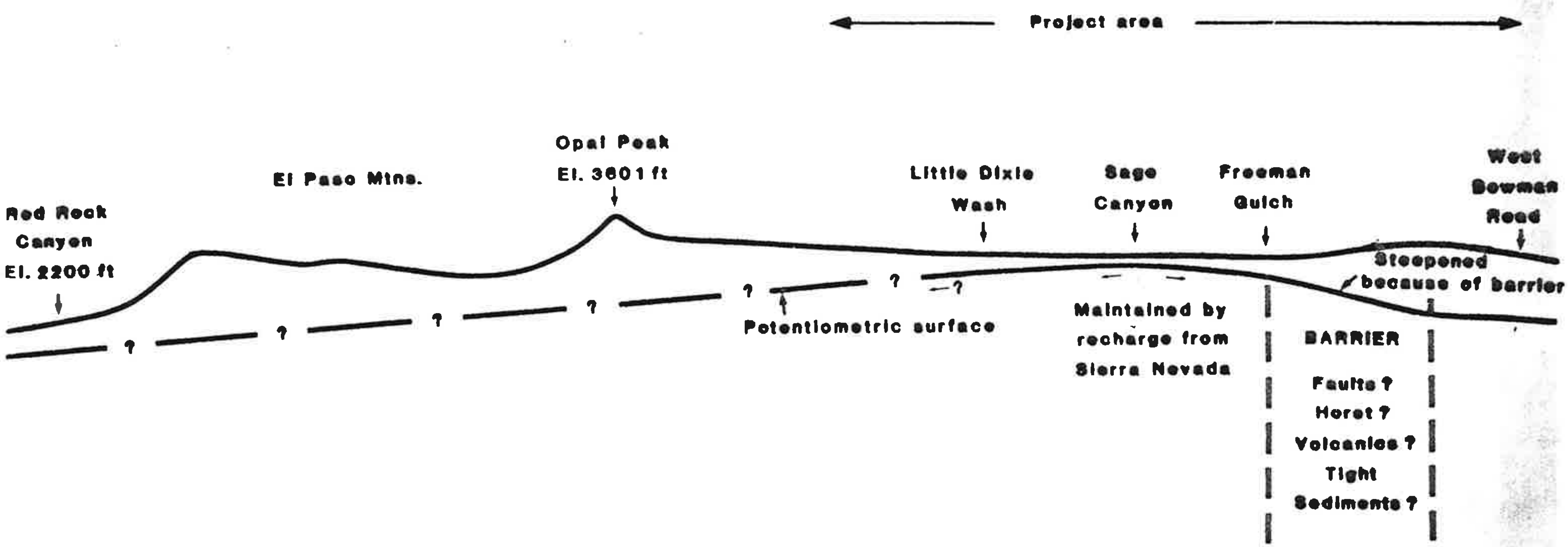

GEOTHERMAL SURVEYS, INC.

Conceptual Model

Figure 9

DISCUSSION

The results of this project indicate some interesting new aspects regarding the geohydrology of the project area and its possible correlation with facets of the local geology. These results also support and refine the major points of a model of the local potentiometric surface developed by the U.S. Geological Survey (Dutcher and Moyle, 1973).

Ground water from Bird Spring and Horse Canyons, and perhaps from Cow Heaven and Sage Canyons, appears to flow southerly through the valley following a well defined thermal trough whose course is independent of the surface drainage pattern. It may be that the ground water is following a buried drainage system in which surface water formerly flowed to the south.

Evidence that an earlier drainage system in and around the project area may have flowed into Fremont Valley is found at Last Chance Canyon and Goler Gulch in the El Paso Mountains. These streams appear to be antecedent to the development of the mountains and may have had their original headwaters in the canyons of the Sierra Nevada.

There is insufficient information to determine the eventual destination of this ground water. It may discharge into Fremont Valley through Red Rock Canyon. Alternatively, south of the project area, it may turn east to the base of the El Paso Mountains and then north toward China Lake, perhaps along a fault zone inferred to occur along the mountain front (please refer to Figure 3).

The drainage basins contributing water to this southerly flow constitute a large proportion, 50% or greater, of the total Sierra Nevada catchment area. Thus, it is likely that the amount of water involved constitutes a similar proportion of the total ground water recharge received from the Sierra Nevada. Using the previously derived (page 9) value of 2,000 acre-feet per year of recharge and assuming that the bulk of this is contributed from the Sierra Nevada leads to a value on the order of 1,000 acre-feet per year of ground water that may be flowing to the south.

The northern part of the project area is thermally more complex than the southern part. The temperature surveys suggest the presence of a ground water barrier extending southeast across the valley from the mouth of Freeman Canyon toward Black Mountain. The exact nature of this barrier is unknown. It may consist of a fault zone, buried volcanics, a horst, a buried bedrock spur, or tight sediments.

EVIDENCE REGARDING THE NATURE OF THE GROUND WATER BARRIER

Evidence for a fault zone from Freeman Canyon to Black Mountain:

- Northwest trending faults have been mapped locally.
- Freeman Canyon is the largest of the local Sierra Nevada Canyons and the only one to head into a pass (Walker Pass) at its upper end.
- A fault up Freeman Canyon may connect into the Pinyon Peak Fault.
- Freeman Gulch trends to the southeast toward Black Mountain rather than northeast down the steeper face of the alluvial fan.
- The eruptive center for the Black Mountain Basalt is in line with this trend.

Evidence for buried volcanics:

- The evidence listed above in support of a fault zone can also be used to infer the presence of buried volcanics.
- The Black Mountain Basalt extends beyond the general mountain front of the El Paso Mountains into the valley near Freeman Gulch. The current northwest edge of the basalt does not appear to be the original flow margin. These suggest that the volcanics extend into the valley at depth.
- The shape of the southwest extension of Indian Wells Valley (widening to the southwest) suggests that it is a downdropped basin that is deepest several miles southwest of Armistead.

Evidence for a buried bedrock spur:

- The El Paso Mountains project further into the valley near Freeman Gulch than at any other point.

Evidence for a buried horst:

- The evidence listed above in support of a fault zone can also be used to infer the presence of a buried horst.

Evidence for the presence of tight sediments:

- No direct evidence exists for the presence of tight sediments.

RECOMMENDATIONS

Based on the results of the present survey, we recommend the following:

- Improve the water budget for the southwest extension of Indian Wells Valley. Assess the ground water recharge from each of the major drainage basins.

- Assess the potential for discharge of ground water from Indian wells Valley into Fremont Valley through Red Rock Canyon. Use presently available data supplemented with a field reconnaissance of the geology.

- If the potential discharge into Fremont Valley appears to be significant, extend the temperature survey southwest to the head of Red Rock Canyon to help define the major ground water flow paths. This will be relatively easy as the sleeves for the present thermal survey are still in place. The surveys could be overlapped without the need to redrill the existing stations.

- Investigate the northeastern ground water barrier using geophysical techniques, either seismic refraction or gravity surveying, to help determine the existence, nature, and dimensions of the inferred ground water barrier.

- Reassess the water budget based on the results of this additional research.

- If the District wishes to develop the ground water in the survey area, we would recommend and prioritize sites for test wells followed by production well drilling and construction.

APPENDIX A

THE THERMAL TECHNIQUE

The thermal method for locating ground water and tracing its movement is based on the principles that: Water moving through the ground changes the temperature of its surroundings by acting as a heat source or a heat sink. If the water is shallow, it can also attenuate or modify the surface ambient temparature cycles.

In application, the sensors do not have to be within the body of the water in order to detect it. The technique maps the thermal effects in the materials overlying or surrounding the moving fluid.

Geothermal Surveys, Inc. uses thermal probes containing thermistors calibrated to 0.01 degrees Centigrade as sensing elements. They are installed in a predetermined areal pattern at depths sufficient to exceed the reach of the diurnal ambient cycle, but within the reach of the annual ambient cycle.

The electrical resistance of a thermistor is a function of temperature and is measured in the field using a Wheatstone Bridge. To ensure accuracy and repeatability, readings are taken only after the probe has reached thermal equilibrium with the surrounding material. The data are computer reduced using coefficients derived from the calibration of the individual thermistors.

After the data are converted, the resulting temperatures are plotted as profiles or contoured as isotherms on base maps. The temperature configuration permits delineation of zones of differential fluid migration and areas of concealed bedrock or other barriers.

APPENDIX B

Temperature Survey Data

Station	Temperature Jan. 13-14, 1986 (degrees C)	Temperature Jan. 22-24,1986 (degrees C)	Temperature Drift (degrees C)
1	17.10	16.60	-0.50
2	17.81	17.27	-0.54
3	17.31	16.88	-0.43
4	18.00	17.48	-0.52
5	18.08	17.72	-0.36
6	17.56	17.03	-0.53
7	16.93	16.49	-0.44
8	17.46	16.90	-0.46
9	17.36	16.54	-0.82
10	17.75	17.20	-0.55
11	17.54	16.86	-0.68
12	17.88	17.22	-0.66
13	18.72	18.03	-0.69
14	18.22	17.54	-0.68
15	17.36	16.71	-0.65
16	17.59	16.99	-9.60
17	17.95	17.23	-0.72
18	17.37	16.81	-0.56
19	17.49	16.95	-0.54
20	18.44	18.06	-0.38
21	17.55	16.87	-0.68
22	17.79	17.22	-0.57
23	17.93	17.47	-9.46
24	17.65	17.28	-0.37
25	17.88	17.40	-0.48
26	18.50	17.98	-0.52
27	17.45	16.92	-0.53
28	17.68	17.05	-0.63
29	17.58	16.81	-0.77
30	17.47	16.87	-0.60
31	17.74	17.17	-0.57
32	17.58	17.03	-0.55
33	17.86	17.33	-0.53
34	18.06	16.78	-1.28
35	17.25	16.65	-0.60
36	18.70	18.23	-0.47
37	19.19	18.77	-0.42
38	18.82	18.48	-0.34
39	17.59	17.13	-0.46
40	17.89	17.52	-0.37
41	17.79	17.35	-0.44
42	19.38	19.00	-0.38
43	18.55	18.11	-0.44
44	17.81	17.44	-0.37
45	18.54	18.04	-0.50

Station	Temperature Jan. 13-14, 1986 (degrees C)	Temperature Jan. 22-24,1986 (degrees C)	Temperature Drift (degrees C)
46	18.39	17.87	-0.52
47	19.42	19.09	-0.33
48	19.26	18.80	-0.46
49	19.24	18.87	-0.37
50	18.72	18.37	-0.35
51	17.38	18.79	-1.41
52	19.21	18.90	-0.31
53	18.73	18.51	-0.22
54	19.86	19.41	-9.45
55	19.89	19.38	-0.51
56	19.53	18.98	-0.55
57	19.95	19.62	-0.33