crystalline rocks along the southwest edge of the San Jacinto Mountain block.

The thermal waters evidently rise from great depth through the metamorphic basement rocks along the Hot Springs fault or its junction with the San Jacinto fault. At Soboba, where the Pleistocene sediments abut the metamorphic rock mass, the waters flow laterally through the sediment to issue from three or more spring sites along the ravine thalweg, and seep from several less well defined sites higher in the ravine.

The poorly consolidated nature of the Bautista formation sediments and the perennial state of saturation near the springs contribute to produce a state of instability. Waring (1915) referred to a former spring that may have been "covered by a landslide". In the season of heavy rainfall and floods of 1979, the resort hotel was devastated by the landslide mentioned above.

A white efflorescence, probably of finely crystalline gypsum, occurs on the near vertical bank eroded in sandy colluvium at the uppermost spring in the ravine. Because of the easily eroded nature and hence, short time of exposure of the sediments to the thermal waters, no significant rock alteration is evident at Soboba.

HISTORY: The springs were referred to as Ritchey Hot Springs, (named after a former owner) by Waring in 1915. However, the name Soboba Hot Springs has prevailed since that time in publications and maps. Water from the springs was marketed as table water, "Soboba Lithia Water", prior to 1904 and used commercially for bathing in 1908. Later, a hotel was built and an extensive resort was developed.

As a result of a catastrophic fire and mudflow in 1979, the site is currently abandoned.

NAME: Sycamore Hot Springs (SL-11)

LOCATION: 35°11.20'N; 120°42.80'W

T31S, R12E, Sec. 32 (MDB&M)

San Luis Obispo County; 12 km south of San Luis Obispo.

QUADRANGLE: Pismo Beach 7.5'

SYNOPSIS: Sycamore Hot Springs is really a well drilled for oil in

1885-1887. The well head is located in a bituminous sandstone of the Pismo Formation. The well as completed in 1887 is 285.6 m deep. At the time of completion and until at least 1925, the well flowed under natural artesian pressure. In 1981, it was necessary to pump the water into storage tanks. The submersible pump was located 12.2 m below the surface. The 24°C water had to be heated prior to use in the mineral baths. Natural gas from the well was not being used.

GEOHERMAL FEATURES: Sycamore Hot Springs is really a well drilled

for oil in 1885-1887. Warm water was hit at 574 feet (175 m); drilling continued to 937 feet (285.6 m) (Myron, 1890). Myron (1890) reported that this well had an artesian flow of 3,000 barrels per day and a temperature of 103°F (39.4°C). In July 1981, the well did not have an artesian flow and the 24°C water had to be heated prior to use in the mineral baths.

The source of heat for the water is probably a warmer-than-normal geothermal gradient. Here, the 285.6 m deep well penetrates the south limb of an east-west trending syncline. The extent of the geothermal resource, if present, is not known.

CHEMISTRY: See table 33, page 197.

GEOLOGY: Sycamore Hot Springs is located in the Coast Ranges Geomorphic Province. The geologic structure of this region has been strongly influenced by the tectonics associated with the northwesterly trending San Andreas fault system located approximately 65 km to the northeast. Several other major faults located between this site and the San Andreas fault zone have also probably left their mark on the structural geologic picture of this area. The Hosgri fault is located 15 km southwest of this site.

The fault nearest to this site is a reverse fault located about 0.6 km east of the site (figure 35); relative movement is up on the west block (Hall, 1973).

Sycamore Hot Springs well is located along San Luis Creek approximately 1.5 km west of Highway 101 and 8.5 km north of Pismo Beach, California. The well was bored here into an outcrop of bituminous sandstone (Edna Member of Pismo Formation (Hall 1973), in hopes of striking oil (Myron, 1890).

This site is located on the south limb of the east-west trending Pismo Syncline (Hall, 1973). The borehole most likely reached into the Monterey Formation which underlies the Pismo Formation.

HISTORY: Sycamore Hot Springs well was drilled in 1885-1887. The site was selected because the bituminous sandstone at the surface indicated that petroleum might be located below. At 574 feet (175 m) in depth, "warm sulfur water accompanied by gas" (Myron, 1890) was hit. The temperature and volume of water flow increased with depth. Drilling continued to 937 feet (285.6 m). The maximum flow

Table 33

SITE NAME: Sycamore Hot Springs (SL-11)

LOCATION: 35° 11.20'N; 120° 42.80'W
T31S, R12E, Section 32 (MDB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	70	Chloride.....	< 139 ppm
K	14	Sulfate.....	_____ ppm
Ca	50	Sulfide.....	_____ ppm
Mg	34	Nitrogen (Ammonia).....	10.2 ppm
Fe	< 0.025	Alkalinity (as CaCO ₃)....	_____ ppm
Al	< 0.625	Salinity (percent).....	0.3
Si (As SiO ₂)	38	pH.....	7.0
Ti	< 0.125	Electrical Conductivity	
P	< 0.625	at 26 °C.....	1000 µmho/cm
Sr	0.26		
Ba	< 0.625		
V	< 1.25		
Cr	< 0.050		
Mn	< 0.250		
Co	< 0.025		
Ni	< 0.125		
Cu	< 0.063		
Mo	< 1.25		
Pb	< 0.250		
Zn	< 0.125		
Cd	< 0.063		
Ag	< 0.050		
Au	< 0.100		
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	< 0.50		
Be	< 0.005		
B	0.2		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	79		
F	4.0		
		<u>CDMG LAB ANALYSIS</u>	
		Carbonate.....	- ppm
		Bicarbonate.....	448.35 ppm
		Sulfate.....	17.59 ppm
		Corrected TDS.....	540 ppm
		<u>OTHER DATA</u>	
		Date of Site Visit.....	7-06-81
		Ambient Temperature.....	22°C
		Surface Temperature of Water.....	24°C
		Flow Rate or Capacity....	
		Field Investigator.....	Leivas

EXPLANATION

QUATERNARY	Qal	Alluvial deposits.	Qls	Landslide deposits.
	Qt	Terrace deposits.		
TERTIARY		UNCONFORMITY		
	Pu	Pismo Formation Upper Pliocene.		
	Pl	Pismo Formation Lower Pliocene-upper Miocene.		
		UNCONFORMITY		
	Tm	Monterey Formation.		
JURASSIC		UNCONFORMITY		
	To	Obispo Formation.		
	Tr	Rincon Formation and Vaqueros Sandstone.		
		UNCONFORMITY		
	Jf	Franciscan rocks and Serpentinite and ultrabasic rocks.

- Contact, approximately located.
- Fault, dashed where approximately located, queried where inferred, dotted where concealed.
- Anticline, approximately located.
- Syncline, approximately located.

Figure 35. Map and section of geology near Sycamore Hot Springs, San Luis Obispo County. Generalized from Hall (1973).

and temperature obtained from this well was "three thousand barrels at a temperature of 103 degrees" per day (Myron, 1890). At the time of completion of this well, it was the deepest in the country.

In 1890, the natural gas was not utilized; however, by 1896 the gas was "collected and used for illumination and fuel" (Crawford, 1896). Crawford (1896) also reported that the well is "said to flow 144,000 gallons water and 16,800 cu. ft. gas per day."

Laizure (1925) reported a "large flow of hot sulfur water, having a temperature of 110°F with a considerable quantity of gas...is utilized for bathing in plunges and tubs". Facilities included "a good hotel, cottages and other accomodations for guests" (Laizure, 1925).

It appears from the brief literature search conducted for this report that the resort has operated continuously since it was opened in the late 1880s, although the name was changed temporarily to "San Luis Hot Springs" from 1905 to 1938.

NAME: Tecopa Hot Springs (IN-19)

LOCATION: 35°52.31'N; 116°13.87'W

T21N, R7E, Sec. 33 (SBB&M)

Inyo County: 11 km south of Shoshone.

QUADRANGLE: Tecopa 15'

SYNOPSIS: Tecopa Hot Springs consists of 3 warm springs which supply warm water to Inyo County Park and to the bath houses located over the springs (photo 29). Water temperature was observed to be 42°C; flow rate was estimated to be 757 liters per minute.

Regionally, the geothermal resource appears to be quite large. However, there is a possibility that extensive tapping of the warm water aquifer could eventually cause a sufficient reduction in pressure of the aquifer system so as to cause the spring to stop flowing, although there would still exist a large low-to-moderate temperature geothermal resource in the area. A careful study of the groundwater/geothermal system should be conducted prior to further development in this area.

GEOHERMAL FEATURES: Tecopa Hot Springs is located at the base of a hill composed of Stirling Quartzite (photo 29). The warm waters probably rise along the contact between the lake beds and the quartzite.

Three springs are the source of warm water for the baths. Two of the springs directly supply the bath houses and the third spring supplies water to the Inyo County recreation facilities located across the road from the springs. In 1908 the temperatures of the springs were 42°C-43°C (108-109°F) Waring (1915). Waring also

Photo 29. Bath houses at Tecopa Hot Springs. The springs rise inside the women's bath (house on left), in the pump house (small house with white door), and in the area between the men's bath (structure on right) and the pumphouse. The hill with the cross on it is composed of Stirling quartzite. The bath houses are built on Quaternary alluvium. View is to the east. Photo by E. Leivas.

observed "heavy alkaline deposits of soda and common salt" near the springs. The nearest such deposits observed are about 0.8 km to the west. Evidence of hydrothermal alteration was not observed.

An unknown number of domestic water-supply wells, which provide warm water, have been installed in the residential area to the northwest of the County hot springs. Several local individuals reported that since these wells went in, the flow has diminished at the County springs, however, there is no study known to County officials which can either prove or disprove this claim. Currently, Inyo County has imposed a moratorium on further development of wells in this area pending an assessment of the water resources of this area. Other wells located easterly of the County springs (east of the hill of quartzite) also produce warm water. Most of these wells are 90 m to 120 m deep and have an artesian flow.

The number of wells in this area, the volume of water that is probably produced from them, the volume of water flowing from the abandoned well north of here (well 21N/7E28P1S), and the extent of the area covered by runoff water (in the shallow lake or marsh west of the County springs), suggests that there is an extensive warm water resource located here. The areal extent, quantity, quality, and source of the geothermal resource needs to be determined by more detailed investigation.

CHEMISTRY: See table 34, page 203.

Table 34

SITE NAME: Tecopa Hot Springs (IN-19)

LOCATION: 35° 52.31'N; 116° 13.87'W
T21S, R7E, Section 33 (MDB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	575	Chloride.....	382 ppm
K	16		
Ca	5	Sulfate.....	ppm
Mg	2		
Fe	< 0.025	Sulfide.....	0.015 ppm
Al	< 0.625		
Si (As SiO ₂)	66	Nitrogen (Ammonia).....	0.85 ppm
Ti	0.3		
P	< 0.625	Alkalinity (as CaCO ₃)....	600 ppm
Sr	0.13		
Ba	< 0.625	Salinity (percent).....	1.7
V	< 1.25		
Cr	< 0.050	pH.....	7.1
Mn	< 0.250		
Co	< 0.025	Electrical Conductivity	
Ni	< 0.125	at 32 °C.....	3790 µmho/cm
Cu	< 0.063		
Mo	< 1.25		
Pb	< 0.250	<u>CDMG LAB ANALYSIS</u>	
Zn	< 0.125	Carbonate.....	- ppm
Cd	< 0.063		
Ag	< 0.050	Bicarbonate.....	710.65 ppm
Au	< 0.100		
As	< 0.625	Sulfate.....	288.9 ppm
Sb	< 0.750		
Bi	< 2.50	Corrected TDS.....	1705 ppm
U	< 6.25		
Te	< 1.25	<u>OTHER DATA</u>	
Sn	< 0.125	Date of Site Visit.....	5-10-81
W	< 0.125		
Li	0.21	Ambient Temperature.....	28°C
Be	< 0.005		
B	7.7	Surface Temperature	
Zr	< 0.125	of Water.....	42°C
La	< 0.125		
Ce	< 0.250	Flow Rate or Capacity....	757 l/m
Th	< 2.50		
Cl	389	Field Investigator.....	Leivas
F	3.5		

GEOLOGY: Tecopa Hot Springs is located in the Basin and Ranges

Geomorphic Province, near the southeastern end of Death Valley.

The springs are located at the depositional contact between the Cambrian Stirling quartzite and the Quaternary lake beds (figure 36) described by Mason (1948) and probably rise along this contact. The lake beds are more fully described by Chesterman (1973) for the area south and southwest of Shoshone.

The thermal property of the water is probably related to a north-south trending fault (herein called the Amargosa River fault) shown by Chesterman (1973) and Jennings (1975). The Amargosa River fault as used here extends from about 3 km north of Shoshone to about section 5 of T20N, R7E, SBB&M (Chesterman, 1973 and Jennings, 1975) and is located approximately along the course of the Amargosa River (approximately 1.6 km west of Tecopa Hot Springs). Thermal waters probably move upward along the Amargosa River fault and disperse laterally into the lacustrine sediments.

Two faults are shown approximately 0.8 km south by Jennings and others (1962). Both faults trend east-west and are approximately 0.4 km to 0.7 km in length. South from these two faults and approximately 1.2 km from the County springs, Mason (1948) shows a thrust fault. The relationship of these three faults to the County springs is not known for certain, however, it appears reasonable to assume that the warm water does not move along these faults.

HISTORY: The springs were first used by the Paiute Indians who told the white travelers and settlers of the "curative" powers of the

EXPLANATION

Qal

Quaternary
alluvium and gravel.

Qlb

Quaternary
lake beds.

Tm

Tertiary sediments
of volcanic
origin (Mason, 1948)

pC-Ew

Pre-Cambrian, Cambrian
Wood Canyon formation.

pCs

Pre-Cambrian
Stirling quartzite.

Contact, dashed
and queried where
inferred.

Fault, dashed and
queried where
inferred, dotted
where concealed.

Movement of warm
water.

Figure 36. Map and section sketch of the geology around Tecopa Hot Springs, Inyo County. Compiled from Mason (1948), Jennings and others (1962), and from data presented in Chesterman (1973), Wright (1974), and Jennings (1975).

springs. The abundance of water in this desert area led to the establishment of the town of Tecopa 3.2 km to the south. The Tonopah and Tidewater Railroad relied on water piped 0.8 km from the hot springs to provide water for its steam engines (Waring, 1915).

In 1961, the County of Inyo leased the land upon which the hot springs are situated from the U.S. Bureau of Land Management. Through the Inyo County Parks and Recreation Department, bath houses, a community center, and campground facilities were erected. Use of the baths is free.

NAME: Tecopa Well 21N/7E28P1S (IN-21)

LOCATION: 35°53.19'N; 116°14.12'W

T21N, R7E, Sec. 28 (SBB&M)

Inyo County; 10 km south of Shoshone.

QUADRANGLE: Tecopa 15'

SYNOPSIS: Warm water at Tecopa Well 21N/7E 28 P1S comes through an abandoned drill hole. The drill hole penetrated more than 107 m of lacustrine deposits. The source of the warm water is probably related to dispersal of upwardly migrating thermal waters from the Amargosa River fault into the +122 m thick lacustrine deposits. Water temperature is 48°C and the flow rate was calculated to be more than 40,000 liters per minute.

Regionally, the geothermal resource appears to be quite large. However, extensive tapping of the warm water aquifer, such as with water wells, could cause the spring and artesian wells at nearby Tecopa Hot Springs to stop flowing, although there would still exist a large low-to-moderate temperature geothermal resource in the area. A careful study of the groundwater/geothermal system should be conducted prior to further development in this area.

GEOHERMAL FEATURES: This artesian warm water source is at the site of an abandoned drill hole (photo 30). To the casual observer the area currently looks like a spring. A flow rate of 41,640 liters per minute was calculated by assuming that two 24" diameter corrugated metal pipes: (1) conduct all of the flow under the county road located 200 m west of the well, and (2) that the pipes act as a weir.

Photo 30. Tecopa Well 21N/7E28PIS. The pool is approximately 60 feet in diameter. Warm water issues from several places in the sandy bottom. The whitish hills in the middle distance are Quaternary lake beds. The Resting Spring Range is to the east in the background. Photo by E. Leivas.

CHEMISTRY: See table 35, page 210.

GEOLOGY: Tecopa Well 21N/7E28P1S is located in the Basin and Ranges Geomorphic Province at the southern end of Death Valley. Jennings and others (1962) and Mason (1948) show the area of the well to be underlain by Quaternary lake deposits (figure 37). Chesterman (1973) described these lacustrine deposits as "fine grained, well bedded, buff colored siltstone with subordinate layers of bentonitic clay, buff colored marl and light-gray volcanic ash." Nobel (1926) estimated that the thickness of the lacustrine deposits in this area does not exceed 400 feet (122 m).

The artesian water flow comes through an abandoned drill hole bored into the lacustrine sediments. The warm water is probably supplied by a north-south trending fault (herein called the Amargosa River fault) shown by Chesterman (1973) and Jennings (1975). The Amargosa River fault as used here extends from about 3 km north of Shoshone to about section 5 of T20N, R7E, SBB&M (Chesterman, 1973 and Jennings, 1975) and is located approximately along the course of the Amargosa River (1.6 km west of well 21N/7E28P1S). Thermal waters probably move upward along the Amargosa River fault and disperse laterally into the lacustrine deposits.

Another unnamed fault shown by Jennings and others (1962), is located approximately 3.2 km to the east.

HISTORY: In March of 1967, Stauffer Chemical Company drilled an exploratory hole at this location while prospecting for sodium. An artesian flow of 47°C water and 1,140 liters per minute occurred at approximately 107 m depth.

Table 35

SITE NAME: Tecopa-Well 21N/7E 28 P1S (IN-21)

LOCATION: 35° 53.19'N; 116° 14.12'W
T21S, R7E, Section 28 (MDB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	705	Chloride.....	587 ppm
K	16	Sulfate.....	ppm
Ca	5	Sulfide.....	0.01 ppm
Mg	< 0.500	Nitrogen (Ammonia).....	1.20 ppm
Fe	< 0.025	Alkalinity (as CaCO ₃)....	600 ppm
Al	< 0.625	Salinity (percent).....	2.05
Si (As SiO ₂)	67	pH.....	8.1
Ti	0.2	Electrical Conductivity	
P	< 0.625	at ____ °C.....	4450 µmho/cm
Sr	0.12		
Ba	< 0.625		
V	< 1.25		
Cr	< 0.050		
Mn	< 0.250		
Co	< 0.025		
Ni	< 0.125		
Cu	< 0.063		
Mo	< 1.25		
Pb	< 0.250		
Zn	0.2		
Cd	< 0.063		
Ag	< 0.050		
Au	< 0.100		
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	0.16		
Be	< 0.005		
B	9.4		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	543		
F	3.2		

<u>CDMG LAB ANALYSIS</u>	
Carbonate.....	24.0 ppm
Bicarbonate.....	643.55 ppm
Sulfate.....	463.90 ppm
Corrected TDS.....	2156 ppm

<u>OTHER DATA</u>	
Date of Site Visit.....	5-10-81
Ambient Temperature.....	28°C
Surface Temperature of Water.....	48°C
Flow Rate or Capacity....	
Field Investigator.....	Leivas

Various attempts to cap or control the flow were unsuccessful. Rhodes (1969) reports that in December 1968-January 1969 an eighty-foot (24.4 m) long, 20 inch (0.5 m) diameter casing was lowered into the hole. 1200 cubic yards (918 cubic meters) of screened, 3/4 (inch) plus, gravel was placed around the lower part of the casing. Approximately 9,000 additional cubic yards (6,885 cubic meters) of gravel were dozed into the cavity around the casing. During the process of filling the cavity, the casing and gravel fill subsided and it was necessary to add 16 (4.9 m) feet of extensions to the casing.

Currently, the well site consists of a circular depression approximately 15.2 m in diameter. There is no obvious evidence of a casing projecting from the ground surface. Except for a dike constructed to confine the water flow to a single channel, there are no obvious signs that this well is not a natural spring!

NAME: Van Loan Well (MD-26); (Formerly Old Williams Ranch Well)

LOCATION: 41°15.70'N; 120°31.82'W

T40N, R13E, Sec. 31 (MDB&M)

Modoc County; 4 km northwest of Likely.

QUADRANGLE: Alturas 15'

SYNOPSIS: The Van Loan Well produces water at 44°C at a rate of 175 liters per minute. The well penetrates a confined thermal-water aquifer that appears to have maintained a consistent temperature over the last 20 years. The reservoir temperature is difficult to determine by geothermometry because of the small amount of dissolved constituents, but may be in the range of 80-100°C. The water quality is excellent and is remarkable because thermal waters are generally not noted for high quality. It is possible that the water is a combination of hot, deep-seated water cooled and diluted substantially by near-surface meteoric waters. These conditions would render the geothermometers unreliable.

Excellent access and avenues of transportation are provided by nearby U.S. 395 and a north-south line of the Southern Pacific Railroad. The agricultural economy of the area could provide applications as could the town of Likely. Temperature is probably the main determinant on how the water can be used.

GEOOTHERMAL FEATURES: The Van Loan well is one of several geothermal features situated in a small area northwest of Likely (figure 38, photos 31 and 32). The well is about 30 m deep and produces 44°C water under artesian head. The chemistry of the water is presented in table 36. Hannah (1975) reported a 29°C, 62 m deep artesian

Figure 38. Geologic map showing thermal water wells of the Van Loan Well area, Modoc County. Geology modified from California Department of Water Resources, Bulletin 98 (1963).

Photo 31. Swimming pool building at the Van Loan (formerly Williams) Ranch. Artesian hot water (44°C) discharges from pipe at corner of building. View southeast toward town of Likely. Photo by C. Higgins.

Photo 32. Two discharge outlets next to swimming pool building. Water is discharged at about 175 liters per minute. Well is up-slope to left, off of photo. Photo by C. Higgins.

well at the new Williams ranch, about a kilometer northwest of the Van Loan ranch. Hannah also mentioned that several wells drilled between these two were also warm. A warm spring is shown on figure 38, but was not observable because of flooding by irrigation waters. The local residents reported that this and a few other nearby springs are mildly warm because the springs do not freeze in the winter.

CHEMISTRY: See table 36, page 217.

GEOLOGY: The Van Loan well is in the South Fork Pit River Valley, a north-trending structural basin bordered by tablelands composed of Tertiary and Quaternary volcanic rocks. The valley bottom is underlain by a thick, deformed sequence of unconsolidated to slightly consolidated Plio-Pleistocene alluvial and lacustrine deposits known as the Alturas Formation. These are overlain by undeformed younger alluvium and basin deposits. The Van Loan well penetrates the younger alluvial deposits.

Structurally, the valley is underlain by a syncline cut by numerous faults, most of which trend northwest, the dominant structural trend in this region. The Van Loan well intersects or is very near a concealed northwest-trending fault mapped by the California Department of Water Resources (1963) that forms the southwest boundary of a graben (figure 38). It is possible that hot water is rising along this fault and may be moving laterally into the permeable alluvial deposits in the graben. The mildly thermal springs also appear to approximately coincide with the concealed fault.

Table 36

SITE NAME: Van Loan Well (MD-26)

LOCATION: 41° 15.70'N; 120° 31.82'W
T40N, R13E, Section 31 (MDB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	41	Chloride.....	<20 ppm
K	3	Sulfate.....	28 ppm
Ca	4	Sulfide.....	ppm
Mg	< 0.544	Nitrogen (Ammonia).....	0.7 ppm
Fe	< 0.027	Alkalinity (as CaCO ₃)....	ppm
Al	< 0.680	Salinity (percent).....	
Si (As SiO ₂)	43	pH.....	8.79
Ti	< 0.136	Electrical Conductivity	
P	< 0.680	at 30 °C.....	248 µmho/cm
Sr	< 0.014		
Ba	< 0.680		
V	< 1.36		
Cr	< 0.054		
Mn	< 0.272		
Co	< 0.027		
Ni	< 0.136		
Cu	< 0.068		
Mo	< 1.36		
Pb	< 0.272		
Zn	< 0.136		
Cd	< 0.068		
Ag	< 0.054		
Au	< 0.109		
As	< 0.680		
Sb	< 0.816		
Bi	< 2.72		
U	< 6.80		
Te	< 1.36		
Sn	< 0.136		
W	< 0.136		
Li	< 0.054		
Be	< 0.005		
B	0.3		
Zr	< 0.136		
La	< 0.136		
Ce	< 0.272		
Th	< 2.72		
Cl	13		
F	0.4		

<u>CDMG LAB ANALYSIS</u>	
Carbonate.....	2.25 ppm
Bicarbonate.....	72.95 ppm
Sulfate.....	43.50 ppm
Corrected TDS.....	186 ppm

<u>OTHER DATA</u>	
Date of Site Visit.....	10-09-80
Ambient Temperature.....	21°C
Surface Temperature of Water.....	44°C
Flow Rate or Capacity....	175 l/m
Field Investigator.....	Higgins

SETTING AND HISTORICAL USE OF THE SITE: The Van Loan well is a few kilometers west of U.S 395, the major north-south all weather highway that traverses northeastern California. The well is at the edge of a gently rolling alluvial terrace that rises several meters above the flat valley bottom. The climate is characterized by warm, dry summers and cold, snowy winters.

The economy of the valley is based mainly on ranching, which includes livestock and raising of alfalfa and wheat. The nearest settlement is Likely, with a few hundred people. Alturas, with several thousand people, is about 25 km to the north. Ranches and residences are common between Likely and Alturas.

At the time of the site visit, the well supplied water for domestic use; unused water drained into irrigation ditches in nearby fields. Adjacent to the discharge pipe from the well is a large building that houses a commercial swimming pool, which once was supplied by the well (photo 31). The pool, which is several decades old, is unused and in disrepair.

NAME: Warner Hot Springs (SD-4)

LOCATION: 33°17.03'N; 116°37.85'W

T10S, R3E, near corner of sections 23, 24, 25, and 26
(SBB&M)

San Diego County; 75 km northeast of San Diego, 65 km south
of Palm Springs.

QUADRANGLE: Warner Springs 7.5'

SYNOPSIS: The 56°C water at Warner Hot Springs issues from about a dozen springs in a creek bed, and is ponded in four rock-lined pools prior to overflowing into the natural drainage. Flow rate is estimated to be more than 500 liters per minute.

The hot water has historically been used only for balneological purposes. Currently the water is used to fill two olympic-size swimming pools. Plans for the geothermal resource include space and water heating for many of the resort's facilities.

The meager data available suggests that the resource is extensive. Upwelling of the water is probably related to conduits provided by intersecting joints and fractures along the Agua Caliente Fault Zone.

GEOHERMAL FEATURES: The hot water at Warner Hot Springs issues from about a dozen springs in a creek bed. Warm water has been encountered in two wells adjacent to the resort. The hot water is ponded (photo 33) in four rock-lined pools prior to overflowing into the natural creek. Gas bubbles were observed effervescing from the green algae-covered bottom of the pools. It is unknown if the bubbles are associated with the vegetation or with the thermal

Photo 33. Warner Hot Springs. Warm water issues in 3 pools such as this one. The jointed rock in the background is tonalite. Photo by E. Leivas.

water. Evidence of hydrothermal alteration was not observed during the brief field visit.

The extent of the geothermal resource was not readily determinable from this brief investigation; however, the springs have consistently produced warm water here at about the current rate and temperature.

The occurrence of several other warm springs in this valley (Waring, 1915), and the existence of two warm water wells adjacent to the resort, suggests that an extensive resource exists. The source of the geothermal heat is probably related to circulation of percolating ground water to deep levels, then upwelling of hot water along joints and fractures that intersect the Agua Caliente Fault Zone.

CHEMISTRY: See table 37, page 222.

GEOLOGY: Warner Hot Springs is located in the Peninsular Ranges Geomorphic Province. The topography of this region is controlled by a series of sub-parallel to parallel, northwest trending faults. The Elsinore Fault Zone is located 12 km to the southwest. The San Jacinto Fault Zone is approximately 24 km to the northeast. Locally, the Pre-Quaternary (Jennings, 1975) Agua Caliente Fault Zone passes just east of the springs.

Warner Hot Springs resort is situated on the southwestern edge of Hot Springs Mountain (figure 39). Hot Springs Mountain is composed of Mesozoic granitic rocks (mostly tonalite) and Pre-Cenozoic granitic and metamorphic rocks (Rogers, 1965). The granitic rocks are part of the Southern California Batholith.

Table 37

SITE NAME: Warner Hot Springs (SD-4)

LOCATION: 33° 17.03'N; 116° 37.85'W
T10S, R3E, Section 25 (SBB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	77	Chloride.....	< 139 ppm
K	4	Sulfate.....	ppm
Ca	3	Sulfide.....	0.1 ppm
Mg	< 0.500	Nitrogen (Ammonia).....	10.5 ppm
Fe	0.08	Alkalinity (as CaCO ₃)....	ppm
Al	< 0.625	Salinity (percent).....	Trace
Si (As SiO ₂)	54	pH.....	9.4
Ti	< 0.125	Electrical Conductivity	
P	< 0.625	at 33 °C.....	550 µmho/cm
Sr	< 0.013		
Ba	< 0.625		
V	< 1.25		
Cr	< 0.050		
Mn	< 0.250		
Co	< 0.025		
Ni	< 0.125		
Cu	< 0.063		
Mo	< 1.25		
Pb	< 0.250		
Zn	< 0.125		
Cd	< 0.063		
Ag	< 0.050		
Au	< 0.100		
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	0.08		
Be	< 0.005		
B	0.6		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	13		
F	0.4		

<u>CDMG LAB ANALYSIS</u>	
Carbonate.....	34.50 ppm
Bicarbonate.....	44.23 ppm
Sulfate.....	23.04 ppm
Corrected TDS.....	244 ppm

<u>OTHER DATA</u>	
Date of Site Visit.....	7-01-81
Ambient Temperature.....	25°C
Surface Temperature of Water.....	56°C
Flow Rate or Capacity....	492 l/m
Field Investigator.....	Leivas

EXPLANATION

- Qal Alluvium.
- Qc Pleistocene nonmarine.
- gr Mesozoic granitic rocks.
- gr-m Pre-Cenozoic granitic and metamorphic rocks.
- Contact, dashed and queried where inferred.
- Fault, dashed where inferred.

Figure 39. Map and section of the geology around Warner Hot Springs, San Diego County. Geology simplified from Rogers (1965).

Valle de San Jose is the basin or valley adjacent to Warner Hot Springs to the west. The basin is occupied by Lake Henshaw and Quaternary nonmarine deposits (Rogers, 1965). Quaternary rocks consist mainly of older alluvial deposits, and sand and silt units. Younger alluvium underlies the washes, gullies, and stream bottoms of present drainage channels.

Generally north trending joints in the tonalite at Warner Hot Springs probably intersect the Agua Caliente Fault Zone at depth, providing a conduit for the rising warm water.

Warm water issuing at Warner Hot Springs is probably meteoric water that has percolated to a depth sufficient to heat it, migrated toward the fault zone, and risen rapidly along the joints and fractures which locally intersect the fault.

HISTORY: Warner Hot Springs were known to the local Indians and Mexicans as Las Aguas Calientes (Tucker, 1925). The site of the springs was also the site of an Indian village prior to 1904. In 1904, the Indians were moved to the Pala Reservation and a resort built at the springs (Waring, 1915). Waring (1915) reports that in "1908 there were about 20 adobe cottages and an equal number of tents". The dining hall was a building converted to that purpose from use as the Indian school.

Currently, the resort includes two olympic-size swimming pools, laundry, post office and store, service station, staff residences, stables, golf course, snack bar, approximately 90 guest cottages (with plans for 100 more), conference rooms, and a main lodge. Plans involve developing the geothermal resource to provide space and water heating to many of the resorts facilities.

NAME: Weidner Well (MD-3)

LOCATION: 41°56.87'N; 120°19.05'W

T47N, R14E, Sec. 2 (MDB&M)

Modoc County; 5 km south-southwest of New Pine Creek.

QUADRANGLE: Willow Ranch 15'

SYNOPSIS: The Weidner well penetrates a thermal-water aquifer, the areal extent of which is unknown. Water temperature was measured at 46°C. The aquifer probably covers at least one square kilometer and appears to have maintained a consistent temperature over the last 20 years. Water quality is good except for high concentrations of fluoride and boron, which may be detrimental to domestic and agricultural uses of the water.

The well is close to both U.S. 395 and a main north-south line of the Southern Pacific Railroad, which allow for excellent access and transportation. Possible applications include space heating and agricultural operations at the site, although the water temperature and chemistry rather than the volume will probably determine how the water is used. New Pine Creek might be a candidate for a district heating project if an adequate volume and temperature of water can be produced.

GEOHERMAL FEATURES: The Weidner well (photo 34), situated along the east side of Goose Lake (figure 40), is about 150 m deep and produces 46.5°C water. A chemical analysis of the water is shown in table 38. An old, abandoned well just east of Weidner house was reported to be of a similar temperature to the main well. This may be the well that was sampled in 1958 (California Department of

Photo 34. Weidner well and pump in Goose Lake Valley.
Discharge temperature measured 46.5°C. View east
toward the Warner Mountains. Photo by C. Higgins.

Cross Section A-A'
Scale 1:62,500
No vertical exaggeration

EXPLANATION

- Qly Recent lacustrine and near-shore deposits associated with Goose Lake.
- Qf Recent alluvial fan deposits.
- Qlo Older Quaternary lacustrine and near-shore deposits associated with lakes ancestral to Goose Lake.
- Tv Tertiary volcanic and volcaniclastic rocks.
- Contact (dashed where approximate)
- Fault
- Fault, concealed

Figure 40. Geologic map and section showing thermal water wells of the Weidner Well area, Goose Lake Valley, Modoc County. Geology modified from California Department of Water Resources, Bulletin 98 (1963).

Table 38

SITE NAME: Weidner Well (47N/14E-2G5M)(MD-3)

LOCATION: 41° 56.87'N; 120° 19.05'W
T47N, R14E, Section 2 (MDB and M)WATER ANALYSIS AND SITE DATA

<u>UURI ANALYSIS</u>		<u>CDMG FIELD ANALYSIS</u>	
Element	Concentration (ppm)		
Na	130	Chloride.....	110 ppm
K	< 2.72	Sulfate.....	87 ppm
Ca	14	Sulfide.....	ppm
Mg	< 0.544	Nitrogen (Ammonia).....	2.3 ppm
Fe	0.10	Alkalinity (as CaCO ₃)....	ppm
Al	< 0.680	Salinity (percent).....	0.2
Si (As SiO ₂)	55	pH.....	8.5
Ti	< 0.136	Electrical Conductivity	
P	< 0.680	at 24 °C.....	610 µmho/cm
Sr	< 0.014		
Ba	< 0.680		
V	< 1.36		
Cr	< 0.054		
Mn	< 0.272		
Co	< 0.027		
Ni	< 0.136		
Cu	< 0.068		
Mo	< 1.36		
Pb	< 0.272		
Zn	0.5		
Cd	< 0.068		
Ag	< 0.054		
Au	< 0.109		
As	< 0.680		
Sb	< 0.816		
Bi	< 2.72		
U	< 6.80		
Te	< 1.36		
Sn	< 0.136		
W	< 0.136		
Li	< 0.054		
Be	< 0.005		
B	4.0		
Zr	< 0.136		
La	< 0.136		
Ce	< 0.272		
Th	< 2.72		
Cl			
F	4.0		

<u>CDMG LAB ANALYSIS</u>	
Carbonate.....	0.00 ppm
Bicarbonate.....	125.81 ppm
Sulfate.....	57.50 ppm
Corrected TDS.....	437 ppm

<u>OTHER DATA</u>	
Date of Site Visit.....	10-08-80
Ambient Temperature.....	24°C
Surface Temperature of Water.....	46.5°C
Flow Rate or Capacity....	3,000 l/m
Field Investigator.....	Higgins

Water Resources, 1960). A domestic well near the house supplies water reported to be about 31°C. A well drilled near the entrance to the Weidner ranch on U.S. 395 reportedly produced hot water.

Just south of the Weidner ranch, a well about 140 m deep was reported by the owner to be about 35°C. At the Steward ranch, just north of the Weidner ranch, a well dug to 10 m in depth was measured at 38°C. Curiously, a well dug to a similar depth, about 50 m north of this well, was reported to be cold. When the Weidner well is pumped, the water level of the Steward well reportedly drops about a meter almost immediately.

CHEMISTRY: See table 38, page 228.

GEOLOGY: Goose Lake Valley is a north-trending graben bounded on the west by a volcanic tableland, known as the Devil's Garden, and on the east by the Warner Mountains, a horst. The oldest rocks in the area are various Miocene-to-Pliocene volcanic rocks that form the Warner Mountains. The valley bottom is composed of Quaternary alluvial fans and younger alluvium and lake basin deposits. All of the observed geothermal wells are in the alluvial fan constructed by Cottonwood Creek.

The dominant structural trend in Goose Lake Valley is north to north-northwest. Mapping and geophysical surveys by the California Department of Water Resources (1963) show several northerly trending faults concealed beneath the Quaternary alluvial deposits. All of the known thermal wells lie in a graben, the eastern boundary of which may represent the major fault bounding the Goose Lake Valley graben and Warner Mountains. As shown in figure 40,

the wells penetrate a thick sequence of moderately to highly permeable fan and possible near-shore deposits. It is possible that hot water is rising along the fault on the east and migrating laterally westward through the permeable sediments.

SETTING AND HISTORICAL USE OF SITE: The Weidner well is less than a kilometer from northeastern California's major north-south highway, U.S. 395. The terrain is rolling to flat at the well, but rises abruptly to the east to form the Warner Mountains (photo 34). The climate is characterized by warm, dry summers and cold, snowy winters.

The economy of the valley depends mainly on ranching, which includes raising of livestock and cultivation of irrigated crops. New Pine Creek is the nearest population center with a few hundred people; Lakeview, Oregon with several thousand people, is about 25 km north of the ranch. Ranches and residences are scattered sparsely along the east side of the entire length of the valley.

At the time of the site visit, the well was used to irrigate cropland by flooding. Historical uses of the hot water are not known.

NAME: Zuncich Well

LOCATION: 34° 10.31'N; 116° 05.92'W

T1N, R8E, Sec. 13 (SBB&M)

San Bernardino County, approximately 4 km northwest of the city of Twentynine Palms.

QUADRANGLE: Twentynine Palms 15'

SYNOPSIS: The Zuncich well is typical of the northwest part of the Twentynine Palms low temperature geothermal zone. It produces water of 39°C from a depth of 120 m. Pumping capacity is probably greater than 800 liters per minute. As with most of the thermal wells in this area, the heat content of the water is wasted. The low temperature resource is considered fairly large and is practically unused.

GEOTHERMAL FEATURES: The thermal anomaly at Twentynine Palms occurs as a warm ground water zone beneath the city, extending northwestward about 8 km, and eastward perhaps 4 km. The boundaries and temperature variations of this body are known only imperfectly. Numerous private wells in the area draw the thermal water for domestic consumption. To many, the heat and mineralized nature of the water is a disadvantage. Some residents have installed heat pumps which utilize the geothermal heat for energy saving space heating.

The Zuncich well draws from the northwestern part of the zone. The well is 120 m deep and water level is 32 m below ground level. The pump is set at 113 m depth. Water of 39°C is obtained from the well. The water is used directly from a pressure tank in a single plumbing system (no separate hot and cold water taps).

CHEMISTRY: See table 39, page 233.

GEOLOGY: The Twentynine Palms area lies on the southern boundary of the Mojave Desert, just north of the Little San Bernardino Mountains. This is a desert area of Quaternary fanglomerate and alluvial sediments sloping gently northward from the mountain range. The local elevation varies from 548.6 to 609.6 m except where isolated hills rise to moderate heights.

The mountains and scattered desert outliers are made up of Precambrian gneissic rocks and granitic intrusives of Mesozoic age (Dibblee, 1968). The basin areas are covered with Quaternary alluvium mainly sand and gravel with minor clays and fanglomerate (figure 41). Some 13 km west of the area are outcrops of Tertiary nonmarine sandstone and Pliocene basalt.

The area is one of interior drainage with no perennial streams. The major water bearing units in the area are the unconsolidated sediments which underlie alluvial fans and fill local structural depressions to varying depths. The water bearing deposits consist generally of lenticular beds of sand, gravel, silt, and clay, except near the mountains where they consist principally of course-grained angular rock detritus.

Water levels in wells in the Yucca Valley-Twentynine Palms area range from near land surface to more than 152 m below the land surface (Bader and Moyle, 1960). Near Mesquite Lake, north of Twentynine Palms, and at the Oasis of Mara, just south of Twentynine Palms, a few wells flow continuously or intermittently. Mesquite Spring is one manifestation of the pressured aquifer

Table 39

SITE NAME: Zuncich Well

LOCATION: 34° 10.31'N; 116° 05.92'W
T1N, R8E, Section 13 (SBB and M)

WATER ANALYSIS AND SITE DATA

UURI ANALYSIS		CDMG FIELD ANALYSIS	
Element	Concentration (ppm)		
Na	196	Chloride.....	ppm
K	3	Sulfate.....	ppm
Ca	17	Sulfide.....	ppm
Mg	5	Nitrogen (Ammonia).....	ppm
Fe	< 0.025	Alkalinity (as CaCO ₃)....	ppm
Al	< 0.625	Salinity (percent).....	
Si (As SiO ₂)	14	pH.....	
Ti	0.2	Electrical Conductivity	
P	< 0.625	at _____ °C.....	µmho/cm
Sr	0.40		
Ba	< 0.625		
V	< 1.25		
Cr	< 0.050		
Mn	< 0.250		
Co	< 0.025		
Ni	< 0.125		
Cu	< 0.063		
Mo	< 1.25		
Pb	< 0.250		
Zn	< 0.125		
Cd	< 0.063		
Ag	< 0.050		
Au	< 0.100		
As	< 0.625		
Sb	< 0.750		
Bi	< 2.50		
U	< 6.25		
Te	< 1.25		
Sn	< 0.125		
W	< 0.125		
Li	< 0.050		
Be	< 0.005		
B	0.4		
Zr	< 0.125		
La	< 0.125		
Ce	< 0.250		
Th	< 2.50		
Cl	59		
F	9.5		

CDMG LAB ANALYSIS	
Carbonate.....	9.00 ppm
Bicarbonate.....	53.38 ppm
Sulfate.....	412.50 ppm
Corrected TDS.....	752 ppm

OTHER DATA	
Date of Site Visit.....	1-25-81
Ambient Temperature.....	°C
Surface Temperature of Water.....	39°C
Flow Rate or Capacity....	800 l/m
Field Investigator.....	Martin

EXPLANATION

Surficial deposits
sand, alluvium, and clay

Older alluvium
Older gravel

Biotite-rich quartz monzonite

Contact, dashed where
approximately located.

Fault, dashed where
indefinite, dotted
where concealed.

Figure 41. Map and section of geology in the vicinity of Twentynine Palms, San Bernardino County. SB-15, SB-16, and SB-17 are the locations of wells noted in Higgins (1980); the locations of the Zuncich and Jewell wells are shown. Geologic map and section from Dibblee (1968).

condition. Thompson (1929) described large areas of alkali efflorescence on the ground surface due to evaporation of rising ground water. Moyle (personal communication) attributes to the rising water an elongate mass of sand dunes west and south of Mesquite Lake; the wind blown sand being stopped by the ground moisture and more dense vegetation, and permanently anchored by continued growth of vegetation over the pressured seepage area. The sand dunes extend southward into the presumed geothermal zone (figure 41), but it is not known if rising thermal waters have taken part in anchoring of the sand dunes.

Low temperature geothermal zone: Based upon the meager evidence provided by five known thermal wells in the area, and a cursory study of water resource tables, it appears that the thermal zone may extend for about 15 km in an east-west direction, and as much as 6 km north-south. It appears that deep seated hot waters are rising along two or three known faults, the Mesquite Lake fault, the Pinto Mountain fault, and an unnamed fault extending northwestward from the center of Twentynine Palms.

The Mesquite Lake fault parallels the sand dune area and forms a pronounced barrier to ground water movement. On the west side of the fault, water levels are generally less than 32 m below the surface. East of the fault water levels are abruptly lower, of the order of 70 m. According to Moyle (personal communication) temperatures are also higher on the east side of the fault. At present, however, this observation is supported only by temperature data from one well east of the fault and meager information on temperature/depth relations on the opposite side of the fault.

HISTORY: Unlike many geothermal areas in California, there has been no natural hot spring activity nor has there been a history of spas in the area. The first documentation of thermal wells here was by W.R. Moyle (1974).

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